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S PLANT SOURCE AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the S 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 S Plant Aggregate Area are provided in the report. Work plans 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.

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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 S Plant Aggregate Area is located within the 200 West Area, near the middle of the Hanford Site. There are four operable units within the S Plant Aggregate Area.

The major processes conducted in the S Plant Aggregate Area involved the initial processing to separate uranium and plutonium from irradiated fuel rods. This process, commonly referred to as the reduction-oxidation (REDOX) process, was conducted at the 202-S Building (commonly known as the S Plant Complex). The 202-S Building was constructed around 1951 and was the first process to recover both plutonium and uranium from fission products. Plant operations continued through 1967 when the plant was shut down. An analytical laboratory (222-S) near the facility is still operating in support of Hanford Site operations and research and development.

The S Plant Aggregate Area contains a large variety of waste disposal and storage facilities. High-level wastes were stored in underground single-shell tanks and double-shell tanks. Low-level wastes such as cooling and condensate water were allowed to infiltrate into the ground through cribs, ditches, and open ponds. Based on construction, purpose, or origin, the S Plant Aggregate Area waste management units fall into one of ten subgroups as follows:

- 4 (No. of waste management units) Plant, Building and Storage Area
- 35 Tanks and Vaults
- 13 Cribs and Drains

- 0 Reverse Well
- 13 Ponds, Ditches and Trenches
- 3 Septic Tanks and Associated Drain Fields
- 18 Transfer Facilities, Diversion Boxes, and Pipelines
- 2 Basins
- 2 Burial Sites
- 45 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 S Plant Aggregate Area (Section 2.7). These programs include RCRA, the Decommissioning and RCRA Closure Program, the Radiation Area Remedial Action (RARA) Program, the Single-Shell Tank Closure Program, and the Waste Management Program. Forty-nine units (primarily single-shell tanks and associated transfer facilities) fall completely within the scope of one of these programs and, therefore, recommendations on these units will be made by the respective programs rather than in this AAMSR. An additional 6 waste management units will be partially addressed by an ongoing program in addition to the actions recommended in the S 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.

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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 S Plant Aggregate Area, (2) identification of exposure pathways applicable to individual waste management units, and (3) estimates of relative hazard based on four available indicators of risk; the CERCLA Hazard Ranking System (HRS) and modified HRS (mHRS), surface radiation survey data, and Westinghouse Environmental Protection Group site scoring.

Potentially ARARs to be used in developing and assessing various remedial action alternatives at the S 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 S 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 S 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 S Plant Aggregate Area are developed in Section 9.1. As a result of the data evaluation process, no waste management units were recommended for an ERA, twenty-five units were recommended for LFIs which could lead to IRMs, and twenty-eight units were recommended for final remedy selection. A discussion of the data evaluation process is provided in Section 9.2. Table ES-1 provides a summary of the results of the data evaluation assessment of each unit. Table ES-2 provides the decision matrix patterns each unit followed in reaching the recommendation. Recommendations for redefining operable unit boundaries and prioritizing operable units for work plan development are provided in Section 9.3. Included in Section 9.3 are the interactions with RCRA required to disposition the 216-S-10P and 216-S-10D RCRA TSD facility. All recommendations for future characterization needs will be more fully developed and

implemented through work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility study (FFS) and treatability study, respectively.

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

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
Cribs and Drains							
216-S-1 & -2 Crib		X	X			X	RARA-Collapse Potential
216-S-5 Crib		X	X				
216-S-6 Crib		X	X				
216-S-7 Crib		X	X			X	RARA-Collapse Potential
216-S-9 Crib		X	X				
216-S-13 Crib		X	X			X	RARA-Collapse Potential
216-S-20 Crib		X	X			X	RARA-Collapse Potential
216-S-22 Crib		X	X				
216-S-23 Crib		X	X				
216-S-25 Crib		X	X			X	WMP-Active
216-S-26 Crib		X	X			X	WMP-Active
216-S-3 French Drain		X	X				
Ponds, Ditches, and Trenches							
216-S-10P Pond		X	X				
216-S-11 Pond		X	X				
216-S-15 Pond		X	X				
216-S-16P Pond		X	X				
216-S-17 Pond		X	X				
216-S-19 Pond		X	X				

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

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
216-S-10D Ditch		X	X				
216-S-16D Ditch		X	X				
216-U-9 Ditch		X	X				Redefined to U Plant Aggregate Area
216-S-8 Trench					X		
216-S-12 Trench					X		
216-S-14 Trench					X		
216-S-18 Trench					X		
Septic Tanks and Associated Drain Fields							
2607-W6 Septic Tank					X		
2607-WZ Septic Tank					X		
Sanitary Crib					X		
Transfer Facilities, Diversion Boxes, and Pipelines							
216-S-172 Control Structure		X	X				
2904-S-160 Control Structure		X	X				
2904-S-170 Control Structure		X	X				
2904-S-172 Control Structure		X	X				
Basins							
207-S Retention Basin					X		
207-SL Retention Basin					X		

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

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
Burial Sites							
218-W-7 Burial Ground					X		
218-W-9 Burial Ground					X		
Unplanned Releases							
UN-200-W-32 Unplanned Release					X		
UN-200-W-34 Unplanned Release					X		
UN-200-W-35 Unplanned Release					X		
UN-200-W-41 Unplanned Release					X		
UN-200-W-42 Unplanned Release					X		
UN-200-W-43 Unplanned Release					X		
UN-200-W-52 Unplanned Release					X		
UN-200-W-56 Unplanned Release					X		
UN-200-W-61 Unplanned Release					X		
UN-200-W-69 Unplanned Release					X		
UN-200-W-83 Unplanned Release					X		
UN-200-W-108 Unplanned Release					X		
UN-200-W-109 Unplanned Release					X		
UN-200-W-116 Unplanned Release					X		
UN-200-W-123 Unplanned Release					X		

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

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
UN-200-W-127 Unplanned Release					X		
UN-216-W-30 Unplanned Release					X		

Key:

ERA = Expedited Response Action
RI = Remedial Investigation/Feasibility Study (RCRA Facility Investigation/Corrective Measures Study)
LFI = Limited Field Investigation
RA = Risk Assessment
IRM = Interim Remedial Measure
OPS = Operational Programs
RARA = Radiation Area Reduction Action Program
WMP = Waste Management Program

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

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
Cribs and Drains													
216-S-1 & -2 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-5 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-6 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-7 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	-	Y	-
216-S-9 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-13 Crib	Y	Y	Y	Y	Y	Y	N	Y	N[a]	N	-	Y	-
216-S-20 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-22 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-23 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-25 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-26 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-3 French Drain	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
Ponds, Ditches, and Trenches													
216-S-10P Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-11 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-15 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-16P Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-17 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-19 Pond	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-10D Ditch	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-16D Ditch	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-U-9 Ditch	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-8 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-S-12 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N

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

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
216-S-14 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-S-18 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Septic Tanks and Associated Drain Fields													
2607-W6 Septic Tank	N	-	-	-	-	-	-	-	N	-	-	-	Y
2607-WZ Septic Tanks	N	-	-	-	-	-	-	-	N	-	-	-	Y
Sanitary Crib	N	-	-	-	-	-	-	-	N	-	-	-	Y
Transfer Facilities, Diversion Boxes, and Pipelines													
216-S-172 Cont. Struct.	N	-	-	-	-	-	-	-	N[b]	N	-	Y	-
2904-S-160 Cont. Struct.	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
2904-S-170 Cont. Struct.	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
2904-S-171 Cont. Struct.	N	-	-	-	-	-	-	-	N[b]	N	-	Y	-
Basins													
207-S Retention Basin	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
207-SL Retention Basin	N	-	-	-	-	-	-	-	N	-	-	-	N
Burial Sites													
218-W-7 Burial Ground	Y	Y	N	-	-	-	-	-	N	-	-	-	N
218-W-9 Burial Ground	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
Unplanned Releases													
UN-200-W-32	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
UN-200-W-34	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
UN-200-W-35	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-41	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-42	Y	Y	Y	N	-	-	-	-	Y	N	-	N	N
UN-200-W-43	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-52	N	-	-	-	-	-	-	-	N	-	-	-	N

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

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
UN-200-W-56	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-61	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-69	Y	Y	Y	N	-	-	-	-	N	N	-	N	N
UN-200-W-83	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-108	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-109	Y	Y	Y	Y	N	-	-	-	Y	N	-	N	N
UN-200-W-116	Y	Y	Y	N	-	-	-	-	N	N	-	N	N
UN-200-W-123	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-127	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-216-W-30	Y	Y	Y	N	-	-	-	-	Y	N	-	N	N

Y = Yes
N = No
- = Decision point not reached on pathway. Evaluation branced to other path.
(a) = Addressed as on IRM candidate because of similarities with other units.
(b) = Addressed as an IRM candidate because unit is ancillary equipment to IRM candiate.

ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management Study
AAMSR	aggregate area management study reports
ARAR	applicable or relevant and appropriate requirement
ASIL	ambient source impact levels
BAT	best available treatment technology
BDAT	best demonstrated available treatment technologies
BWIP	Basalt Waste Isolation Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	corrective measures studies
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
EPA	Environmental Protection Agency
ERA	expedited response action
ES&H	Environment, Safety, and Health
FIC	Food Instrument Corporation
FS	feasibility study
FWQC	Federal Water Quality Criteria
Health	Washington State Department of Health
HEPA	High efficiency particulate air
HISS	Hanford Inactive Site Survey
HRS	Hazard Ranking System
IRM	interim remedial measure
LDR	land disposal restriction
LFI	limited field investigation
MCL	maximum contaminant levels
mHRS	modified Hazard Ranking System
MTCA	Model Toxics Control Act
NAAQS	National Primary and Secondary Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NSPS	New Source Performance Standards
PA	preliminary assessment
PARCC	precision, accuracy, representativeness, completeness, and comparability
PNL	Pacific Northwest Laboratory

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ACRONYMS AND ABBREVIATIONS (cont.)

PUREX	Plutonium Uranium Extraction
QA	quality assurance
RA	risk assessment
RAO	remedial action objective
RARA	Radiation Area Remedial Action
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
redox	reduction-oxidation
RFI	RCRA Facility Investigation
RI	remedial investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SI	site inspection
SST	single-shell tank
TBC	To-be-Considered Materials
TCLP	Toxicity Characteristic Leaching Procedure
TLD	thermoluminescent dosimeters
TOC	total organic carbon
TRAC	Tracks Radioactive Components
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TSD	treatment, storage, or disposal
UNH	uranyl nitrate hexahydrate
USC	U.S. Code
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company
WIDS	Waste Information Data System
WPCA	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 S 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.

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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

9 3 1 2 8 6 9 0 7 2 0

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 North Geologic and Geophysics Data Package
- Semiworks Geologic and Geophysics Data Package
- Geologic and Geophysics Data Packages
- 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 FFS 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.

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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 sites.

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.

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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 FFS
- 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.

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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.

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- 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 S 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.

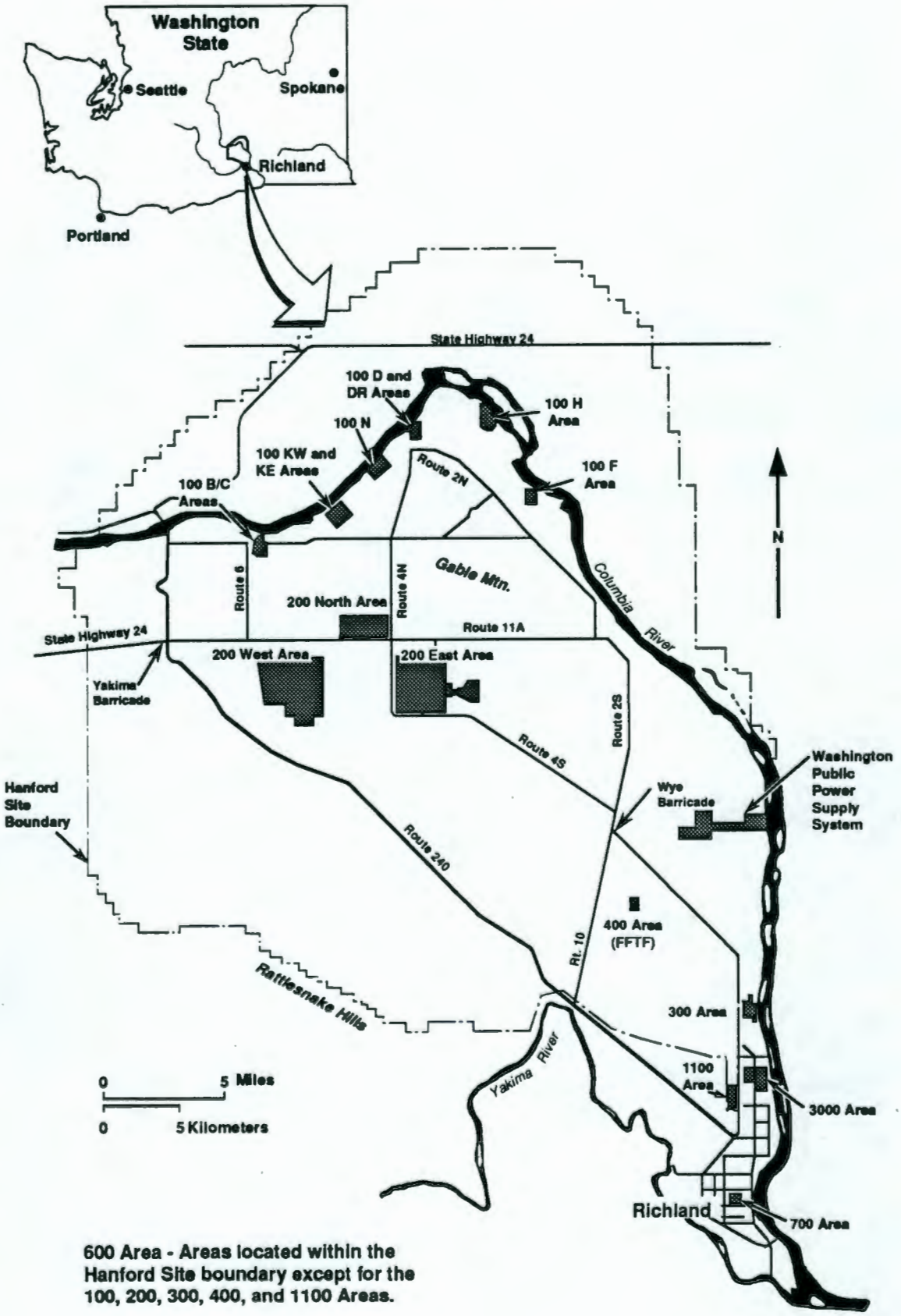

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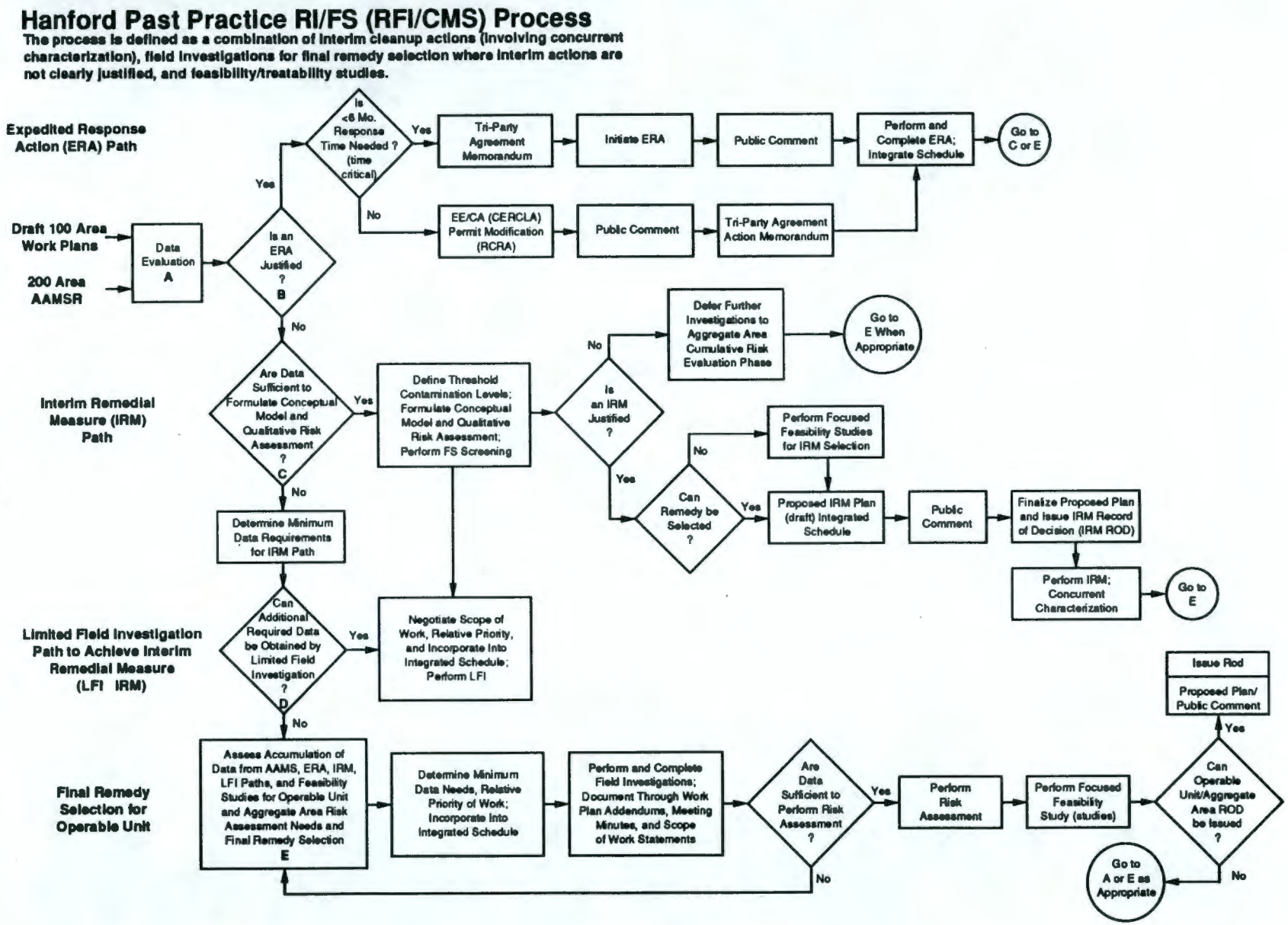
Figure 1-2. Hanford Past-Practice Strategy Flow Chart.



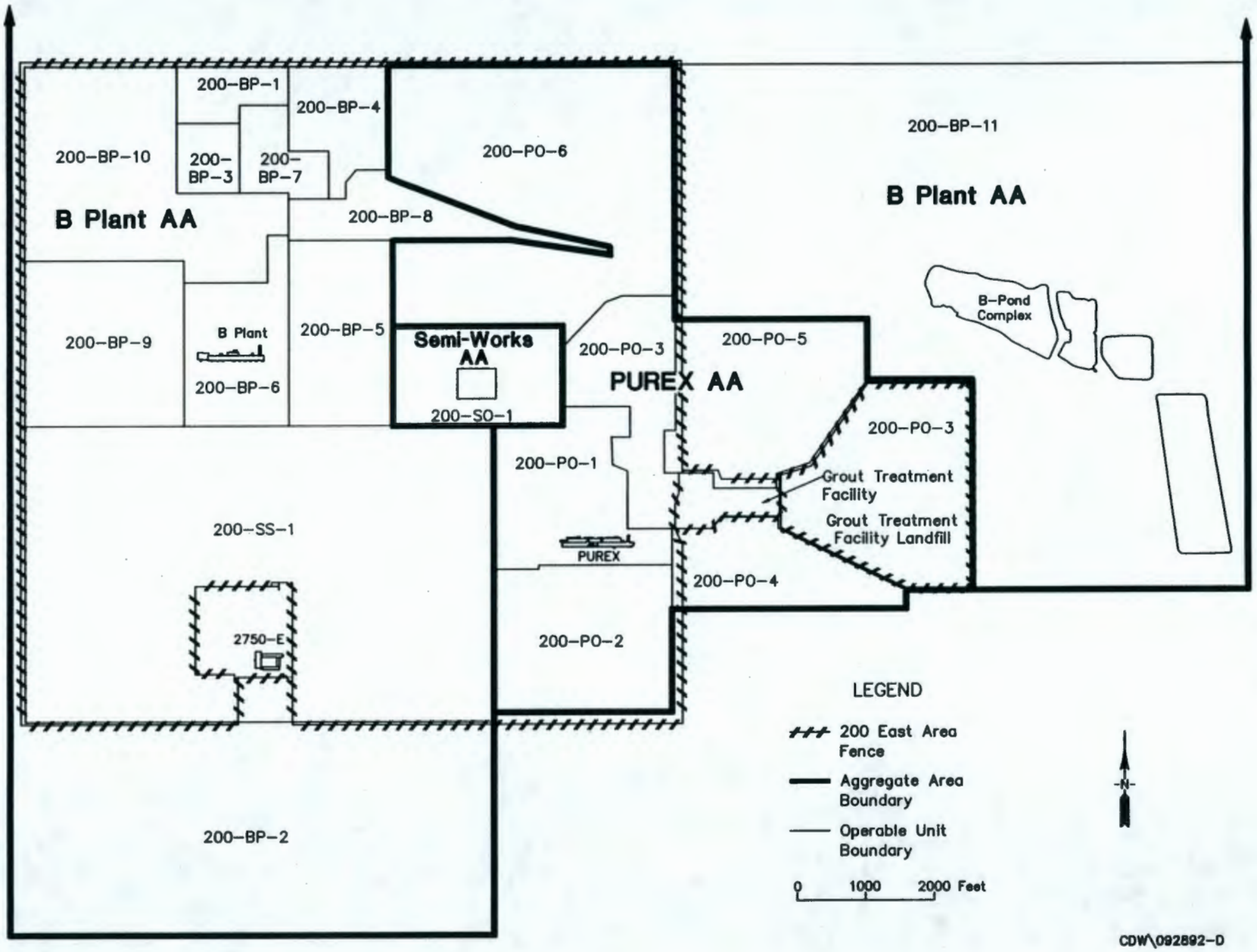


Figure 1-3. 200 East Aggregate Areas.

Figure 1-4. 200 West Aggregate Areas.

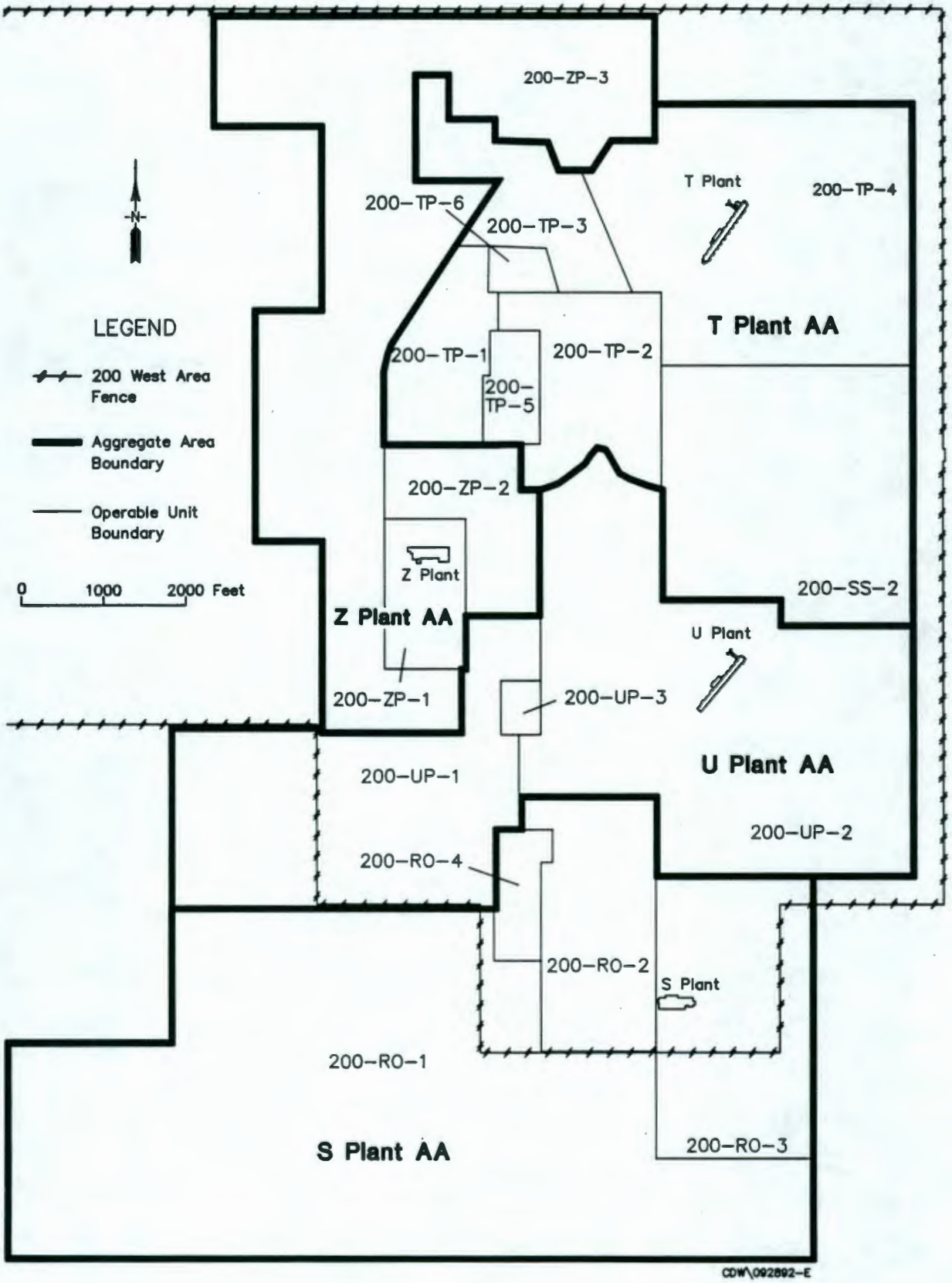


Figure 1-5. 200 NPL Site Isolated Operable Units.

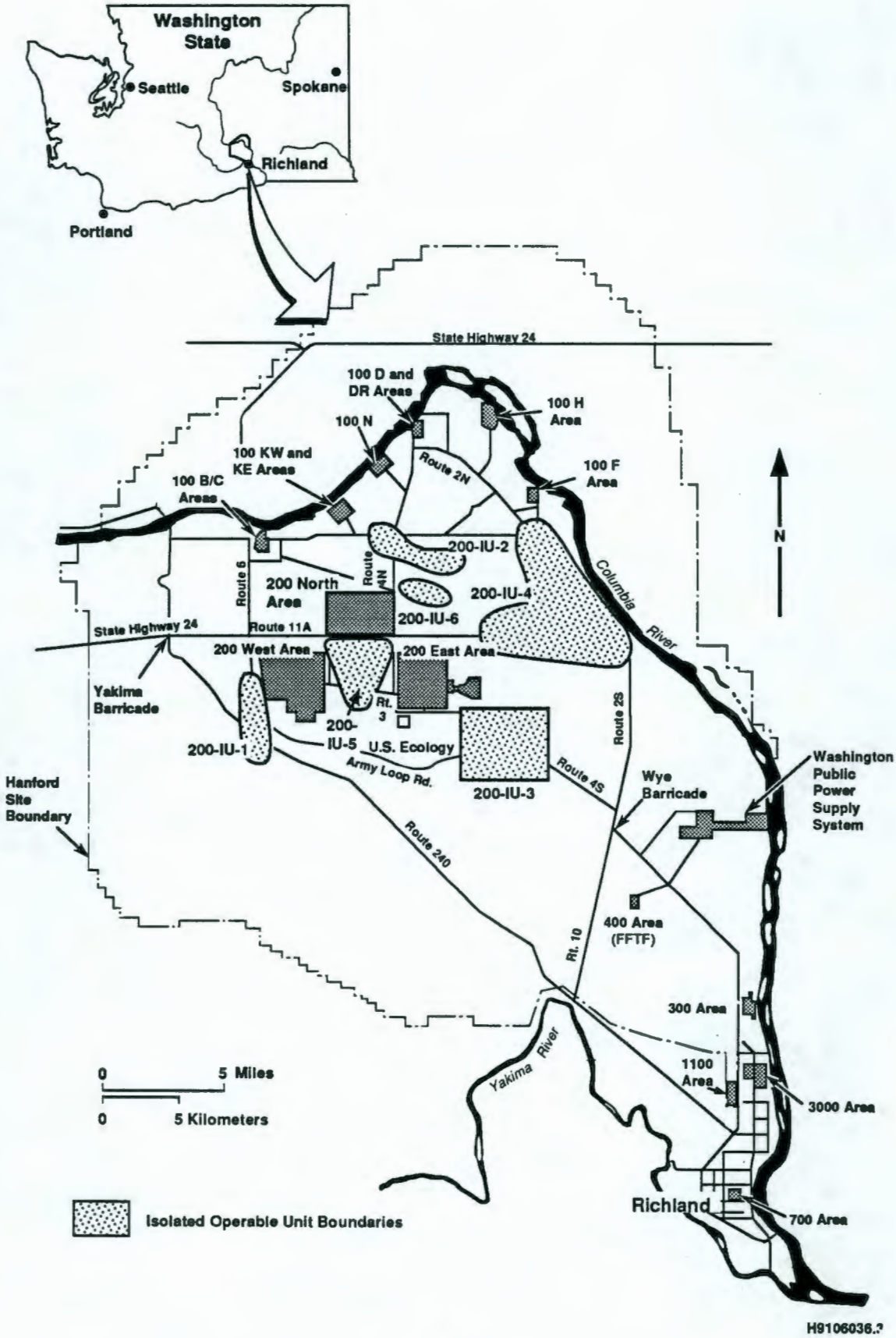


Table 1-1. Overall Aggregate Area Management Study (AAMS) Schedule for the 200 NPL Site.

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

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2.0 FACILITY, PROCESS, AND OPERATIONAL HISTORY DESCRIPTIONS

Section 2.0 of the aggregate area management study (AAMS) presents historical data on the S 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 S Plant Aggregate Area (Section 2.1), summarizes the history of operations (Section 2.2), describes the facilities, buildings, and structures of the S Plant Aggregate Area (Section 2.3), and describes S 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) and other Hanford programs.

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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 source operable units grouped into four source aggregate areas in the 200 West Area (Figure 1-4). The S Plant Aggregate Area (consisting of the 200-RO-1, 200-RO-2, 200-RO-3, and 200-RO-4 Operable Units) lies in the southern portion of the 200 West Area (Figure 1-4). The location of the buildings and waste management units are shown on Plate 1. Plate 2 shows the topography of the S Plant Aggregate Area. The media sampling locations are depicted on Plate 3.

2.2 HISTORY OF OPERATIONS

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B, D, and F Reactors) and three chemical processing facilities (B, T, and U Plants). After World War II, six more reactors were built (H, DR, C, KW, KE, and N Reactors). Beginning in the 1950's, energy research and development, isotope use, and other activities were added to the Hanford operation. In early 1964, a presidential decision was made to begin shut down of the

reactors. Eight of the reactors were shut down by 1971. The N Reactor operated through 1987 and was placed on cold standby status in October 1989. Westinghouse Hanford was notified September 20, 1991 that they should cease preservation and proceed with activities leading to a decision on ultimate decommissioning of the reactor. These activities are scoped within a N Reactor shutdown program which is scheduled to be completed in 1999.

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

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

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

The major processes conducted in the S Plant Aggregate Area involved the initial processing to separate uranium and plutonium from irradiated fuel rods. This process, commonly referred to as the redox (short for reduction-oxidation) process, was conducted at the 202-S Building (commonly known as the S Plant Complex). The 202-S Building was constructed between May 1950 and August 1951 and was the first process to recover both plutonium and uranium from fission products. Plant operations continued through 1967 when the plant was shut down. An analytical laboratory (222-S Laboratory) near the facility is still operating. This laboratory supports Hanford Site operations and performs research and development to support waste management and environmental control operations.

The 241-S, -SX, and -SY Tank Farms contain 30 single-shell and double-shell tanks constructed in 1950 to 1951, 1953 to 1954, and 1974 to 1976 respectively. The single-shell tanks received high-level waste from the S Plant Aggregate Area and other facilities, and the three double-shell tanks receive waste concentrate and saltwell liquor from the single-shell tanks, high-level wastes from all operating facilities in the 200 West Area, and groundwater treatment wastes from 216-U-1 and -2 Cribs. The transfer from single-shell tanks to double-shell tanks is an ongoing process of waste stabilization (DOE 1987).

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2.3 FACILITIES, BUILDINGS, AND STRUCTURES

The S Plant Aggregate Area contains a variety of facilities that were involved in waste generation, transfer, treatment, storage, or disposal. Radiologically contaminated processing wastes were discharged to the soil column through cribs, trenches, and other facilities Wastes which were not normally contaminated, but have the potential to contain radionuclides, such as cooling water and condensate water, were allowed to infiltrate into the ground through ponds and open ditches. Radiologically contaminated waste types are defined in DOE Order 5820.2(A)(DOE 1988a):

- High-level waste is defined as: highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of transuranic (TRU) waste and fission products in concentrations as to require permanent isolation.

- TRU waste is defined as: without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g. Heads of Field Elements can determine that other alpha contaminated wastes peculiar to a specific site must be managed as a TRU waste.

- Low-level waste is defined as: radioactive waste not classified as high-level waste, TRU waste, spent nuclear fuel, or IIe(2) byproduct material as defined by this Order. Test specimens of fissionable material irradiated for research and development only, and not for 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 to the process of producing or utilizing special nuclear material. For purposes of determining their applicability of the Resource Conservation and Recovery Act to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended int he waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under the Resource Conservation and Recovery Act: (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."

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Based on construction, purpose, or origin, the S 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 and includes the source description and type, waste volume received, the contaminated soil volume, and the operable unit. In addition, the aggregate area contains several unplanned release sites. The locations of these waste management units are shown on separate figures for each waste management group and on Plate 1. Figure 2-1 summarizes the operational history of each of the waste management units (WHC 1991a; DOE/RL 1992b). Tables 2-2 and 2-3 summarize data available regarding the quantity and types of wastes disposed of to the waste management units. These data have been compiled from the Waste Information Data System (WIDS) inventory sheets (WHC 1991a) and from the Hanford Inactive Site Survey (HISS) database (DOE 1986). These inventories include all of the contaminants reported in the databases, but do not necessarily include all of the contaminants disposed 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.

2.3.1 Plants, Buildings, and Storage Areas

Plants and buildings are not generally identified as past-practice waste management units according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) and will generally be addressed under the Decommissioning and RCRA Closure Program. The program is responsible for the surveillance, maintenance, and decommissioning of surplus facilities within the Environmental Restoration Program. Section 2.7 details the interaction of the Hanford programs. Because several of the S Plant

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Aggregate Area plants or buildings were the primary generators of waste disposed within the S Plant Aggregate Area, a description of these is provided in Section 2.3.1.1. The S Plant Aggregate Area plants and buildings that are also waste management units are addressed in Section 2.3.1.2. Some plants and buildings are or contain RCRA treatment, storage, or disposal (TSD) facilities. A description of such facilities is provided in Section 2.6. The locations of plants, buildings, and storage areas in the aggregate area are shown in Figure 2-2.

The 202-S Building and the 222-S Laboratory were the primary generators of waste within the S Plant Aggregate Area. These plants and the associated buildings are described in Section 2.3.1.1.

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

- 241-S Reagent Tank Farm
- 219-S Waste Handling Facility (treats radioactive waste from the 222-S Laboratory)
- 276-S Solvent Handling Facility (storage and treatment of MIBK)
- 2711-S Stack Monitoring Building (instrumentation for monitoring exhaust)
- 2718-S Filter Sampler (monitoring of the pressure drop and radioactivity in effluent air)
- 222-S Waste Storage Facility (storage shed for mixed wastes).

2.3.1.1 Process Facilities.

2.3.1.1.1 202-S Building. The 202-S Building was one of the primary waste generating sources in the S Plant Aggregate Area and is the dominant physical structure in the aggregate area. The 202-S Building was constructed between May 1950 and August 1951 to separate plutonium and uranium from their fission products. Plant operations continued through 1967. The building contained all of the equipment for dissolution, separation, and decontamination of uranium and plutonium as well as equipment for waste concentration, waste neutralization, and solvent recovery. Facilities were also provided for the make-up of process chemicals. The 202-S Building is included in the Decommissioning and RCRA Closure Program.

Effluent ventilation air from the canyon cells and silo process areas was passed through a graduated gravel and sand filter to capture radioactive particles prior to discharge to the environment through the 291-S Stack Complex. Ventilation air from regulated (i.e., uncontaminated) areas was discharged to the atmosphere.

The 202-S Building high-level process wastes were stored in underground tank farms in the 200 West Area, specifically in the 241-S and 241-SX Tank Farms within the S Plant Aggregate Area. Wastes stored in these underground tanks included zirconium and niobium scavenging wastes, ruthenium scrubber wastes, main process wastes (from the extraction columns, organic wash column, organic distillation column bottoms, and condensate evaporator bottoms), coating removal slurry, and dissolver flush. Section 2.4 describes the wastes in greater detail.

Low-level condensate waste was disposed of to cribs, french drains, ditches, trenches, and ponds. Cooling water was discharged to the 207-S Retention Basin and ultimately disposed in the 216-S-16 or 216-S-17 Ponds.

Several unplanned releases occurred in the vicinity of the 202-S Building. These are UPR-200-W-59, UN-200-W-61, and UPR-200-W-96.

2.3.1.1.2 222-S Laboratory. The 222-S Laboratory is one of the primary waste generators in the S Plant Aggregate Area. It is located immediately south of the 202-S Building. The laboratory was constructed during 1950 and 1951. The laboratory provides high-level and low-level chemical and radiological analytical services for the operations in the 200 Areas. It supports all Hanford Site operations with emphasis on waste management, offsite shipment certification, chemical processing, and environmental monitoring programs throughout the 200 West and East Areas including B Plant, U Plant, the tank farms, 242-A and 242-S Evaporators, waste encapsulation storage facility, PUREX Plant, and Plutonium Finishing Plant (Z Plant).

Radioactive and radioactive mixed liquid wastes from the laboratory are treated in the 219-S Waste Handling Facility. Laboratory wastewater (along with wastewater from the 291-S Stack Complex and 219-S Waste Handling Facility) is then directed through the 207-SL Retention Basin and ultimately to the 216-S-26 Crib. The 222-SA Chemical Standards Laboratory contributes nonradiological, nonhazardous wastewater downstream of the 207-SL Retention Basin.

2.3.1.1.3 203-S and 204-S Tank Farms. The 203-S and 204-S Tank Farms included six aboveground uranyl nitrate hexahydrate storage tanks in open concrete basins. Adjacent to the south wall of the 204-S Basin was a pumphouse for transfer of uranyl nitrate hexahydrate. Uranyl nitrate hexahydrate solution was transferred by pipeline to the 224-UA Building Calcination Plant. In 1966, the 204-S facility was converted for unloading radioactive waste from rail tank cars and for storage of thorium nitrate solutions. This building was included in the Radiation Area Reduction Action (RARA) Program. The 203-S and 204-S Tank Farms were removed.

2.3.1.1.4 205-S Building Silica Gel House. The 205-S Building (Silica Gel House) included a two-story building that housed two chemical make-up tanks, a uranyl nitrate hexahydrate sampling room, extensive piping, and an underground process vault housing two silica gel adsorption columns (to remove trace fission products [zirconium and niobium] from uranyl nitrate hexahydrate) and a 10,410 L (2,750 gal) waste neutralizer tank. This facility

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was occasionally used to further remove fission products from decontaminated uranium solutions from the PUREX Plant. This building was included in the RARA Program. The 205-S Building was removed.

2.3.1.1.5 233-S Plutonium Concentration Facility. The 233-S Plutonium Concentration Facility is located on the north side of the 202-S Building. The facility is a concrete steel structure with metal siding, 26 m (80 ft) long, 13 m (43 ft) wide, and 10 m (33 ft) abovegrade. Some previous decommissioning and decontamination has already taken place with the remainder to be completed by 2004. The decommissioning of the 233-S Plutonium Concentration Facility will also include the 233-SA Exhaust Air Filter Building and the 296-S-7 Stack.

Prior to 1963, the facility provided final purification and concentration of plutonium solutions using an ion-exchange process. After an unplanned release the facility was used for concentration (by evaporation) of plutonium and neptunium nitrate solutions from S Plant. In 1967, the building was sealed off and retired from service.

One unplanned release (UPR-200-W-57) is associated with the 233-S Plutonium Concentration Facility. On November 6, 1963, a fire occurred in the plutonium extraction column near the 233-S Plutonium Concentration Facility releasing plutonium to the immediate area. Parts of the building were cleared of gross contamination and nonsmearable alpha contamination was fixed.

2.3.1.2 Waste Management Unit Buildings.

2.3.1.2.1 241-SX-401 Building. The 241-SX-401 Building (alias 241-SX-401 Condenser Shielding Waste Disposal Condenser House) is located west of the 241-SX-106 Single-Shell Tank, north of and in line with the 241-SX-402 Building. The 241-SX-401 Building started operating in 1954 and ceased operations prior to 1976. The unit was built to provide condensation for the 241-SX Tank Farm off-gases. The unit is 11 x 7 m (36 x 24 ft) and constructed of reinforced concrete with the wall varying from 0.3 to 0.8 m (1 to 2.5 ft) thick for shielding purposes. The building is 5 m (17.5 ft) above grade with approximately 2 m (7 ft) below grade. The unit contains 6 condensers, instrumentation, and 2 condensate receiving tanks. Attached to the south end is a single-story, 4 x 2.5 (12 x 8 ft) control room made of wood and plaster board.

The unit contains radioactively contaminated equipment and concrete. The quantity of waste has not been determined. The 241-SX-401 Building is an ancillary facility of the 241-SX Tank Farm and will be addressed by the Single-Shell Tank Closure Program.

No unplanned releases are associated with this unit.

2.3.1.2.2 241-SX-402 Building. The 241-SX-402 Building (alias 241-SX-402 Waste Disposal Condenser House) is located west of the 241-SX-109 Single-Shell Tank, south of and in line with the 241-SX-401 Building. The 241-SX-402 Building started operating in 1954 and ceased operations prior to 1976. The unit was built to provide condensation for the

241-SX Tank Farm off-gases. The unit is 11 x 7 m (36 x 24 ft) and constructed of reinforced concrete with the wall varying from 0.3 to 0.8 m (1 to 2.5 ft) thick for shield purposes. The building is 5 m (17.5 ft) above grade with approximately 2 m (7 ft) below grade. The unit contains 6 condensers, instrumentation, and 2 condensate receiving tanks. Attached to the south end is a single-story, 4 x 2.5 m (12 x 8 ft) control room made of wood and plaster board.

The unit contains radioactively contaminated equipment and concrete. The quantity of waste has not been determined. The 241-SX-402 Building is an ancillary facility of the 241-SX Tank Farm and will be addressed by the Single-Shell Tank Closure Program.

No unplanned releases are associated with this unit.

2.3.1.2.3 242-S Evaporator. The 242-S Evaporator is located in the northwest corner of the 241-S Tank Farm and northwest of the 241-SY Tank Farm. The evaporator started operating in 1973 and stopped in the early 1980's. Steam and process condensate was sent to the 216-S-25 Crib. Cooling water was sent to the 216-U-10 Pond via the 216-U-14 Ditch. The evaporator remains on active status as part of the Waste Management Program. The purpose of the 242-S Evaporator is to reduce the volume of radioactive liquid waste by evaporating water from the feed solutions to produce a concentrated salt solution. The solution separates upon cooling to form salt cake and residual liquor. The 242-S Building contains the evaporator vessel, supporting process equipment, and the principal process components of the evaporator-crystallizer system.

The 242-S Evaporator received single-shell tank supernate, phosphate waste, complexed radioactive waste, and miscellaneous dilute radioactive waste.

No unplanned releases are associated with the 242-S Evaporator.

2.3.1.2.4 291-S Fan and Filter Building. The 291-S Fan and Filter Building is located east of the northeast corner of the 202-S Building. The unit started operating in 1952 and is an active unit. The fan house is a concrete structure with outside dimensions of approximately 4 x 6 x 3 m (14 x 20 x 10 ft). The sand filter is a below-grade concrete structure that is approximately 26 x 26 x 4 m (85 x 85 x 12 ft). Tar and gravel over the concrete roof is visible above grade.

The unit receives exhaust air from the 202-S Process Building.

One unplanned release (UPR-200-W-87) is associated with the 291-S Fan and Filter Building.

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

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present in the S Plant Aggregate Area including 4 catch tanks, 27 single-shell tanks, 3 double-shell tanks, and 1 receiver tank. Catch tanks are generally associated with diversion boxes and other transfer units, and were designed to accept overflows and spills. The receiver tank (frequently called a double-contained receiver tank or vault) receives waste from single-shell tanks. Single-shell tanks were used to collect and store large quantities of mixed wastes. Double-shell tanks are active tanks that are currently used to collect and store large quantities of mixed wastes. The catch tanks and receiver tank will be discussed individually in this section. The septic tanks are discussed in Section 2.3.6. The single-shell and double-shell tanks will be addressed below.

All single-shell tanks will be evaluated under the Single-Shell Tank Closure Program and the double-shell tanks will be evaluated under the Waste Management Program as discussed in Section 9.0. Therefore, detailed discussions need not be addressed in this AAMSR. General information related to the tanks will be described in this report but investigation and remediation strategies will be deferred to the Single-Shell Tank Closure and Waste Management Programs as applicable. Tables 2-1 and 2-4 list single-shell and double-shell tank information that is of importance to this report, including source description, tank integrity, waste volume remaining, and drainable waste volume. The operational history is presented in Figure 2-1 and a reference list for additional single-shell and double-shell tank information is provided in Table 2-5.

Twelve of the twenty-seven single-shell tank waste management units in the S Plant Aggregate Area are contained within the 241-S Tank Farm and fifteen are contained within the 241-SX Tank Farm. The three double-shell tanks are located in the 241-SY Tank Farm. The 241-S Tank Farm is located northeast of the Cooper Avenue and 13th Street intersection. The 241-SX Tank Farm is located south of the 241-S Tank Farm. The tank farms and tank locations are shown on Figures 2-3 and 2-4.

The single-shell tanks in the 241-S and 241-SX Tank Farms were constructed from 1950 to 1951 and 1953 to 1954, respectively. The tank designs were very similar in both tank farms with the tanks being vertical cylinders with a domed top, and constructed of reinforced concrete with a carbon steel liner on the base and sides of the vessel. Figure 2-5 is a schematic of a typical single-shell tank. The tanks are all underground with at least 1.8 m (6 ft) of earth cover above the tank dome. The twelve tanks in 241-S Tank Farm are numbered 241-S-101 through 241-S-112 and the fifteen tanks in the 241-SX Tank Farm are numbered 241-SX-101 through 241-SX-115. The 241-S tanks have a 23 m (75 ft) diameter and a capacity of 3,785,000 L (1,000,000 gal). The 241-SX tanks are 23 m (75 ft) in diameter with a capacity of 3,785,000 L (1,000,000 gal). The current waste volumes and drainable waste volumes for each tank are listed in Table 2-4.

The double-shell tanks in the 241-SY Tank Farm were constructed from 1974 to 1976. The tanks were designed as vertical cylinders with an inner primary tank, an outer secondary tank surrounded by a steel-reinforced concrete shell, and a steel-reinforced domed top. The tanks are all underground with at least 2.1 m (7 ft) of earth cover above the tank dome. Figure 2-6 is a schematic of a typical double-shell tank. The three tanks in the 241-SY Tank Farm are numbered 241-SY-101 through 241-SY-103. the tanks have a 23 m (75 ft)

diameter and a capacity of 3,785,600 L (1,000,000 gal). The current waste volumes and drainable waste volumes for each tank are listed in Table 2-4.

Single-shell tank stabilization and isolation are two objectives of single-shell tank engineering. Interim stabilization criteria for single-shell waste storage and auxiliary tanks is set forth in *Tank Farms Facility Interim Stabilization Evaluation* (Hamrick 1988). Generally, a 100 series tank (a tank with a volume greater than 1,895,500 L [500,793 gal]) is considered interim stabilized if the tank contains less than 19,000 L (5,000 gal) of supernatant and less than 189,000 L (50,000 gal) of drainable liquid (Hanlon 1992). Interim isolation is an administrative designation reflecting the completion of the physical effort required to minimize the unplanned addition of liquids into a tank. Partially interim isolated is an administrative designation reflecting the completion of the physical effort required for interim isolation except for isolation of risers and piping that are required for stabilization (pumping) efforts. Interim isolation and interim stabilization have been performed on the single-shell tanks to varying degrees as listed in Table 2-4. Double-shell tanks are active facilities, thus, they are not considered for stabilization or isolation.

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

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

2.3.2.1 240-S-302 Catch Tank. The 240-S-302 Catch Tank is located north of the 202-S Building. The tank operated in association with the 240-S-151 and 240-S-152 Diversion Boxes. Figure 2-7 is a schematic of a typical catch tank.

The tank operated from 1950 to March 1987. Approximately 189,000 L (50,000 gal) per year of waste are transferred through the 240-S-151 Diversion Box from the 222-S Laboratory. The tank currently contains 9,000 L (2,380 gal) of waste.

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While no unplanned releases are identified for this tank, approximately 2,300 L (600 gal), consisting mainly of rainwater, were released between June 1985 and January 1986 (WHC 1991a).

2.3.2.2 241-S-302A Catch Tank. The 241-S-302A Catch Tank is located east of the 241-SX Tank Farm at the southeast corner of Camden Avenue and 13th Street. The catch tank operated in association with the 241-S-151 Diversion Box and the 241-S Tank Farm.

The catch tank began operation in 1952. It has not been officially retired, but it is currently not in service. It was used for transfer of waste solutions from processing and decontamination operations from the 222-S Laboratory. The catch tank currently contains 200 L (54 gal) of waste and was partially filled with grout in February 1991; however, after a leak test it was still assumed to be a leaker (Hanlon 1991). All drainage lines have been cut and routed to the 241-S-304A Catch Tank.

No unplanned releases are identified for this tank.

2.3.2.3 241-S-302B Catch Tank. The 241-S-302B Catch Tank is located south of the 241-SY-102 Double-Shell Tank and southeast of the 241-SY-103 Double-Shell Tank.

The catch tank began operation in 1952. It was isolated in 1985 and is no longer active. It was used for transfer of waste solutions from processing and decontamination operations. The catch tank currently contains 12,300 L (3,240 gal) of waste.

No unplanned releases are identified for this unit.

2.3.2.4 241-SX-302 Catch Tank. The 241-SX-302 Catch Tank is located at the southwest corner of Camden Avenue and 13th Street. The catch tank operated in association with 241-SX-152 Diversion Box, 241-SX-151 Diversion Box, and 241-SX Tank Farm.

The tank operated from 1954 to 1983. The tank was isolated in 1985 and is no longer active. It was used for transfer of waste solutions from processing and decontamination operations.

No unplanned releases are identified for this tank.

2.3.2.5 244-S Receiver Tank. The 244-S Double-Contained Receiver Tank is an active waste unit located 620 m (2,030 ft) northwest of 202-S Building near the 241-S Tank Farm. The unit receives waste solutions from processing and decontamination operations. It contains approximately 41,465 L (10,954 gal) of waste although it has a design capacity of 76,768 L (20,280 gal). The tank is situated vertically within a reinforced concrete, steel-lined vault with 0.3 m (1 ft) thick walls. The bottom of the vault is 15 m (50 ft) below grade.

2.3.3 Cribs and Drains

The cribs and drains were all designed to inject or percolate wastewater into the ground without exposing it to the open air. The locations of cribs and drains in the aggregate area are shown on Figure 2-8. Cribs are shallow excavations that are either backfilled with permeable material or held open by wooden structures. Both types of cribs are covered with an impermeable layer. Water flows directly into the backfill material or covered open space and percolates into the vadose zone soils. A typical crib is illustrated in Figure 2-9. French Drains are generally constructed of steel or concrete pipe and may be either open or filled with gravel. The S Plant Aggregate Area contains 12 cribs and 1 french drain.

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 the 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 S Plant Aggregate Area.

2.3.3.1 216-S-1 and 216-S-2 Cribs. The 216-S-1 and 216-S-2 Cribs are located approximately 488 m (1,600 ft) northwest of 202-S Building. The bottom of the excavation is approximately 10 m (34 ft) below grade with bottom dimensions of 12 x 27 m (40 x 90 ft) and 45 degree side slopes. The bottom 3 m (10 ft) were filled with screened, crushed stone greater than 1.3 cm (0.5 in.) in diameter. Two open-bottomed, square, wooden crib boxes, 3.7 m (12 ft) on a side and 2.9 m (9.5 ft) high, were placed 1.8 m (5.9 ft) into the gravel layer. The crib boxes were constructed with 15 x 15 cm (6 x 6 in.) timbers and cross braces (DOE/RL 1992b). The two crib boxes were connected in series with overflow from the 216-S-1 Crib flowing into the 216-S-2 Crib via a pipe. The crib dimensions are 27 x 12 x 11 m (90 x 40 x 35 ft). While these cribs do not have a marker, the wooden construction of the cribs does present a collapse potential.

The cribs were in service from January 1952 to January 1956 and received approximately 160,000,000 L (42,000,000 gal) of liquid waste. The 216-S-1 and 216-S-2 Cribs received cell drainage waste from the D-1 Receiver Tank and redistilled condensate from the D-2 Receiver Tank located in 202-S Building. These radioactive process condensate wastes were slightly acidic. Waste was discharged to the crib in batches of about 19,000 L (5,000 gal) at an average rate of 10 batches per day.

Before the cribs were put into service, three vadose zone monitoring wells (299-W22-1, -2, and -3) were installed to depth of 45 m (150 ft).Well 299-W22-3 was deepened from 46 to 95 m (150 to 310 ft) and perforated from 64 to 95 m (210 to 310 ft) in January 1955 to provide a groundwater monitoring well for the crib. In June 1955, the well was found to

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contain liquid waste within 15 m (49 ft) of the ground surface. Waste had flowed to the bottom of the well and into the saturated sediments through perforations in the casing. The leak occurred in the part of the well that contained new casing, and since the old casing had not failed in the previous 3-year period before the well was deepened, the casing failure was probably not due to the acidic waste corroding the casing. Another source of failure is a weld in the casing. An examination of driller's logs for this well shows that two welds in the casing are located within 1 m (3 ft) from the bottom of the crib. Either weld could have provided an entry point for wastes to flow into the well, but the acid waste is suspected of corroding through the casing (WHC 1991a). Early in August 1955, Well 299-W22-3 was filled with sand, and in January 1956, the crib was removed from service. The pipeline to the crib was capped at the 241-S-151 Diversion Box and the pipeline effluent was rerouted to the 216-S-7 Crib.

One unplanned release (UPR-200-W-36) is associated with these cribs.

2.3.3.2 216-S-5 Crib. The 216-S-5 Crib is located 915 m (3,000 ft) southwest of the 207-S Retention Basin and west of the 216-S-10D Ditch and southeast of the 216-S-6 Crib. The site dimensions are 64 x 64 x 4.6 m (210 x 210 x 15 ft). The side slope is 1.5:1. Two lengths of 76 cm (30 in.) diameter, perforated, corrugated metal pipe form a cross with dimensions of 55 x 58 m (180 x 190 ft). The excavation has been filled with approximately 12,488 m^3 (16,333 yd^3) of gravel. Approximately 13,000 m^3 (459,090 ft^3) of contaminated soil and 12,000 m^3 (39,370 ft^3) of overburden soil are also present at this unit (WHC 1991a). This unit has no barricade, but there are concrete marker posts surrounding it with metal plates labeling the unit. The surface is sand with no vegetation. The unit does have underground radiation contamination warning signs.

The crib operated from March 1954 to March 1957 and was built as a replacement for the contaminated 216-S-17 Pond. The crib received 4,100,000,000 L (1,100,000,000 gal) of acidic process vessel cooling water and steam condensate from the 202-S Building via a 61 cm (24 in.) polyvinyl chloride waste supply line. The unit was deactivated because of insufficient capacity and a series of vessel coil failures, which resulted in operational problems and surface contamination. The crib was deactivated by valving out and locking the pipeline to the unit when the top of the crib began to cave in. The effluent was rerouted to the 216-S-6 Crib and 216-S-16 Pond. Four cave-ins in the 216-S-5 Crib were filled in 1974. The unit surface was stabilized on August 24, 1990 (WHC 1991a).

No unplanned releases are associated with this unit

2.3.3.3 216-S-6 Crib. The inactive 216-S-6 Crib is located 1,112 m (3,648 ft) southwest of the 202-S Building and approximately 500 m (1,500 ft) southwest of the 200 West Area perimeter fence (Maxfield 1979). The crib is 64 x 64 x 4.6 m (210 x 210 x 15 ft). The unit is filled with approximately 91,750 m^3 (3,143,000 ft^3) of gravel fill. Approximately 13,000 m^3 (459,090 ft^3) of contaminated soil and 12,000 m^3 (423,776 ft^3) of overburden soil are also contained at this waste management unit. Waste distribution lines are 2 m (7 ft) below the surface. The risers are 0.6 m (2 ft) above the surface. The unit has no barricade, but there are concrete monuments surrounding the site with metal plates marking it as the

216-S-6 Crib. The unit is labeled with underground radiation contamination warning signs. There is no vegetation and the surface is sand and gravel at grade. The 2904-S-171 Control Structure is adjacent at the north boundary of the unit. This unit is included in the Radiation Area Remedial Action (RARA) Program.

The crib started receiving waste in November 1954 and stopped receiving waste in July 1972. The crib has received a total of 4.47 x 10^9 L (1.18 x 10^9 gal) of low salt, neutral/basic liquid waste (DOE/RL 1992b). Up to June 1967, the crib received the process vessel cooling water and steam condensate from 202-S Building. From June 1967 to July 1967, production operations were shut down and S Plant was put on standby. After July 1967, the crib received the steam condensate from the D-12 and D-14 waste concentrators in the 202-S Building.

In September 1955, the 216-S-6 Crib operated at greater than capacity most of the month, and some grade level seepage was observed. Temporary relief was provided by blading a small corner from the 216-S-6 Crib and providing a run-off ditch area, rather than allow the cavern water to seep through the roof and damage the roof seal. No water overflowed to this area and no contamination was detected (Maxfield 1979).

No unplanned releases are associated with this unit.

2.3.3.4 216-S-7 Crib. The inactive 216-S-7 Crib is located northwest of S Plant The crib dimensions are 30 x 15 x 7 m (100 x 50 x 22 ft) and consist of two 4.9 x 4.9 x 1.5 m (16 x 16 x 5 ft) wooden structures 10 m (34 ft) apart in one excavation. The wooden structures are surrounded by gravel fill and covered with 4.6 m (15 ft) of dirt. A double light chain barricade encircles the unit; the outer chain surrounds the entire area with underground radiation contamination signs, and the inner chain, with underground radiation and potential cave-in warning signs, surrounds each of two riser vents.

The crib began operating in January 1956 and was retired in July 1965. Until April 1959, the crib received cell drainage from the D-1 Receiver Tank, process condensate from the D-2 Receiver Tank, and condensate from the H-6 condenser in the 202-S Building. The crib received a total of 3.9 x 10^8 L (1.0 x 10^8 gal) of waste (WHC 1991a).

When the crib was retired, the D-1 waste was rerouted to REDOX process concentrators for boil-down and discharge to underground storage. The D-2 waste went to the 216-S-9 Crib. After April 1959, the H-6 condenser condensate was rerouted to underground storage (DOE/RL 1992b). The 216-S-7 Crib was deactivated by sealing the pipeline to the unit at the northwest corner of S Plant Complex perimeter fence. In 1991, the surface was stabilized with approximately 0.6 m (2 ft) of sand and gravel. This unit is included in the RARA Program.

No unplanned releases are associated with this unit.

2.3.3.5 216-S-9 Crib. The inactive 216-S-9 Crib is located east of the 241-S and 241-SY Tank Farms. The unit dimensions are 91 x 9.1 x 9.1 m (300 x 30 x 30 ft) with a 1.5:1

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slope, and the entire distribution system is 6.4 m (21 ft) below grade. Waste flowed into the unit through the distribution system, which consists of 177 m (581 ft) of 15 cm (6 in.) diameter vitrified clay perforated pipe in a U shape, 4.6 m (15 ft) by 90 m (295 ft) and connected by 7.3 m (24 ft) of 7.6 cm (3 in.) schedule 10 pipe in a Y shape (DOE/RL 1992b). The unit is surrounded by a light chain barricade with both surface and underground radiation contamination warning signs. There are three steel risers at the crib but there are no permanent concrete markers. The surface is sand and gravel with heavy vegetation. This unit is included in the RARA Program.

The crib began operating in July 1965 and was retired in January 1969. The crib received 5.03×10^7 L (1.33×10^7 gal) of process condensate from the D-2 Receiver Tank in the 202-S Building. The waste was primarily composed of nitric acid. The crib was retired and the waste was rerouted to the 216-S-13 Crib. The 216-S-9 Crib was deactivated by sealing the pipeline at the south end of the unit (WHC 1991a).

Unplanned Release UN-200-W-108 is associated with this unit and is discussed in Table 2-6.

2.3.3.6 216-S-13 Crib. The inactive 216-S-13 Crib is located 162 m (532 ft) west of the 202-S Building and 185 m (608 ft) north of 10th Street. The unit is a 3.6 x 3.6 x 2.7 m (12 x 12 x 9 ft) wooden structure, approximately 366 m (1,200 ft) of 15 x 20 cm (6 x 8 in.) lumber enclosed on four sides by 2.5 cm (1 in.) sheathing with an open bottom and 1:1 side slope. The crib is 12 x 12 m (40 x 40 ft) and 10 m (34 ft) deep. The top of the structure is located 6 m (20 ft) below grade (DOE/RL 1992b). The surface is sand and gravel at grade.

The crib was built in January 1952 and stopped receiving waste in July 1972. Until June 1967, the crib received liquid waste from the 203-S Decontaminated Metal Storage Facility and 204-S Uranyl Nitrate Hexahydrate Facility, and the 276-S Organic Solvent Make-up Facility (DOE/RL 1992b). After June 1967, the crib received occasional sump waste from the 204-S Uranyl Nitrate Hexahydrate Facility. The unit received a total of 5.0×10^6 L (1.3×10^6 gal) of waste. The waste was low-salt, neutral/basic, and mainly composed of nitrate, sodium, and sodium dichromate. The 216-S-13 Crib has been stabilized and posted as an underground radioactive material area (Huckfeldt 1991a).

The crib has a wooden structure that may collapse (Maxfield 1979). A 6 m (20 ft) polyvinyl chloride pipe encased in concrete connects the crib to the 296-S-12 Building. This unit is included in the RARA Program.

No unplanned releases are associated with this unit.

2.3.3.7 216-S-20 Crib. The inactive 216-S-20 Crib is located 93 m (300 ft) southeast of the 202-S Building and 91 m (300 ft) north of 10th Street. The unit contains two 3.7 x 3.7 x 2.7 m (12 x 12 x 9 ft) wooden structures, 15 m (50 ft) apart, with the top of each being 5.2 m (17 ft) below grade and has a side slope of 1:1. The bottom of each wooden structure is suspended in a gravel fill 1.2 m (4 ft) above the bottom of the unit (DOE/RL 1992b). The outer area of the crib is barricaded with a light chain with surface contamination warning

signs and a concrete post marker. The surface is sand and gravel with a slight depression around the riser vents. Within the outer barricade are two inner barricades around each of the crib metal riser vents. These inner chains have underground radiation contamination and cave-in potential warning signs. The area has very little vegetation. This unit is included in the RARA Program.

The crib began operating in January 1952 and retired in May 1973. The unit received 1.35×10^8 L (3.57×10^7 gal) of waste. Until July 1953, the crib received miscellaneous waste from laboratory hoods and decontamination sinks in S Plant via a 219-S Waste Handling Facility. From July 1953 to September 1963, the crib received the above effluent via pipelines from the 207-SL Retention Basin and 219-S Waste Handling Facility and 300 Area laboratory waste via a tanker truck by means of a manhole located south of the unit. From September 1963 to January 1969, the crib received miscellaneous waste from laboratory hoods and decontamination sinks in the 222-S Laboratory via the 219-S Waste Handling Facility. After January 1969, 300 Area laboratory wastes were rerouted to the 216-T-28 Crib. From January 1969 to November 1972, the unit was inactive due to the ground caving in above the unit. The pipelines were valved out from the unit in the 219-S Retention Building and at the 207-SL Retention Basin and the 222-S Laboratory effluent rerouted to 202-S Building concentrators for boildown and discharge to the underground storage.

The unit has had a history of subsidence. Since the completion of stabilization December 13, 1974, the sink holes have been filled on three different occasions with fill dirt. It is doubtful that any cavities remain below the ground surface (Maxfield 1979).

No unplanned releases are associated with this crib.

2.3.3.8 216-S-22 Crib. The inactive 216-S-22 Crib is located approximately 152 m (500 ft) east of 202-S Building and 183 (600 ft) north of 10th Street. The crib dimensions are 30 x 1 x 3 m (100 x 3.5 x 10 ft) and the unit is 2.1 m (7 ft) below grade. The crib is a gravel filled structure with a side slope of 1.5:1. A 10 cm (4 in.) vitrified clay pipe enters the unit 2.1 m (7 ft) below grade, branches out at right angles downwards to the bottom, and runs along the bottom for the length of the unit. The pipe has open joints along the entire section of the bottom (DOE/RL 1992b). The unit is surrounded by a single light weight chain with signs warning of underground radiation contamination. Inside the chain are two riser vents; one is capped. The surface is composed of sand and gravel with no obvious signs of subsidence. This unit is included in the RARA Program.

The crib operated from October 1957 to June 1967. The crib received 98,400 L (26,000 gal) of liquid waste containing nitrate and sodium from the acid recovery facility in the 293-S Building (WHC 1991a). The unit was retired when production operations were shut down at the S Plant Complex and the inlet piping in the 293-S Building was blanked (WHC 1991a).

No unplanned releases are associated with this crib.

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2.3.3.9 216-S-23 Crib. The inactive 216-S-23 Crib is located 732 m (2,400 ft) north-northwest of the 202-S Building and northeast of the 216-S-9 Crib. The crib dimensions are 110 x 3 x 8.2 m (360 x 10 x 27 ft) with a side slope of 1:1 and approximately 122 m^3 (4,300 ft^3) of gravel fill. A 15 cm (6 in.) inside diameter perforated pipe runs the length of the unit 0.3 m (1 ft) from its base (DOE/RL 1992b). There is a light chain barricade surrounding the area with surface and underground contamination warning signs. The unit has two metal risers, and a stubbed pipe from the 216-S-9 Crib. The surface is sand and gravel at grade. The barricade for the Unplanned Release UPR-216-W-30 is adjacent to this unit. This unit is included in the RARA Program.

The crib operated from January 1969 to July 1972. The crib received 3.41 x 10^7 L (9.0 x 10^6 gal) of process condensate from the D-2 Receiver Tank in 202-S Building. The waste was low salt and neutral/basic (DOE/RL 1992b).

No unplanned releases are associated with this crib.

2.3.3.10 216-S-25 Crib. The active 216-S-25 Crib is located 850 m (2,800 ft) northwest of the 202-S Building outside the 200 West Area perimeter fence, south and east of the 216-U-10 Pond. The unit dimensions are 175 x 3 x 3 m (575 x 10 x 10 ft). A distribution pipe is approximately 2 m (7 ft) below grade running the length of the unit. The unit contains 1,160 m^3 (41,000 ft^3) of gravel, 1,100 m^3 (38,846 ft^3) of contaminated soil, and 2,600 m^3 (91,818 ft^3) of overburden soil. The crib has a light chain barricade posted with underground radiation contamination warning signs. A metal sign on a fence post is labelled "216-25-S". The crib has three risers. The surface is about 30 cm (12 in.) above grade. This crib is included in the RARA Program.

The unit began operation in November 1973 and received 242-S Evaporator process steam condensate through November 1980. Since November 1980, the 242-S Evaporator has been in standby mode, and the crib has only received 241-SX Tank Farm cooling water. The crib has received approximately 3.0 x 10^8 L (8.0 x 10^7 gal) of liquid waste.

No unplanned releases are associated with this crib.

2.3.3.11 216-S-26 Crib. The active 216-S-26 Crib is located 150 m (500 ft) southeast of the 222-S Laboratory outside the 200 West Area perimeter fence. The dimensions are 128 x 3 x 3.7 m (420 x 10 x 12 ft) and a 15 cm (6 in.) vitrified clay, perforated distribution pipe runs the length of the unit, 0.5 m (1.5 ft) above the bottom of the unit. The bottom of the unit is gravel lined and is covered with a membrane barrier and 2.9 m (9.5 ft) of soil (DOE/RL 1992b). The crib was designed to handle laboratory wastewater at 283,500 L/day (75,000 gal/day) or 94,500 L/8 hr shift (25,0000 L/8 hr shift). Facility inspections performed on April 27, 1990 showed little deep rooted vegetation and more short rooted grasses on the 216-S-26 Crib. There are two steel risers about 61 cm (24 in.) above grade. One riser is a vent at the downstream end of the crib and the other riser is a liquid level riser approximately one-third of the way from the headend of the crib. There is a manhole at the west end of 216-S-26 Crib that allows access to the waste line that runs south to the 216-S-19

Pond. The crib is posted "underground radioactive material" and the manhole is posted "surface contamination."

The crib has been in operation since October 1984. Between October 1984 and December 1988, the crib received 1.64 x 10^8 L (4.02 x 10^7 gal) of steam condensate, equipment cooling water and sink wastes, wastes from the 222-S Laboratory via the 207-SL Retention Basin and an addition of 2,340,000 L/month (619,000 gal/month) between October 1989 and March 1990 (WHC 1990b). The crib also receives water from the 222-SA Chemical Standards Laboratory and the 291-S Stack Complex; however, these waste streams are not routed through the 207-SL Retention Basin. The wastes contain a variety of chemicals, including acetone, nitrate, nitric acid, and lesser amounts of sulfuric and hydrofluoric acids (WHC 1991a). The crib also received three or more 4,200 L (1,100 gal) tanker discharges of Plutonium Finishing Plant caustic flushwater with pH of 12.5. After receiving these wastes, percolation decreased and has been a problem since that time.

During the week of October 20, 1984, an unnamed spill occurred at the 222-S Laboratory resulting in the release of water contaminated with ^{90}Sr to the 207-SL Retention Basin. Concentrations did not exceed the DOE Administrative Control Limit standardsand the water was released to the 216-S-26 Crib (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.3.12 216-S-3 French Drain. The inactive 216-S-3 French Drain is located along the east border of the 241-S Tank Farm east of the 241-S-104 Single-Shell Tank. The unit consists of two structures, each with 3 x 3 m (10 x 10 ft) bottom surface dimensions, spaced 15 m (50 ft) apart and 1.8 m (6 ft) deep. The unit is surrounded by a lightweight chain barricade. There are surface and underground radiation contamination warning signs marking the area. This unit is included in the RARA Program.

The french drain operated from September 1953 to August 1956. The french drain received 4.2 x 10^6 L (1.06 x 10^6 gal) of condensate from condensers on the 241-S-101 and 241-S-104 Single-Shell Tanks in the 241-S Tank Farm (DOE/RL 1992b). The waste is low salt and neutral/basic.

No unplanned releases are associated with the 216-S-3 French Drain.

2.3.4 Reverse Wells

A reverse well is a buried or covered, encased, drilled hole with a perforated or open lower end of the pipe to allow seepage of liquid to the ground. Reverse wells were used in various areas on the Hanford Site, but none exist in the S Plant Aggregate Area.

2.3.5 Ponds, Ditches, and Trenches

The ponds, ditches, and trenches in the S Plant Aggregate Area were designed to percolate wastewater into the ground. Generally, low-level liquid waste was disposed of into the ponds and no attempt was made to isolate the wastewater from the open air. Locations of ponds, ditches, and trenches are depicted in Figure 2-10. There are three ditches, four trenches, and six ponds discussed in this section.

2.3.5.1 Ponds. Ponds are bodies of water enclosed in a natural or diked surface depression used for the disposal of high-volume, low-level liquid effluent and designed to promote percolation of the liquid effluent. As the liquid infiltrated into the ground, many of the radionuclides were absorbed and concentrated by the upper soil layer. Pond bottoms were covered with clean soil and stabilized after deactivation to prevent the dispersal of radionuclides by wind erosion (Stenner et al. 1988).

2.3.5.1.1 216-S-10P Pond. The inactive 216-S-10P Pond is located approximately 1,300 m (4,300 ft) southwest of the 202-S Building and covers approximately 20,300 m^2 (218,000 ft^2) (Figure 2-11). The 216-S-10D Ditch and 216-S-10P Pond were designed to percolate approximately 567,000 L (150,000 gal) of waste per day. This unit has a light chain barricade and has regularly spaced concrete monuments with brass plates that state that the 216-S-10, -11, and -17 Ponds are all contained within the barricade. Underground radiation contamination warning signs surround the entire area. The present surface is 31 to 61 cm (12 to 24 in.) above grade and has been seeded with grass. The marker post does not distinguish between the 216-S-10D Ditch and 216-S-10P Pond. This unit is a RCRA TSD facility and is included in the Decommissioning and RCRA Closure Program.

The pond started operation in February 1954 and closed in October 1984 (WHC 1991a). The 216-S-10P Pond has received approximately 4.12×10^9 L (1.07×10^9gal) of liquid discharge. Until 1965, the pond received the chemical sewer waste from the S Plant Complex and overflow from the high water tower via the 216-S-10D Ditch. In the 1960's, the pond received bearing cooling water from the S Plant Complex. The 216-S-10P Pond also received one discharge of dangerous waste. This discharge consisted of approximately 454 kg (1,000 lb) of simulated double-shell tank shiny. An area between the 216-S-10D Ditch and 216-S-17 Pond and south of the 216-S-5 Crib overflow area, is posted "surface contamination." The unit has been backfilled and was stabilized in October 1984.

No unplanned releases are associated with this pond.

2.3.5.1.2 216-S-11 Pond. The inactive 216-S-11 Pond is located approximately 940 m (3,100 ft) southwest of the 202-S Building and covers approximately 6,070 m^2 (65,300 ft^2). There are two ponds with one lobe overflowing into the other. The two small ponds were dug to provide additional leaching surface to dispose water from the 216-S-10D Ditch. The pond inlets from the ditch were cut somewhat above the level of the 216-S-10D Ditch bottom so that the ponds would dry whenever the water in the 216-S-10D Ditch receded and would fill again when the 216-S-10D Ditch water level became high enough to overflow the ponds. The unit contains 5,700 m^3 (201,290 ft^3) of overburden soil. The total

site area is 6,070 m^2 (65,300 ft^2) (WHC 1991a). This unit has a lightweight chain barricade and regularly spaced concrete monuments with brass plates stating that the 216-S-10, -11, and -17 Ponds are all contained within the barricade. Underground radiation contamination warning signs surround the entire area. The present surface is 31 to 61 cm (12 to 24 in.) above grade and has been seeded with grass. This unit is included in the RARA Program.

The pond began operation in May 1954 and closed in August 1965. The pond received waste from air conditioning drains and chemical sewer waste from 202-S Building via the 216-S-10D Ditch. In August 1965, the 216-S-10D Ditch to this unit was dammed, diverting all building effluent to the 216-S-10P Pond. A total of 2.23×10^9 L (5.89×10^8 gal) of liquid waste were discharged to this unit. The south pond was covered in the summer of 1975 and is now being used as a root depth penetration study area.

No unplanned releases are associated with this unit.

2.3.5.1.3 216-S-15 Pond. The inactive 216-S-15 Pond is located directly east of the 241-S Tank Farm and has dimensions of 11 x 1.5 x 1.5 m (35 x 5 x 5 ft). A lightweight chain barricade surrounds the area. There are surface and underground radiation contamination warning signs marking the area. This unit is included in the RARA Program.

The pond was built in December 1951 and retired in October 1952. The pond received 10,000 L (2,600 gal) of condenser spray cooling water from the 241-S-110 Single-Shell Tank. The waste was low salt, neutral/basic, and was mainly composed of nitrate and MIBK.

No unplanned releases are associated with this unit.

2.3.5.1.4 216-S-16P Pond. The inactive 216-S-16P Pond is located approximately 2,100 m (7,000 ft) southwest of 202-S Building. This unit includes four smaller ponds separated by dikes and a leach trench, 3 m (10 ft) deep and 340 m (1,100 ft) long, extending east from the pond. One of the ponds (No. 4 Pond) was never used and is free from radioactive contamination (Maxfield 1979). The total unit area is approximately 125,400 m^2 (1,350,000 ft^2), and the ponds have an average depth of 0.9 m (3 ft). This pond has a light chain barricade and regularly spaced concrete monuments with brass plates labeled 216-S-16. Underground radiation contamination warning signs surround the entire area. The pond has been stabilized. The present surface is 31 to 61 cm (12 to 24 in.) above grade and has been seeded with grass. The marker post does not distinguish between the 216-S-16D Ditch and 216-S-16P Pond. This unit is included in the RARA Program.

The pond began operations in January 1957 and stopped receiving waste in February 1975. Approximately 4.07×10^{10} L (1.08×10^{10} gal) of liquid waste was discharged to this unit including 3.7×10^2 g (0.81 lb) of Pu (Meinhardt and Frostenson 1979). Until June 1967, the pond received process cooling water and steam condensate from the S Plant Complex. From June 1967 to July 1967, production operations were shut down and the S Plant Complex was put on standby. After July 1967, the pond received condenser and vessel cooling water from the concentrator boil-down operations in 202-S Building.

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Three unplanned releases (UPR-200-W-47, UPR-200-W-59, and UPR-200-W-124) have occurred at this pond.

2.3.5.1.5 216-S-17 Pond. The inactive 216-S-17 Pond is located approximately 1,100 m (3,700 ft) southwest of 202-S Building. The pond dimensions are approximately 290 x 290 x 3 m (960 x 960 x 10 ft) with a total area of approximately 85,000 m^2 (920,000 ft^2). This unit has a light chain barricade and has spaced concrete monuments with brass plates that state that the 216-S-10, -11, and -17 Ponds are all contained within the barricade. Underground radiation contamination warning signs surround the entire area. The present surface is 31 to 61 cm (12 to 24 in.) above the original ground level. This unit is included in the RARA Program.

The pond operation began in October 1951 and became inactive in April 1954. Approximately 6.44 x 10^9 L (1.7 x 10^9 gal) of liquid waste were discharged to this pond. Until January 1953, it received the process cooling water and steam condensate from the S Plant Complex. After January 1953, the pond received 202-S Building effluent and the overflow from 216-U-10 Pond via the 216-U-9 Ditch. A detailed account of historical events is given in Section 4.0. A series of process vessel coil failures beginning in October 1952 resulted in high levels of radioactivity released to the 207-S Retention Basin and subsequently to the 216-S-17 Pond. The 216-S-17 Pond has been stabilized.

No unplanned releases are associated with this unit.

2.3.5.1.6 216-S-19 Pond. The inactive 216-S-19 Pond is located approximately 740 m (2,400 ft) southeast of 202-S Building. The unit area is 14,200 m^2 (176,600 ft^2). The unit has metal posts surrounding it but no barricade chain. The unit is marked with underground radiation contamination warning signs. The surface is gravel and is 46 to 61 cm (18 to 24 in.) above grade. This unit is included in the RARA Program.

The pond began operating in February 1952 and stopped receiving waste in October 1984. A total of 1.33 x 10^9 L (3.51 x 10^8 gal) of liquid waste were discharged to the pond. Until December 1954, the pond received effluent from the 222-S Laboratory ventilation cooling water and miscellaneous wastes from laboratory hoods and decontamination pond via the 207-SL Retention Basin. From December 1954 to October 1955, the pond was inactive because the radionuclide concentration in the 207-SL Retention Basin liquid waste was above the prescribed disposal guidelines (WHC 1991a). The building effluent was rerouted to the 216-S-20 Crib. After October 1955, the pond received ventilation cooling water and miscellaneous wastes from laboratory hoods and decontamination sinks in the 222-S Laboratory via the 207-SL Retention Basin. The pond was stabilized and seeded with grass in October 1984, and the wastes were rerouted to the 216-S-26 Crib (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.5.2 Ditches. A ditch is a long, open, unlined excavation used to transfer low-level liquid wastes from process facilities to ponds (Figure 2-10). Three ditches exist in the S Plant Aggregate Area.

2.3.5.2.1 216-S-10D Ditch. The 216-S-10D Ditch is located approximately 450 m (1,500 ft) southwest of 202-S Building. The ditch is 686 m (2,250 ft) long and 1.83 m (6 ft) wide and has a flow rate of 0.38 m^3/min (13 ft^3/min) (Meinhardt and Frostenson 1979; WHC 1990b). This unit has a lightweight chain barricade and has regularly spaced concrete monuments with brass plates that state that the 216-S-10P, -11, and -17 Ponds are all contained within the barricade. Underground radiation contamination warning signs surround the entire area. The present surface is 31 to 61 cm (12 to 24 in.) above grade and has been seeded with grass. The marker post does not distinguish between the 216-S-10D Ditch and 216-S-10P Pond. Approximately 122 m (400 ft) of the 216-S-10D Ditch has not been stabilized. In the portion of the unit that has not been stabilized, there is approximately 0.3 m (1 ft) of standing water with cattails growing in it. There is a stairway at the northeastern end of the ditch leading to the ditch floor. The active part of ditch has its own barricade, separate from the rest, and has surface radiation contamination warning signs and danger signs surrounding it. This unit is a RCRA TSD facility and is included in the Decommissioning and RCRA Closure Program.

The ditch began transferring wastes in August 1951. The 216-S-10D Ditch has received 4,340,000,000 L (1,157,000,000 gal) of liquid waste. In the past, 420 L (112 gal) of hazardous waste salts in solution (sodium nitrite, sodium hydroxide) were discharged to the unit. Discharges were received from the 202-S Building drains, funnels, process vessel cooling water, and chemical sewer lines and also the 241-S Tank Farm, 211-S Valve House and 276-S Solvent Handling Facility. Inadvertent dumping of aluminum nitrate narohydrate (ANN) solution to the chemical sewer seriously plugged soil at the terminus of this stream, and the liquid level increased significantly. During the summer of 1955, 0.6 m (2 ft) of "muck" was dredged from the bottom of the 216-S-10D Ditch to improve water percolation in the ditch. The contaminated "muck" was buried in scooped out holes along the sides of the ditch. The depth and location of each burial site is unknown (Maxfield 1979). A number of excavations by backhoe across the 216-S-10D Ditch in 1971 showed it to be free of contamination (Maxfield 1979). Until 1965, the unit received discharges from chemical sewer lines, floor drains, funnels, process vessel cooling water, air compressor cooling water from 202-S Building, overflow from the 2901-S-901 Water Tower, drains from the 241-S Tank Farm, station drains in 211-S Valve House, and floor drains from the 276-S Solvent Handling Facility, and transferred this discharge to the 216-S-10P and 216-S-11 Ponds (WHC 1990b). No dangerous wastes have been discharged to this unit since February 1987. The 216-S-10D Ditch stopped receiving waste on October 1, 1991.

No unplanned releases are associated with this unit.

2.3.5.2.2 216-S-16D Ditch. The inactive 216-S-16D Ditch is located 1,670 m (5,470 ft) southwest of the 202-S Building. The ditch dimensions are 519 x 1.2 x 0.9 m (1,700 x 4 x 3 ft) with a 2:1 side slope. A light chain barricade and regularly spaced concrete monuments with brass plates labeled 216-S-16 encircle the ditch. Underground radiation contamination warning signs surround the entire area. The present surface is 31 to 61 cm (12 to 24 in.) above grade and has been seeded with grass. This unit is included in the RARA Program.

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The ditch was constructed in January 1957 and was not used after February 1975. A total of 4.07×10^8 (1.1×10^8 gal) of liquid waste was discharged to this unit. Until June 1967, the ditch received process cooling water and steam condensate from S Plant and transferred it to the 216-S-16P and 216-S-17 Ponds and the 216-S-5 and 216-S-6 Cribs. From June 1967 to July 1967, production operations were shut down, and S Plant Complex was put on standby. After July 1967, the ditch received condenser and vessel cooling water from concentrator boil-down operations in the S Plant Complex. Nitrate is suspected to be present at this unit (WHC 1991a). Removal of the 216-S-16P Pond and ditch system from active service began in May 1969. This work was prompted by several releases over the years including 370 g (0.8 lb) of plutonium.

The ditch has been stabilized and backfilled and contains 770 m^3 (27,191 ft^3) of overburden soil (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.5.2.3 216-U-9 Ditch. The inactive 216-U-9 Ditch is located approximately 600 m (2,000 ft) west of the 241-S Tank Farm. The ditch is Y-shaped with an eastern fork and western fork (Plate 1). The ditch dimensions are 1,100 x 2 x 2 m (3,500 x 6 x 6 ft) with a 1:2 slope. The unit originally connected the 216-U-10 Pond and the 216-S-17 Pond. A new ditch was dug later incorporating the first 152 m (500 ft) of the original 216-U-9 Ditch and then running somewhat west of the original route (WHC 1991a). No contamination was found in the first 152 m (500 ft) of the ditch during this construction (Maxfield 1979). The ditch is now cut into the side of the 216-S-16D Ditch, which went to the 216-S-16P Pond. The eastern fork of the ditch has no chain barricades or radiation warning signs and is partially backfilled. There is mature sage brush growing in the ditch. The western fork similarly has no chain barricades or radiation warning signs. There has been no obvious backfilling. The ditch is 2.4 to 3 m (8 to 10 ft) deep with sparse vegetation.

The eastern fork began receiving the 216-U-10 Pond overflow in December 1952 (Maxfield 1979). The west fork was never used. The east fork became contaminated in September 1953 and was covered in spring 1954 with 0.6 m (2 ft) of clean soil. No documented source for the contamination has been found regarding the level of contamination. The unit has been released from radiation zone status.

One unplanned release (UPR-200-W-139) is associated with the ditch.

2.3.5.3 Trenches. Trenches are unlined excavations used for disposing material from the process facilities by infiltration into the subsurface. Quantities are usually limited as compared to cribs or ponds (Figure 2-10). All of the trenches are inactive and are backfilled.

2.3.5.3.1 216-S-8 Trench. The inactive 216-S-8 Trench is adjacent to the east side of the 241-SX Tank Farm and has dimensions of 31 x 18 x 7.6 m (100 x 60 x 25 ft). The unit is surrounded by a light chain barricade that also encompasses the 216-S-1 and -2 Cribs as well as Unplanned Release UN-200-W-114, allowing no close inspections of the actual area.

There are also surface radiation contamination warning signs surrounding the area. This unit is included in the RARA Program.

The trench was built in November 1951 and retired in February 1952. The trench received 1.0 x 10^7 L (2.6 x 10^6 gal) of unirradiated uranium startup waste from 202-S Building. The only inorganic waste constituent suspected in the waste was nitrate. The trench was retired when the discharge of startup waste to the unit was completed. The trench was deactivated by removing the aboveground piping and backfilling the unit (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.5.3.2 216-S-12 Trench. The inactive 216-S-12 Trench is northeast of 202-S Building (Figure 2-10). The trench is barricaded with a light chain with underground radiation contamination signs and a concrete marker post. The surface is sand and gravel with no vents or evidence of subsidence. Slightly west of the 216-S-12 Trench is a light chain barricade containing two wooden structures approximately 2.4 x 2.4 x 1.5 m (8 x 8 x 5 ft). One of the boxes contains 6.4 cm (2.5 in.) diameter rubber hose.

The unit was constructed in July 1954 to receive approximately 68,100 L (18,000 gal) of flush water containing ammonium nitrate from the 291-S Stack Complex. The trench was retired when the flush of the 291-S-1 Stack was complete, also in July 1954 (WHC 1991a). This trench was deactivated by removing the above-ground piping and then backfilling.

One unplanned release (UN-200-W-30) is associated with this unit. However, the unplanned release is a duplicate of the 216-S-12 Trench and is scheduled for deletion (WHC 1991a).

2.3.5.3.3 216-S-14 Trench. The inactive 216-S-14 Trench is located approximately 390 m (1,300 ft) south of the 202-S Building and has dimensions of 31 x 2.4 x 1.8 m (100 x 8 x 6 ft). This trench had a cave-in leaving a 3 x 3 m (10 x 10 ft) pit. This pit is marked by a rope suspended by four corner posts. Just south of and in line with the trench, there is a row of ten clay tile pipes that rise above grade running in an east-west line. These pipes are 1.2 to 1.8 m (4 to 6 ft) tall. This trench is included in the RARA Program.

The trench began operating in December 1951 and became inactive in January 1952 (WHC 1991a). The trench received an unknown quantity of contaminated (unirradiated uranium) MIBK from the initial test runs in the 202-S Building. The unit was retired when discharge of MIBK was completed, and it was deactivated by removing the above-ground piping and backfilling the area (WHC 1991a). The unit was investigated with core drilling in February 1971. There was a strong odor of MIBK from the samples taken, but no radioactivity was found (WHC 1991a).

No unplanned releases are associated with this trench.

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2.3.5.3.4 216-S-18 Trench. The inactive 216-S-18 Trench is located northeast of the 241-SX Tank Farm. The trench dimensions are 38 x 4.6 x 3 m (125 x 15 x 10 ft). Some concrete debris is present and the area is moderately vegetated. The unit is L-shaped, the surface is composed of sand and gravel, and is 1.2 to 1.8 m (4 to 6 ft) below grade. This unit is included in the RARA Program.

The trench was built and retired in October 1954. This trench was a steam cleaning pit for radioactively contaminated equipment and received vehicle decontamination waste. Research strongly suggests that solvents, and in particular chlorinated solvents, were used in the cleaning process. The trench, which was deactivated by backfilling, was retired in the same month that vehicle decontamination was complete (WHC 1991a).

In October 1972, this trench was excavated and the radioactive objects found in the trench were taken to the 200 West Dry Burial Ground for burial. The objects included some 2 cm (0.75 in.) piping, one lab sink, and approximately 1.5 m^3 (53 ft^3) of soil. The unit was then released from radiation zone status.

No unplanned releases are associated with this trench.

2.3.6 Septic Tanks and Associated Drain Fields

The location of the septic tanks and drain fields are shown in Figure 2-11. There are two septic tanks and one Sanitary Crib in the S Plant Aggregate Area.

2.3.6.1 2607-W6 Septic Tank and Drain Field. This unit is located south of the 2901-S Building and south of 10th Street. This unit includes a drain field. No data pertaining to unit dimensions could be found.

The 2607-W6 Septic Tank and Drain Field has been active since 1951. It receives sanitary wastewater and sewage. The estimated rate of waste received is 34,800 L/day (9,200 gal/day) (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.6.2 2607-WZ Septic Tank and Drain Field. This unit is located approximately 55 m (180 ft) south of 10th Street and south of the 2704-W Building. This unit includes a drain field. No data pertaining to unit dimensions could be found.

The 2607-WZ Septic Tank has been active since 1944. It receives sanitary wastewater and sewage. The estimated rate of waste received is 22,600 L/day (5,970 gal/day) (WHC 1991b).

No unplanned releases are associated with this unit.

2.3.6.3 Sanitary Crib. The Sanitary Crib is located approximately 24 m (80 ft) west of the southwest corner of the 241-SX Tank Farm. The crib dimensions are 23 m (75 ft) x 7.6 m (25 ft), and it is oriented north-south. It lies under the entrance to a gravel parking area that has two vents from the crib rising through it. The unit includes a drain field.

The Sanitary Crib was constructed in 1954 and is still active. It receives nonhazardous and nonradioactive sanitary wastewater from the 241-SX-701 Compressor House (WHC 1991a). The estimated rate of waste received is 22,600 L/day (5,970 gal/day).

No unplanned releases are associated with this 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 storage facilities. Most high-level waste transfer lines are 7.6 cm (3 in) diameter stainless steel pipes with welded joints. These lines are generally enclosed in steel reinforced concrete encasements and are set below grade. The major process lines in the S Plant Aggregate Area, and the facilities that they connect are shown on Figure 2-12. 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.

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 purposes 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.

Transfer facilities in the S Plant Aggregate Area included control structures, diversion boxes, and valve pits. Control structures are concrete encasements with a manhole cover housing a large Y-valve or T-valve or weir used to divert or regulate waste flow. Diversion boxes are concrete structures that contain several pipes to divert waste from waste generating and storage facilities to treatment, storage or disposal facilities. Valve pits are concrete structures which house valves associated with the transfer of waste between tanks in the tank farms.

There are four control structures, eight diversion boxes, and six valve pits in the S Plant Aggregate Area. Refer to Figures 2-13 through 2-15 for examples of a typical control structure, diversion box, and valve pit.

2.3.7.1 216-S-172 Control Structure. The inactive 216-S-172 Control Structure is located southwest of the 241-SX Tank Farm. The unit includes a weir box. The structure is a reinforced concrete box 4 x 2 x 2 m (13 x 7 x 8 ft) with 25 cm (10 in.) thick walls and a 30 cm (12 in.) thick bottom. Float wells consisting of 41 cm (16 in.) in diameter pipe centered in 71 cm (28 in.) columns are attached vertically to the north and south outside walls of the structure. Piping includes one 25 cm (10 in.) inlet pipe and three 30 cm (12 in.) outlet pipes, and a 61 cm (24 in.) vitrified clay inlet pipe that enters from the floor (DOE/RL

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1992b). The structure extends 15 cm (6 in.) above grade and 2 m (7 ft) below grade. The 216-S-172 Control Structure is stabilized and has a lightweight chain outer barricade with underground radiation warning signs and an inner chain barricade around the area. The inner barricade has underground radiation contamination and cave-in potential warning signs. The surface is approximately 61 cm (24 in.) above grade and has no vegetation. This unit is included in the Decommissioning and RCRA Closure Program.

The unit operated from 1956 to 1976. The control box was built to divert the S Plant process vessel cooling water and steam condensate to the 216-S-16D Ditch. The unit was interim stabilized in 1991.

No unplanned releases are associated with this unit.

2.3.7.2 2904-S-160 Control Structure. The inactive 2904-S-160 Control Structure is located southwest of the 241-SX Tank Farm. The 2904-S-160 weir is a below-grade pentagonal structure consisting of 0.3 m (1 ft) thick reinforced concrete walls, roof, and floor. The structure is 3 m (9 ft) high with walls about 1.5 m (5 ft) long and extends 15 cm (6 in.) above grade. Piping includes two 61 cm (24 in.) diameter vitrified clay outlet pipes and one 61 cm (24 in.) diameter vitrified clay inlet pipe (DOE/RL 1992b). The 2904-S-160 Control Structure has a light chain outer barricade with underground radiation warning signs surrounding it, and an inner chain barricade around the unit. The inner barricade has underground radiation contamination and cave-in potential warning signs. The surface is approximately 61 cm (24 in.) above grade and has no vegetation.

The structure operated from 1954 until its closure in 1976. The unit was built to divert process vessel cooling water and steam condensate from the S Plant Complex to 216-S-17 Pond, 216-S-6 Crib, or 216-S-16P Pond (WHC 1991a). The area was interim stabilized in 1991.

No unplanned releases are associated with this unit.

2.3.7.3 2904-S-170 Control Structure. The inactive 2904-S-170 Control Structure is located southeast of the 241-SX Tank Farm. The structure is underground and made of reinforced concrete. The walls, floor, and roof are 25 cm (10 in.) thick. It is approximately 4.9 x 1.5 x 3.4 m (16 x 5 x 11 ft). The structure extends 15 cm (6 in.) above grade and 2.9 m (9.5 ft) below grade. One meter (3 ft) of the weir's south end is covered by the 2904-SA Sample Building. Piping includes one inlet and one outlet pipe, both 76 cm (30 in.) diameter vitrified clay pipe (DOE/RL 1992b). This structure contains low-level contaminated concrete and piping. The quantity of contaminated waste has not been determined.

The unit operated from 1954 until 1976 and was built to regulate and measure the process waste flow from the S Plant Complex prior to routing liquid to waste disposal sites (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.4 2904-S-171 Control Structure. The inactive 2904-S-171 Control Structure is located west of the 241-SX Tank Farm. It is a below grade reinforced concrete structure roughly 2.6 x 4.0 x 3 m (8.4 x 13 x 10 ft). The walls and roof are 25 cm (10 in.) thick and the floor is 30 cm (12 in.) thick. The unit extends 15 cm (6 in.) above grade and 2.9 m (9.5 ft) below grade. Float wells are attached vertically to the north and south outside walls. The float wells are 41 cm (16 in.) diameter metal pipes centered in 71 cm (28 in.) square concrete columns. Piping includes a 46 cm (18 in.) diameter vitrified clay inlet pipe and a 46 cm (18 in.) diameter galvanized corrugated metal outlet pipe (DOE/RL 1992b).

The unit operated from 1954 and closed in 1976 and was built to measure and regulate flow of process waste routed to the 216-S-6 Crib (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.5 240-S-151 Diversion Box. The inactive 240-S-151 Diversion Box is located north of the 202-S Building.

The unit was started in 1950 and became inactive in March 1987. This diversion box was used for transfer of low-level and high-level mixed waste solution from processing and decontamination operations. The unit has been isolated and weather covered (DOE/RL 1992b).

The 240-S-151 Diversion Box was the main diversion box for the S Plant Complex. Wastes were transferred to the 216-S-172 Control Structure that diverted wastes to the 216-S-16D Ditch, the 216-S-16P and 216-S-17 Ponds, and the 216-S-5 and 216-S-6 Cribs. The 240-S-151 Diversion Box also transferred low- and high-level mixed waste to the 216-S-7, 216-S-9, and 216-S-23 Cribs, and the 240-S-152 and 241-S-151 Diversion Boxes, and interacted with the 241-U-153 Diversion Box. This structure drained to the 240-S-302 Catch Tank.

No unplanned releases are associated with this unit.

2.3.7.6 240-S-152 Diversion Box. The inactive 240-S-152 Diversion Box is located north of the 202-S Building and the 240-S-151 Diversion Box.

The box was activated in 1977 and became inactive in 1980. This unit was used for the transfer of high-level waste solution from processing and decontamination operations. It also received uranyl nitrate hexahydrate from the 240-S-151 Diversion Box and transferred it to the 205-S Chemical Makeup Building. This unit has been isolated and covered (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.7 241-S-151 Diversion Box. The active 241-S-151 Diversion Box is located northeast of the 241-SX Tank Farm. It is a reinforced concrete structure with dimensions of 17 x 3 x 5 m (56 x 10 x 17 ft). The diversion box transfers low-level and high-level mixed waste

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solutions from processing and decontamination operations. The unit interconnects the 240-S-151 and 241-SX-151 Diversion Boxes, and the 241-S Tank Farm (WHC 1991a).

The unit began operating in 1952. The 241-S-151 Diversion Box received low-level and high-level mixed waste from the 240-S-151 Diversion Box. The waste was transferred to the 216-S-1 and -2 Cribs, the 241-SX-151 and -152 Diversion Boxes, the 241-S Tank Farm, and the 244-S Receiver Tank and interacts with the 241-U-151 and 241-UX-154 Diversion Boxes. This unit was drained to the 241-S-302A and 241-S-302B Catch Tanks.

There are four known releases at this unit: UPR-200-W-20, UPR-200-W-51, UN-200-W-52, UPR-200-W-82 (WHC 1991a). These releases are described in Section 2.3.10.

2.3.7.8 241-S-152 Diversion Box. The inactive 241-S-152 Diversion Box is located 27 m (90 ft) northwest of the 241-SY-102 Double-Shell Tank and east of 242-S Evaporator.

The box was placed in service in 1977 and taken out of service in November 1980. This unit was used for transfer of high-level mixed waste solutions from processing and decontamination operations. The 241-S-152 Diversion Box received high-level mixed waste from the 241-S and 241-SX Tank Farms and transferred it to the 242-S Evaporator for separation. This unit has been isolated and covered.

No unplanned releases are associated with this unit.

2.3.7.9 241-SX-151 Diversion Box. The inactive 241-SX-151 Diversion Box is located east of the 241-SX Tank Farm. This unit interconnects with the 241-S-151 and 241-SX-152 Diversion Boxes, and the 241-SX Tank Farm.

The box was placed in service in 1954 and became inactive in October 1983. The unit was used for transfer of high-level mixed waste solutions from processing and decontamination operations. The 241-SX-151 Diversion Box received high-level mixed waste from the 241-S-151 Diversion Box and transferred it to the 241-SX Tank Farm. This structure drained to the 241-SX-302 Catch Tank. This unit has been isolated and covered (WHC 1991a).

One unplanned release (UPR-200-W-114) is associated with this unit.

2.3.7.10 241-SX-152 Diversion Box. The inactive 241-SX-152 Diversion Box is located northeast of the 241-SX Tank Farm. This unit interconnects with the 241-SX-151 and 241-U-151 Diversion Boxes, and the 241-SX Tank Farm.

This unit was placed in service in 1954 and retired in May 1981 and was used to transfer high-level mixed waste solutions from processing and decontamination operations. The 241-SX-152 Diversion Box received high-level mixed waste from the 241-SX-151

Diversion Box and transferred it to the 241-SX Tank Farm . This unit drained to the 241-SX-302 Catch Tank. The unit has been covered and isolated.

No unplanned releases are associated with this unit.

2.3.7.11 241-S-A Valve Pit. The 241-S-A Valve Pit is an active waste management unit started in 1952 and located between 241-S-101 and 241-S-102 Single-Shell Tanks. The unit housed valve controls for transfers of waste solutions from processing and decontamination operations. This unit can drain to either a double-shell or single-shell tank (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.12 241-S-B Valve Pit. The 241-S-B Valve Pit is an active waste management unit started in 1952, and located between the 241-S-101 and 241-S-102 Single-Shell Tanks. The unit housed valve controls for transfers of waste solutions from processing and decontamination operations. This valve pit can drain to either a double-shell or single-shell tank (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.13 241-S-C Valve Pit. The 241-S-C Valve Pit is an active waste management unit located between the 241-S-107 and 241-S-108 Single-Shell Tanks. This pit was placed in service in 1952. This unit housed valve controls for transfers of waste solutions from processing and decontamination operations. This unit can drain to either a double-shell or single-shell tank (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.14 241-S-D Valve Pit. The 241-S-D Valve Pit is an active waste management unit located between 241-S-107 and 241-S-108 Single-Shell Tanks. This pit became active in 1952. The unit housed valve controls for transfers of waste solutions from processing and decontamination operations. The pit can drain to either a double-shell or single-shell tank (WHC 1991a).

No unplanned releases are associated with this unit.

2.3.7.15 241-SX-A Valve Pit. The 241-SX-A Valve Pit is an active waste management unit located between the 241-SX-105 and 241-SX-104 Single-Shell Tanks of the 241-SX Tank Farm. This unit is assumed to have been activated in 1954 and deactivated in 1980, but is considered active as defined by RCRA. This unit housed valve controls for transfers of waste solutions from processing and decontamination operations.

No unplanned releases are associated with this unit.

2.3.7.16 241-SX-B Valve Pit. The 241-SX-B Valve Pit is an active waste management unit located between the 241-SX-105 and 241-SX-104 Single-Shell Tanks of the 241-SX Tank

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Farm. This unit is assumed to have been activated in 1954 and deactivated in 1980, but is considered active as defined by RCRA. This unit housed valve controls for transfers of waste solutions from processing and decontamination operations.

No unplanned releases are associated with this unit.

2.3.7.17 241-SY-A Diversion Box. The 241-SY-A Diversion Box is an active waste management unit located south of and between the 241-SY-101 and 241-SY-102 Double-Shell Tanks in the 241-SY Tank Farm. This diversion box became active in 1977. This unit housed valve controls for transfers of waste solutions from processing and decontamination operations.

No unplanned releases are associated with this unit.

2.3.7.18 241-SY-B Diversion Box. The 241-SY-B Diversion Box is an active waste management unit located south of and in between the 241-SY-101 and 241-SY-102 Double-Shell Tanks in the 241-SY Tank Farm. This diversion box became active in 1977. The unit housed valve controls for transfers of waste solutions from processing and decontamination operations.

No unplanned releases are associated with this unit.

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2.3.8 Basins

Retention basins were used for intermittent storage of liquid waste before it was transferred to ponds, ditches, or cribs. There are two retention basins in the S Plant Aggregate Area. The locations of the basins are shown on Figure 2-16.

2.3.8.1 207-S Retention Basin. The 207-S Retention Basin, also referred to as the 202-S Building Retention Basin, was a concrete structure with a volume of 3,220,000 L (850,000 gal) and a surface area of approximately 430 m^2 (4,600 ft^2) (Figure 2-17). The basin dimensions are 40 x 40 x 2 m (130 x 130 x 8 ft). The walls of the concrete structure are approximately 25 cm (10 in.) thick and the floor is 20 cm (8 in.) thick. The system includes approximately 610 m (2,000 ft) of 61 cm (24 in.) diameter vitrified clay pipe that is used to convey wastewater to and from the basin. The concrete walls and floors of the basin were filled with dirt to prevent contamination spread. In June 1975, the soil was treated with herbicides and covered with 23 cm (9 in.) of gravel to prevent vegetation growth (DOE/RL 1992b).

The basin received low-level liquid wastes such as process cooling water and steam condensate from the 202-S Building from October 1951 through April 1954. The wastes were then discharged to the 216-S-17 or 216-S-16P Ponds.

There are three unplanned releases, UPR-200-W-13, UPR-200-W-15, UPR-200-W-95, associated with the unit due to leaks in process vessel coils in the 202-S Building. These

leaks released radioactivity into the basin from late 1952 until spring 1954 and are discussed in Section 2.3.10.

2.3.8.2 207-SL Retention Basin. The 207-SL Retention Basin, located approximately 61 m (200 ft) east of the 222-S Laboratory, is also referred to as 222-S Laboratory Retention Basin. The unit dimensions are 15 x 15 x 3.7 m (50 x 50 x 12 ft). The unit has reinforced concrete walls 30 to 41 cm thick (12 to 16 in.) and the floor is 38 cm thick (15 in.). The basin contains two 94,500 L (75,000 gal) capacity compartments that allow batch collection and sampling prior to discharge. A 2 m (7 ft) chain link fence on top of the walls lines the perimeter of the unit (DOE/RL 1992b).

The basin is currently operational and has received wastes since February 1952. Until 1954, the unit received low-level wastes such as ventilation cooling water and miscellaneous wastes from laboratory hoods and sinks in the 222-S Laboratory. These wastes were then discharged to the 216-S-19 Pond. The basin was inactive from December 1954 to October 1955 due to exceedances in radioactivity levels. The 207-SL Retention Basin currently acts as a temporary holding facility for potentially radioactive or hazardous liquid effluents before they are discharged to the 216-S-26 Crib. A time-proportional sampler at the inlet of the basin is used to automatically collect effluent samples. The 222-S Laboratory, 214-S Waste Treatment Building, and 222-SA Chemical Standards Laboratory waste streams all pour through the inlet to the basin; however, the 291-S Exhaust Fan Control House and Stack waste stream are not sampled since it is added directly to the 207-SL Retention Basin. The wastewater is retained in the basin until chemical and radionuclide analysis are complete. If the wastewater meets discharge specifications for surface discharge, then the water is released to the 216-S-26 Crib.

No unplanned releases are associated with this unit.

2.3.9 Burial Sites

There are two solid waste burial grounds in the S Plant Aggregate Area. The location of the burial grounds are shown on Figure 2-18.

2.3.9.1 218-W-7 Burial Ground. The inactive 218-W-7 Burial Ground is located near the 222-S Laboratory. The burial ground is made of carbon steel with one coat of hot coal tar enamel, is 4.3 m (14 ft) deep, and rests on a 0.3 m (1 ft) concrete foundation (Figure 2-19). The unit has a dome and vent structure that extends 3.2 m (11 ft) to the surface. The unit is barricaded by a lightweight chain and four concrete posts with posted signs warning of underground radiation contamination. The surface of this unit is sand and gravel at grade.

The unit started operating in 1952 and stopped operating in 1960. It received a volume of approximately 160 m^3 (5,650 ft^3) consisting of dry, packaged laboratory and sample waste from the 222-S Laboratory.

No unplanned releases are associated with this unit.

2.3.9.2 218-W-9 Burial Ground. The inactive 218-W-9 Burial Ground is located directly east of the 241-SX Tank Farm. The burial ground is designated by four corner posts encompassing an area of 41.8 x 297 m (137 x 975 ft) and received 490 m^3 (17,300 ft^3) of waste. There is no available information on the actual size of the burial ground (DOE/RL 1992b).

The area is barricaded with a light chain and a concrete marker post. The burial ground was used and deactivated during September 1954. The unit contains an unknown amount of metal scrap including the 211-S Reagent Tank Farm taken from the S Plant Complex. The unit was interim stabilized in 1991 with sand and gravel. The surface is approximately 0.46 m (1.5 ft) above grade. There are no vents or vegetation in this area.

No unplanned releases are associated with this unit.

2.3.10 Unplanned Releases

Forty-five distinct unplanned releases were identified in the S Plant Aggregate Area. Their locations are shown on Figure 2-20. Unplanned releases designated with a "UPR" are releases from or within the operations of specific waste management units, and are considered part of that unit for remediation purposes. Releases designated with a "UN" are considered a distinct waste management unit for remediation purposes.

The UPRs are not included as independent sites in the Tri-Party Agreement 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.

No waste inventory information was identified for the unplanned releases. Table 2-6 summarizes the known information for each unplanned release and, where applicable, lists the waste management unit to which it is related. Most of the information available for the unplanned releases is derived from the WIDS sheets (WHC 1991a).

2.4 WASTE GENERATING PROCESSES

This section describes the feed preparation, solvent extraction, solvent recovery, and waste treatment and disposal process that occurred at the S Plant Complex from 1951 to 1967. Table 2-7 summarizes the available information concerning the waste streams produced within the aggregate area. The chemicals or radionuclides that are known or suspected to be present in the S Plant Aggregate Area waste streams are listed in Table 2-8; Table 2-9 lists the chemicals used in the 222-S Laboratory; and Table 2-10 lists radionuclides, organic and inorganic chemicals disposed at S Plant Aggregate Area waste management units. These lists have been compiled from inventory data, sampling data, and process descriptions.

2.4.1 REDOX Process Overview

As part of the mission at the Hanford Site, several processes were developed to separate uranium, plutonium, and their fission products from irradiated uraniumfuel. In 1951, the REDOX process replaced the existing bismuth phosphate process because of lower costs, improved output, and enhanced recovery of uranium and plutonium. The REDOX process, used between 1951 and 1967, was a solvent-extraction process that extracted plutonium and uranium from dissolved fuel into a MIBK solvent (DOE 1987). This process was carried out in the 202-S Building where irradiated uranium fuel elements from the 100 Areas were processed, resulting in numerous waste streams and relatively pure product streams. The slightly acidic waste streams contained fission products and large quantities of aluminum nitrate that were used to promote the extraction of plutonium and uranium (DOE 1987) in the REDOX process. The wastes were neutralized and stored in tanks, or disposed in cribs, trenches, ditches, or ponds that leached wastes directly into the soil column. Product streams were directed to other processing facilities. The REDOX process was designed to recover at least 98% of the uranium and plutonium from the irradiated fuel. With the exception of the feed preparation and dissolution processes, which operated in batch, the REDOX process was continuous.

The solvent-extraction process was based on the preferential distribution of uranyl nitrate and the nitrates of plutonium between an aqueous phase and an immiscible organic phase. This process is described in greater detail below; however, the descriptions generally exclude mention of water or water vapor that was present in many of the process streams.

2.4.1.1 Feed Preparation. The first step in the REDOX process involved preparing the uranium fuel elements (brought from the 100 Area reactors by rail) for processing. Fission products resulting from the fission of uranium and plutonium were a function of the time of irradiation and subsequent "cooling." The "cooling" period ranged from 40 to 90 days and allowed the short-lived (half-life less than 1 day) radioactive isotopes in the uranium slugs to decay to negligible radioactivity levels. Approximately 100 short-lived radioactive isotopes, or fission products, were present in irradiated uranium during "cooling." About 20 of the short-lived fission products had yields above 1%. Longer-lived fission products that may have been present in the process streams (in approximate order of abundance) included various isotopes of americium, curium, neptunium, ruthenium, rhodium, zirconium, niobium, cerium, praseodymium, krypton, strontium, yttrium, cesium, tellurium, barium, lanthanum, neodymium, and promethium. Impurities found in the uranium metal that may have been present in small quantities throughout the separation process included carbon, nitrogen, iron, silicon, and trace quantities of cobalt, zinc, potassium, copper, aluminum, cadmium, and boron.

The irradiated uranium slugs were removed from their aluminum alloy jackets (aluminum, silicon, tin, iron, copper and trace magnesium, manganese, and titanium) by immersion in a solution of sodium hydroxied (NaOH) and sodium nitrate ($NaNO_3$). This process produced an aqueous coating waste stream, containing sodium aluminate ($NaAlO_2$), Sodium nitrite ($NaNO_2$), $NaNO_3$, NaOH, sodium metasilicate (Na_2SiO_3), and small amounts of uranium, plutonium, and fission products. This stream was directed to the 241-S Tank

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Farm. Aluminum oxide (Al_2O_3) may have precipitated if the ratio of NaOH to aluminum was low. Ammonia (NH_3) and hydrogen (H_2) gases were also emitted.

After the uranium slugs were removed from their jackets, they were rinsed in Nitric acid (HNO_3) to remove residual alkalinity. The rinse water, containing small amounts of uranium and plutonium, was also directed to 241-S Tank Farm. The uranium slugs were then dissolved in HNO_3, creating a metal solution containing primarily uranyl nitrate ($UO_2(NO_3)_2$) and oxidized plutonium (III or IV) as soluble nitrates. Uranyl nitrate crystallizes as $UO_2(NO_3)_2 \bullet 6H_2O$ or (uranyl nitrate hexahydrate), so the dissolved metal may occasionally be referenced as uranyl nitrate hexahydrate solution. The off-gases, primarily nitrogen dioxide (NO_2) and nitrous oxide (NO) with lesser amounts of HNO_3 and water, were put through a condenser, where the HNO_3 and water were condensed and returned to the dissolver tank. The returning condensate served to scrub NO_2 and NO from the exiting gaseous phase. The remaining gaseous effluent that was not condensed or scrubbed was passed through a "silver reactor" to capture the toxic volatile radioisotope of iodine (^{131}I) by reaction with silver nitrate ($AgNO_3$) forming silver iodide (AgI). Off-gas from the "silver reactor" was passed through fiberglass filters to remove radioactive particulate and was then discharged to the atmosphere through the 291-S Stack Complex.

The metal remaining in the dissolver tank solution was next treated with sodium dichromate ($Na_2Cr_2O_7$) to oxidize the plutonium to the VI valence state (the uranium already existed in this state as uranyl nitrate). Concurrently, the fission product of ruthenium was oxidized with potassium permanganate ($KMnO_4$) to form the volatile, ruthenium tetroxide (RuO_4), that was removed by sparging with air. The off-gas was scrubbed with caustic, resulting in the formation of sodium ruthenium tetroxide (Na_2RuO_4). The scrubber bottoms were disposed with other wastes in the 241-S Tank Farm. The ruthenium was removed because it was the primary contaminant in purified plutonium and uranium streams.

The manganese dioxide (MnO_2), precipitated from the reduction of $KMnO_4$ with chromic nitrate ($Cr(NO_3)_3$), and a filter aid (an activated clay containing mostly silicon dioxide [SiO_2] and Al_2O_3), carried away the adsorbed fission products of zirconium and niobium and was separated from solution by centrifugation. The centrifugation cake was dissolved with a ferrous sulfamate ($Fe(NH_2SO_3)_2$)/HNO_3 solution and was slurried and pumped to the 241-S Tank Farm. This dissolved cake contained inorganic ions (SO^{-2}_3, NO^{-}_3, Fe^{+++}, Mn^{++}) and small quantities of uranium and plutonium.

The metal solution (containing uranium, plutonium, $Na_2Cr_2O_7$, HNO_3, and potassium dichromate [$K_2Cr_2O_7$]) was adjusted to an acid-deficient state by addition of NaOH; this ensured neutralization of the solution when it contacted acidified MIBK in the subsequent process.

The metal solution then went through several solvent-extraction cycles, as necessary, to achieve the desired uranium and plutonium purity. These solvent-extraction cycles resulted in three aqueous phases containing essentially all the plutonium, all the uranium, and the bulk of the fission products.

Waste streams generated by the feed preparation process include both gaseous and liquid/solid wastes. An off-gas stream containing radioactive iodine (^{131}I) was generated by the dissolvers, treated in the "silver reactor" to remove the radioactive iodine, filtered through fiberglass filters (Filters A-4, B-4, and C-4) to remove particulate, and discharged to the atmosphere through the 291-S Stack Complex. Off-gases were also produced at the oxidizer. These gases, which contained radioactive ruthenium, were put through a ruthenium scrubber to remove the ruthenium, filtered through the J-1 Fiberglass Filter to remove particulate, and discharged to the atmosphere through the 291-S Stack Complex. The gaseous wastes discharged to the atmosphere contained essentially no radioactive particulate matter or ruthenium and little radioiodine. Volatile radioisotopes of xenon and krypton may also have been present.

Liquid and slurry wastes generated by the feed preparation process included the coating removal solution, the acid flush from the dissolvers, the dissolved or slurried centrifuge cake, and the ruthenium scrubber solution. All of these waste streams were considered to be high-level radioactive wastes and, with the exception of the ruthenium scrubber solution, all were sent to the 241-S Tank Farm via the 240-S and 241-S Diversion Boxes. The ruthenium scrubber solution was sent to the neutralizer one or two times a week, where it was used to help adjust the acid deficiency of the metals solution.

Waste management units that received process wastes included:

- 241-S Tank Farm
- 291-S Stack Complex.

2.4.1.2 First Extraction Cycle. In the first extraction cycle, the metal solution was contacted with acidified MIBK and aqueous ($Al(NO_3)_3$); the uranium and plutonium were extracted into the organic phase while the fission products remained in the aqueous phase. The $Al(NO_3)_3$, a salting agent, reduced the aqueous solubility of the uranium and plutonium nitrates by increasing the nitrate concentration in the aqueous phase. Less than 0.2% of the plutonium, and more than 99% of the fission products, remained in the aqueous stream. This aqueous stream contained the wastes from the extraction cycle, and was subjected to further processing before disposal (see Section 2.4.1.6).

The organic phase was then directed to a column where the stream was contacted with ferrous sulfamate reducing the plutonium to the III valence state; the plutonium (III) partitioned into the aqueous phase containing $Al(NO_3)_3$ while the uranium remained in the organic phase. The aqueous phase was scrubbed with additional acidified MIBK to remove residual uranium. The aqueous plutonium solution was directed to the Second and Third Plutonium Cycles, as necessary.

In a third column, the remaining organic phase was contacted with a new aqueous phase (not containing the $Al(NO_3)_3$) where the uranium partitioned into the aqueous phase. The aqueous product stream was stripped to remove any dissolved MIBK and adjusted to be

acid deficient. The aqueous uranium solution was directed to the Second and Third Uranium Cycles, as necessary.

The primary waste stream generated by the first extraction cycle was an aqueous stream containing fission products from the dissolved uranium fuel element stream. This stream was sent to the waste concentrator (discussed in Section 2.4.1.6) for further treatment prior to disposal. Spent solvent from the separation process contained small amounts of uranium, plutonium, and fission products and was routed to the solvent treatment system (discussed in Section 2.4.1.5) for purification prior to being recycled into the extraction process.

The aqueous uranium stream produced by the first extraction cycle was steam stripped, resulting in a gaseous stream with traces of MIBK; and then concentrated, resulting in an air/water vapor stream with (potentially) small amounts of uranium.

Both of these streams were routed to the condensate stripper, as described in Section 2.4.1.6.

2.4.1.3 Second and Third Plutonium Cycles. If needed, the aqueous plutonium-rich stream from the first extraction was passed through additional cycles (similar to those described above) to achieve the desired purity. Prior to any additional plutonium purification cycles, the aqueous plutonium (III) was again oxidized with $Na_2Cr_2O_7$ to the IV or VI valence states to permit the solvent extraction process to proceed. The purified plutonium stream was then directed to a final isolation process in 231-S or 234-S Buildings. The plutonium production rate is still classified. The final plutonium product was a plutonium nitrate solution containing approximately 10 g of plutonium and 400 to 600 g of free nitric acid per liter. The uranium impurity in the plutonium product stream was estimated at 0.1 weight percent of the plutonium metal. Other impurities in the plutonium stream were expected to be aluminum and iron at 30,000 and 10,000 ppm parts of plutonium, respectively.

The primary waste streams generated by the second and third plutonium cycles were an aqueous stream containing impurities from the plutonium stream produced in the first extraction cycle and spent solvent, also containing trace impurities from the plutonium stream. The aqueous stream was directed to the waste concentrator (described in Section 2.4.1.6) and the spent solvent was directed to the solvent recovery system (described in Section 2.4.1.5). In addition, the plutonium product stream is concentrated prior to shipping. Water vapor produced during this process is sent to the condensate stripper (described in Section 2.4.1.6).

All of the waste streams generated during the second and third plutonium cycles received further treatment prior to disposal; therefore, no waste management units received wastes directly from this process.

2.4.1.4 Second and Third Uranium Cycles. If needed, the aqueous uranium-rich stream from the first extraction was passed through additional cycles (similar to those described

above) to achieve the desired purity. The purified uranium stream was then directed to the Uranium Conversion Plant (224-U Building) where the uranyl nitrate was calcinated to uranium trioxide (UO_3) for shipment off site. The uranium production was designed for approximately 2,300 kg (2.5 short tons) per day, assuming an 80% operating efficiency. The uranium product stream was a solution containing approximately 1,004 grams of uranyl nitrate hexahydrate per liter; the plutonium impurity in the uranium stream was expected to be approximately 10 ppb. Other impurities in the uranium stream were expected to be HNO_3, sodium, aluminum, and iron at 10,000, 400, 600, and 150 ppm, respectively.

Waste streams generated by the second and third uranium cycles are very similar to those produced by the second and third plutonium cycles. Aqueous wastes were directed to the waste concentrator (described in Section 2.4.1.6) and spent solvent was directed to the solvent recovery system (described in Section 2.4.1.6). In addition, the aqueous uranium product stream was steam stripped prior to final shipment. This produced a gaseous stream containing water vapor and MIBK, which was routed to the condensate stripper (described in Section 2.4.1.6).

All of the waste streams generated during the second and third uranium cycles received further treatment prior to disposal; therefore, no waste management units received wastes directly from this process.

2.4.1.5 Solvent Recovery. Spent MIBK from the extraction cycles was directed to a scrubber where a sodium carbonate (Na_2CO_3) solution was used to remove the bulk of the fission products and residual plutonium and uranium present in the solvent. The MIBK was then fed to a column where, by distillation and contact with caustic, further removal of plutonium, uranium, and fission products was achieved and any organic impurities such as methyl isopropyl diketone or organic acids (from decomposition of MIBK) were removed. Additional treatments may have been used as necessary to remove solvent impurities such as methyl isobutyl carbinol. Make-up MIBK and acid were added to the purified recycle stream for further use in the extractions.

Waste streams generated by the solvent treatment process included an aqueous stream containing plutonium, uranium, and fission product impurities from the spent MIBK and an aqueous stream with trace impurities from the distillation of the cleaned MIBK. The first of these streams had higher concentrations of radioactive elements than the second stream and was directed to the waste concentrator (described in Section 2.4.1.6) for further treatment prior to disposal. The second stream was very dilute and was disposed in the 276-S Crib. The waste management unit that received wastes from the solvent recovery was the 276-S Crib.

2.4.1.6 Waste Treatment and Disposal. Generally, waste treatment was intended to treat and segregate aqueous wastes according to their radioactivities and to recover MIBK. Liquid wastes that contained appreciable quantities of radioactive materials (such as aqueous fission product wastes from the extraction, zirconium and niobium scavenging, aluminum jacket removal, and solvent recovery cycles) were concentrated to the highest practicable $Al(NO_3)_3$ content in a waste concentrator, blended with wastes from the ruthenium scrubber and from

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the 222-S Laboratory, neutralized with caustic to convert the $Al(NO_3)_3$ to $NaAlO_2$ to minimize corrosion problems, and stored in the 241-S Tank Farm. Wastes were routed to the tanks via the 240-S and 241-S Diversion Boxes. The underground storage tanks operated as a cascade system with successive overflow tanks containing less contaminated wastes than upstream tanks.

Condensate from the waste concentrator and condensate from the uranium and plutonium concentrators contained very low levels of radioactive wastes. These streams were combined and put through a condensate stripper to remove residual MIBK, which was returned to the solvent recovery process. The aqueous product stream was evaporated to the extent possible and disposed as low-radioactive waste in the 216-S Cribs. Residuals from the condensate stripper were returned to the waste concentrator. Other liquid wastes that contained only trace quantities of radioactive materials such as floor drain wastes were also disposed in cribs.

Off-specification products were recycled to the process or to parallel columns designed specifically for purifying off-specification products. The 222-S Laboratory generated relatively small quantities of waste, most of which was directed to underground storage tanks. Sanitary wastes were directed to septic tanks with tile fields.

In addition to the gaseous wastes generated by the feed preparation process (as discussed in Section 2.4.1.1), gaseous waste streams were also generated from the 202-S Building ventilating system and the 202-S Building equipment vent headers. The ventilating system air was passed through sand and gravel filter to remove particulate material and then was discharged to the atmosphere through the 291-S Stack Complex. Air or inert gas from the equipment vent headers was passed through fiberglass filters (Filters J-3, J-4, and/or J-5) before it was also discharged to the 291-S Stack Complex. The stack gases may have included small quantities of xenon and krypton.

Chemical sewers drained nonradioactive portions of the buildings (such as operating galleries, service areas, and aqueous make-up) and flowed directly to a pond 1,070 m (3,500 ft) southwest of the 202-S Building. Process sewers received water and steam condensate from process equipment jackets and coils. This water should not have been contaminated and was directed to the 207-S Retention Basin prior to discharge to the pond to ensure any leakage of radionuclides from process equipment was within acceptable limits. The water in the pond was disposed through evaporation and seepage into the soil column.

Organic wastes from the laboratory or other buildings were decontaminated and treated with aqueous solutions in the laboratory where they were produced. The organic liquids were transported to a designated site for burial.

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Dry laboratory wastes (absorbent tissues, wood, metal parts, etc.) with low radioactivity were placed in quart cardboard containers which in turn were placed in larger cardboard cartons. When the radioactivity of the carton reached tolerance, the carton was sealed and transported to the 200 West Area Burial Ground. Highly contaminated dry wastes were placed in containers and disposed in the 218-W-7 Burial Ground adjacent to 222-S Laboratory.

Waste management units that received wastes from the waste treatment and disposal processes include the following:

- 241-S Tank Farm
- 216-S Cribs
- 291-S Stack Complex
- 207-S Retention Basin
- 216-S Ponds
- 200 West Area Burial Ground
- 218-W-7 Burial Ground.

2.5 INTERACTIONS WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

The 200 Areas have two distinct operational areas, 200 East and 200 West (Figures 1-3 and 1-4). These areas are used for chemical separations and waste management. Supernatant from the 241-SY-102 Double-Shell Tank is transferred to the 200 East Area tank farms. The complexant in the 241-SY-101 and 241-SY-102 Double-Shell Tanks comes from the 200 East Area. Interaction of the S Plant Complex facilities with 200 East facilities is described below.

- 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. The 222-S Laboratory continues to provide analytical support for current B Plant operations.

- The PUREX facility separated uranium, plutonium, and neptunium from their fission products similar to the REDOX process except the PUREX process used an organic phase of tributyl phosphate in kerosene instead of MIBK a salting agent of nitric acid instead of aluminum nitrate, and a pulse column instead of continuous packed columns. The final plutonium nitrate stream was concentrated

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and sent to the Plutonium Finishing Plant (Z Plant) to be converted to metal form. The facility was in operation from 1956 to 1972 and was placed on standby until 1983 when operations were resumed. The silica gel adsorption columns in the 205-S Building were occasionally used to further remove fission products from decontaminated uranium solutions from the PUREX Plant. The 205-S Building was decommissioned when the 202-S Building was shut down. The 222-S Laboratory served as a backup to the PUREX Plant analytical laboratory.

The 200 West Area Plants consists of the U Plant, S Plant, T Plant, and Plutonium Finishing Plant. The interaction of the U Plant, T Plant, and Plutonium Finishing Plant with the S Plant is as follows:

- The U Plant was designed as a bismuth phosphate plant but was later converted to a solvent-extraction plant for the recovery of uranium from bismuth phosphate process wastes. This operation used a series of tanks located in the 241-U Tank Farm. The tank farm has single-shell tanks used to store radioactive waste from the U Plant and other plants. Decontaminated uranyl nitrate hexahydrate solution was transferred from the 203-S and 204-S Tank Farms to U Plant for calcination in the 224-U (and 224-UA) Uranium Oxide Plant. The 203-S and 204-S Tank Farms are no longer present. The 203-U uranyl nitrate hexahydrate Storage Tanks were used to receive and store the uranyl nitrate hexahydrate solution from the S Plant Complex and other plants. From January 1953 to April 1954, the 216-S-17 Pond received overflow from the 216-U-10 Pond via the 216-U-9 Ditch. The 222-S Laboratory provides analytical support services for the U Plant. The 216-S-4 French Drain and the 216-S-21 Crib are physically located in the U Plant Aggregate Area, but received waste from the S Plant; these two units are described in the U Plant AAMSR.

- The T Plant was one of the original bismuth phosphate fuels separation facilities (similar to the B Plant) and was in operation from 1944 to 1956. Some T Plant wastes were disposed in the S Plant Complex single-shell tanks.

- Plutonium finishing operations were conducted at Plutonium Finishing Plant. Solid wastes from the 202-S Building and other areas were routed to the Plutonium Finishing Plant for separation. The 222-S Laboratory serves as a backup to the Plutonium Finishing Plant analytical laboratory. Some of the Plutonium Finishing Plant wastes are being disposed in the 241-SY Tank Farm.

The 204-S Waste Load-In Facility received contaminated liquid waste from the 100 and 300 Area laboratories but has been removed.

In addition to 202-S Building wastes, wastes from a variety of sources outside the 202-S Building were discharged to 202-S Building tanks. Although a specific tank is identified as having received waste from outside sources, any of the tanks within the

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associated cascade system may have received the same wastes. Wastes from buildings other than the 202-S Building associated with specific tanks are identified below:

- 241-S-101 Single-Shell Tank: Supernatant containing Pacific Northwest Laboratory (PNL) waste, PUREX low-level radioactive waste, B Plant high-level radioactive waste, and double-shell slurry feed from the 241-U Tank Farms

- 241-S-107 Single-Shell Tank: B Plant low-level radioactive wastes, PNL waste, N Reactor waste, and complexed concentrate from 241-BX, -C, and -U Tank Farms

- 241-S-110 Single-Shell Tank: 224-U wastes, B Plant low-level radioactive waste, and organic wash waste from 241-BX, -T, -TX, and -U tanks

- 241-SX-101 Single-Shell Tank: Complexed wastes from 241-BX and -U Tank Farms

- 241-SX-102 Single-Shell Tank: Partial neutralization feed from the 241-BX and 241-TX Tank Farms

- 241-SX-103 Single-Shell Tank: Partial neutralization feed from the 241-BX Tank Farm

- 241-SX-105 Single-Shell Tank: Partial neutralization feed from the 241-BX and -U Tank Farms

- 241-SX-106 Single-Shell Tank: Hanford laboratory waste, PNL waste, B Plant low-level radioactive waste, PUREX low-level radioactive waste, and partial neutralization feed from 241-B, -BX, -C, -TX, and -U Tank Farms

- 241-SX-110 Single-Shell Tank: PNL waste, B Plant low-level radioactive waste, and 224-U Building waste from 241-B and -BX Tank Farms

- 241-SY-101 Double-Shell Tank: Evaporator bottoms from the 241-SY-102 Double-Shell Tank, and transfers from the 241-SX-106 and 241-U-111 Single-Shell Tanks

- 241-SY-102 Double-Shell Tank: Decontamination wastes from T Plant operations and radioactive wastes from the 222-S Laboratory and the Plutonium Finishing Plant.

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2.6 INTERACTION WITH RESOURCE CONSERVATION AND RECOVERY ACT PROGRAM

Appendices B and C of the Tri-Party Agreement list RCRA TSD facilities on the Hanford Site that have entered interim status and, thus, will require final permitting or closure. Within the geographical extent of the S Plant Aggregate Area there are 13 facilities which fall into this category:

- 276-S-141 and 276-S-142 Hexone Tanks
- 216-S-10P Pond and 216-S-10D Ditch
- 222-S Storage Pad and 222-S tanks 102 and 103
- 219-S Waste Handling Facility
- 240-S-152, 241-S-152, 241-SX-151, and 241-SX-152 Diversion Boxes
- 241-S Tank Farm and ancillary equipment
- 241-SX Tank Farm and ancillary equipment
- 241-SY Tank Farm and ancillary equipment
- 244-S Receiver Tank
- 2727-S Nonradioactive Dangerous Waste Storage Facility.

The 276-S-141 and 276-S-142 Hexone Tanks were identified as RCRA TSD facilities because they contained F003 spent solvent. The waste consisted of hexone, tributyl phosphate, normal paraffin hydrocarbon, and water. Both tanks are contaminated with radioactive fission products. The tanks are currently under closure activities. A clean closure plan is currently being prepared, and will be submitted to Ecology and EPA by November 1992.

The 216-S-10P Pond and 216-S-10D Ditch are identified as RCRA TSD facilities because of the disposal of wastes with the characteristics of ignitability, corrosivity, and EP toxicity. They also contain radioactive fission products. A closure plan is scheduled for submission to Ecology and EPA by May 1996.

The 219-S Waste Handling Facility was identified as a RCRA TSD facility because it contained mixed wastes with the characteristics of corrosivity, toxicity, spent nonhalogenated solvents (F003 and F005), and state-only wastes (WT01). The 222-S Dangerous and Mixed Waste Facility was identified as a RCRA TSD facility because it contained mixed and nonradioactive dangerous wastes of the following types: corrosive, ignitable, reactive, toxic, spent halogenated and nonhalogenated (F002, F002, F003, F005, and F027), and state-only

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(WC01, WC02, WP01, WT01, and WT02). A clean closure plan for these facilities was submitted to Ecology and EPA in December 1991.

The single-shell tanks and their associated facilities will be closed under RCRA rather than seeking a RCRA operating permit. The preferred closure option will be resolved through the preparation and completion of a supplemental environmental impact statement. The waste management units in this category include: the 240-S-152, 241-S-152, 241-SX-151, and 241-SX-152 Diversion Boxes; the 241-S-101 through 241-S-112 Single-Shell Tanks (12 total); the 241-SX-101 through 241-SX-115 Single-Shell Tanks (15 total); and the 241-S-302A Catch Tank.

The 241-SY-101 through 241-SY-103 Double-Shell Tanks (3 total) and the 244-S Receiver Tank are active facilities under the control of the Waste Management Program. These units have a current RCRA operating permit.

The 2727-S Nonradioactive Dangerous Waste Storage Facility has been identified as a RCRA facility under interim status. It is currently not operating, but received a variety of wastes including heavy metals; chlorinated solvents; and corrosive, ignitable, and reactive wastes. A clean closure plan for this facility was submitted to Ecology and EPA in January 1992.

Many of these units are part of the single-shell tanks and will be closed under RCRA rather than seeking a RCRA operating permit. The preferred closure option will be resolved through the preparation and completion of a supplemental environmental impact statement.

2.7 INTERACTIONS WITH OTHER HANFORD PROGRAMS

Other ongoing Hanford programs include the single-shell tank closure program (part of RCRA), the Decommissioning and RCRA Closure Program, the RARA Program, and the Waste Management 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 S Plant Aggregate Area are covered under this program. This program is also responsible for managing the RCRA closure activities. It establishes the cost, schedule, and technical baselines for individual projects and provides the program management for completing the work. The work activities relative to projects are completed by various functional organizations through a matrix management system. Performing organizations are assigned work by the program office using cost account authorizations and cost account plans. Project status is reported to the program office using an earned-value system. The majority of decommissioning and RCRA closure

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field work at the Hanford Site is performed by Hanford Restoration Operations (Winship and Hughes 1991). The S Plant Complex facilities identified as part of the Decommissioning and RCRA Closure Program (Hughes et al. 1990) include the following:

- 202-S Building
- 207-S Retention Basin
- 216-S-172 Control Structure
- 233-S Plutonium Concentration Facility
- 233-SA Exhaust Air Filter Building
- 241-SX-401 and 241-SX-402 Condenser Shielding Buildings
- 276-S Solvent Handling Facility
- 276-S-141 and 276-S-142 Hexone Storage Tanks
- 291-S Fan House and Filter
- 291-S-1 Stack
- 292-S Jet Pit House
- 293-S Off-Gas Treatment Facility
- 296-S-1, -2, -4, -6, -7, -12 Stacks
- 2711-S Stack Monitoring Building
- 2718-S Sand Filter Sampler
- 2904-S-160 Control Structure
- 2904-S-170 and 2904-S-171 Weir Box
- 2904-SA Sampler Building.

The RARA Program is responsible for the surveillance, maintenance, decontamination, and/or interim stabilization of inactive burial sites, 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 S Plant Aggregate Area are

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covered by this program. The S Plant Complex facilities identified as part of the RARA Program (Winship and Hughes 1991) include the following:

- 203-S through 205-S Underground Zones
- 207-S Retention Basin (also in the Decommissioning and RCRA Closure Program)
- 216-S-1 through 216-S-7, -9, -13, and -20 through -23 Cribs
- 216-S-8 and 216-S-19 Trenches
- 216-S-10P, -15, -16P, -17, -19 Ponds
- 216-S-10D and 216-S-16D Ditches (216-S-10D Ditch is also a RCRA TSD)
- 2904-S-160 Control Structure
- 2904-S-170 and 2904-S-171 Weir Boxes (also in Decommissioning and RCRA Closure Program)
- 216-S-172 Weir and Control Structure (also in Decommissioning and RCRA Closure 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 27 single-shell tank operable units, including the 241-S Tank Farm and the 241-SX Tank Farm. The primary regulatory drivers of this program are the Tri-Party Agreement and RCRA.

The Waste Management Program is responsible for all actively operating waste management unitsin the S Plant Aggregate Area. These facilities include the 216-S-25 and -26 Cribs, the 207-SL Retention Basin, the 241-S-151 Diversion Box, and the 241-S-A, -B, -C, and -D, 241-SY-A, and -B Valve Pits the 241-SX-A and 241-SX-B Valve Pits, and all high-level waste process lines and their associated diversion boxes and catch tanks.

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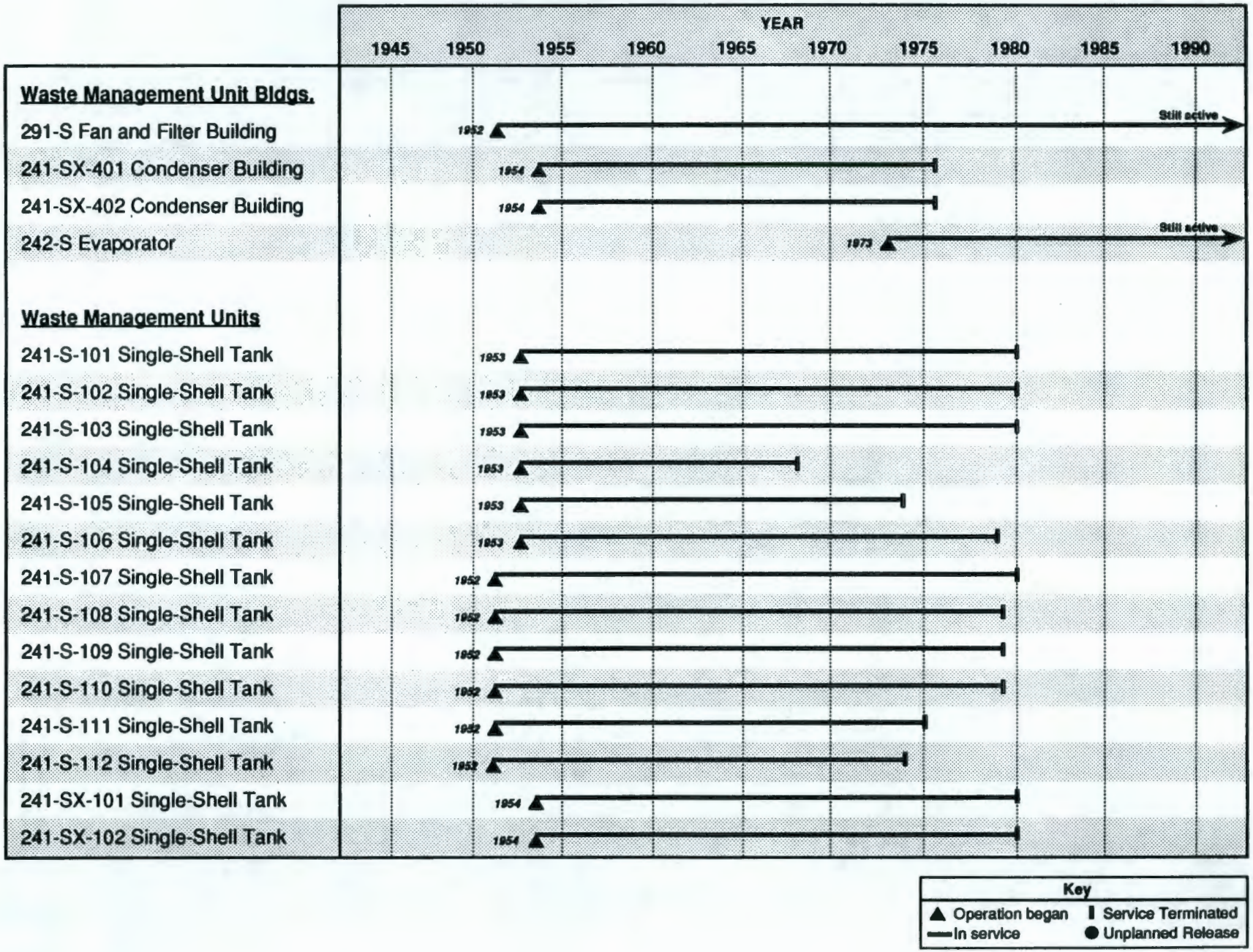

Figure 2-1. S Plant Aggregate Area Timeline.

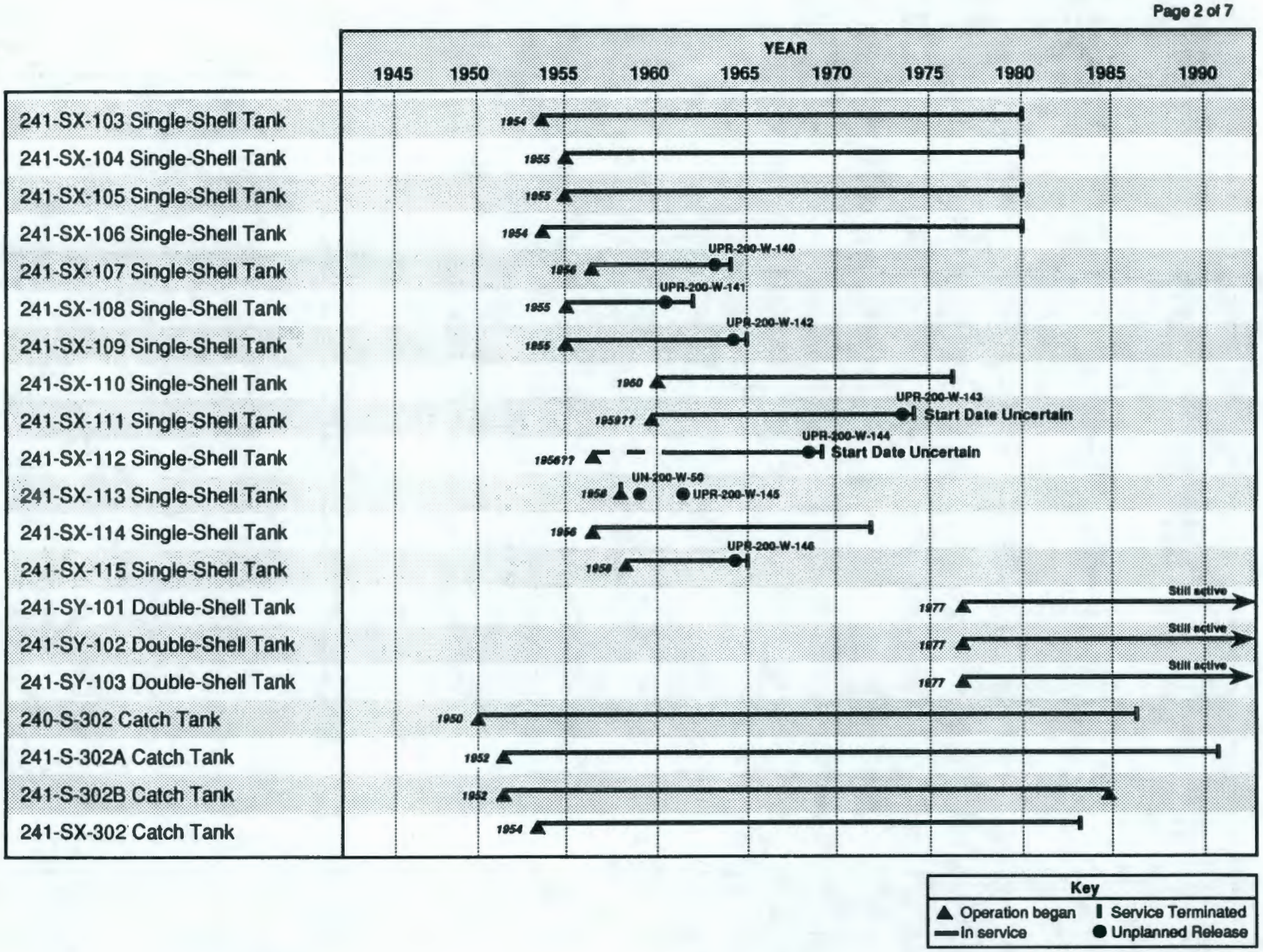

Figure 2-1. S Plant Aggregate Area Timeline.

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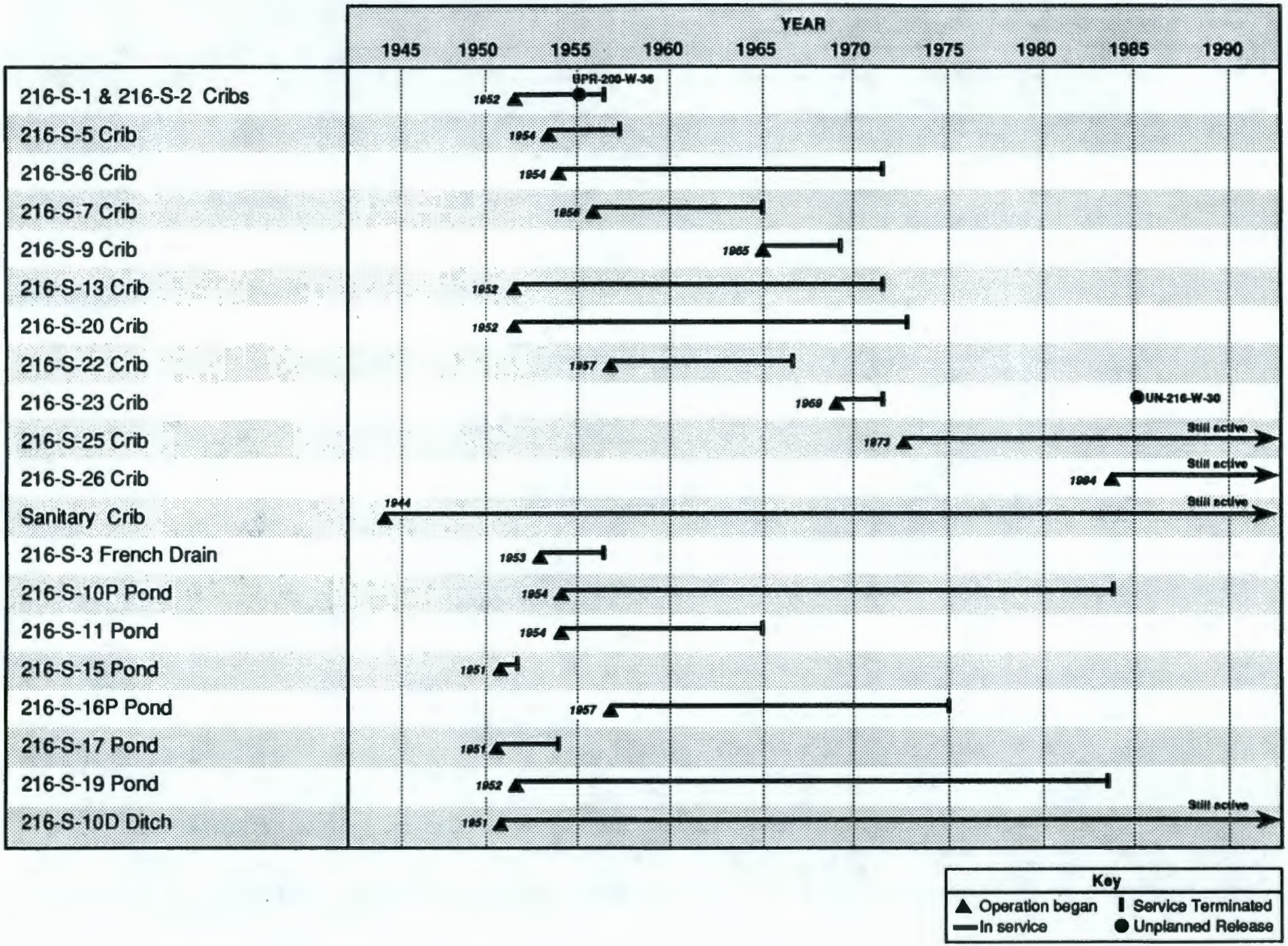
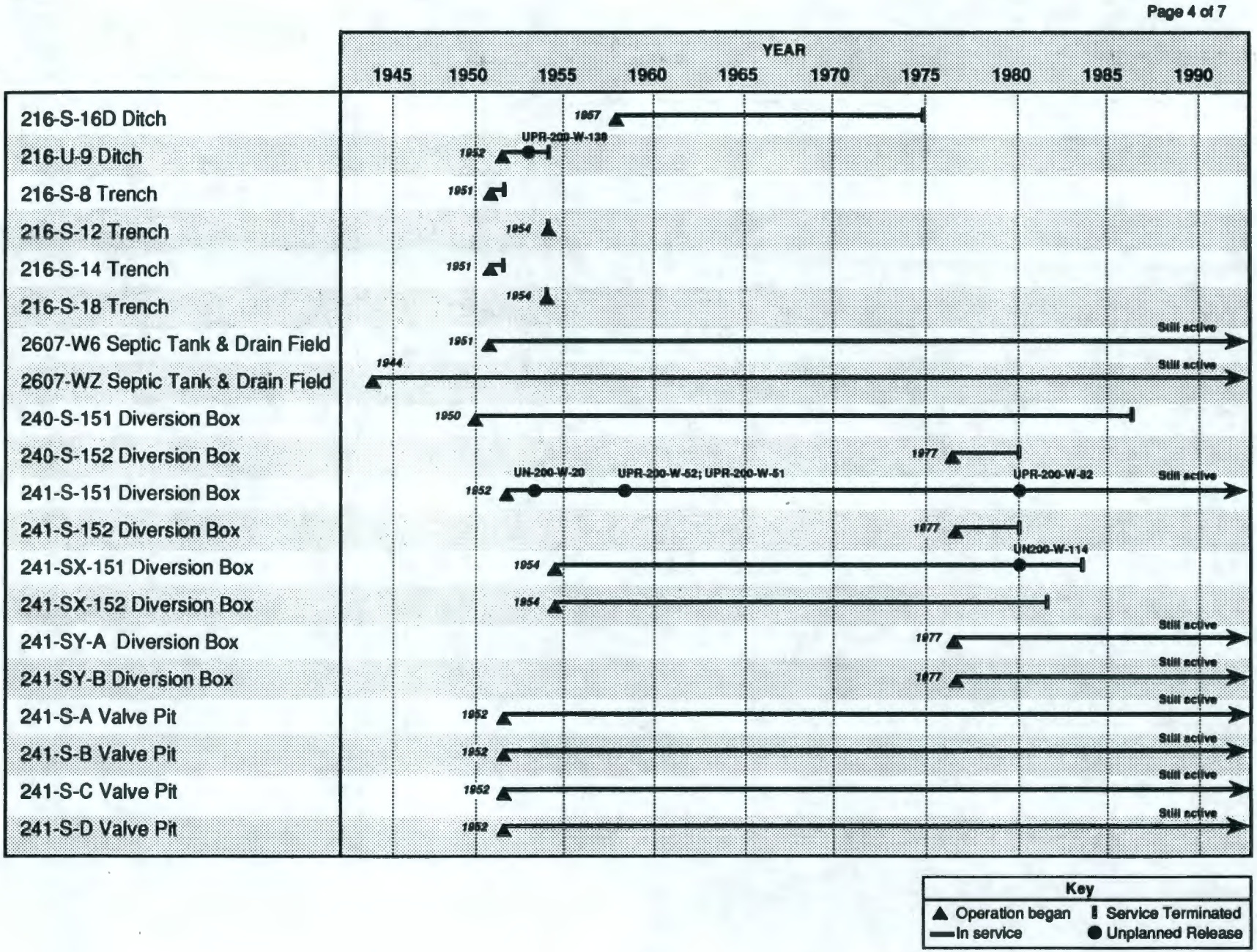


Figure 2-1. S Plant Aggregate Area Timeline.



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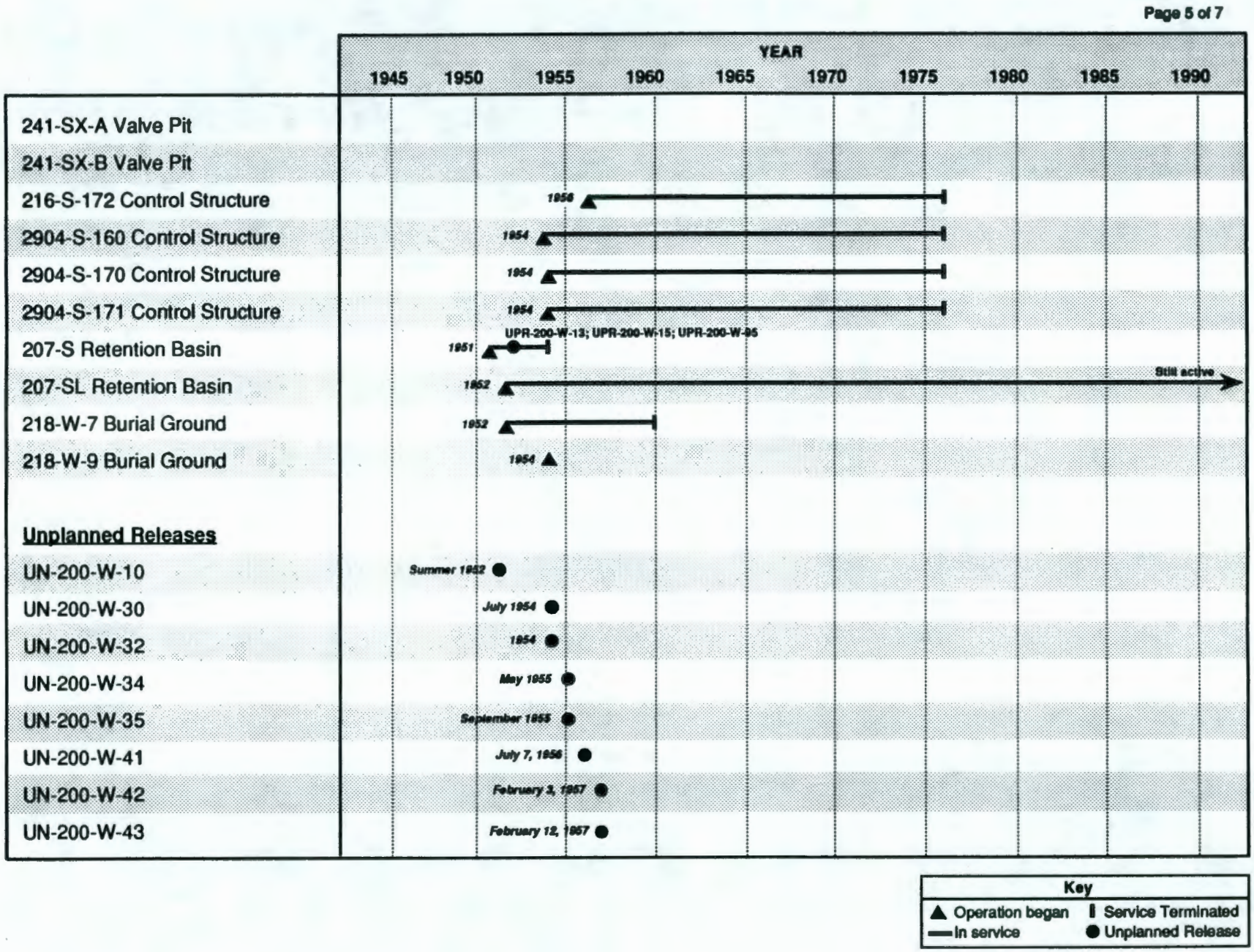

Figure 2-1. S Plant Aggregate Area Timeline.

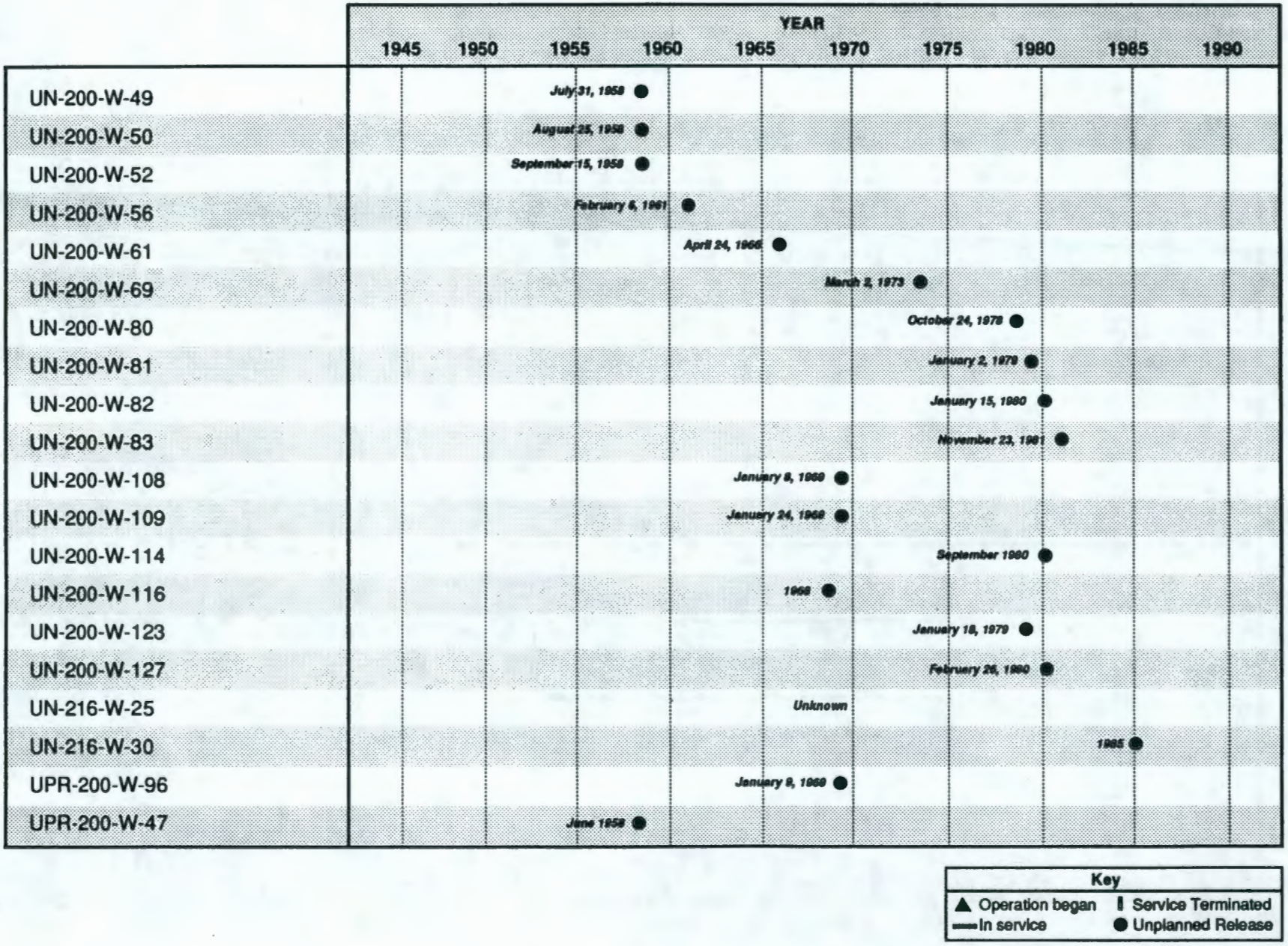

Figure 2-1. S Plant Aggregate Area Timeline.

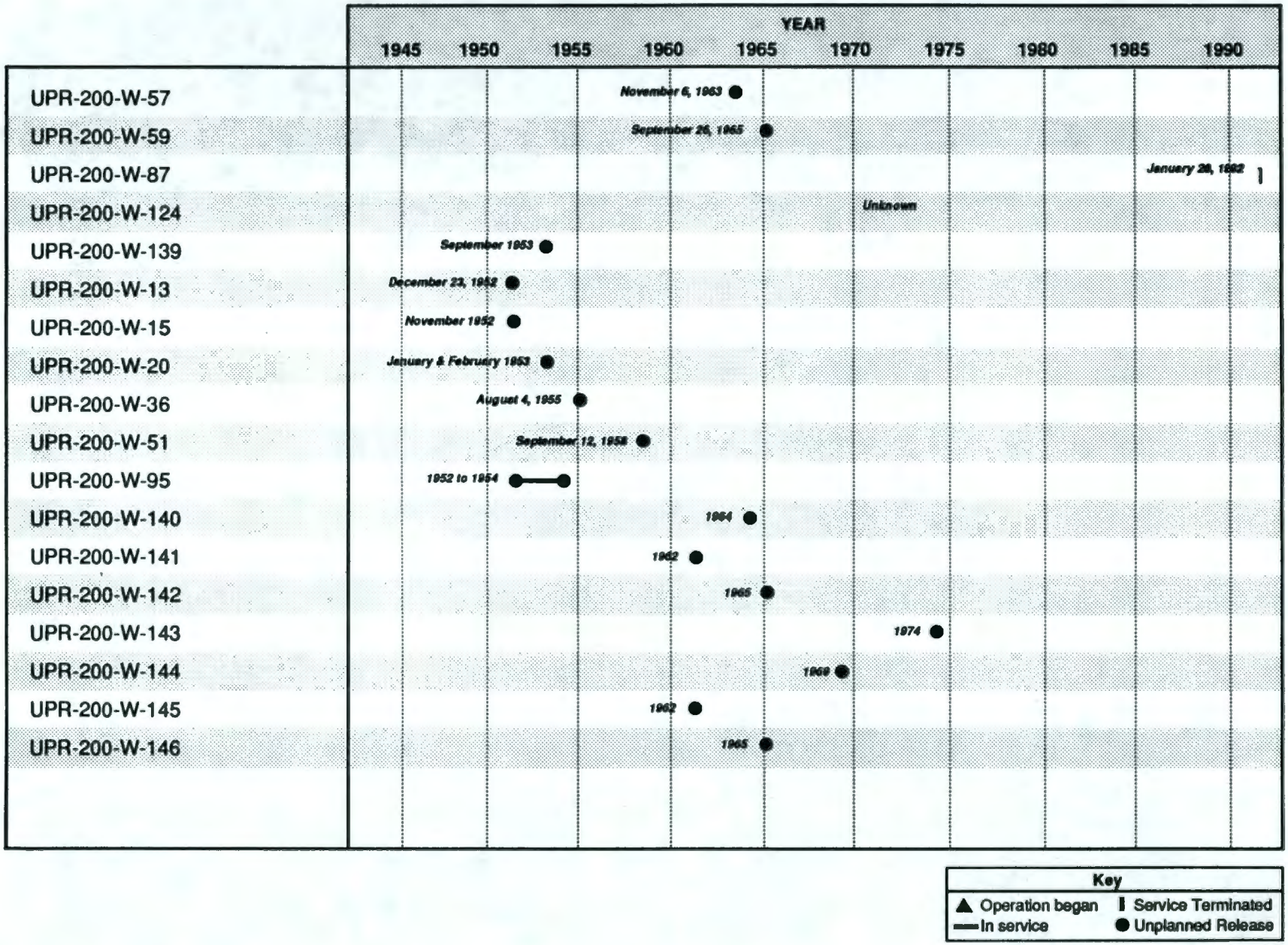

Figure 2-1. S Plant Aggregate Area Timeline.

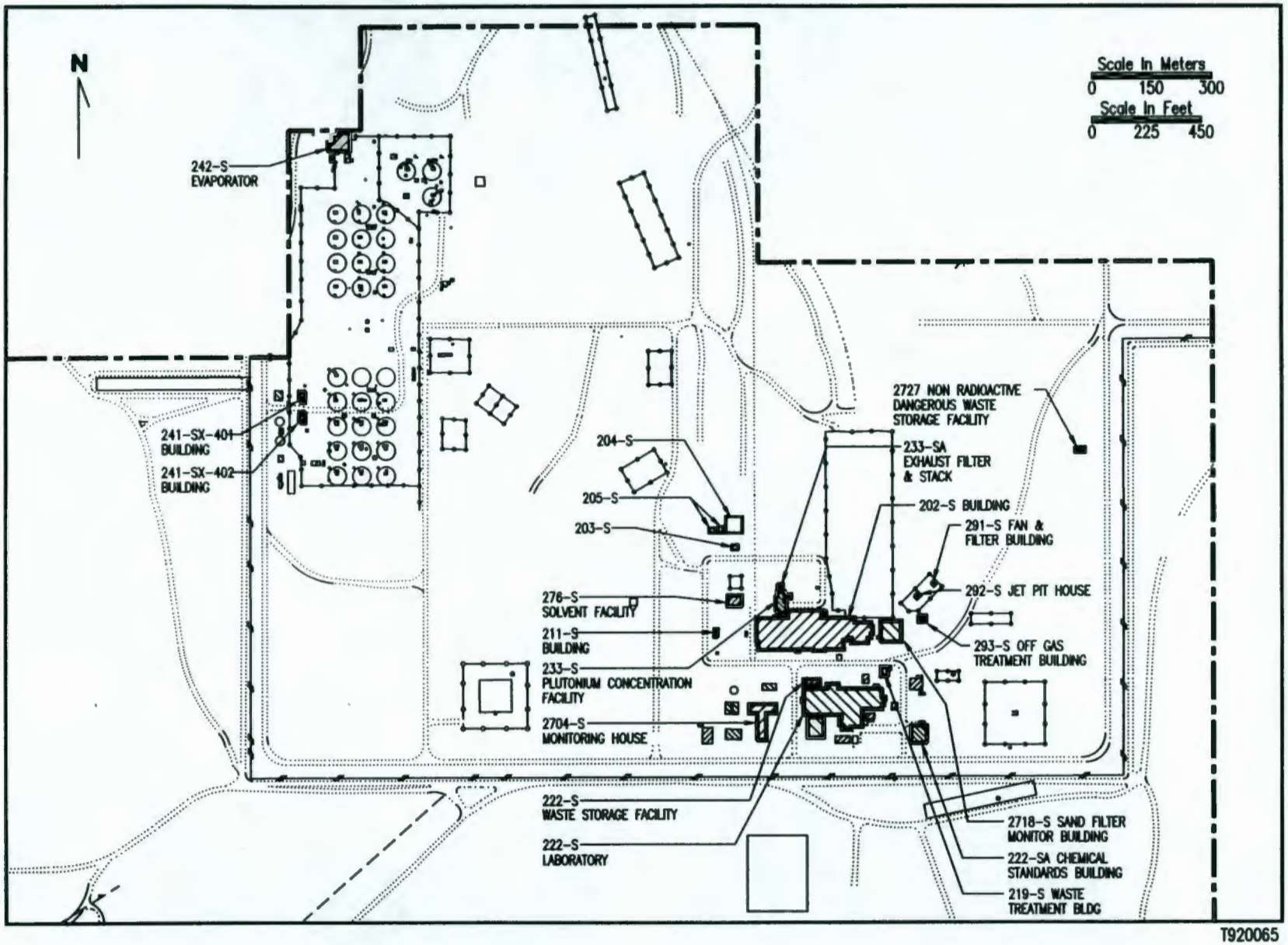

Figure 2-2. Location of Plants, Buildings, and Storage Areas.

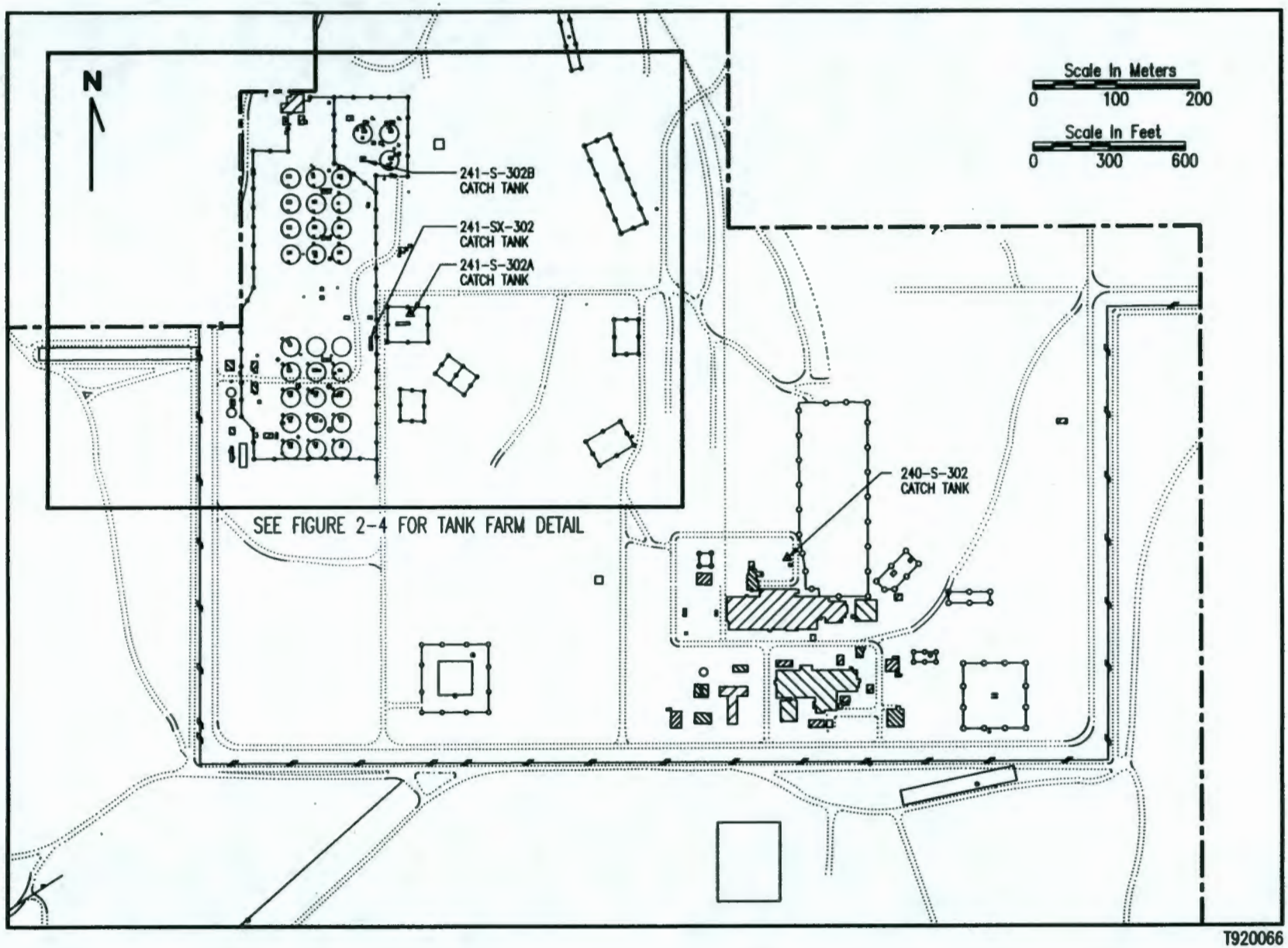

Figure 2-3. Location of Tanks and Vaults.

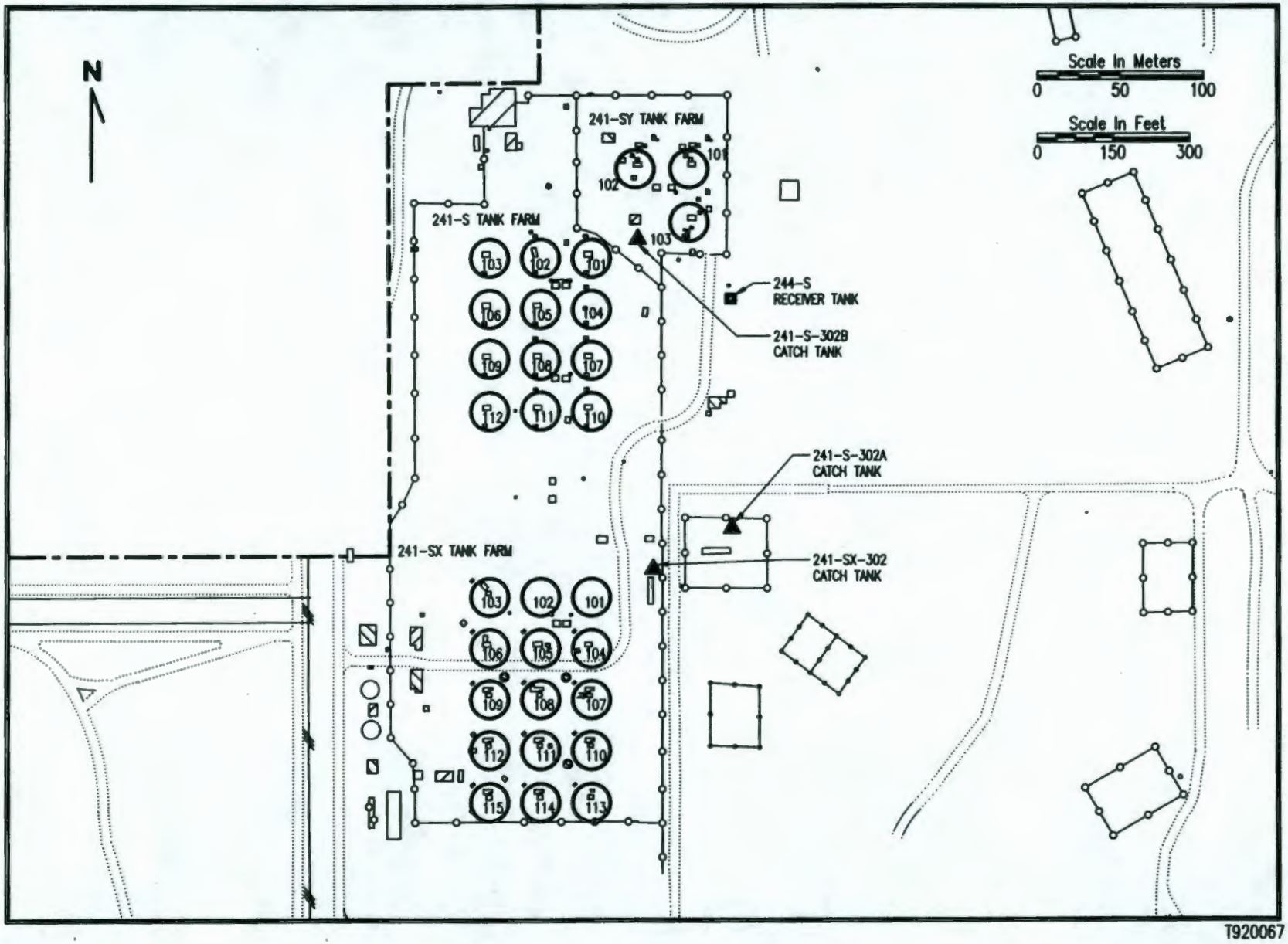

Figure 2-4. Tank Farm Detail.

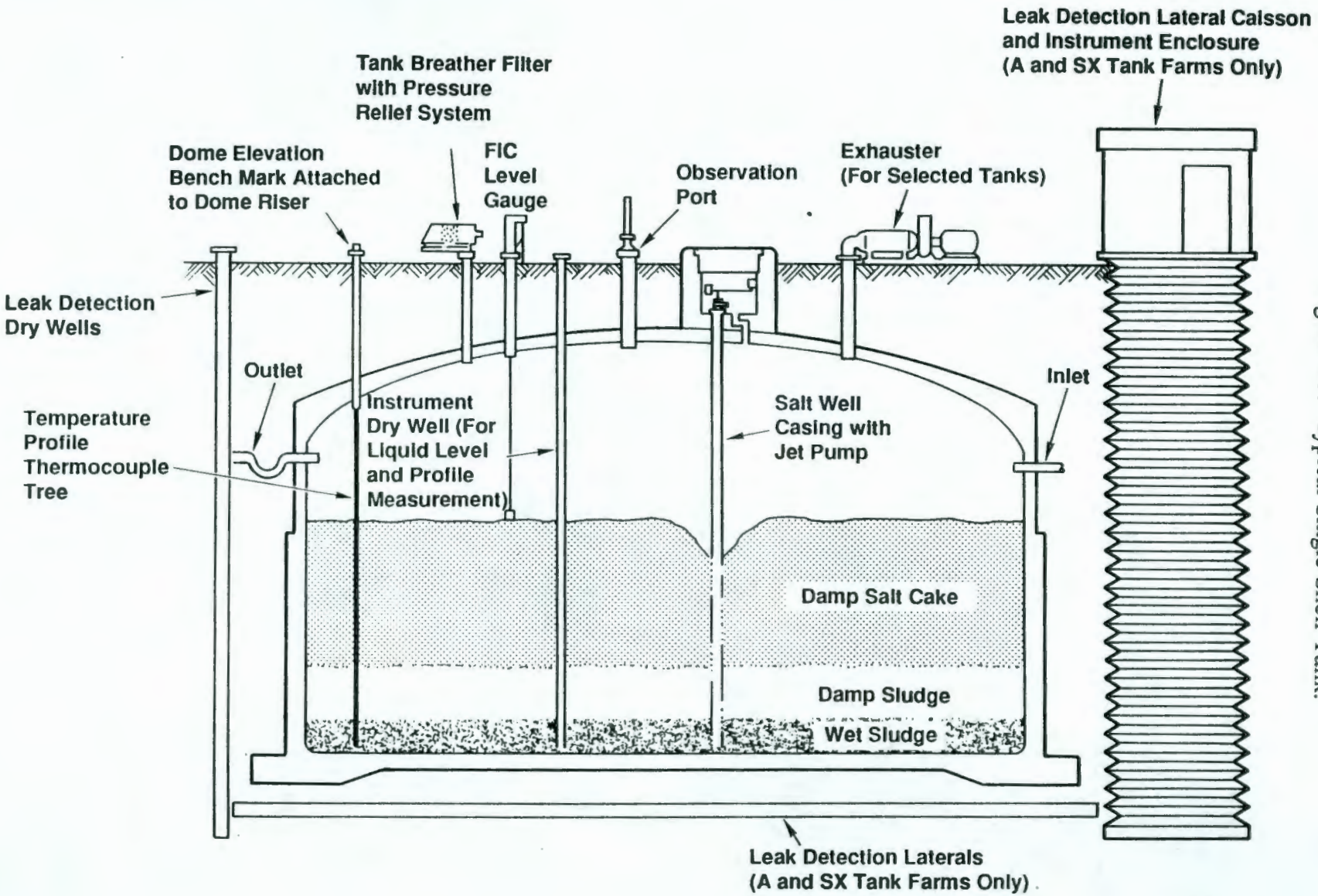

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Figure 2-5. Typical Single-Shell Tank.

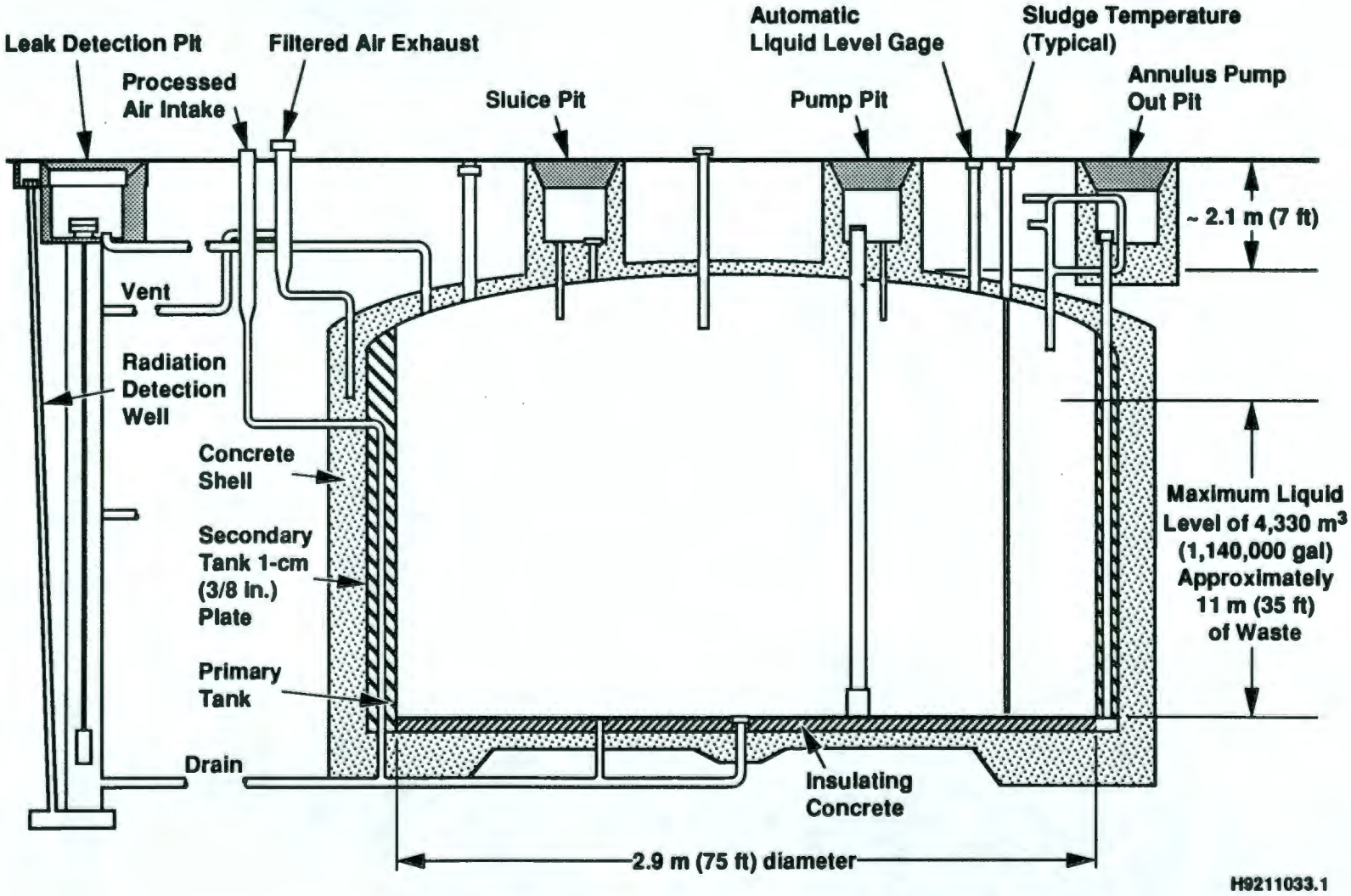
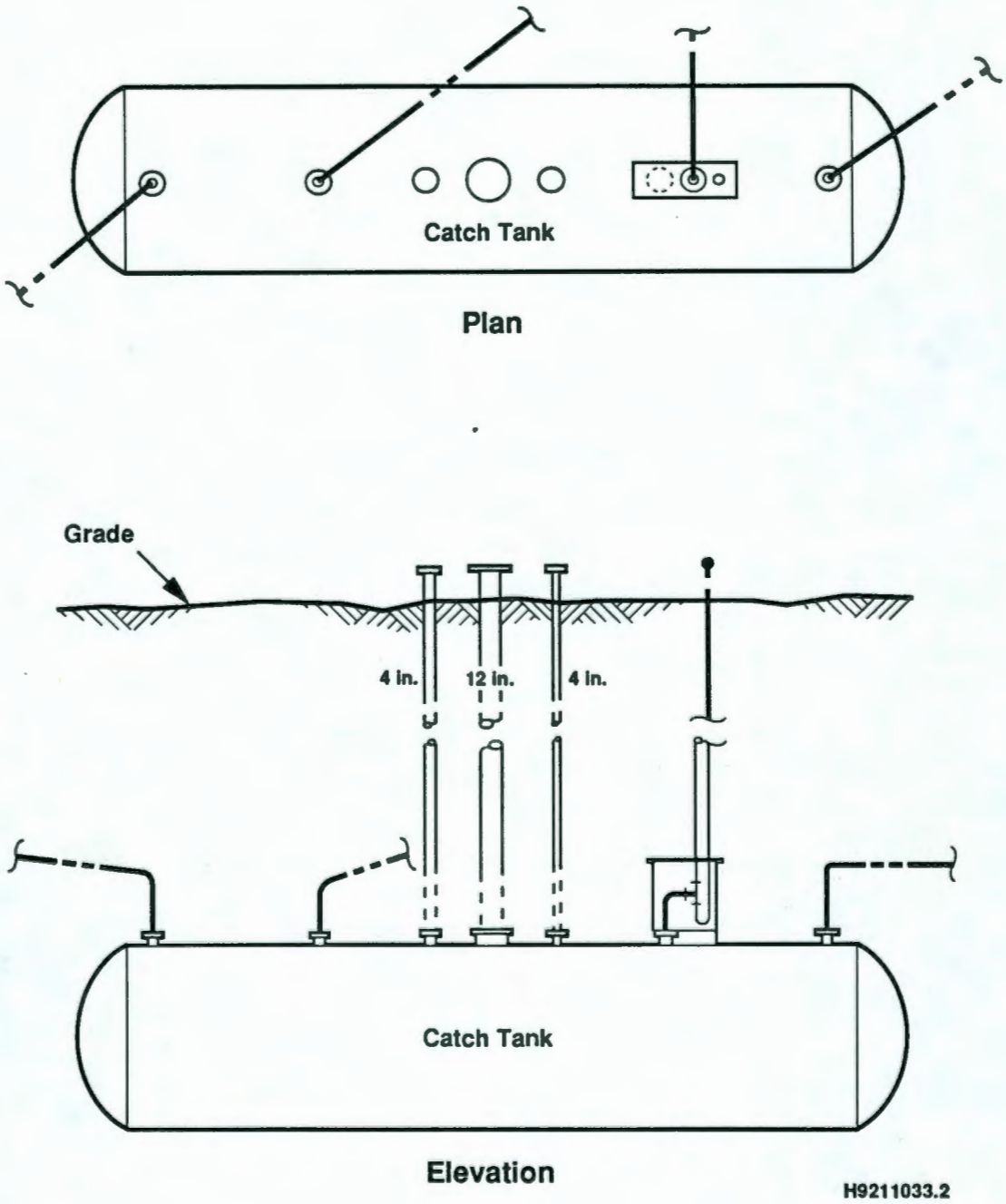


Figure 2-6. Double-Shell Storage Tank (Type V).

Figure 2-7. Typical Catch Tank.



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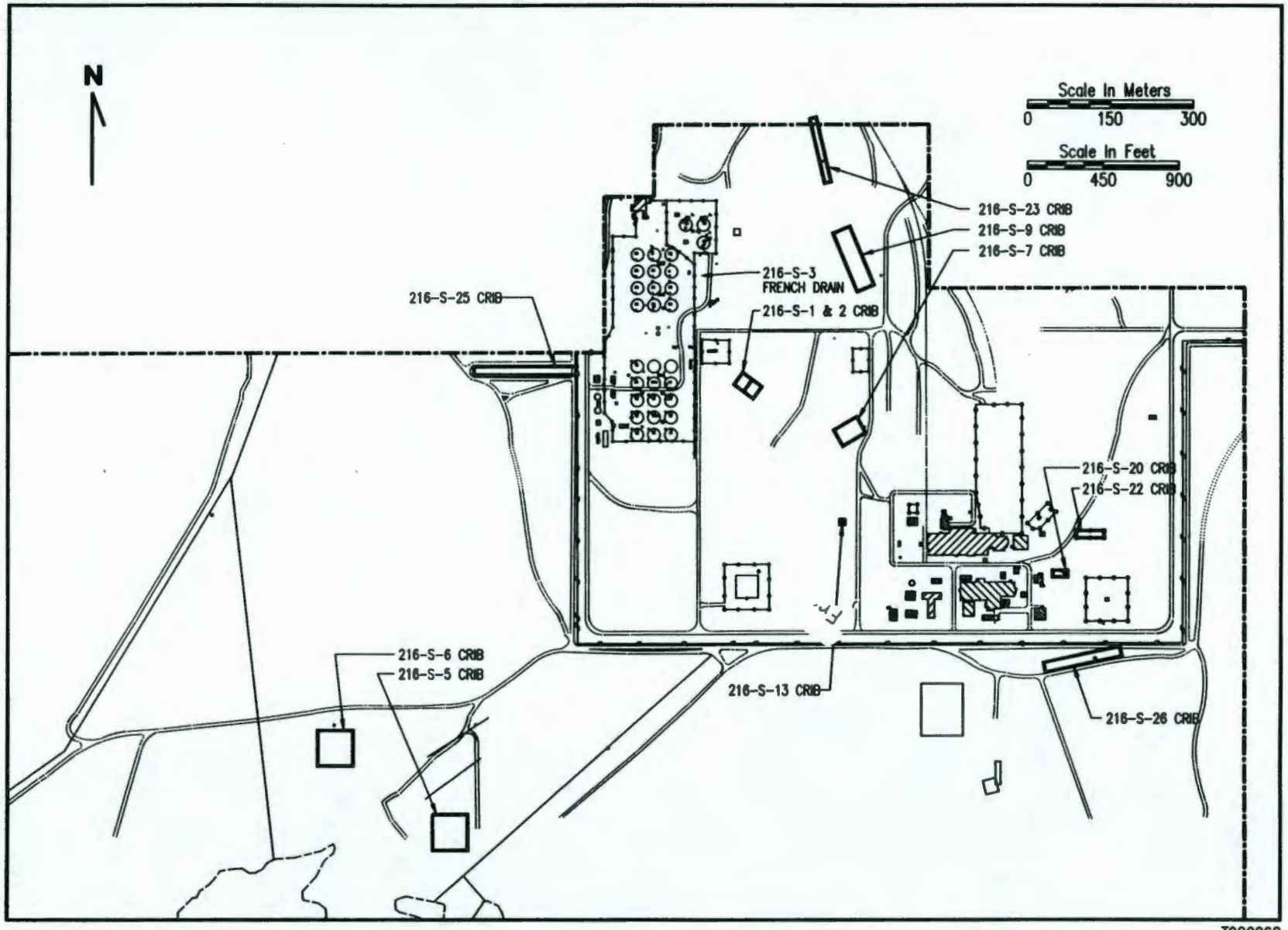
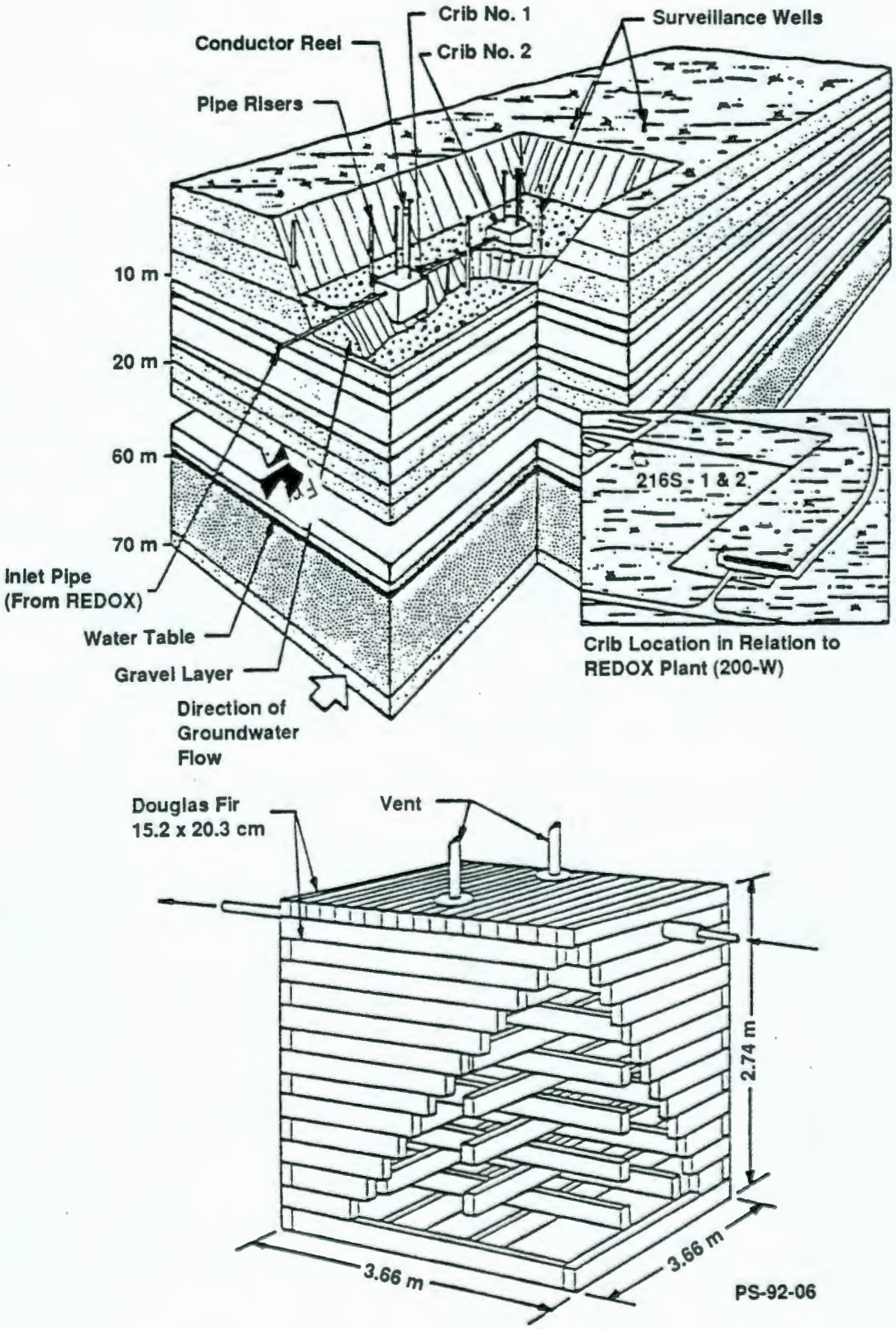


Figure 2-8. Location of Cribs and Drains.

Figure 2-9. Typical Crib.



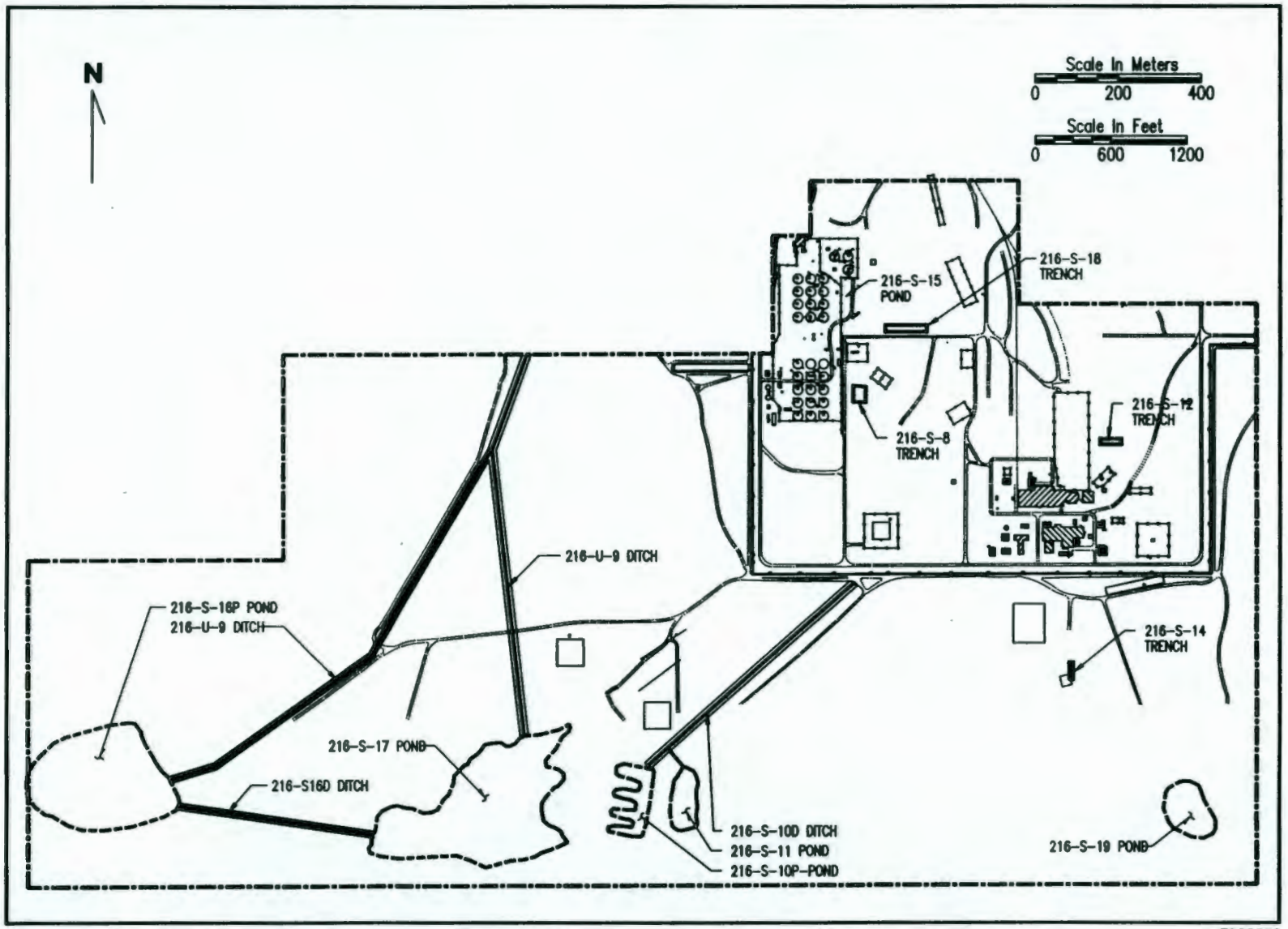
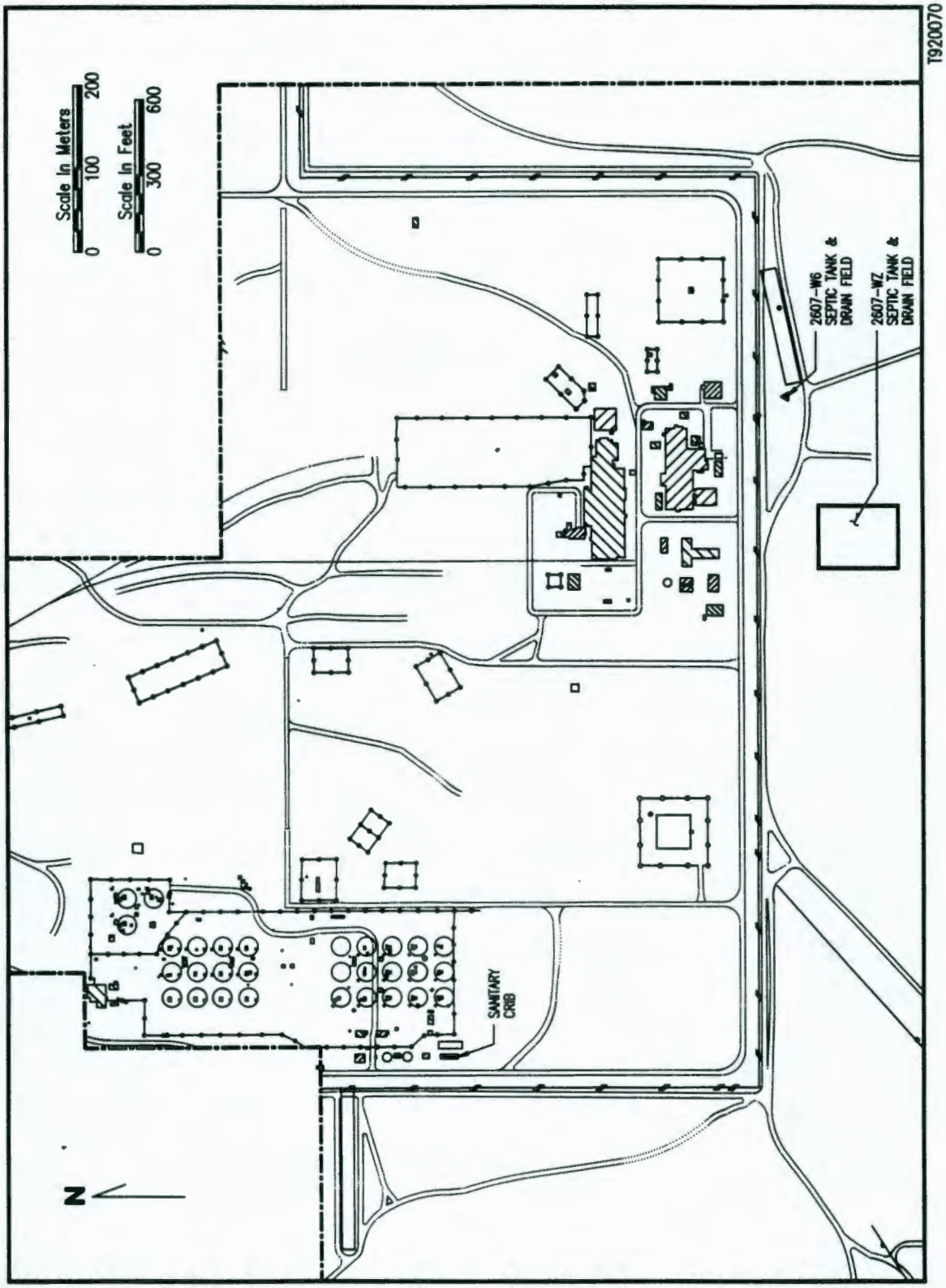


Figure 2-10. Location of Ponds, Ditches, and Trenches.

Figure 2-11. Location of Septic Tanks and Associated Drain Fields.



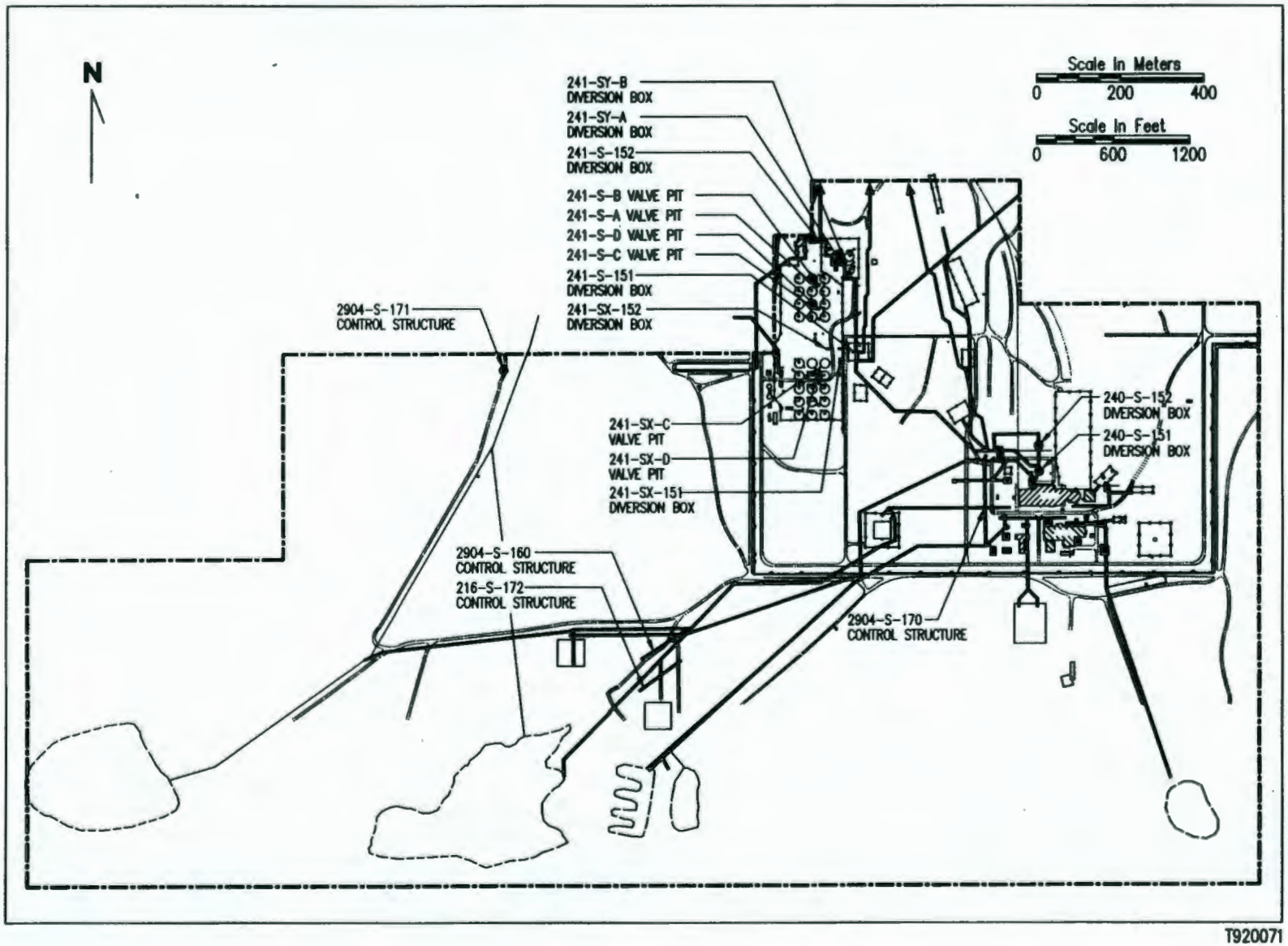


Figure 2-12. Location of Transfer Facilities, Diversion Boxes, and Pipelines.

Figure 2-13. Typical Control Structure.

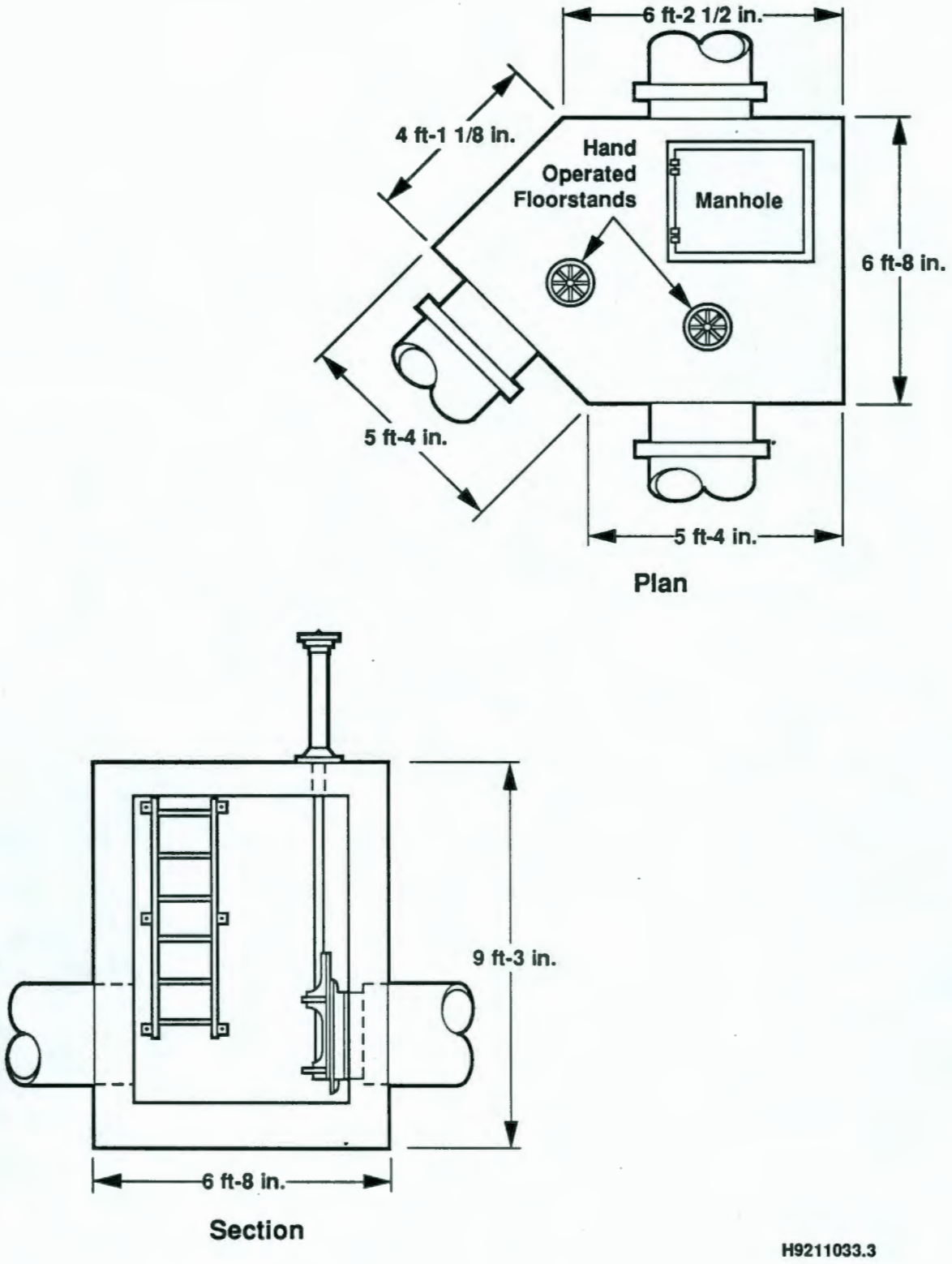


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Figure 2-14. Typical Diversion Box.

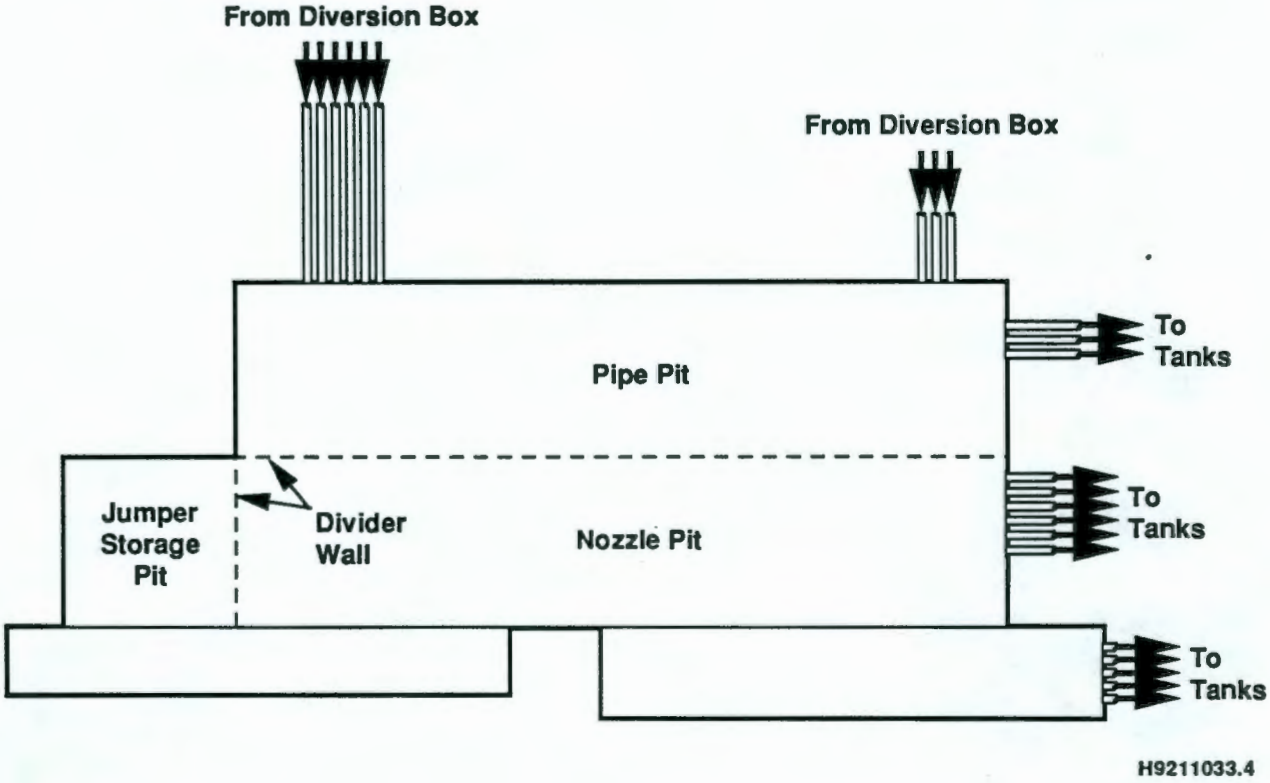

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Figure 2-15. Typical Valve Pit.

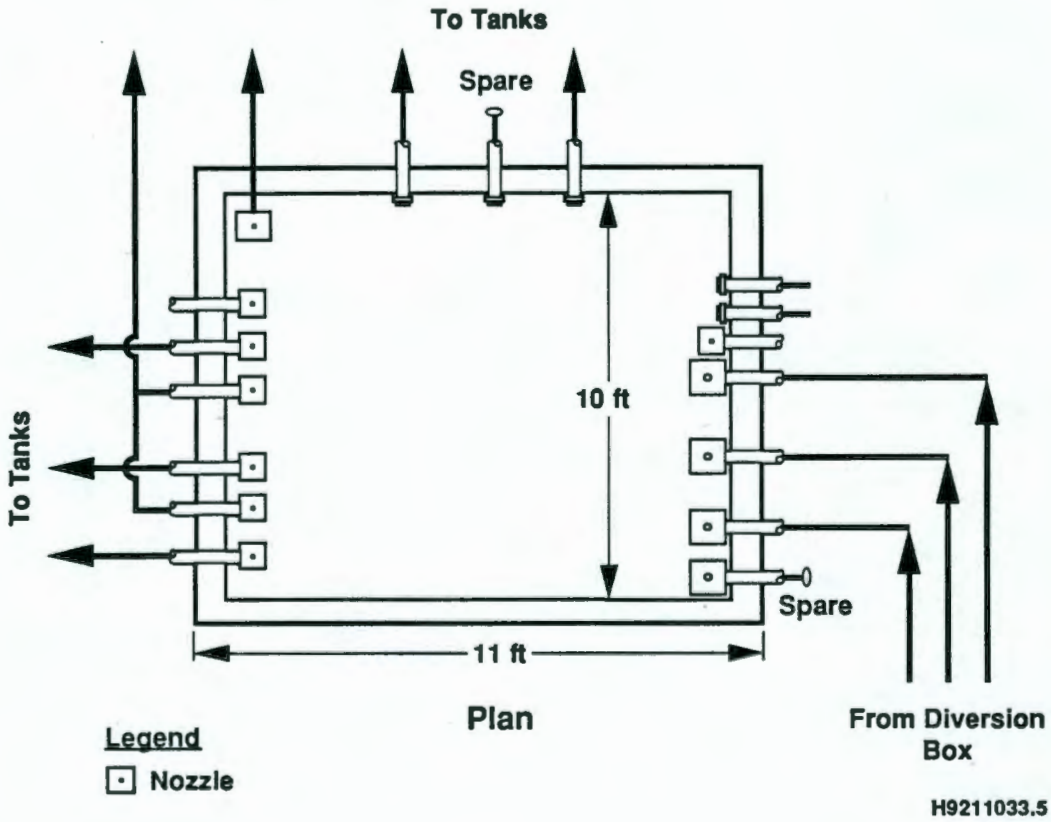

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Figure 2-16. Location of Basins.

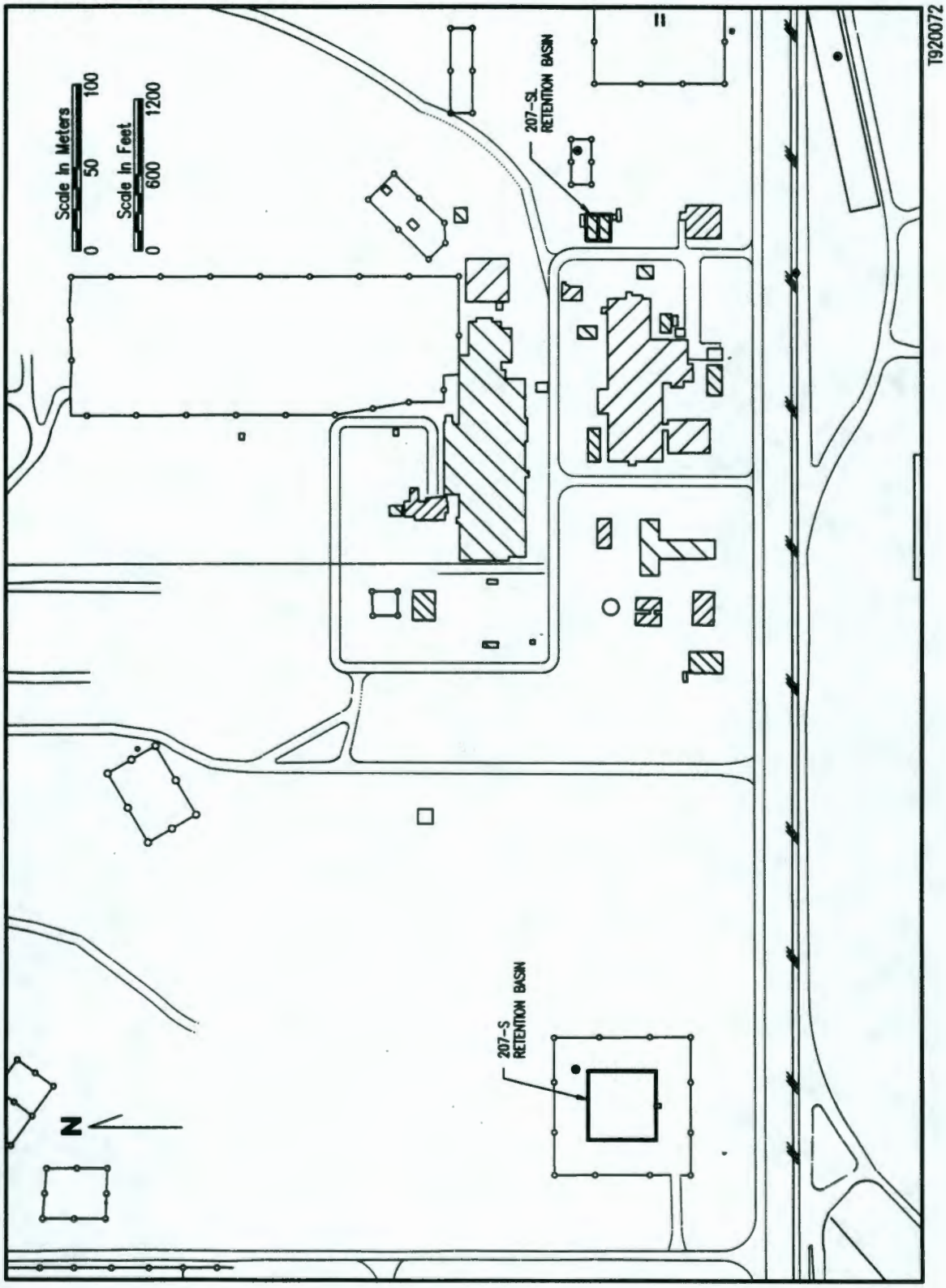

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Figure 2-17. Retention Basin 207-S.

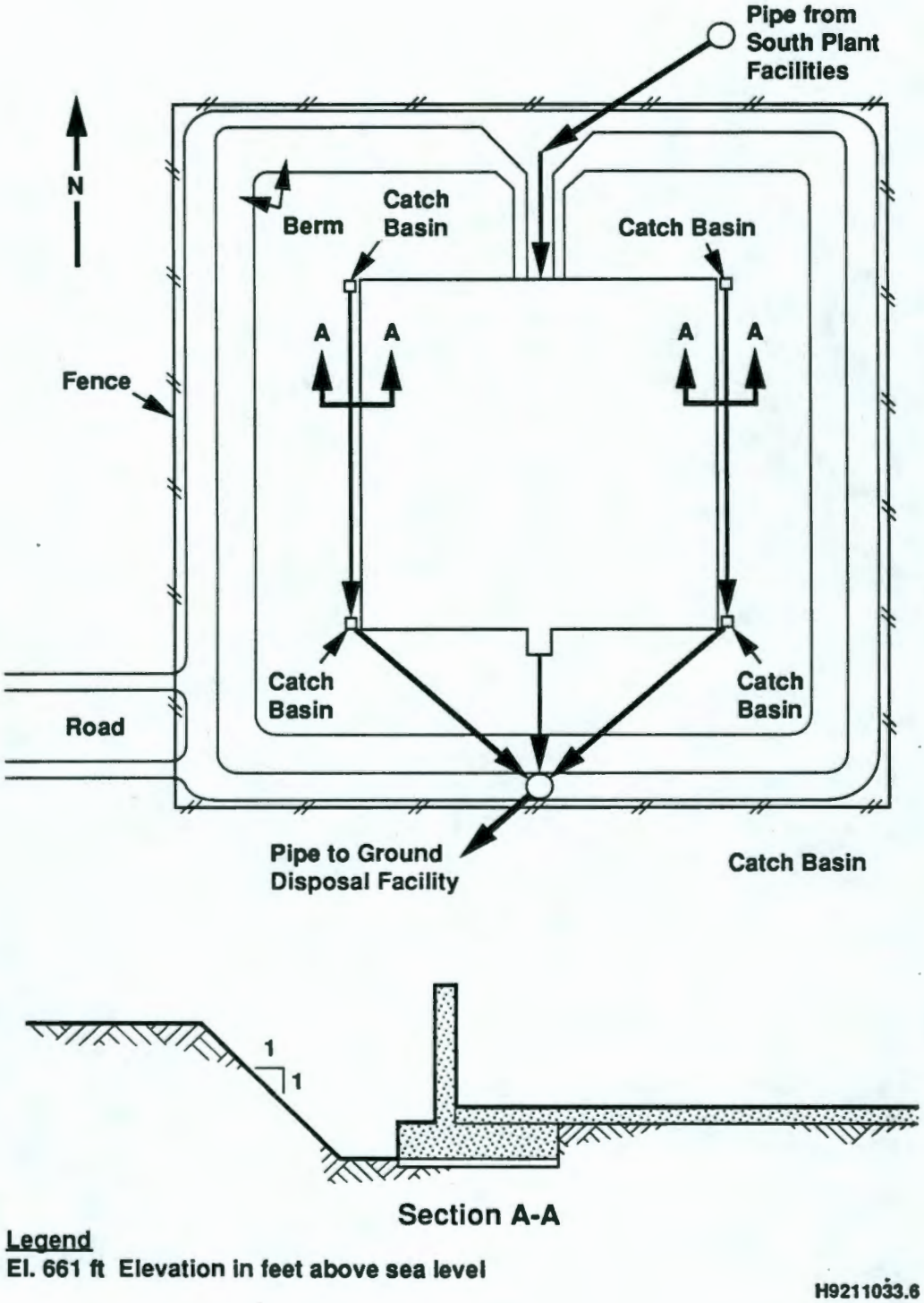

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Figure 2-18. Location of Burial Grounds.

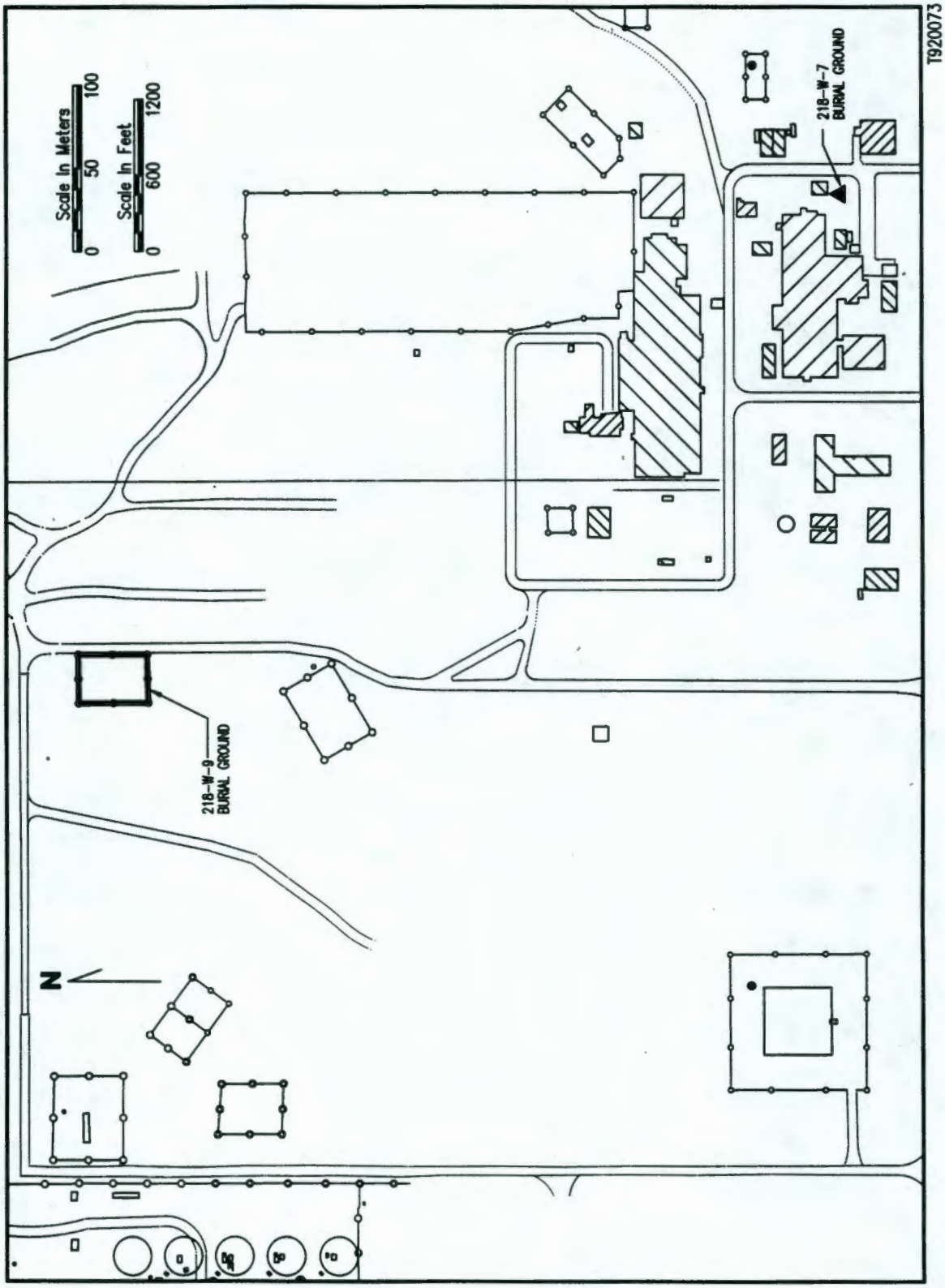

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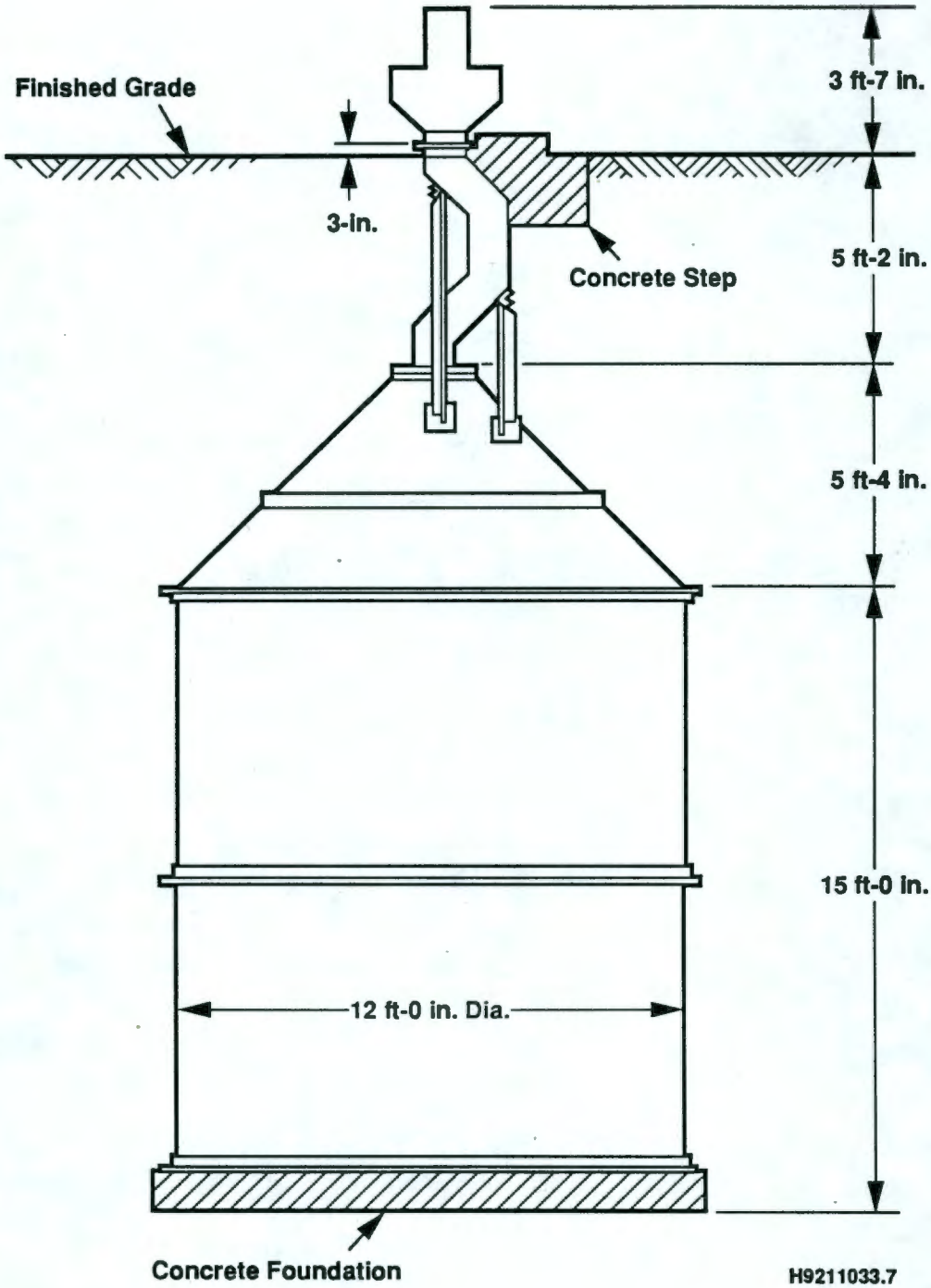
Figure 2-19. 218-W-7 Burial Ground.



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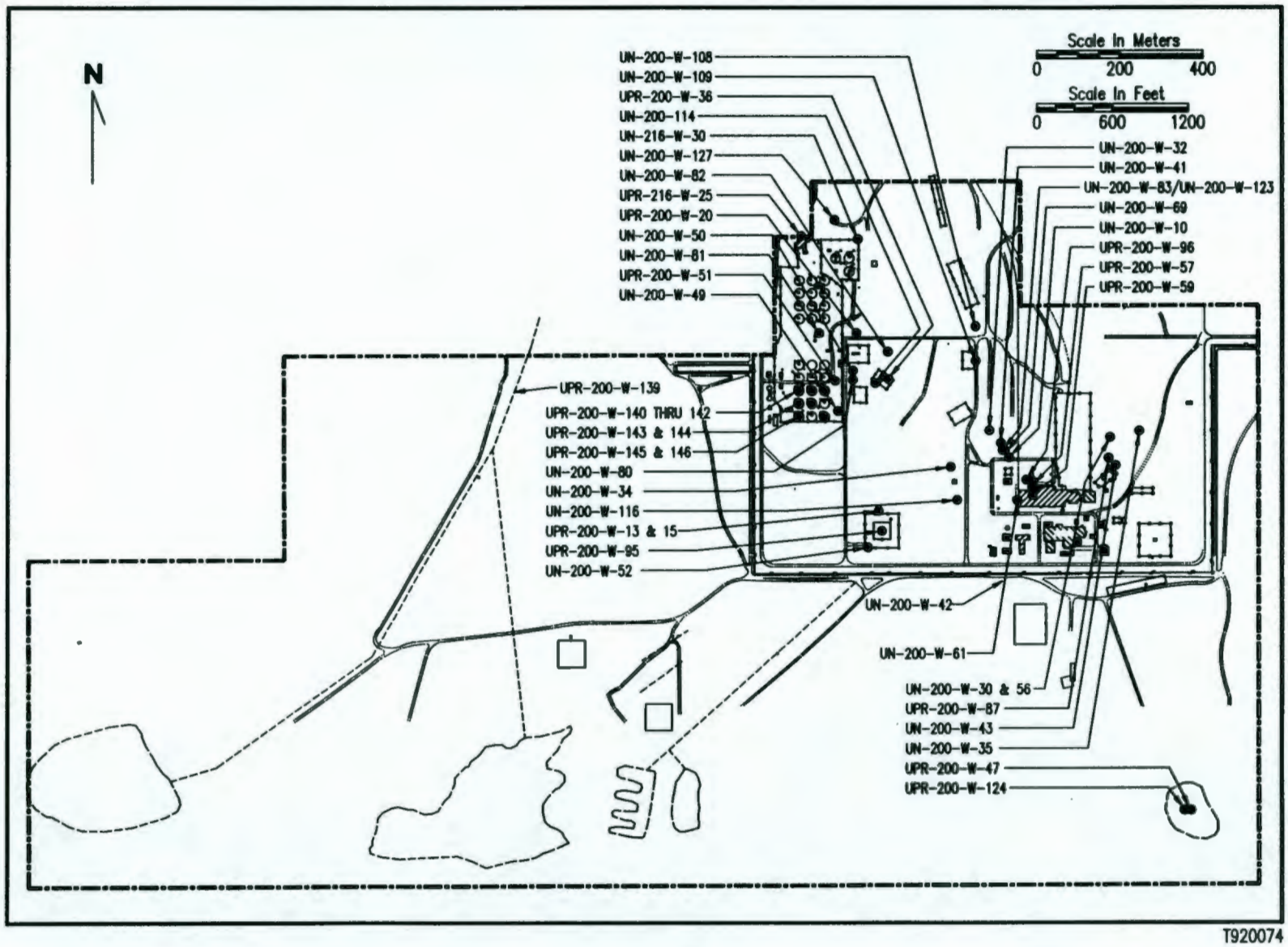

Figure 2-20. Location of Unplanned Releases.

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
Plants, Buildings, and Storage Areas				
241-SX-401 Building	Radioactively contaminated equipment and concrete/HLW	NA	NA	200-RO-4
241-SX-402 Building	Radioactively contaminated equipment and concrete/HLW	NA	NA	200-RO-4
242-S Evaporator	Single-shell tank supernate, phosphate waste, complexed radioactive waste/HLW	NA	NA	200-RO-4
291-S Fan and Filter Building	Exhaust air from the 202-S Process Building/LLW	NA	NA	200-RO-3
Tanks and Vaults				
241-S-101 Single-Shell Tank	REDOX high-level waste, coating waste, PNL waste, PUREX low-level waste, B Plant high-level waste, N reactor waste/HLW	1,616,200	NA	200-RO-4
241-S-102 Single-Shell Tank	REDOX high-level waste, HNO3/KMnO4 solution, double-shell slurry feed/HLW	2,078,000	NA	200-RO-4
241-S-103 Single-Shell Tank	REDOX high-level and coating waste, HNO3/KMnO4 solution, double-shell slurry feed/HLW	938,700	NA	200-RO-4
241-S-104 Single-Shell Tank	REDOX high-level waste, coating waste, supernatant from 241-S Tank Farm/HLW	1,112,800	NA	200-RO-4

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
241-S-105 Single-Shell Tank	REDOX high-level waste, coating waste/HLW	1,726,000	NA	200-RO-4
241-S-106 Single-Shell Tank	REDOX high-level waste/HLW	2,055,300	NA	200-RO-4
241-S-107 Single-Shell Tank	REDOX high-level waste, coating waste, B Plant high- and low-level waste, N Reactor waste, PUREX low-level waste/HLW	1,392,900	NA	200-RO-4
241-S-108 Single-Shell Tank	REDOX high-level waste/HLW	2,286,100	NA	200-RO-4
241-S-109 Single-Shell Tank	REDOX high-level waste/HLW	2,149,900	NA	200-RO-4
241-S-110 Single-Shell Tank	REDOX high-level waste, coating waste, 224-U waste, B Plant low-level waste/HLW	2,619,200	NA	200-RO-4
241-S-111 Single-Shell Tank	REDOX high-level waste/HLW	2,255,900	NA	200-RO-4
241-S-112 Single-Shell Tank	REDOX high-level waste/HLW	2,411,000	NA	200-RO-4
241-SX-101 Single-Shell Tank	REDOX high-level waste, complexed waste from 241-S, -BX, -SX, and -U Tank Farms/HLW	1,726,000	NA	200-RO-4

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
241-SX-102 Single-Shell Tank	REDOX high-level waste, carbonate waste, concrete, partial neutralization feed from 241-BX, -SX, -TX, and -S Tank Farms/HLW	2,055,300	NA	200-RO-4
241-SX-103 Single-Shell Tank	REDOX high-level waste, coating waste, concrete, partial neutralization feed from 241-BX, -SX, and -S Tank Farms/HLW	2,467,800	NA	200-RO-4
241-SX-104 Single-Shell Tank	REDOX high-level waste, supernatant containing REDOX ion exchange waste, double-shell slurry feed/HLW	2,324,000	NA	200-RO-4
241-SX-105 Single-Shell Tank	REDOX high-level waste, ion exchange waste, double-shell slurry feed/HLW	2,585,200	NA	200-RO-4
241-SX-106 Single-Shell Tank	Hanford Laboratory waste, PNL waste, HNO3/KMnO4 solution, B Plant low-level waste, coating waste/HLW	2,036,300	NA	200-RO-4
241-SX-107 Single-Shell Tank	REDOX high-level waste, coating waste, concrete, 41 small bottles of neutralized waste (100-F), each containing less than 1 g Pu-239/HLW	393,600	NA	200-RO-4
241-SX-108 Single-Shell Tank	REDOX high-level waste, concrete/HLW	435,300	NA	200-RO-4
241-SX-109 Single-Shell Tank	REDOX high-level waste/HLW	946,300	NA	200-RO-4

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
241-SX-110 Single-Shell Tank	REDOX high-level waste, concrete, PNL waste, B Plant low-level waste, ion exchange waste 224-U waste from 241-B, -BX, and -SX Tank Farms/HLW	234,700	NA	200-RO-4
241-SX-111 Single-Shell Tank	REDOX high-level waste/HLW	473,100	NA	200-RO-4
241-SX-112 Single-Shell Tank	REDOX high-level waste/HLW	348,200	NA	200-RO-4
241-SX-113 Single-Shell Tank	REDOX high-level waste, diatomaceous earth added in 1962/HLW	98,400	NA	200-RO-4
241-SX-114 Single-Shell Tank	REDOX high-level waste, REDOX ion exchange waste/HLW	685,100	NA	200-RO-4
241-SX-115 Single-Shell Tank	REDOX high-level waste/HLW	45,400	NA	200-RO-4
241-SY-101 Double-Shell Tank	Supernate containing double-shell slurry and complexed waste/HLW	4,126,000	NA	200-RO-4
241-SY-102 Double-Shell Tank	$HNO_3/KMnD_4$ solution and supernatant containing partial neutralization feed and non-complexed wastes/HLW	2,426,000	NA	200-RO-4
241-SY-103 Double-Shell Tank	Supernate containing complexed waste and double-shell slurry/HLW	2,835,000	NA	200-RO-4
240-S-302 Catch Tank	Waste solutions from processing and decontamination operations/HLW	9,000	NA	200-RO-3

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
241-S-302A Catch Tank	Waste solutions from processing and decontamination operations/HLW	200	NA	200-RO-2
241-S-302B Catch Tank	Waste solutions from processing and decontamination operations/HLW	12,300	NA	200-RO-4
241-SX-302 Catch Tank	Waste solutions from processing and decontamination operations/HLW	NR	NA	200-RO-2
244-S Receiver Tank	Waste solutions from processing and decontamination operations/HLW	41,465	NA	200-RO-2
Cribs and Drains				
216-S-1 & 2 Crib	Cell drainage from D-1 Receiver Tank and redistilled condensate from D-2 Receiver Tank in 202-S Building/TRU	160,000,000	1,700	200-RO-2
216-S-5 Crib	202-S process vessel cooling water and steam condensate/LLW	4,100,000,000	13,000	200-RO-1
216-S-6 Crib	202-S process vessel cooling water and steam condensate/LLW	4,470,000,000	13,000	200-RO-1
216-S-7 Crib	Cell drainage and condensate from 202-S Building/LLW	390,000,000	1,100	200-RO-2
216-S-9 Crib	Process condensate from 202-S Building/LLW	50,300,000	1,800	200-RO-2
216-S-13 Crib	Various liquid wastes from 203-S, 204-S, and 276-S/LLW	5,000,000	770	200-RO-2

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
216-S-20 Crib	Laboratory wastes from 222-S Building/LLW	135,000,000	1,500	200-RO-3
216-S-22 Crib	Mixed liquid waste from the acid recovery facility in 293-S Building/LLW	98,400	170	200-RO-3
216-S-23 Crib	REDOX process condensate from 202-S Building/LLW	34,100,000	310	200-RO-2
216-S-25 Crib	245-S Evaporator process steam condensate, 241-SX Tank Farm cooling water/LLW	300,000,000	1,100	200-RO-1
216-S-26 Crib	Steam condensate and sink waste from 222-S Laboratory/LLW	164,000,000	NR	200-RO-3
216-S-3 French Drain	Condensate from condensers on 241-S-101 and 241-S-104 Single-Shell Tanks/LLW	4,200,000	36	200-RO-2
Ponds, Ditches, and Trenches				
216-S-10P Pond	202-S Chemical Sewer waste, bearing cooling water, and overflow from the high water tower/LLW	4,120,000,000	7,100	200-RO-1
216-S-11 Pond	Various wastes from 202-S Building/LLW	2,230,000,000	2,100	200-RO-1
216-S-15 Pond	Condenser spray cooling water from 241-S-110 Single-Shell Tank/LLW	10,000	NR	200-RO-2
216-S-16P Pond	Various wastes from 202-S Building/LLW	40,700,000,000	43,000	200-RO-1

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
216-S-17 Pond	Various wastes from 202-S Building and overflow from 216-U-10 Pond/LLW	6,440,000,000	24,000	200-RO-1
216-S-19 Pond	Laboratory waste from 222-S Building/LLW	1,330,000,000	5,000	200-RO-1
216-S-10D Ditch	202-S Chemical Sewer waste and overflow from the high water tower/LLW	4,340,000,000	2,200	200-RO-1
216-S-16D Ditch	Various wastes from 202-S Building/LLW	407,000,000	2,000	200-RO-1
216-U-9 Ditch	Overflow from 216-U-10 Pond/LLW	NR	2,800	200-RO-1
216-S-8 Trench	Unirradiated start-up waste from 202-S Building/LLW	10,000,000	600	200-RO-2
216-S-12 Trench	Flush water form 291-S Stack/LLW	68,100	66	200-RO-3
216-S-14 Trench	Contaminated MIBK from initial test runs in 202-S Building/LLW	NR	NR	200-RO-3
216-S-18 Trench	Vehicle decontamination waste/LLW	NR	NR	200-RO-2
Septic Tanks and Associated Drain Fields				
2607-W6 Septic Tank & Drain Field	Sanitary wastewater and sewage/NRH	34,800/day	NA	200-RO-3
2607-WZ Septic Tank & Drain Field	Sanitary wastewater and sewage/NRH	22,600/day	NA	200-RO-1

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
Sanitary Crib	Sanitary wastewater from 241-SX-701 Compressor House/NRH	22,600/day	NR	200-RO-4
Transfer Facilities, Diversion Boxes, and Pipelines				
240-S-151 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-3
240-S-152 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-3
241-S-151 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-2
241-S-152 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SX-151 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SX-152 Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SY-A Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SY-B Diversion Box	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-S-A Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
241-S-B Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-S-C Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-S-D Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SX-A Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
241-SX-B Valve Pit	Waste solutions from processing and decontamination operations/HLW	NA	NA	200-RO-4
216-S-172 Control Structure	Diverted 202-S process vessel cooling water and steam condensate to 216-S-16 Ditch/LLW	NA	NA	200-RO-1
2904-S-160 Control Structure	Diverted process cooling water and steam condensate from 202-S Building/LLW	NA	NA	200-RO-1
2904-S-170 Control Structure	Process waste flow from S Plant/LLW	NA	NA	200-RO-1
2904-S-171 Control Structure	Process waste being routed to 216-S-6 Crib/LLW	NA	NA	200-RO-1
Basins				
207-S Retention Basin	202-S process cooling water and steam condensate/LLW	NA	NA	200-RO-2

Table 2-1. Summary of Waste Management Units.[a]

Waste Management Unit	Source Description/Type	Waste Volume Received (L)[b]	Contaminated Soil Volume (m^3)	Operable Unit
207-SL Retention Basin	222-S Laboratory wastes/LLW	NA	NA	200-RO-3
Burial Sites				
218-W-7 Burial Ground	Dry, packaged laboratory and sampler waste from 222-S Laboratory/LLW	159 M^3	4	200-RO-3
218-W-9 Burial Ground	Metal scrap, including the 241-S-211 Tank from S Plant/LLW	486 M^3	4,025	200-RO-2

[a] Data taken from WHC 1991a
[b] Waste volume remaining (Hanlon 1992)
NA - Not applicable
NR - No value reported
Waste Type: HLW - high-level waste
TRU - transuranic waste
LLW - low-level waste
NRH - non-radiological, non-hazardous waste

Table 2-2. Radionuclide Waste Inventory Summary.

Waste Management Unit Number	Quantity of Reported Radionuclides (Ci)[a]									
	Sr-90	Cs-137	Pu Total[b]	Pu-239	Ru-106	Total U	Am-241	H-3	Alpha	Beta
Tanks and Vaults										
240-S-302	–	–	–	–	–	–	–	–	–	–
241-S-302A	–	–	–	–	–	–	–	–	–	–
241-S-302B	–	–	–	–	–	–	–	–	–	–
241-SX-302	–	–	–	–	–	–	–	–	–	–
244-S Receiver Tank	–	–	–	–	–	–	–	–	–	–
Cribs and Drains										
216-S-1 & 2	1,250	1,100	1,200	–	0.0000000619	0.756	–	–	73.7	4,750
216-S-5	54.1	26.4	580	–	0.000000000714	0.0907	–	–	35.6	159
216-S-6	204	115	473	–	0.00000589	0.0906	–	–	29	630
216-S-7	1,390	703	440	–	0.0000013	0.862	–	–	27	4,180
216-S-9	96.3	290	65	–	0.000287	0.0113	–	–	3.99	753
216-S-13	0.0204	2.77	8	–	0.00000236	0.0303	–	–	0.491	5.5
216-S-20	22.7	56.5	171	–	0.000000249	0.0125	–	–	10.5	156
216-S-22	0.455	0.478	0.101	–	0.00000000141	0.000015	–	–	0.0062	1.83
216-S-23	1.14	3.47	0.994	–	0.0000349	0.000129	–	–	0.0611	9.07
216-S-25	0.041	0.0647	0.0466	–	0.000016	0.0555	–	148	0.012	0.247
216-S-26	0.00183	0.00309	–	0.000172	–	–	0.00058	–	0.000763	0.01
216-S-3	0.414	21.9	0.5	–	0.00000000109	0.000127	–	–	0.0307	43

Table 2-2. Radionuclide Waste Inventory Summary.

Waste Management Unit Number	Quantity of Reported Radionuclides (Ci)[a]									
	Sr-90	Cs-137	Pu Total[b]	Pu-239	Ru-106	Total U	Am-241	H-3	Alpha	Beta
Ponds, Ditches, and Trenches										
216-S-10P	–	–	–	–	–	–	–	–	–	–
216-S-11	0.814	0.82	0.31	–	0.292	0.00685	–	–	0.00553	1.94
216-S-15	–	–	–	–	–	–	–	–	–	–
216-S-16P	45.1	30	–	–	0.00000447	1.05	–	–	22.6	148
216-S-17	15.9	12.7	3	–	0.000000000312	0.0453	–	–	0.184	56.3
216-S-19	1.3	1.29	20.6	–	0.000000389	0.0518	–	0.187	1.26	5.12
216-S-8	0.386	4.92	2	–	0.00000000013	0.065	–	–	0.123	10.5
216-S-18	–	–	–	–	–	–	–	–	–	–
216-S-12	0.41	0.434	1	–	0.0000000000138	0.00166	–	–	0.0614	1.66
216-S-14	–	–	–	–	–	–	–	–	–	–
216-S-10D	1.07	1.24	0.1	0.00468	0.346	0.0671	0.0152	–	0.0244	3.51
216-S-16D	–	–	–	–	–	–	–	–	–	–
216-U-9	–	–	–	–	–	–	–	–	–	–
Septic Tanks and Associated Drain Fields										
2607-WZ	–	–	–	–	–	–	–	–	–	–
2607-W6	–	–	–	–	–	–	–	–	–	–
Sanitary Crib	–	–	–	–	–	–	–	–	–	–
Transfer Facilities, Diversion Boxes, and Pipelines										
240-S-151	–	–	–	–	–	–	–	–	–	–
240-S-152	–	–	–	–	–	–	–	–	–	–
241-S-151	–	–	–	–	–	–	–	–	–	–
241-S-152	–	–	–	–	–	–	–	–	–	–

Table 2-2. Radionuclide Waste Inventory Summary.

Waste Management Unit Number	Quantity of Reported Radionuclides (Ci)[a]									
	Sr-90	Cs-137	Pu Total[b]	Pu-239	Ru-106	Total U	Am-241	H-3	Alpha	Beta
241-SX-151	–	–	–	–	–	–	–	–	–	–
241-SX-152	–	–	–	–	–	–	–	–	–	–
241-SX-A	–	–	–	–	–	–	–	–	–	–
241-SX-B	–	–	–	–	–	–	–	–	–	–
241-SY-A	–	–	–	–	–	–	–	–	–	–
241-SY-B	–	–	–	–	–	–	–	–	–	–
241-SY-A	–	–	–	–	–	–	–	–	–	–
241-SY-B	–	–	–	–	–	–	–	–	–	–
216-S-172	–	–	–	–	–	–	–	–	–	–
2904-S-160	–	–	–	–	–	–	–	–	–	–
2904-S-170	–	–	–	–	–	–	–	–	–	–
2904-S-171	–	–	–	–	–	–	–	–	–	–
241-S-A	–	–	–	–	–	–	–	–	–	–
241-S-B	–	–	–	–	–	–	–	–	–	–
241-S-C	–	–	–	–	–	–	–	–	–	–
241-S-D	–	–	–	–	–	–	–	–	–	–
Basins										
207-S	–	–	–	–	–	–	–	–	–	–
207-SL	–	–	–	–	–	–	–	–	–	–

Table 2-2. Radionuclide Waste Inventory Summary.

Waste Management Unit Number	Quantity of Reported Radionuclides (Ci)[a]									
	Sr-90	Cs-137	Pu Total[b]	Pu-239	Ru-106	Total U	Am-241	H-3	Alpha	Beta
Burial Sites										
218-W-7[c]	34.84	39.24	0.7	–	0.00000002295	700[b]	–	–	–	–
218-W-9[c]	0.000815	0.000921	–	–	5.766000000e-14	–	–	–	–	–

[a] Values are decayed through December 31, 1989 unless otherwise noted.
[b] Values are reported in grams.
[c] Values are decayed through December 31, 1990.
Dashes indicate data are not available.

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

Waste Management Unit Number	Quantity of Reported Chemicals (kg)[a]								
	Nitrate	Nitric Acid	Sodium	Sodium Alumi-nate	Sodium Dichro-mate	Sodium Hydrox-ide	Ammo-nium Nitrate	Alum-inum Nitrate	MIBK
Tanks and Vaults									
240-S-302	–	–	–	–	–	–	–	–	–
241-S-302A	–	–	–	–	–	–	–	–	–
241-S-302B	–	–	–	–	–	–	–	–	–
241-SX-302	–	–	–	–	–	–	–	–	–
244-S	–	–	–	–	–	–	–	–	–
Cribs and Drains									
216-S-1 & 2	60,000	100,000	10,000	–	–	–	–	60,000	–
216-S-5	100	–	–	–	–	–	–	–	–
216-S-6	140	–	–	–	–	–	–	–	–
216-S-7	110,000	250,000	7,000	–	–	–	–	40,000	–
216-S-9	–	30,000	–	–	–	–	–	–	–
216-S-13	10,000	–	1,000	–	10,000	–	–	10,000	10,000
216-S-20	20,000	–	–	–	–	–	–	–	–
216-S-22	7,000	–	3,000	–	–	–	–	–	–
216-S-23	–	300	–	–	–	–	–	–	–
216-S-25	1	–	–	–	–	–	–	–	–
216-S-26	30	–	–	–	–	–	–	–	–
216-S-3	9	–	5	3	2	2	–	–	–
Ponds, Ditches, and Trenches									
216-S-10P	–	–	–	–	–	–	–	–	–
216-S-11	–	–	–	–	–	–	–	–	–
216-S-15	1	–	–	–	–	–	–	10,000	10,000
216-S-16P	–	–	–	–	–	–	–	–	–
216-S-17	140	–	–	–	–	–	–	–	–
216-S-19	–	–	–	–	–	–	–	–	–
216-S-8	100	–	–	–	–	–	–	–	–
216-S-18	–	–	–	–	–	–	–	–	–
216-S-12	–	–	–	–	–	–	600	–	–
216-S-14	–	–	–	–	–	–	–	–	–
216-S-10D	–	–	–	–	–	–	–	–	–
216-S-16D	10	–	–	–	–	–	–	–	–
216-U-9	–	–	–	–	–	–	–	–	–

Table 2-3. Chemical Waste Inventory Summary.

Waste Management Unit Number	Quantity of Reported Chemicals (kg)[a]								
	Nitrate	Nitric Acid	Sodium	Sodium Alumi-nate	Sodium Dichro-mate	Sodium Hydrox-ide	Ammo-nium Nitrate	Alum-inum Nitrate	MIBK
Septic Tanks and Associated Drain Fields									
2607-WZ	–	–	–	–	–	–	–	–	–
2607-W6	–	–	–	–	–	–	–	–	–
Sanitary Crib	–	–	–	–	–	–	–	–	–
Transfer Facilities, Diversion Boxes, and Pipelines									
240-S-151	–	–	–	–	–	–	–	–	–
240-S-152	–	–	–	–	–	–	–	–	–
241-S-151	–	–	–	–	–	–	–	–	–
241-S-152	–	–	–	–	–	–	–	–	–
241-SX-151	–	–	–	–	–	–	–	–	–
241-SX-152	–	–	–	–	–	–	–	–	–
241-SX-A	–	–	–	–	–	–	–	–	–
241-SX-B	–	–	–	–	–	–	–	–	–
241-SY-A	–	–	–	–	–	–	–	–	–
241-SY-B	–	–	–	–	–	–	–	–	–
216-S-172	–	–	–	–	–	–	–	–	–
2904-S-160	–	–	–	–	–	–	–	–	–
2904-S-170	–	–	–	–	–	–	–	–	–
2904-S-171	–	–	–	–	–	–	–	–	–
241-S-A	–	–	–	–	–	–	–	–	–
241-S-B	–	–	–	–	–	–	–	–	–
241-S-C	–	–	–	–	–	–	–	–	–
241-S-D	–	–	–	–	–	–	–	–	–
Basins									
207-S	–	–	–	–	–	–	–	–	–
207-SL	–	–	–	–	–	–	–	–	–
Burial Sites									
218-W-7	–	–	–	–	–	–	–	–	–
218-W-9	–	–	–	–	–	–	–	–	–

[a] Not all sites have reported inventories. These inventories do not necessarily list all of the contaminants disposed of at a site.
Dashes indicate data are not available.

Table 2-4. Description of S Plant Aggregate Area Tank Farms.

Name	Type	Integrity	Interim Stabilized	Isolation	Total Waste Volume Remaining (L)	Drainable Waste Volume (L)
241-S Tank Farm						
241-S-101	single-shell	sound	no	PI	1,616,200	363,400
241-S-102	single-shell	sound	no	PI	2,078,000	870,600
241-S-103	single-shell	sound	no	PI	938,700	386,100
241-S-104	single-shell	assumed leaker	IS	II	1,112,800	109,800
241-S-105	single-shell	sound	IS	II	1,726,000	132,500
241-S-106	single-shell	sound	no	PI	2,055,300	700,200
241-S-107	single-shell	sound	no	PI	1,392,900	193,000
241-S-108	single-shell	sound	no	PI	2,286,100	480,700
241-S-109	single-shell	sound	no	PI	2,149,900	533,700
241-S-110	single-shell	sound	no	PI	2,619,200	416,400
241-S-111	single-shell	sound	no	PI	2,255,900	775,900
241-S-112	single-shell	sound	no	PI	2,411,000	507,200
241-SX Tank Farm						
241-SX-101	single-shell	sound	no	PI	1,726,000	552,600
241-SX-102	single-shell	sound	no	PI	2,055,300	692,700
241-SX-103	single-shell	sound	no	PI	2,467,800	881,900
241-SX-104	single-shell	assumed leaker	no	PI	2,324,000	760,800
241-SX-105	single-shell	sound	no	PI	2,585,200	987,900
241-SX-106	single-shell	sound	no	PI	2,036,300	965,200
241-SX-107	single-shell	assumed leaker	IS	II	393,600	18,900
241-SX-108	single-shell	assumed leaker	IS	II	435,300	22,700
241-SX-109	single-shell	assumed leaker	IS	II	946,300	37,900
241-SX-110	single-shell	assumed leaker	IS	II	234,700	0
241-SX-111	single-shell	assumed leaker	IS	II	473,100	26,500
241-SX-112	single-shell	assumed leaker	IS	II	348,200	11,400
241-SX-113	single-shell	assumed leaker	IS	II	98,400	0

9 3 1 2 8 6 9 0 8 2 3

Table 2-4. Description of S Plant Aggregate Area Tank Farms. Page 2 of 2

Name	Type	Integrity	Interim Stabilized	Isolation	Total Waste Volume Remaining (L)	Drainable Waste Volume (L)
241-SX-114	single-shell	assumed leaker	IS	II	685,100	53,000
241-SX-115	single-shell	assumed leaker	IS	II	45,400	0
241-SY Tank Farm						
241-SY-101	double-shell	sound	NA	NA	4,126,400	972,700
241-SY-102	double-shell	sound	NA	NA	2,426,200	2,157,500
241-SY-103	double-shell	sound	NA	NA	2,835,000	632,100

Notes: IS - interim stabilized
II - interim isolated
PI - partially interim isolated
na - not applicable
Source: Tank Farm Surveillance and Waste Status Summary Report for January 1992

9 3 1 2 8 6 9 0 8 2 4

Table 2-5. General Information Reference Locator. Page 1 of 2

Desired Single-Shell Tank Information	Reference Document
Watch List Tanks: Identification per Public Law 101-510, Section 3137, "Safety Measures for Waste Tanks at Hanford Nuclear Reservation." (Wyden Bill Amendment)	WHC-EP-0182, *Tank Farm Surveillance and Waste Status Summary Report*, Table 1
Definitions: Definitions include Interim Stabilized (IS), Partial Interim Isolated (PI), Interim Isolated (II), Tank Integrity (Sound or Assumed Leaker), Intrusion, Drywells, Laterals, Surface Levels, Automatic FIC, Liquid Observation Well (LOW), Thermocouple (TC), Sludge, and Salt Cake.	WHC-EP-0182, Appendix A
Tank Schematic: Quick reference for tank capacities and relative dimensions.	WHC-EP-0182, Figure B-1
Tank Information: Tank waste material, tank integrity ("sound" or "assumed leaker" stabilization/isolation status, total waste, supernatant waste, drainable interstitial, sludge volume, salt cake volume, last in-tank photo date.	WHC-EP-0182, Table C-5
Single-Shell Tank Leak Volume Estimates	WHC-EP-0182, Table H-1
Leak Detection Equipment: Type and description of leak detection devices for each tank, and detection criteria.	WHC-SD-WM-TI-357, *Waste Storage Tank Status and Leak Detection Criteria*
West Area Waste Storage Tank Criteria: Criteria is discussed by tank farm and includes leak detection drywells (type of probe used, radiation criteria, well location, well depths and monitoring frequency), surface level measurement (decrease/increase criteria, monitoring frequency).	WHC-SD-WM-TI-357, Section 6.0
Tank Farms Facility Interim Stabilization Evaluation: Provides the stabilization criteria for single-shell tanks and auxiliary tanks.	WHC-CM-5-7 Section 1.11

9 3 1 2 8 6 9 0 8 2 5

Table 2-5. General Information Reference Locator. Page 2 of 2

Desired Single-Shell Tank Information	Reference Document
Single-Shell Tank Operating Specifications: Information includes structural limitations (tank content composition, dome loading, waste temperatures, vapor space pressures), radiological containment requirements, cross-connection requirements, and leak detection control.	OSD-T-151-00013
Double-Shell Tank Farm Facility Safety Analysis Report: Site characteristic, facility design, process system.	WHC-SD-WM-SAR-016
Double-Shell Tank Operating Specifications:	Not Available. OSD-T-151-00007

9 3 1 2 8 6 9 0 8 2 6

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-10	Near the 203-S Uranium Storage Tanks	1952	NA	• An unknown source caused spotty uranium contamination. • Maximum readings of 10,000 ct/min at 2 cm (1 in.) were noted. • The contaminated area was covered with asphalt and posted with radiation zone signs.
UN-200-W-30	216-S-12 Trench	July 1954	216-S-12 Trench	• The contaminated area was limited to a pit near the northeast corner of the S Plant stack. The pit was covered with several feet of clean soil. • Contamination consisted predominantly of Ru and ZrNb with approximately 5 Ci of beta activity and 2 to 3 Ci of gamma activity. • This site is scheduled for deletion, as it is a duplicate of the 216-S-12 Trench.
UN-200-W-32	Near northwest corner of S Plant exclusion area	1954	NA	• A ruptured transfer line enroute to 224-U from S Plant spilled uranyl nitrate hexahydrate solution to the ground. • No analytical data provided on the level of contamination associated with this release. • The contaminated area was covered with clean soil, and the site removed from radiation zone status in February 1971.
UN-200-W-34	An acre between the open ditch and the 202-S Chemical Sewer Trenches	May 1955	NA	• Release involved overflow from an open ditch and the 202-S Chemical Sewer Trenches resulting in contamination of approximately 5,000 m^2 between the open ditch and the trenches. • Maximum exposure rate of 1 R/h was recorded. • The ditch was dredged and the sludge removed, placed in low spots on both sides of the ditch and covered with 0.6 m (2 ft) of soil. The area was removed from radiation zone status in March 1971.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-35	Outside and north of S Plant exclusion area	September 1955	NA	• Release from a leak in the uranyl nitrate hexahydrate process line from S Plant to U Plant. • Contamination was removed to the 200 West Area Burial Ground. The area was removed from radiation zone status in January 1972.
UN-200-W-41	Right-of-way from the 202-S railroad cut to the burial ground	July 7, 1956	NA	• Transport of a burial box caused ground contamination at the right-of-way from the 202-S railroad cut to the burial ground. • Unknown beta/gamma readings to 1,000 mrad/h were recorded. • Remedial actions not identified.
UN-200-W-42	Ground around a railroad shack near 202-S Building	February 3, 1957	NA	• Contaminated spots from an unknown source were found in the S Plant Aggregate Area near a railroad shack. • Contamination consisted of unknown beta/gamma readings to 500 mrad/h. • The site was cleaned to readings of 2,000 to 5,000 ct/min.
UN-200-W-43	Blacktop area near radiation zone east of 223-S	February 12, 1957	NA	• Site originated from wind blown contamination from a nearby radiation zone. Site is approximately 110 m^2 (1,200 ft^2) with 4,500 kg (5 tons) of contaminated soil. • Unknown alpha with readings to 2,000 dis/min. • Remedial actions not identified.
UN-200-W-49	241-SX Tank Farm, outside of southeast corner	July 31, 1958	241-SX Tank Farm	• Release from the 241-SX Tank Farm caused contamination of approximately 46 m^2 (500 ft^2) outside of the southeast corner of the tank farm. • Unknown beta/gamma readings up to 150 mrad/h were noted, with a single spot with readings up to 10 rad/h. • Remedial actions not identified.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-50	East 241-SX Tank Farm	August 25, 1958	241-SX-113 Single-Shell Tank	• A release from 241-SX Tank Farm resulted in the contamination of an area approximately 8,000 m^2 (2 acres) east of the tank farm. • Unknown beta/gamma readings of 40,000 ct/min with spots up to 100 mrad/h were noted. • Remedial actions not identified.
UN-200-W-52	South of the 241-S-151 Diversion Box toward 10th Street	September 15, 1958	207-S Retention Basin and 241-S-151 Diversion Box	• Leakage from the 241-S-151 Diversion Box caused ground contamination in an oval shaped area approximately 91 m (300 ft) wide, lying immediately south of the diversion box toward 10th Street, including the 207-S Retention Basin.
UN-200-W-56	Near the 202-S Column Carrier Trench	February 6, 1961	NA	• Heavy rainfall washed contamination from a radiation zone (216-S-12) and contaminated 19 m^2 (200 ft^2) of graveled surface, and 5 m^2 (50 ft^2) of blacktop. • Unknown beta/gamma readings of 30,000 ct/min on graveled surface and 80,000 ct/min on the blacktop were recorded. • The contaminated area was roped off.
UN-200-W-61	Near the southwest corner of the 202-S Building	April 24, 1966	NA	• A firehose ruptured while flushing the H-10 to the 241-SX transfer line, resulting in contamination of an area approximately 19 m^2 (200 ft^2) and containing 9,000 kg (10 tons) of soil. • Unknown beta/gamma readings from 4,000 to 100,000 ct/min were recorded. • Contaminated walkways were washed down and released from radiation zone status. The top 15 cm (6 in.) of contaminated soil were removed.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-69	Between the 204-S railroad spur and the S Plant railroad cut	March 2, 1973	NA	• Numerous spots of ground contamination of 2,000 to 50,000 ct/min with infrequent spots of 20 to 100 mrads/h were noted north and northeast from the 204-S Unloading Station and between the 204-S railroad spur and the S Plant railroad cut. • Inside established radiation zone, the sump pit was found contaminated from 1,000 to 5,000 mrads/h and the grating from the sump stacked nearby to 800 mrads/h. • Extension of survey outside the S Plant exclusion fence produced readings of 5,000 to 100,000 ct/min between 204-S railroad spur and the S Plant railroad cut embankment. • Remedial actions not identified.
UN-200-W-80	244-S Receiver Tank and areas adjacent to the 241-S and 241-SX Tank Farms	October 24, 1978	241-S Tank Farm 241-SX Tank Farm	• The 241-S and 241-SX Tank Farms contaminated the 244-S Receiver Tank construction site and other areas adjacent to the tank farms. • Radionuclides known to be present are ^{90}Sr and ^{137}Cs with readings to 60,000 ct/min. • Remedial actions not identified.
UN-200-W-81	Between the 241-S and 241-SX Tank Farms	January 2, 1979	241-S Tank Farm 241-SX Tank Farm	• Airborne migration of contamination from the 241-S and 241-SX Tank Farms. • Unknown beta/gamma with readings from 500 to over 100,000 ct/min were recorded. • The area was cleaned and released; however, upon detection of subsequent contamination the area was roped off and reposted as a radiation zone.
UN-200-W-82	Area near the 241-S-151 Diversion Box and the 241-S-302 Catch Tank	January 15, 1980	241-S-151 Diversion Box and 241-S-302 Catch Tank	• Traffic from daily routine surveillance deposited specks of contamination outside the radiation zone. • Unknown beta/gamma readings were noted with spots outside of the zone reading up to 80,000 ct/min. • The specks were picked up and removed to the burial ground.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-83	Vicinity of 204-S radiation zone	November 23, 1981	NA	• An unknown amount of radioactive contamination was spilled on the ground in the vicinity of the 204-S radiation zone.
UN-200-W-108	Underground crib waste line between 216-S-9 Crib and 216-S-23 Crib	January 8, 1969	NA	• Ruptures in the underground crib waste lines produced unknown beta/gamma with exposure rates 40 R/h detected at the bottom of the waste line. • Leakage occurred over an unknown time period releasing an unknown amount of waste. • Release was cleaned up by redirecting approximately 110 L (30 gal) of waste solution into a hole in the ground below the opening of the line and approximately 6 m (20 ft) below the ground surface. • Annual surface radiological monitoring is performed at this site; during the October 1990 survey no contamination was detected. This was a decrease from the previous survey.
UN-200-W-109	Underground crib waste line between 216-S-9 Crib and 216-S-23 Crib	January 24, 1969	NA	• Ruptures in underground crib waste lines resulted in waste water bubbling to the surface; radiation exposure rates of unknown beta/gamma were measured at 450 mR/h and decreased to 20 mR/h after the water sank back into the ground. • Annual surface radiological monitoring is performed at that site; during the October 1990 survey general contamination was detected from 200 to 6,000 ct/min, indicating no change in contamination from the previous survey. • Remedial actions not identified.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-200-W-114	Area east of 241-SX Tank Farm	September 1980	241-SX Tank Farm, 241-SX-151 Diversion Box, and the 241-SX-152 Diversion Box	• Annual surface contamination monitoring performed October 1990 in the vicinity of the 241-SX Tank Farm, 241-SX-151 Diversion Box, and the 241-SX-152 Diversion Box detected contamination from 200 to 450 ct/min with specks of contamination up to 4 mR/h. • Similar conditions were reported during surveys in September 1988 and 1989. • Cleanup operations have reduced but not eliminated particulate contamination.
UN-200-W-116	91 m (300 ft) north of the 202-S Building	1968	NA	• Site was contaminated with particulate matter spread by wind from the 204-S Waste Storage Tank exhaust and the related railroad tanker waste unloading station. • General contamination was measured at 200 ct/min with isolated specks up to 2 mrem/h during surface radiation monitoring in October 1990.
UN-200-W-123	204-S Unloading Facility Area	January 18, 1979	NA	• Release of 73,000 L (19,300 gal) of radioactive liquid waste occurred at the 204-S Unloading Facility area, caused by a frozen discharge line. • Contaminated ground beneath the tank car was cleaned up.
UN-200-W-127	East side of 242-S Building	February 26, 1980	NA	• A pool of liquid was found on the found at the east side of 242-S Building; high radiation levels were noted all around the building. • Spill area was covered with clean soil.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UN-216-W-25	Encasement containing transfer lines between the 242-S Evaporator and the 241-U Tank Farm	Unknown	242-S Evaporator	• Not an unplanned release, but has been given that designation; an encasement containing transfer lines between the 242-S Evaporator (inactive) to the 241-U Tank Farm is emitting radioactivity. • No release of radioactive material has occurred; current levels range from 2,000 to 40,000 dis/min beta. • A series of 24 clean-out boxed are regularly surveyed for radiation.
UN-216-W-30	Northeast of the 241-SY Tank Farm including 216-S-23 Crib	1985	241-SY Tank Farm	• Release of unknown origin and type resulted in contamination of a site extending 900 ft to the northeast of the 241-SY Tank Farm and spreading 250 ft. wide. • Current levels of radioactivity are 3,500 dis/min beta, less than 0.5 mrem/h. • Site crosses the northern portion of the 216-S-23 Crib; it is heavily vegetated and shows no sign of stabilization.
UPR-200-W-96	Adjacent to and north of the 233-S Filter House	January 9, 1969	NA	• Release consisted of 0.01 g of Pu-239 contaminated water. Smear samples taken of the water and surfaces involved were as follows: water on the floor of the 233-S Filter House was greater than 40,000 dis/min; the concrete pad outside the filter building was 10,000 dis/min; the electric motor pad was 10,000 dis/min; and the water in the overflow pool was 600 dis/min. • The site was covered with 71 m (234 ft) of clean gravel. • The October 1991 radiological survey detected contamination of 200 to 3,000 ct/min at the northwest corner of the site.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UPR-200-W-47	Approximately 137 m (150 yd) to the west of the 216-S-16P Pond	June 1958	216-S-16P	• Dike break resulted in soil contamination that spread approximately 137 m (150 yd) to the west of the S Plant Pond dike and extended 274 m (300 yd) from north to south. • Readings to a maximum of 750 mR/h were observed. • Contaminated ground was bladed under during a remediation effort in 1959.
UPR-200-W-57	233-S Building	November 6, 1963	233-S Building	• A fire in the plutonium column at the 233-S Building spread plutonium contamination throughout and in the immediate vicinity of the building. • Parts of the building were cleaned of gross contamination and nonflammable alpha contamination was remediated.
UPR-200-W-59	No. 1 Pond at 202-S Building	September 26, 1965	202-S Building	• Failure of an F-1 process vessel coil in the 202-S Building allowed effluent to mix with the cooling water. • Unknown beta/gamma readings with a maximum dose rate of 190 mrad/h at the No. 1 Pond inlet. • Remedial actions not identified.
UPR-200-W-87	291-S HEPA filter housing	January 28, 1992	291-S Stack Complex	• Water leak from the 291-S HEPA filter housing contaminated the ground at its base. • Readings to 2,000 ct/min were recorded. • Contaminated soil was removed.
UPR-200-W-124	216-S-19 Pond	Unknown	216-S-19 Pond	• Dike break caused contamination over an area 9 m (30 ft) wide and extending approximately 305 m (1,000 ft) southwest of the 216-S-19 Pond dike. • No monitoring data reported this release. • Remedial actions not identified.
UPR-200-W-139	216-U-9 Ditch	September 1953	216-U-9 Ditch	• Contamination from an unknown source was detected at the 216-U-9 Ditch. • No radiation readings or analytical data reported. • Site was covered in the Spring of 1954.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UPR-200-W-13	207-S Retention Basin and swamp area outside 200 West Area	December 23, 1952	207-S Retention Basin	• Release may have been related to the failure of the H-4 oxidizer coil at the 202-S Building. • Unknown beta/gamma readings with a dose rate that increased from 6 mrem/h to 700 mrem/h over a 3-day period. • Remedial actions not identified.
UPR-200-W-15	207-S Retention Basin and swamp area outside 200 West Area	November 1952	207-S Retention Basin	• Release resulted from the failure of a steam coil in the 202-S Building D-12 Waste Concentrator. • Unknown beta/gamma activity with dose rates up to 2 rem/h. Contamination was measured at 35 mrem/h 1 in. from the ground. • The swamp was diked to maintain a constant water level.
UPR-200-W-20	Area near 241-S-151 Diversion Box and 241-SX Tank Farm	January through February 1953	241-S-151 Diversion Box	• Release occurred as a result of leakage from the 241-S-151 Diversion Box, contaminating a 92 m^2 (1,000 ft^2) area near the 241-SX Tank Farm. • Reported readings indicated unknown beta/gamma contamination. • Contamination was covered with 92 m^2 (1,000 ft^2) of gravel. The site was removed from radiation zone status in January 1971.
UPR-200-W-36	216-S-1 and -2 Crib area	August 4, 1995	216-S-1 and -2 Cribs	• A ruptured test well caused a release from the 216-S-1 and -2 Cribs. • No data concerning contamination detailed. • Remedial actions not identified.
UPR-200-W-51	South of 241-S-151 Diversion Box	September 12, 1958	241-S-151 Diversion Box	• Leakage from the 241-S-151 Diversion Box contaminated a narrow strip of ground south of the diversion box. • Unknown beta/gamma readings up to 50 mrad/h were taken within 30 m (100 ft) of the diversion box and readings outside the fenced area were recorded at approximately 4,000 ct/min. • Contaminated soil was saturated with water and turned over with a bulldozer.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UPR 200-W-95	207-S Retention Basin	Late 1952 until April 1954	207-S Retention Basin	• A number of process coil leaks from the 202-S Building caused the 207-S Retention Basin to become contaminated. • The site has been interpreted as low-activity containing approximately 10 Ci of mixed fission products. • No monitoring data provided. • The gross amounts of radioactivity remaining on the concrete floors and walls of this site were covered by an overfill of soil.
UPR-200-W-140	241-SX-107 Single-Shell Tank	1964	241-SX-107 Single-Shell Tank	• Spill of 19,000 L (5,000 gal) from the 241-SX-107 Single-Shell Tank resulted in the lateral spread of contamination 17 to 18 m (55 to 60 ft) below ground surface. • Tank is currently inactive and was removed from service in 1964.
UPR-200-W-141	241-SX-108 Single-Shell Tank	1962	241-SX-108 Single-Shell Tank	• Release of approximately 9,100 L (2,400 gal) of supernatant containing REDOX high-level waste and concrete. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1962.
UPR-200-W-142	241-SX-109 Single-Shell Tank	1965	241-SX-109 Single-Shell Tank	• Release of approximately 19,000 L (5,000 gal) of REDOX high-level liquid waste. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1965.
UPR-200-W-143	241-SX-111 Single-Shell Tank	1974	241-SX-111 Single-Shell Tank	• Release of approximately 7,570 L (2,000 gal) of REDOX high-level liquid waste and ion exchange liquid waste from the 241-SX tanks. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1974.

Table 2-6. Summary of Unplanned Releases.

Unplanned Release No.	Location	Date	Associated Waste Management Unit	Reported Waste - Related History
UPR-200-W-144	241-SX-112 Single-Shell Tank	1969	241-SX-112 Single-Shell Tank	• Release of approximately 114,000 L (30,000 gal) of REDOX high-level liquid waste. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1969.
UPR-200-W-145	241-SX-113 Single-Shell Tank	1962	241-SX-113 Single-Shell Tank	• Release of approximately 57,000 L (15,000 gal) of REDOX high-level liquid waste. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1958.
UPR-200-W-146	241-SX-115 Single-Shell Tank	1965	241-SX-115 Single-Shell Tank	• Release of approximately 190,000 L (50,000 gal) of REDOX high-level liquid waste. • Remedial actions not identified. • The tank is currently inactive and was removed from service in 1965.

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

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Feed Preparation	Jacket dissolution	Fission products, jacket constituents (alloy) sodium hydroxide, sodium aluminate	High	Basic	Low	High
	Fuel dissolution	Sodium hydroxide, ferrous sulfamate, zirconium, niobium	High	Basic	Low	High
Extraction Cycles	Aqueous process waste	Sodium aluminate, fission products, sodium hydroxide	High	Neutral -Basic	Low	Low
	Organic process waste	Hexone	Low	Neutral	High	Low
Solvent Recovery	Aqueous waste	Sodium hydroxide, sodium carbonate	High	Basic	Low to Medium	High
Analytical Laboratory	Laboratory waste	Sodium hydroxide, organics, fission projects	Low	Basic	Low	Low

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

RADIONUCLIDES		
Actinium-225	Plutonium	Uranium-236
Actinium-227	Plutonium-238	Uranium-238
Americium-241	Plutonium-239/240	Yttrium-90
Americium-242	Plutonium-241	Zirconium-93
Americium-242m	Polonium-210	Zirconium-95
Americium-243	Polonium-213	
Antimony-126	Polonium-214	ORGANIC CHEMICALS
Antimony-126m	Polonium-215	Methyl isobutyl ketone
Astitine-217	Polonium-218	Normal paraffin hydrocarbon
Barium-135m	Praseodymium	Tributyl phosphate
Barium-137m	Promethium-147	
Bismuth-210	Protactinium-233	INORGANIC CHEMICALS
Carbon-14	Protactinium-234m	Aluminum
Cerium-141	Radium	Aluminum nitrate nonahydrate
Cerium-144	Radium-223	Aluminum nitrate (mono basic)
Cesium-134	Radium-225	Boric Acid
Cesium-135	Radium-226	Ceric ammonium nitrate
Cesium-137	Radium-228	Dibasic aluminum nitrate
Curium-242	Rhodium-106	Ferrous ammonium sulfate
Curium-244	Ruthenium-103	Ferrous sulfamate
Curium-245	Samarium-151	Ferrous sulfate
Francium-221	Selenium-79	Hydrazine
Francium-223	Strontium-90	Iron
Gross alpha	Technetium-99	Nitric acid
Gross beta	Tellurium-121	Oxalic acid
Iodine-131	Tellurium-125m	Periodic acid
Iodine-129	Tellurium-127	Silicon
Krypton-85	Tellurium-129m	Silver nitrate
Lanthanium	Thallium-207	Sodium bismuthate
Lead-209	Thallium-208	Sodium carbonate
Lead 210	Thorium-227	Sodium dichromate
Lead 211	Thorium-229	Sodium fluroide
Lead 212	Thorium-230	Sodium hydroxide
Lead-214	Thorium-231	Sodium nitrate
Neodymium	Thorium-234	Sodium nitrite
Neptunium-237	Tritium	Sulfuric acid
Neptunium-239	Uranium	Zirconium
Nickel-63	Uranium-233	
Niobium-93m	Uranium-234	
Niobium-95	Uranium-235	

Table 2-9. Partial List of Chemicals Used in the 222-S Laboratory.

Compound Name	Formula
Acetone	$CH_3C_2OH_3$
Aluminum nitrate nonahydrate	$A1(NO_3)_3 \cdot 9H_2O$
Ammonium hydroxide	NH_4OH
Ammonium oxalate	$(NH_4)_2C_2O_4H_2O$
Bromonaphthalene	$C_{10}H_7Br$
Butylated hydroxytoluene	--
Ceric sulfate	$Ce(SO)_2$
Di2-ethyl hexyl phosphoric acid	$C_{16}H_{34}POOH$
Ferrous sulfamate	$Fe(SO_3NH_2)_2$
Ferrous sulfate	$FeSO_4$
Hydrazine	$H_2NNH_2 \cdot H_2O$
Hydrochloric acid	HCl
Hydroxylammine hydrochloride	$NH_2OH \cdot HCL$
Hydroxyquinoline	C_9H_6NOH
Lead nitrate	$Pb(NO_3)_2$
Mercuric thiocyanate	$Hg(SCN)_2$
Methyl ethyl ketone	$CH_3COC_2H_5$
Methyl isobutyl ketone	$CH_3COC_4H_9$
Mineral oil	Light hydrocarbons
Nitrate	NO_3
Nitric acid	HNO_3
Normal paraffin hydrocarbon	$C_{10}H_{22}$ to $C_{14}H_{30}$
O-phenanthroline	$C_{12}H_8N_2$
Potassium fluoride	KF
Potassium oxlate	$K_2C_2O_4$
Potassium permanganate	$KMnO_4$
S-diphenyl carbazide	$C_{13}H_{14}N_4O$
Sodium dichromate	$Na_2CR_2O_7 \cdot 2H_2O$

Table 2-9. Partial List of Chemicals Used in the 222-S Laboratory.

Compound Name	Formula
Sodium fluoride	NaF
Sodium hydroxide	$NaOH$
Sodium nitrite	$NaNO_2$
Sulfate	SO_3
Sulfuric acid	H_2SO_4
Tetrabromoethane	$(CHBr_2)_2$
Tetraphenyl boron	$(C_6H_5)B$
Thenoyltrifluoroacetone	$C_7H_5SO_2F_3$
Tributyl phosphate	$(C_4H_9)_3\ PO_4$
Trichloro methane	--
Titanium chloride	$TiCl_4$
Tri-iso-octylamine	$C_{24}H_{51}N$
Tri-n-octylamine	$C_{24}H_{51}N$
Vanadium	V
Xylene	$C_6H_4(CH_3)_2$
Zinc amalgam	$ZnHg$

Source: Klem 1990

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

INORGANIC CHEMICALS		
Aluminum	Potassium dichromate	Carbon-14
Aluminum nitrate	Potassium fluoride	Cerium-141
Aluminum oxide	Potassium oxalate	Cesium-134
Ammonia	Potassium permanganate	Cesium-137
Ammonium fluroide	Silicon	Chlroine-36
Ammonium hydroxide	Silicon dioxide	Chromium-51
Ammonium nitrate	Silver nitrate	Cobalt-57
Ammonium oxalate	Sodium aluminate	Cobalt-58
Boron	Sodium bismuthate	Cobalt-60
Boric acid	Sodium carbonate	Curium-243
Cadmium	Sodium dichromate	Einsteinium-254
Ceric ammonium nitrate	Sodium fluoride	Europium-152
Ceric sulfate	Sodium hydroxide	Europium-154
Chromic nitrate	Sodium metasilicate	Europium-155
Copper	Sodium nitrate	Gadolinium-153
Ferrous ammonium sulfate	Sodium nitrite	Germanium-68
Ferrous sulfamate	Sulfamic acid	Iodine-123
Ferrous sulfate	Tetrabromoethane	Iodine-125
Hydrazine	Tin	Iodine-129
Hydrochloric acid	Titanium chloride	Iron-55
Hydrofluoric acid	Xenon	Iron-59
Hydrogen	Zinc	Krypton-85
Hydroxylamine		Lead-212
Hydrochloride	RADIONUCLIDES	Lead-214
Iron	Aluminum-28	Manganese-54
Lead nitrate	Americium-241	Molybdenum-93
Magnesium	Antimony-122	Niobium-93m
Manganese dioxide	Antimony-124	Niobium-94
Mercuric nitrate	Antimony-125	Niobium-95
Mercuric thiocyanate	Antimony-126	Nickel-59
Mercury	Barium-133	Nickel-63
Nitric acid	Barium-137	Phosphorus-32
Nitric oxide	Beryllium-7	Plutonium-238
Nitrogen dioxide	Beryllium-10	Plutonium-239
Oxalic acid	Cadmiun-109	Plutonium-240
Periodic acid	Calcium-45	Plutonium-241

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

Potassium-40	Hydroxyquinoline
Polonium-210	Methyl isobutyl carbinal
Promethium-147	Methyl isopropyl diketone
Protactinium-231	Mineral oil
Radium-228	Normal paraffin
Rhenium-187	hydrocarbon
Rhodium-106	O-phenanthroline
Rubidium-86	Propane
Ruthenium-103	S-diphenyl carbazide
Ruthenium-106	Tetraphenyl boron
Scandium-46	Thenoyltrifluoroacetone
Selenium-75	Tributyl phosphate
Silver-108	Tri-iso-octylamine
Silver-110	Tri-n-octylamine
Sodium-22	Xylene
Sulfur-35	
Tin-121	
Tin-123m	
Tritium	
Strontium-82	
Strontium-90	
Tantalum-182	
Technetium-99	
Tellurium-121	
Tellurium-125m	
Tellurium-127	
Tellurium-129m	
Thallium-204	
Thullium-170	
Uranium-234	
Uranium-235	
Uranium-236	
Uranium-238	
Vanadium-49	
Ytrium-87	
Yttrium-88	
Zinc-65	
Zirconium-95	
ORGANIC CHEMICALS	
Acetone	
Bromonapthalene	
Di2-ethyl hexyl phosphoric acid	

3.0 SITE CONDITIONS

The following sections describe the physical nature and setting of the Hanford Site, the 200 West Area, and the S 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 S Plant Aggregate Area ranges from approximately 219 m (720 ft) in the eastern part of the unit to about 197 m (647 ft) above msl in the western part. A detailed topographic map of the area is provided as Plate 2. There are no significant natural surface drainage channels within the area.

3.2 METEOROLOGY

The following subsections 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.

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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% in 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

The following subsections provide information on regional (Section 3.3.1), Hanford Site (Section 3.3.2), and S Plant Aggregate Area (Section 3.3.3) surface hydrology including surface water features and their relationship to Hanford areas.

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

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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 S Plant Aggregate Area Surface Hydrology

No natural surface water bodies exist in the four operable units of the S Plant Aggregate Area which lays within the Yakima River System. There are three ditches, six ponds, four trenches, and two retention basins in the S Plant Aggregate Area. All are inactive waste management units and have been either stabilized or backfilled except the unlined portion of the 216-S-10D Ditch.

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

3.4 GEOLOGY

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

The geologic characterization of the Hanford Site, including the 200 West Area and S 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 subsections 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

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syncline in the north, and Cold Creek syncline in the southBoth 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 subsections 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 the 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 Ma) (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 by 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 [illegible] 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 content 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, 1.6 ft) 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--[illegible] consists of laminated to massive silt, silty fine-grained [illegible] containing variable amounts of calcium carbonate. [illegible] lenticular interbeds (<0.5 m to 2 m, <1.6 ft to [illegible] and associations and as thick (up to 10 m, 33 ft) [illegible] These sediments record deposition in a [illegible] 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 [illegible] (3.3 ft) to 10 m (33 ft) thick are common in the association. [illegible] comprising the association were deposited in a lake under [illegible]

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- 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 the 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 [illegible] originally proposed by Newcomb (1958) and Myers et al. [illegible]

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 [illegible] to interbedded caliche-rich and caliche-poor silts and sand. [illegible] consists of weathered and unweathered basaltic gravels [illegible] slope wash, colluvium, and sidestream alluvium. [illegible] correlative to other sidestream alluvial and pedogenic deposits [illegible] ridges bounding the Pasco Basin on the north, west, and south. [illegible] pedogenic deposits are inferred to have a late Pliocene to early [illegible] stratigraphic position and magnetic polarity of interfingering [illegible]

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 [illegible]). These gravels, called the pre-Missoula gravels (PSPL 1982) are [illegible] less basalt than underlying Ringold gravels and [illegible] white or bleached color, and sharply truncate underlying [illegible] contact between the pre-Missoula gravels and the overlying Hanford [illegible] In addition, it is unclear whether

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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; 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. These facies are referred to as coarse-grained deposits, plane-laminated sand facies, and rhythmite facies, respectively, in Baker et al. (1991). The silt-dominated deposits also are referred to as the "Touchet Beds" or slackwater deposits, while the gravel-dominated 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 subsections 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 and sand-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

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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 S 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 discusses notable stratigraphic characteristics, thickness variations, and the geometric relationships of the sediments. Stratigraphic variations pertinent to the S 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 S Plant Aggregate Area are presented in Figures 3-14 through 3-19. Figure 3-14 illustrates the cross-sections locations. A legend for symbols used on the cross-sections is provided in Figure 3-15. The cross-sections are based on geologic information from wells shown in the figures, as interpreted in Lindsey et al. (1991). To develop these stratigraphic interpretations, logs for all the wells in the S Plant Aggregate Area were reviewed and a selection was made of the most relevant to the Aggregate Area. Chamness et al. (1991) provide a compilation of these ten geologic logs from the S 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 S Plant Aggregate Area Management Study. The cross sections depict subsurface geology in the S Plant Aggregate Area. For each cross-section, locations of S Plant Aggregate Area waste management units are identified for reference. Figures 3-20 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 S Plant Aggregate Area. The structure and isopach maps are included from Lindsey et al. (1991). Plate 1 should be consulted to identify locations of S Plant Aggregate Area buildings and waste management units referenced in the text.

3.4.3.1 Elephant Mountain Basalt. The Elephant Mountain Member of the Saddle Mountains Basalt is continuous beneath the entire 200 West Area. The top of the Elephant Mountain Member dips to the southwest and south into the Cold Creek syncline, reflecting the structure of the area (Figure 3-20). 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.

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 and in the southern part of the 200 West Area. In the overlying lower mud sequence, stratigraphic trends seen elsewhere in the Pasco Basin suggest that paleosols in the unit become more common progressing structurally up-dip (Lindsey et al. 1991). In the Ringold unit E gravels, intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is difficult. The upper unit of the Ringold in the 200 West Area tends to be dominated by sand, unlike the upper unit elsewhere in the Pasco Basin where paleosols tend to dominate the upper unit.

Beneath the 200 West Area, the fluvial gravels of Ringold unit A, and the Ringold lower mud sequence tend to thicken and dip to the south-southwest, toward the axis of the Cold Creek Syncline (Figures 3-16 and 3-21 through 3-24). The top of unit A is relatively flat in the 200 Area, dipping gently to the west and southwest. Like the unit A gravels, the

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Ringold lower mud sequence thickens and dips to the south and southwest over the 200 West Area (Figures 3-23 and 3-24). 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 S Plant Aggregate Area, unit A thins in the east and northeast (Figures 3-17, 3-21, and 3-22). The top of the unit is a relatively flat surface. The overbank and lacustrine deposits of the lower mud sequence also thicken and dip to the south and southwest. The lower mud unit shows a depression in the northern part of the S Plant Aggregate Area.

Isopach and structure contour maps of fluvial gravel unit E (Figures 3-25 and 3-26) and the upper unit (Figures 3-27 and 3-28) 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 including a depression in the northern part of the S Plant Aggregate Area. The top of unit E generally dips to the southeast and climbs to the northeast. Intercalated lenticular beds of sand and silt occur throughout the 200 West Area, although predicting where they will occur is very difficult. The gravels of unit E are thinnest in the southern area of the S Plant Aggregate Area. Unit E gravels vary in thickness from 31 m (100 ft) in the southeastern corner to over 88 m (285 ft) in the northern part of the S Plant Aggregate Area.

The upper unit of the Ringold Formation is present only in the western, northern, and central portion of the 200 West Area (Figures 3-27 and 3-28). Where the upper unit is present, the top generally dips to the south-southwest. The upper unit is completely absent in the S Plant Aggregate Area.

3.4.3.3 Plio-Pleistocene Unit. The carbonate-rich strata of the Plio-Pleistocene unit largely is restricted to the vicinity of 200 West Area, pinching out near the north, east, and southern boundaries of the area (Figures 3-16 through 3-19, 2-29, and 3-30). The westernmost extent of the unit is not clear, although it seems to extend west and northwest of the 200 West Area. Thickness variations in the unit are very irregular. It is thickest in the southeast, southwest, and northcentral parts of the area while it thins in the south-central and central parts of the area. It pinches out on a diagonal from northwest to southeast in the S Plant Aggregate Area. Although no erosional windows through the units have been encountered in boreholes, there is a good possibility they exist, especially in the areas where the unit thins and depressions exist. In addition, fracturing in the carbonate is potentially common and interbedded carbonate-poor lithologies are found at many locations. The top of the unit generally dips to the south and southwest although irregularities occur, especially in the center of the 200 West Area. The unit pinches out in the southern part and may also in the north central part of the S Plant Aggregate Area (Figure 3-29). The Plio-Pleistocene unit is thickest (7 m, 21 ft) south of the 241-SX Tank Farm. The unit thins (< 1.5 m, 5 ft) out northeast of the 241-SX Tank Farm.

3.4.3.4 Early "Palouse" Soil. Like the Plio-Pleistocene unit, the early "Palouse" soil is largely restricted to the vicinity of the 200 West Area (Figures 3-16 through 3-19, 3-31, and 3-32). The unit pinches out in the west-central part of the 200 West Area and near the southern, eastern, and northern boundaries. The thickness of the unit varies irregularly. It

is thickest in the south, southeast, and central parts of the 200 West Area. The unit is thinnest immediately adjacent to these thicker intervals, and at one location in the central part of the 200 West Area it appears to pinch out. Generally, the top of the unit dips to the south although it becomes fairly irregular in the southern half of the area. The unit pinches out through the center of the S Plant Aggregate Area and is thickest in the northeast and northwest sections of the area ranging from approximately 12 m (40 ft) in the northeast to approximately 15 m (50 ft) (Figures 3-31 and 3-32). The early "Palouse" soil thins out and is not present south of the 200 West Area perimeter fence.

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

The lower fine-grained unit of the Hanford formation in the 200 West Area is thick, but locally discontinuous (Figures 3-16 through 3-19, and 3-33, through 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 found in the northern part of the 200 West Area and it generally thickens to the south. Erosional windows through the unit are found, most notably in the central part of the 200 West Area. These erosional windows are elongated in a north-south direction. The unit appears thickest in the S Plant Aggregate Area in the southeast and thins to the northwest attaining a maximum thickness of 75 m (245 ft) in the southeast near the 216-S-19 Pond, and 18 m (60 ft) in the northwest and northeast (Figure 3-33).

The upper coarse-grained unit of the Hanford formation consists of interstratified gravel, sand, and lesser silt (Figures 3-16 through 3-19, 3-36, and 3-37). Deposits typical of the gravel-dominated 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 part of the area (Figure 3-36). The

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base of the unit is incised into the underlying strata of the lower fine unit and where that unit is absent, the upper coarse unit fills an erosional window. The contact between the upper coarse unit and underlying strata is generally sharp, consisting of gravel-dominated facies strata overlying the fines of the lower unit, the early "Palouse" soil, and the Plio-Pleistocene unit. The unit is discontinuous in the S Plant Aggregate Area, being thickest in the north section near the 216-S-23 Crib (23 m, 76 ft) and pinching out south of the 241-SX Tank Farm and the 216-S-9 Crib (Figure 3-36).

3.4.3.6 Surficial Deposits. Holocene-age surficial deposits in the 200 West Area are dominated by eolian sands. These deposits have been removed from much of the area by construction activities. Where the eolian sands are found they tend to consist of thin (<3 m, 10 ft) sheets that cover the ground (Figure 3-38). Dunes are not generally well developed within the 200 West Area, but two dunes existed in the northeastern part of the S Plant Aggregate Area.

3.5 HYDROGEOLOGY

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

3.5.1 Regional Hydrogeology

The hydrogeology of the Pasco Basin is characterized by a multiaquifer system that consists of four hydrogeological units that correspond to the upper three formations of the Columbia River Basalt Group (Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt) and the suprabasalt sediments. The basalt aquifers consist of the tholeiitic flood basalts of the Columbia River Basalt Group and relatively minor amounts of intercalated fluvial and 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 was above normal.

3.5.2 Hanford Site Hydrogeology

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

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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 3-39). 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 the 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 Genutchen 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 3-40.

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

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should be considered. For waste management units 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 because of 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 S Plant Aggregate Area are discussed in Section 3.5.3.1.2.

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

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

3.5.2.1.3 Unconfined Aquifer. The uppermost aquifer system in the 200 Areas occurs primarily within the sediments of the Ringold Formation and Hanford formation. In the 200 West Area the upper aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semi-confined 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.

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The upper part of the uppermost aquifer in the 200 West Area consists of a 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 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:

- 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 3-41. 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 S Plant Aggregate Area.

- A lysimeter study reported by Routson and Johnson (1990) was conducted at a location 1.6 km south of the 200 East Area. During much of the lysimeters' 13-year study period between 1972 and 1985, the surface of the lysimeters were maintained unvegetated with herbicides. No information regarding the soil types in the lysimeters was found. To a precision of +/- 0.2 cm, no downward moisture movement was observed in the instruments during periodic neutron-moisture measurements or as a conclusion of a final soil sample collection and moisture content analysis episode.

- An assessment of precipitation recharge involving the redistribution of ^{137}Cs in vadose zone soil also reported by Routson and Johnson (1990). In this study, split-spoon soil samples were collected beneath a solid waste burial trench in the T Plant Aggregate Area. The trench, apparently located just south and west of the 218-W-3AE Burial Ground, received soil containing ^{137}Cs from an unspecified spill. Cesium-137 was not detected below the bottom of the burial trench. However, increased ^{137}Cs activity was observed above the top of the waste fill

which Routson and Johnson concluded indicated that net negative recharge (loss of soil moisture to evapotranspiration) had occurred during the 10-year burial period.

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

- A weighing lysimeter study reported by Rockhold et al. (1990) which was conducted at a grassy plot approximately 5 km (3 mi) northwest of the 300 Area. The grass test site was located in a broad, shallow topographic depression approximately 900 m (2,953 ft) wide, several hundred meters long, trending southwest. The area is covered with annual grasses (cheatgrass and bluegrass). The upper 3.5 m (11.5 ft) of the soil profile consists of slightly silty to silty sand (sandy loam) with an estimated saturated hydraulic conductivity of 9×10^{-3} cm/s. 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 3-42) 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) are 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-S-10D Ditch, 216-S-25 Crib, and the 216-S-26 Crib) located within the S 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 200 (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 S Plant Aggregate Area Hydrogeology

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

3.5.3.1 Hydrostratigraphy. The hydrostratigraphic units of concern beneath the S 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 S 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 S Plant AAMSR, this discussion will be limited to the vadose zone and possible perching horizons with the vadose zone underlying the aggregate area. Additional information on the aquifer systems is contained in the 200 West Groundwater AAMSR.

3.5.3.1.1 Vadose Zone. The vadose zone beneath the S Plant Aggregate Area ranges in thickness from about 71 m (230 ft) along the northern part of the aggregate area boundary to 56 m (190 ft) in the vicinity of the 216-S-10D Ditch 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 southwest and northwest of the S Plant Building Complex (Figure 3-43). As discussed in Section 3.5.2.4, the mound apparently originated from historic discharges to the U Pond and 216-S-10 Ditch.

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

3.5.3.1.2 Perched Water Zones. The characteristics, extent and stratigraphic position of the Plio-Pleistocene and early "Palouse" soil units in the 200 West Area (see Figures 3-15 through 3-19, and 3-29 through 3-32) provide conditions for collection and possible movement of vadose zone recharge water above the unit. The high cementation, laterally continuous nature, and relatively gentle (1.5degree) dip to the southwest of the Plio-Pleistocene unit indicate the possibility of perched water zones.

In 1966, perched water was detected at approximately 43 m (140 ft) in Wells 299-W22-26A and 299-W22-27A, near the 216-S-9 Crib (Plate 3). In more recent years, perched water was detected at approximately 38 m (125 ft) in Well 299-W26-11 and at approximately 45 m (146 ft) in Well 299-W26-12 both located near the active portion of the 216-S-10D Ditch (Plate 3).

Apparently the calcareous cementation in the Plio-Pleistocene produces a significantly lower permeability than the overlying soils. The perched water is confined on the top by the silt-dominated facies of the Hanford formation but can extend up into it. The silt-dominated facies is a laterally discontinuous unit and thus may only permit the development of perched conditions locally.

Information about hydraulic properties of the perched water zones is very limited and will vary according to how far vertically and in which unit the perched water reaches.

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

S Plant Aggregate Area. However, the amount of precipitation infiltration is likely comparable to the range of values identified for various Hanford test sites, i.e., 0 to 10 cm/yr (0 to 4 in./yr).

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

3.5.3.3 Groundwater Flow Beneath the S Plant Aggregate Area. Within the S Plant Aggregate Area, groundwater flow is generally toward the east, based on December 1990 Hanford wells groundwater elevation data (Kasza et al. 1990) (Figure 3-42). Flow is generally very gradual with some influence from the 216-U-10 Pond mound and possibly from the 216-S-10D Ditch and 216-S-26 Crib. 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 in the southern portion of the aggregate area.

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

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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 (*Pursia 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 (*Koleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Spheracea munroana*), balsamroot (*Basamorhiza 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 principle 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 State Department of Resources 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 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 (*Cyrptantha 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 216-B-3 Pond, the 216-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.

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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's 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*

virticalis), 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 (*Pertx 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 douglassi*), 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 have the ability to excavate and bring up material from as far down as 4.6 to 6.1 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 S Plant Aggregate Area is the location of S plant and its attendant facilites and structures (202-S Building, 222-S Laboratory, etc.). Past activites at S Plant and related facilites were mainly to separate uranium and plutonium from irradiated fuel reds. Other buildings within the unit served mainly as storage or office space. Currently the 202-S building is inactive and is expected to undergo decommissioning and cleanup in 2004. Waste management units that remain active are noted on Figure 2-1, Operational and Waste-Related History.

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

3.6.3 Water Use

Only one surface water facility exists in the S Plant Aggregate Area. The 216-S-10D Ditch is a manmade structure constructed in 1952 to dispose liquid effluents from the S Plant Building Complex (WHC 1990b). This waste site is located 427 m (1,470 ft) southwest of the S Plant and was recently deactivated. In the past, discharges were received from 202-S floor drains, funnels, process vessel cooling water, and chemical sewer lines and drains from the 241-S Tank Farm, 211-S Station, and 276 Building. Until 1965, the unit received chemical sewer waste from the S Plant and overflow from the 2901-S-901 Water Tower. Since October 1984, the unit has been used as a trench because the 216-S-10P pond was stabilized. No dangerous wastes have been discharged to this unit since February 1987. This unit is unlined and a portion remains uncovered. It has been partially stabilized. In the portion of the unit that has not been stabilized, there is approximately 1 ft of standing water with cattails growing in it. Water from the 216-S-10D Ditch has apparently never been used for any purpose.

There is no consumptive use of groundwater within the S Plant Aggregate Area. Water for drinking and emergency use, and facilities process water is drawn from the Columbia River, treated, and imported to the 200 West Area. The nearest wells used to supply drinking water are located at the Yakima Barricade (Well 699-49-100-C) about 5 km (3.1 mi) west of the 200 West Area; at the Hanford Safety Patrol Training Academy

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

3.7 HUMAN RESOURCES

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

3.7.1 Demography

There are no residences on the Hanford Site. The nearest inhabited residences are farm homes on land located 23 km (14 mi) north of the S 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 S Plant Aggregate Area. The closest site of interest is the remains of the White Bluffs Road, located approximately 1.6 km (1 mi) northwest of the aggregate area, which was previously an Indian trail.

3.7.3 Historical Resources

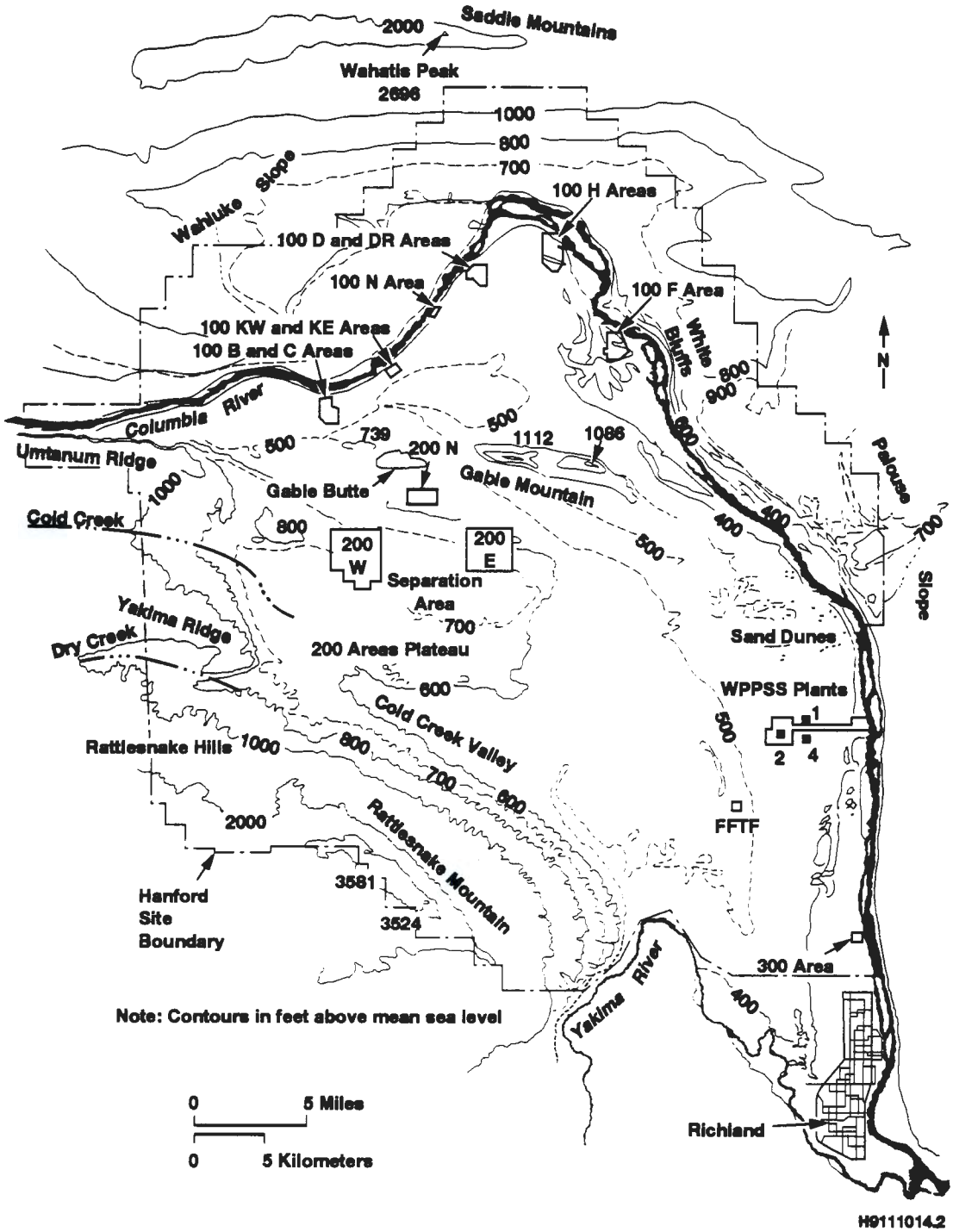
The only historic site in 200 West Area is the old White Bluffs freight road which crosses diagonally through the 200 West Area. This site is not considered to be eligible for the National Register.

3.7.4 Community Involvement

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

9 1 1 2 0 6 . 0 0 7 8

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



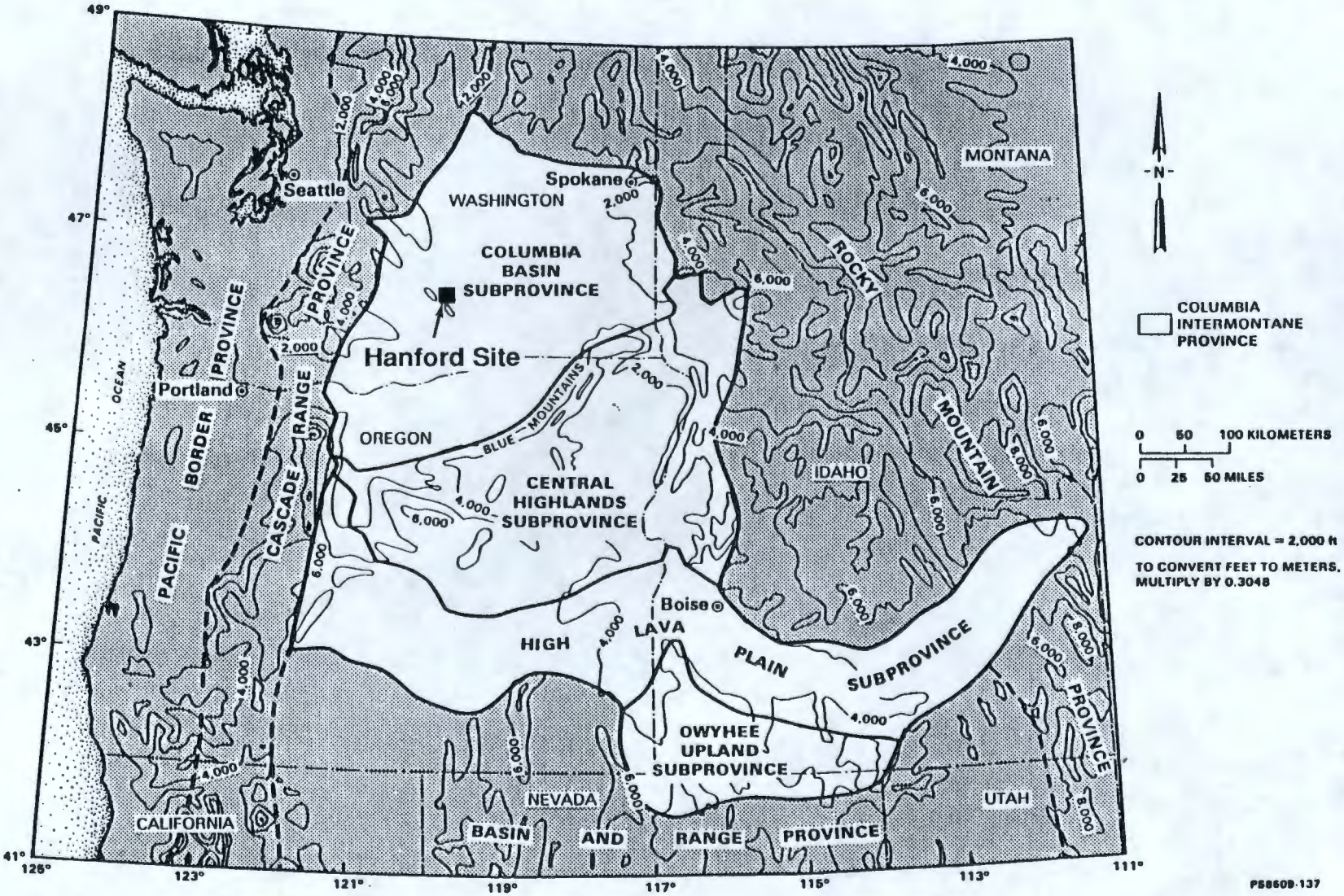


Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province.

Figure 3-3. Geomorphic Units Within the Central Highlands and Columbia Basin Subprovinces that Contain the columbia River Basalt Group.

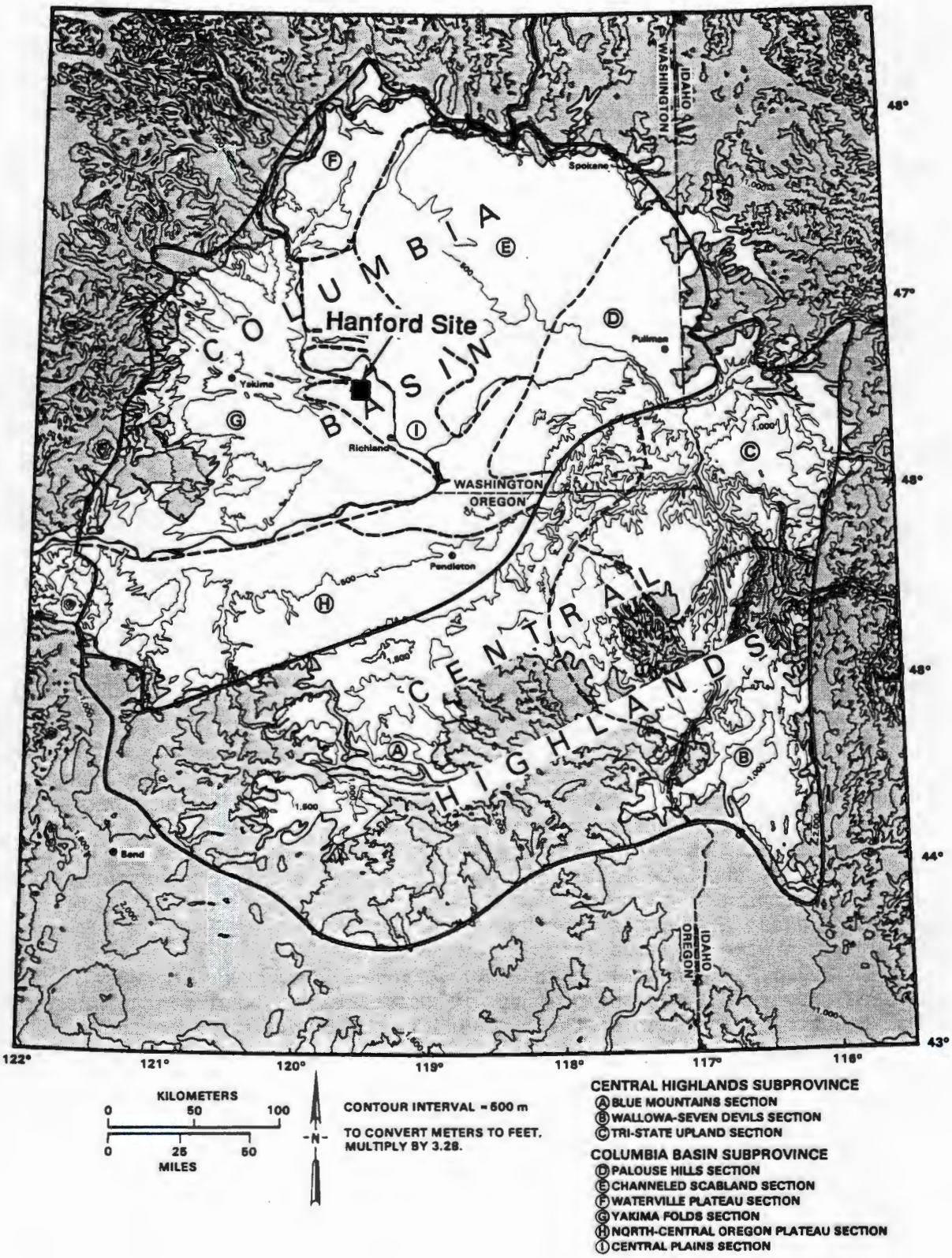


Figure 3-4. Landforms of the Pasco Basin and the Hanford Site.

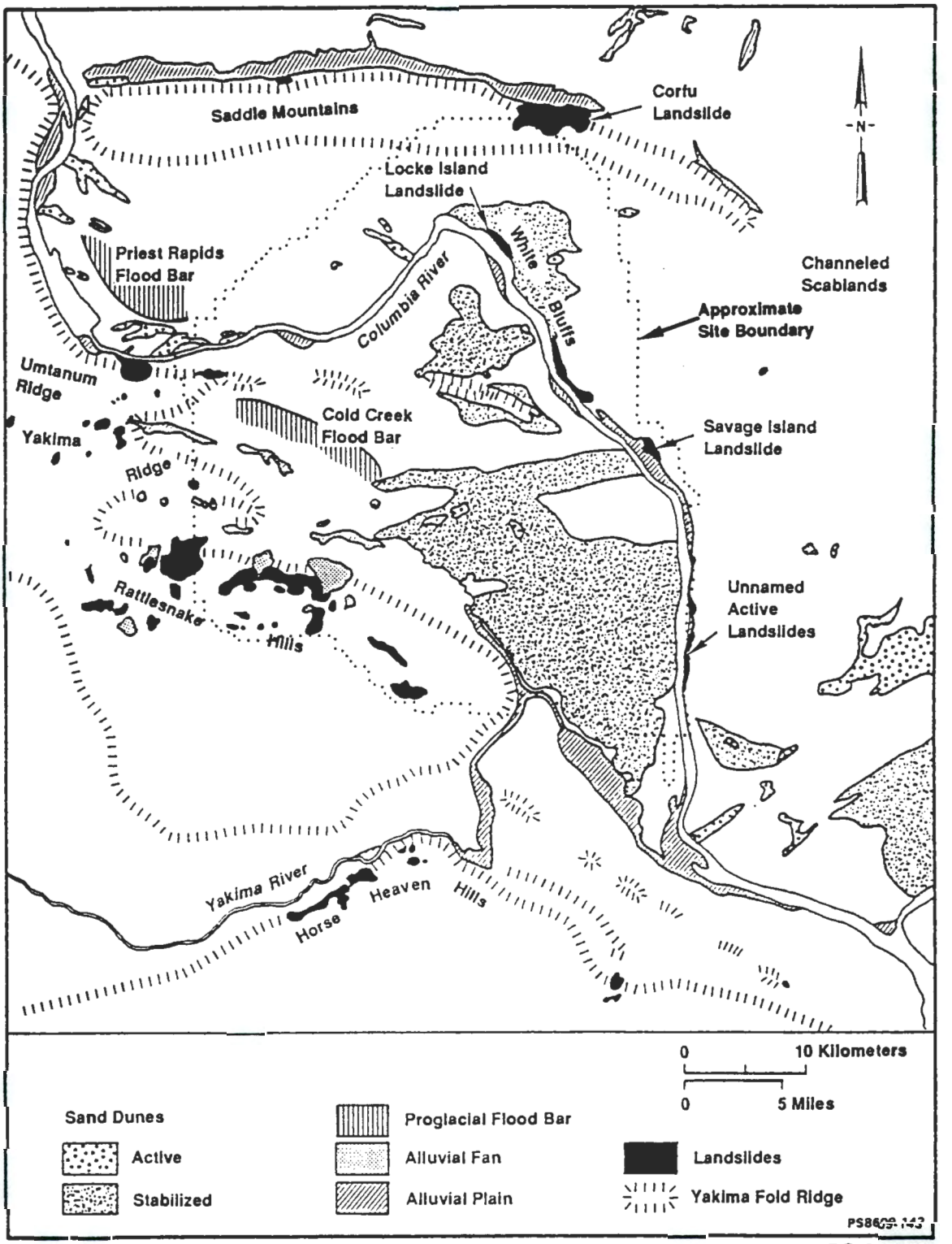


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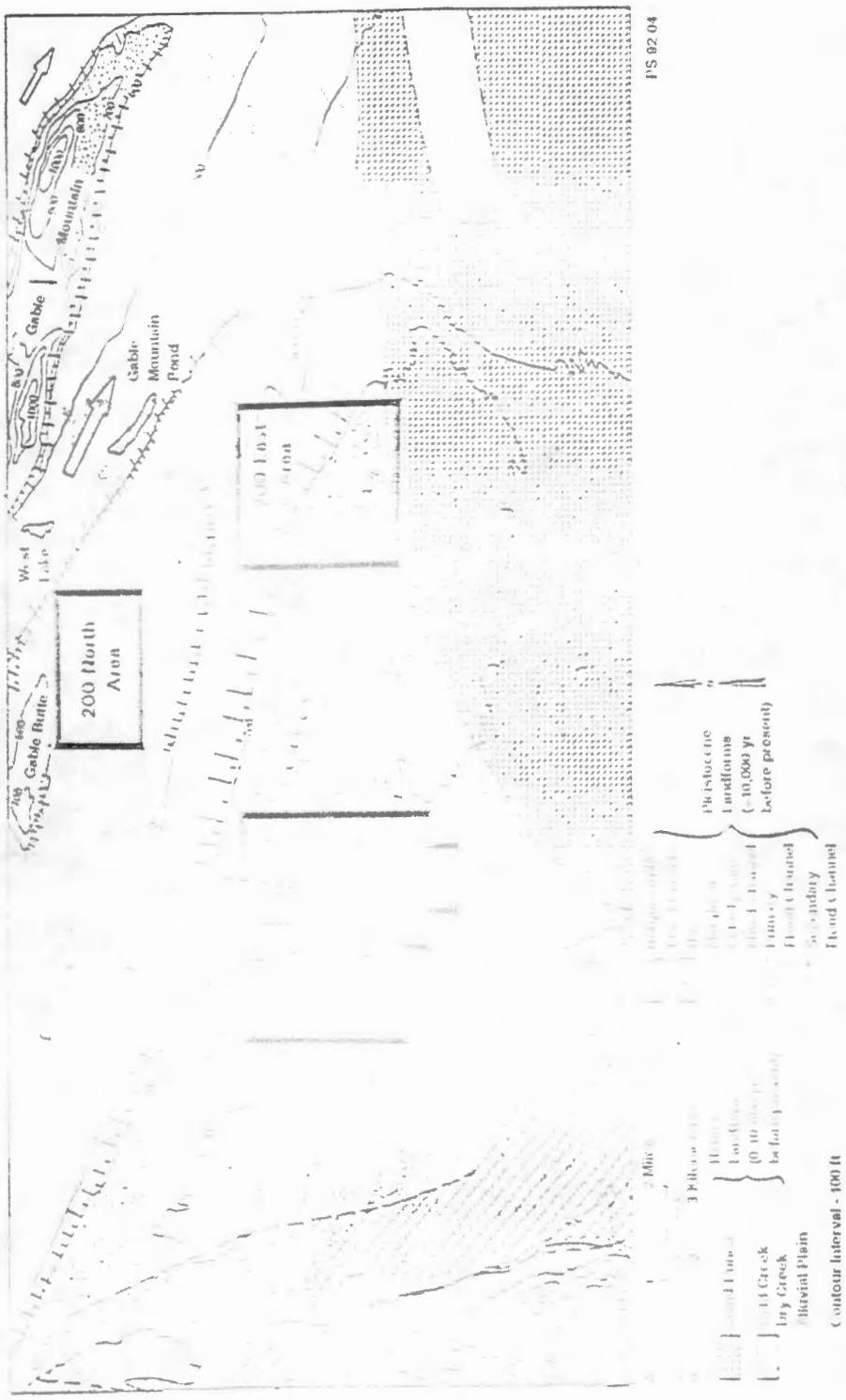
Figure 3-5. Geomorphic Features Surrounding the 200 Areas.



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

9 3 1 2 8 9 0 8 8 3

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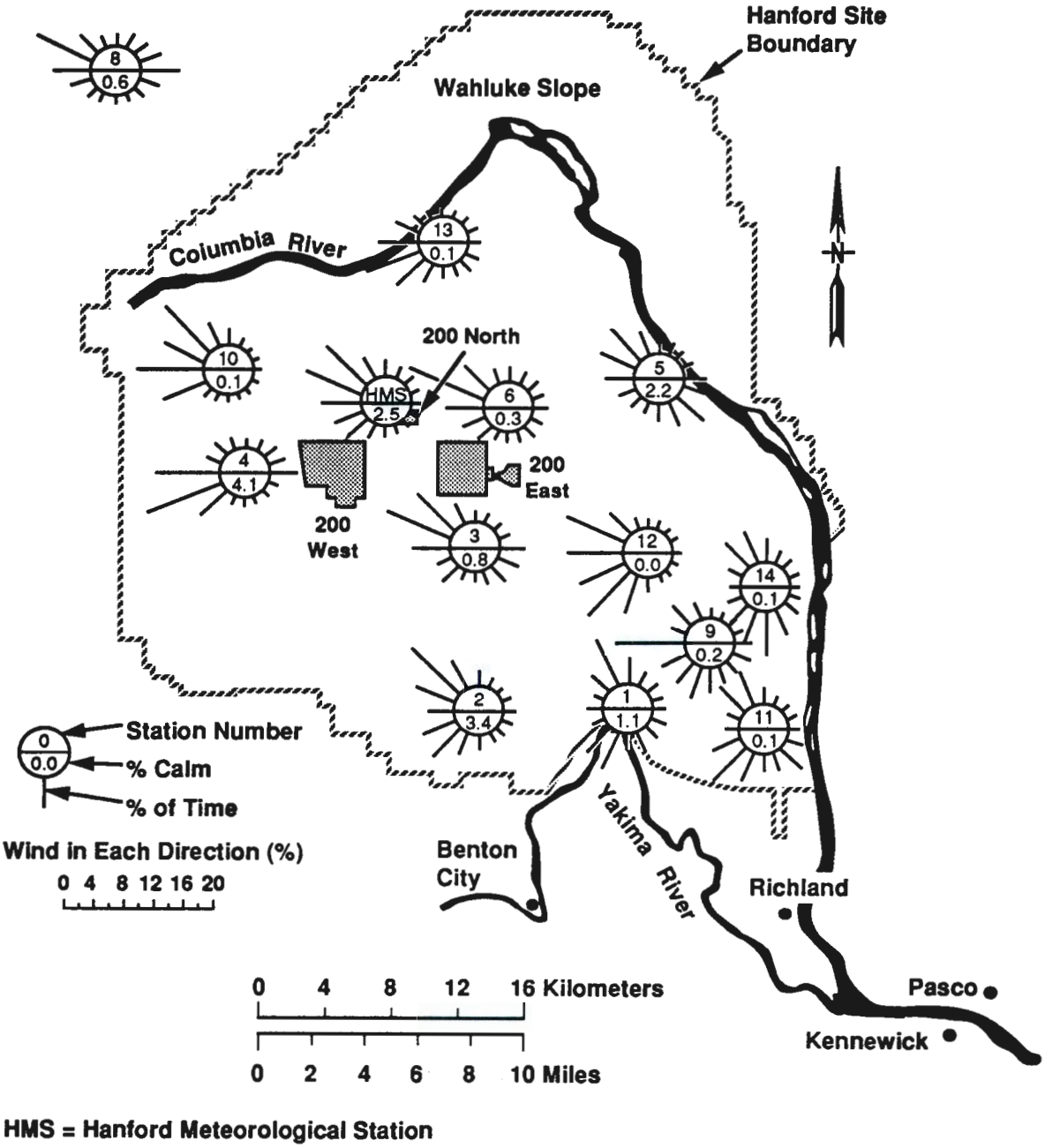
Figure 3-6. Hanford Site Wind Roses, 1979 through 1982.



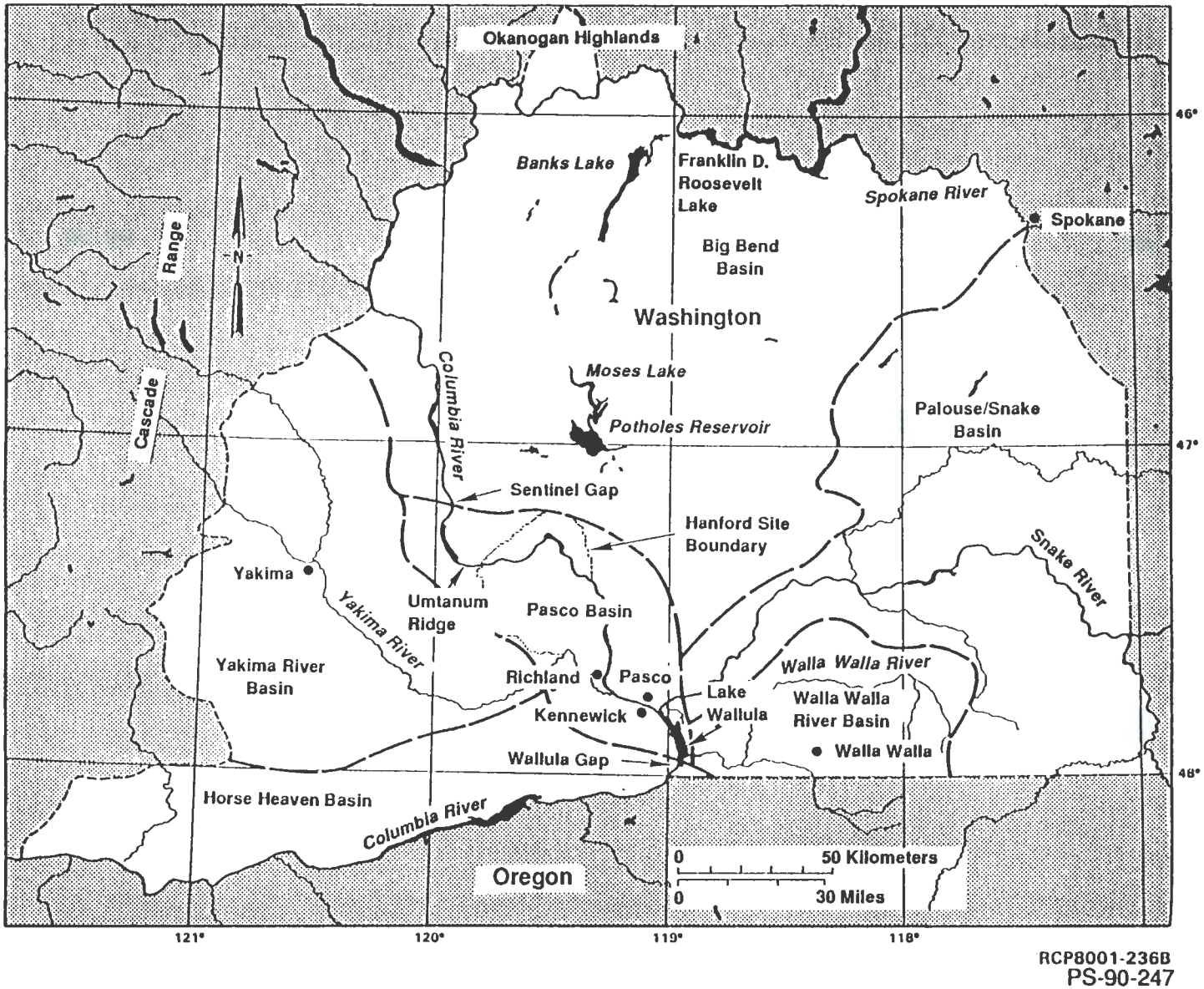


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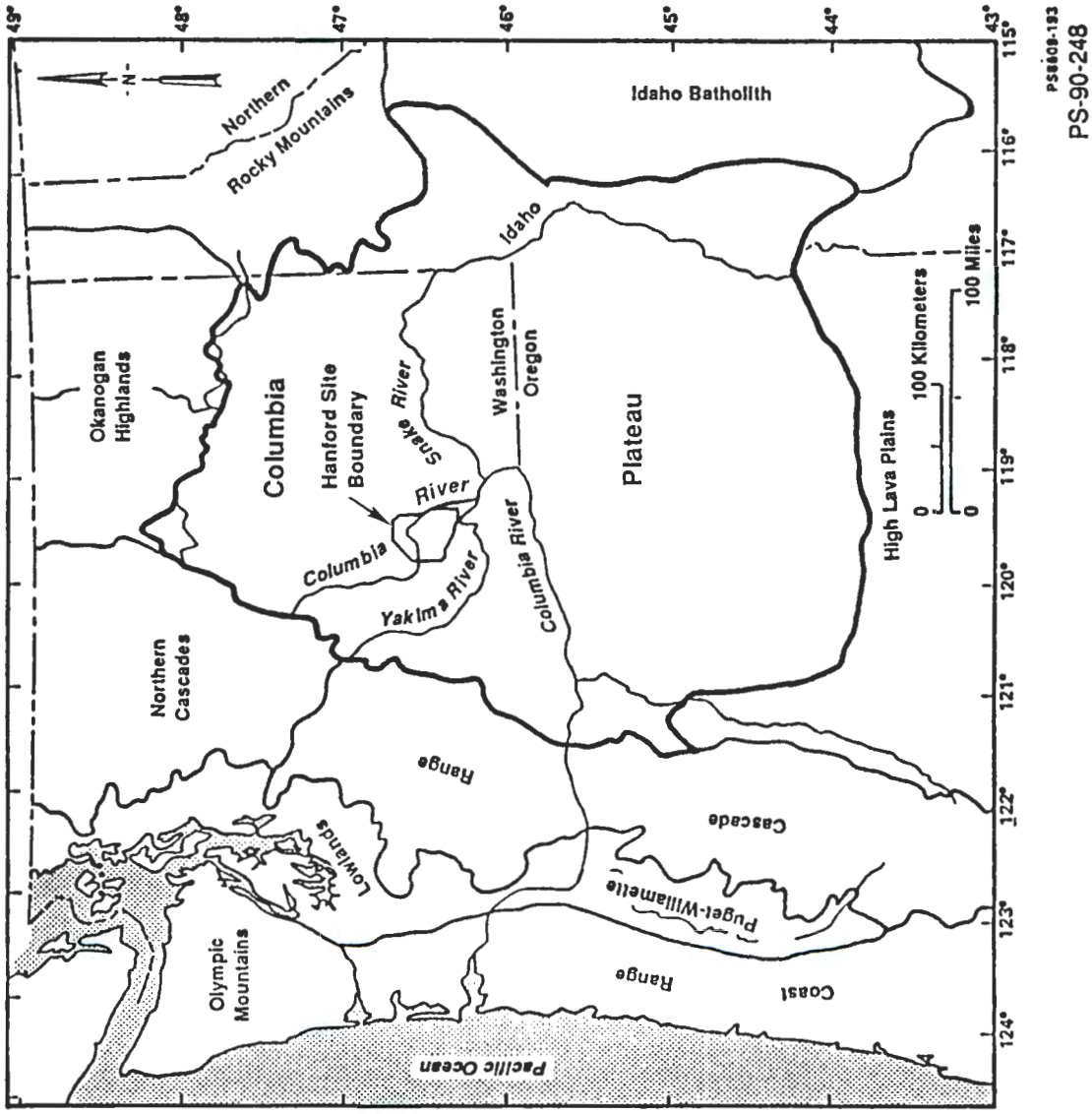
Figure 3-7. Hydrologic Basins Designated for the Washington State Portion of the Columbia Plateau.

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



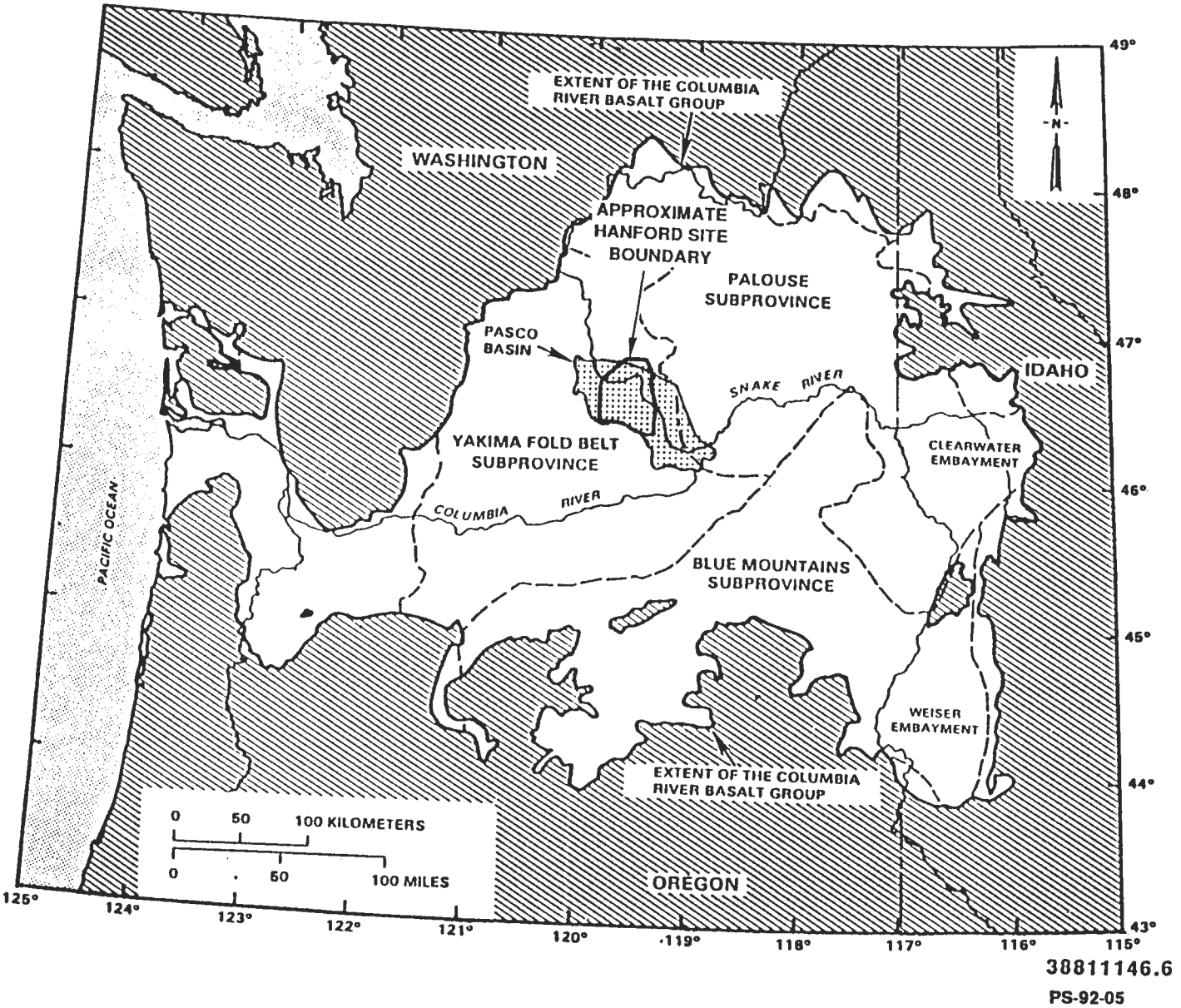


Figure 3-9. Structural Subprovinces of the Columbia Plateau.

Figure 3-10 Structural Elements of the Yakima Fold Belt Subprovince.

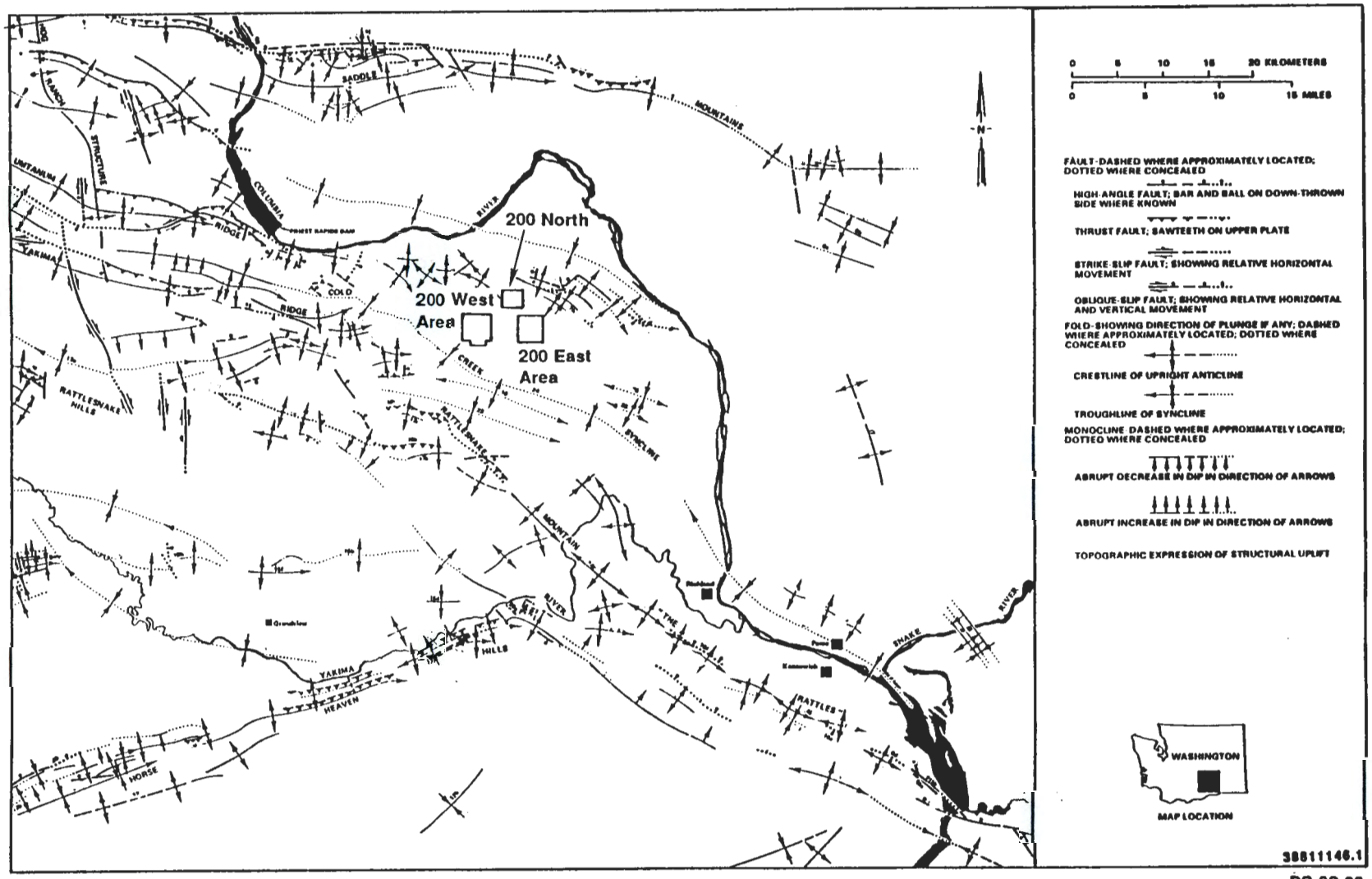


Figure 3-11. Geologic Structures of the Basco Basin and the Hanford Site.

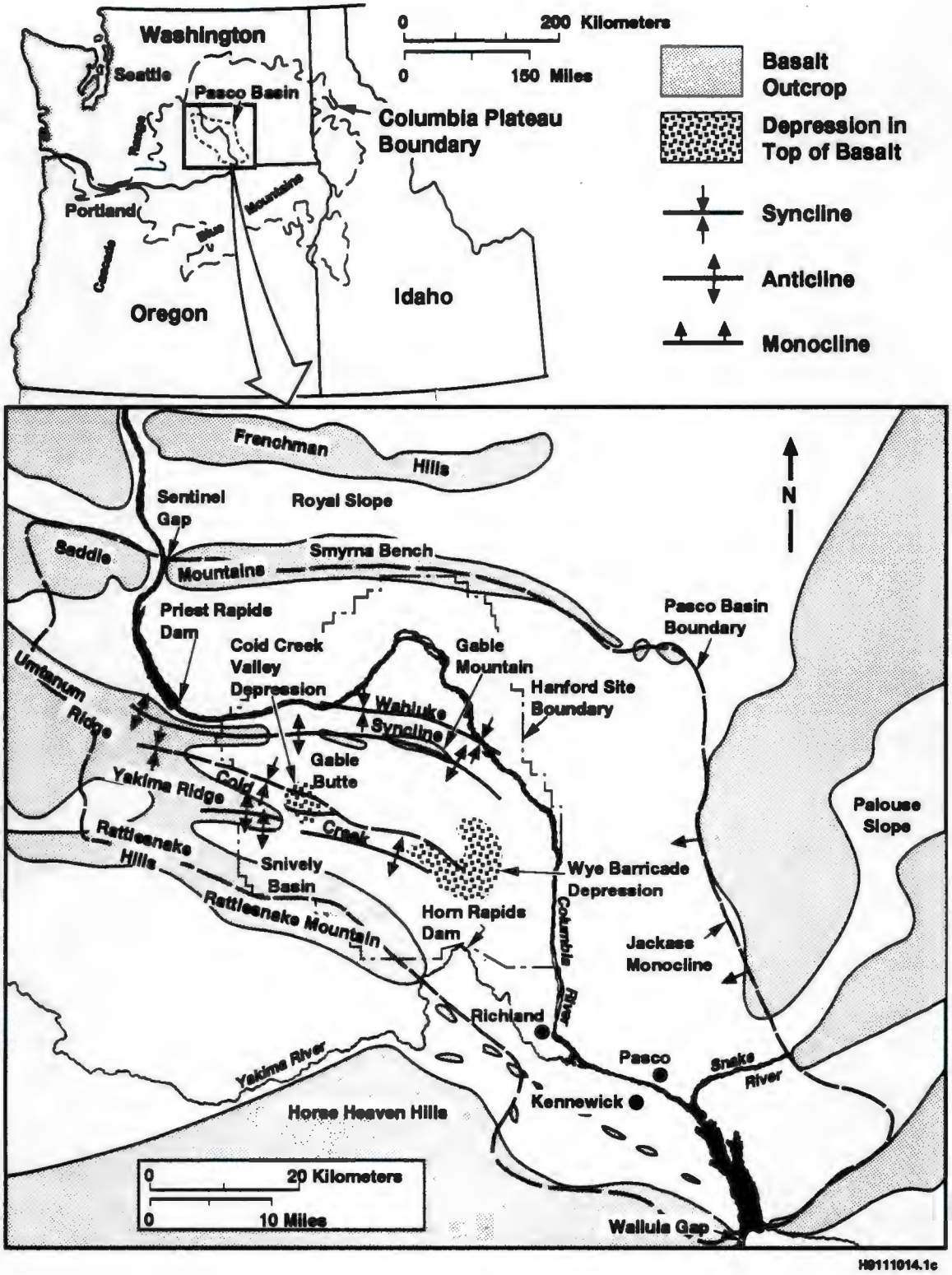
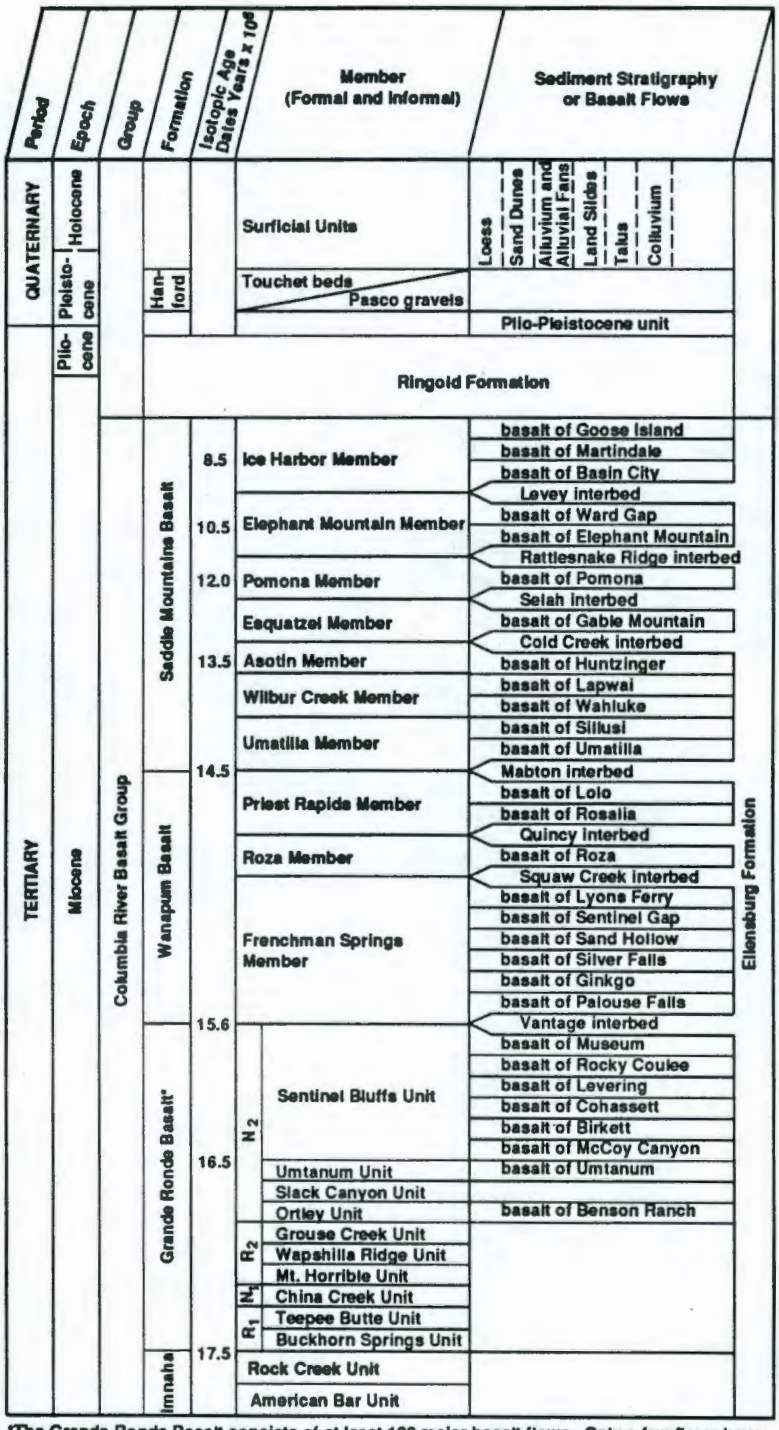


Figure 3-12. Generalized Stratigraphy of the Hanford Site.



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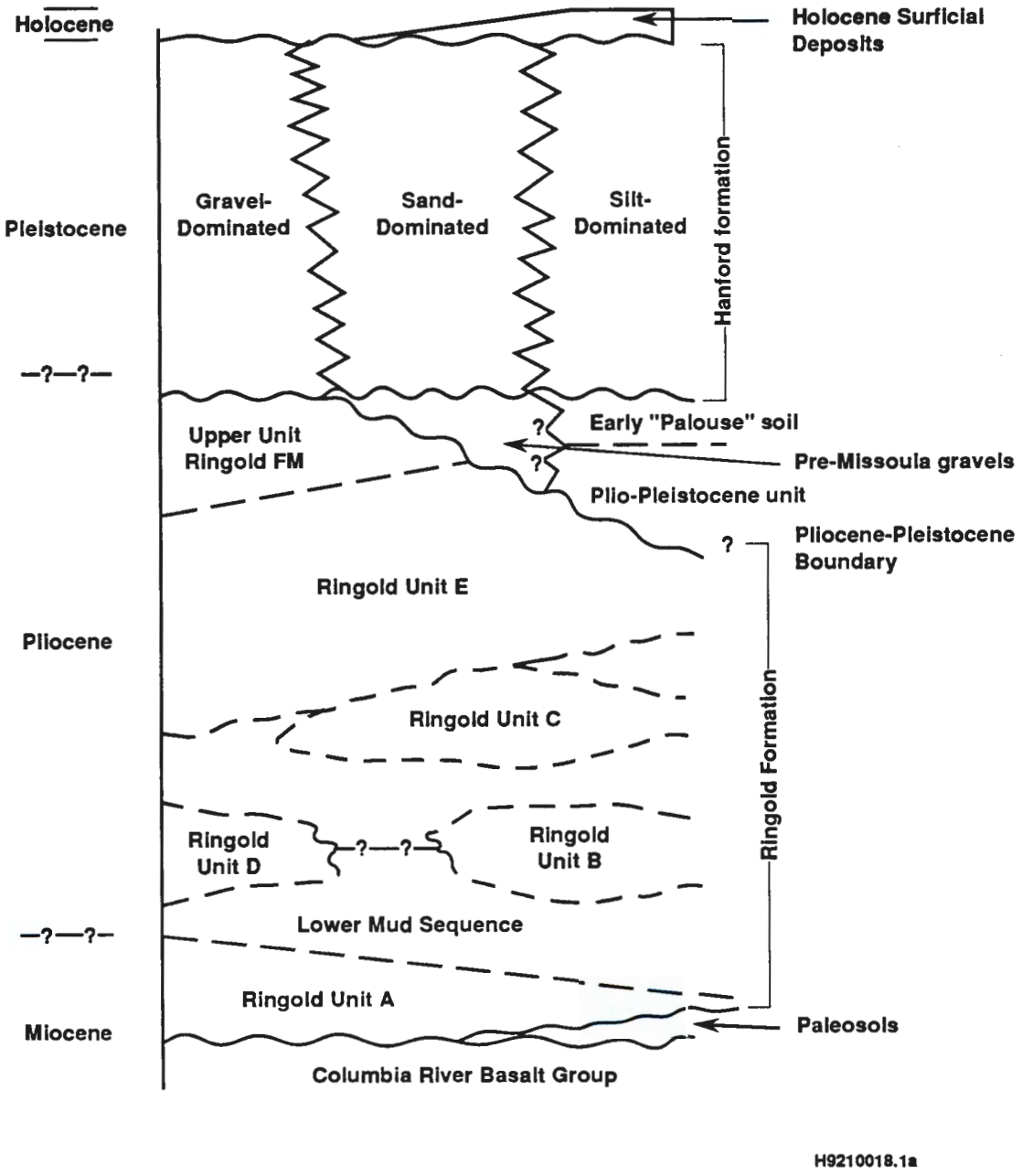
Figure 3-13. Generalized Strtigraphy of the Suprabasalt Sediments Beneath the Hanford Site.



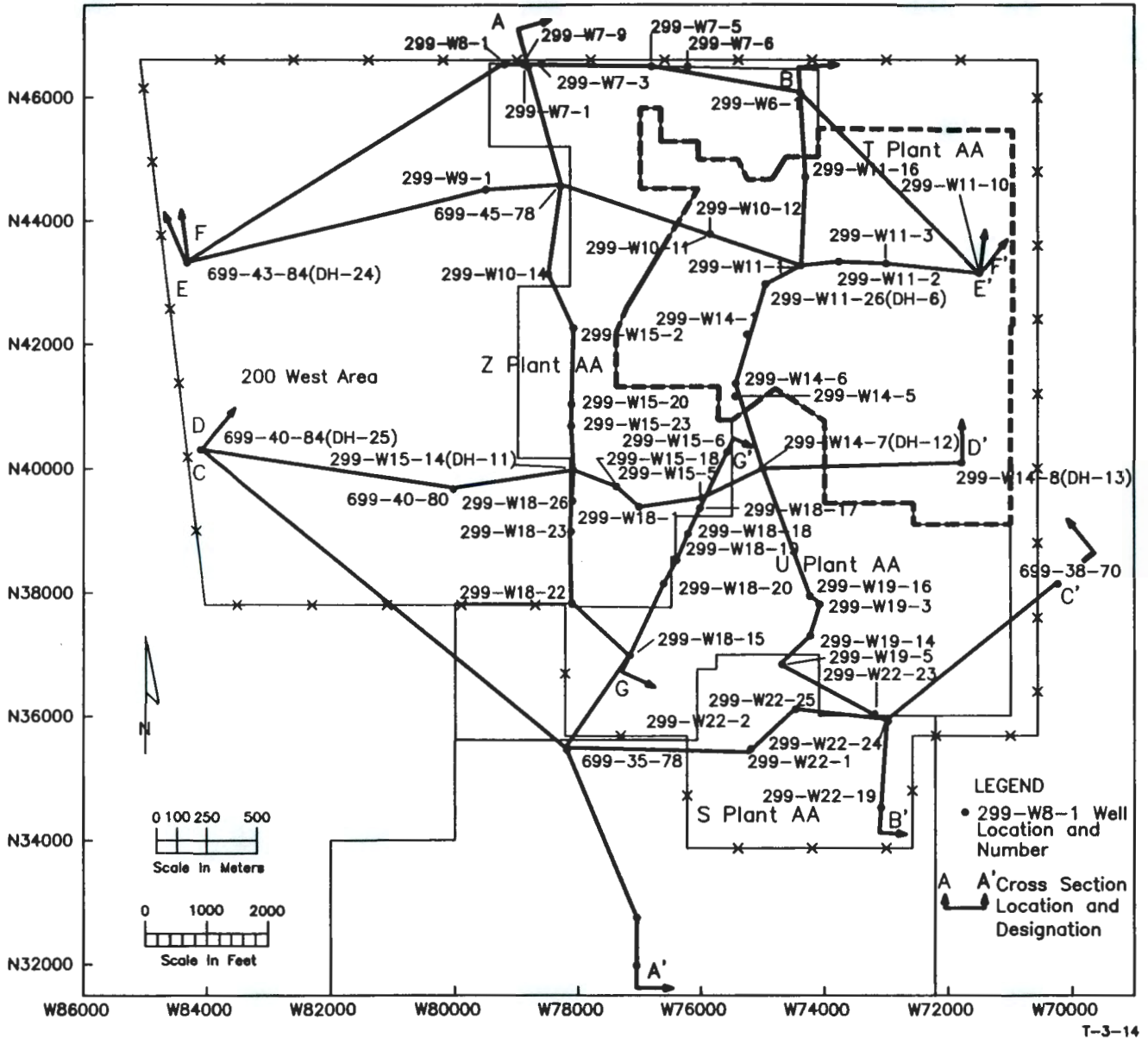


Figure 3-14. Location of Cross-Sections.

Figure 3-15. Legend for 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

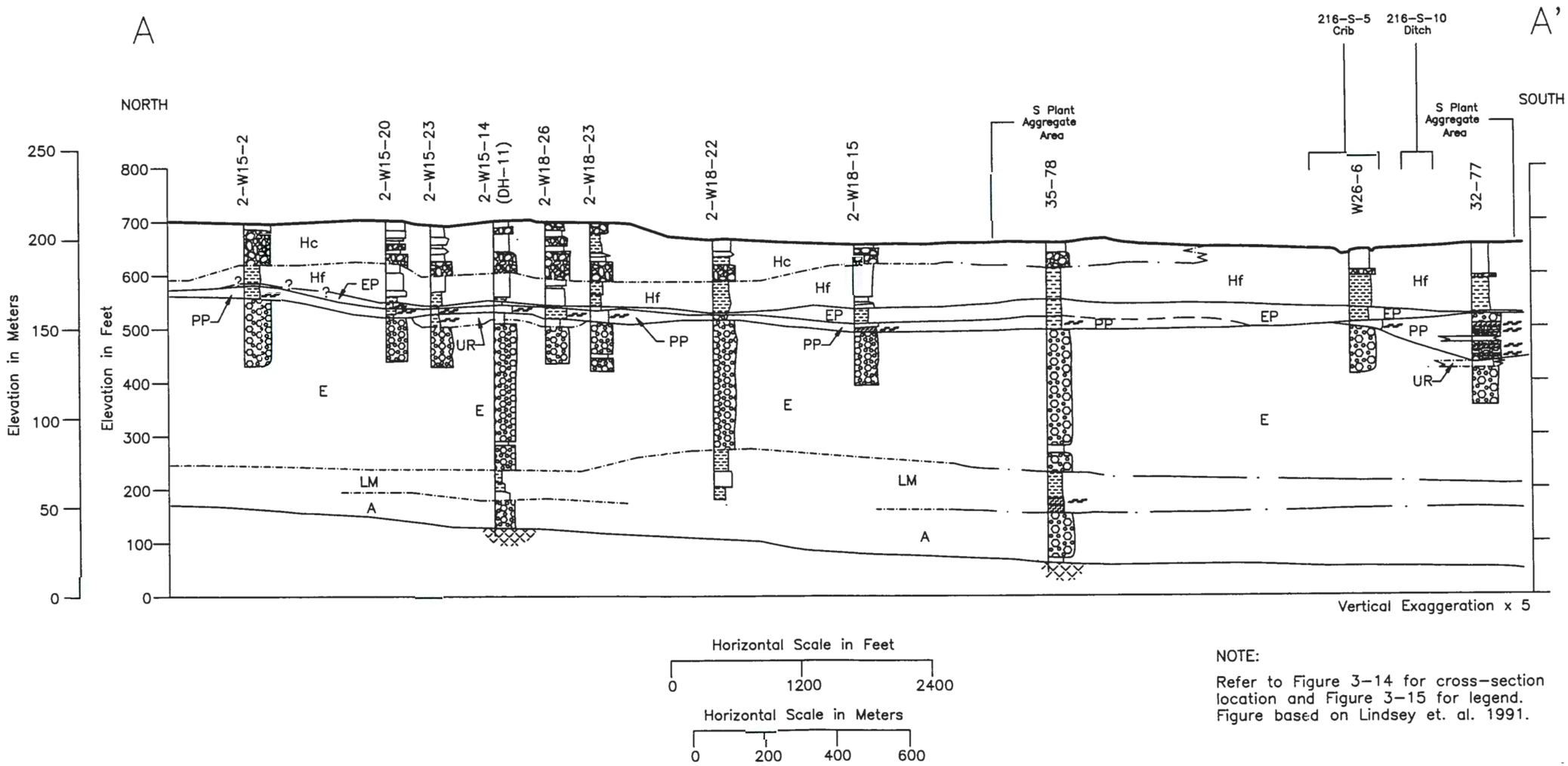
Basalt

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 3–19.

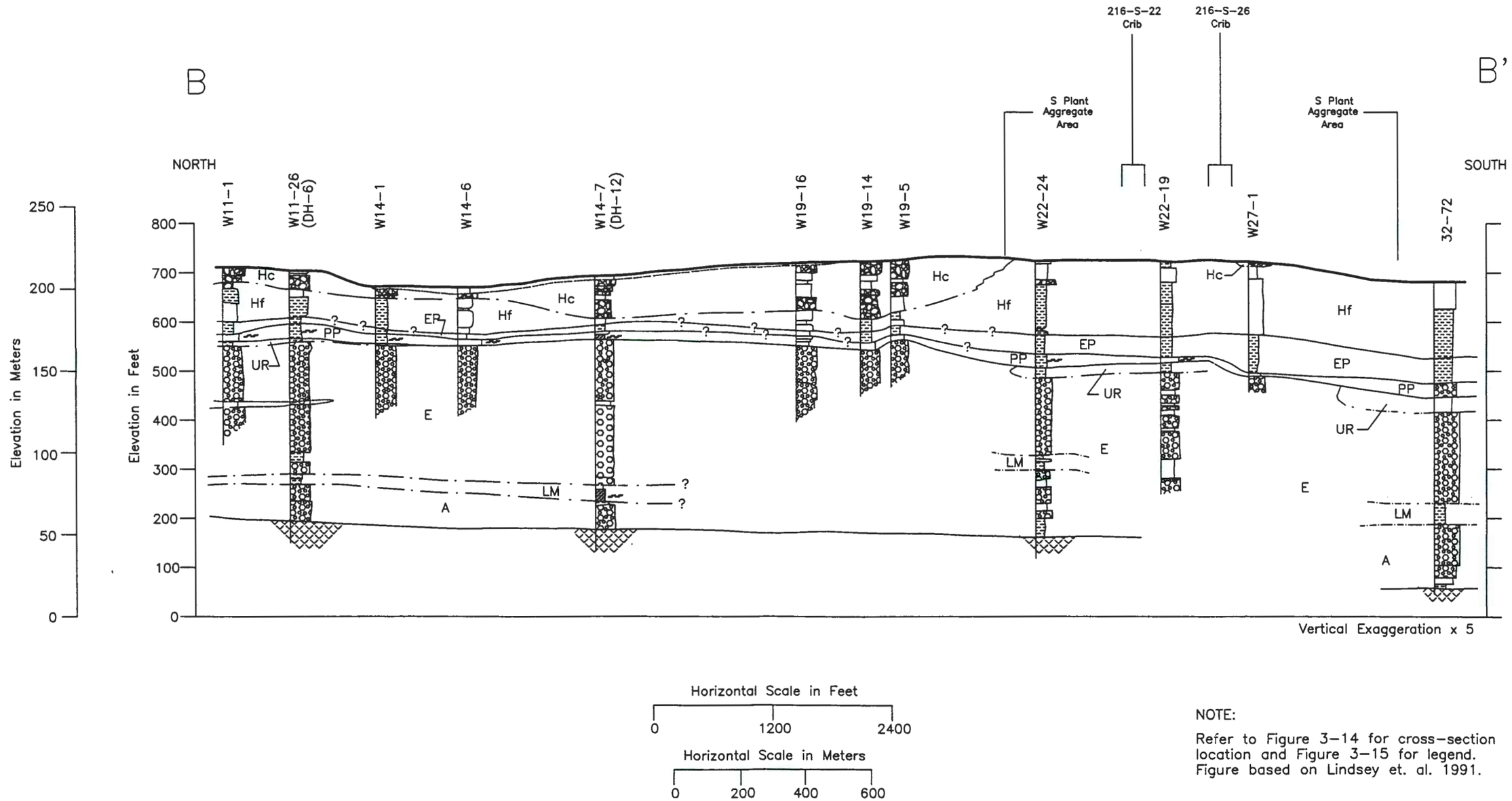
2. Figures based on Lindsey et al. 1991.



NOTE:

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

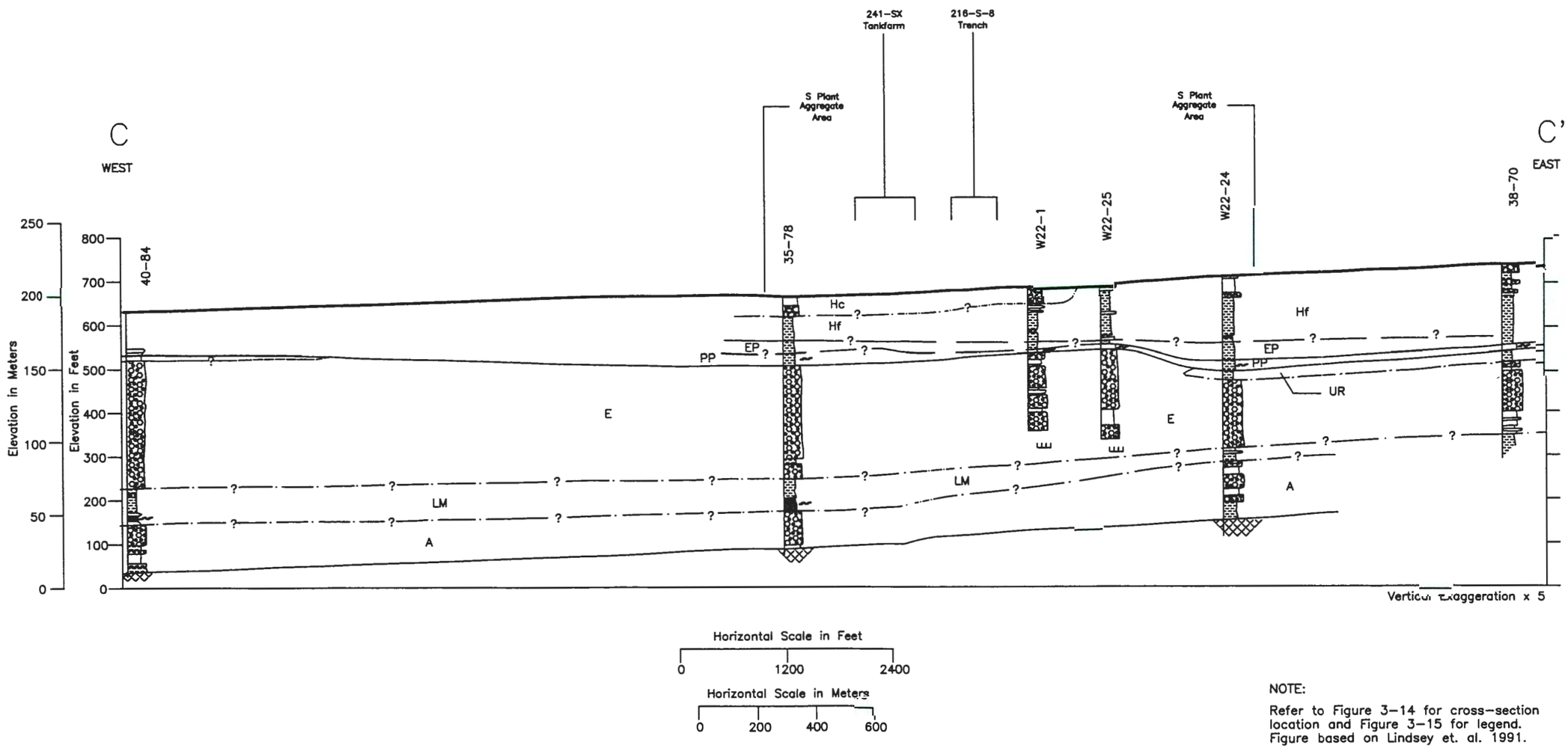
Figure 3-16. Geologic Cross-Section A-A'.



NOTE:

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

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

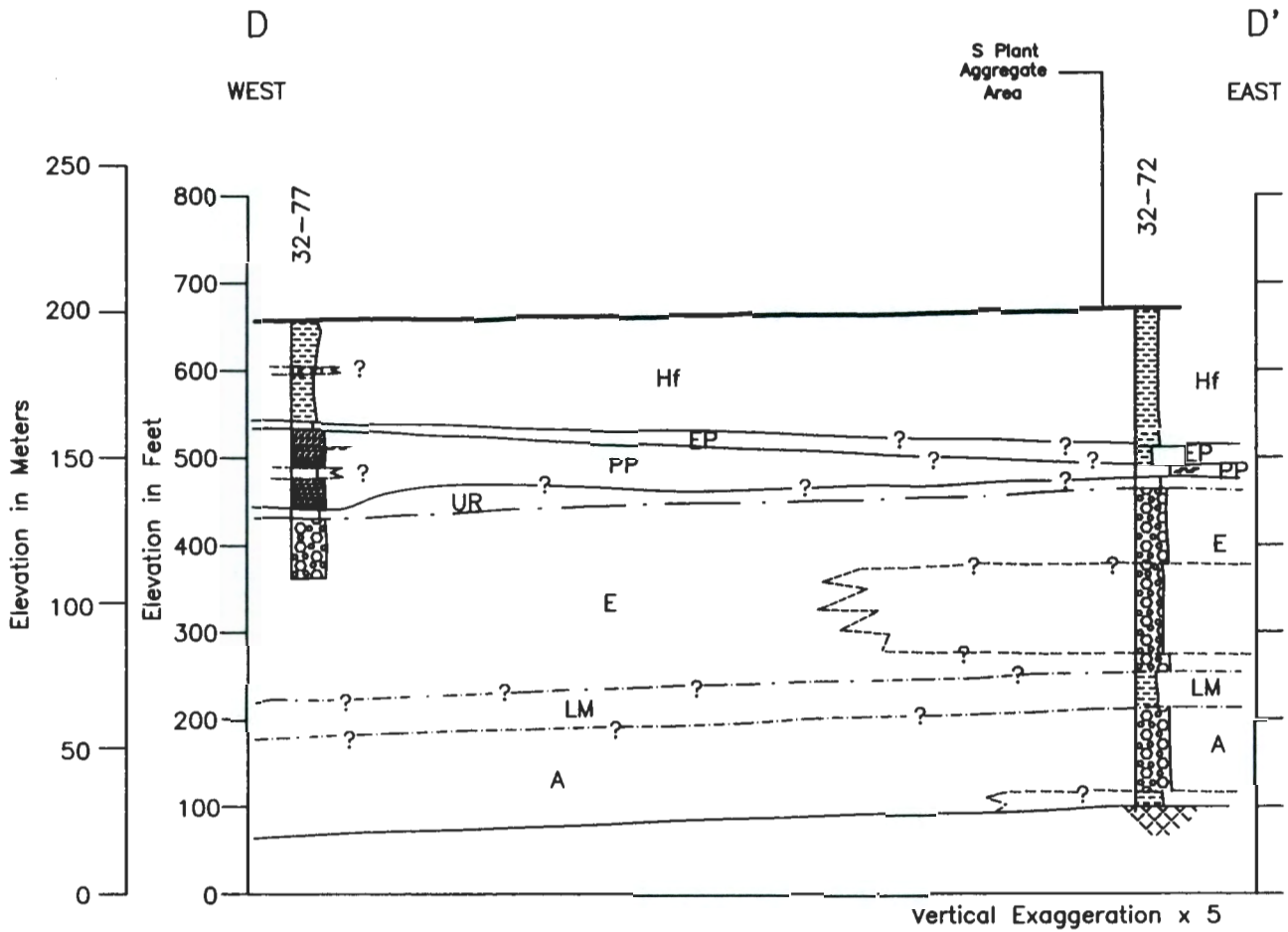


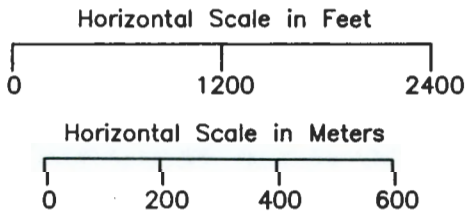
NOTE:

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. Geologic Cross-Section C-C'.

Figure 3-19. Geologic Cross-Section D-D'.





NOTE:

Refer to Figure 3-14 for cross-section location and Figure 3-15 for legend. Figure based on Airhart et. al. 1990.

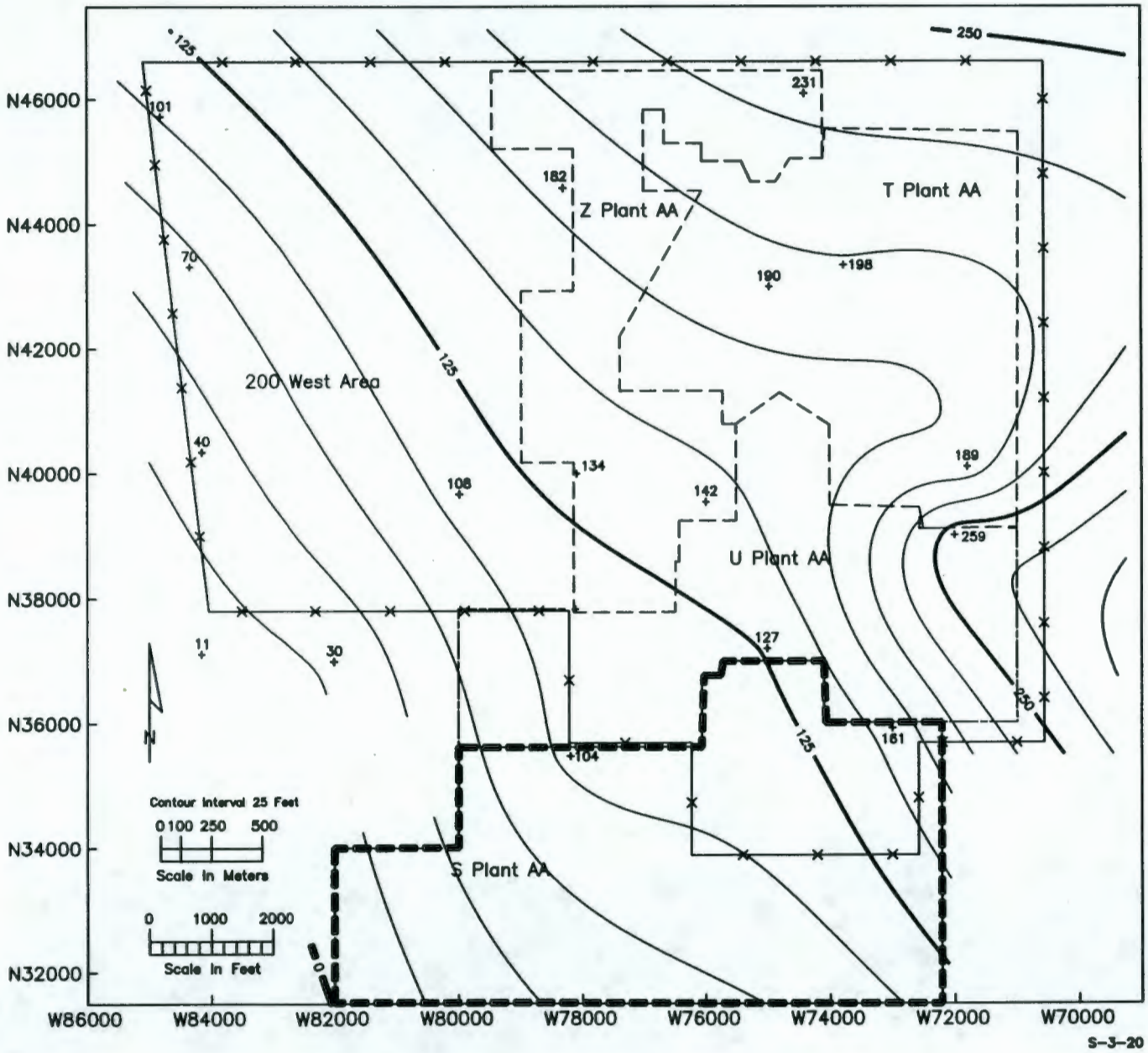


Figure 3-20. Top of the Elephant Mountain Basalt.

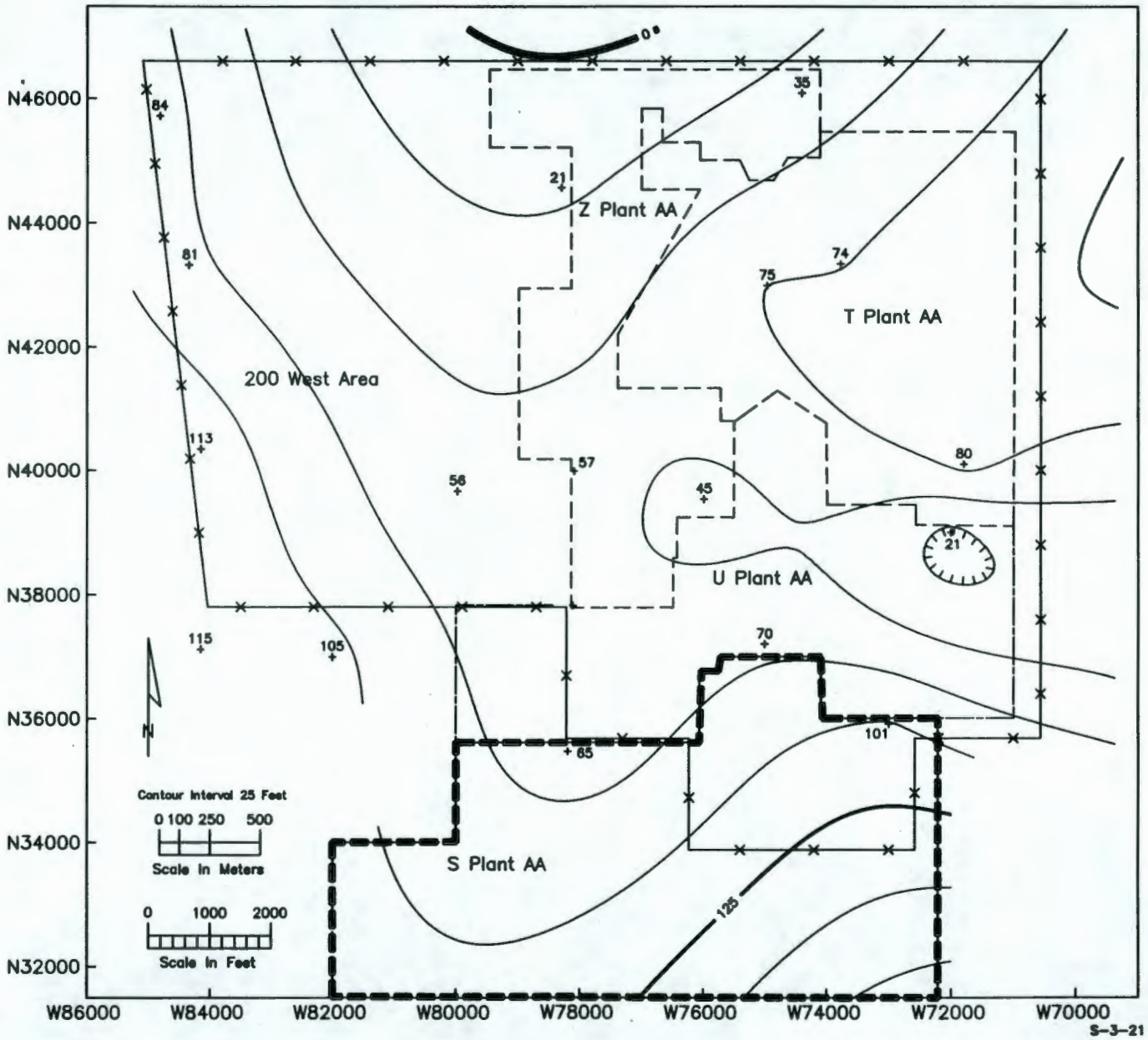


Figure 3-21. Isopach Map of the Ringold Gravel Unit A.

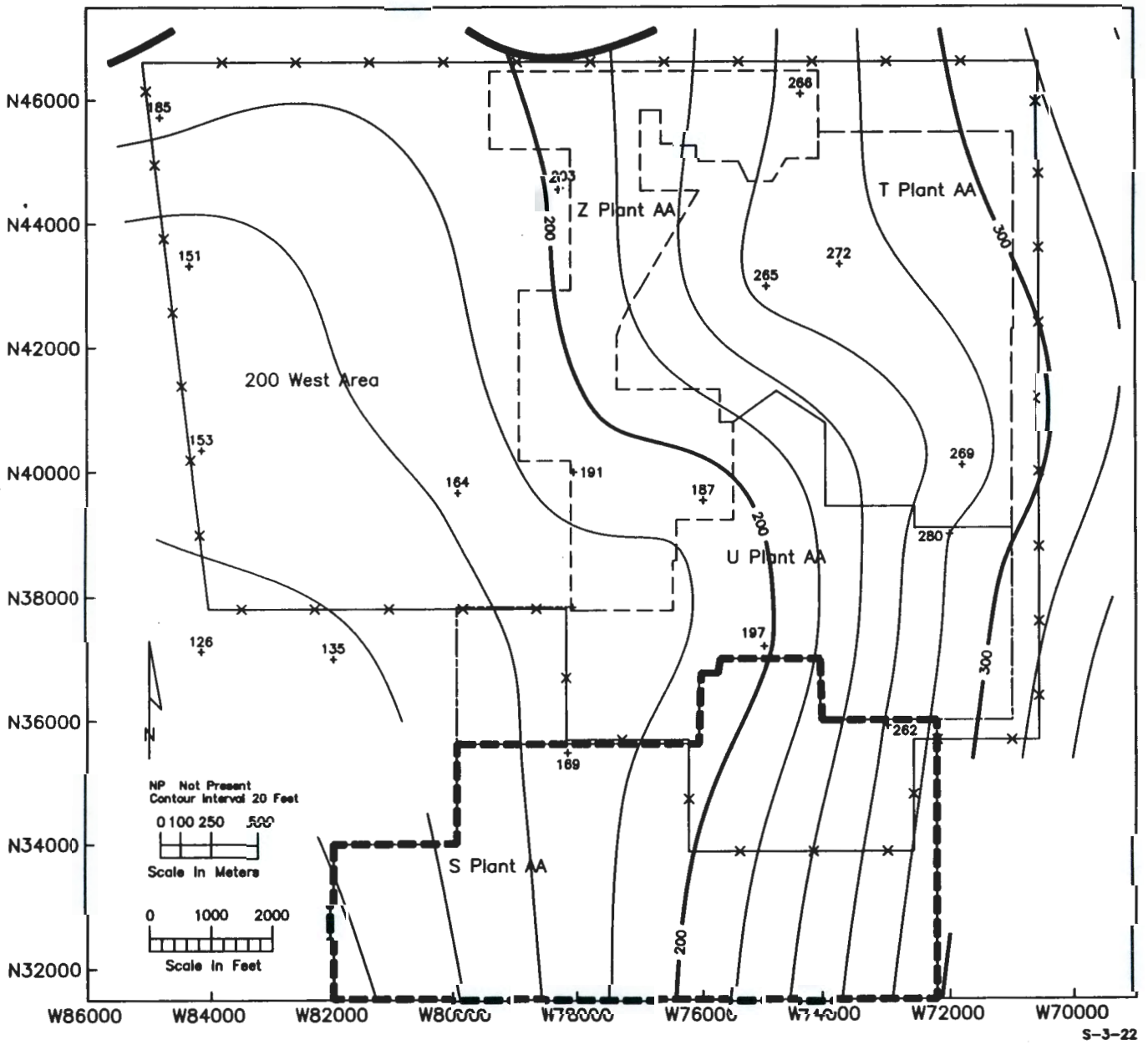


Figure 3-22. Structure Map of the Ringold Gravel Unit A.

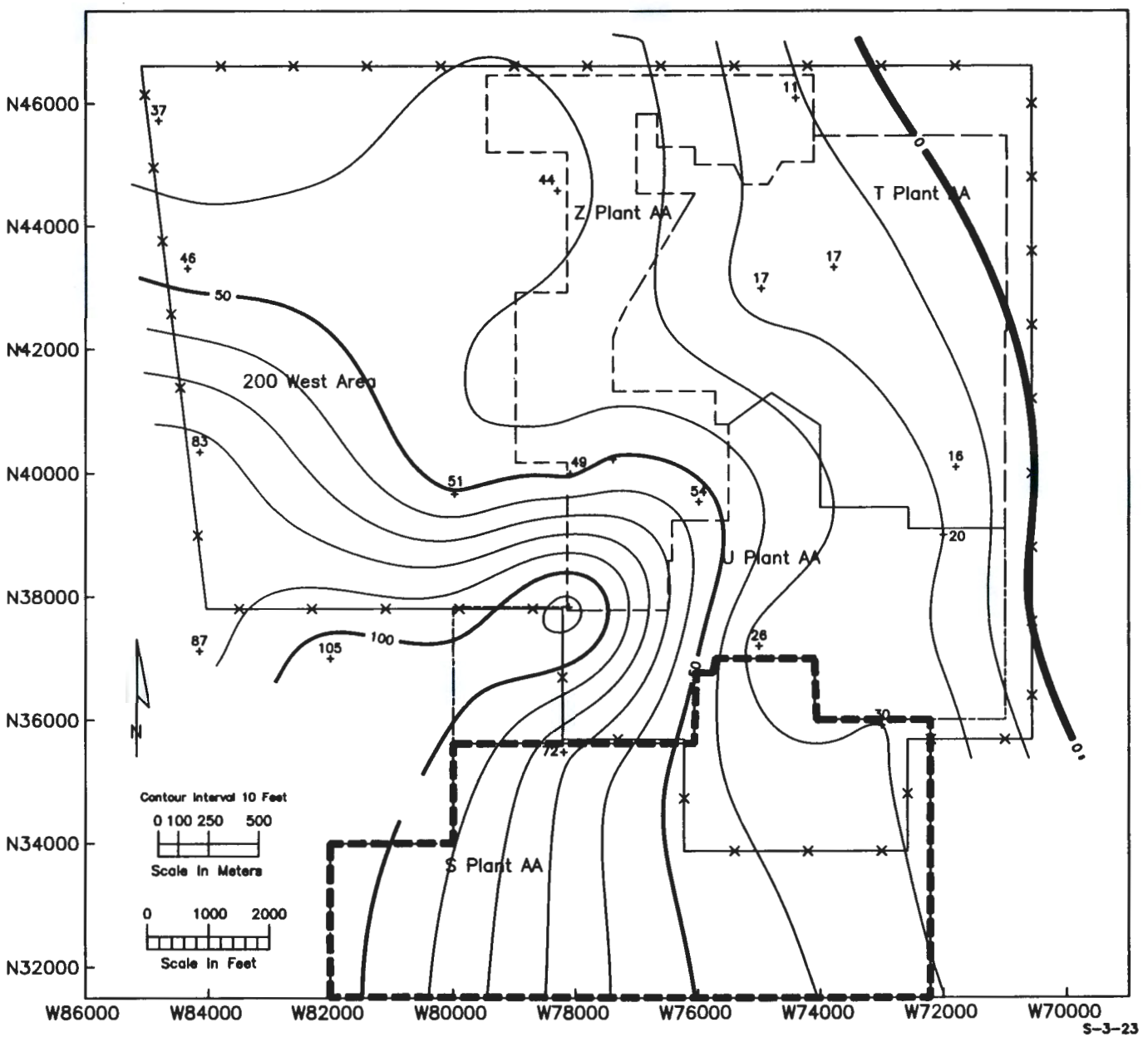


Figure 3-23. Isopach Map of the Ringold Lower Mud Unit.

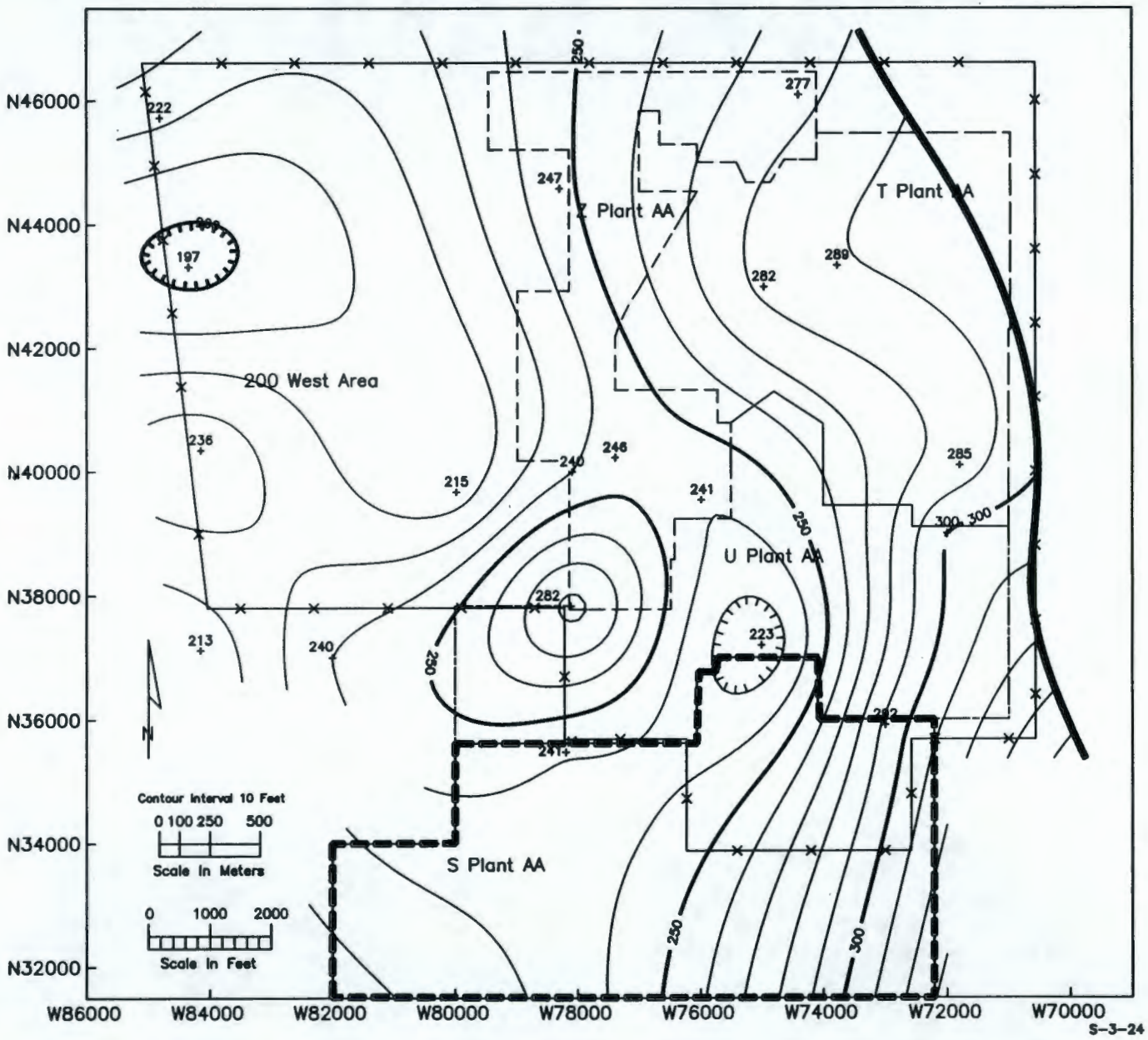


Figure 3-24. Structure Map of the Ringold Lower Mud Unit.

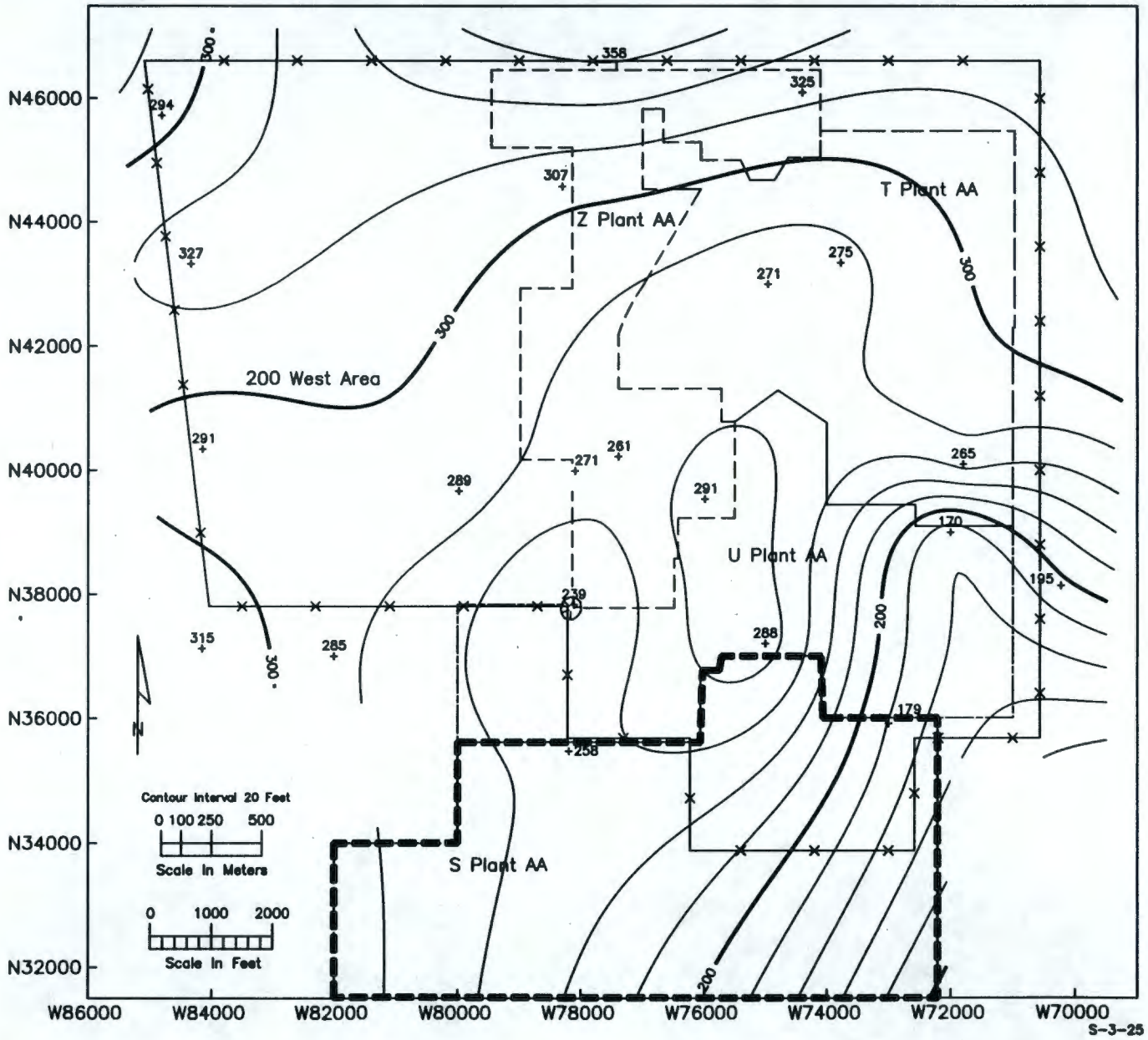


Figure 3-25. Isopach Map of the Ringold Gravel Unit E.

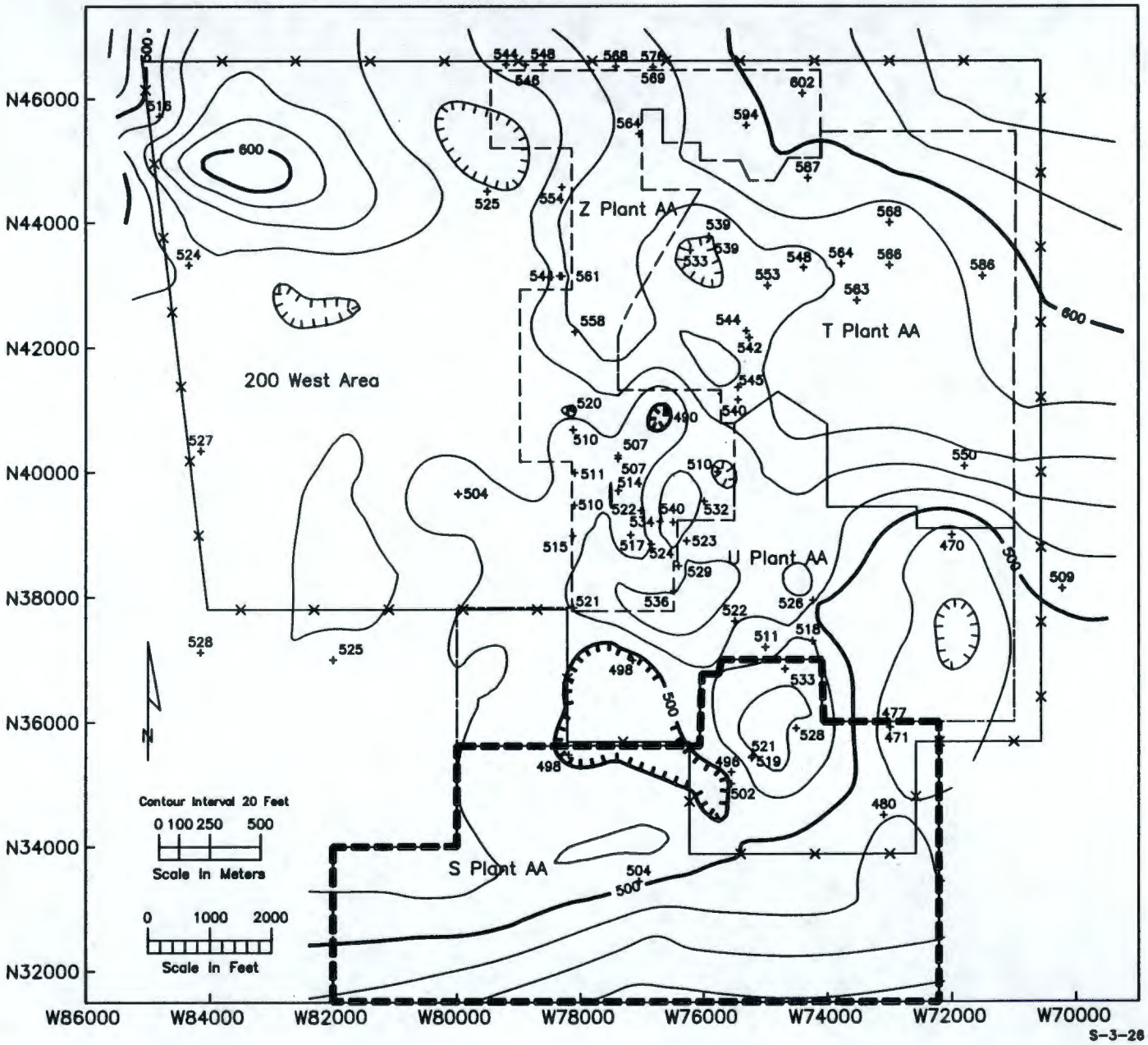


Figure 3-26. Structure Map of the Ringold Gravel Unit E.

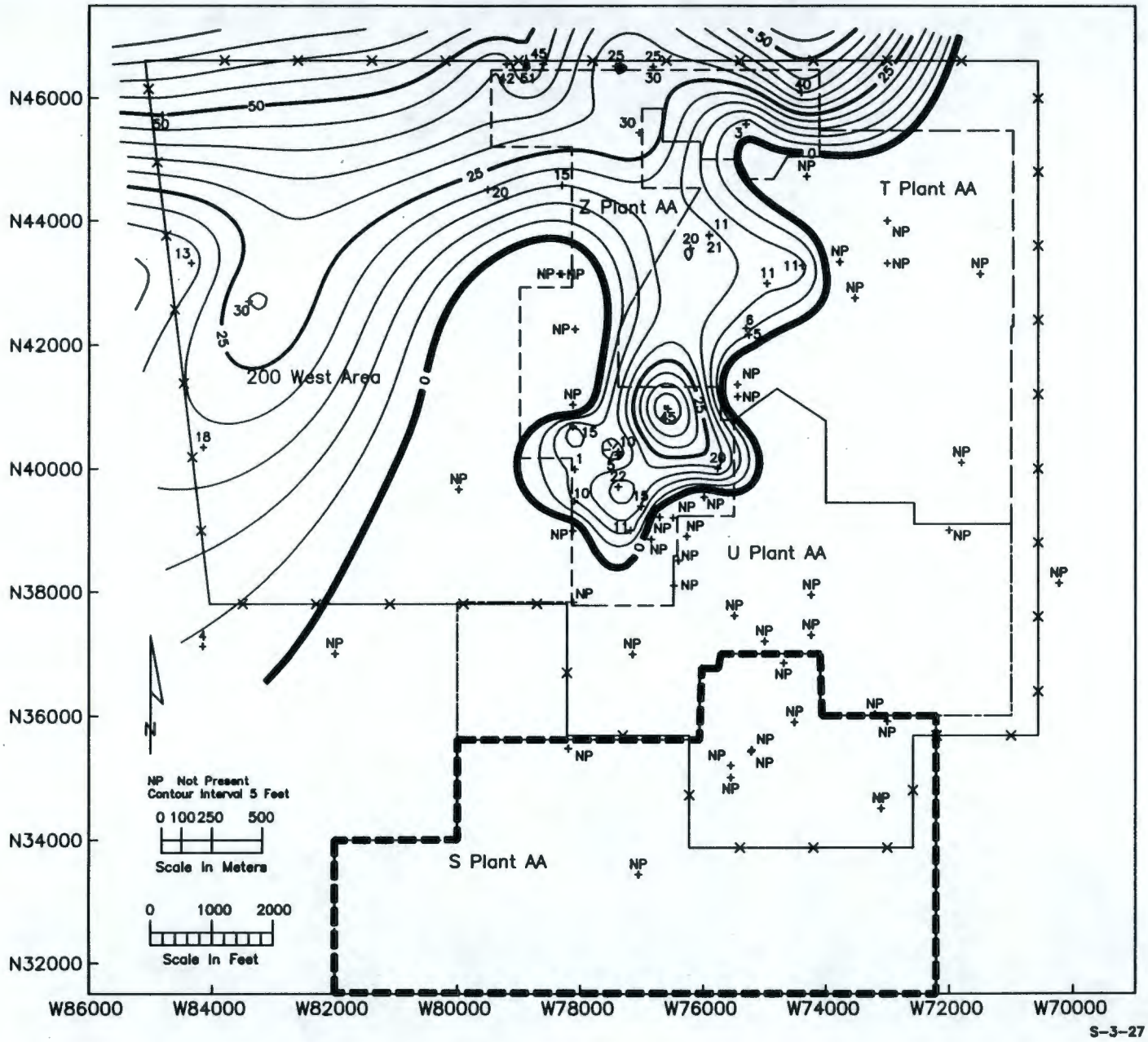


Figure 3-27. Isopach Map of the Upper Ringold Formation.

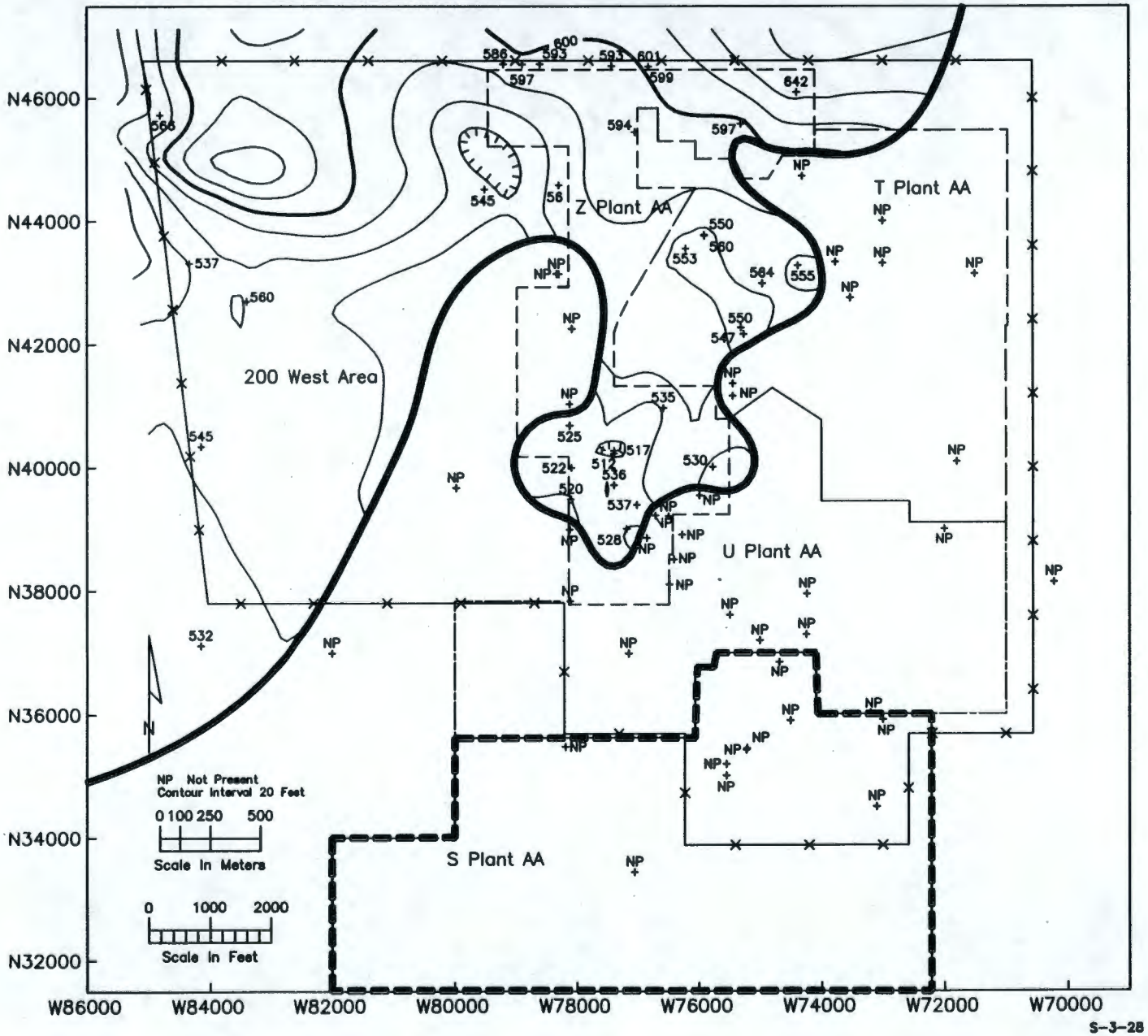


Figure 3-28. Structure Map of the Upper Ringold Formation.

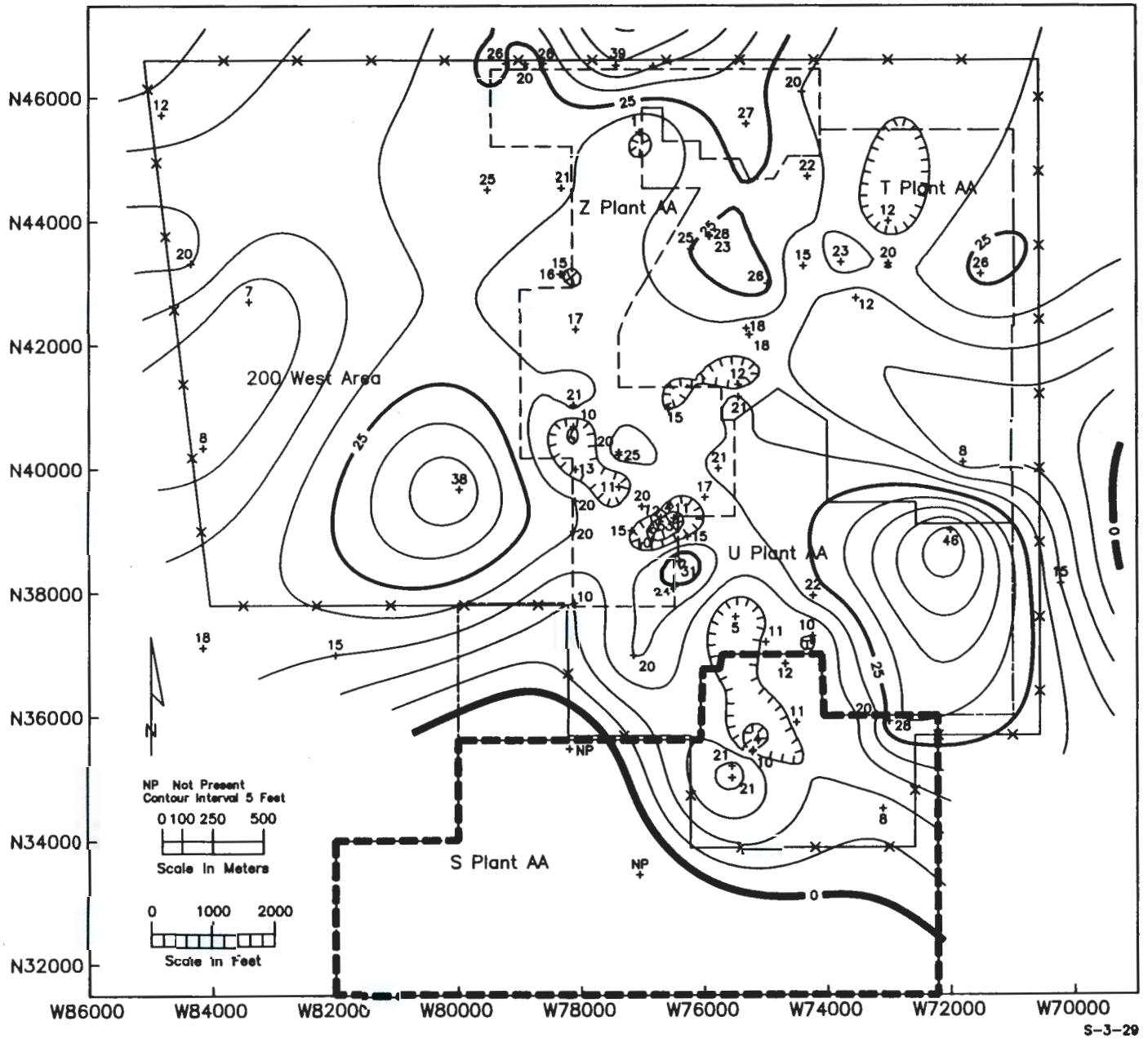


Figure 3-29. Isopach Map of the Plio-Pleistocene Unit.

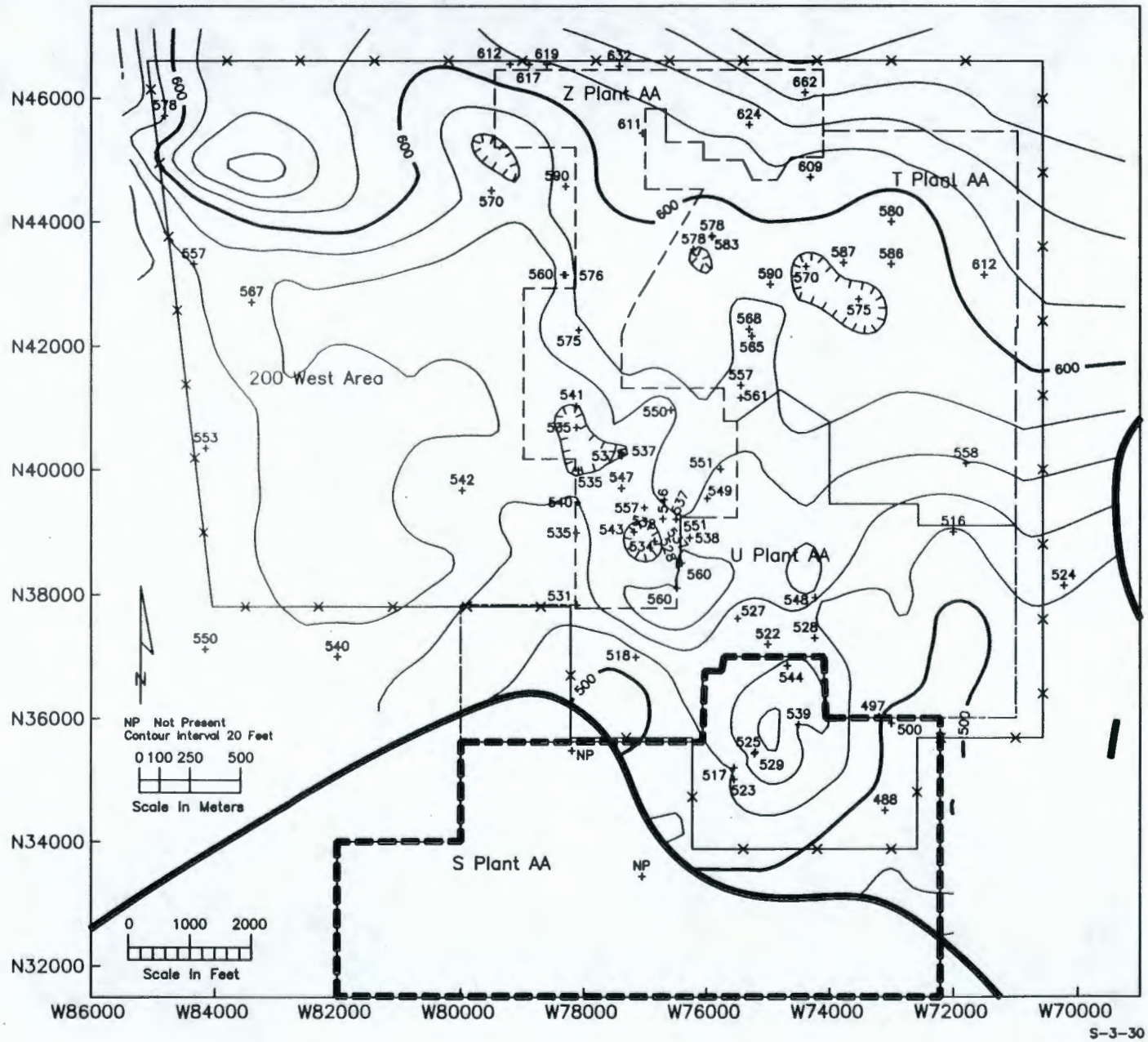


Figure 3-30. Structure Map of the Plio-Pleistocene Unit.

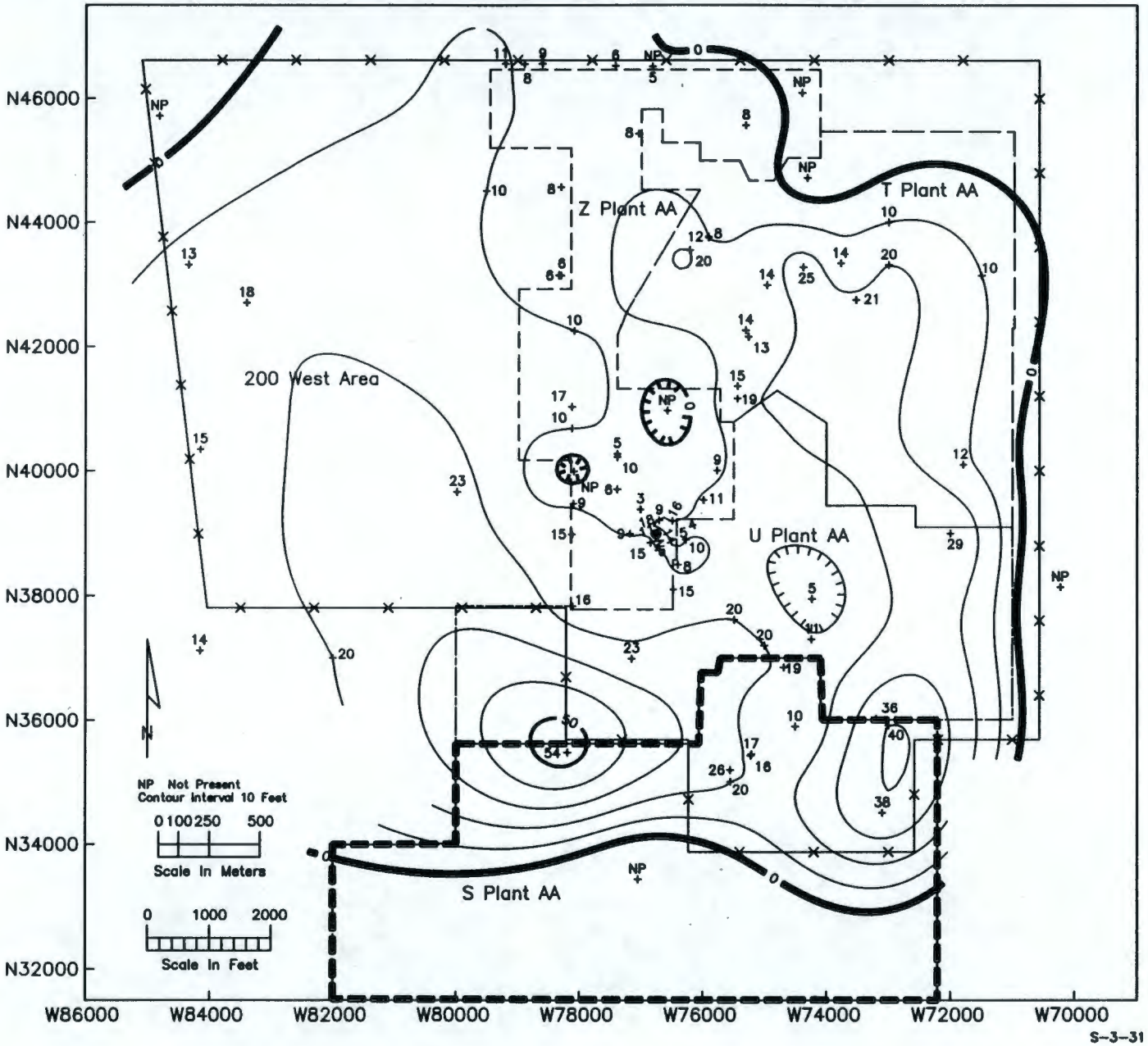


Figure 3-31. Isopach Map of the Early "Palouse" Soils.

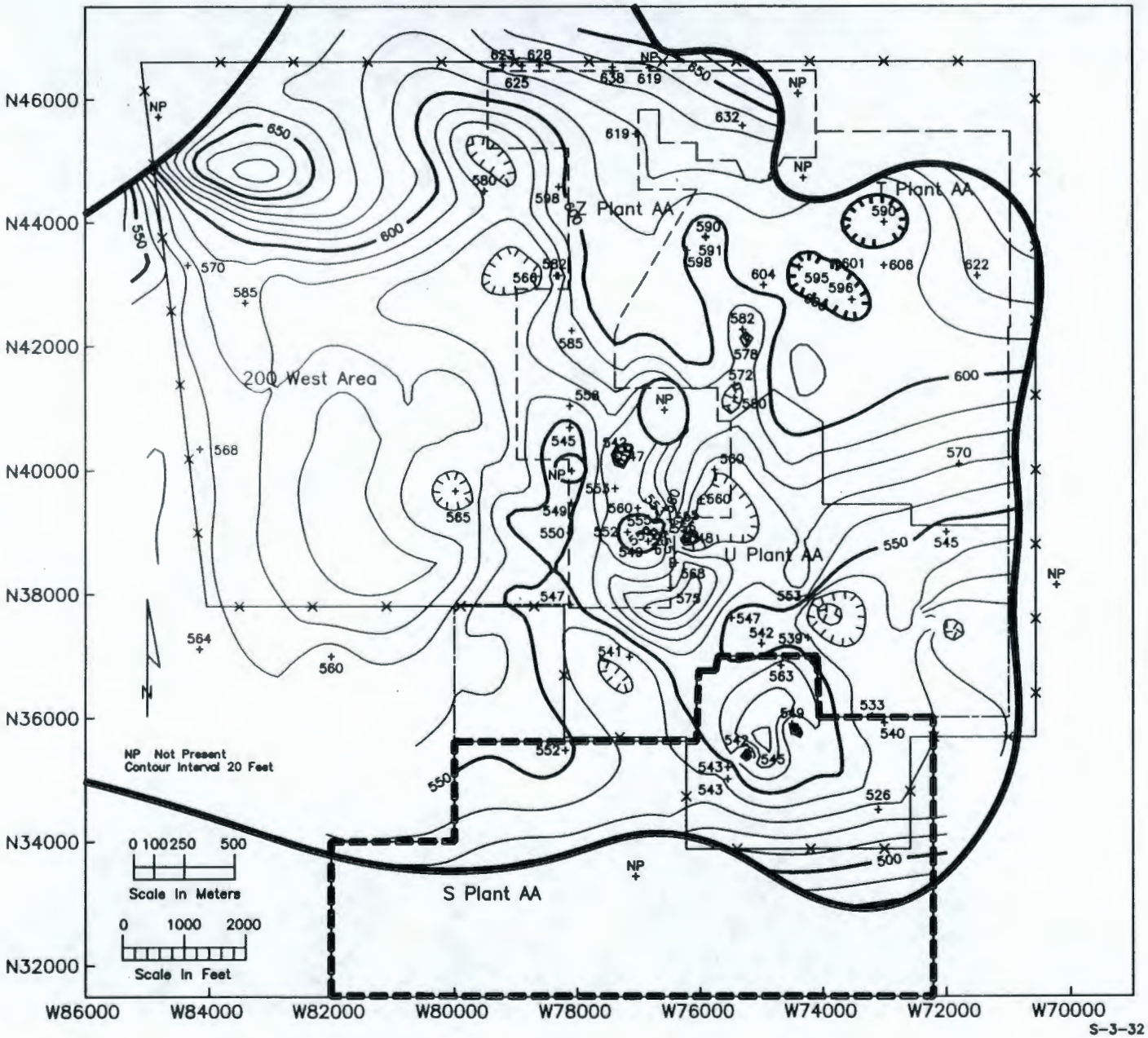


Figure 3-32. Structure Map of the Early "Palouse" Soils.

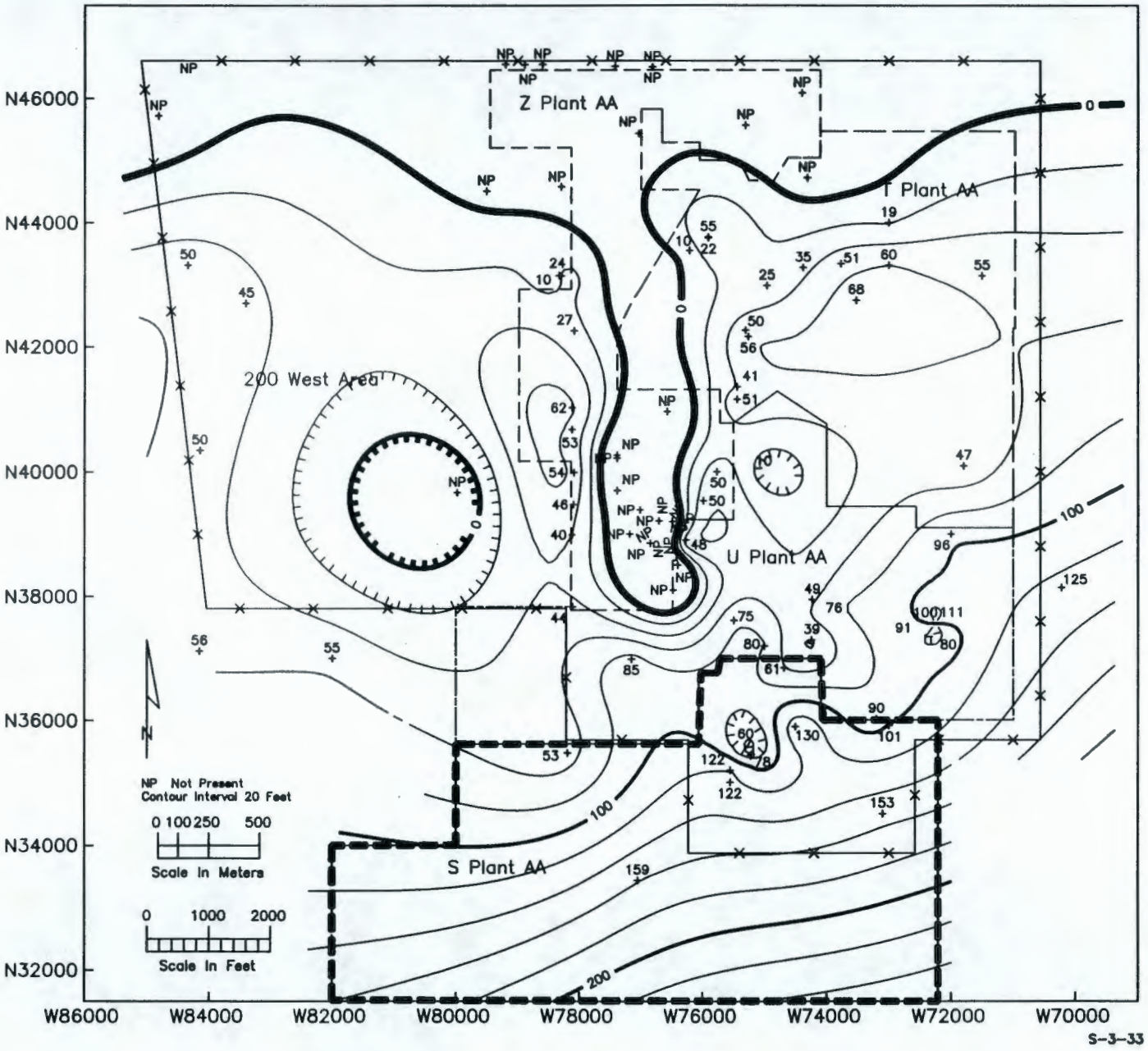


Figure 3-33. Isopach Map of the Lower Fine-Grained Unit of the Hanford Formation.

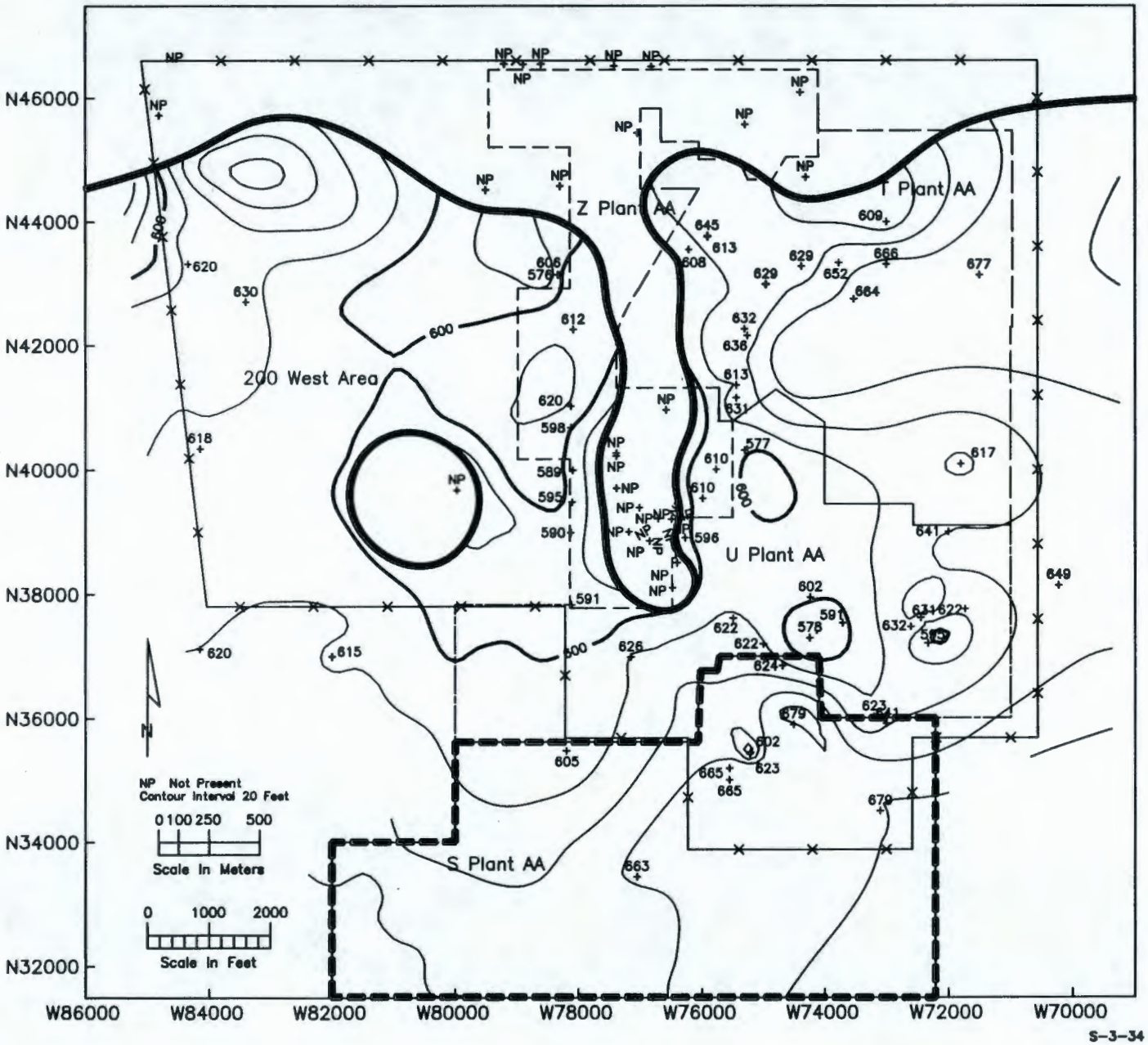
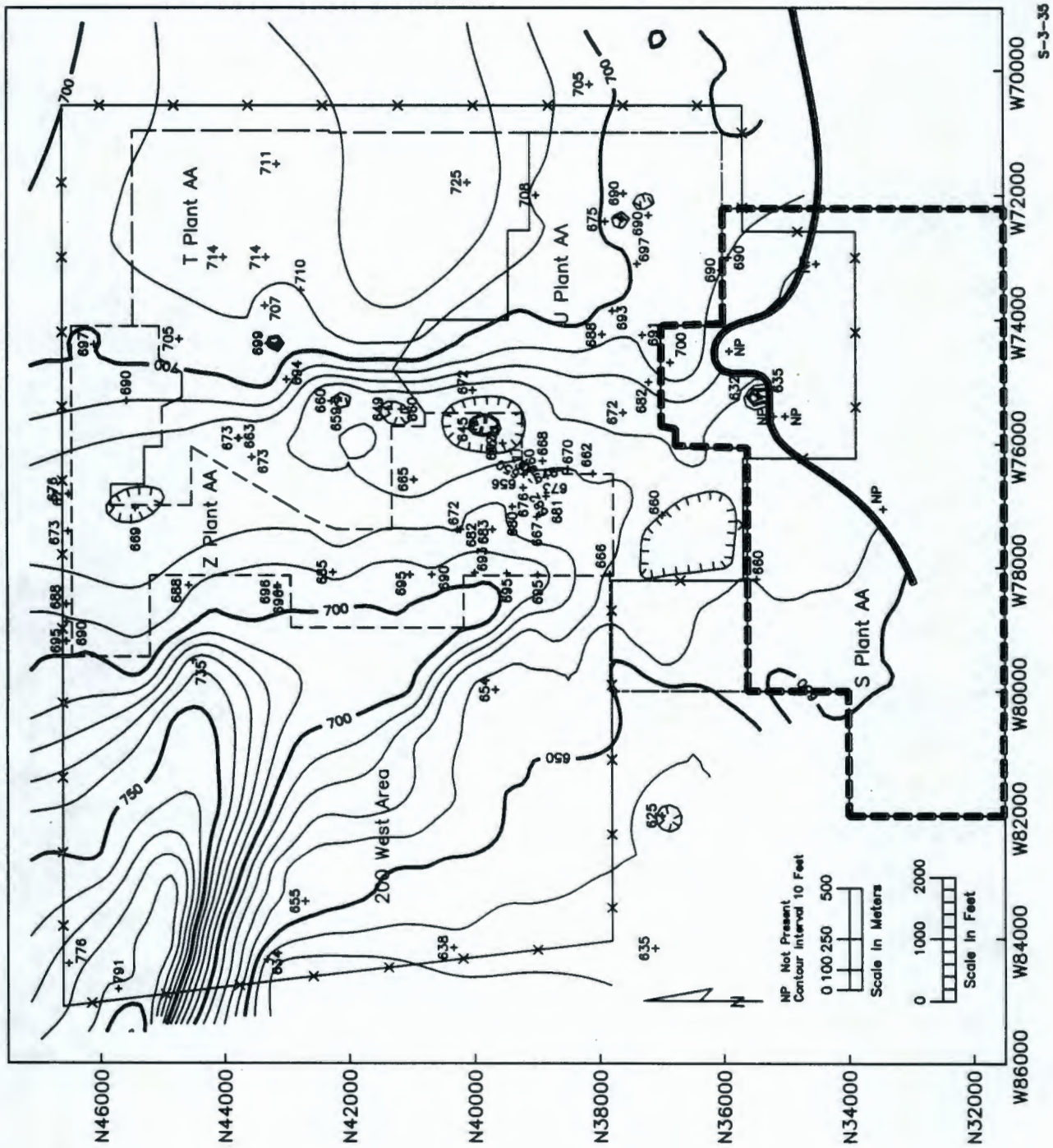


Figure 3-34. Structure Map of the Lower Fine-Grained Unit of the Hanford Formation.

Figure 3-35. Structure Map of the Silt-Dominated Facies (Slackwater) of the Hanford Formation.



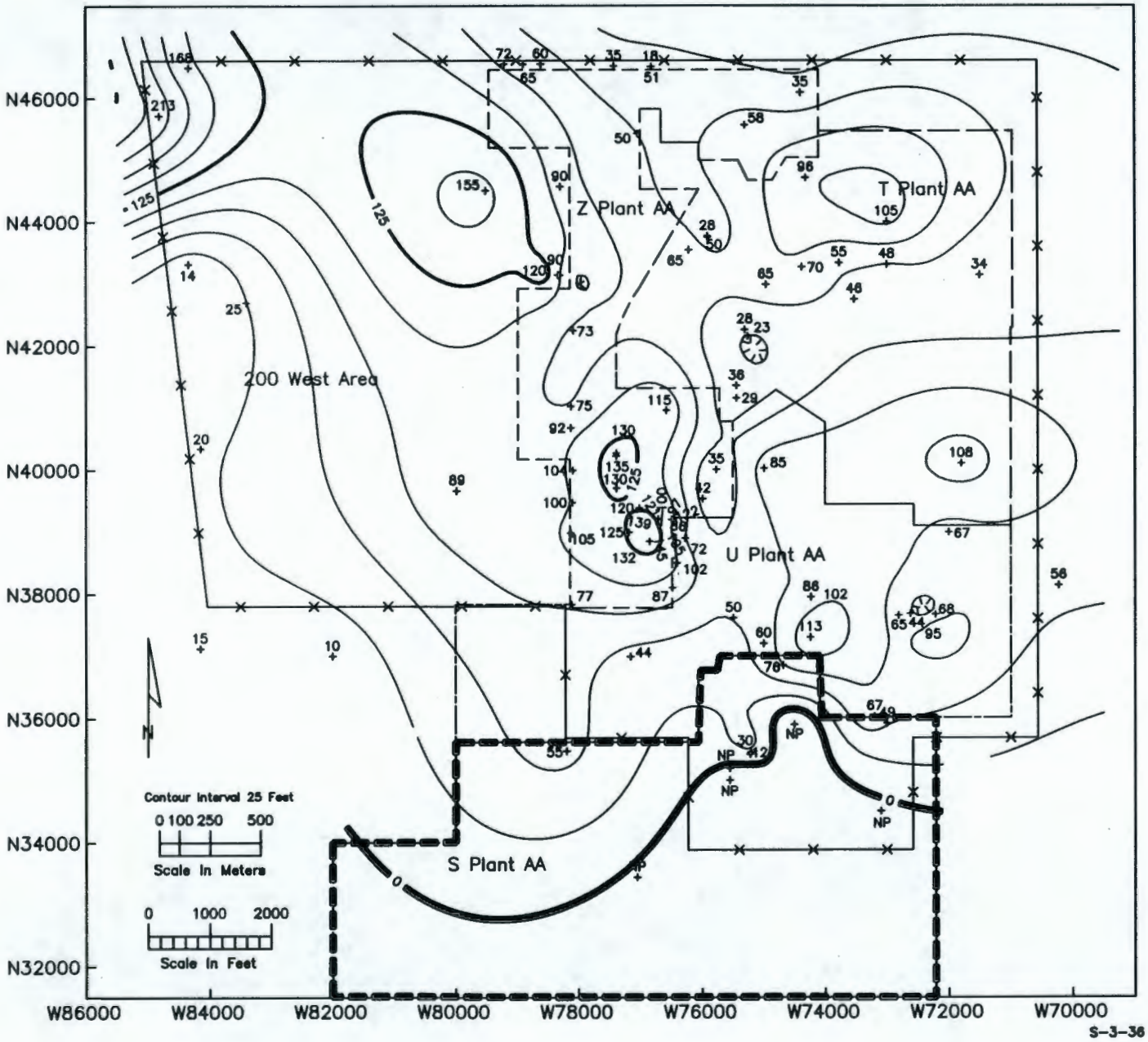


Figure 3-36. Isopach Map of the Upper Coarse-Grained Unit of the Hanford Formation.

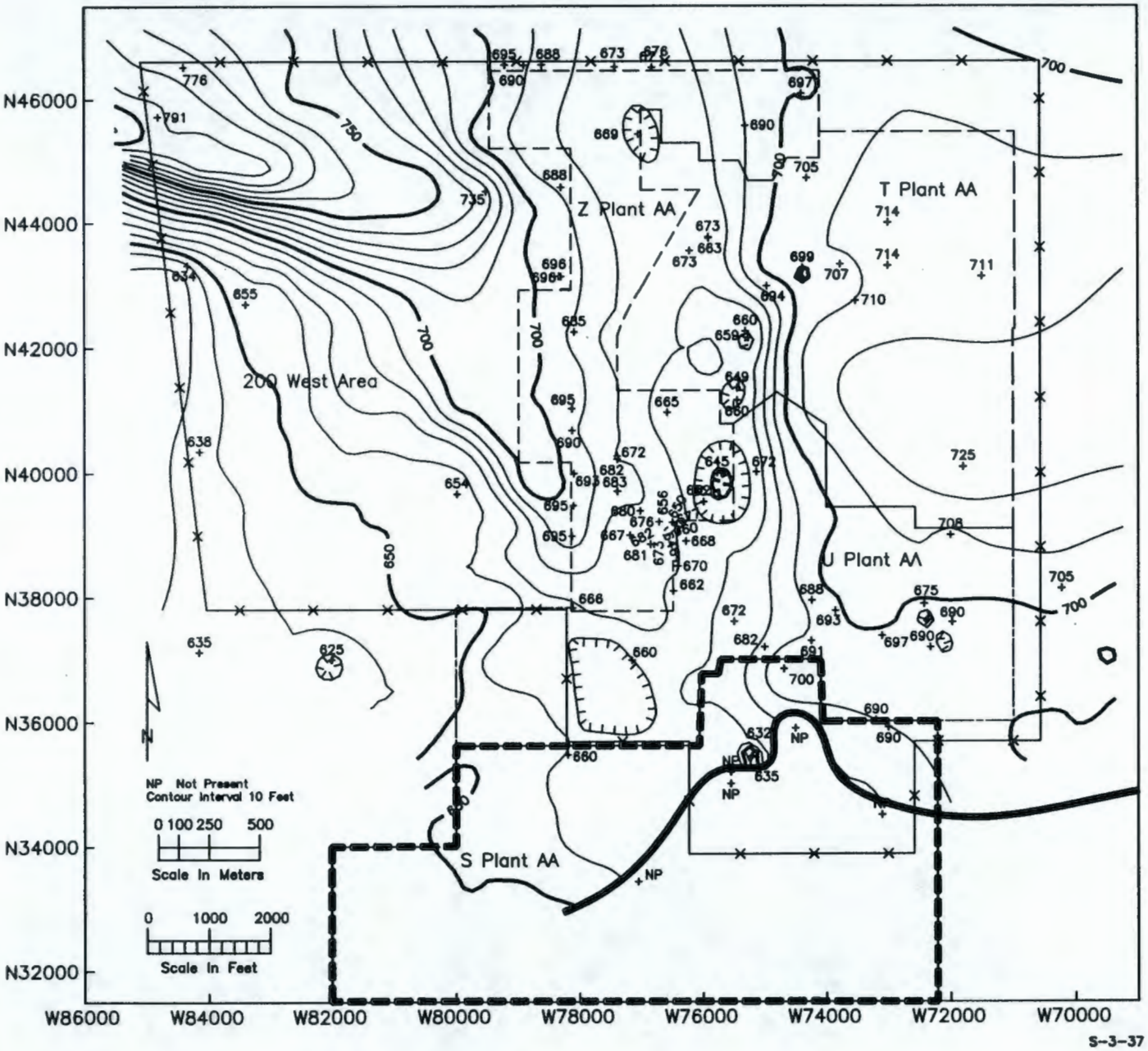


Figure 3-37. Structure Map of the Upper Coarse-Grained Unit of the Hanford Formation.

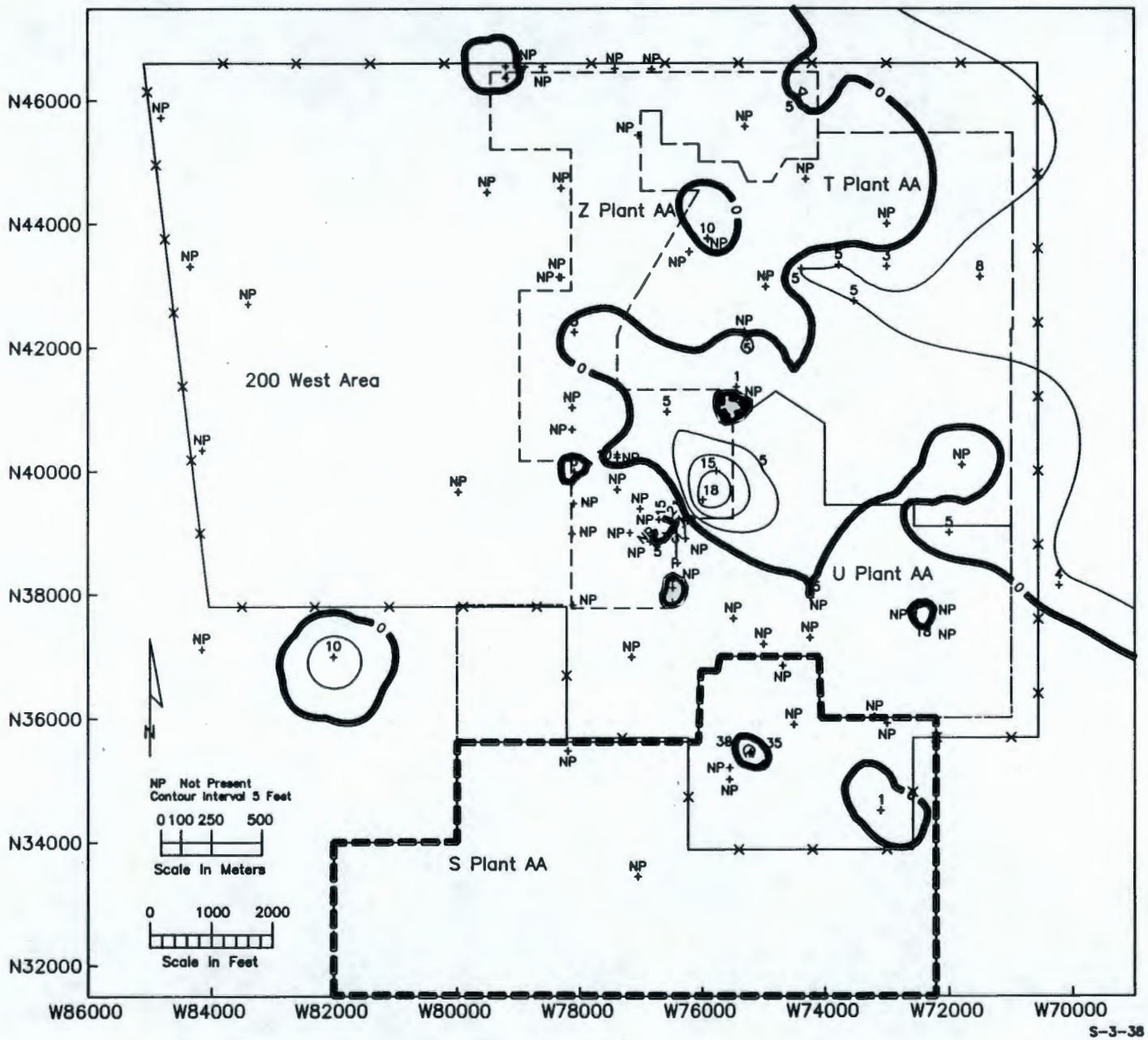


Figure 3-38. Isopach Map of the Backfilled Gravels and Eolian Sands.

Figure 3-39. Conceptual Geologic and Hydrogeologic Column for the 200 West Area.

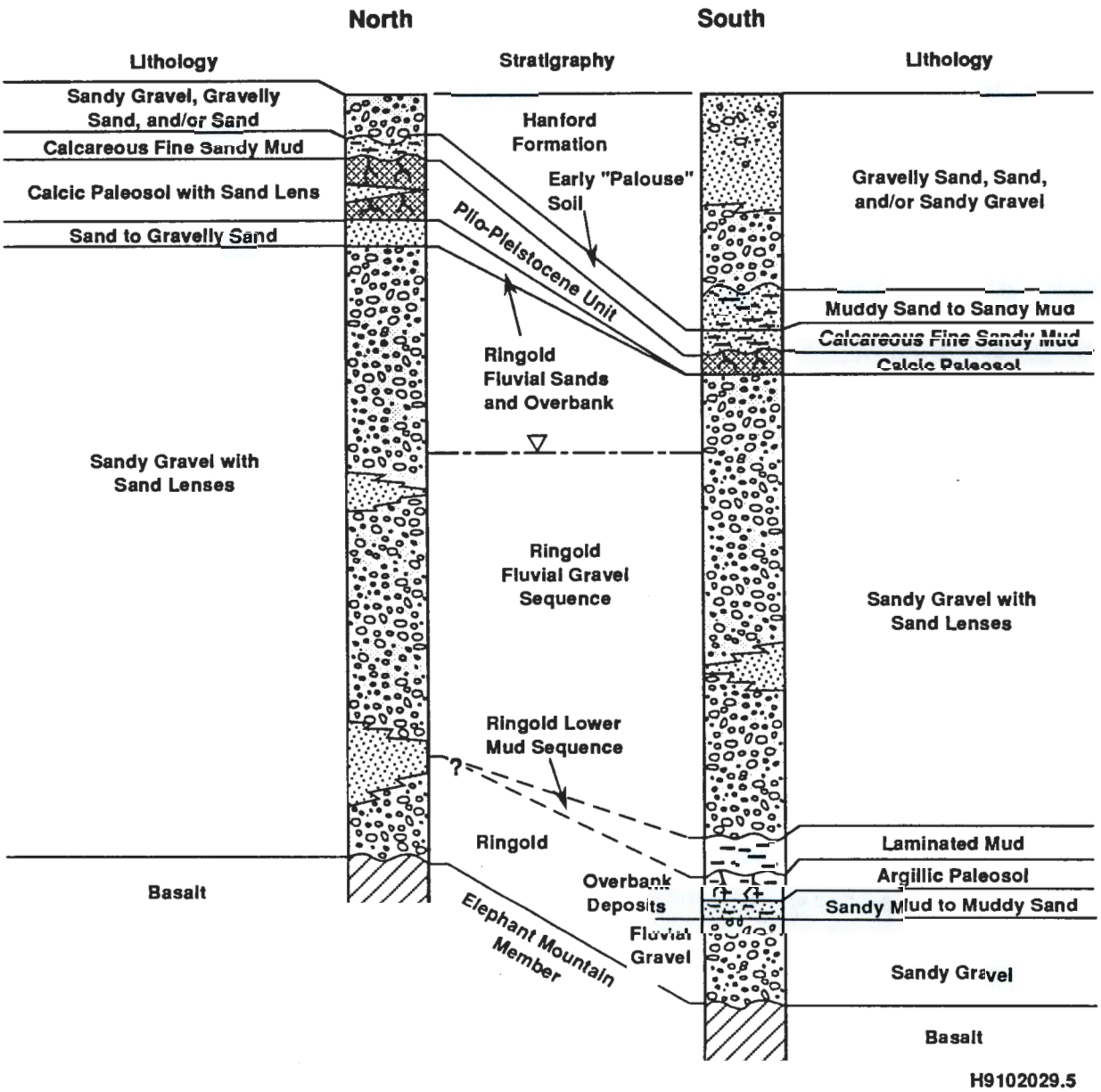


Figure 3-40. Wetting and Drying Curves for Well 299-W18-21.

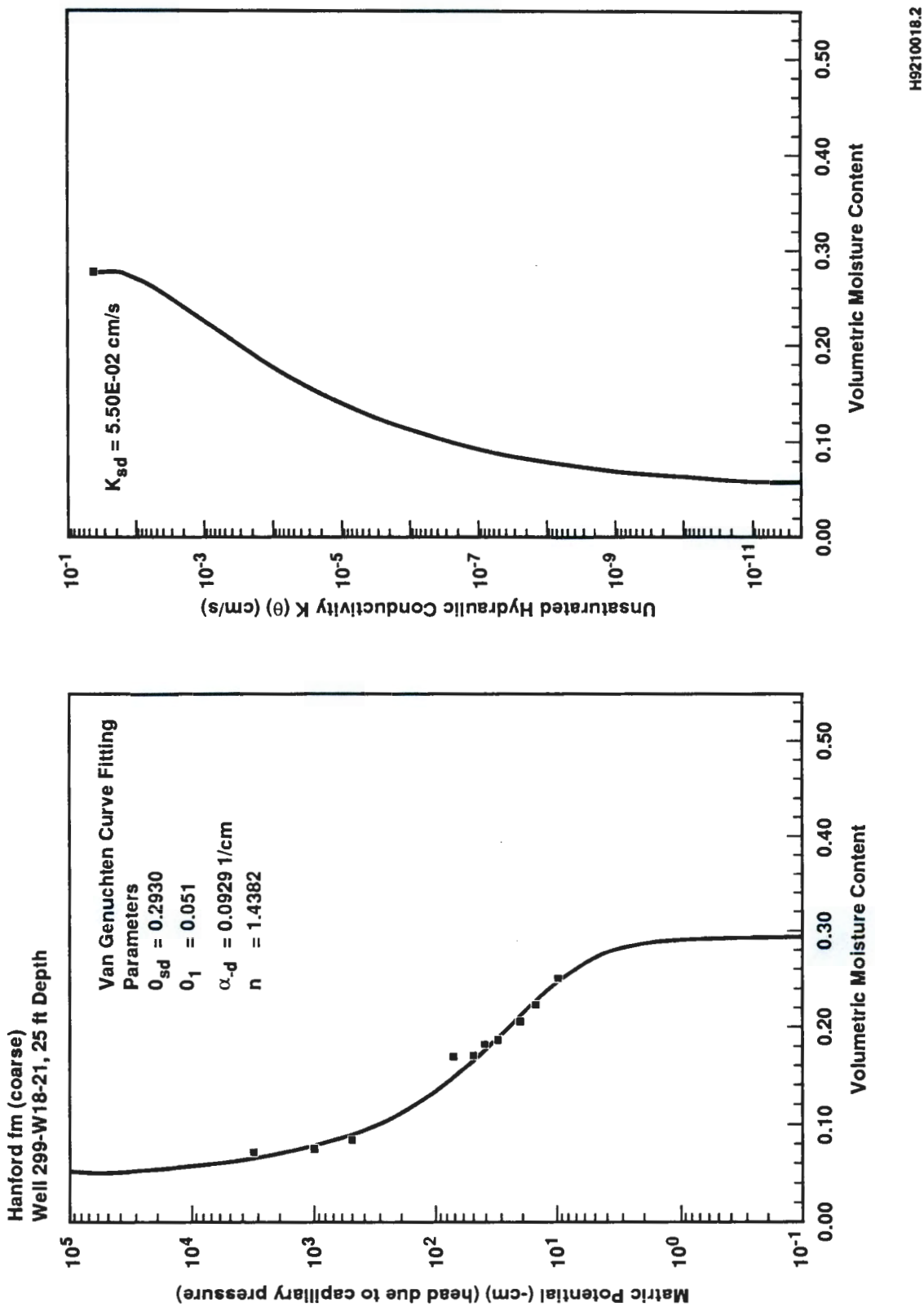
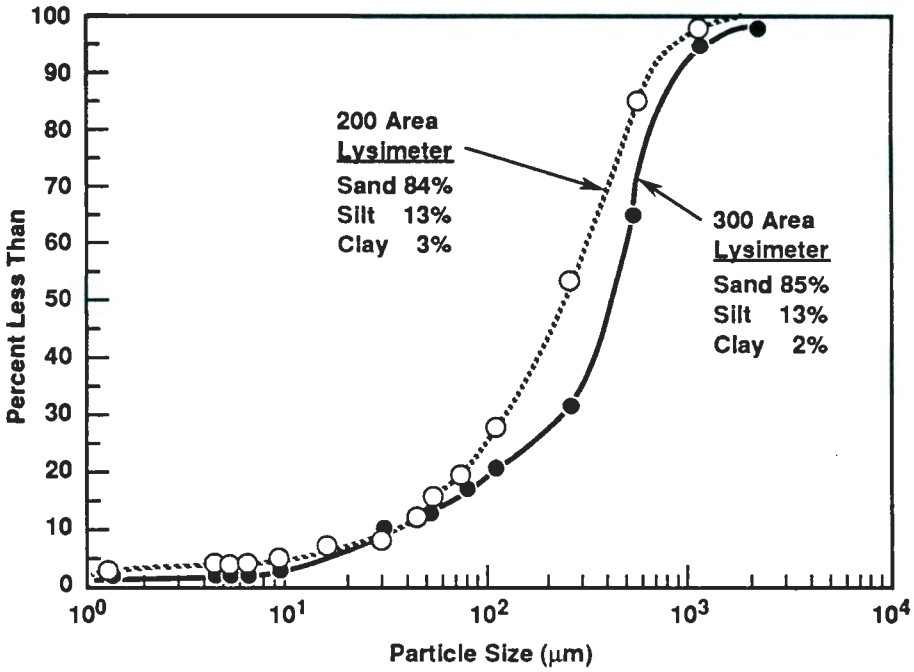
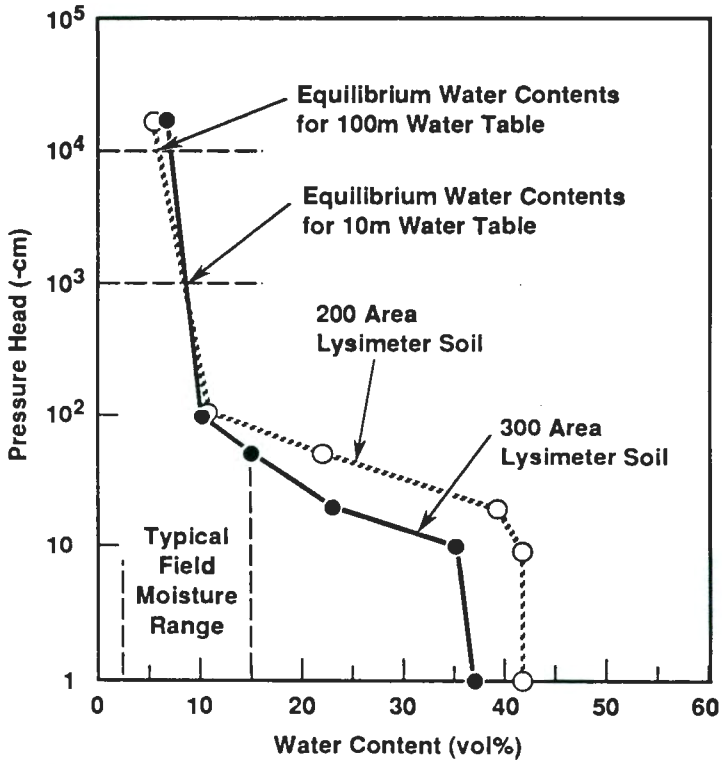


Figure 3-41. Particle-Size Distribution and Water Retention Characteristics of Soils from Hanford Site Lysimeters.



a. Particle Size Distribution



b. Water Retention Characteristics

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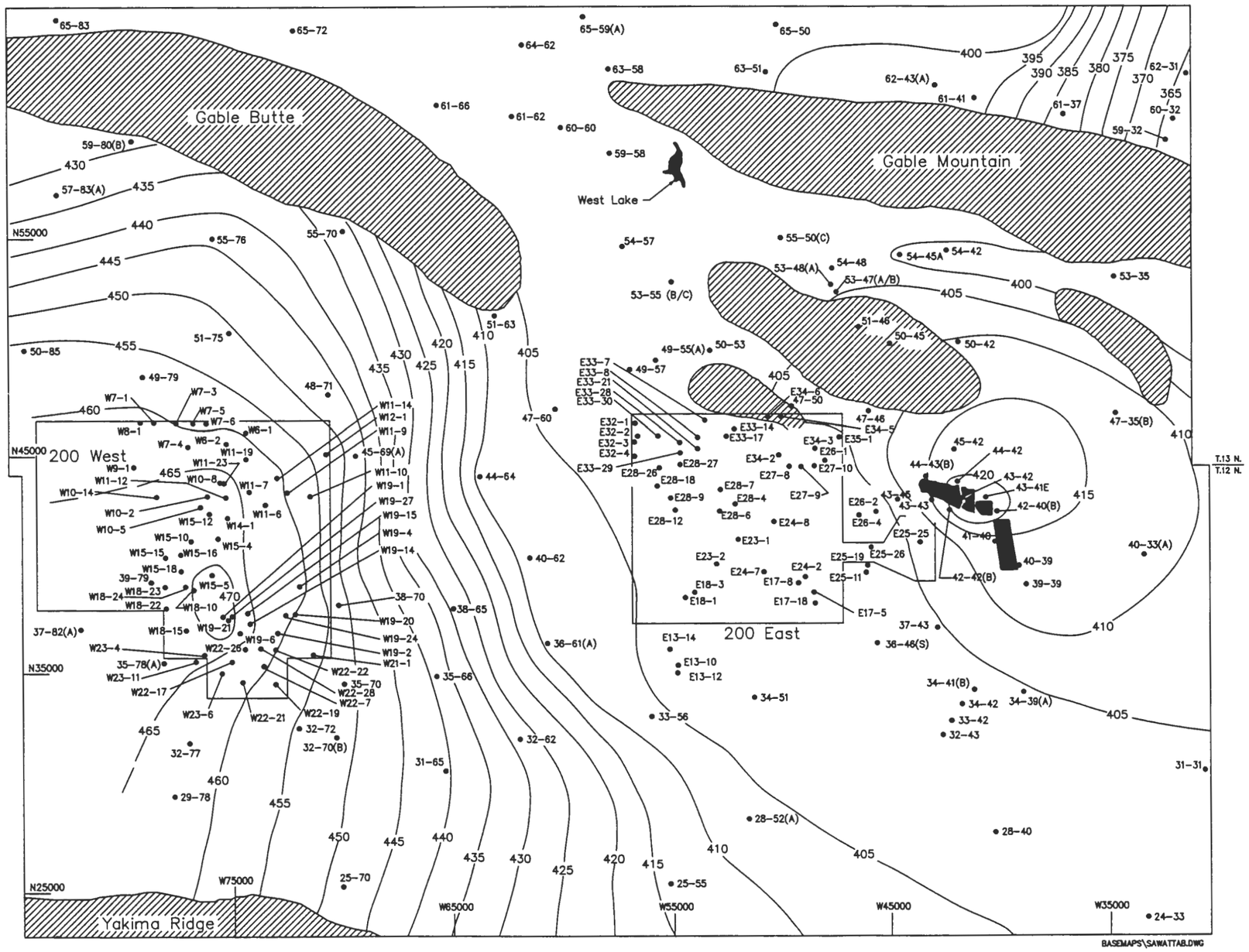
Figure 3-42.

200 Areas Water Table Map June 1990



Water table contours in feet above mean sea level

W22-26 Data points used to prepare map

Ponds

Areas where the basalt surface is generally above the water table

The 200 Areas water table map has been prepared by the Geosciences Group, Environmental Division, of Westinghouse Hanford Company.

Note: To convert to metric, multiply elevation (ft) by 0.3048 to obtain elevation (m).

0 1 Mile

0 1 Kilometer

-N-

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

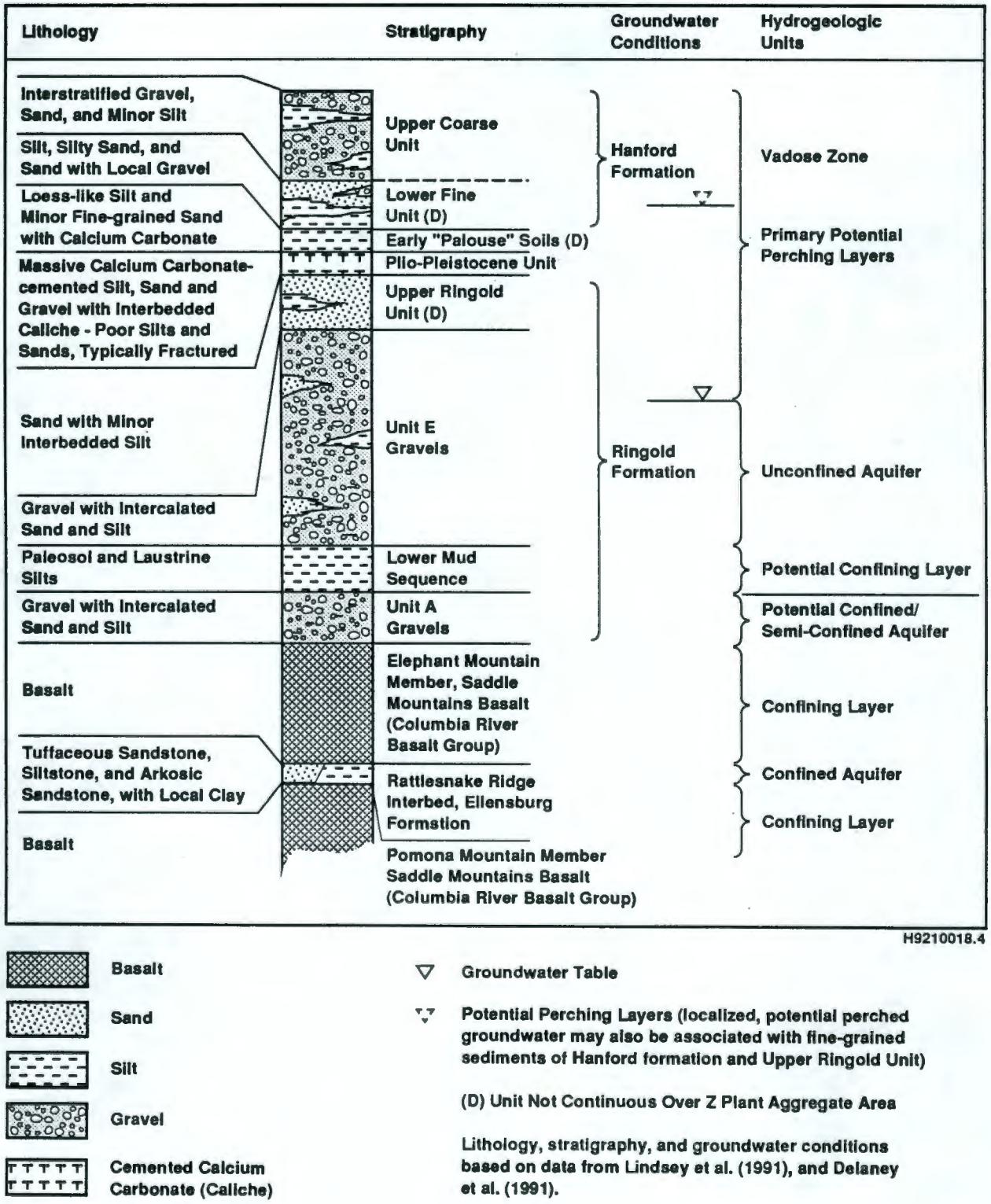


Table 3-1. Hydraulic Parameters for Various Areas and Geologic Units at the Hanford Site.

Location	Interval tested	Hydraulic conductivity (m/day)
Pasco Basin	Hanford formation	150 - 6,200
	Ringold Formation 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 216-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

9 3 1 2 8 2 9 0 9 2 2

Table 3-2. Summary of Reported Hydraulic Conductivity Values for Hanford Site Vadose Zone Sediments. Page 1 of 2

Reported Hydraulic Conductivity Value or Range of Values in cm/s	Water Content Volume Percent	Reported Geologic Unit or Sediment Type	Test Area or Sampling Location	Measurement Method or Basis for Reported Value
6.7×10^{-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

9 3 1 2 8 4 9 0 9 2 3

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

Reported Hydraulic Conductivity Value or Range of Values in cm/s	Water Content Volume Percent	Reported Geologic Unit or Sediment Type	Test Area or Sampling Location	Measurement Method or Basis for Reported Value
1×10^{-3} (Upper Soil, arithmetic mean of 7 measurements) 9.2×10^{-3} (Lower Soil, arithmetic mean of 4 measurements)	Field Saturation Field Saturation	Loam sand over sand na	Grass Site; 3 km of BWTF	Guelph permeameter field measurements
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.

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

Scientific Name	Common Name	Family	Washington State Status
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
Astragulus 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.

9 3 1 2 8 6 9 0 9 2 5

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

Common 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 lucovicianus)*	--	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 State 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 potential applicable or relevant and appropriate requirements (ARARs) (Section 6.0). Contaminant information is assessed in Section 7.0 to provide a basis for selecting technologies which can be implemented at the units.

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

4.1 KNOWN AND SUSPECTED CONTAMINATION

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

Table 4-3 summarizes the types of unit-specific data for each of the waste management units. It should be emphasized that the table only summarizes what types of data are available; it does not indicate the sufficiency of the data, either in terms of quality or quantity. Data quality issues 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 units in Section 4.1.2.

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

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

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

Section 4.1 describes available data regarding known and suspected contamination in the S Plant Aggregate Area on a media-specific basis (air, surface soil and biota, and vadose zone soil). The text summarizes sources of chemical and radiological sampling information. Section 4.1.1 presents data on a media-specific basis. Section 4.1.1.1 describes results of air quality sampling data. Section 4.1.1.2 describes surface soil data. Section 4.1.1.3 presents results of surface water sampling. Results of vegetation and other biota sample analyses are presented in Section 4.1.1.4. Available vadose zone sampling data are presented in Section 4.1.1.5. Section 4.1.1.5 also discusses evidence for contamination migration within the vadose zone to the unconfined aquifer underlying the site. Additional assessment of the

nature and extent of groundwater contamination is presented in the 200 West Groundwater Aggregate Area Management Study Report (AAMSR).

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

Available data were reviewed to assess whether air, surface soil, vadose zone soil, or groundwater was potentially impacted by waste handling activities at each S Plant Aggregate Area waste management unit. Table 4-1 summarizes available information regarding known or suspected radionuclide contamination at the S Plant Aggregate Area. Table 4-2 summarizes available information regarding known and suspected chemical contamination. In Tables 4-1 and 4-2 waste management units are arranged by physical type (cribs, burial grounds, unplanned releases, etc.). Entries in the tables identify known or suspected releases based on available sampling information or historical waste inventory data.

4.1.1 Affected Media

4.1.1.1 Air. Two high volume air samplers are stationed within the S Plant Aggregate Area (Plate 3). The air samples are collected by drawing samples through a 47-mm, open-face 3μ filter at about 1 m (3 ft) above the ground 0.2 m^3/min (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.

Ambient air monitoring has been conducted within or adjacent to the S Plant Aggregate Area since 1979. One high volume particulate sampler is located east of the 241-S and 241-SX Tank Farms and the other sampler is located on 10th Street due east of the 222-S Laboratory. The filters are analyzed quarterly for ^{90}Sr, ^{137}Cs, ^{239}Pu, and total uranium. The results have shown a steady decline over time in the concentration of these radionuclides throughout the sampling program throughout the 200 West Area (Schmidt et al. 1990). The only exception to this trend was during the four weeks following the partial meltdown of unit 4 at the Chernobyl Nuclear Power Station. Data from this period, approximately May 13 to June 3, 1986, were analyzed separately and assumed to be anomalous (Elder

et al. 1987). The last five years of data for the S Plant Aggregate Area have been averaged and the values are summarized in Table 4-4. The complete data set since 1985 is summarized in Appendix A.2.

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

4.1.1.2.1 Radiological Surveys. Radiological survey results may be influenced by buried or airborne radionuclide contamination but are generally indicative of surface and shallow soil contamination. Depending upon the instrumentation and survey techniques used, results may be reported in ct/min, dis/min, mR/h or mrem/yr. Typical natural background levels for these measurements are approximately: 50 ct/min, 2,000 dis/min (for an NaI detector), 0.047 mR/h and 84 mrem/yr (Woodruff et al. 1991). An aerial gamma-ray radiation survey was performed over the 200 West Area in July and August 1988 (Reiman and Dahlstrom 1988). The survey lines were flown with a 122 m (400 ft) spacing at an altitude of 61 m (200 ft). The data were normalized to a height of 1 m (3 ft) above the ground surface. Figure 4-1 presents the gross count data (counts per second) on an isoradiation contour map that covers the entire 200 West Area. In this figure background activity has been subtracted from the data. Background was determined onsite by suppressing specie-specific, naturally occurring activity and confirming with additional background measurements south and east of the Hanford Site.

The entire area has gross gamma counts that are above background. However, several high gamma count anomalies can be identified within the aggregate area. The highest gross count results in the S Plant Aggregate Area were between 220,000 and 700,000 ct/s measured over the 202-S Building (Figure 4-1). The second highest results were between 70,000 and 220,000 ct/s as measured over the 241-S and 241-SX Tank Farms (location 5 in Figure 4-1). Other significant areas in S Plant include the 216-S-17 Pond and 216-S-16P Pond.

It is impossible to accurately convert these gross gamma counts to a meaningful exposure rate because of the complex distribution of radionuclides on the site. Many of the spectra do not have readily identifiable photo peaks but rather occur on a smear or continuum. Also, aerial systems integrate radiation levels over an area whose diameter may be ten times the height of the platform above the ground. Because of the large-area integration of the airborne system, localized anomalies will appear to be spread over a larger area with lower activities than actually exist on the ground (Reiman and Dahlstrom 1988). Spectra logs were generated for five sites within the S Plant Aggregate Area and these had one identifiable photopeak. A photopeak is a specific energy or wavelength that can be associated with the emissions from a specific radionuclide. Cesium-137 was the only radionuclide that could be identified from spectra information collected over the 216-S-17 Pond, 216-S-10P Pond, S Plant Complex, 241-S, -SX, and -SY Tank Farms, and

9 3 1 2 8 5 9 0 9 3 0

the 216-S-10D Ditch during the 1988 survey. As such, the aerial radiation survey data should only be used as a qualitative tool for identifying more highly contaminated areas within the survey boundaries. In addition, the gamma counts noted in the survey probably result from both surface and shallow buried radionuclides, and are thus not entirely indicative of surface contamination.

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

- The 241-S, -SX, and -SY Tank Farms
- The 207-S Retention Basin
- The 216-S-8 Crib
- The 241-S-151 Diversion Box
- An area surrounding the 216-S-1 and 216-S-2 Cribs
- The 221-S Building in the vicinity of the railroad spur
- The 202-S Building
- The 211-S Reagent Tank Farm
- The propane storage yard.

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

- The east side of the 241-S Tank Farm and the 241-SY Tank Farm
- An area on the northeast corner of the 241-SY Tank Farm extending northeast
- The area surrounding the 216-U-1 and 216-U-2 Cribs, the 241-S-151 Diversion Box, and the 216-S-8 Crib.

Table 4-5 summarizes the radiological survey results for each waste management unit and unplanned release. The areas of surface contamination and contaminant migration will be discussed in more detail in the section dealing with the individual waste management units and unplanned releases (Section 4.1.2). Surface radiological surveys are done quarterly, semiannually, or annually at the waste management units. The surface contamination posting

may change often because of resurveying and because of cleanups affected under the Radiation Reduction Program. These surveys yield data on gross contaminant levels (ct/min and dis/min) which are useful in identifying the presence of contamination at a waste management unit and in making available comparisons between waste management units.

4.1.1.2.2 External Radiation Dose Rate Measurements. Dose rates from penetrating radiation were measured annually at 6 locations within or adjacent to the S Plant Aggregate Area between 1985 and 1989. The sample locations are shown on Plate 3, and the survey results are listed on Table 4-6. The measurements were taken with thermoluminescent dosimeters (TLDs) and are reported in mrem/yr. The TLDs measure dose rates resulting from all types of external radiation sources including cosmic radiation, naturally occurring radioactivity, fallout from nuclear weapons testing and contributions from other Hanford Site activities.

In 1990, two new sampling locations were established in the S Plant Aggregate Area. The new sites were generally located on or near areas of known contamination and the results appear to be slightly elevated over the previous sampling rounds. The sampling location near the 216-S-19 Pond was measured at 97 mrem/yr total. The highest total reading was 125 mrem/yr from a location just north of the 241-S Tank Farm. These results are summarized in Table 4-7.

4.1.1.2.3 Surface Soil Sampling. Between 1978 and 1989, surface soil samples were collected annually or semiannually from a regular rectangular grid that covers the 200 West Area with 33 sampling points. Six of these sampling locations are located within or adjacent to the S Plant Aggregate Area. The grid sample points are generally located close to the intersections of Hanford Site coordinate lines at 305 m (1,000 ft) spacings, and are intended to monitor the overall 200 West Area environment without being specific to any potential source site. In addition to the grid sites, there are three fenceline sampling locations surrounding the three Tank Farms in the S Plant Aggregate Area.

The samples from the grid and fenceline sampling are analyzed for common radionuclides found in the 200 West Area, that is, gamma-emitting radionuclides, ^{90}Sr, uranium, and plutonium isotopes. The results are compared to mean regional background levels derived from offsite data gathered by PNL. This comparison allows identification of radionuclide contributions from the 200 West Area versus contributions from natural background and fallout from nuclear weapons testing. Any radionuclide detections which are above the mean regional background are not considered significant until they exceed the mean plus two standard deviations. The detections are also compared to the soil contamination standards established for the 200 West Area. The soil standards represent permissible radionuclide concentrations, above which restrictions are posted restricting the area.

The results of the sampling indicate that the regional background concentrations were exceeded in the S Plant Aggregate Area, however, the soil contamination standards were not exceeded. In general, the concentration of radiological contamination decreased within the S

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Plant Aggregate Area, with the exception of ^{90}Sr at the S-TF-SE station, located at the southeast corner of the 241-S, -SX, -SY Tank Farms. This location has exhibited an upward trend in concentration since 1986. It is possible that the increase at this sampling location is related to the upward trend displayed at grid site 2W28, located east of the 241-S and -SX Tank Farms (Schmidt et al. 1990). The sampling locations are presented in Plate 3. The yearly averages of sampling are presented in Appendix A.2. Tables 4-8 and 4-9 present the results of grid and fenceline soil sampling within the S Plant Aggregate Area.

4.1.1.3 Surface Water. No natural surface water bodies exist within the S Plant Aggregate Area. However, three man-made ditches (216-U-9, 216-S-10D, and 216-S-16D) formerly received a variety of wastes, and surface water and sediment within the remaining open sections of the ditches are suspected to be contaminated. The 207-S and 207-SL Retention Basins have also received a variety of aqueous wastes; thus, sediments and water within the basins may also be contaminated. No recent data from these basins are available.

There are data for water quality in the 216-S-10D Ditch. The samples are taken weekly, composited, and analyzed monthly for total beta, total alpha, ^{137}Cs, and ^{90}Sr. The results are presented in Table 4-10 and 4-11, in the form of maximum and minimum recorded levels. Judging from the maximum concentrations (as the minimum levels were generally below detection) the radioactivities appear to be trending downward.

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

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

Biota samples have been collected since 1978 from locations within or adjacent to the S Plant Aggregate Area. Vegetation samples were collected from the same locations as the grid soil samples described in Section 4.1.1.2.3. The vegetation samples have radionuclide concentrations that are slightly elevated above regional background, but have not exhibited statistically significant trends since 1979 (Schmidt et al. 1990). The most commonly detected radionuclides include ^{137}Cs, ^{90}Sr, ^{60}Co, ^{238}Pu, and ^{239}Pu. The sampling locations are presented in Plate 3, and summaries of the analytical results are presented in Appendix A.2. Analytical results for vegetation samples and feces samples are presented in Tables 4-12 and 4-13.

4.1.1.5 Vadose Zone. The extent of contamination in the vadose zone has been most extensively studied by geophysical well logging. This technique has been conducted in the

S Plant Aggregate Area since the late 1950's. Gross gamma-ray logs have been used to evaluate radionuclide migration in the vadose zone beneath selected waste management units. However, very little gross gamma data have been published. Table 4-14 lists all of the logs that were reviewed as part of this study. The log interpretations are discussed in detail in Appendix A. The evaluation process 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 to logs from the same holes. Any significant changes may be indicative of contaminant migration in the vadose zone. Interpretations were complicated by the fact that logging equipment and procedures have evolved over time. Consequently, a standardized, comparative baseline for interpreting gamma log results is not available. The results of the log interpretations are included for each applicable site in Section 4.1.2.

Waste management units that have received large volumes of liquid are more likely to have caused subsurface contaminant migration. The potential for liquid wastes to have migrated through the vadose zone to the groundwater was estimated by comparing the volume of waste discharged at each waste management unit to the estimated pore volume in the vadose zone soil column below the waste management unit. If the volume of liquid discharged to the ground is larger than the total soil column pore volume, then it is likely that wastewater may have reached the groundwater. These calculations are summarized in Table 4-15. They are based upon several conservative assumptions: (1) the discharged water does not spread out laterally from the point of discharge (i.e., the volume of affected vadose zone is equal to the depth to groundwater times the plan view cross-sectional area of the base of the waste management unit); (2) there is no significant change in liquid volume being introduced to the soil column due to evapotranspiration; and (3) the average porosity of the soil column is between 0.10 and 0.30 (the upper and lower estimates shown on Table 4-15). If the amount of waste received was greater than the porosity (0.1) then the waste management unit was considered to have the potential to migrate to the groundwater. According to these calculations, 18 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 units 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 (Baker et al. 1988).

4.1.2 Site-Specific Data

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

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4.1.2.1 Plants, Buildings, and Storage Areas. No chemical or radiological site-specific data were available for any of the plants, buildings or storage areas in the S Plant Aggregate Area.

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

4.1.2.2.1 Single-Shell and Double-Shell Tanks. All of the single-shell tanks in the S Plant Aggregate Area are located within the boundaries of the 241-S and 241-SX Tank Farms. The double-shell tanks are located in the 241-SY Tank Farm. The tank farms are characterized as areas of surface contamination and there is an area of active surface contamination migration on the eastern and northeastern sides of the 241-S and 241-SY Tank Farm properties (Huckfeldt 1991b).

A TLD stationed on the eastern margin of the 241-SX Tank Farm averaged 98 mrem/yr between 1985 and 1989 (Table 4-6). The high annual dose rate is probably indicative of a combination of surface contamination in the tank farm area and some emissions from the tanks themselves. The upper surfaces of single-shell and double-shell tanks are all approximately 2 m (7 ft) below grade, so the waste contained within the tanks is largely, but not entirely shielded from the ground surface.

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

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

The TRAC inventory data are presented in Table 4-16. These data are for the total tank inventories and do not differentiate between drainable liquid and solids within the tanks. As shown in Table 2-4, some of the nonstabilized tanks still contain large volumes of liquid drainable waste. It is the radionuclides that are partitioned to this liquid phase which are of primary concern should a tank begin to leak. From a comparison of solid and liquid phase data presented in an earlier TRAC report, it appears that ^{241}Am, ^{14}C, ^{135}Cs, ^{137}Cs, ^{93}Nb, ^{99}Tc, ^{79}Se, and ^{90}Sr are most strongly partitioned to the liquid phase in the tanks and would be the most likely radionuclides, present at high concentrations, to migrate in the event of a leak (Jungfleish 1984).

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

The available chemical data for each tank are summarized in Table 4-17. The information on the table was compiled from analytical data sheets from the MO-037 Library. The table includes any radionuclide data that are available for each sample, as well as pH and total organic carbon (TOC) data. Solutions with low pHs and high TOC (organic solvents) would tend to enhance radionuclide migration through the soil column.

Chemical Explosion Potential. There are three possible mechanisms recognized as having chemical explosion potential for Hanford single-shell and double-shell tanks. The three are ferrocyanide in excess of 1,000 gram moles, hydrogen gas generation, and TOC greater than 3 wt%. None of the single-shell or double-shell tanks is suspected of having a ferrocyanide problem, but several have the potential to generate significant quantities of hydrogen gas (Hanlon 1992). A watch list has been generated by the U.S. Department of Energy (DOE) that ranks tanks according to their potential for explosion. The factors in this ranking include: surface level fluctuation, temperature, total curies of waste, organic content, volume of solids, waste type, pressurization, crust formation, and past flammable gas detections. Eleven tanks in the 241-S, 241-SX, and 241-SY Tank Farms are on the hydrogen gas watch list (241-S-111, 241-S-112, 241-SX-101, 241-SX-102, 241-SX-103, 241-SX-104, 241-SX-105, 241-SX-106, 241-SX-109, 241-SY-101, and 241-SY-103).

The 241-S-102 and 241-SX-106 Single-Shell Tanks are on the watch list for tanks containing concentrations of organic salts greater than 3 wt% TOCs. These tanks have organic chemicals which are potentially flammable and mixtures of organic materials mixed with nitrate and nitrate salts can deflagrate.

Vadose Zone Well Geophysical Logging. Most of the tanks are surrounded by an array of vadose zone wells. Gamma logging is performed on these wells on a regular basis to identify new tank leaks and to monitor the migration of existing contaminant releases to

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the soil. Six of the eleven assumed leaking tanks in the 241-S and 241-SX Tank Farms exhibit elevated gamma radiation levels in their associated monitoring wells.

Single-Shell and Double-Shell Tanks Unplanned Releases. There are eight unplanned releases associated with the tanks in the 241-S, 241-SX, and 241-SY Tank Farms. All of these unplanned releases resulted from tank leaks (UPR-200-W-140 through -146 and UN-200-W-50). Most of the available information on these releases is summarized on Table 2-6.

4.1.2.2.2 Catch Tanks. Very little data are available for the catch tanks and receiver tank. For most units the total volume of waste is known (see Section 2.0), but there is no chemical or radiological information available. Approximately 2,300 L (600 gal), consisting primarily of rainwater, were released from the 240-S-302 Catch Tank between June 1985 and January 1986. The unit is located within an exclusion zone (UN-200-W-116).

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

4.1.2.3.1 216-S-1 and 216-S-2 Cribs. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. Annual radiological monitoring indicate that this unit has surface contamination. A sagebrush stump in the center of the waste management unit had a reading of 35,000 dis/min. The cribs are posted as having surface contamination.

Gross gamma-ray logs are available for 15 wells around the 216-S-1 and 216-S-2 Cribs. These logs indicate that elevated gamma activity is present from just beneath the cribs to the groundwater. Details of the gross gamma-ray evaluations are presented in Appendix A.

The unit has a known release associated with it; UPR-200-W-36, where contamination spread downward via a leak in a test well. This leak appears to have allowed the spread of contaminants to the groundwater.

The crib area has also been affected by UN-200-W-114 which was an airborne release resulting from activities in the 241-SX Tank Farm.

4.1.2.3.2 216-S-5 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys in August 1990 and August 1991, no contamination was detected.

Gross gamma-ray logs are available for 4 wells around the 216-S-5 Crib. These logs indicate the presence of elevated gamma activity from 1.5 m to 11.6 m (5 ft to 38 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

This unit was deactivated because of insufficient capacity and a series of vessel coil failures, which resulted in operational problems and surface contamination. An area just south of this crib between the 216-S-17 Pond and 216-S-10D Ditch was used as an overflow for effluent volumes exceeding the capacity of the crib. The 216-S-6 Crib discharged to this area in May 1956. Samples of the overflow water indicated gross beta emitter concentrations in the 10^{-5} μc/cc range. After the area dried in June 1956, contamination levels on the surface were recorded up to 50,000 ct/min in some areas with general levels of 10,000 ct/min. A surface radiological survey of the overflow area, after a September 1956 discharge, detected levels of radioactivity increasing at a rate of 5 to 100 mR/h at the pond edge and averaging 350 mR/h with localized spots up to 17 mR/h at the pond interior (Maxfield 1979).

4.1.2.3.3 216-S-6 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological survey in August 1991, no contamination was detected.

Gross gamma-ray logs are available for 2 wells monitoring the 216-S-6 Crib. These logs indicate the presence of elevated gamma activity from 1.2 m to 21.3 m (4 ft to 70 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.4 216-S-7 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys around the perimeter of the unit, no contamination has been detected since 1988. Surveys were conducted only around the perimeter because this crib has a collapse potential.

Gross gamma-ray logs are available for 5 wells monitoring the 216-S-7 Crib. These logs indicate the presence of elevated gamma activity from 6.7 to 12.8 m (22 to 42 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.5 216-S-9 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological survey in August 1991 and August 1990, no contamination was detected.

Wells 299-W22-26A and 299-W22-27A were drilled to a depth of 65.5 m (215 ft) next to this unit in 1966 to determine the radionuclide distribution below the unit. Only low-level ^{90}Sr (1.0E-11 Ci/g) was detected in a perched water zone at 42.7 m (140 ft) in Well 299-W22-26A, and no long-lived isotopes were detected in Well 299-W22-27A.

Gross gamma-ray logs are available for 4 wells monitoring the 216-S-9 Crib. These logs indicate the presence of elevated gamma activity from 8.5 to 18.9 m (28 to 62 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.6 216-S-13 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During a surface radiological survey in December 1991, a small area of contamination was noted near the center of the unit in some

rabbitbrush. Readings were up to 4,000 dis/min (beta). The area was stabilized when efforts to decontaminate it were unsuccessful. The area around the center post of the unit was also noted as an area with cave-in potential.

Gross gamma-ray logs are available for one well monitoring the 216-S-13 Crib. These logs indicate the presence of elevated gamma activity from 1.8 m to 32.6 m (6 ft to 107 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.7 216-S-20 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys around the perimeter of the unit, no contamination has been detected. Surveys were conducted only around the perimeter because this crib has a collapse potential. The crib has been recapped three times since December 13, 1974, due to subsidence.

Gross gamma-ray logs are available for 2 wells monitoring the 216-S-20 Crib. These logs indicate the presence of possible elevated gamma activity at 11.6 m (38 ft) beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.8 216-S-22 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys of the unit, no contamination has been detected.

Gross gamma-ray logs are available for 1 well monitoring the 216-S-22 Crib. These logs do not indicate the presence of elevated gamma activity beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.9 216-S-23 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys of the unit in August 1990 and August 1991, no contamination was detected. This was a decrease from the August 1989 survey.

Gross gamma-ray logs are available for 5 wells monitoring the 216-S-23 Crib. These logs do not indicate the presence of elevated gamma activity beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.3.10 216-S-25 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During the annual surface radiological surveys of the unit in September 1990 and September 1991, no contamination was detected.

Gross gamma-ray logs are available for 3 wells monitoring the 216-S-25 Crib. These logs do not indicate the presence of elevated gamma activity beneath the surface. Details of the gross gamma-ray evaluations are presented in Appendix A.

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4.1.2.3.11 216-S-26 Crib. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. During a surface radiological survey of the unit in December 1991, no contamination was detected.

4.1.2.3.12 216-S-3 French Drain. Specific chemical and radionuclide inventory data for this unit are summarized on Tables 2-2 and 2-3. No contamination was found during surface radiological surveys in August 1991 and August 1990. These results are a decrease from the 1989 survey.

4.1.2.4 Ditches, Trenches, and Ponds. The types of information available for the ditches, trenches, and ponds include inventory data, some surface radiological data, as well as limited amounts of waste, soil, or sediment sampling data, borehole geophysics, and biota sampling. External radiation monitoring, and air monitoring data are generally unavailable for these waste management units. Inventory and radiological information have largely been compiled from WHC (1991a).

4.1.2.4.1 216-S-10P Pond. Specific chemical and radionuclide inventory data for this unit are not available. However, the 216-S-10P Pond received waste via the 216-S-10D Ditch, and the specfic radionuclide inventory of the ditch is summarized in Table 2-2. Semiannual surface radionuclide monitoring indicate that no surface contamination exists at this waste management unit.

Gross gamma-ray logs are available for four wells around the 216-S-10P Pond. These logs indicate that no elevated gamma activity is present in the subsurface area surrounding this unit. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.4.2 216-S-11 Pond. Specific radionuclide inventory data for this unit is summarized in Table 2-2. Semiannual surface radionuclide monitoring indicate that no surface contamination exists at this waste management unit.

Gross gamma-ray logs are available for four wells around the 216-S-11 Pond. These logs indicate that no elevated gamma activity is present in the subsurface area surrounding this unit. Details of the gross gamma-ray evaluations are presented in Appendix A.

4.1.2.4.3 216-S-15 Pond. Specific chemical inventory data for this unit is summarized in Table. Annual radionuclide monitoring conducted during August 1990 indicated that no surface contamination was found at this pond.

4.1.2.4.4 216-S-16P Pond. Specific radionuclide inventory data for this unit is summarized in Table 2-3. No contamination was detected during semiannual radionuclide monitoring conducted in August 1990.

Three unplanned releases are associated with this it; UPR-200-W-47, UPR-200-W-59, and UPR-200-W-124. Unplanned Release UPR-200-W-47 was caused when a dike broke spreading contamination 137m (450 ft) to the west of the 216-S-16P Pond and 274m (900 ft)

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from north to south. Unplanned Release UPR-200-W-59 occurred when a process vessel coil in the 202-S Building failed allowing process effluent to mix with cooling water. Unplanned Release UPR-200-W-124 occurred when a dike broke allowing contamination to spread over the surface.

4.1.2.4.5 216-S-17 Pond. Specific chemical and radionuclide inventory data for this unit is summarized in Tables 2-2 and 2-3. Radionuclides present include ^{137}Cs, ^{90}Sr, and ^{106}Ru. Nitrate is also present in the pond. Radiological surveys of the surface and biota sampling are performed semiannually. Decaying tumbleweeds on the south berm of the pond read 1,000 ct/min for the July 1990 survey. Tumbleweeds with elevated radiation levels have been an ongoing problem at the pond since its closure. A detailed account of the 216-S-17 Pond history is discussed in the following sections.

<u>October 1952</u>

Followup investigation of an above normal reading on the 207-S Retention Basin HM chamber led to the discovery that gross amounts of contamination were sent to the 216-S-17 Pond via the process cooling water. Surveys of the 216-S-17 Pond revealed general contamination with a maximum dose rate of 2 R/h including 35 mR/h at 2.5 cm (1 in.) from ground surface. Dose rates up to 50 mR/h including 18 mR/h both measured at 1.5 m (5 ft) from the surface of the water at the 207-S Pond were observed. Vegetation removed from the pond gave dose rates to 2.2 R/h including 80 mR/h at 5 cm (2 in.). Analytical results of this vegetation revealed approximately 42 uCi of beta activity per gram of sample. Approximately 75% of the activity was due to rare earths, with only a few percent of the activity due to ruthenium, zirconium, or iodine.

Investigation of possible sources within the building revealed that the D-12 waste concentrator had a steam coil leak (Maxfield 1979).

<u>November 1952</u>

Although the activity of the process cooling water dropped considerably following replacement of the D-12 cooling coil, sporadic increases were detected by the 207-S Retention Basin monitoring chamber. Investigation showed that a similar leak in the H-4 coil existed. An attempt was made to prevent contamination of the cooling water by keeping pressure on the coil at all times pending its replacement at the next scheduled shutdown. As the coil rupture became worse, this failed, and gross amounts of contamination were again being discharged to the Redox swamp. During a 3-day period, dose rates increased from 20 to 200 mR/h at 5 cm (2 in.) from the process cooling water header, from 80 mR/h including 40 mR/h to 250 mR/h, including 70 mR/h approximately 1.5 m (5 ft) above the water at 207-S Retention Basin, and from approximately 6 mR/h to 700 mR/h including 30 mR/h 15 cm (6 in.) above the water at the 216-S-17 Pond inlet (Maxfield 1979).

December 1952

Following replacement of the H-4 pot, the activity of the process cooling water dropped to 10^{-5} μc/cc. Positive activity was still evident, but was probably due to flushing of the contaminated line. A serious problem was discovered, however, when wild fowl were observed feeding on the grossly contaminated 216-S-17 Pond. A duck was killed on the swamp showing a dose rate of 100 mR/h on its surface. In an effort to keep fowl off the 216-S-17 Pond colored balloons were anchored around the swamp and a continuous noisemaker was installed. This was apparently successful, since no further birds were seen. High dose rates were observed on a particular form of unidentified vegetation at the 216-S-17 Pond. A dose rate of 5 R/h including 300 mR/h was measured at 7.5 cm (3 in.) from one mass of this material. In some cases, the vegetation was entangled in tumbleweeds, which could easily be spread outside the swamp area by windstorms (Maxfield 1979).

February 1953

Replacement of the D-12 pot eliminated this source of contamination of the 216-S-17 Pond, but a leak in the D-4 coil continued to allow low-level contamination to be discharged to the pond (Maxfield 1979).

April 1953

Solvent naphtha was introduced into the 216-S-17 Pond late in an effort to kill vegetation and thus make the area less attractive to wild fowl. The result of the experiment could not yet be evaluated (Maxfield 1979).

May 1953

Solvent naphtha into the 216-S-17 Pond was discontinued when no evidence of vegetation kill could be found (Maxfield 1979).

July 1953

The Biology Section recommended the following methods to eliminate vegetation at the 216-S-17 Pond and thus discourage use of the Pond by wild fowl: copper sulfate added to the water; 2, 4-D sprayed over the Pond, and sodium chlorate broadcast by hand at the periphery of the Pond. These steps were taken as soon as possible and were continued during the fall migratory period. Surveys downwind of the Pond indicated that no detectable contamination had been spread by the wind (Maxfield 1979).

August 1953

A leaking coil in the H-4 pot was detected near the end of the month. Since the spare was not yet completed, operations in H-4 continued, attempting to minimize leakage into the

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coil by maintaining pressure on the coil at all times. This was not completely successful, however, as dose rates rose from 25 to 180 mR/h at 1.5 cm (2 in.) from the utility outlet header and from 30 to 350 mR/h approximately 1.5 m (5 ft) above the water at 207-S Retention Basin (Maxfield 1979).

September 1953

The leak in the H-4 pot coil became worse rapidly. Before the coil was blanked off, dose rates rose to 2 R/h over the 207-S Retention Basin and to 1 R/h at 5 cm (2 in.) from the utility outlet header. Replacement of the H-4 pot eliminated this as a source of further contamination going to the 216-S-17 Pond, but another leak in the D-12 pot coil was discovered late in the month (Maxfield 1979).

February 1954

Contamination surveys around the 216-S-17 Pond indicate the contamination remains reasonably fixed. Dose rates at the Pond edge were as high as 1,500 mrads/h surface, which is comparable to previous survey results. No contamination was detected at the temporary fence isolating the new underground swamp project (Maxfield 1979).

March 1954

The 216-S-17 Pond was bypassed on March 15, 1954 and minor construction forces filled the original Pond. The 207-S Retention Basin was bypassed and backfilled during current scheduled shutdown (Maxfield 1979).

The pond was retired when the radionuclide inventory in the sediments exceeded prescribed limits. The pond was deactivated by plugging the pipeline to the unit north of the 216-S-5 Crib and covering the unit with 0.17 to 1.2 m (0.5 to 4 ft) of sterile, coarse black sand. The vegetation layer beneath the fill trapped 90% of the radioactivity (Maxfield 1979). In April 1982, areas where backfill measured 0.17 mL (0.5 ft), contaminated Russian thistle containing levels up to 4,000 ct/min beta-gamma existed. The southeastern portion of the pond where fill was 1.2 m (4 ft) had radioactivity levels up to 1,500 ct/min beta-gamma from windblown Russian thistle. The effluent was rerouted to the 216-S-5 Crib. The unit has been stabilized and has approximately 24,000 m^3 (31,000 yd^3) of contaminated soil and 85,000 m^3 (110,000 yd^3) of overburden soil. In the early 1970's when contaminated weeds were observed in the area, the unit was seeded with Siberian wheatgrass to compete with the Russian thistle. The Russian thistle was removed and buried in a 4.6 x 23 m (15 x 75 ft) trench located within the radiation zone.

4.1.2.4.6 216-S-19 Pond. Specific radionuclide inventory data for this unit is summarized in Table 2-2. During the semiannual surface radionuclide survey in August 1990, no contamination was detected. Mud samples were collected from the unit in 1977. The results of these samples indicated that ^{241}Am activity was present at the unit.

No gross gamma-ray logs are available for this unit.

4.1.2.4.7 216-S-10D Ditch. Specific radionuclide inventory data for this unit is summarized in Table 2-3. Surface radionuclide monitoring is performed semiannually, water samples are collected weekly, and sediment and vegetation samples are collected annually. During the survey conducted in July 1989, no contamination was detected. The results of water sample analyses are summarized in Tables 4-10 and 4-11 and discussed in Section 4.1.1.3.

Gross gamma-ray logs are available for four wells around the 216-S-10D Ditch. These logs indicate that no elevated gamma activity is present in the subsurface area surrounding this unit. Details of the gross gamma-ray evaluations are in Appendix A.

4.1.2.4.8 216-S-16D Ditch. Specific chemical inventory data for this unit is summarized in Table 2-3. Radionuclide monitoring on this unit is performed on a special basis only. No contamination was detected during August 1984 which was the last monitoring performed on this unit.

4.1.2.4.9 219-U-9 Ditch. Specific chemical and radionuclide inventory data for this unit are not available. This unit has been released from radiation zone status, and is not currently monitored.

No gross gamma-ray logs are available for this unit.

One unplanned release is associated with this unit, UPR-200-W-139. There is no known source of contamination for this unplanned release, and no mention of levels of contamination is made (WHC 1991a).

4.1.2.4.10 216-S-8 Trench. Specific chemical and radionuclide data for this unit are summarized on Tables 2-2 and 2-3. Radiological surveys of the surface are performed annually. During the August 1990 survey, three area of contamination were identified at levels of 0.6 mR/h, 2.6 mR/h, and 1.1 mR/h. These readings represent an increase from the 1989 survey. The August 1991 survey did not identify any specific areas of contamination.

Gross gamma-ray logs are available from one well drilled near the 216-S-8 Trench. These logs do not indicate the presence of elevated gamma activity beneath the surface. Details of the gross gamma-ray evaluations are in Appendix A.

4.1.2.4.11 216-S-12 Trench. Specific chemical and radionuclide data for this unit are summarized on Tables 2-2 and 2-3. Radiological surveys of the surface are performed annually. No contamination was detected during the August 1989, 1990, and 1991 surveys.

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4.1.2.4.12 216-S-14 Trench. Specific chemical and radionuclide data for this unit are not available. The site was investigated with core drilling in February 1971. There was a strong odor of hexone from the samples taken, but no radioactivity was found. This site was removed from radiation zone status in February 1971.

4.1.2.4.13 216-S-18 Trench. Specific chemical and radionuclide data for this unit are not available. In October 1972, this site was dug up and the remaining radioactive objects found were taken to the 200 West Burial Ground for disposal. The site has been released from radiation zone status.

4.1.2.5 Septic Tanks and Associated Drain Fields. None of the septic tanks and associated drain fields are thought to have received any hazardous waste so there is no significant sampling information available.

4.1.2.5.1 2607-W6 Septic Tank and Tile Field. This unit is not thought to have received any hazardous waste, but no chemical or radiological data are available.

4.1.2.5.2 2607-WZ Septic Tanks (2) and Tile Field. This unit is not thought to have received any hazardous waste but no chemical or radiological data are available.

4.1.2.5.3 Sanitary Crib. This unit is not thought to have received any hazardous waste, but no chemical or radiological data are available.

4.1.2.6 Transfer Facilities. The types of information available for the transfer facilities include surface radiological surveys. Radiological and chemical inventory, soil, vegetation, borehole geophysics, and air monitoring are unavailable for these sites.

4.1.2.6.1 216-S-172 Control Structure. This unit contains unquantified amounts of low-level radioactive solid waste. The maximum radiation reading is 25 mR/h. Routine radiation surveys, airborne radionuclide monitoring, and visual inspections are performed.

4.1.2.6.2 2904-S-160 Control Structure. This unit contains low-level contaminated concrete and piping. The quantity of contaminated waste has not been determined. There is 5,000 ct/min beta/gamma in the soil and up to 300 ct/min smearable contamination on the surface of the box. Routine radiation surveys, airborne radionuclide monitoring, and visual inspections are performed.

4.1.2.6.3 2904-S-170 Control Structure. This unit contains low-level contaminated concrete and piping. The quantity of contaminated waste has not been determined. There is less than 200 ct/min beta/gamma smearable contamination, less than 7 mR/h penetrating radiation, and indications of nonpenetrating radiation present. Routine radiation surveys, airborne radionuclide monitoring, and visual inspections are performed.

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4.1.2.6.4 2904-S-171 Control Structure. This unit contains low-level contaminated concrete and piping. The quantity of contaminated waste has not been determined. There is less than 100 ct/min beta/gamma smearable contamination and a 20 mR/h reading at contact with an open or closed window Cutie Pie radiation monitoring instrument. Routine radiation surveys, airborne radionuclide monitoring, and visual inspections are performed.

4.1.2.6.5 240-S-151 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.6 240-S-152 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.7 241-S-151 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

There are three or possibly four known unplanned releases at this site: UPR-200-W-20, UPR-200-W-51, UN-200-W-82, and possibly one unnamed release.

Unplanned Release UPR-200-W-20 occurred during January and February of 1953. Leakage from the diversion box contaminated about 92 m^2 (330m^2 [1,000 ft^2]) around the box. The contamination was unidentified, and the area was covered with gravel.

Unplanned Release UPR-200-W-51 took place on September 12, 1958. It involved leakage from the diversion box. The leakage covered a narrow strip of ground south of the diversion box, across 10th Street and about 91 m (300 ft) beyond the area fence. There were unknown sources of beta and gamma radiation measured at a maximum of 50 mR/h within 30 m (100 ft) of the box. The contaminated soil was saturated with water and turned over with a bulldozer. The unnamed unplanned release has an almost identical description but is dated September 15, 1958. It is likely that this is the same incident.

Unplanned Release UN-200-W-82 involved spots of contamination resulting from melting snow and rain penetrating the plastic cover of a piece of equipment. Run-off ran toward the diversion box and spread spots of contamination. This was detected on January 15, 1980. The specks of contamination outside the zone around the diversion box were removed.

4.1.2.6.8 241-S-152 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.9 241-SX-151 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.10 241-SX-152 Diversion Box. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

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4.1.2.6.11 241-S-A Valve Pit. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.12 241-S-B Valve Pit. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.13 241-S-C Valve Pit. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.6.14 241-S-D Valve Pit. Leak detection and air monitoring are performed continuously within the tank farm in which this unit is located.

4.1.2.7 Basins. The types of information available for the basins include inventory data and surface radiological survey results. Inventory data, soil, vegetation, borehole geophysics, and air monitoring data are unavailable for these waste management units. Radiological information has largely been compiled from waste management units WHC (1991a) and the HISS database entries.

4.1.2.7.1 207-S Retention Basin. Annual surface radiological surveys are conducted at the site. Readings taken in July 1990 indicate that the center of the basin is heavily contaminated up to 60,000 dis/min. There are also areas of lesser contamination on the perimeters. Similar conditions were reported for the July 1989 survey.

Three unplanned releases are associated with this site: UPR-200-W-13, -15, and -95. UPR-200-W-13 involved the failure of the H-4 oxidizer coil at REDOX in December 1952. This released an unknown beta/gamma source that increased from 6 mrem/h to 700 mrem/h over a 30 day period. Unplanned Release UPR-200-W-15 dates from November 1952 and was caused by the failure of a steam coil in the REDOX D-12 waste concentrator. This released an unknown beta/gamma source with dose rates up to 2 rem/h and was measured at 35 mrem/h at 2.5 cm (1 in.) from the ground. Unplanned Release UPR-200-W-95 was a series of releases from late 1952 to late 1954. These releases were caused by process coil leaks at the S Plant. Over this period of time, roughly 10 Ci of mixed fission products were released.

4.1.2.7.2 207-SL Retention Basin. Annual surface radiological surveys are conducted around the perimeter of the unit, and during the July 1990 survey no contamination was detected. The surface monitoring indicated a change in the survey results since the July 1988 survey. Liquid effluent sampling and analysis is performed weekly.

4.1.2.8 Burial Sites. The types of information available for the burial sites include inventory data and surface radiological survey results. Soil, vegetation, borehole geophysics, and air monitoring data are unavailable for these sites. Inventory and radiological information have largely been compiled from WHC (1991a) and the HISS database entries.

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4.1.2.8.1 218-W-7 Burial Ground. Specific radionuclide data for the burial ground are summarized in Table 2-2. Annual surface radiological surveys are performed on this site. Readings taken in July 1990 indicate 3.5 mR/h directly over the waste chute. A similar condition was reported in the July 1989 survey.

4.1.2.8.1 218-W-9 Burial Ground. Specific radionuclide data for the burial ground are summarized in Table 2-2. Annual surface radiological surveys are performed on this site. During the July 1990 survey contaminated specks were found with readings up to 25,000 dis/min. Similar contamination was noted in the July 1988 and July 1989 surveys.

4.1.2.9 Unplanned Releases. Very little chemical or radiological data are available for the unplanned releases not already discussed in the text. All available information on the unplanned releases is summarized in Table 2-5.

4.2 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This preliminary assessment is intended to provide a qualitative evaluation of potential human health and environmental hazards associated with the known and suspected contaminants at the S Plant Aggregate Area. The assessment includes a discussion of potential release mechanisms, potential transport pathways, develops a conceptual model of human and environmental exposure based on these pathways, and presents the physical, radiological, and toxicological characteristics of the known or suspected contaminants.

In developing the conceptual model, potential exposures to groundwater have not been addressed in detail. Since migration to groundwater is the primary route for potential future exposures to many of the chemicals disposed at the Hanford Site, this pathway (i.e., travel time, receptors) will be addressed in the 200 West Groundwater AAMSR.

It is important to note that these evaluations do not attempt to quantify potential human health or environmental risks associated with exposure to S Plant Aggregate Area waste management unit contaminants. Such a risk assessment cannot be performed until additional waste management unit characterization data are acquired. Risk assessment activities will be performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* document) being prepared in response to the Tri-Party Agreement M-29 milestone. This methodology incorporates the requirements established in the *Risk Assessment Guidance for Superfund* (EPA 1989a) and the *EPA Region 10 Supplemental Risk Assessment Guidance for Superfund* (EPA 1991a).

The ability of this qualitative assessment to address potential environmental and ecological risks is severely constrained by the relative lack of data regarding potentially exposed biotic populations and exposure pathways. As discussed in Section 3.6, past studies of biota have been mostly conducted on a site-wide basis and do not provide useful data to evaluate the potential impacts of the S Plant Aggregate Area. The extent of S Plant Aggregate Area biota sampling has been limited to vegetation sampling (Section 4.1.1.4).

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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 S Plant Aggregate Area contaminants is currently constrained by the lack of data. This data gap is addressed in Section 5.0, and is discussed further in Section 8.2.3.

4.2.1 Release Mechanisms

The S 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 inside a containment structure and bypassed an engineered barrier to reach the environment

In the first group are those waste management units where release of wastes to the soil column was an integral part of the waste disposal strategy. Included in this group are tile fields, septic system drain fields, ditches, french drains, seepage basins, cribs without liners, reverse wells, and some disposal trenches. Also in this group are unplanned releases that involved waste material released to the soil. For this group of waste management units, if discharges to the unit contained contaminants of concern, it can be assumed that soils underlying the waste management unit are contaminated. The first task in developing a conceptual model for these units is to determine whether contaminants of concern are retained in soil near the waste management unit, or are likely to migrate to the underlying aquifer and then to receptor points such as drinking water wells or surface water bodies. Factors affecting migration of chemicals away from the point of release will be discussed in the following section.

In the second group are units that were intended to act as a barrier to environmental releases. Included in this group are burial grounds containing drains or other containers, cribs with membrane liners, vaults, tanks, waste transfer facilities, and unplanned releases that occurred within containment structures. Waste management units that received only dry waste could also be included in this category, since the potential for wastes to migrate to soils outside of the unit is low due to the negligible natural recharge rate in the 200 Areas at the Hanford Site. For these waste management units, the first consideration to be addressed in developing a conceptual model is the integrity of the containment structure.

The ability of this report to evaluate the efficacy of engineered barriers is limited by the lack of vadose zone soil sampling data and air sampling data for many waste management units. Available sampling information for the waste management units and unplanned releases was summarized in Section 4.1. The data indicate that membrane liner systems used in waste management units with significant liquid inputs were ineffective in preventing releases to the subsurface.

The efficacy and integrity of concrete liners (207-S Retention Basin) and steel tanks (vaults), have not been determined. For those units (218-W-7 Burial Ground) that received

only dry and packaged laboratory waste, the potential for release is expected to be low. However, releases of small amounts of liquid wastes (222-S Laboratory) are known to have been disposed of in these waste management units, and early records are incomplete. Thus, releases from these structures to the surrounding soil are possible.

In addition to evaluating releases to the subsurface, the conceptual model must address the potential for releases to air and, for radionuclides, the potential for direct irradiation. All units have some type of barrier to releases to the surface; however, barriers can fail over time or may not be designed to prevent migration by certain transport pathways (e.g., volatilization).

Some of the cribs in the S Plant Aggregate Area have the potential for cave-ins 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. Westinghouse Hanford has an ongoing program (Radiation Area Remedial Action [RARA] Program) to detect and remediate cave-ins by covering the cribs with additional soil, and any exposures from these incidents are generally short-term.

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4.2.2 Transport Pathways

Transport pathways expected within the S Plant Aggregate Area are summarized in this section, including:

- Drainage and leaching from soil to groundwater
- Volatilization from wastes, surface water, and shallow soils
- Wind erosion of contaminated surface soils
- Deposition of fugitive dust on soils, plants, and surface water
- Uptake from soils and surface water by vegetation
- Uptake by animals via direct contact with soils or surface water or ingestion of soils, surface water, vegetation, and other animals
- Direct exposure to radiation.

In addition, transport within the saturated zone and subsequent release to groundwater wells or to 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 S Plant Aggregate Area, whether the release is directly to soil or through failure of a containment system. Several factors determine whether chemicals that are introduced into the vadose zone will reach the unconfined aquifer, which lies at a depth of approximately 61 m (200 ft) below ground surface. These factors are discussed in the following sections.

4.2.2.1.1 Depth of Release. As a general rule, for a given volume, waste management units that released wastes at a greater depth below the surface have a higher potential to contaminate groundwater than waste management units where the release was shallow. Other factors, however, such as rate of discharge, underlying geology, and many others will all significantly impact contaminant movement.

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 S Plant Aggregate Area, the primary source of moisture for mobilizing contaminants are waste management units that discharge liquid waste to the soil column and to a much lesser extent precipitation recharge. As discussed in Section 3.5.2, a number of studies have estimated natural precipitation recharge in a range from 0 to 10 cm/yr (0 to 4 in./yr), depending primarily on surface soil type, vegetation, and topography. The upper value in the range was a computer model generated estimation rather than actual measurement. The actual natural precipitation recharge for the S Plant Aggregate Area is likely to fall at the middle and lower end of this range. 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 in./yr) of natural recharge. However, other researchers (Routson and Johnson 1990) have concluded that no net precipitation recharge occurs in the 200 Areas, particularly at waste management units that are capped with fine-grained soils or impermeable covers.

With respect to artificial recharge, some waste management units (e.g., the 216-S-6 Crib) were identified in which the known volume of liquid waste discharged substantially exceeded the total estimated soil pore volume present below the footprint of the facility. In this case, the moisture content of soil below the waste management units likely approached saturation during the periods of use of these facilities. Because vadose zone hydraulic conductivities are maximized at water contents near saturation, the volume of liquid

wastewater historically discharged to the waste management units probably enhanced fluid migration in the vadose zone beneath these units.

Long-term gravity drainage is also a potential mechanism of contaminant migration. It is unknown how long after shutdown the soil under such a unit will continue to drain and to transport contamination down to the groundwater.

Contaminants that are not initially transported to the water table by drainage may be mobilized at a later date if a large volume of liquid is added to the unit. In addition, liquids discharged to one unit could mobilize wastes discharged to an adjacent unit if lateral migration takes place within the vadose zone. An example of this process occurred with the U Plant Aggregate Area 216-U-16 Crib where lateral migration of acidic waste above a caliche layer mobilized radionuclides below the 216-U-1 and 216-U-2 Cribs (Baker et al. 1988). No examples of interactions between units are known to have occurred at S Plant.

4.2.2.1.3 Soil Moisture Transport Properties. The moisture flux in the vadose zone is dependent on hydraulic conductivity as well as gradients of moisture content or matrix suction. Higher unsaturated hydraulic conductivities are associated with higher moisture contents. However, higher unsaturated hydraulic conductivities may be associated with fine-grained soils compared to coarse-grained soils at low moisture contents. Because of the stratified nature of the Hanford Site vadose zone soils and the moisture content dependence of unsaturated hydraulic conductivity, vertical anisotropy is expected, i.e., vadose zone soils are likely to be more permeable in the horizontal direction than in the vertical. This vertical anisotropy may reduce the potential for contaminant migration to the unconfined aquifer.

4.2.2.1.4 Retardation. The rate at which contaminants will migrate out of a complex waste mixture and be transported through unsaturated soils depends on a number of characteristics of the chemical, the waste, and the soil matrix. In general, chemicals that have low solubilities in the leaching fluid or are strongly adsorbed to soils will be retarded in their migration velocity compared to the movement of soil pore water. Studies have been conducted of soil parameters affecting waste migration at the Hanford Site to attempt to identify the factors that control migration of radionuclides and other chemicals. Recent studies of soil sorption are summarized in Serne and Wood (1990). Some of the processes that have been shown to control the rate of transport are:

- **Adsorption to Soils.** Most contaminants are chemically attracted to some degree to the solid components of the soil matrix. For organic compounds, the adsorption is generally to the organic fraction of the soil, although in extremely low-organic soils, adsorption to inorganic components may be of greater importance. Soil components contributing to adsorption of inorganic compounds include clays, organic matter, and iron and aluminum oxyhydroxides. In general, Hanford surface soils are characterized as sandy or gravelly with very low organic content (less than 0.1%) and low clay content (less than 12%) (Tallman

et al. 1981). Thus, site-specific adsorption factors are likely to be lower, and rate of transport higher, than the average for soils nationwide.

- **Filtration.** Filtration of suspended particulates by fine-grained sediments has been suggested as a mechanism for concentration of radionuclides in certain sedimentary layers. This finding suggests that migration of suspended particulates may be an important mechanism of transport for poorly soluble contaminants.

- **Solubility.** The rate of release of some chemicals is controlled by the rate of dissolution of the chemical from a solid form. The concentration of these chemicals in the pore water will be extremely low, even if they are poorly sorbed. An example cited by Serne and Wood (1990) is the solubility of plutonium oxide which appears to be the limiting factor controlling the release of plutonium from waste materials at neutral and basic pH.

- **Ionic Strength of Waste.** For some inorganics, the dominant mechanism leading to desorption from the soil matrix is ion exchange. 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.

- **Waste pH.** The pH of a leachant has a strong effect on inorganic contaminant transport. Acidic leachates tend to increase migration both by increasing the solubility of precipitates and by changing the distribution of charged species in solution. The exact impact of acidic or basic wastes will depend on whether the chemical is normally in cationic, anionic, or neutral form, and the form that it takes at the new pH. Cationic species tend to be more strongly adsorbed to soils than neutral or anionic species. The extent to which addition of acidic leachate will cause a contaminant to migrate will also depend on the buffering or neutralizing capacity of the soil which is correlated with the calcium carbonate ($CaCO_3$) content of the soil. The soils in the Hanford formation beneath the S Plant Aggregate Area generally have carbonate contents that range from 0.1 to 5%. Higher carbonate contents (20 to 30%) are observed within the Plio-Pleistocene caliche layer.

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

  - The remobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs in the U Plant Aggregate Area is believed to have occurred in part because of this introduction of low pH solutions.

- Leaching of americium from the Z Plant Aggregate Area 216-Z-9 Trench sediments was found to be solubility controlled and correlated to solution pH.

4.2.2.1.5 Complexation by Organics. Certain organic materials disposed at the S Plant Aggregate Area are known to form complexes with inorganic ions, which can enhance their solubility and mobility. Methyl isobutyl ketone is the primary organic complexing agent disposed at the S Plant Aggregate Area.

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.** Radioactive materials decay over time, generally decreasing the quantities and concentrations of radioactive isotopes.

- **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 acetone, radon (a decay product of uranium), and tritium (HTO in tritiated water). Some elements (mainly fission products such as iodine, ruthenium, cerium, and antimony) are referred to as "semivolatiles" because they have a lesser tendency to volatilize.

4.2.2.2 Transport from Soils and Surface Water to Air. Transport of contaminants from waste management units to the atmosphere can occur by means of vapor transport or by fugitive dust emissions.

Vapor transport may occur from waste management units where volatile organics (e.g., CCl_4 or volatile radionuclides [^{14}C, CO_2, ^{129}I, and ^{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.

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In order for fugitive dust emissions to occur, contaminants must be exposed at the surface of the waste management unit. A number of mechanisms could lead to exposure of contaminants in soil-covered waste management units. These mechanisms include uptake by vegetation, transport by animals, disruption of the waste management unit (e.g., cave-ins at cribs), and wind erosion. Wind erosion can strip off surface soil and uncover waste materials. This mechanism has been identified as an ongoing problem in some of the waste management unit areas. The processes by which biota may expose contaminated soils are discussed in Section 4.2.2.4.

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

4.2.2.3 Transport from Soils to Surface Water. The only surface water available in the S Plant Aggregate Area is at the 216-S-10D Ditch that was constructed in 1952 to dispose of liquid effluent from the 202-S Building. The ditch receives wastewater from the 202-S Building (principally air compressor cooling water) and the 2901-S-901 water tower (sanitary water overflow). Transport of contaminants to surface water bodies outside of the 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 S 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 1992c) being prepared in response to 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 S Plant Aggregate Area waste management units. Roots of sagebrush and other native species can take up radionuclides from soils below the surface and transport these chemicals to the foliage. Wind dispersal of portions of the contaminated vegetation, or entire plants (tumbleweeds) can lead to transport of contaminants outside of the unit. Westinghouse Hanford has an ongoing vegetation control (herbicide application, reseeding with shallow-rooted vegetation, and mechanical removal) and radiological survey program to prevent radioactivity from being transported by this mechanism. However, the

program does not ensure complete removal of vegetation, and incidents of detection of contaminated vegetation are reported occasionally in the radiological surveys.

4.2.2.4.2 Transport by Animals. Disturbance of waste management unit barriers by animals occasionally leads to release of contaminants to the surface. Subsurface soils can be transported to the surface by burrowing animals, thus exposing contaminants for release to the air. Additionally, animals that become contaminated by direct contact with subsurface waste or through ingestion of subsurface contaminants (e.g., chemical salts) and contaminated vegetation, water, or other animals can spread contamination in their feces on the surface and outside of the waste management unit. Burrowing rodents and harvester ants can transport near-surface contaminants to the surface. Rabbits were noted as causing the greatest spread of contamination in the separations area in 1985 (Elder et al. 1986).

4.2.3 Conceptual Model

Figure 4-3, and in more detail on Plate 4, presents a graphical summary of the physical characteristics and mechanisms at the site that could potentially affect the generation, transport, and impact of contamination in the S Plant Aggregate Area on humans and biota (conceptual model).

The sources of contamination include process wastes (condensates, cooling water, sewage, discharge product, sludge removal, drain waste, organic waste, cold organic uranium scrap, immiscible organics) from S Plant, unirradiated uranium wastes from the cold startup of S Plant, "interface crud," condensate from 241-S and 241-SX Tank Farms, washwater from the 241-S Stack decontamination, waste from the 293-S caustic scrubber, laboratory wastes, drainage from diversion boxes, sanitary wastes, emissions from various stacks, and process feed materials, and some materials from outside the aggregate area (e.g., laundry water and powerhouse wastewater) and contaminated equipment or waste material that was spilled during transit or disposed in the burial ground.

Contaminants from these sources have been disposed at the waste management units that are under investigation. Waste management units include ponds, ditches, retention basins, trenches, cribs, french drains, diversion boxes, catch tanks, septic tanks and drain fields, single-shell tanks, a vault, a burial ground, and the various unplanned releases that have occurred on the site. These releases and disposal activities are described in Sections 2.0 and 4.1. Some of the unplanned releases are associated with specific waste management groups, and are shown in Figure 4-3 and Plate 4 as dashed lines with "U" designations.

From these waste management units, contaminants may have been released via several mechanisms to the potentially affected media. Volatilization could release chemicals from surficial soils or surface waters into the atmosphere. Some of the more volatile constituents could be released from the vadose zone to the atmosphere through the soil gas system. Materials in the ditches flowing toward the ponds may have infiltrated/percolated into the

vadose zone, or sorbed to the sediments in the ditch. The retention basins may have released contaminants in a similar fashion, with the exception of offsite flow. Biota may have taken up contaminants from the surface water and near-surface contaminated soils (via deep roots or burrowing animals).

Many waste management units discharge their waste effluents directly to the near surface (vadose zone) soils. The trenches are potential release points via leaching or drainage of the liquid portion of the disposed materials. The cribs provide seepage discharge and similarly the french drains, reverse wells, and septic system drain fields directly inject their effluents into the subsurface sediments. The unplanned releases have mainly impacted surface soils although some contamination may have 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 from surface soils have been buried or removed to offsite disposal.

The primary mechanism of vertical contaminant migration is the downward movement of water from the surface through the vadose zone to the unconfined aquifer. The contaminants generally move as a dissolved phase in the water and their rate of migration is controlled both by groundwater movement rates and by adsorption and desorption reactions involving the surrounding sediments. Some contaminants are strongly sorbed on sediments and their downward movement through the stratigraphic column is greatly retarded. Significant lateral migration of contaminants is restricted to perched water zones and to the unconfined aquifer, where water is moving laterally. Again adsorption and desorption reactions may greatly retard lateral contaminant migration. Contaminants that were introduced to the soil column outside of the aggregate area may migrate into the area along with perched or aquifer water. Historically, perched water has been discovered beneath the 216-S-9 Crib and the 216-S-10D Ditch.

Figure 4-4 is a schematic diagram illustrating these processes and describing probable contaminant distributions in the vadose zone. For liquid waste management units, the point of release shown on this figure may be in the subsurface, such as at cribs, drains, and reverse wells, or it may be exposed to the surface, such as at ponds, ditches, trenches, or at most unplanned releases. Small-scale contaminant releases are much less likely to impact the lower vadose zone or groundwater than large scale releases. Liquid disposal units in the S Plant Aggregate Area are dominated by cribs and the S Pond and associated ditches. Table 4-15 identifies those units that had liquid discharges large enough to reach the unconfined aquifer.

Contaminant distributions near the burial ground type units in the S Plant Aggregate Area are likely significantly different from those associated with the liquid waste management units. Because burial grounds received only dry waste, the burial grounds are unlikely to release contaminants to the vadose zone. As a result, only surface contaminant releases have been identified at burial grounds. In this case, wind and near surface biological activity are the dominant processes for transporting and redistributing contaminants.

Contaminant distribution at most unplanned releases is expected to be at or just below the surface. These sites generally received little, if any, liquid, therefore, migration into the lower vadose zone is not expected. The primary process for transporting and redistributing contaminants in this case is wind and near surface biological activity.

The schematic diagram is based on the stratigraphy underlying the S Plant Aggregate Area, the chemical characteristics of the primary suspected contaminants in the area, and known vadose zone contaminant distributions identified from previous studies. The subsurface geology of the aggregate area is presented in Sections 3.4 and 3.5, and the chemical characteristics of various contaminants are detailed in Section 4.2.4.

In the past, drilling and sampling programs have been conducted at the 216-Z-1A Tile Field (Price et al. 1979), the 216-Z-9 Trench (Smith 1973), the 216-Z-12 Crib (Kasper 1981), the 200-BP-1 Operable Unit cribs (the BY Cribs) (Buckmaster and Kaczor 1992), the 216-U-10 Pond (Last and Duncan 1980), and the 216-Z-19 Ditch (Last and Duncan 1980). These studies, in conjunction with geophysical well logging data, have been used to estimate the expected contaminant distributions beneath comparable waste management units in the S Plant Aggregate Area.

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

(1) Maximum radionuclide contaminant concentrations should be expected directly beneath the main discharge points of the units with the exception of highly mobile contaminants such as tritium.

(2) Radionuclide contamination is not expected to spread laterally more than 15 to 30 m (50 to 100 ft) beyond the point of discharge and should be at much lower concentrations than those noted beneath the center of the discharge point; a possible exception being areas of perched water.

(3) Radionuclide contamination decreases rapidly with depth. The highest concentrations should occur within 2 or 3 m (6 to 10 ft) of the bottom of the discharge point and concentrations should be near background levels at 20 m (65 ft) depth.

(4) The maximum lateral radionuclide contaminant movement tends to occur along relatively impermeable horizons.

(5) Radionuclide contaminants should be concentrated in fine-grained horizons compared to surrounding coarse-grained horizons and when found in coarse-grained horizons they are associated with the fine-grained particles.

(6) Perched water zones are most likely to occur immediately above the caliche layer. With rapid loading, 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.

(7) The caliche layer is an important physical and chemical barrier to vertical contaminant migration.

(8) Most chemical contaminants of concern have distributions that tend to mimic radionuclide contaminant distributions in the vadose zone.

There are four exposure routes by which humans (offsite and onsite) and other biota (plants and animals) can be exposed to these possible contaminants:

- Inhalation of airborne volatiles or fugitive dust 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, pipelines and other facilities, or fugitive dusts.

4.2.4 Characteristics of Contaminants

Table 4-18 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 S Plant Aggregate Area. Table 4-19 summarizes the types of known or suspected contamination thought to exist at the individual waste management units. Known contaminants are those that have been proven to exist from sampling and inventory data (Tables 2-2 and 2-3). Suspected contaminants are those which could have occurred at a unit based upon historical practices, chemical associations or in-growth during radiological decay of discharged radionuclides. Given the large number of chemicals known or suspected to be present, it is appropriate to focus this assessment on those contaminants that have been detected through sampling efforts and which pose the greatest risk to human health or the environment.

The EPA Region 10 guidance on risk-based contaminant screening (EPA 1991a), as summarized in the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992c), was consulted to establish the S 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 S 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 S 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 4-20 lists the contaminants of potential concern for the S Plant Aggregate Area. This list was developed from Table 4-18 and includes only those contaminants which meet the following criteria:

- Radionuclides that have a half-life of greater than one year. Radionuclides with half-lives less than one year will not persist in the environment at concentrations sufficient to contribute to overall risks.

- Radionuclides with a half-life of less than one year and are part of long-lived decay chains that result in the buildup of the short-lived radionuclide activity to a level of 1% or greater of the parent radionuclide's activity within the time period of interest. Although daughter radionuclides are adequately identified during normal parent radionuclide investigations, they are also identified as contaminants of concern through this criterion. This provides an additional level of assurance that all primary contaminants will be addressed.

- Contaminants that are known or suspected carcinogens or have an Environmental Protection Agency (EPA) noncarcinogenic toxicity factor. In addition, chemicals with known toxic effects but no toxicity factors are included. In some instances the criteria have been withdrawn by EPA pending review of the toxicological data and will be reissued at a future date. Chemicals with known toxicity for which toxicity factors are presently not available include lead, selenium, kerosene, and tributyl phosphate.

The following characteristics will be discussed for the contaminants listed in Table 4-20:

- 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, groundwater, air, and biota contamination have not yet been adequately characterized for the S Plant Aggregate Area. All recent environmental monitoring data were reviewed and summarized for each media in Section 4.1.

The most extensive monitoring data available has been for groundwater. Because groundwater will be evaluated in the 200 West Groundwater AAMSR, it will not be discussed further here. Surface soil and biota samples have been collected from locations on a regular rectangular grid. However, these sampling locations do not correspond to any of the waste management units, but are intended to characterize the S Plant Aggregate Area as a whole. Air and external radiation samples have been collected at several locations within or adjacent to the S Plant Aggregate Area. These sampling stations are also not located directly on any of the waste management units, and therefore, the sampling results cannot be attributed to any particular unit. The only routine sampling data that correspond directly to waste management units are the external radiation surveys, which are performed on a regular basis. There is little soil or vegetation sampling data available for any of the units.

4.2.4.2 Historical Association with S Plant Aggregate Area Activities. Radionuclides and chemicals that are known components of S Plant Aggregate Area waste streams are listed in Table 2-10. This list includes chemicals in the process wastes as well as chemicals that were detected at elevated levels in wastewater. Since these waste streams are known to have been disposed of directly to the soil column in some waste management units, it is probable that the chemicals on this list have affected environmental media.

Based on WHC (1991a), radionuclides that are known to have been disposed of to S Plant Aggregate Area waste management units in the greatest quantities are as follows:

- ^{239}Pu
- ^{240}Pu
- ^{106}Ru
- ^{241}Am
- ^{137}Cs
- ^{58}Co
- ^{90}Sr

- ^{3}H
- ^{235}U
- ^{238}U.

Note that a complete radionuclide analysis of the S Plant Aggregate Area waste streams is not available. Thus, it is possible that additional radionuclides were disposed of to S Plant Aggregate Area waste management units that are not included in the waste inventories.

Nonradioactive chemicals reportedly released into S Plant Aggregate Area waste management units in large quantities include nitric acid, nitrates, sodium, ammonium nitrate, aluminum nitrate, sodium dichromate, and hexone.

4.2.4.3 Mobility. Since most wastes at the S Plant Aggregate Area were released directly to subsurface soils via injection, infiltration, or burial, the mobility of the wastes in the subsurface will determine the potential for future exposures. The mobility of the contaminants listed in Table 4-22 varies widely and depends on site-specific factors as well as the intrinsic properties of the contaminant. These site-specific factors include site stratigraphy, hydraulic conductivity, porosity, and other factors. Much of the site-specific information needed to characterize mobility is not available and will need to be obtained during future field investigations. However, it is possible to make general statements about the relative mobility of the candidate contaminants of concern.

4.2.4.3.1 Transport to the Subsurface. The mobility of radionuclides and other inorganic elements in groundwater depends on the chemical form and charge of the element or molecule, which in turn depends on site-related factors such as the pH, redox state, and ionic composition of the groundwater. Cationic species (e.g., Cd^{2+}, Pu^{4+}) generally are retarded in their migration relative to groundwater to a greater extent than anionic species such as nitrate. 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 4-21 presents a summary of K_d values that have been developed for many of the inorganic chemicals of concern at the S 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.

9 3 1 2 3 5 9 0 9 6 2

Serne and Wood (1990) recommended K_d values for use with Hanford waste assessments for a limited number of important radionuclides 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 of <1 is recommended for americium, cesium, plutonium, and strontium 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, 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 4-22 are for conditions of neutral waste pH and less than 10% adsorbent material, which is likely to be most representative of Hanford Site soils.

The mobility of inorganic species in soil can be divided roughly into three classes, using site-specific values (Serne and Wood 1990) where available and generic values otherwise: highly mobile ($K_d<5$), moderately mobile ($5<K_d<100$), and low mobility ($K_d>100$). Table 4-22 lists the class ranking for each of the inorganic contaminants of concern. The ranking presented in this table indicates general mobility characteristics. Actual mobility of specific contaminants will be influenced by their valence state and ligands. Specific mobilities will be determined in future site investigations and will address these potential influences.

The tendency of organic compounds to adsorb to the organic fraction of soils is indicated by the soil organic matter partition coefficient, K_{oc}. Partition coefficients for the organic chemicals of concern at the S Plant Aggregate Area are listed in Table 4-23. 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 primarily organic compounds; however, some of the radionuclides detected at the site are subject to evaporation and could be lost from shallow soils to the ambient air. The most important species in this category are ^{14}C, ^{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 organic candidate contaminants of concern are presented in Table 4-23. Compounds with a K_h greater than about 10^{-3} will be lost rapidly to the atmosphere from surface water and shallow soils. Organic contaminants of concern that fall into this class include chloroform and xylene.

4.2.4.4 Persistence. Once released to environmental media, the concentration of a contaminant may decrease because of biological or chemical transformation, radioactive decay, or the intermediate transfer processes discussed above that remove the chemical from the medium (e.g., volatilization to air). Radiological, chemical, and biological decay processes affecting the persistence of the S Plant Aggregate Area contaminants of concern are discussed below.

The persistence of radionuclides depends primarily on their half-lives. A comparison of the radiological properties for most radionuclide contaminants of concern for S Plant Aggregate Area is presented in Table 4-24. 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 4-24 range from seconds to over one billion years. Also listed are the principal radiation emissions of concern for the radionuclide. Note that radionuclides can emit multiple types of radiation and often undergo several decay steps in quick succession (e.g., beta decay followed by release of one or more gamma rays associated with daughter radionuclides). The daughter products of these decays are often themselves radioactive.

Decay will occur during transport (e.g., through the vadose zone to the aquifer, through the aquifer) and may lead to significant reductions in levels ultimately produced offsite. For direct exposures (e.g., to surface soils or air), the half-life of the radionuclide has less importance, unless the half-life is so short that the radionuclide undergoes substantial decay between the time of disposal and release to the environment.

Nonradioactive inorganic chemicals detected at the site are generally persistent in the environment, although they may decline in concentration due to transport processes or change their chemical form due to chemical or biological reactions. Nitrate undergoes chemical and biological transformations that may lead to its loss to the atmosphere (as N_2) or incorporation into living organisms, depending on the reduction/oxidation 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, reduction/oxidation conditions, and the presence of nutrients and of organisms capable of degrading the compound. Ketones, such as acetone and methyl isobutyl ketone (MIBK), are easily degraded by microorganisms in soil and thus would tend not to persist. Volatile aromatics such as xylene are generally intermediate in their biodegradability.

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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 non-carcinogenic human health effects. The toxicity characteristics of the chemicals detected at the aggregate area are summarized below.

4.2.4.5.1 Radionuclides. All radionuclides are classified by EPA as known human carcinogens based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancers in humans. Non-carcinogenic health effects associated with radiation exposure include genetic and teratogenic effects; however, these effects generally occur at higher exposure levels than those required to induce cancer. Thus, the carcinogenic effect of radionuclides is the primary identified health concern for these chemicals (EPA 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, which deposit energy over much larger distances, are of concern as both external and internal hazards. A fourth mode of radioactive decay, neutron emission, is generally not of major health concern, since this mode of decay is much less frequent than other decay processes. In addition to the mode of radioactive decay, the degree of hazard from a particular radionuclide depends on the rate at which particles or gamma radiation are released from the material.

Excess cancer risks for exposure to the primary radionuclide contaminants of concern by inhaling air, drinking water, ingesting soil, and by external irradiation are shown in Table 4-25. 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 1991b). These values are computed as the slope factor (risk per unit intake or exposure) multiplied by the inhalation or ingestion rate and the number of days in a 70 year lifetime (EPA 1991b).

For those radionuclides without EPA slope factors, the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992c) will be consulted. This document proposes to consult the EPA Office of Radiation Programs to request the development of a slope factor or to use the dose conversion factors developed by the International Commission on Radiological Protection to calculate a risk value. Any Hanford Site risk assessments will be performed in accordance with the *Hanford Baseline Risk Assessment Methodology* document (DOE/RL 1992c) which includes the guidance established in the *Risk Assessment Guidance for Superfund* (EPA 1989a) and the *EPA Region 10 Supplement Risk Assessment Guidance for Superfund* (EPA 1991a).

The unit risk factors for different radionuclides 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, and physical half-life.

Based on the factors listed in Table 4-25, the highest risk for continuous exposure to 1 pCi/m^3 in air is from plutonium, americium and uranium isotopes, which are alpha emitters. Among the radionuclide contaminants of concern for the S Plant Aggregate Area, the highest risks from ingestion of soil at 1 pCi/g are for ^{210}Pb, ^{227}Ac, ^{241}Am, ^{243}Am, ^{238}Pu, ^{244}Cm, ^{134}Cs, ^{129}I, ^{237}Np, ^{231}Pa, ^{226}Ra, ^{228}Ra, ^{229}Th, and the uranium isotopes. The primary gamma-emitters are ^{214}Bi, ^{60}Co, ^{134}Cs, ^{137}Cs (because of its metastable decay product, ^{137m}Ba), ^{152}Eu, ^{154}Eu, ^{239}Np, and ^{214}Pb. It is important to note that this table only presents unit risk factors for the listed radionuclides and does not necessarily include potential contributions from daughter products.

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

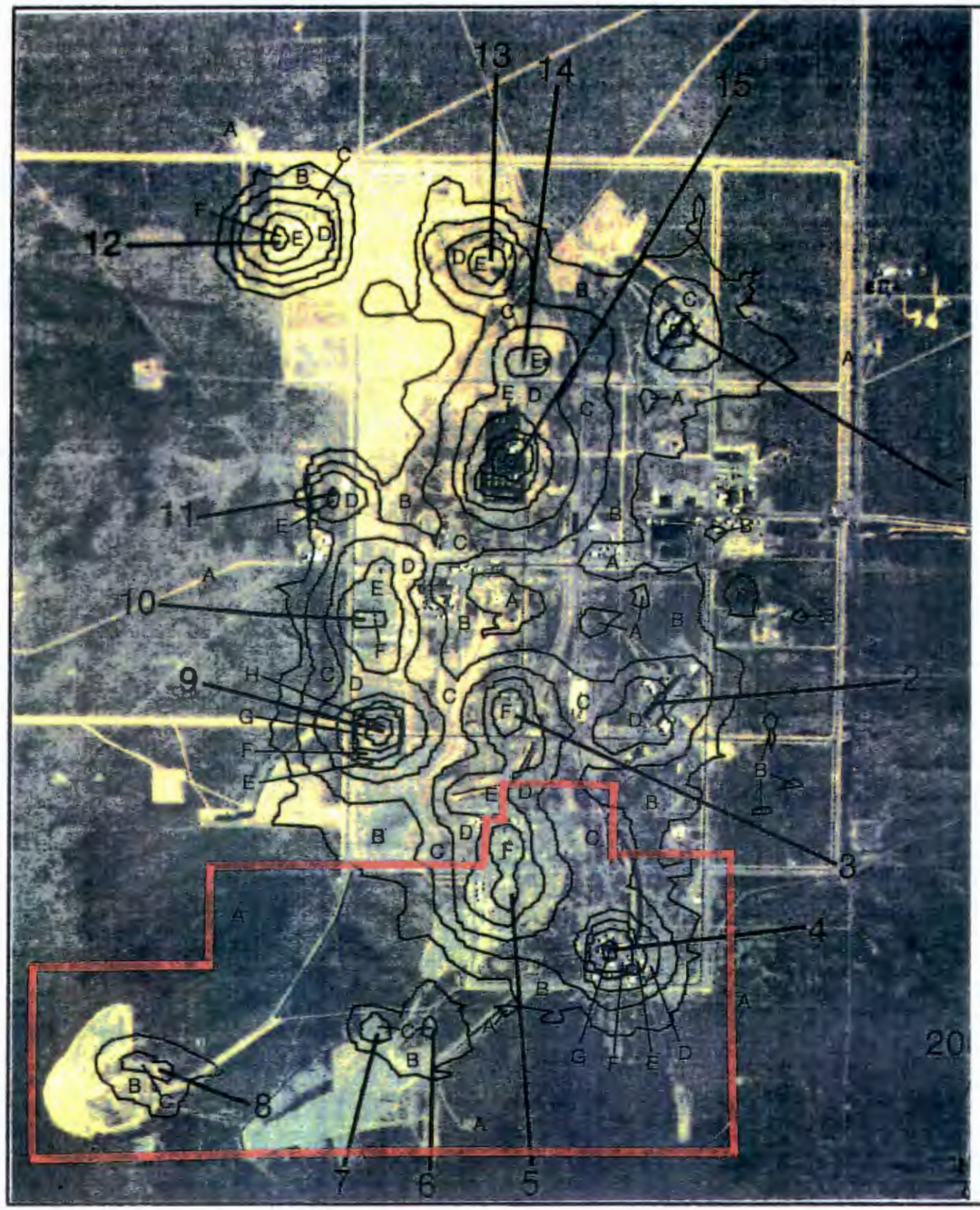
4.2.4.5.2 Hazardous Chemicals. Carcinogenic and non-carcinogenic health effects associated with chemicals anticipated at the aggregate area are summarized in Table 4-26.

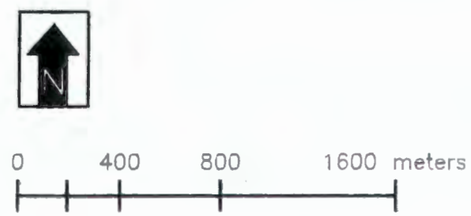
The basis for these potential health effects is described in the respective reference documents and may be associated with either human or animal data. Health effects were developed according to the hierarchy established in the Risk Assessment Guidance for Superfund (EPA 1989a). References were consulted in the following order: IRIS (Integrated Risk Information System) (EPA 1991b), HEAST (Health Effects Assessment Summary Tables) (EPA 1991c), and other toxicity articles and documents.

Several of the chemicals have known toxic effects but no toxicity criterion is presently available. In some instances the criteria have been withdrawn by EPA pending review of the toxicological data and will be reissued at a future date. Chemicals with known toxicity for which toxicity factors are presently not available include lead, selenium, kerosene and tributyl phosphate.

4.2.4.6 Bioaccumulation Potential. Contaminants may be of concern for exposure if they have a tendency to accumulate in plant or animal tissues at levels higher than those in the surrounding medium (bioaccumulation) or if their levels increase at higher trophic levels in the food chain (biomagnification). Contaminants may be bioaccumulated because of element-specific uptake mechanisms (e.g., incorporation of strontium into bone) or by passive partitioning into body tissues (e.g., concentration of organic chemicals in fatty tissues).

9 3 1 2 8 6 9 0 9 9 6 6



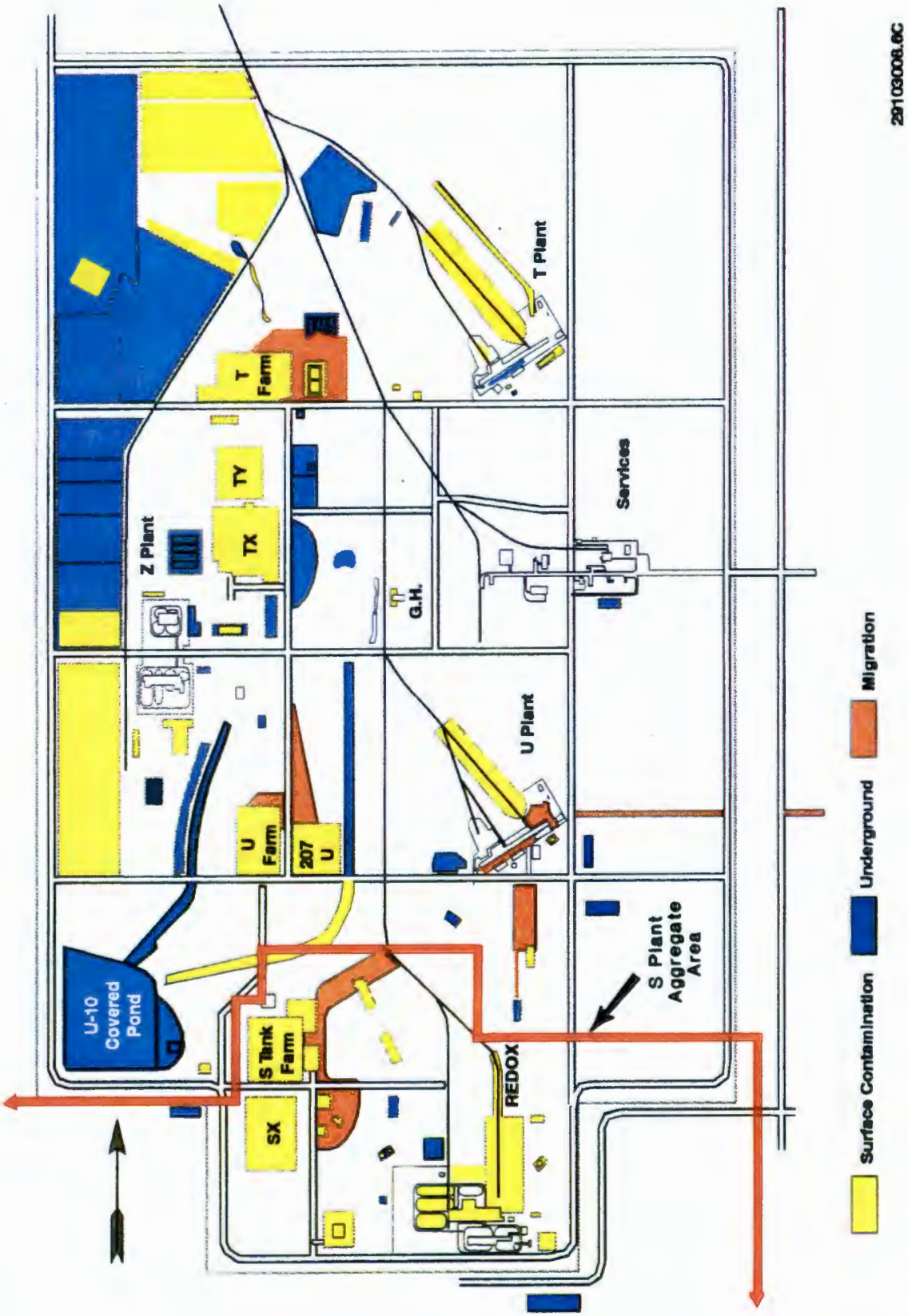


Zone A = <700 ct/s
Zone B = 700 to 2,200 ct/s
Zone C = 2,200 to 7,000 ct/s
Zone D = 7,000 to 22,000 ct/s
Zone E = 22,000 to 70,000 ct/s
Zone F = 70,000 to 220,000 ct/s
Zone G = 220,000 to 700,000 ct/s
Zone H = 700,000 to 2,200,000 ct/s
4 = S Plant Building Complex
5 = 241 - S, - SX, and - ST Tank Farms
6 = 216 - S - 10 D Ditch
7 = 216 - S - 17 P Pond
8 = 216 - S - 16 P Pond
Other numbers refer to sites outside the S Plant Aggregate Area.
S 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).

9 3 1 2 8 4 7 0 9 6 7

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



9 3 1 2 8 ' 9 0 9 9 6 8

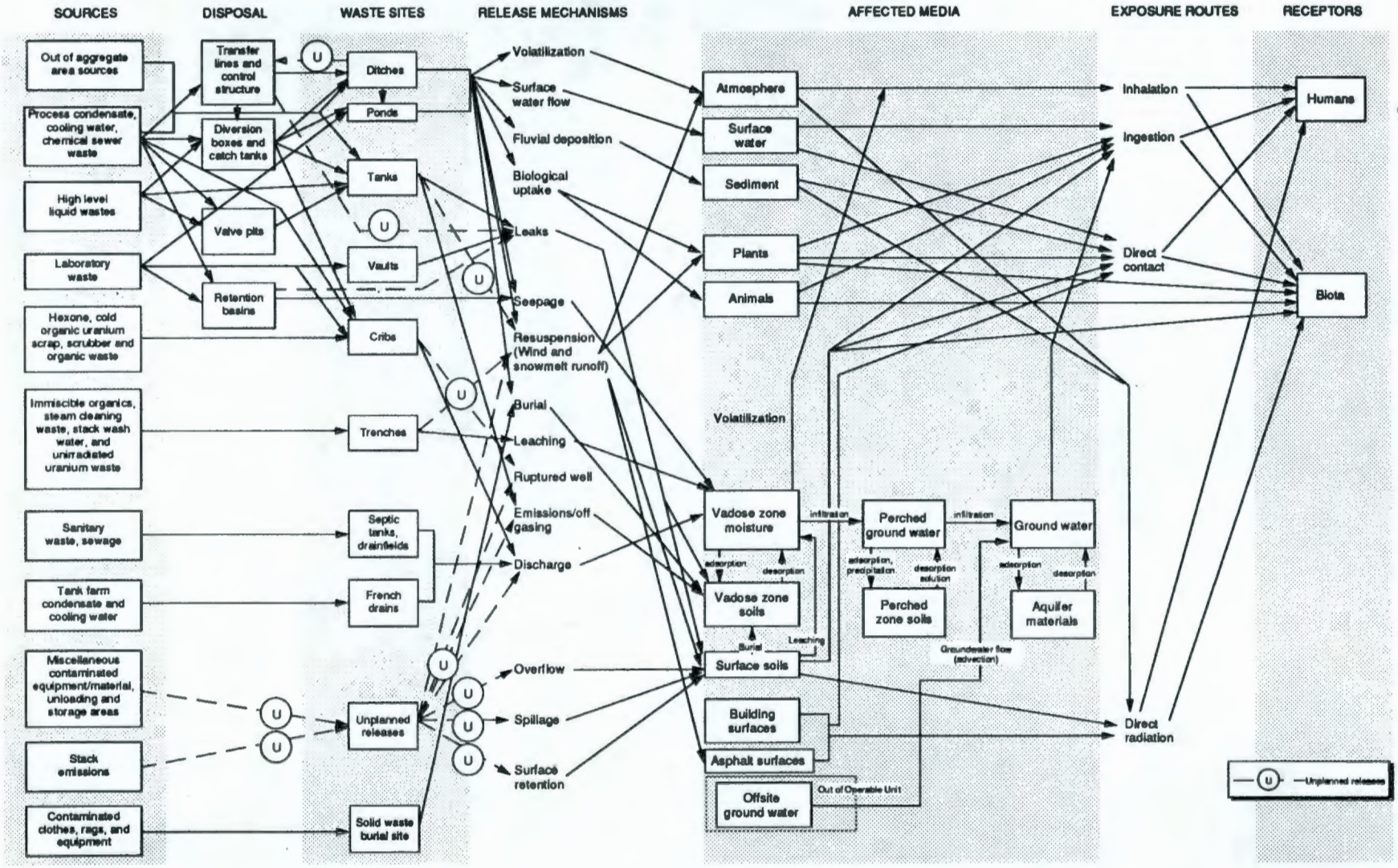
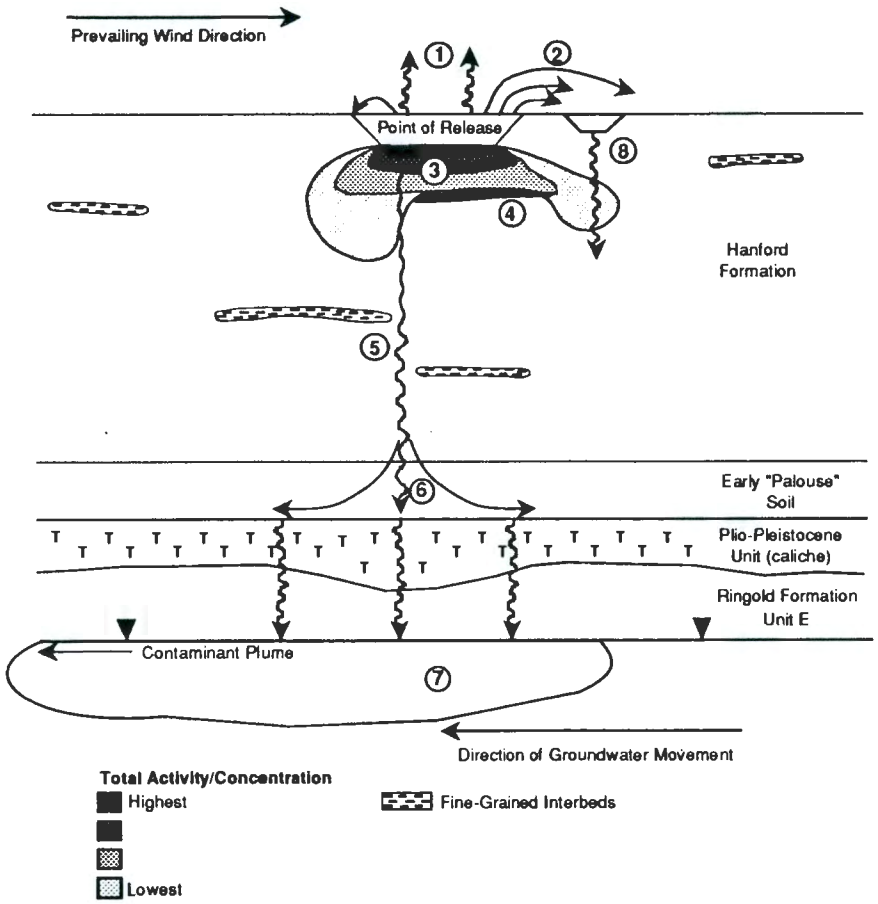


Figure 4-3. Conceptual Model of the S Plant Aggregate Area.

Figure 4-4. Physical Conceptual Model of Contaminant Distribution.



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.

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Plants, Buildings, and Storage Areas						
291-S Fan and Filter Building	--	--	--	--	--	
241-SX-401 Building	--	--	--	--	--	
241-SX-402 Building	--	--	--	--	--	
242-S Evaporator	--	--	--	--	--	
Tanks and Vaults						
241-S-101 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-102 Single-Shell Tank	--	S	--	--	S	No reported release
241-S-103 Single-Shell Tank	--	S	--	--	S	No reported release
241-S-104 Single-Shell Tank	--	S	--	--	S	No reported release
241-S-105 Single-Shell Tank	--	S	--	--	S	No reported release
241-S-106 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-107 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-108 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-109 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-110 Single-Shell Tank	--	S	--	--	S	No reported release
241-S-111 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-112 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-101 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-102 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-103 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-104 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-105 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-106 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-107 Single-Shell Tank	--	S	--	--	S	No reported release

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
241-SX-108 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-109 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-110 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-111 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-112 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-113 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-114 Single-Shell Tank	--	S	--	--	S	No reported release
241-SX-115 Single-Shell Tank	--	S	--	--	S	No reported release
241-SY-101 Double-Shell Tank	--	--	--	--	--	No reported release
241-SY-102 Double-Shell Tank	--	--	--	--	--	No reported release
241-SY-103 Double-Shell Tank	--	--	--	--	--	No reported release
240-S-302 Catch Tank	--	S	--	--	S	Approximately 2,2701 L, consisting mainly of rainwater, were released between June 1986 and January 1986
241-S-302A Catch Tank	--	S	--	--	S	No reported release
241-S-302B Catch Tank	--	--	--	--	--	No reported release
241-SX-302 Catch Tank	--	--	--	--	--	No reported release
244-S Receiver Tank	--	--	--	--	--	No reported release
Cribs and Drains						
216-S-1 & 2 Crib	--	S	--	K	S	Also described by UPR-200-W-36
216-S-5 Crib	--	--	--	--	S	No reported release
216-S-6 Crib	--	S	--	--	S	No reported release
216-S-7 Crib	--	--	--	--	S	No reported release
216-S-9 Crib	--	S	--	--	S	No reported release
216-S-13 Crib	--	S	--	--	S	No reported release
216-S-20 Crib	--	S	--	--	S	No reported release

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
216-S-22 Crib	--	--	--	--	S	No reported release
216-S-23 Crib	--	S	--	--	S	No reported release
216-S-25 Crib	--	--	--	S	S	No reported release
216-S-26 Crib	--	--	--	--	S	No reported release
216-S-3 French Drain	--	S	--	--	S	No reported release
Ponds, Ditches, and Trenches						
216-S-10P Pond	--	--	--	--	S	
216-S-11 Pond	--	--	--	--	S	
216-S-15 Pond	--	S	--	--	S	
216-S-16P Pond	--	--	--	--	S	Associated with UPR-200-W-47,-124, and -59
216-S-17 Pond	--	S	--	K	S	
216-S-19 Pond	--	S	S	--	S	
216-S-8 Trench	S	K	--	--	S	
216-S-12 Trench	--	--	--	--	S	Also described by UPR-200-W-30
216-S-14 Trench	--	--	--	--	S	
216-S-18 Trench	--	--	--	--	--	
216-S-10D Ditch	--	--	S	S	S	
216-S-16D Ditch	--	--	--	--	S	
216-U-9 Ditch	--	--	--	--	S	Associated with UPR-200-W-139
Septic Tank and Associated Drain Fields						
2607-WZ Septic Tank	--	--	--	--	--	No reported contaminants
2607-W6 Septic Tank	--	--	--	--	--	No reported contaminants
Sanitary Crib	--	--	--	--	--	No reported contaminants
Transfer Facilities, Diversion Boxes, and Pipelines						
241-S-151 Diversion Box	--	--	--	--	--	Associated with UPR-200-W-20 and -51

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
240-S-151 Diversion Box	--	S	--	--	--	No reported release
240-S-152 Diversion Box	--	--	--	--	--	No reported release
241-S-152 Diversion Box	--	--	--	--	--	No reported release
241-SX-151 Diversion Box	--	--	--	--	--	No reported release
241-SX-152 Diversion Box	--	--	--	--	--	No reported release
241-SX-A Valve Pit	--	--	--	--	--	No reported release
241-SX-B Valve Pit	--	--	--	--	--	No reported release
241-SY-A Diversion Box	--	--	--	--	--	No reported release
241-SY-B Diversion Box	--	--	--	--	--	No reported release
216-S-172 Control Structure	--	--	--	--	--	No reported release
2904-S-160 Control Structure	--	--	--	--	--	No reported release
2904-S-170 Control Structure	--	--	--	--	--	No reported release
2904-S-171 Control Structure	--	--	--	--	--	No reported release
241-S-A Valve Pit	--	--	--	--	--	No reported release
241-S-B Valve Pit	--	--	--	--	--	No reported release
241-S-C Valve Pit	--	--	--	--	--	No reported release
241-S-D Valve Pit	--	--	--	--	--	No reported release
Basins						
207-S Retention Basin	--	K	--	--	S	
207-SL Retention Basin	--	S	--	--	S	
Burial Sites						
218-W-7 Burial Ground	--	K	--	--	S	
218-W-9 Burial Ground	--	K	--	--	S	
Unplanned Releases						
UN-200-W-10	--	K,R?	--	--	--	

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UN-200-W-30	--	--	--	--	--	
UN-200-W-32	--	S,R	--	--	--	
UN-200-W-34	--	S	--	--	S	
UN-200-W-35	--	S,R	--	--	--	
UN-200-W-41	--	S	--	--	S	
UN-200-W-42	--	S	--	--	S	
UN-200-W-43	--	S	--	--	S	
UN-200-W-49	--	S	--	--	S	
UN-200-W-50	--	S	--	--	S	
UN-200-W-52	--	S,R?	--	--	--	
UN-200-W-56	--	S	--	--	S	
UN-200-W-61	--	S,R	--	--	--	
UN-200-W-69	--	S	--	--	S	
UN-200-W-80	--	K	--	--	S	
UN-200-W-81	--	S	--	--	S	
UN-200-W-82	--	S	--	--	S	
UN-200-W-83	--	S	--	--	S	
UN-200-W-108	--	S	--	--	S	
UN-200-W-109	--	K	--	--	S	
UN-200-W-114	--	K	--	--	S	
UN-200-W-116	--	K	--	--	--	
UN-200-W-123	--	S,R?	--	--	S	
UN-200-W-127	--	S,R?	--	--	S	
UN-216-W-25	--	--	--	--	--	
UN-216-W-30	--	--	--	--	--	

Table 4-1. Summary of Known and Suspected Radionuclide Contamination.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UPR-200-W-15	--	S	--	--	--	
UPR-200-W-20	--	S	--	--	--	
UPR-200-W-36	--	S	--	--	S	
UPR-200-W-47	--	S,R?	--	--	--	
UPR-200-W-51	--	S,R?	--	--	--	
UPR-200-W-59	--	--	--	--	--	
UPR-200-W-95	--	S,R?	--	--	--	
UPR-200-W-96	--	K	--	--	S	
UPR-200-W-124	--	S	--	--	S	
UPR-200-W-139	--	S,R?	--	--	S	
UPR-200-W-140	--	S	--	--	S	
UPR-200-W-141	--	S	--	--	S	
UPR-200-W-142	--	S	--	--	S	
UPR-200-W-143	--	S	--	--	S	
UPR-200-W-144	--	S	--	--	S	
UPR-200-W-145	--	S	--	--	S	
UPR-200-W-146	--	S	--	--	S	

Notes:

S Suspected contamination, primarily based on WHC (1991a) and other waste inventory data.

K Known contamination based on chemical analytical data, WHC (1991a), or other sources.

R Complete remediation reported.

R? Remediation attempted, effectiveness not documented.

Dashes indicate no contamination is known or suspected.

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
Plants, Buildings, and Storage Areas						
291-S Fan and Filter Building	--	--	--	--	--	
241-SX-401 Building	--	--	--	--	--	
241-SX-402 Building	--	--	--	--	--	
242-S Evaporator	--	--	--	--	--	
Tanks and Vaults						
241-S-101 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-102 Single-Shell Tank	--	--	---	--	S	No reported release
241-S-103 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-104 Single-Shell Tank	--	--	--	--	S	No reported release
241-S-105 Single-Shell Tank	--	--	--	--	S	No reported release
241-S-106 Single-Shell Tank	--	--	--	--	S	No reported release
241-S-107 Single-Shell Tank	--	--	--	--	S	No reported release
241-S-108 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-109 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-110 Single-Shell Tank	--	--	--	--	S	No reported release
241-S-111 Single-Shell Tank	--	--	--	--	--	No reported release
241-S-112 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-101 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-102 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-103 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-104 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-105 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-106 Single-Shell Tank	--	--	--	--	--	No reported release
241-SX-107 Single-Shell Tank	--	--	--	--	S	No reported release

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
241-SX-108 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-109 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-110 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-111 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-112 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-113 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-114 Single-Shell Tank	--	--	--	--	S	No reported release
241-SX-115 Single-Shell Tank	--	--	--	--	S	No reported release
241-SY-101 Double-Shell Tank	--	--	--	--	--	No reported release
241-SY-102 Double-Shell Tank	--	--	--	--	--	No reported release
241-SY-103 Double-Shell Tank	--	--	--	--	--	No reported release
240-S-302 Catch Tank	--	--	--	--	S	Approximately 2,270 L, consisting mainly of rainwater, were released between June 1986 and January 1986
241-S-302A Catch Tank	--	--	--	--	S	No reported release
241-S-302B Catch Tank	--	--	--	--	--	No reported release
241-SX-302 Catch Tank	--	--	--	--	--	No reported release
244-S Receiver Tank	--	--	--	--	--	No reported release
Cribs and Drains						
216-S-1 & 2 Crib	--	--	--	--	S	Also described by UPR-200-W-36
216-S-5 Crib	--	--	--	--	S	No reported release
216-S-6 Crib	--	--	--	--	S	No reported release
216-S-7 Crib	--	--	--	--	S	No reported release
216-S-9 Crib	--	--	--	--	S	No reported release
216-S-13 Crib	--	--	--	--	S	No reported release
216-S-20 Crib	--	--	--	--	S	No reported release

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
216-S-22 Crib	--	--	--	--	S	No reported release
216-S-23 Crib	--	--	--	--	S	No reported release
216-S-25 Crib	--	--	--	--	S	No reported release
216-S-26 Crib	--	--	--	--	S	No reported release
216-S-3 French Drain	--	--	--	--	S	No reported release
Ponds, Ditches, and Trenches						
216-S-10P Pond	--	--	--	--	S	
216-S-11 Pond	--	--	--	--	S	
216-S-15 Pond	--	--	--	--	S	
216-S-16P Pond	--	--	--	--	--	Associated with UPR-200-W-47, -124, and -59
216-S-17 Pond	--	--	--	--	S	
216-S-19 Pond	--	--	--	--	S	
216-S-8 Trench	--	--	--	--	S	
216-S-12 Trench	--	--	--	--	S	Also described by UPR-200-W-30
216-S-14 Trench	--	--	--	--	S	
216-S-18 Trench	--	--	--	--	S	
216-S-10D Ditch	--	--	--	--	--	
216-S-16D Ditch	--	--	--	--	S	
216-U-9 Ditch	--	--	--	--	--	Associated with UPR-200-W-139
Septic Tank and Associated Drain Fields						
2607-WZ Septic Tank	--	--	--	--	--	No reported contaminants
2607-W6 Septic Tank	--	--	--	--	--	No reported contaminants
Sanitary Crib	--	--	--	--	--	No reported release
Transfer Facilities, Diversion Boxes, and Pipelines						
241-S-151 Diversion Box	--	--	--	--	--	Associated with UPR-200-W-20 and -51

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
240-S-151 Diversion Box	--	--	--	--	--	No reported release
240-S-152 Diversion Box	--	--	--	--	--	No reported release
241-SX-151 Diversion Box	--	--	--	--	--	No reported release
241-SX-152 Diversion Box	--	--	--	--	--	No reported release
241-SX-A Valve Pit	--	--	--	--	--	No reported release
241-SX-B Valve Pit	--	--	--	--	--	No reported release
241-SY-A Diversion Box	--	--	--	--	--	No reported release
241-SY-B Diversion Box	--	--	--	--	--	No reported release
216-S-172 Diversion Box	--	--	--	--	--	No reported release
2904-S-160 Control Structure	--	--	--	--	--	No reported release
2904-S-170 Control Structure	--	--	--	--	--	No reported release
2904-S-171 Control Structure	--	--	--	--	--	No reported release
241-S-A Valve Pit	--	--	--	--	--	No reported release
241-S-B Valve Pit	--	--	--	--	--	No reported release
241-S-C Valve Pit	--	--	--	--	--	No reported release
241-S-D Valve Pit	--	--	--	--	--	No reported release
Basins						
207-S Retention Basin	--	--	--	--	--	
207-SL Retention Basin	--	--	--	--	--	
Burial Sites						
218-W-7 Burial Ground	--	--	--	--	--	
218-W-9 Burial Ground	--	--	--	--	--	
Unplanned Releases						
UN-200-W-10	--	--	--	--	--	
UN-200-W-30	--	--	--	--	--	

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UN-200-W-32	--	--	--	--	--	
UN-200-W-34	--	--	--	--	--	
UN-200-W-35	--	--	--	--	--	
UN-200-W-41	--	--	--	--	--	
UN-200-W-42	--	--	--	--	--	
UN-200-W-43	--	--	--	--	--	
UN-200-W-49	--	--	--	--	--	
UN-200-W-50	--	--	--	--	--	
UN-200-W-52	--	--	--	--	--	
UN-200-W-56	--	--	--	--	--	
UN-200-W-61	--	--	--	--	--	
UN-200-W-69	--	S	--	S	--	
UN-200-W-80	--	S	--	S	--	
UN-200-W-81	--	--	--	--	--	
UN-200-W-82	--	S	--	S	--	
UN-200-W-83	--	--	--	--	--	
UN-200-W-108	--	--	--	--	--	
UN-200-W-109	--	--	--	--	--	
UN-200-W-114	--	--	--	--	--	
UN-200-W-116	--	--	--	--	--	
UN-200-W-123	--	--	--	--	--	
UN-200-W-127	--	--	--	--	--	
UN-216-W-25	--	--	--	--	--	
UN-216-W-30	--	--	--	--	--	
UPR-200-W-15	--	--	--	--	--	

Table 4-2. Summary of Chemical Contamination in Various Affected Media for S Plant Aggregate Area.

Source Waste Management Unit	Air	Surface Soil (0-1 m)	Surface Water	Biota	Vadose Zone	Remarks
UPR-200-W-20	--	--	--	--	--	
UPR-200-W-36	--	--	--	--	--	
UPR-200-W-47	--	--	--	--	--	
UPR-200-W-51	--	--	--	--	--	
UPR-200-W-59	--	--	--	--	--	
UPR-200-W-95	--	--	--	--	--	
UPR-200-W-96	--	--	--	--	--	
UPR-200-W-124	--	--	--	--	--	
UPR-200-W-139	--	S	--	--	S	
UPR-200-W-140	--	S	--	--	S	
UPR-200-W-141	--	--	--	--	--	
UPR-200-W-142	--	S	--	--	S	
UPR-200-W-143	--	S	--	--	S	
UPR-200-W-144	--	--	--	--	--	
UPR-200-W-145	--	S	--	--	S	
UPR-200-W-146	--	S	--	--	S	

Notes:

S Suspected contamination, primarily based on WHC (1991a) and other waste in inventory data.

K Known contamination based on chemical and analytical data, WHC (1991a), or other sources.

Dashes indicate no contamination is known or suspected.

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
Tanks and Vaults						
241-S Fan and Filter Building	--	--	--	--	--	--
241-SX-401 Building	--	--	--	--	--	--
241-SX-402 Building	--	--	--	--	--	--
242-S Evaporator	--	--	--	--	--	--
241-S-101 Single-Shell Tank	R,C	R	--	--	--	R
241-S-102 Single-Shell Tank	R,C	R	--	--	--	R
241-S-103 Single-Shell Tank	R,C	R	--	--	--	R
241-S-104 Single-Shell Tank	R,C	R	--	--	--	R
241-S-105 Single-Shell Tank	R,C	R	--	--	--	R
241-S-106 Single-Shell Tank	R,C	R	--	--	--	R
241-S-107 Single-Shell Tank	R,C	R	--	--	--	R
241-S-108 Single-Shell Tank	R,C	R	--	--	--	R
241-S-109 Single-Shell Tank	R,C	R	--	--	--	R
241-S-110 Single-Shell Tank	R,C	R	--	--	--	R
241-S-111 Single-Shell Tank	R,C	R	--	--	--	R
241-S-112 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-101 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-102 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-103 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-104 Signle-Shell Tank	R,C	R	--	--	--	R
241-SX-105 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-106 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-107 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-108 Single-Shell Tank	R,C	R	--	--	--	R

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
241-SX-109 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-110 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-111 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-112 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-113 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-114 Single-Shell Tank	R,C	R	--	--	--	R
241-SX-115 Single-Shell Tank	R,C	R	--	--	--	R
241-SY-101 Single-Shell Tank	R,C	--	--	--	--	--
241-SY-102 Single-Shell Tank	R,C	--	--	--	--	--
241-SY-103 Single-Shell Tank	R,C	--	--	--	--	--
240-S-302 Catch Tank	R,C,	--	--	--	--	--
241-S-302A Catch Tank	R,C	--	--	--	--	--
241-S-302B Catch Tank	R,C	--	--	--	--	--
241-SX-302 Catch Tank	R,C	--	--	--	--	--
244-S Receiver Tank	--	--	--	--	--	--
Cribs and Drains						
216-S-1 & 2 Crib	R,C	R	--	--	R	R
216-S-5 Crib	R,C	R	--	--	--	R
216-S-6 Crib	R,C	R	--	--	--	R
216-S-7 Crib	R,C	R	--	--	--	R
216-S-9 Crib	R,C	R	--	--	--	R
216-S-13 Crib	R,C	R	--	--	--	R
216-S-20 Crib	R,C	R	--	--	--	R
216-S-22 Crib	R,C	R	--	--	--	R

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
216-S-23 Crib	R,C	R	--	--	--	R
216-S-25 Crib	R,C	R	--	--	--	R
216-S-26 Crib	R,C	R	--	--	--	--
216-S-3 French Drain	R,C	R	--	--	--	--
Ponds, Ditches, and Trenches						
216-S-10P Pond	--	R	--	--	--	R
216-S-11 Pond	R	R	--	--	--	R
216-S-15 Pond	C	R	--	--	--	--
216-S-16P Pond	R	R	--	--	--	--
216-S-17 Pond	R,C	--	--	--	R	--
216-S-19 Pond	R	--	--	R	--	--
216-S-8 Trench	R,C	R	--	--	--	R
216-S-12 Trench	R,C	R	--	--	--	--
216-S-14 Trench	--	--	--	R	--	--
216-S-18 Trench	--	--	--	R	--	--
216-S-10D Ditch	R	--	--	R	R	R
216-S-16D Ditch	C	--	--	--	--	--
216-U-9-Ditch	--	--	--	--	--	--
Septic Tanks and Associated Drain Fields						
2607-WZ Septic Tank	--	--	--	--	--	--
2607-W6 Septic Tank	--	--	--	--	--	--
Sanitary Crib	--	--	--	--	--	--
Transfer Facilities, Diversion Boxes, and Pipelines						
241-S-151 Diversion Box	--	--	--	--	--	--

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
240-S-151 Diversion Box	--	--	--	--	--	--
240-S-152 Diversion Box	--	--	--	--	--	--
241-S-152 Diversion Box	--	--	--	--	--	--
241-SX-151 Diversion Box	--	--	--	--	--	--
241-SX-152 Diversion Box	--	--	--	--	--	--
241-SX-A Valve Pit	--	--	--	--	--	--
241-SX-B Valve Pit	--	--	--	--	--	--
241-SY-A Diversion Box	--	--	--	--	--	--
241-SY-B Diversion Box	--	--	--	--	--	--
216-S-172 Control Structure	--	R	--	--	--	--
2904-S-160 Control Structure	--	R	--	--	--	--
2904-S-170 Control Structure	--	R	--	--	--	--
2904-S-171 Control Structure	--	R	--	--	--	--
241-S-A Valve Pit	--	--	--	--	--	--
241-S-B Valve Pit	--	--	--	--	--	--
241-S-C Valve Pit	--	--	--	--	--	--
241-S-D Valve Pit	--	--	--	--	--	--
Basins						
207-S Retention Basin	--	R	--	--	--	--
207-SL Retention Basin	--	R	--	R,C	--	--
Burial Sites						
217-W-7 Burial Ground	R	R	--	--	--	--
218-W-9 Burial Ground	R	--	--	--	--	--
Unplanned Releases						

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
UN-200-W-10	--	--	--	--	--	--
UN-200-W-30	--	--	--	--	--	--
UN-200-W-32	--	--	--	--	--	--
UN-200-W-34	--	--	--	--	--	--
UN-200-W-35	--	--	--	--	--	--
UN-200-W-41	--	--	--	--	--	--
UN-200-W-42	--	--	--	--	--	--
UN-200-W-43	--	--	--	--	--	--
UN-200-W-49	--	--	--	--	--	--
UN-200-W-50	--	--	--	--	--	--
UN-200-W-52	--	--	--	--	--	--
UN-200-W-56	--	--	--	--	--	--
UN-200-W-61	--	--	--	--	--	--
UN-200-W-69	--	--	--	--	--	--
UN-200-W-80	--	--	--	--	--	--
UN-200-W-81	--	--	--	--	--	--
UN-200-W-82	--	--	--	--	--	--
UN-200-W-83	--	--	--	--	--	--
UN-200-W-108	--	R	--	--	--	--
Un-200-W-109	--	R	--	--	--	--
UN-200-W-114	--	R	--	--	--	--
UN-200-W-116	--	R	--	--	--	--
UN-200-W-123	--	--	--	--	--	--
UN-200-W-127	--	--	--	--	--	--
UN-216-W-25	--	--	--	--	--	--

Table 4-3. Types of Data Available for Each Waste Management Unit.

Waste Management Unit or Unplanned Release	Inventory	Surface Radiological Survey	External Radiation Monitoring	Waste, Soil, or Sediment Sampling	Biota Sampling	Borehole Geophysics
UN-216-W-30	--	--	--	--	--	--
UPR-200-W-15	--	--	--	--	--	--
UPR-200-W-15	--	--	--	--	--	--
UPR-200-W-20	--	--	--	--	--	--
UPR-200-W-36	--	--	--	--	--	--
UPR-200-W-47	--	--	--	--	--	--
UPR-200-W-51	--	--	--	--	--	--
UPR-200-W-59	--	--	--	--	--	--
UPR-200-W-95	--	--	--	--	--	--
UPR-200-W-96	--	R	--	--	--	--
UPR-200-W-124	--	--	--	--	--	--
UPR-200-W-139	--	--	--	--	--	--
UPR-200-W-140	--	--	--	--	--	--
UPR-200-W-141	--	--	--	--	--	--
UPR-200-W-142	--	--	--	--	--	--
UPR-200-W-143	--	--	--	--	--	--
UPR-200-W-144	--	--	--	--	--	--
UPR-200-W-145	--	--	--	--	--	--
UPR-200-W-146	--	--	--	--	--	--

Notes:
C = Chemical-related data
R = Radionuclide-related data
Dashes indicate types of data not available.

Table 4-4. Summary of Air Monitoring Results (pCi/m^3).

Radionuclide	Sampling Location	
	N956	N963
Sr-90	8.37E-04	8.13E-04
Cs-137	8.64E-04	2.00E-04
Pu-239	9.55E-06	1.36E-05
U (Total)	7.15E-05	9.83E-05

Note: All values are averages for each year with a detection from 1985 to 1989.

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
Plants, Buildings, and Storage Areas						
291-S	Stack Complex	NA	NA	NA	--	--
Tanks and Vaults						
241-S-101	Single-Shell Tank	NA	NA	NA	--	--
241-S-102	Single-Shell Tank	NA	NA	NA	--	--
241-S-103	Single-Shell Tank	NA	NA	NA	--	--
241-S-104	Single-Shell Tank	NA	NA	NA	--	--
241-S-105	Single-Shell Tank	NA	NA	NA	--	--
241-S-106	Single-Shell Tank	NA	NA	NA	--	--
241-S-107	Single-Shell Tank	NA	NA	NA	--	--
241-S-108	Single-Shell Tank	NA	NA	NA	--	--
241-S-109	Single-Shell Tank	NA	NA	NA	--	--
241-S-110	Single-Shell Tank	NA	NA	NA	--	--
241-S-111	Single-Shell Tank	NA	NA	NA	--	--
241-S-112	Single-Shell Tank	NA	NA	NA	--	--
241-SX-101	Single-Shell Tank	NA	NA	NA	--	--
241-SX-102	Single-Shell Tank	NA	NA	NA	--	--
241-SX-103	Single-Shell Tank	NA	NA	NA	--	--
241-SX-104	Single-Shell Tank	NA	NA	NA	--	--

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
241-SX-105	Single-Shell Tank	NA	NA	NA	--	--
241-SX-106	Single-Shell Tank	NA	NA	NA	--	--
241-SX-107	Single-Shell Tank	NA	NA	NA	--	--
241-SX-108	Single-Shell Tank	NA	NA	NA	--	--
241-SX-109	Single-Shell Tank	NA	NA	NA	--	--
241-SX-110	Single-Shell Tank	NA	NA	NA	--	--
241-SX-112	Single-Shell Tank	NA	NA	NA	--	--
241-SX-113	Single-Shell Tank	NA	NA	NA	--	--
241-SX-114	Single-Shell Tank	NA	NA	NA	--	--
241-SX-115	Single-Shell Tank	NA	NA	NA	--	--
241-SY-101	Double-Shell Tank	NA	NA	NA	--	--
241-SY-102	Double-Shell Tank	NA	NA	NA	--	--
241-SY-103	Double-Shell Tank	NA	NA	NA	--	--
240-S-302	Catch Tank	NA	NA	NA	--	--
241-S-302A	Catch Tank	NA	NA	NA	--	--
241-S-302B	Catch Tank	NA	NA	NA	--	--
241-SX-302	Catch Tank	NA	NA	NA	--	--
244-S	Receiver Tank	NA	NA	NA	--	--
Cribs and Drains						

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
216-S-1&2	Cribs	--	150,000	--	Aug-90	β
216-S-3	French Drain	NC	NC	NC	Aug-91	--
216-S-5	Crib	NC	NC	NC	Aug-91	--
216-S-6	Crib	NC	NC	NC	Aug-91	--
216-S-7	Crib	NC	NC	NC	Aug-91	--
216-S-9	Crib	NC	NC	NC	Aug-91	--
216-S-13	Crib	NC	4,000	NC	Dec-91	β
216-S-20	Crib	NC	NC	NC	Aug-91	--
216-S-22	Crib	NC	NC	NC	Aug-91	--
216-S-23	Crib	NC	NC	NC	Aug-91	--
216-S-25	Crib	NC	NC	NC	Sep-91	--
216-S-26	Crib	NC	NC	NC	Dec-91	--
Ponds, Ditches, and Trenches						
216-S-10P	Pond	NC	NC	NC	Jul-91	--
216-S-11	Pond	NC	NC	NC	Jan-92	--
216-S-15	Pond	NC	20,000	NC	Aug-91	β
216-S-16P	Pond	NC	NC	NC	Feb-91	--
216-S-17	Pond	1,000	NC	NC	Jul-90	Unknown
216-S-19	Pond	NC	NC	NC	Oct-91	--

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
216-S-10D	Ditch	NC	NC	NC	Jan-92	--
216-S-16D	Ditch	NC	NC	NC	Sep-84	--
216-U-9	Ditch	NA	NA	NA	--	--
216-S-8	Trench	--	--	2.6	Aug-90	Unknown
216-S-12	Trench	NC	NC	NC	Aug-91	--
216-S-14	Trench	NC	NC	NC	Feb-71	--
216-S-18	Trench	NC	NC	NC	Oct-72	--
Septic Tanks and Associated Drain Fields						
2607-W6	Septic Tank and Tile Field	NA	NA	NA	--	--
2607-WZ	Septic Tank (2) and Drain Field	NA	NA	NA	--	--
--	Sanitary Crib	NA	NA	NA	--	--
Transfer Facilities and Pipelines						
216-S-172	Control Structure	--	--	25[a]	Unknown	Unknown
2904-S-160	Control Structure	5,000	--	--	Unknown	β,δ
2904-S-170	Control Structure	<200	--	<7[a]	Unknown	β,δ
2904-S-171	Control Structure	100	--	20	Unknown	β,δ
240-2-151	Diversion Box	NA	NA	NA	--	--
240-S-152	Diversion Box	NA	NA	NA	--	--

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
241-S-151	Diversion Box	NA	NA	NA	--	--
241-S-152	Diversion Box	NA	NA	NA	--	--
241-SX-151	Diversion Box	NA	NA	NA	--	--
241-SX-152	Diversion Box	NA	NA	NA	--	--
241-S-A	Valve Pit	NA	NA	NA	--	--
352-S-B	Valve Pit	NA	NA	NA	--	--
241-S-C	Valve Pit	NA	NA	NA	--	--
241-S-D	Valve Pit	NA	NA	NA	--	--
241-SX-A	Valve Pit	NA	NA	NA	--	--
241-SX-B	Valve Pit	NA	NA	NA	--	--
241-SY-A	Valve Pit	NA	NA	NA	--	--
241-SY-B	Valve Pit	NA	NA	NA	--	--
Basins						
207-S	Retention Basin	--	60,000	--	Jul-90	Unknown
207-SL	Retention Basin	NC	NC	NC	Jul-90	--
Burial Sites						
218-W-7	Burial Ground	--	--	3.5[a]	Jul-90	Unknown
218-W-9	Burial Ground	--	25,000	--	Jul-90	Unknown
Unplanned Releases						

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
UN-200-W-10	Unplanned Release	NA	NA	NA	--	--
UN-200-W-30	Unplanned Release	NA	NA	NA	--	--
UN-200-W-32	Unplanned Release	--	30,000	--	1991	β
UN-200-W-34	Unplanned Release	NA	NA	NA	--	--
UN-200-W-35	Unplanned Release	NA	NA	NA	--	--
UN-200-W-41	Unplanned Release	NA	NA	NA	--	--
UN-200-W-42	Unplanned Release	NA	NA	NA	--	--
UN-200-W-43	Unplanned Release	NA	NA	NA	--	--
UN-200-W-49	Unplanned Release	NA	NA	NA	--	--
UN-200-W-50	Unplanned Release	NA	NA	NA	--	--
UN-200-W-52	Unplanned Release	NA	NA	NA	--	--
UN-200-W-56	Unplanned Release	NA	NA	NA	--	--
UN-200-W-61	Unplanned Release	NA	NA	NA	--	--
UN-200-W-69	Unplanned Release	NA	NA	NA	--	--
UN-200-W-80	Unplanned Release	60,000	--	--	Unknown	Unknown
UN-200-W-81	Unplanned Release	NA	NA	NA	--	--
UN-200-W-82	Unplanned Release	NA	NA	NA	--	--
UN-200-W-83	Unplanned Release	NA	NA	NA	--	--
UN-200-W-108	Unplanned Release	NC	NC	NC	Oct-90	--

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
UN-200-W-109	Unplanned Release	6,000	--	--	Oct-90	Unknown
UN-200-W-114	Unplanned Release	450	--	--	Oct-90	Unknown
UN-200-W-116	Unplanned Release	200	--	--	Oct-90	Unknown
UN-200-W-123	Unplanned Release	NA	NA	NA	--	--
UN-200-W-127	Unplanned Release	NA	NA	NA	--	--
UN-216-W-25	Radiation Emissions	40,000	--	--	1991	β
UN-216-W-30	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-13	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-15	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-20	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-36	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-47	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-51	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-57	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-59	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-87	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-95	Unplanned Release	NA	NA	NA	--	--
UPR-2OO-W-96	Unplanned Release	3,000	--	--	Oct-90	Unknown
UPR-200-W-124	Unplanned Release	--	--	--	--	--

Table 4-5. Radiation and Dose Rate Surveys at the S Plant Aggregate Area Waste Managment Units.

Waste Management Unit	Waste Management Unit Type	ct/min	Radiation Surveys dis/min	mrem/h	Survey Date	Radiation Type
UPR-200-W-139	Unplanned Release	--	--	--	--	--
UPR-200-W-140	Unplanned Release	--	--	--	--	--
UPR-200-W-141	Unplanned Release	--	--	--	--	--
UPR-200-W-142	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-143	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-144	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-145	Unplanned Release	NA	NA	NA	--	--
UPR-200-W-146	Unplanned Release	NA	NA	NA	--	--

NA = No data available
NC = No contamination detected
[a] = It was assumed that 1 mR/h was equivalent to 1 mrem/h

Table 4-6. Results of External Radiation Monitoring, 1985 through 1989: TLDs (mrem/yr).

Location	1985	1986	1987	1988	1989	Average Total
2W28: 241-SX Tank Farm E						
Max	86	105	130	134	136	
Min	73	72	84	102	76	
Total	79	83	101	111	116	98
2W29: NE Corner S Plant Aggregate Area						
Max	81	95	120	123	--	
Min	64	70	79	94	--	
Total	73	79	100	104	--	89
2W30: 200-W SE						
Max	78	100	112	114	--	
Min	59	66	78	90	--	
Total	68	78	95	98	--	85
2W31: 200-W SW						
Max	72	95	99	108	--	
Min	62	65	70	83	--	
Total	68	73	83	94	--	80
2W32: 200-W S						
Max	74	95	97	114	--	
Min	61	64	71	90	--	
Total	66	75	83	98	--	81
2W33: 207-S Retention Basin SE						
Max	80	106	101	125	--	
Min	66	52	81	86	--	
Total	74	80	88	103	--	86
2W34: REDOX ESE						
Max	75	93	100	107	--	
Min	58	65	73	84	--	
Total	66	74	84	92	--	79

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.
Dashes indicate data are not available.

Table 4-7. Results of External Radiation Monitoring, 1990 and 1991: TLDs (mrem/yr).

Location	1990	1991	Average Total
210: E-122 Baseline Site			
Max	164	168	
Min	100	110	
Total	125	138	132
213: 216-S-19 Pond			
Max	108	119	
Min	92	71	
Total	97	91	94

Source: Schmidt et al. 1992

Table 4-8. Summary of Grid Soil Sampling Results: 1985 through 1989 (pCi/g).

	Sampling Location					
Radionuclide	2W28	2W29	2W31	2W32	2W33	2W34
Ce-141	1.12E-02	1.80E-02	7.80E-03	--	1.83E-02	3.79E-02
Ce-144	2.48E-02	1.73E-01	6.00E-02	--	3.69E-02	5.20E-02
Co-58	1.26E-02	5.20E-03	5.40E-03	--	1.22E-02	1.08E-03
Co-60	1.24E-02	1.64E-02	1.24E-02	9.80E-03	1.34E-02	2.29E-02
Cs-134	3.34E-02	2.80E-02	2.60E-02	--	4.11E-02	4.17E-02
Cs-137	7.95E+00	1.62E+00	7.75E-01	6.60E-01	1.76E+00	1.22E+00
Eu-152	1.13E-01	1.05E-01	6.80E-02	1.40E-01	8.72E-02	1.11E-01
Eu-154	4.39E-02	3.30E-02	4.30E-02	2.50E-02	5.57E-02	2.41E-02
Eu-155	5.06E-02	4.00E-02	1.80E-02	7.20E-02	2.52E-02	7.10E-02
I-129	1.37E-01	--	8.30E-02	--	1.75E-01	3.70E-01
K-40	1.17E+01	--	--	--	1.47E+01	1.33E+01
Mn-54	1.04E-02	5.40E-03	1.55E-02	3.70E-03	1.24E-02	6.90E-03
Nb-95	2.79E-02	1.30E-02	1.40E-02	3.10E-02	1.59E-02	3.73E-02
Pb-212	5.89E-01	--	--	--	7.36E-01	7.42E-01
Pb-214	4.88E-01	6.50E-01	5.70E-01	6.50E-01	5.90E-01	5.34E-01
Pu-238	1.98E-03	5.53E-03	3.75E-03	1.00E-03	3.60E-03	3.54E-01
Pu-239	2.09E-02	7.00E-02	1.44E-01	4.30E-02	1.11E-01	1.37E-01
Ru-106	1.87E-01	3.50E-01	1.09E-01	2.70E-02	1.63E-02	5.83E-02
Sr-90	1.05E+00	7.35E-01	2.30E-01	3.20E-01	6.20E-01	9.04E-01
Tc-99	2.17E-01	--	1.30E-01	--	9.25E-02	1.51E-01
U (total)	3.47E-01	3.93E-01	2.30E-01	2.60E-01	3.50E-01	3.73E-01
Zn-65	3.55E-02	6.80E-03	3.50E-02	--	6.74E-02	6.31E-02
Zr-95	9.23E-03	2.60E-02	1.46E-02	1.40E-02	1.79E-02	9.75E-03

Dashes indicate data not available.

Table 4-9. Summary of Fenciline Soil Sampling Results (pCi/g).

	Sampling Location		
Radionuclide	S-TF-SE	S-TF-NE	S-TF-W
Ce-141	5.70E-02	6.93E-03	1.14E-02
Ce-144	1.32E-01	3.59E-02	2.61E-02
Co-58	1.04E-02	3.59E-02	2.15E-02
Co-60	9.30E-03	2.29E-02	3.16E-02
Cs-134	2.83E-02	4.04E-02	2.80E-02
Cs-137	2.46E+01	3.80E+00	3.74E+00
Eu-152	6.55E-02	8.62E-02	6.09E-02
Eu-154	2.98E-02	2.41E-02	1.60E-02
Eu-155	2.47E-02	4.17E-02	3.26E-02
I-129	--	--	--
K-40	1.38E+01	1.45E+01	1.36E+01
Mn-54	1.36E-02	1.45E-02	9.97E-03
Nb-95	7.43E-02	6.43E-02	3.79E-02
Pb-212	6.32E-01	7.62E-01	5.90E-01
Pb-214	5.07E-01	5.08E-01	4.39E-01
Pu-238	6.17E-03	1.11E-03	8.30E-04
Pu-239	3.03E-02	2.15E-02	1.52E-02
Ru-106	1.95E-01	3.33E-02	8.90E-02
Sr-90	4.74E+00	2.55E+00	1.50E+00
Tc-99	--	--	--
U (total)	3.13E-01	3.33E-01	2.79E-01
Zn-65	7.46E-03	1.14E-01	2.54E-02
Zr-95	2.07E-02	1.28E-02	1.11E-02

Note: All values are averages for each year with a detection from 1985 to 1989.
Dashes indicate data are not available.

Table 4-10. Results of Surface Water Sampling (pCi/mL).

RM28: 216-S-10D Ditch							
Radionuclide	1985		1986		1990		Detection Limit (DL)
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	
Total Beta	0.106	0.008	0.036	<DL	<DL	<DL	0.1
Total Alpha	0.007	0.001	0.012	<DL	<DL	<DL	0.04
^{137}Cs	0.121	0.043	0.127	<DL	<DL	<DL	0.2
^{90}Sr	0.030	0.020	0.040	<DL	<DL	<DL	0.1

Sources: Elder et al. 1986, 1987, 1989; Schmidt et al. 1992.

Table 4-11. Nonradiological Parameters for Water in the 216-S-10 Ditch.

Year	Sample Location	Sample Number	Maximum pH	Minimum pH	Average pH	Maximum NO_3 ppm	Minimum NO_3 ppm	Average NO_3 ppm
1986	216-S-10 Ditch	RM 28	8.6	7.1	7.9	<DL	<DL	<DL
1988	216-S-10 Ditch	RM 28	9.6	7.0	7.8	<DL	<DL	<DL
1990	216-S-10 Ditch	RM 28	9.21	7.56	8.15	<DL	<DL	<DL

NOTE: pH maximum and minimum are from weekly samples
<DL = less than detection limit (~ 1.2 ppm).
Source: Elder et al. 1987, 1989; Schmidt et al. 1992.

Table 4-12. Summary of Vegetation Sampling Results: 1985 through 1989 (pCi/g).

	Sampling Location					
Radionuclide	2W28	2W29	2W31	2W32	2W33	2W34
Be-7	--	--	--	--	--	--
Ce-141	7.79E-03	--	--	--	1.58E-02	7.32E-04
Co-58	1.94E-01	9.70E-02	--	--	--	--
Co-60	1.37E-02	5.00E-02	1.82E-02	3.80E-04	3.14E-02	3.08E-02
Cs-134	--	9.00E-02	2.90E-02	--	1.14E-01	7.80E-02
Cs-137	1.42E+00	6.53E-01	1.50E-01	3.00E-01	4.35E-01	3.21E-01
Eu-152	2.36E-02	1.14E-01	1.45E-02	4.70E-03	1.48E-01	8.44E-02
Eu-154	9.93E-02	6.60E-02	2.95E-02	4.80E-02	6.29E-02	3.87E-02
Eu-155	1.40E-02	3.70E-03	2.50E-02	6.00E-02	5.67E-03	1.33E-02
I-129	6.66E-02	--	1.40E-01	--	1.84E-01	--
K-40	1.16E+01	--	--	--	1.12E+01	1.51E+01
Nb-95	1.15E-02	1.30E-02	2.97E-02	1.14E-01	2.10E-02	4.25E-02
Pb-212	2.31E-02	--	--	--	1.15E-02	1.08E-01
Pb-214	2.58E-02	--	--	--	4.47E-02	7.83E-02
Pu-238	1.46E-04	--	--	--	1.25E-03	2.20E-02
Pu-239	4.66E-03	--	--	--	6.08E-02	5.63E-03
Ru-103	--	8.10E-02	--	--	1.54E-01	1.55E-01
Ru-106	--	--	--	--	--	--
Sr-90	4.68E-01	4.20E-01	--	3.80E-01	3.06E-01	4.01E-01
Tc-99	6.58E-01	--	4.10E-01	--	4.44E-01	6.15E-01
Zn-65	--	--	--	--	2.36E-01	1.68E-01
Zr-95	2.55E-02	--	4.60E-02	--	1.60E-03	2.93E-02

Dashes indicate data are not available.

Table 4-13. Grid Site Feces Results in the S Plant Aggregate Area for 1985 (pCi/g dry weight).

Grid Site	Type	^{54}Mn ±error	^{58}Co ±error	^{60}Co ±error	^{65}Zn ±error	^{106}Ru ±error	^{134}Cs ±error	^{137}Cs ±error	^{152}Eu ±error	^{155}Eu ±error
2WC	Rabbit	--	0.254 ±0.218	--	--	--	--	0.392 ±0.171	--	--

Note: ± error = counting error.
[--] = indicates that radionuclide concentration is less than detectable.
Source: Elder et al. 1986.

Table 4-14. Summary of Gamma-Ray Logs that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
	Cribs and Drains		
216-S-1 and -2 Cribs	299-W22-1	4	1/58 to 3/66
	299-W22-2	5	1/58 to 7/79
	299-W22-5	7	5/63 to 8/87
	299-W22-6	5	2/58 to 8/87
	299-W22-10	6	5/63 to 3/87
	299-W22-11	1	8/87
	299-W22-15	6	4/66 to 8/87
	299-W22-16	5	5/63 to 8/87
	299-W22-17	6	2/58 to 8/87
	299-W22-18	6	2/68 to 8/87
	299-W22-29	3	2/68 to 2/86
	299-W22-30	4	2/68 to 6/80
	299-W22-31	4	2/68 to 3/80
	299-W22-36	3	2/68 to 2/86
	299-W22-67	5	2/68 to 8/87
216-S-5 Cribs	299-W26-1	1	5/76
	299-W26-3	1	5/76
	299-W26-4	1	5/76
	299-W26-5	1	5/76
26-S-6 Crib	299-W26-2	1	5/76
	299-W26-51	1	8/87
216-S-7 Crib	299-W22-12	3	2/58 to 2/76
	299-W22-13	3	5/63 to 5/76
	299-W22-14	4	2/58 to 2/87
	299-W22-32	3	2/68 to 2/79
	299-W22-33	5	2/68 to 8/87
216-S-9 Crib	299-W22-25	4	3/70 to 8/87
	299-W22-26	2	3/66 to 3/70
	299-W22-34	3	5/76 to 8/87
	299-W22-35	3	5/76 to 8/87
216-S-13 Crib	299-W22-21	3	5/63 to 2/76
216-S-20 Crib	299-W22-20	3	5/63 to 5/76
	299-W22-74	1	3/84

Table 4-14. Summary of Gamma-Ray Logs that were Reviewed.

Waste Management Unit	Well Number	Number of Times Logged	Inclusive Dates
216-S-22 Crib	299-W22-19	4	7/63 to 3/84
216-S-23 Crib	299-W19-5	1	5/76
	299-W19-6	1	5/76
	299-W19-7	1	5/76
	299-W22-37	1	5/76
	299-W22-38	1	5/76
216-S-25 Crib	299-W23-9	1	2/76
	299-W23-10	1	5/76
	299-W23-11	1	5/76
Ponds, Ditches and Trenches			
216-S-10P Pond	699-32-77	2	8/80 to 4/90
216-S-11 Pond	299-W26-9	2	4/90
216-S-10D Ditch	299-W26-8	1	4/90
	299-W26-11	3	4/90 to 5/90
216-S-8 Trench	299-W22-39	2	1/91 to 2/91

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Table 4-15. Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 1 of 2

Waste Management Unit	Range of Soil Column Pore Volumes (m^3)[a]	Liquid Effluent Volume Received (m^3)	Potential Migration to Unconfined Aquifer
Cribs and Drains			
216-S-1 and -2 Cribs	2,007 to 6,020	160,000	Yes
216-S-5 Crib	24,582 to 73,746	4,100,000	Yes
216-S-6 Crib	11,706 to 35,117	4,470,000	Yes
216-S-7 Crib	2,787 to 8,361	390,000	Yes
216-S-9 Crib	5,017 to 15,050	50,300	Yes
216-S-13 Crib	892 to 2,676	5,000	Yes
216-S-20 Crib	2,007 to 6,020	135,000	Yes
216-S-22 Crib	195 to 585	98	No
216-S-23 Crib	2,007 to 6,020	34,100	Yes
216-S-25 Crib	3,205 to 9,615	288,00	Yes
216-S-26 Crib	2,341 to 7,023	164,000	Yes
216-S-3 French Drain	111 to 334	4,200	Yes
Ponds, Ditches, and Trenches			
216-S-11 Pond	36,422 to 109,265	2,230,000	Yes
216-S-15 Pond	98 to 293	10	No
216-S-16P Pond	752,715 to 2,258,146	40,700,000	Yes
216-S-17 Pond	509,904 to 1,529,712	6,440,000	Yes
216-S-19 Pond	84,984 to 254,952	1,330,000	Yes
216-S-10D Ditch	7,525 to 22,575	4,340,000	Yes

Table 4-15. Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 2 of 2

Waste Management Unit	Range of Soil Column Pore Volumes (m^3)[a]	Liquid Effluent Volume Received (m^3)	Potential Migration to Unconfined Aquifer
216-S-16D Ditch	6,689 to 20,067	400,000	Yes
216-S-8 Trench	3,344 to 10,033	10,000	Yes[b]
216-S-12 Trench	1,003 to 3,010	68	No

Source: 1991a

[a] Pore volume calculation: (waste unit section area) x (nominal depth to groundwater, assumed to be 60 m) x (porosity). 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.

[b] The effluent volume received by these units exceeds the lower pore volume estimate but is below the high estimate. Given the high permeability of the soil column in general, it is likely that some of the discharge waste volume reached groundwater.

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank S-101 (Ci)	Tank S-102 (Ci)	Tank S-103 (Ci)	Tank S-104 (Ci)	Tank S-105 (Ci)	Tank S-106 (Ci)	Tank S-107 (Ci)	Tank S-108 (Ci)
1. Ac225	5E-09	4E-09	4E-17	6E-10	8E-10	2E-09	4E-10	4E-08
2. Ac227	3E-05	1E-05	2E-13	5E-06	5E-06	6E-05	6E-06	2E-04
3. Am241	1E+02	5E+01	2E-06	7E-04	6E-04	4E+00	7E+00	8E+02
4. Am242	2E-01	8E-02	2E-09	2E-06	3E-07	7E-03	1E-02	2E+00
5. Am242M	2E-01	8E-02	2E-09	2E-06	3E-07	7E-03	1E-02	2E+00
6. Am243	9E-02	4E-02	1E-09	5E-07	8E-08	3E-03	5E-03	7E-01
7. At217	5E-09	4E-09	4E-17	6E-10	8E-10	2E-09	4E-10	3E-08
8. Bs137M	2E+03	1E+04	7E-04	3E+02	6E+02	9E+02	1E+04	9E+00
9. Bi210	1E-12	9E-13	3E-21	2E-14	4F-13	3E-13	2E-13	3E-13
10. Bi211	1E-05	1E-05	2E-13	5E-06	5E-06	8E-06	6E-06	2E-06
11. Bi213	2E-09	4E-09	4E-17	6E-10	8E-10	1E-09	4E-10	4E-10
12. Bi214	6E-12	9E-12	2E-19	6E-14	1E-12	1E-12	1E-12	1E-12
13. C14	7E+01	3E+01	5E-07	1E+01	2E+01	3E+01	1E+01	4E+02
14. Cm242	2E-01	7E-02	2E-09	2E-06	2E-07	5E-03	1E-02	1E+00
15. Cm244	6E-01	2E-01	9E-09	5E-03	3E-03	4E-02	5E-02	SE+00
16. Cm245	3E-05	9E-06	3E-13	9E-08	5E-08	1E-06	2E-06	2E-04
17. Cs135	7E-01	3E-01	5E-09	8E-01	1E+00	2E+00	5E-02	4E+00
18. Cs137	1E+05	6E+04	7E-04	1E+05	1E+05	2E+05	1E+04	7E+05
19. Fr221	5E-09	4E-09	4E-17	6E-10	8E-10	2E-09	4E-10	4E-08
20. Fr223	4E-07	2E-07	3E-15	6E-08	8E-08	2E-07	8E-08	2E-06
21. I129	2E-01	8E-02	1E-09	4E-02	5E-02	1E-01	3E-02	1E+00
22. N693M	3E+00	2E+00	5E-08	4E-02	7E-02	9E-01	6E-01	2E+01
23. Ni63	4E-01	2E-02	5E-07	3E+02	3E+02	4E+02	5E-03	1E+03
24. NP237	2E-01	1E-01	2E-09	1E-01	1E-01	2E-01	1E-02	1E+00
25. NP239	9E-02	4E-02	1E-09	5E-07	8E-08	3E-03	5E-03	7E-01
26. Pa231	7E-05	3E-05	6E-13	8E-06	9E-06	2E-05	1E-05	4E-04

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank S-101 (Ci)	Tank S-102 (Ci)	Tank S-103 (Ci)	Tank S-104 (Ci)	Tank S-105 (Ci)	Tank S-106 (Ci)	Tank S-107 (Ci)	Tank S-108 (Ci)
27. Pa233	2E-01	1E-01	2E-09	1E-01	1E-01	2E-01	1E-02	1E+00
28. Pa234M	7E-15	1E-14	8E-23	7E-16	2E-13	2E-12	1E-15	8E-10
29. Pb209	5E-09	4E-09	4E-17	6E-10	8E-10	2E-09	4E-10	2E-08
30. Pb210	3E-12	9E-13	3E-21	2E-14	4E-13	4E-13	2E-13	1E-11
31. Pb211	3E-05	1E-05	2E-13	5E-06	5E-06	1E-05	6E-06	7E-05
32. Pb214	2E-11	9E-12	2E-19	7E-14	1E-12	2E-12	1E-12	5E-11
33. Po107	4E-11	1E-01	3E-09	6E-02	7E-02	2E-01	5E-02	2E+00
34. Po210	3E-12	9E-13	2E-20	2E-14	4E-13	4E-13	2E-13	2E-11
35. Po213	3E-09	4E-09	4E-17	6E-10	8E-10	2E-10	4E-10	3E-08
36. Po214	2E-11	1E-11	2E-19	8E-14	2E-12	2E-12	2E-12	1E-10
37. Po215	3E-05	1E-05	2E-13	5E-05	5E-06	1E-05	6E-06	2E-04
38. Po218	2E-11	9E-12	2E-19	7E-14	1E-12	2E-12	1E-12	1E-10
39. Pu238	3E-03	1E-03	2E-11	0	0	2E-04	2E-04	1E-02
40. Pu239	1E-05	3E-06	6E-14	0	0	2E-06	7E-06	8E-05
41. Pu240	1E-04	5E-05	1E-12	0	0	2E-05	2E-05	7E-04
42. Pu241	3E-05	1E-05	3E-13	0	0	2E-05	6E-05	1E-04
43. Ra223	3E-05	1E-05	2E-13	5E-06	5E-06	1E-05	6E-06	2E-04
44. Ra225	5E-09	4E-09	4E-17	6E-10	8E-10	2E-09	4E-10	4E-08
45. Ra226	2E-11	9E-12	2E-19	7E-14	1E-12	2E-12	1E-12	1E-10
46. Ru106	3E-02	5E-02	1E-09	3E-04	9E-05	1E-02	2E-02	4E-01
47. Sb126	1E-06	9E-06	1E-08	6E-14	1E-13	4E-06	6E-08	2E-07
48. Sb126M	1E-06	9E-06	1E-08	6E-14	1E-13	4E-06	6E-05	2E-07
49. Sb79	4E+00	1E+00	4E-08	7E-01	9E-01	2E+00	6E-01	2E+01
50. Sm151	3E+02	9E+02	1E-05	2E-04	2E-04	4E+01	8E+01	3E+03
51. Sm126	7E-01	7E-01	1E-08	6E-14	1E-13	3E-02	7E-02	3E+00
52. Sr90	1E+05	5E+04	1E-03	2E-07	1E+02	7E+03	7E+03	1E+06

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank S-101 (Ci)	Tank S-102 (Ci)	Tank S-103 (Ci)	Tank S-104 (Ci)	Tank S-105 (Ci)	Tank S-106 (Ci)	Tank S-107 (Ci)	Tank S-108 (Ci)
53. Tc99	1E+02	5E+01	8E-07	3E+01	3E+01	7E+01	2E+01	8E+02
54. Th227	3E-05	1E-05	2E-13	5E-14	5E-14	1E-05	5E-06	2E-04
55. Th229	5E-09	4E-09	4E-17	5E-18	1E-17	2E-09	4E-10	4E-08
56. Th230	5E-10	7E-10	2E-17	1E-25	1E-24	3E-11	7E-11	3E-09
57. Th231	2E-14	3E-15	1E-23	2E-25	5E-23	1E-13	1E-14	2E-11
58. Th234	7E-15	1E-14	8E-23	9E-24	2E-21	2E-12	1E-15	4E-10
59. Tl207	3E-05	1E-05	2E-13	5E-06	5E-06	1E-05	6E-05	2E-04
60. U233	9E-08	1E-07	3E-15	5E-08	8E-08	1E-07	6E-08	2E-08
61. U234	9E-10	8E-10	1E-17	1E-14	9E-14	2E-10	7E-10	4E-10
62. U235	2E-15	1E-15	1E-23	5E-19	2E-16	3E-15	1E-14	2E-14
63. U238	3E-16	4E-18	8E-27	1E-17	4E-15	4E-14	2E-16	4E-13
64. Y90	1E+05	5E+04	2E-03	3E-07	2E+02	7E+03	7E+03	1E+06
65. Zr93	0	0	0	0	0	0	0	0
66. Ag	0	0	0	0	0	0	0	0
67. Al	0	0	0	0	0	0	0	0
68. C2H3O3	0	0	0	0	0	0	0	0
69. Ba	0	0	0	0	0	0	0	0
70. Bi	0	0	0	0	0	0	0	0
71. CoH507	0	0	0	0	0	0	0	0
72. Co3	0	0	0	0	0	0	0	0
73. Ca	0	0	0	0	0	0	0	0
74. Ce	0	0	0	0	0	0	0	0
75. Cl	0	0	0	0	0	0	0	0
76. Ca	0	0	0	0	0	0	0	0
77. EDTA	0	0	0	0	0	0	0	0
78. F	0	0	0	0	0	0	0	0

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank S-101 (Ci)	Tank S-102 (Ci)	Tank S-103 (Ci)	Tank S-104 (Ci)	Tank S-105 (Ci)	Tank S-106 (Ci)	Tank S-107 (Ci)	Tank S-108 (Ci)
79. Fl	0	0	0	0	0	0	0	0
80. HEDTA	0	0	0	0	0	0	0	0
81. K	0	0	0	0	0	0	0	0
82. La	0	0	0	0	0	0	0	0
83. Mn	0	0	0	0	0	0	0	0
84. NO2	0	0	0	0	0	0	0	0
85. NO3	0	0	0	0	0	0	0	0
86. Na	0	0	0	0	0	0	0	0
87. Ni	0	0	0	0	0	0	0	0
88. OH	0	0	0	0	0	0	0	0
89. Po4	0	0	0	0	0	0	0	0
90. Pu	0	0	0	0	0	0	0	0
91. S103	0	0	0	0	0	0	0	0
92. SO4	0	0	0	0	0	0	0	0
93. Sr	0	0	0	0	0	0	0	0
94. Zro	0	0	0	0	0	0	0	0
Total Curies	3E+05	1E+05	4E-03	1E+05	1E+05	2E+05	3E+05	3E+06

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 5 of 24

Component	Tank S-109 (Ci)	Tank S-110 (Ci)	Tank S-111 (Ci)	Tank S-112 (Ci)
1. Ac225	4E-08	5E-08	5E-08	2E-08
2. Ac227	9E-05	4E-05	3E-04	7E-05
3. Am241	4E+02	7E+02	2E+03	2E-02
4. Am242	6E-01	1E+00	3E+00	4E-01
5. Am242M	6E-01	1E+00	3E+00	4E-01
6. Am243	3E-01	6E-01	1E+00	2E-01
7. At217	4E-08	5E-08	5E-08	2E-06
8. Bs137M	7E+01	4E+01	6E+01	1E+02
9. Bi210	1E-13	8E-12	5E-12	1E-12
10. Bi211	1E-06	1E-04	3E-05	1E-05
11. Bi213	6E-10	1E-08	5E-09	4E-09
12. Bi214	6E-13	3E-11	2E-11	6E-12
13. C14	2E+02	8E+02	7E+02	2E+02
14. Cm242	5E-01	1E+00	2E+00	4E-01
15. Cm244	2E+00	5E+00	9E+00	1E+00
16. Cm245	6E-05	2E-04	4E-04	5E-05
17. Cs135	3E+00	6E+00	8E+00	1E+00
18. Cs137	5E+05	2E+06	1E+05	2E+05
19. Fr221	4E-08	5E-08	5E-08	2E-08
20. Fr223	1E-06	6E-06	4E-06	9E-07
21. I129	7E-01	3E+00	2E+00	5E-01
22. N693M	1E+01	5E+01	4E+01	8E+00
23. N163	2E+02	7E+02	4E+03	2E+02
24. NP237	6E-01	3E+00	2E+00	4E-01
25. NP239	3E-01	6E-01	1E+00	2E-01
26. Pa231	2E-04	1E-03	7E-04	2E-04
27. Pa233	6E-01	3E+00	2E+00	4E-01

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 6 of 24

Component	Tank S-109 (Ci)	Tank S-110 (Ci)	Tank S-111 (Ci)	Tank S-112 (Ci)
28. Pa234M	7E-03	1E-11	6E-12	1E-02
29. Pb209	4E-08	4E-08	5E-09	2E-06
30. Pb210	9E-12	3E-11	5E-11	6E-12
31. Pb211	9E-05	4E-04	3E-04	7E-05
32. Pb214	5E-11	1E-10	2E-10	3E-11
33. Po107	1E+00	4E+00	4E+00	8E-01
34. Po210	9E-12	3E-11	5E-11	6E-12
35. Po213	4E-08	5E-08	5E-08	2E-08
36. Po214	6E-11	2E-10	3E-10	4E-11
37. Po215	9E-05	4E-04	3E-04	7E-05
38. Po218	5E-11	1E-10	2E-10	3E-11
39. Pu238	2E-05	3E-02	2E-02	6E-06
40. Pu239	2E-04	3E-04	5E-05	2E-04
41. Pu240	5E-05	2E-03	1E-03	4E-05
42. Pu241	4E-04	2E-03	1E-04	3E-04
43. Ra223	9E-05	4E-04	3E-04	7E-05
44. Ra225	4E-08	5E-08	5E-08	2E-06
45. Ra226	5E-11	1E-10	2E-10	3E-11
46. Ru106	2E-01	8E-01	8E-01	1E-01
47. Sb126	7E-08	1E-07	1E-07	9E-09
48. Sb126M	7E-08	2E-07	1E-07	9E-09
49. Sb79	1E+01	5E+01	4E+01	9E+00
50. Sm151	5E+03	8E+03	7E+03	1E+03
51. Sm126	4E+00	7E+00	6E+00	1E+00
52. Sr90	3E+05	7E+05	2E+06	3E+05
53. Tc99	4E+02	2E+03	1E+03	3E+02
54. Th227	9E-05	4E-04	3E-04	6E-05

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 7 of 24

Component	Tank S-109 (Ci)	Tank S-110 (Ci)	Tank S-111 (Ci)	Tank S-112 (Ci)
55. Th229	4E-08	5E-08	5E-08	2E-08
56. Th230	4E-09	5E-09	5E-09	1E-09
57. Th231	3E-04	4E-12	2E-12	5E-04
58. Th234	7E-03	1E-11	6E-12	1E-02
59. Tl207	9E-05	4E-04	3E-04	7E-05
60. U233	3E-13	1E-07	1E-07	3E-13
61. U234	8E-14	1E-09	3E-09	4E-14
62. U235	4E-12	7E-15	5E-15	8E-12
63. U238	8E-11	2E-14	1E-14	2E-10
64. Y90	4E+05	7E+05	2E+05	3E+05
65. Zr93	0	0	0	0
66. Ag	0	0	0	0
67. Al	0	0	0	0
68. C2H3O3	0	0	0	0
69. Ba	0	0	0	0
70. Bi	0	0	0	0
71. CoH507	0	0	0	0
72. Co3	0	0	0	0
73. Ca	0	0	0	0
74. Ce	0	0	0	0
75. Cl	0	0	0	0
76. Ca	0	0	0	0
77. EDTA	0	0	0	0
78. F	0	0	0	0
79. Fl	0	0	0	0
80. HEDTA	0	0	0	0
81. K	0	0	0	0

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 8 of 24

Component	Tank S-109 (Ci)	Tank S-110 (Ci)	Tank S-111 (Ci)	Tank S-112 (Ci)
82. La	0	0	0	0
83. Mn	0	0	0	0
84. NO2	0	0	0	0
85. NO3	0	0	0	0
86. Na	0	0	0	0
87. Ni	0	0	0	0
88. OH	0	0	0	0
89. Po4	0	0	0	0
90. Pu	0	0	0	0
91. S103	0	0	0	0
92. SO4	0	0	0	0
93. Sr	0	0	0	0
94. Zro	0	0	0	0
Total Curies	1E+06	3E+06	2E+06	8E+05

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-101 (Ci)	Tank SX-102 (Ci)	Tank SX-103 (Ci)	Tank SX-104 (Ci)	Tank SX-105 (Ci)	Tank SX-106 (Ci)
1. Ac225	0	7E-16	3E-09	5E-11	1E-09	6E-08
2. Ac227	1E-29	7E-12	3E-05	2E-07	3E-05	2E-04
3. Am241	1E-23	2E-05	3E+01	8E-01	3E+01	1E+-3
4. Am242	1E-26	7E-08	5E-02	1E-03	4E-02	2E+00
5. Am242M	1E-26	7E-08	5E-02	1E-03	4E-02	2E+00
6. Am243	1E-26	2E-08	3E-02	6E-04	2E-02	1E+00
7. At217	0	7E-15	3E-09	5E-11	1E-09	6E-08
8. Bs137M	2E-20	5E-03	2E+03	1E+01	1E+04	6E+02
9. Bi210	0	7E-20	4E-12	2E-14	1E-12	6E-13
10. Bi211	0	7E-12	5E-05	2E-07	3E-05	4E-05
11. Bi213	0	7E-16	3E-09	6E-11	1E-09	1E-05
12. Bi214	0	3E-18	1E-11	1E-13	5E-12	3E-11
13. C14	6E-24	7E-08	7E+01	4E-01	7E+01	6E+02
14. Cm242	2E-26	5E-08	5E-02	1E-03	4E-02	2E+00
15. Cm244	3E-26	1E-07	4E-01	4E-03	2E-01	7E+00
16. Cm245	1E-30	5E-12	2E-05	2E-07	8E-06	3E-04
17. Cs135	5E-25	2E-08	5E-01	5E-03	2E-01	4E+00
18. Cs137	2E-20	6E-03	1E+05	1E+03	5E+04	8E+05
19. Fr221	0	7E-16	3E-09	6E-11	1E-09	6E-08
20. Fr223	0	1E-13	7E-07	3E-09	5E-07	4E-05
21. I129	4E-26	2E-08	3E-01	1E-03	2E-01	2E+00
22. N693M	1E-24	1E-06	3E+00	4E-02	3E+00	4E+01
23. N163	8E-25	1E-04	1E+02	2E-03	2E+00	6E+02
24. NP237	7E-26	4E-08	5E-01	2E-03	5E-02	2E+00
25. NP239	9E-27	2E-08	3E-02	6E-04	2E-02	1E+00
26. Pa231	4E-30	1E-11	1E-04	5E-07	8E-05	6E-04

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 10 of 24

Component	Tank SX-101 (Ci)	Tank SX-102 (Ci)	Tank SX-103 (Ci)	Tank SX-104 (Ci)	Tank SX-105 (Ci)	Tank SX-106 (Ci)
27. Pa233	7E-26	4E-08	5E-01	2E-03	5E-02	2E+00
28. Pa234M	0	2E-24	2E-16	2E-16	2E-15	8E-14
29. Pb209	0	7E-16	3E-09	5E-11	1E-09	6E-08
30. Pb210	2E-33	7E-20	3E-12	2E-14	1E-12	4E-12
31. Pb211	1E-29	7E-12	5E-05	2E-07	3E-05	2E-04
32. Pb214	0	3E-15	1E-11	1E-13	5E-12	2E-10
33. Po107	9E-26	5E-08	4E-01	2E-03	3E-01	3E+00
34. Po210	0	3E-19	3E-12	2E-14	1E-12	2E-11
35. Po213	0	7E-16	3E-09	5E-11	1E-09	6E-08
36. Po214	0	4E-18	2E-11	2E-13	6E-12	3E-10
37. Po215	0	7E-12	5E-05	2E-07	3E-05	3E-04
38. Po218	0	3E-18	1E-11	1E-13	5E-12	2E-10
39. Pu238	8E-28	4E-10	4E-03	2E-05	1E-03	2E-02
40. Pu239	3E-30	1E-12	5E-05	6E-08	5E-05	6E-05
41. Pu240	4E-29	2E-11	3E-04	8E-07	1E-04	1E-03
42. Pu241	9E-30	8E-13	4E-04	2E-07	5E-04	2E-04
43. Ra223	1E-29	7E-12	5E-05	2E-07	3E-05	2E-04
44. Ra225	0	7E-16	3E-09	6E-11	1E-09	6E-08
45. Ra226	5E-36	3E-18	1E-11	1E-13	5E-12	2E-10
46. Ru106	3E-26	3E-08	7E-02	7E-04	1E-01	1E+00
47. Sb126	7E-25	1E-07	8E-06	1E-09	1E-05	6E-05
48. Sb126M	7E-25	1E-07	8E-06	1E-09	1E-05	6E-05
49. Sb79	6E-25	7E-07	5E+00	2E-02	4E+00	3E+01
50. Sm151	8E-22	1E-04	2E+02	1E+01	2E+02	1E+04
51. Sm126	7E-25	1E-07	1E-01	1E-02	1E-01	1E+01
52. Sr90	1E-20	2E-02	1E+04	6E+02	3E+04	1E+06

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-101 (Ci)	Tank SX-102 (Ci)	Tank SX-103 (Ci)	Tank SX-104 (Ci)	Tank SX-105 (Ci)	Tank SX-106 (Ci)
53. Tc99	4E-23	1E-05	2E+02	9E-01	1E+02	1E+03
54. Th227	1E-29	7E-12	4E-05	2E-07	3E-05	2E-04
55. Th229	5E-33	7E-15	3E-09	5E-11	1E-09	6E-08
56. Th230	9E-34	3E-16	1E-10	1E-11	2E-10	1E-08
57. Th231	0	5E-22	3E-14	5E-17	9E-14	2E-14
58. Th234	0	2E-24	2E-16	2E-16	2E-15	8E-14
59. Tl207	0	7E-12	5E-05	2E-07	3E-05	2E-04
60. U233	3E-31	8E-14	1E-07	5E-10	1E-07	7E-08
61. U234	3E-33	5E-15	5E-10	4E-12	2E-09	5E-10
62. U235	2E-39	5E-22	3E-15	4E-18	5E-14	5E-16
63. U238	4E-39	2E-25	2E-17	3E-21	6E-16	2E-19
64. Y90	1E-20	2E-02	1E+04	8E+02	3E+04	2E+06
65. Zr93	0	0	0	0	0	
66. Ag	0	0	0	0	0	
67. Al	0	0	0	0	0	
68. C2H3O3	0	0	0	0	0	
69. Ba	0	0	0	0	0	
70. Bi	0	0	0	0	0	
71. CoH507	0	0	0	0	0	
72. Co3	0	0	0	0	0	
73. Ca	0	0	0	0	0	
74. Ce	0	0	0	0	0	
75. Cl	0	0	0	0	0	
76. Ca	0	0	0	0	0	
77. EDTA	0	0	0	0	0	
78. F	0	0	0	0	0	

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 12 of 24

Component	Tank SX-101 (Ci)	Tank SX-102 (Ci)	Tank SX-103 (Ci)	Tank SX-104 (Ci)	Tank SX-105 (Ci)	Tank SX-106 (Ci)
79. Fl	0	0	0	0	0	
80. HEDTA	0	0	0	0	0	
81. K	0	0	0	0	0	
82. La	0	0	0	0	0	
83. Mn	0	0	0	0	0	
84. NO2	0	0	0	0	0	
85. NO3	0	0	0	0	0	
86. Na	0	0	0	0	0	
87. Ni	0	0	0	0	0	
88. OH	0	0	0	0	0	
89. Po4	0	0	0	0	0	
90. Pu	0	0	0	0	0	
91. S103	0	0	0	0	0	
92. SO4	0	0	0	0	0	
93. Sr	0	0	0	0	0	
94. Zro	0	0	0	0	0	
Total Curies	6E-20	5E-02	1E+05	2E+03	1E+03	4E+06

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 13 of 24

Component	Tank SX-107 (Ci)	Tank SX-108 (Ci)	Tank SX-109 (Ci)	Tank SX-110 (Ci)
1. Ac225	2E-20	5E-17	2E-09	1E-17
2. Ac227	3E-15	6E-13	2E-05	4E-13
3. Am241	9E-14	1E-11	2E-05	6E-06
4. Am242	1E-16	2E-14	3E-09	8E-09
5. Am242M	1E-16	2E-14	3E-08	8E-09
6. Am243	4E-17	5E-15	7E-09	5E-09
7. At217	2E-20	5E-17	2E-09	1E-17
8. Bs137M	1E-04	2E-02	6E-02	5E-04
9. B1210	1E-24	4E-21	8E-14	2E-19
10. B1211	4E-16	6E-13	8E-06	4E-13
11. B1213	9E-22	5E-17	9E-10	1E-17
12. B1214	4E-24	1E-20	2E-13	3E-19
13. C14	1E-08	2E-06	4E+01	2E-06
14. Cm242	1E-16	1E-14	5E-07	7E-09
15. Cm244	2E-11	3E-09	4E-02	5E-08
16. Cm245	6E-16	4E-14	9E-04	1E-12
17. Cs135	SE-10	4E-08	1E+00	5E-10
18. Cs137	1E-04	2E-02	4E+05	3E-04
19. Fr221	2E-20	5E-17	2E-03	1E-17
20. Fr223	1E-16	8E-15	3E-07	3E-15
21. I129	4E-11	5E-09	1E-01	3E-09
22. Nb93H	4E-10	5E-08	2E+00	8E-08
23. Ni63	2E-17	8E-13	6E+01	1E-10
24. Np237	6E-13	1E-09	8E-02	3E-09
25. Np239	4E-17	5E-15	1E-07	5E-09
26. Pa231	2E-14	1E-12	4E-05	1E-12
27. Pa233	6E-13	1E-19	8E-02	8E-09

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 14 of 24

Component	Tank SX-107 (Ci)	Tank SX-108 (Ci)	Tank SX-109 (Ci)	Tank SX-110 (Ci)
28. Pa234M	0	7E-17	1E-09	3E-25
29. Pb209	2E-20	5E-17	2E-09	1E-17
30. Pb210	3E-23	4E-21	2E-13	2E-19
31. Pb211	2E-04	8E-15	6E-13	4E-13
32. Pb214	9E-23	1E-20	5E-13	8E-19
33. Pd107	1E-10	7E-09	2E-01	7E-09
34. Po210	3E-23	4E-21	2E-13	2E-19
35. Po213	2E-20	5E-17	2E-09	1E-17
36. Po214	1E-22	1E-20	6E-13	9E-19
37. Po215	8E-15	6E-13	2E-05	4E-13
38. Po218	9E-23	1E-20	5E-13	8E-19
39. Pu238	0	0	0	1E-11
40. Pu239	0	0	0	1E-13
41. Pu240	0	0	0	5E-12
42. Pu241	0	0	0	1E-13
43. Ra223	7E-15	6E-13	2E-05	4E-13
44. Ra225	2E-20	5E-17	2E-08	1E-17
45. Ra226	9E-23	1E-20	5E-13	8E-19
46. Ru106	6E-13	3E-10	3E-02	1E-08
47. Sb126	6E-24	8E-16	1E-05	8E-16
48. Sb126M	6E-24	8E-16	1E-08	8E-16
49. Se79	6E-10	8E-08	2E+00	8E-08
50. Sm151	3E-14	6E-12	6E-06	3E-12
51. Sn126	6E-24	8E-16	2E-13	8E-16
52. Sr90	6E-17	1E-10	2E-03	3E-03
53. Tc99	3E-08	3E-36	8E+01	3E-36
54. Th227	9E-23	2E-18	2E-13	3E-13

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-107 (Ci)	Tank SX-108 (Ci)	Tank SX-109 (Ci)	Tank SX-110 (Ci)
55. Th229	2E-28	2E-22	2E-17	1E-17
56. Th230	4E-30	5E-25	4E-21	3E-20
57. Th231	0	2E-23	8E-19	3E-21
58. Th234	0	3E-22	9E-18	3E-25
59. Tl207	8E-15	6E-13	2E-05	4E-13
60. U233	1E-19	8E-14	1E-13	5E-14
61. U234	2E-20	2E-15	3E-13	2E-15
62. U235	3E-31	4E-18	2E-15	3E-21
63. U238	3E-35	7E-17	4E-14	3E-25
64. Y90	6E-17	1E-10	2E-03	5E-03
65. Zr93	0	0	0	0
66. Ag	0	0	0	0
67. Al	0	0	0	0
68. Ba	0	0	0	0
69. Bi	0	0	0	0
70. C2H303	0	0	0	0
71. C6H507	0	0	0	0
72. Co3	0	0	0	0
73. Ca	0	0	0	0
74. Ce	0	0	0	0
75. Cl	0	0	0	0
76. Cr	0	0	0	0
77. EDTA	0	0	0	0
78. F	0	0	0	0
79. Fe	0	0	0	0
80. HEDTA	0	0	0	0
81. K	0	0	0	0

Table 4-16. TRAC Estimated Waste Tank Inventories Data. Page 16 of 24

Component	Tank SX-107 (Ci)	Tank SX-108 (Ci)	Tank SX-109 (Ci)	Tank SX-110 (Ci)
82. La	0	0	0	0
83. Mn	0	0	0	0
84. No2	0	0	0	0
85. No3	0	0	0	0
86. Na	0	0	0	0
87. N1	0	0	0	0
88. OH	0	0	0	0
89. Po4	0	0	0	0
90. Pu	0	0	0	0
91. S103	0	0	0	0
92. So4	0	0	0	0
93. Sr	0	0	0	0
94. Zro	0	0	0	0
Total Curies				

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-111 (Ci)	Tank SX-112 (Ci)	Tank SX-113 (Ci)	Tank SX-144 (Ci)	Tank SX-115 (Ci)
1. Ac225	2E-17	2E-10	2E-10	4E-18	4E-18
2. Ac227	3E-13	2E-06	1E-05	2E-13	4E-14
3. Am241	1E-07	1E-05	3E-05	6E-09	1E-12
4. Am242	3E-10	2E-08	6E-08	8E-12	2E-15
5. Am242M	3E-10	2E-08	6E-08	8E-12	2E-15
6. Am243	2E-10	5E-09	2E-08	3E-12	1E-15
7. At217	2E-17	2E-10	2E-10	4E-18	4E-15
8. Bs137M	6E-04	2E-01	3E-01	1E-06	9E-04
9. Bi210	2E-20	6E-15	3E-13	3E-21	2E-22
10. Bi211	3E-13	2E-06	1E-05	2E-13	4E-14
11. Bi213	2E-17	2E-10	2E-10	4E-18	4E-18
12. Bi214	9E-20	2E-14	2E-12	1E-20	4E-22
13. C14	5E-07	4E+00	3E+01	2E-07	6E-08
14. Cm242	2E-10	1E-07	4E-03	7E-12	2E-15
15. Cm244	3E-09	4E-03	2E-02	2E-09	8E-11
16. Cm245	1E-13	7E-08	4E-07	4E-14	2E-15
17. Cs135	5E-09	1E-01	7E-01	6E-10	1E-09
18. Cs137	6E-04	4E+04	2E+05	3E-04	1E-03
19. Fr221	2E-17	2E-10	2E-10	4E-18	43-18
20. Fr223	4E-15	3E-08	2E-07	3E-15	6E-16
21. I129	1E-09	1E-02	7E-02	1E-09	2E-10
22. N693M	2E-08	1E-01	6E-01	2E-08	7E-10
23. N163	9E-07	3E+01	8E+01	1E-08	2E-06
24. NP237	2E-09	7E-03	2E-03	3E-10	8E-11
25. NP239	2E-10	5E-08	1E-03	3E-12	1E-15
26. Pa231	6E-13	4E-06	3E-05	6E-13	8E-14
27. Pa233	3E-09	7E-03	2E-03	3E-10	8E-11

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-111 (Ci)	Tank SX-112 (Ci)	Tank SX-113 (Ci)	Tank SX-144 (Ci)	Tank SX-115 (Ci)
28. Pa234M	2E-23	3E-13	9E-03	1E-22	2E-21
29. Pb209	2E-17	2E-10	2E-10	4R-18	4E-18
30. Pb210	2E-20	6E-15	3E-13	3E-21	2E-22
31. Pb211	3E-13	2E-06	1E-05	2E-13	4E-14
32. Pb214	9E-20	2E-14	2E-12	1E-20	4E-22
33. Po107	3E-09	2E-02	1E-01	3E-09	2E-10
34. Po210	2E-20	6E-15	3E-13	3E-21	2E-22
35. Po213	2E-17	2E-10	2E-10	4E-18	4E-18
36. Po214	1E-19	2E-14	2E-12	1E-20	5E-22
37. Po215	3E-13	2E-06	1E-05	2E-13	4E-14
38. Po218	9E-20	2E-14	2E-12	1E-20	4E-22
39. Pu238	4E-11	0	0	7E-12	5E-20
40. Pu239	9E-13	0	0	9E-14	6E-27
41. Pu240	4E-12	0	0	8E-13	1E-21
42. Pu241	4E-12	0	0	8E-13	1E-23
43. Ra223	3E-13	2E-06	1E-05	2E-13	4E-14
44. Ra225	2E-17	2E-10	2E-10	4E-18	4E-18
45. Ra226	9E-20	2E-14	2E-12	1E-20	4E-22
46. Ru106	4E-10	4E-03	2E-01	1E-10	2E-12
47. Sb126	2E-22	1E-14	1E-09	2E-22	9E-23
48. Sb126M	2E-22	1E-14	1E-09	2E-22	9E-23
49. Sb79	4E-08	2E-01	1E+00	2E-08	5E-09
50. Sm151	4E-13	4E-06	1E-05	4E-13	8E-13
51. Sm126	2E-22	1E-15	2E-09	2E-22	9E-23
52. Sr90	1E-05	1E+02	2E+04	6E-07	4E-09
53. Tc99	2E-06	8E+00	5E+01	8E-07	1E-07
54. Th227	3E-13	2E-14	9E-14	3E-21	1E-18

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-111 (Ci)	Tank SX-112 (Ci)	Tank SX-113 (Ci)	Tank SX-144 (Ci)	Tank SX-115 (Ci)
55. Th229	2E-17	3E-18	3E-18	4E-26	1E-22
56. Th230	2E-20	1E-21	8E-18	1E-28	7E-25
57. Th231	6E-21	2E-22	7E-12	2E-29	4E-27
58. Th234	2E-23	4E-21	8E-11	2E-30	7E-26
59. Tl207	3E-13	2E-06	1E-05	2E-13	4E-14
60. U233	8E-14	9E-10	2E-15	4E-16	5E-15
61. U234	7E-16	6E-12	8E-14	1E-17	3E-16
62. U235	6E-21	4E-17	4E-12	6E-23	1E-22
63. U238	2E-23	9E-10	8E-11	5E-24	2E-21
64. Y90	1E-05	1E+01	3E+01	6E-07	4E-09
65. Zr93	0	0	0	0	0
66. Ag	0	0	0	0	0
67. Al	0	0	0	0	0
68. C2H3O3	0	0	0	0	0
69. Ba	0	0	0	0	0
70. Bi	0	0	0	0	0
71. CoH507	0	0	0	0	0
72. Co3	0	0	0	0	0
73. Ca	0	0	0	0	0
74. Ce	0	0	0	0	0
75. Cl	0	0	0	0	0
76. Ca	0	0	0	0	0
77. EDTA	0	0	0	0	0
78. F	0	0	0	0	0
79. Fl	0	0	0	0	0
80. HEDTA	0	0	0	0	0
81. K	0	0	0	0	0

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SX-111 (Ci)	Tank SX-112 (Ci)	Tank SX-113 (Ci)	Tank SX-144 (Ci)	Tank SX-115 (Ci)
82. La	0	0	0	0	0
83. Mn	0	0	0	0	0
84. NO2	0	0	0	0	0
85. NO3	0	0	0	0	0
86. Na	0	0	0	0	0
87. Ni	0	0	0	0	0
88. OH	0	0	0	0	0
89. Po4	0	0	0	0	0
90. Pu	0	0	0	0	0
91. S103	0	0	0	0	0
92. SO4	0	0	0	0	0
93. Sr	0	0	0	0	0
94. Zro	0	0	0	0	0
Total Curies	1E-03	4E+04	2E+05	3E-04	2E-03

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SY-101 (Ci)	Tank SY-102 (Ci)	Tank SY-103 (Ci)
1. Ac225	5E-08	5E-08	6E-08
2. Ac227	1E-04	2E-04	2E-04
3. Am241	8E+02	1E+03	1E+03
4. Am242	1E+00	2E+00	2E+00
5. Am242M	1E+00	2E+00	2E+00
6. Am243	6E-01	9E-01	1E+00
7. At217	5E-08	5E-08	6E-08
8. Bs137M	7E+03	1E+03	2E+03
9. Bi210	2E-12	1E-12	1E-12
10. Bi211	5E-05	6E-05	9E-05
11. Bi213	2E-08	2E-08	2E-08
12. Bi214	5E-11	5E-11	8E-11
13. C14	3E+02	5E+02	6E+02
14. Cm242	1E+00	2E+00	2E+00
15. Cm244	3E+00	6E+00	7E+00
16. Cm245	1E-04	3E-04	3E-04
17. Cs135	2E+00	3E+00	3E+00
18. Cs137	4E+05	7E+05	8E+05
19. Fr221	5E-08	5E-08	6E-08
20. Fr223	2E-06	3E-06	3E-06
21. I129	8E-01	1E+00	2E+00
22. N693M	3E+01	4E+01	4E+01
23. N163	2E+01	6E+01	1E+00
24. NP237	1E+00	2E+00	2E+00
25. NP239	6E-0	9E-01	1E+00
26. Pa231	3E-04	5E-04	6E-04
27. Pa233	1E+00	2E+00	2E+00

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SY-101 (Ci)	Tank SY-102 (Ci)	Tank SY-103 (Ci)
28. Pa234M	3E-10	5E-14	7E-14
29. Pb209	5E-08	5E-08	6E-08
30. Pb210	4E-12	3E-12	4E-12
31. Pb211	1E-04	2E-04	2E-04
32. Pb214	1E-10	2E-10	2E-10
33. Po107	1E-00	3E+00	3E+00
34. Po210	9E-12	1E-11	1E-11
35. Po213	5E-03	5E-08	6E-08
36. Po214	1E-10	2E-10	3E-10
37. Po215	1E-04	2E-04	2E-04
38. Po218	1E-10	2E-10	2E-10
39. Pu238	1E-02	2E-02	2E-02
40. Pu239	3E-05	5E-05	6E-05
41. Pu240	5E-04	8E-04	1E-03
42. Pu241	1E-04	1E-04	2E-04
43. Ra223	1E-04	2E-04	2E-04
44. Ra225	5E-08	5E-08	6E-08
45. Ra226	1E-10	2E-10	2E-10
46. Ru106	7E-01	9E-01	1E+00
47. Sb126	2E-05	7E-06	1E-05
48. Sb126M	2E-05	7E-06	1E-05
49. Sb79	2E+01	3E+01	3E+01
50. Sm151	1E+04	1E+04	1E+04
51. Sm126	9E+00	9E+00	1E+01
52. Sr90	8E+05	1E+06	1E+06
53. Tc99	5E+02	9E+02	1E+03
54. Th227	1E+04	2E-04	2E-04

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SY-101 (Ci)	Tank SY-102 (Ci)	Tank SY-103 (Ci)
55. Th229	5E-08	5E-08	6E-08
56. Th230	8E-09	8E-09	1E-08
57. Th231	2E-11	1E-14	2E-14
58. Th234	3E-10	6E-14	7E-14
59. Tl207	1E-04	2E-04	2E-04
60. U233	3E-08	9E-08	1E-07
61. U234	7E-10	5E-10	9E-10
62. U235	4E-13	5E-16	9E-16
63. U238	7E-12	3E-19	5E-19
64. Y90	8E+05	1E+06	2E+06
65. Zr93	0	0	0
66. Ag	0	0	0
67. Al	0	0	0
68. C2H3O3	0	0	0
69. Ba	0	0	0
70. Bi	0	0	0
71. CoH507	0	0	0
72. Co3	0	0	0
73. Ca	0	0	0
74. Ce	0	0	0
75. Cl	0	0	0
76. Ca	0	0	0
77. EDTA	0	0	0
78. F	0	0	0
79. Fl	0	0	0
80. HEDTA	0	0	0
81. K	0	0	0

Table 4-16. TRAC Estimated Waste Tank Inventories Data.

Component	Tank SY-101 (Ci)	Tank SY-102 (Ci)	Tank SY-103 (Ci)
82. La	0	0	0
83. Mn	0	0	0
84. NO2	0	0	0
85. NO3	0	0	0
86. Na	0	0	0
87. Ni	0	0	0
88. OH	0	0	0
89. Po4	0	0	0
90. Pu	0	0	0
91. S103	0	0	0
92. SO4	0	0	0
93. Sr	0	0	0
94. Zro	0	0	0
Total Curies	2E+06	3E+06	4E+06

Table 4-17. Summary of Tank Sampling Data.

Tank 101-S							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$		
Sludge	6/4/75	5.97×10^{-3}	2.95×10^{5}	--	1.01×10^{6}		
Tank 102-S							
Description	Date	Pu(g/g)	$^{137}Cs(\mu Ci/g)$	$^{134}Cs(\mu Ci/g)$	$^{89,90}Sr(\mu Ci/g)$		
Solids (top layer)	4/75	5.2×10^{-7}	17.3	--	19.2		
Solids (bottom layer)	4/75	7.5×10^{-7}	6.6	--	0.5		
Tank 105-S							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$				
Liquid	3/74	--	0.097				
Solids	3/74	--	56.3				
Tank 106-S							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/g)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$		
Liquid	3/74	--	0.356	--	--		
Solids	6/4/75	2.71×10^{-5}	200.0	--	0.69		
Supernatant Liquid	6/4/75	1.17×10^{-6}	5.29×10^{5}	2.02×10^{5}	1.22×10^{5}		
Tank 107-S							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	Total Organic Carbon (g/L)	
Sludge	7/1/74	7.20×10^{-2}	4.19×10^{6}	--	4.84×10^{6}	--	
Gelatinous Mixture	8/78	--	2.26×10^{5}	--	--	11.8	
Tank 108-S							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/g)$				
Liquid	3/74	--	0.344				

Table 4-17. Summary of Tank Sampling Data.

Tank 110-S							
Description	Date	Pu(g/L)	^{137}Cs(μCi/L)	^{134}Cs(μCi/L)	^{89,90}Sr(μCi/L)		
Sludge	10/22/74	6.29×10^{-4}	8.10×10^{5}	4.57×10^{3}	5.43×10^{5}		
Tank 111-S							
Description	Date	Pu(μCi/g)	^{137}Cs(μCi/L)	^{134}Cs(μCi/g)	^{89,90}Sr(μCi/g)	^{241}Am(g/g)	Total Organic Carbon (g/L)
Salts	2/2/78-6/27/78	1.10×10^{-7}	129.0	--	13.0	--	--
Core 1001-C	2/2/78-6/27/78	3.60×10^{-10} g/g	72.1	0.1	1.03	1.02×10^{-10}	1.29
Core 1003-C, 1004-C	2/2/78-6/27/78	2.12×10^{-10} g/g	180.0	--	1.2	4.03×10^{-11}	2.38
Core 1009-C	2/2/78-6/27/78	4.25×10^{-9} g/g	109.0	--	1.71	4.23×10^{-11}	2.80
Supernatant Liquid	2/2/78-6/27/78	1.08×10^{-5} g/g	6.82×10^{5}	9.82×10^{2}	2.04×10^{4}	--	6.0
Supernatant of Core 1009-C	2/2/78-6/27/78	8.95×10^{-6} g/g	4.68×10^{5}	--	2.51×10^{5}	--	6.2
Tank 101-SX							
Description	Date	Pu(g/L)	^{137}Cs(μCi/L)	^{134}Cs(μCi/L)	^{89,90}Sr(μCi/L)	Sr(μCi/L)	Total Organic Carbon (g/L)
Liquid Supernatant	1978	2.14×10^{-7}	6.68×10^{5}	--	5.17×10^{2}	--	--
Supernatant	7/80	2.55×10^{-6}	4.27×10^{4}	--	--	--	--
Liquid	4/26/89	<0.3	2.85×10^{4}	--	2.2	13.1	0.32
Tank 102-SX							
Description	Date	Pu(g/L)	^{137}Cs(μCi/L)	^{134}Cs(μCi/L)	^{89,90}Sr(μCi/L)	^{60}CO(μCi/L)	^{154,155}Eu(μCi/L)
Liquids	5/9/75	--	3.24×10^{5}	1.66×10^{3}	--	--	2.89×10^{2}
Solids	5/9/75	2.73×10^{-3}	3.43×10^{4}	3.11×10^{2}	1.09×10^{5}	6.55×10^{2}	4.7×10^{3}
Solids	8/17/77	2.3×10^{-3}	2.7×10^{5}	--	1.3×10^{3}	--	--

Table 4-17. Summary of Tank Sampling Data.

Tank 103-SX							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	Total Organic Carbon (g/L)	
Sludge	4/11/75	9.73×10^{-3}	2.29×10^{5}	4.85×10^{5}	2.63×10^{5}	9.0	
Supernatant Liquid	4/11/75	2.23×10^{-6}	2.96×10^{5}	1.13×10^{5}	1.87×10^{5}	--	
Supernatant Liquid	10/10/77	--	3.4×10^{5}	6.5×10^{2}	7.3×10^{5}	--	
Solid	10/10/77	2.2×10^{-4}	3.5×10^{5}	6.4×10^{2}	1.5×10^{5}	92.0	

Tank 104-SX							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	pH	Total Organic Carbon (g/L)
Liquid	5/14/88	$0.7 \pm 20\%$	4.5×10^{5}	--	$3 \times 10^{2} \pm 20\%$	13	5.0

Tank 106-SX									
Description	Date	Pu(g/gal)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	$^{60}Co(\mu Ci/L)$	$^{154}Eu(\mu Ci/L)$	$^{155}Eu(\mu Ci/L)$	Total Organic Carbon (g/L)
Supernatant	4/18/78	--	3.8×10^{5}	8.32×10^{2}	1.05×10^{5}	2.03×10^{5}	1.97×10^{5}	4.46×10^{5}	6.8
Solid	4/18/78	1.88×10^{7}	1.62×10^{2}	0.350	38.5	0.934	1.06	2.68	--

Tank 111-SX							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{134}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$		
Sludge	8/1/75	1.31×10^{-3}	2.15×10^{5}	--	3.38×10^{6}		
Supernatant Liquid	8/1/75	<1.17	1.59×10^{5}	5.92×10^{2}	80.3		

Tank 101-SY							
Description	Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	Total Organic Carbon (g/L)		
Liquid	11/88	0.16	3,900	1.75	0.212		
Liquid	11/88	5.94	7.7×10^{4}	190	2.2		
Sludge: Wet	11/18/90	$<3.9 \times 10^{-3}$	434	13	--		
Sludge: Dry	11/18/90	$<3.1 \times 10^{-3}$	315	23	--		
Sludge: Loose	11/18/90	$<7.3 \times 10^{-3}$	469	98	--		

Table 4-17. Summary of Tank Sampling Data.

Tank 103-SY								
Description		Date	Pu(g/L)	$^{137}Cs(\mu Ci/L)$	$^{89,90}Sr(\mu Ci/L)$	Am	Total Organic Carbon (g/L)	
Surface Sample:	Slurry	6/24/85	8.28	6.01×10^5	3.21×10^5	<2.94	20.11	
	Solids	6/24/85	<1	<1	<1	<1	6	
Middle Sample:	Filtrate	7/2/85	–	4.15×10^5	6.85×10^5	7.15	9.43	
	Solids	7/2/85	<1	<1	<1	–	19	
	Slurry	7/2/85	1.57	4.27×10^6	5.78×10^5	3.67	50.7	
Bottom Sample:	Filtrate	7/2/85	*	8.13×10^5	3.93×10^5	1.01×10^1	17.35	
	Solids	7/2/85	*	<1	*	*	*	
	Slurry	7/2/85	*	1.19×10^6	2.14×10^5	5.49	61.4	

* Insufficient sample.

Table 4-18. Candidate Contaminants of Potential Concern for the S Plant Aggregate Area. Page 1 of 2

RADIONUCLIDES	FISSION PRODUCTS (Cont.)	HEAVY METALS
Gross alpha	Lead-209	
Gross beta	Lead 210	Aluminum
	Lead 211	Barium
TRANSURANICS	Lead-212*	Bismuth
Americium-241	Lead-214	Cadmium
Americium-242	Nickel 63	Chromium
Americium-242m	Niobium-93m	Copper
Americium-243	Niobium-95*	Iron
Curium-242	Neodymium	Lanthanum
Curium-244	Polonium-210	Lead
Curium-245	Polonium-213*	Manganese
Neptunium-237	Polonium-214	Nickel
Neptunium-239	Polonium-215	Silver
Plutonium	Polonium-218	Strontium
Plutonium-238	Praseodymium	Tin
Plutonium-239/240	Promethium-147	Titanium
Plutonium-241	Protactinium-231	Uranium
	Protactinium-233*	Vanadium
URANIUM	Protactinium-234m*	Zinc
Uranium-235	Radium	
Uranium-233	Radium-223	OTHER INORGANICS
Uranium-234	Radium-225	
Uranium-236	Radium-226	Ammonium nitrate
Uranium-238	Radium-228	Aluminum oxide
	Rhodium-106*	Ammonium fluoride
FISSION PRODUCTS	Ruthenium-103*	Ammonium hydroxide
Actinium-225	Ruthenium-106	Ammonium oxalate
Actinium-227	Samarium-151	Boric acid
Antimony-126	Selenium-79	Ceric ammonium nitrate
Antimony-126m	Strontium-90	Ceric sulfate
Astitine-217*	Technetium-99	Chromic nitrate
Barium-135m*	Tellurium-121*	Di (2-ethylhexyl) phosphoric acid
Barium-137m	Tellurium-125m*	
Bismuth-210	Tellurium-127*	Ferrous ammonium sulfate
Carbon-14	Tellurium-129m*	Ferrous sulfamate
Cerium-141	Thallium-207	Ferrous sulfate
Cerium-144	Thallium-208	Hydrazine
Cesium-134	Thorium-227	Hydrochloric acid
Cesium-135	Thorium-229	Hydrofluoric acid
Cesium-137	Thorium-230	Hydrogen
Francium-221	Thorium-231	Hydroxylammine hydrochloride
Francium-223*	Thorium-234	
Iodine-129	Tritium	Hydroxyquinoline
Iodine-131*	Yttrium-90	Lead nitrate
Lanthanium	Zirconium-93	Magnesium
	Zirconium-95*	Manganese oxide

Table 4-18. Candidate Contaminants of Potential Concern for the S Plant Aggregate Area. Page 2 of 2

OTHER INORGANICS (Continued)	VOLATILE ORGANICS
Mercuric nitrate	Acetone
Mercuric thiocyanate	Chloroform
Mercury	MIBK ("Hexone")
Molybdate - Citrate reagent	Propane
Nitrate	Periodic acid
Nitric acid	Tetrabromoethane
Nitrite	Xylene
Oxalic acid	SEMIVOLATILE ORGANICS
Phosphate	Bromonaphthalene
Potassium	Butylated hydroxy toluene
Potassium dichromate	Ethylene diamine tetraacetate (EDTA)
Potassium fluoride	Hydrazine
Potassium oxalate	Methyl isopropyl diketone
Potassium permanganate	N-(2-hydroxyethyl) ethylenediaminetriacetate (HEDTA)
Silica	O-phenanthroline
Silicon	Paraffin hydrocarbons
Silver nitrate	S-diphenyl carbazide
Sodium aluminate	Tri-iso-octylamine
Sodium bismuthate	Tri-n-octylamine
Sodium carbonate	
Sodium dichromate	
Sodium fluoride	
Sodium hydroxide	
Sodium metasilicate	
Sodium nitrate	
Sodium nitrite	
Sulfamic acid	
Sulfuric acid	
Tetraphenyl boron	
Titanium chloride	
Tributyl phosphate	
Zinc	
Zirconium oxide	

* 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 radionuclides' initial activity.

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
Tanks and Vaults							
241-S-101 Single-Shell Tank	K	K	K	K	K	S	S
241-S-102 Single-Shell Tank	K	K	K	K	K	S	S
241-S-103 Single-Shell Tank	K	K	K	S	S	S	S
241-S-104 Single-Shell Tank	K	K	K	S	S	S	S
241-S-105 Single-Shell Tank	K	K	K	S	K	S	S
241-S-106 Single-Shell Tank	K	K	K	S	K	S	S
241-S-107 Single-Shell Tank	K	K	K	K	K	S	S
241-S-108 Single-Shell Tank	K	K	K	S	S	S	S
241-S-109 Single-Shell Tank	K	K	K	S	K	S	S
241-S-110 Single-Shell Tank	K	K	K	K	K	S	S
241-S-111 Single-Shell Tank	K	K	K	K	K	S	S
241-S-112 Single-Shell Tank	K	K	K	S	K	S	S
241-SX-101 Single-Shell Tank	K	K	K	S	K	S	S
241-SX-102 Single-Shell Tank	K	K	K	K	K	S	S
241-SX-103 Single-Shell Tank	K	K	K	K	K	S	S
241-SX-104 Single-Shell Tank	K	K	K	K	K	S	S
241-SX-105 Single-Shell Tank	K	K	K	K	K	S	S
241-SX-106 Single-Shell Tank	K	K	K	S	S	S	S

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
241-SX-107 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-108 Single-Shell Tank	K	K	K	S	K	S	S
241-SX-109 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-110 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-111 Single-Shell Tank	K	K	K	K	K	S	S
241-SX-112 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-113 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-114 Single-Shell Tank	K	K	K	S	S	S	S
241-SX-115 Single-Shell Tank	K	K	K	K	K	S	S
241-SY-101 Double-Shell Tank	K	K	K	S	S	S	S
241-SY-102 Double-Shell Tank	K	K	K	S	S	S	S
241-SY-103 Double-Shell Tank	K	K	K	S	S	S	S
240-S-302 Catch Tank	K	S	S	S	S	K	S
241-S-302A Catch Tank	S	S	S	S	S	S	S
241-S-302B Catch Tank	S	S	S	S	S	S	S
241-SX-302 Catch Tank	S	S	S	S	S	S	S
244-S Receiver Tank	S	S	S	S	S	S	S
Cribs and Drains							
216-S-1 & -2 Crib	K	K	K	S	K	S	S

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
216-S-5 Crib	K	K	K	S	K	S	S
216-S-6 Crib	K	K	K	S	K	S	S
216-S-7 Crib	K	K	K	S	K	S	S
216-S-9 Crib	K	K	K	S	K	S	S
216-S-13 Crib	K	K	K	S	K	S	S
216-S-20 Crib	K	K	K	S	K	S	S
216-S-22 Crib	K	K	K	S	K	-	-
216-S-23 Crib	K	K	K	S	K	S	S
216-S-25 Crib	K	K	K	S	K	S	S
216-S-26 Crib	K	K	K	S	K	S	S
216-S-3 French Drain	K	K	K	K	K	K	K
Ponds, Ditches, and Trenches							
216-S-10P Pond	K	K	K	S	S	S	S
216-S-11 Pond	K	S	S	S	K	S	S
216-S-15 Pond	S	K	S	S	K	K	S
216-S-16P Pond	K	K	S	S	S	S	S
216-S-17 Pond	K	S	S	S	S	S	S
216-S-19 Pond	K	K	K	S	K	K	K
216-S-10D Ditch	K	K	K	K	K	K	K

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
216-S-16D Ditch	K	S	S	S	K	S	S
216-U-9 Ditch	K	S	S	S	S	S	S
216-S-8 Trench	K	K	K	S	K	S	S
216-S-12 Trench	K	K	S	S	K	S	S
216-S-14 Trench	S	S	S	S	S	K	S
216-S-18 Trench	S	S	S	S	S	K	S
Septic Tanks and Associated Drain Fields							
2607-W6 Septic Tank and Tile Field	-	-	-	-	-	-	-
2607-WZ Septic Tanks	-	-	-	-	-	-	-
Sanitary Crib	-	-	-	-	-	-	-
Transfer Facilities, Diversion Boxes, and Pipelines							
216-S-172 Control Structure	S	S	S	S	S	S	S
2904-S-160 Control Structure	S	S	S	S	S	S	S
2904-S-170 Control Structure	S	S	S	S	S	S	S
2904-S-171 Control Structure	S	S	S	S	S	S	S
240-S-151 Diversion Box	S	S	S	S	S	S	S
240-S-152 Diversion Box	S	S	S	S	S	S	S
241-S-151 Diversion Box	S	S	S	S	S	S	S
241-S-152 Diversion Box	S	S	S	S	S	S	S
241-SX-151 Diversion Box	S	S	S	S	S	S	S

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
241-SX-152 Diversion Box	S	S	S	S	S	S	S
241-S-A Valve Pit	S	S	S	S	S	S	S
241-S-B Valve Pit	S	S	S	S	S	S	S
241-S-C Valve Pit	S	S	S	S	S	S	S
241-S-D Valve Pit	S	S	S	S	S	S	S
241-SX-A Valve Pit	S	S	S	S	S	S	S
241-SX-B Valve Pit	S	S	S	S	S	S	S
241-SY-A Diversion Box	S	S	S	S	S	S	S
241-SY-B Diversion Box	S	S	S	S	S	S	S
Basins							
207-S Retention Basin	S	K	S	S	S	S	S
207-SL Retention Basin	K	K	K	K	K	K	K
Burial Sites							
218-W-7 Burial Ground	K	K	S	S	S	S	S
218-W-9 Burial Ground	K	K	-	S	-	S	
Unplanned Releases							
UN-200-W-10	-	-	S	-	-	-	-
UN-200-W-30	S	S	S	S	S	S	S
UN-200-W-32	-	-	-	-	K	-	-

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
UN-200-W-34	S	S	S	S	S	S	S
UN-200-W-35	S	S	S	S	S	S	S
UN-200-W-41	S	S	S	S	S	S	S
UN-200-W-42	S	S	S	-	-	-	-
UN-200-W-43	S	S	S	-	-	-	-
UN-200-W-49	S	S	S	-	-	-	-
UN-200-W-50	S	S	S	-	-	-	-
UN-200-W-52	S	S	S	S	S	S	S
UN-200-W-56	S	S	S	S	S	S	S
UN-200-W-61	S	S	S	S	S	S	S
UN-200-W-69	S	S	S	-	-	-	-
UN-200-W-80	S	S	S	S	S	S	S
UN-200-W-81	S	S	S	-	-	-	-
UN-200-W-82	S	S	S	S	S	S	S
UN-200-W-83	S	S	S	-	-	-	-
UN-200-W-108	S	S	S	S	S	S	S
UN-200-W-109	S	S	S	S	S	S	S
UN-200-W-114	S	S	S	-	-	-	-
UN-200-W-116	S	S	S	-	-	-	-

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types.

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
UN-200-W-123	S	S	S	S	S	S	S
UN-200-W-127	S	S	S	S	S	S	S
UN-216-W-25	S	S	S	S	S	S	S
UN-216-W-30	S	S	S	-	-	-	-
UPR-200-W-13	S	S	S	S	S	S	S
UPR-200-W-15	S	S	S	S	S	S	S
UPR-200-W-20	S	S	S	S	S	S	S
UPR-200-W-36	S	S	S	S	S	S	S
UPR-200-W-47	S	S	S	S	S	S	S
UPR-200-W-51	S	S	S	S	S	S	S
UPR-200-W-57	-	-	-	-	-	-	-
UPR-200-W-59	S	S	S	S	S	S	S
UPR-200-W-87	-	-	-	-	-	-	-
UPR-200-W-95	S	S	S	S	S	S	S
UPR-200-W-96	K	S	S	S	S	S	S
UPR-200-W-124	S	S	S	S	S	S	S
UPR-200-W-139	S	S	S	S	S	S	S
UPR-200-W-140	S	S	S	S	S	S	S
UPR-200-W-141	S	S	S	S	S	S	S

Table 4-19. Contamination Types Expected at Each Waste Management Unit and Unplanned Release Types. Page 8 of 8

Waste Management Unit or Unplanned Release	TRU	Fission Products	Uranium	Heavy Metals	Other Inorganics	Volatiles	Semi-volatiles
UPR-200-W-142	S	S	S	S	S	S	S
UPR-200-W-143	S	S	S	S	S	S	S
UPR-200-W-144	S	S	S	S	S	S	S
UPR-200-W-145	S	S	S	S	S	S	S
UPR-200-W-146	S	S	S	S	S	S	S

K - Contaminant known to be present.
S - Contaminant suspected to be present.
-- - Dashes indicate data is not available.

Table 4-20. Contaminants of Potential Concern for the S Plant Aggregate Area.

RADIONUCLIDES	Lead-209	OTHER INORGANICS
Gross alpha	Lead-210	Boron
Gross beta	Lead-211	Fluoride
	Lead-212	Nitrate/Nitrite
TRANSURANICS	Lead-214	
Americium-241	Niobium-93m	VOLATILE ORGANICS
Americium-242	Polonium-214	Acetone
Americium-242m	Polonium-215	Chloroform
Americium-243	Polonium-218	MIBK
Curium-242	Promethium-147	Xylene
Curium-245	Pratactinium-231	
Neptunium-237	Protactinium-234m	SEMIVOLATILE ORGANICS
Neptunium-239	Radium-225	Hydrazine
Plutonium-238	Radium-226	
Plutonium-239/240	Radium-228	
Plutonium-241	Ruthenium-106	
	Samarium-151	
URANIUM	Selenium-79	
Uranium-233	Strontium-90	
Uranium-234	Technetium-99	
Uranium-235	Thallium-207	
Uranium-236	Thallium-208	
Uranium-238	Thorium-227	
	Thorium-229	
FISSION PRODUCTS	Tritium	
Actinium-225	Yttrium-90	
Actinium-227	Zirconium-93	
Antimony-126		
Antimony-126m	HEAVY METALS	
Barium-137m	Barium	
Bismuth-210	Cadmium	
Bismuth-211	Chromium	
Bismuth-213	Copper	
Bismuth-214	Iron	
Carbon-14	Lead	
Cesium-134	Manganese	
Cesium-135	Nickel	
Cesium-137	Silver	
Cobalt-60	Titanium	
Europium-152	Vanadium	
Europium-154	Zinc	
Eupopium-155		
Francium-221		
Iodine-129		

9 3 1 2 8 4 9 1 0 4 8

Table 4-21. Soil-Water Distribution Coefficient K_d for Radionuclides[a] and Inorganics of Concern at S Plant Aggregate Area Waste Management Units. Page 1 of 2

Element or Chemical	Recommended K_d for Hanford Site (Serne and Wood 1990) in mL/g	Conservative Default K_d[b] (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9[c] (Strenge and Peterson 1989) in mL/g	Mobility Class
Actinium	-	-	228	low
Americium	2 100 - 1000 (<1 @ pH 1-3)	100	82	low
Antimony	—	—	2	high
Barium	—	50	530	moderate
Bismuth	-	20	-	moderate
Boron	-	-	0.19	high
Cadmium	—	15	14.9	moderate
Carbon (^{14}C)	—	—	0	high
Cesium	200 - 1,000 1 - 200 (acidic waste)	50	51	low
Chromium	-	0	16.8	moderate
Cobalt	500 - 2000	10	1.9	low
Copper	-	15	41.9	moderate
Curium	100 - >2,000	100	82	low
Cyanide	-	-	-	unknown
Europium	—	—	228	low
Fluoride	—	—	0	high
Francium	-	-	-	unknown
Iodine	<1	0	0	high
Iron	—	20	15	moderate
Krypton	-	-	-	unknown
Lead	—	30	234	moderate
Manganese	—	20	16.5	moderate
Neptunium	<1-5	3	3	high
Nickel	—	15	12.2	moderate
Niobium	—	—	50	moderate
Nitrate/nitric acid	—	—	0	high
Plutonium	100 - 1,000 < 1 at pH 1 - 3	100	10	low

Table 4-21. Soil-Water Distribution Coefficient K_d for Radionuclides[a] and Inorganics of Concern at S Plant Aggregate Area Waste Management Units. Page 2 of 2

Element or Chemical	Recommended K_d for Hanford Site (Serne and Wood 1990) in mL/g	Conservative Default K_d[b] (Serne and Wood 1990) in mL/g	MEPAS Default K_d pH 6-9[c] (Strenge and Peterson 1989) in mL/g	Mobility Class
Polonium	—	—	5.9	high
Promethium	-	-	-	unknown
Protactinium	—	—	0	high
Radium	—	20	24.3	moderate
Ruthenium	20 - 700 (<2 at >1 M nitrate)	—	274	moderate
Samarium	—	—	228	low
Selenium	—	0	5.91	moderate
Silver	-	20	0.4	moderate
Strontium	5 - 100 3 - 5 (acidic conditions) 200 - 500 (w/phosphate or oxalate)	10	24.3	moderate
Technetium	0 - 1	0	3	high
Thallium	—	—	0	high
Thorium	-	50	100	moderate
Titanium	-	-	-	unknown
Tritium	0	0	0	high
Uranium	—	0	0	high
Vanadium	—	—	50	moderate
Yttrium	—	—	278	low
Zinc	—	15	12.7	moderate
Zirconium	-	30	50	moderate

a/ Radionuclides with half-lives of greater than 3 months.

b/ Average K_Ds for low salt and organic solutions with neutral pH.

c/ Default values for pH 6-9 and soil content of [clay + organic matter + metal oxyhydroxides] < 10% (Strenge and Peterson 1989).

9 3 1 2 8 6 9 1 0 5 0

Table 4-22. Mobility of Inorganic Species in Soil.

Highly mobile ($K_d < 5$)	
Antimony	Protactinium
Boron	Selenium
Carbon (as $^{14}CO_2$)	Silver
Fluoride	Sodium
Iodine	Technetium
Neptunium	Thallium
Nitrate	Tritium
	Uranium
Moderately mobile ($5 < K_d < 100$)	
Arsenic	Nickel
Barium	Niobium
Bismuth	Polonium
Cadmium	Radium
Cesium	Strontium
Chromium	Thorium
Copper	Vanadium
Iron	Zinc
Lead	Zirconium
Manganese	
Low mobility ($K_d > 100$)	
Actinium	
Americium	
Cesium	
Cobalt	
Curium	
Europium	
Mercury	
Plutonium	
Ruthenium	
Samarium	
Yttrium	

9 3 1 2 8 , 9 1 0 5 1

Table 4-23. Physical/Chemical Properties of Organic Contaminants of Concern for the S Plant Aggregate Area Waste Management Units.

Compound	Molecular Weight in g/mole	Water Solubility in mg/L	Vapor Pressure in mm Hg	Henry's Law Constant in atm-m^3/mo	Soil/Organic Matter Partition Coef. K_{oc} in mL/g
Acetone	58.0	miscible	270	2.1×10^{-5}	2.2
Carbon tetrachloride	154.0	758	90	2.4×10^{-2}	110
Chloroform (trichloromethane)	119	8,200	150	2.9×10^{-3}	31
Kerosene[a/]	142.2	32	0.045	2.9×10^{-4}	4,500
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
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

Source: Strenge and Peterson (1989).

[a/] Kerosene properties are represented by 2-methyl naphthalene.

Table 4-24. Radiological Properties of Potential Radionuclides of Concern in S Plant Aggregate Area Waste Management Units. Page 1 of 2

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Principal Radiation of Concern[b]
^{225}Ac	10 d	5.8×10^{4}	α
^{227}Ac	21.8 yr	7.2×10^{1}	β, α
^{241}Am	432 yr	3.4×10^{0}	α
^{242}Am	16 hr	8.1×10^{5}	β
^{242m}Am	152 yr	9.7×10^{0}	α
^{243}Am	7,380 yr	2.0×10^{-1}	α
^{137m}Ba	2.6 min	5.3×10^{8}	γ
^{210}Bi	5.01 d	1.2×10^{5}	β
^{211}Bi	2.13 min	4.2×10^{8}	α, β
^{213}Bi	45.6 min	1.9×10^{7}	β, α
^{214}Bi	19.9 min	4.4×10^{7}	β, γ
^{14}C	5,730 yr	4.5×10^{0}	β
^{242}Cm	163.2 d	3.3×10^{3}	α
^{244}Cm	18.1 yr	8.1×10^{1}	α
^{245}Cm	8,500 yr	1.7×10^{-1}	α, γ
^{60}Co	5.3 yr	1.1×10^{3}	γ
^{134}Cs	2.06 yr	1.3×10^{3}	γ
^{135}Cs	3×10^{6} yr	8.8×10^{-4}	β
^{137}Cs	30 yr	8.7×10^{1}	γ
^{152}Eu	13.3 yr	7.7×10^{2}	β, γ[c]
^{154}Eu	8.8 yr	2.7×10^{2}	β, γ[c]
^{155}Eu	4.96 yr	4.6×10^{2}	β, γ
^{221}Fr	4.8 min	1.8×10^{8}	α, γ
^{129}I	1.6×10^{7} yr	1.7×10^{-4}	β
^{93m}Nb	14.6 yr	2.8×10^{2}	γ[c]
^{237}Np	2.14×10^{6} yr	7.0×10^{-4}	α, γ
^{239}Np	2.35 d	2.3×10^{5}	β
^{231}Pa	32,800 yr	4.7×10^{-2}	α
^{234m}Pa	1.2 min	6.7×10^{8}	β, γ
^{209}Pb	3.25 hr	4.5×10^{6}	β
^{210}Pb	22.3 yr	7.6×10^{1}	β
^{211}Pb	36.1 min	2.5×10^{7}	β
^{212}Pb	10.6 hr	1.4×10^{6}	β, γ[c]
^{214}Pb	26.8 min	3.3×10^{7}	β, γ[c]
^{147}Pm	2.6 yr	2.0×10^{7}	β
^{214}Po	6×10^{-5} sec	8.8×10^{14}	α

Table 4-24. Radiological Properties of Potential Radionuclides of Concern in S Plant Aggregate Area Waste Management Units. Page 2 of 2

Radionuclide	Half-Life	Specific Activity[a/] in Ci/g	Principal Radiation of Concern[b/]
^{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	6.7 yr	1.2×10^{7}	β
^{106}Ru	1.0 yr	3.4×10^{3}	β, γ[c/]
^{126m}Sb	12.4 d	1.3×10^{9}	β, γ
^{79}Se	<65,000 yr	7.0×10^{-2}	β
^{151}Sm	90 yr	2.6×10^{1}	β
^{90}Sr	28.5 yr	1.4×10^{2}	β
^{99}Tc	213,000 yr	1.7×10^{-2}	β
^{227}Th	18.7 d	3.1×10^{4}	α
^{229}Th	7,340 yr	2.1×10^{-1}	α
^{230}Th	77,000 yr	2.1×10^{-2}	α
^{231}Th	25.5 hr	5.3×10^{5}	β
^{207}Tl	4.8 min	1.9×10^{8}	β, γ
^{233}U	159,000 yr	9.7×10^{-3}	α
^{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	2.342×10^{7} yr	3.6×10^{0}	α, γ
^{238}U	4.5×10^{9} yr	3.4×10^{-7}	α
^{90}Y	6.41 hr	5.4×10^{5}	β
^{93}Zr	1.5×10^{6} yr	2.6×10^{-3}	β

a/ Calculated from half-life and atomic weight.
b/ α - alpha decay; β - negative beta decay; γ - release of gamma rays.
c/ Daughter radiation.

Table 4-25. Comparison of Radionuclide Relative Risks for Radionuclides of Concern at the S Plant Aggregate Area. Page 1 of 2

Radionuclide	Half-Life	Air Unit Risk[b] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[c] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[d] in $(pCi/g)^{-1}$	External Exposure Unit Risk[e] in $(pCi/g)^{-1}$
^{225}Ac	10 d	1.2×10^{-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}
^{242}Am	16 hr	na	na	na	na
^{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}
^{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
^{242}Cm	163.2 d	na	na	na	na
^{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 (3.4×10^{-4})[f]
^{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	
^{129}I	1.6×10^{7} yr	6.1×10^{-5}	9.6×10^{-6}	5.1×10^{-7}	1.5×10^{-5}
^{93m}Nb	14.6 yr	na	na	na	na
^{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}
^{212}Pb	10.6 hr	2.4×10^{-5}	3.7×10^{-7}	1.9×10^{-8}	9.2×10^{-5}
^{214}Pb	26.8 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	1.5×10^{-4}
^{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}
^{240}Pu	6,560 yr	2.1×10^{-2}	1.6×10^{-5}	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
^{225}Ra	14.8 d	8.2×10^{-4}	3.4×10^{-6}	1.8×10^{-7}	8.0×10^{-6}

Table 4-25. Comparison of Radionuclide Relative Risks for Radionuclides of Concern at the S Plant Aggregate Area. Page 2 of 2

Radionuclide	Half-Life	Air Unit Risk[b/] in $(pCi/m^3)^{-1}$	Drinking Water Unit Risk[c/] in $(pCi/L)^{-1}$	Soil Ingestion Unit Risk[d/] in $(pCi/g)^{-1}$	External Exposure Unit Risk[e/] in $(pCi/g)^{-1}$
^{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}
^{106}Ru	1.0 yr	2.3×10^{-4}	4.9×10^{-7}	2.6×10^{-8}	0
^{79}Se	<65,000 yr	na	na	na	na
^{151}Sm	90 yr	na	na	na	na
^{90}Sr	28.5 yr	2.8×10^{-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}	3.4×10^{-10}
^{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}
^{233}U	159,000 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	3.2×10^{-7}
^{234}U	244,500 yr	1.4×10^{-2}	7.2×10^{-6}	3.8×10^{-7}	5.6×10^{-7}
^{235}U	7.0×10^{8} yr	1.3×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	9.7×10^{-5}
^{238}U	4.5×10^{9} yr	1.2×10^{-2}	6.6×10^{-6}	3.5×10^{-7}	4.5×10^{-7}
^{90}Y	64.1 hr	2.8×10^{-6}	1.6×10^{-7}	8.6×10^{-9}	0

a/ Calculated from half-life and atomic weight.

b/ Excess cancer risk associated with lifetime exposure to 1 pCi/m^3 (10^{-12} curies) per day in air (EPA 1991b).

c/ Excess cancer risk associated with lifetime exposure to 1 pCi (10^{-12} curies) per day in drinking water (EPA 1991b).

d/ Excess cancer risk associated with lifetime exposure to 1 pCi/g (10^{-12} curies/g) per day in soil (EPA 1991b).

e/ Excess cancer risk associated with lifetime exposure to surface soils containing 1 pCi/g of gamma-emitting radionuclides (EPA 1991b).

f/ External radiation risk from ^{137m}Ba, a short-lived decay product of ^{137}Cs.

na No information available.

Table 4-26. Potential Chronic Human Health Effects of Chemicals Detected or Disposed of at S Plant Aggregate Area. Page 1 of 2

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Reference
INORGANIC CHEMICALS			
Aluminum			
Ammonium ion		decreased pulmonary function; degrades odor, taste of water	EPA 1991a
Barium		fetotoxicity; increased blood pressure	EPA 1991b
Boron		NA; testicular lesions	EPA 1991a
Cadmium	respiratory tract [B1]; NA	cancer; renal damage	EPA 1991b
Calcium			
Chloride			
Chromium	lung [A] - Cr(VI) only; NA	nasal mucosa atrophy; hepatotoxicity	EPA 1991a
Copper		NA; gastrointestinal irritation	EPA 1991b
Fluoride		NA; dental flurosis at high levels	EPA 1991a
Iron			
Lead	[B2][b]; [B2]	central nervous system (CNS) effects[b]; CNS effects	EPA 1991a
Magnesium			
Mercury		neurotoxicity; kidney effects	EPA 1991b
Nickel	respiratory tract [A]; NA	cancer; reduced weight	EPA 1991b
Nitrate/Nitrite		NA; methemoglobinemia in infants[c]	EPA 1991a
Phosphate			
Potassium			
Silica			
Silver			

Table 4-26. Potential Chronic Human Health Effects of Chemicals Detected or Disposed of at S Plant Aggregate Area. Page 2 of 2

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route	Reference
Sodium			
Sulfate			
Uranium (soluble salts)		NA; body weight loss, nephrotoxicity	EPA 1991a
Zinc		NA; anemia	EPA 1991b
ORGANIC CHEMICALS			
Acetone		NA; kidney and liver effects	EPA 1991a
Carbon tetrachloride	liver [B2]	NA; liver lesions	EPA 1991a
Chloroform	liver; kidney [B2]	NA; liver lesions	EPA 1991b
Methylene chloride	lung, liver [B2]; liver [B2]	NA; liver toxicity	EPA 1991a
Methyl isobutyl ketone		liver and kidney effects; liver and kidney effects	EPA 1991b
Toluene		CNS effects, eye irritation; change in liver and kidney weights	EPA 1991a
Tributyl phosphate		respiratory irritant; kidney damage	NIOSH 1987

[a] Weight of Evidence Groups for carcinogens: A - Human carcinogen (sufficient evidence of carcinogenicity in humans); B - Probable human carcinogen (B1 - Limited evidence of carcinogenicity in humans; B2 - Sufficient evidence of carcinogenicity in animals with inadequate or lack of data in humans); C - Possible human carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data); D - Not classifiable as to human carcinogenicity (inadequate or no evidence).

[b] Lead is considered by EPA to have both neurotoxic and carcinogenic effects; however, no toxicity criteria are available for lead at the present time.

[c] Toxic effect is considered to occur from exposure to nitrite; nitrate can be converted to nitrite in the body by intestinal bacteria.

NA = Information not available.

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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 S 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 S 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 S 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 4-18. 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 S 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 waste management unit 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 S 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, irreversible results of continuing residence of contaminants, etc., were not used because they generally require unit-specific data which 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 unit 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 action (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 unit 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 S 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 S Plant Aggregate Area contaminants is currently constrained by the lack of data. This gap in the S Plant Aggregate Area data is discussed in Section 8.2.3. As a result, the risk-based screening of waste management unit priorities discussed in this section is by necessity limited to potential human health risks.

The U.S. Environmental Protection Agency (EPA 1989b) considers a human exposure pathway to consist of four elements: (1) a source and mechanism for contaminant release, (2) a retention or transport medium (or media), (3) a point of potential human contact, and (4) an exposure route (e.g., ingestion) at the contact point. The probability of the existence of a particular pathway is dependent upon the physical and institutional controls affecting waste management unit access and use. In the absence of unit 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 S 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 S 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 S 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 S 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 of or contact with groundwater was not evaluated as exposure pathways. However, since migration of waste constituents within the saturated zone will be addressed in the 200 West Groundwater Aggregate Area Management Study Report (AAMSR), 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. Potential exposures by other pathways were evaluated based on available knowledge regarding contaminants disposed of to the waste management units and the integrity of engineered barriers to releases.

5.2.1 External Exposure

External dose rate surveys, which are performed on a waste management unit basis, were used as the measure of a unit's potential for impacting human health through direct external radiation exposure. The contaminants of potential concern for this pathway are the radionuclides that emit moderate to high energy penetrating gamma radiation. The measured dose rates at S Plant Aggregate Area waste management units are presented in Table 5-1 from the available survey data.

For 20 of the 53 S Plant Aggregate Area waste management units, no radiation survey data are available. For the remaining 33 units that do have radiation survey data of some type, 21 were reported as having no contamination detected.

Westinghouse Hanford manual WHC-CM-4-10, Section 7 (WHC 1988c) was used as the basis for setting one of the criteria used to identify waste management units that can be considered high priority sites. The manual indicates that waste management units with radition levels of 2 mrem/h be posted with "Radiation Area" signs and undergo access controls for the purpose of personnel protection. With the same objective in mind, the level of 2 mrem/h is recommended as one of the criteria for distinguishing high priority from low priority sites. No waste management units or unplanned releases are known to have exceeded the 2 mrem/h criteria.

High levels of radiation were reportedly associated with some of the unplanned releases that are listed in Table 5-1. However, many of these releases occurred in the early years of the Hanford Site and more recent survey data are not available. Some of the releases were reportedly remediated by removing contaminated soil for disposal in burial grounds, paving or covering the area with soil, or flushing the soil with water. The effectiveness of the various remediation measures is not known, and confirmatory survey measurements are not available. Thus, with the exception of unplanned releases located within engineered waste units, which are routinely surveyed, information on the current radiological status of remediated unplanned releases is deficient and is identified as a data gap in Section 8.0.

5.2.2 Ingestion of Soil or Inhalation of Fugitive Dust

Radionuclides and nonradioactive contaminants 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 levels of specific radionuclides or nonradioactive contaminants in surface soils. Surface radiological contamination surveys were performed at many of the waste management units and provide measures of unit specific gross contamination levels. Available gross contamination survey data for the S Plant Aggregate Area waste management units are provided in Table 5-1.

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The Westinghouse Hanford Environmental Protection Group policies state that the presence of any smearable alpha constitutes a potential threat to human health and qualifies a waste management unit for a high remediation priority (Huckfeldt 1991b). Waste management units that exhibit elevated alpha readings in radiological surveys can be presumed to have surface contamination, since alpha radiation cannot penetrate solids.

Westinghouse Hanford manual *Radiation Protection* (WHC 1988c) was also used to set criteria for identifying waste management units that can be considered high remediation priority sites. The manual indicates that waste management units with a level of 100 ct/min (1,000 dis/min) above background beta/gamma, and/or 20 dis/min alpha, be posted with "Surface Contamination Area" signs and undergo access controls 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 identifying high priority waste management units. For those beta/gamma survey readings that are in units of dis/min, a conversion was made to ct/min assuming a survey detector efficiency of 10%.

It should be noted that these radiation readings may indicate transient conditions (e.g., presence of contaminated vegetation) and that routine stabilization of surface contamination is carried out under the auspices of the Westinghouse Hanford Radiation Area Remedial Action (RARA) Program.

Units subject to collapse of containment structures pose a potential threat of exposure through release of contaminants to the surface. Four of the older cribs are open wooden structures that could fail, which could force contaminants from the buried cribs to the surface and expose onsite personnel. The 216-S-1 and 216-S-2, 216-S-5, 216-S-7, and 216-S-13 and 216-S-20 Cribs all have a potential for collapse and are believed to contain dispersable contaminants that would exceed reporting requirements if released.

5.2.3 Inhalation of Volatiles

As summarized in Section 4.1, the distribution of volatile organics in soils is not well-defined in the S Plant Aggregate Area. Although several semivolatile compounds, such as bromonaphthalene and ethylene diamine tetracetate have been disposed in the cribs, no information is available on whether these compounds are still present in the near surface soil column for transport to the soil surface.

The primary volatile radionuclide of concern is tritium. Exposure to tritium (as tritiated water vapor) and the potential for tritium release via radiolytic production of hydrogen from aqueous radioactive wastes is of concern. The mode of disposal of this material cannot be determined from available information.

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 AAMSR and will not, therefore, be discussed in the S Plant AAMSR. 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 1991b).

Both of these ranking systems take into account some measure of hazard and environmental mobility and are thus appropriate to consider for waste unit prioritization. The HRS ranking system evaluates units 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 is a site ranking methodology that was designed to determine whether sites should be placed on the CERCLA National Priority 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 S 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

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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 (Huckfeldt 1991b). A score of 7 or greater results in the assignment of a "high" priority to the unit. A value of 7 was chosen to represent the approximate midpoint of the scoring range.

For the HRS ranking, 10 units of the 53 S Plant Aggregate Area waste management units were given a score of 28.5 or greater. For the mHRS ranking, 9 units were given a score of 28.5 or greater (all of which had HRS scores greater than 28.5). Seven units received a qualitative "high" score and 24 units received a qualitative "low" score. Each of the units that received a qualitative "high" HRS and mHRS score (two cribs, two ditches, two ponds, and an unplanned release), was given such a rating based on their discharge history of large quantities of hazardous materials that potentially could have been transported to the groundwater. The units that received qualitative "low" scores (three septic tanks, one pond, one trench, two burial sites, four control structures, two retention basins, and eleven unplanned releases) were given that ranking because there is no known history of liquid hazardous material disposal that could affect groundwater beneath the S Plant Aggregate Area. One site did not receive a ranking, although investigated in the preliminary assessment/site inspection because of insufficient data. These were denoted as "ENS" according to the terminology used in "ENS" by the preliminary assessment/site inspection to indicate sites not scored because of insufficient data.

5.4 SUMMARY OF SCREENING RESULTS

The screening process was used to sort units as either high priority or low priority. Table 5-1 lists the S Plant Aggregate Area waste management units that exceeded one or more of the screening criteria identified in the preceding sections. In total, 26 units were identified as high priority.

Radiation survey results (dose rate and/or contamination) were available for 33 of the 53 waste management units and unplanned releases. Twenty-one were reported as having no detectable results. Eleven of the remaining 12 units had survey results that exceeded one or more of the criteria (2 mrem/h, 100 ct/min beta/gamma, and 20 dis/min alpha).

For the HRS scores, 10 waste management units were given scores of 28.5 or greater. For the mHRS, 9 units received a score of 28.5 or greater. Seven units received qualitative "high" scores. Some units were designated as high priority for 2 or more of the criteria, hence only 27 total waste management units and unplanned releases are designated high priority. Two of the waste management units were assigned a Westinghouse Hanford Environmental Protection Group score of 7 or greater. Scoring values of 9 and 10 were assigned to 216-S-1 and 216-S-2 Cribs, and 216-S-7 Crib, respectively.

Table 5-1. Hazard Ranking Scores for the S Plant Aggregate Area.

Waste Management Unit Name	WMU Type	HRS Rating	mHRS Rating	Radiation Surveys ct/min	dis/min	mrem/h	Environmental Protection Score	High Priority
Cribs and Drains								
216-S-1&2	Cribs	55.36	57.73	3,500[a]	NA	NA	9	Yes
216-S-5	Crib	47.81	30.75	NC	NA	NC	--	Yes
216-S-6	Crib	47.81	42.14	NC	NA	NC	--	Yes
216-S-7	Crib	57.88	59.63	NC	NA	NC	10	Yes
216-S-9	Crib	50.33	39.23	NC	NA	NC	--	Yes
216-S-13	Crib	1.45	1.45	NC	NA	NA	--	No
216-S-20	Crib	50.33	43.70	NC	NA	NC	--	Yes
216-S-22	Crib	1.03	0.82	NC	NA	NC	--	No
216-S-23	Crib	1.03	1.14	NC	NA	NC	--	No
216-S-25	Crib	High[b]	High[b]	NC	NA	NC	--	Yes
216-S-26	Crib	High[b]	High[b]	NC	NA	NC	--	Yes
216-S-3	French Drain	47.81	49.97	NC	NA	NA	--	Yes
Ponds, Ditches, and Trenches								
216-S-10P	Pond	High[b]	High[b]	NC	NA	NC	--	Yes
216-S-11	Pond	45.30	17.70	NC	NA	NC	--	Yes
216-S-15	Pond	1.03	0.71	2,000[a]	NA	NA	--	Yes
216-S-16P	Pond	High[b]	High[b]	NA	NA	NA	--	Yes
216-S-17	Pond	47.81	42.14	1,000	NA	NA	--	Yes
216-S-19	Pond	Low[c]	Low[c]	NC	NA	NC	--	No

Table 5-1. Hazard Ranking Scores for the S Plant Aggregate Area.

Waste Management Unit Name	WMU Type	HRS Rating	mHRS Rating	Radiation Surveys ct/min	dis/min	mrem/h	Environmental Protection Score	High Priority
216-S-10D	Ditch	High[b]	High[b]	NC	NA	NC	--	Yes
216-S-16D	Ditch	47.81	42.14	NC	NA	NC	--	Yes
216-U-9	Ditch	High[b]	High[b]	NA	NA	NA	--	Yes
216-S-8	Trench	2.07	2.29	NA	NA	NA	--	No
216-S-12	Trench	1.03	0.82	NC	NC	NC	--	No
216-S-14	Trench	1.03	0.71	NC	NC	NA	--	No
216-S-18	Trench	Low[d]	Low[d]	NC	NA	NC	--	No
Septic Tanks and Associated Drain Fields								
2607-W6	Septic Tank & Tile Field	Low[d]	Low[d]	NA	NA	NA	--	No
2607-WZ	Septic Tanks (2) & Drain Field	Low[d]	Low[d]	NA	NA	NA	--	No
--	Sanitary Crib	Low[d]	Low[d]	NA	NA	NA	--	No
Transfer Facilities, Diversion Boxes, and Pipelines								
216-S-172	Control Structure	Low[d]	Low[d]	NA	NA	NA	--	No
2904-S-160	Control Structure	Low[d]	Low[d]	5,000	NA	NA	--	Yes
2904-S-170	Control Structure	Low[d]	Low[d]	<200	NA	NA	--	Yes
2904-S-171	Control Structure	Low[d]	Low[d]	<100	NA	NA	--	No
Basins								
207-S	Retention Basin	Low[d]	Low[d]	6,000	NA	NA	--	Yes
207-SL	Retention Basin	Low[d]	Low[d]	NC	NA	NA	--	No

Table 5-1. Hazard Ranking Scores for the S Plant Aggregate Area.

Waste Management Unit Name	WMU Type	HRS Rating	mHRS Rating	Radiation Surveys ct/min	dis/min	mrem/h	Environmental Protection Score	High Priority
Burial Sites								
218-W-7	Burial Ground	Low[c]	Low[c]	NA	NA	NA	--	No
218-W-9	Burial Ground	Low[c]	Low[c]	2,500[a]	NA	NA	--	Yes
Unplanned Releases								
UN-200-W-32	Unplanned Release	Low[c]	Low[c]	3,000[a]	NA	NA	--	Yes
UN-200-W-34	Unplanned Release	High[b]	High[b]	NA	NA	NA	--	Yes
UN-200-W-35	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No
UN-200-W-41	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No
UN-200-W-42	Unplanned Release	0.80	--	5,000	NA	NA	--	Yes
UN-200-W-43	Unplanned Release	0.80	--	NA	NA	NA	--	No
UN-200-W-52	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No
UN-200-W-56	Unplanned Release	1.00	--	NA	NA	NA	--	No
UN-200-W-61	Unplanned Release	1.00	--	NA	NA	NA	--	No
UN-200-W-69	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No
UN-200-W-83	Unplanned Release	ENS	--	NA	NA	NA	--	No
UN-200-W-108	Unplanned Release	Low[c]	Low[c]	NC	NC	NC	--	No
UN-200-W-109	Unplanned Release	Low[c]	Low[c]	6,000	NA	NA	--	Yes
UN-200-W-116	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No
UN-200-W-123	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	--	No

Table 5-1. Hazard Ranking Scores for the S Plant Aggregate Area.

Waste Management Unit Name	WMU Type	HRS Rating	mHRS Rating	Radiation Surveys ct/min	dis/min	mrem/h	Environmental Protection Score	High Priority
UN-200-W-127	Unplanned Release	Low[c]	Low[c]	NA	NA	NA	–	No
UN-216-W-30	Unplanned Release	Low[c]	Low[c]	350	NA	NA	–	Yes

NA = No data available.
NC = No contamination detected.
ENS = Classification given in PA/SI when sufficient information was not available for scoring.

[a] Beta/gamma measurement converted from dis/min to ct/min.

[b] A high value is given to those units for which no similarities to other ranked sites exist and a qualitative investigation indicates a "high" score.

[c] A low value is given to those units for which no similarities to other ranked sites exist and a qualitative investigation indicates a "low" score.

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 S 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.

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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 S Plant Aggregate Area, potential contaminant-specific ARARs address chemical constituents and/or radionuclides. The potential contaminant-specific ARARs that were evaluated for the S 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 S 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 S 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 S 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.

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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 S Plant Aggregate Area are outlined in Table 4-18. 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 S Plant Aggregate Area, as no natural surface water bodies exist. The only existing man-made surface water bodies at S Plant Aggregate Area are waste management units.

- **Safe Drinking Water Act (42 USC 300(f)).** Under the authority of the Safe Drinking Water Act (42 USC 300(f)), MCLs (40 CFR 141) apply when the water may be used for drinking. Currently, 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 and 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. The 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 onsite at the S Plant Aggregate Area will comply with the substantive requirements of RCRA, and not 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-OSFS, 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

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redisposed of onsite 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 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 (NESHAP) (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 S 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 Method 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 S 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 potential ARARs in Table 6-1.

In addition to Method A, Method B and Method C cleanup standards may also be considered potential ARARs for the S 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

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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 potentially applicable include carbon monoxide, ozone, 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 (Chapter 246-247 WAC).** These standards by the Washington State Department of Health (Health) adopt the Ecology standards for maximum accumulated dose limits to members of the public. 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 173-460 WAC, 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. The ASILs for preliminary contaminants of concern are provided in Table 6-1.

- **Water Quality Standards.** Washington State has promulgated various numerical standards related to surface water and groundwater contaminants. These 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 modify and incorporate numerical criteria for toxic chemicals, and to 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.

  Groundwater will be addressed in the 200 West Groundwater AAMSR in which pertinent groundwater-related potential ARARs will be covered. No surface water bodies exist within the S 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 for 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 (RCW 90.48, WAC 173-220 and 40 CFR 122).** National Pollutant Discharge Elimination System (NPDES) regulations govern point

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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 S Plant Aggregate Area as the aggregate area is not located in 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 S 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 S 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 S Plant Aggregate Area. However, Wild and Scenic Rivers Act

requirements may be potential ARARs for actions taken as a result of S Plant Aggregate Area cleanup efforts 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 the site. These remedial actions will not be fully defined until a remedial approach has been selected. However, the universe of potential 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 potential 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 Part 300) include selection criteria for remedial actions. Under the criteria, excavation and off-site land disposal options are least favored when onsite 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.

  The 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 state wide 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.

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- **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 or 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 area of potential 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), 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:

  - 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 S 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 LDR 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 the NPDES mandate use of best available treatment technologies (BAT) prior to discharging contaminants to surface waters. The NPDES requirements would not be ARARs for actions conducted only within the S 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 6.2.2, 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 potential 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 S 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 S 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 soil disposal.

  The WPCA requirements for surface water would not be ARARs for actions conducted only within the S 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 S 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 well drillers.

- **State Waste Discharge Permit Program (Chapter 173-216 WAC).** Chapter 173-216 WAC establishes a permit system for discharges of wastewater to groundwater and surface water via 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, guidance, and similar materials are "to be considered" in determining the appropriate degree of remediation for the S Plant Aggregate Area. A myriad of resources may be potentially evaluated. The following represents an initial assessment of pertinent TBC provisions.

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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 of 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 30798), 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 include requirements that would be TBCs for determining an appropriate level of cleanup at the S 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. 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.** 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. 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/yr. 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/yr 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 (TRU), 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 S Plant Aggregate Area remediation activities include those related to TRU waste and low-level radioactive waste. These are summarized below.

  - **Management of Transuranic Waste.** The TRU waste resulting from the S 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.

  - The TRU 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 TRU 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 TRU 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 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 S 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 S 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 S 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.

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The point at which compliance with identified ARARs must be achieved will be a significant factor in evaluating appropriate remedial alternatives in the S 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 S 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

- During detailed analysis 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.

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- 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. The ARARs may need to be reevaluated if unanticipated circumstances are encountered during remediation which prevent the ability to satisfy the identified ARARs.

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic and Organic Contaminants of Concern.

	RCRA TCLP Designation Limits	RCRA Land Ban Limits Nonwastewater		MTCA Method A Cleanup Levels Industrial Soil	WCAA Toxic Air Pollutants ASIL	RCRA Corrective Action Levels (Proposed) (1)	
	in mg/L	CCWE in mg/L	CCW in mg/kg	in mg/kg	in $\mu g/m^3$	Air in $\mu g/m^3$	Soil in mg/kg
INORGANIC CHEMICALS							
Barium	100	100	—	—	—	—	—
Cadmium	1.0	1.0	—	10	.00056	.0006	40
Chromium	5.0	5.0	—	500	.000083	.00009	40
Copper	—	—	—	—	3.3	—	—
Fluoride	—	—	—	—	8.3	—	—
Lead	5	5.0	—	1,000	—	—	—
Iron	—	—	—	—	2.7	—	—
Manganese	—	—	—	—	—	—	—
Nickel	—	134	—	—	—	—	2000
Nitrite	—	—	—	—	—	—	—
Silver	5.0	5.0	—	—	0.3	—	200
Titanium	—	—	—	—	—	—	—
Uranium	—	—	—	—	0.7	—	—
Vanadium	—	—	—	—	—	—	—
Zinc	—	—	—	—	—	—	—
ORGANIC CHEMICALS							
Acetone	—	160	.59	—	5927.4	—	8000
Chloroform	6	5.6	—	—	0.043	0.04	100
Hydrazine	—	—	—	—	—	0.0002	0.2
MIBK ("Hexone")	—	33	.33	—	682.7	70	4000
Xylene	—	0.15	28	20	1448.6	1000	200,000

ASIL = Acceptable Source Impact Level
CCWE = Constituent Concentration in Waste Extract
CCW = Constituent Concentration in Waste
MTCA = Washington State Model Toxics Control Act
RCRA = Federal Resource Conservation and Recovery Act
TCLP = Toxic Characteristic Leaching Procedure
WCAA = Washington State Clean Air Act

mg/L = milligrams per liter
mg/kg = milligrams per kilogram
$\mu g/m^3$ = micrograms per cubic meter

(1) RCRA Corrective Action Levels are only proposed at this time (40 CFR Part 264 Subpart S), so are not ARARs yet; they are "To Be Considered."

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Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
GEOLOGICAL:			
Within 154 m (500 ft) of a fault displaced in Holocene time.	New treatment, storage or disposal of hazardous waste prohibited.	Hazardous waste management near Holocene fault.	40 CFR 264.18; WAC 173-303-282
Holocene faults and subsidence areas.	New solid waste disposal facilities prohibited over faults with displacement in Holocene time, and in subsidence areas.	New solid waste management activities near Holocene fault.	WAC 173-304-130
Unstable slopes.	New solid waste disposal areas prohibited from hills with unstable slopes.	New solid waste disposal on an unstable slope.	WAC 173-304-130
100-year floodplains.	Solid and hazardous waste disposal facilities must be designed, built, operated, and maintained to prevent washout.	Solid or hazardous waste disposal in a 100-year floodplain.	40 CFR 264.18; WAC 173-303-282; WAC 173-304-460
	Avoid adverse effects, minimize potential harm, restore/preserve natural and beneficial values in floodplains.	Actions occurring in a floodplain.	40 CFR Part 6 Subpart A; 16 USC 661 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 within 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.	WAC 173-304-130
	Protects the upper aquifers and upper aquifer zones to avoid depletions, excessive water level declines, or reductions in water quality. State regulations for upper aquifer zones are applicable to remedial alternatives that involve treating groundwater or presenting risks of groundwater contamination.	Activities within an aquifer.	Chapter 173-154 WAC
	Requires that Ecology review and approve plans for waste water treatment facilities that discharge to groundwater.	New treatment facilities discharging to the groundwater.	Chapter 173-240 WAC
Aquifer Protection Areas.	Activities restricted within designated Aquifer Protection Areas.	Activities within an Aquifer Protection Area.	Chapter 36.36 RCW.
Groundwater Management Areas.	Activities restricted within Ground Water Management Areas.	Activities within a Groundwater Management Area.	Chapter 90.44 RCW; Chapter 173-100 WAC
DRINKING WATER SUPPLY:			
Drinking water supply well.	New solid waste disposal areas prohibited within 305 m (1,000) feet upgradient, or 90 days travel time, of drinking water supply well.	New solid waste disposal within 305 m (1,000 feet) of drinking water supply well.	WAC 173-304-130
Watershed.	New solid waste disposal areas prohibited within a watershed used by a public water supply system for municipal drinking water.	New solid waste disposal in a public watershed.	WAC 173-304-130

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 U.S.C. 742 16 U.S.C. 2901 50 C.F.R. 17
	Actions within critical habitats must conserve endangered/threatened species.	Activities where endangered or threatened species exist.	50 CFR Parts 200 and 402.
Parks.	No new solid waste disposal areas within 305 m (1,000 feet) of state or national park.	New solid waste disposal near state/national park.	WAC 173-304-130
	Restrictions on activities in areas that are designated state parks, or recreation/ conservation areas.	Activities in state parks or recreation/conservation areas.	Chapter 43.51 RCW; Chapter 352.32 WAC
Wilderness areas.	Actions within designated wilderness areas must ensure area is preserved and not impaired.	Activities within designated wilderness areas.	16 USC 1131 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

Table 6-2. Potential Location-Specific ARARs.

Location	Requirement	Prerequisite	Citation
Natural areas preserves.	Activities restricted in areas designated as having special habitat value (Natural Heritage Resources).	Activities within identified Natural Area Preserves.	Chapter 79.70 RCW; Chapter 332-650 WAC
Wild, scenic, or recreational rivers.	Avoid actions that would have adverse effects on designated wild, scenic, or recreational rivers.	Activities near wild, scenic, and recreational rivers.	16 USC 1271 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 U.S.C. 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 feet) of the facility's property line.	New solid waste disposal within 30.5 m (100 feet) of facility property line.	WAC 173-304-130
	No new solid waste disposal areas within 76 m (250 feet) of property line of residential zone properties.	New solid waste disposal within 76 m (250 feet) of property line of residential property.	WAC 173-304-130
Proximity to airports.	Disposal of garbage that could attract birds prohibited within 3,050 m (10,000 ft) (turbojet aircraft)/1,524 m (5,000 ft) (piston-type aircraft) of airport runways.	Garbage disposal near airport.	WAC 173-304-130

7.0 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

Previous sections identified contaminants of concern at the S 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 S 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 S 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 S 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 for 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 acceptable 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 S 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 S 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 permanent 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 S 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 and 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 Areas).

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 S Plant Aggregate Area. The media of concern for the S 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 Closure Program. In addition, groundwater as an exposure medium is not addressed in this source aggregate area management study report (AAMSR) but will be addressed in the 200 West Groundwater AAMSR.

7.2 PRELIMINARY GENERAL RESPONSE ACTIONS

General response actions represent broad classes of remedial measures that may be appropriate to achieve both interim and final RAOs at the S Plant Aggregate Area, and are presented in Table 7-2. The following are the general response actions for the S Plant Aggregate Area followed by a brief description:

- 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 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 interim remedial measures. Because the 200 Areas are already committed to waste management for the long term, institutional controls will also be important for final remedial measures 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 the Hanford Site or offsite for permanent 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 may not be needed, or may only be required at 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 the Hanford Site. Some treatment technologies must be pilot tested before they could be implemented. Waste treatment could be conducted either as an interim or final action and may be appropriate in meeting RAOs for all potential future land uses.

Waste containment includes the use of capping technologies (i.e., capping and grouting) to minimize the driving force for downward or lateral migration of contaminants. Vertical barriers can also be used to minimize lateral migration and to prevent biota from penetrating into contaminated areas. Containment also provides a radiation exposure barrier and a 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 biological treatment. 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 criterion 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 criterion 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 criterion places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services, and the availability of necessary equipment and skilled workers to implement the technology. It also focuses on the process option's developmental status, whether it is an experimental or established technology.

The relative cost criterion is an estimate of the overall cost of a process, including capital and operating costs. At this stage in the process, the cost analysis is made on the basis of engineering judgement, and each process is evaluated as to whether the 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 criterion. 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.

9 3 1 2 8 6 9 1 1 0 3

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 semivolatile organic compounds (VOCs). These alternatives are not intended as recommended actions for any individual units, but are intended only to provide potential options applicable to most units where multiple contaminants are present. Selection of actual remedial alternatives that should be applied to the individual units 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 S 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 unit.

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 S Plant Aggregate Area. Both no action and institutional control options are required to be considered as part of the CERCLA RI/FS guidance (EPA 1988b). 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.

9 3 1 2 8 6 9 1 1 0 5

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 FSs. 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 multi-media 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-synthetic liners. 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 (FSS) which may be supported by treatability studies and performance testing. The barrier would be designed to minimize infiltration of surface water and to minimize biological intrusion (e.g., deep-rooting plants and burrowing animals). 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 semivolatile organic compounds VOCs from the affected soil. This

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technology has not been proven to be effective for volatile organic compounds, so it is not recommended as the sole remedial action for volatile organic compounds. 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 that have been used at industrial sites. In the first method (shown on 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 semivolatile 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 semivolatile 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 a combination of institutional controls, caps, and vertical barriers might also be required on a case-by-case basis for the waste management units at the S Plant Aggregate Area.

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 excavated soil 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 unit-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 is expected to be effective in treating radionuclides, heavy metals, and inorganic contamination and may also destroy organic contaminants thereby reducing 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 soil heating process. Therefore, this technology must include provisions for collecting 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 the situ vitrification is a relatively new technology which is experiencing some "growing pains," and has not yet 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 TRU Radionuclides

Some of the waste management units in the S 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 the facility 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 its 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 would contain TRU radionuclides at concentrations less than 100 nCi/g would 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 unit 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 unit 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 disposed 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 percent have often been achieved using 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 S 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. The process 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 waste management units with VOCs (e.g., MIBK). 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 modified to include other technologies if contaminants other than VOCs are present. However, because of the limited number of S Plant Aggregate Area sites that contain VOCs, the use of soil vapor extraction will not be extensive.

7.5 PRELIMINARY REMEDIAL ACTION ALTERNATIVES APPLICABLE TO WASTE MANAGEMENT UNITS AND UNPLANNED RELEASE SITES

The purpose of this section is to discuss which preliminary remedial action alternatives could be used to remediate each S 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 (Alterative 4) could be used at most waste management units or unplanned release sites, although vapor extraction may be needed when volatile organic compounds 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 (Alterative 5) could only be used on those waste management units and unplanned releases that contain TRU radionuclides. Since a geologic repository is likely to accept only TRU radioactive soils, the non-TRU radioactive soils will not be remediated using this alternative.

- In situ soil vapor extraction (Alterative 6) could be used on any waste management unit or unplanned release site 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. Each waste management unit or unplanned release may require just one alternative or a combination of many alternatives. Furthermore, similar units may be remediated simultaneously. Also, more specific waste treatment alternatives could be identified and evaluated as more information is obtained. Note that a single alternative may not be sufficient to remediate all contamination at a single waste management unit or unplanned release site. For example, soil vapor extraction could precede in situ vitrification to remove organic contaminants. Also, different combinations of technologies are possible besides those presented in these preliminary alternatives. Table 7-4 excludes units that are covered by other programs. For example, single-shell tanks are excluded because they are addressed by the Single-Shell Tank Closure Program.

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 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 they may require site-specific performance assessment (treatability) studies.

The 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.

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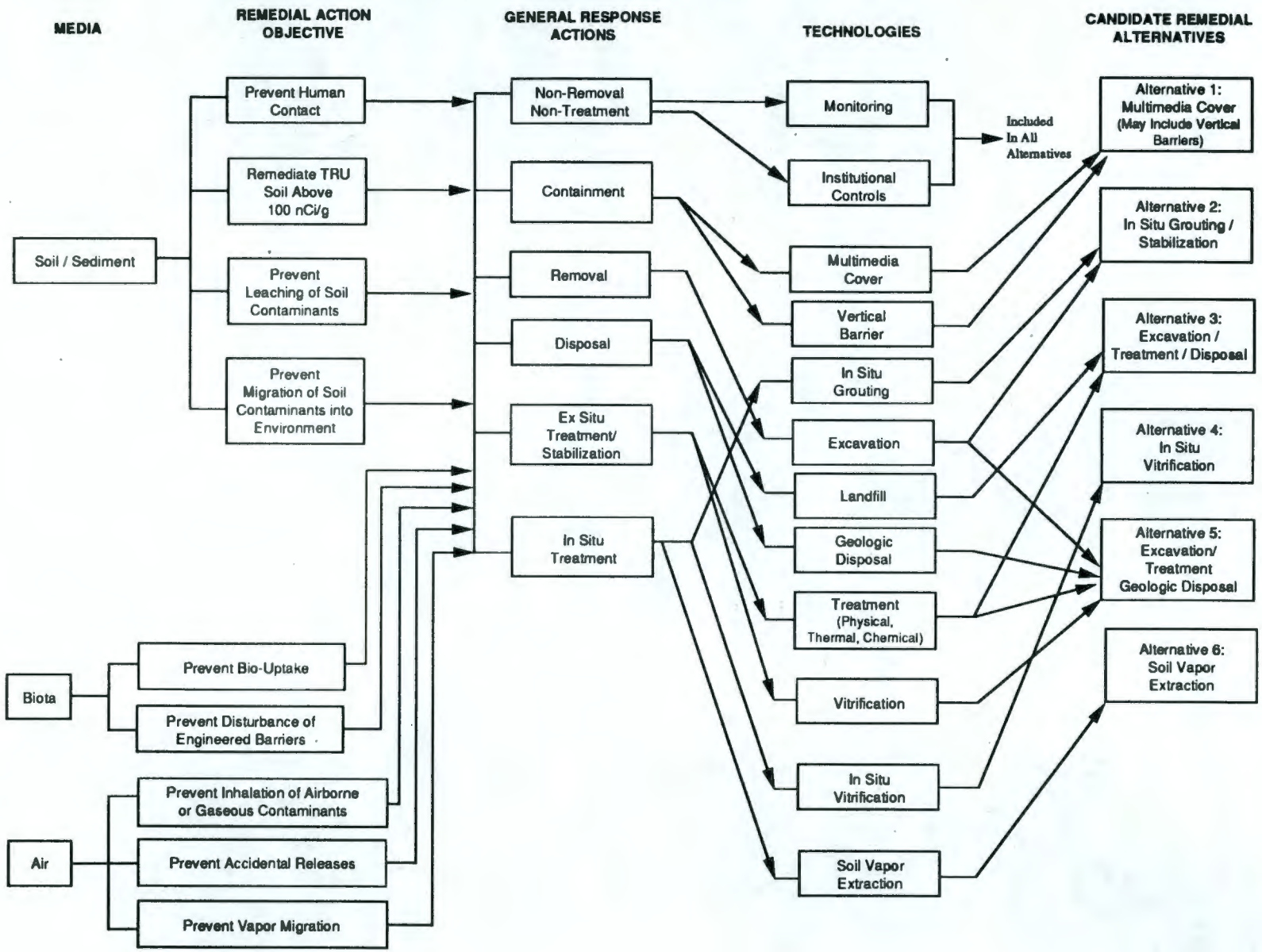

Figure 7-1. Development of Candidate Remedial Alternatives for S Plant Aggregate Area.

Figure 7-2. Alternative 1: Multi-Media Cover with Vertical Barriers.

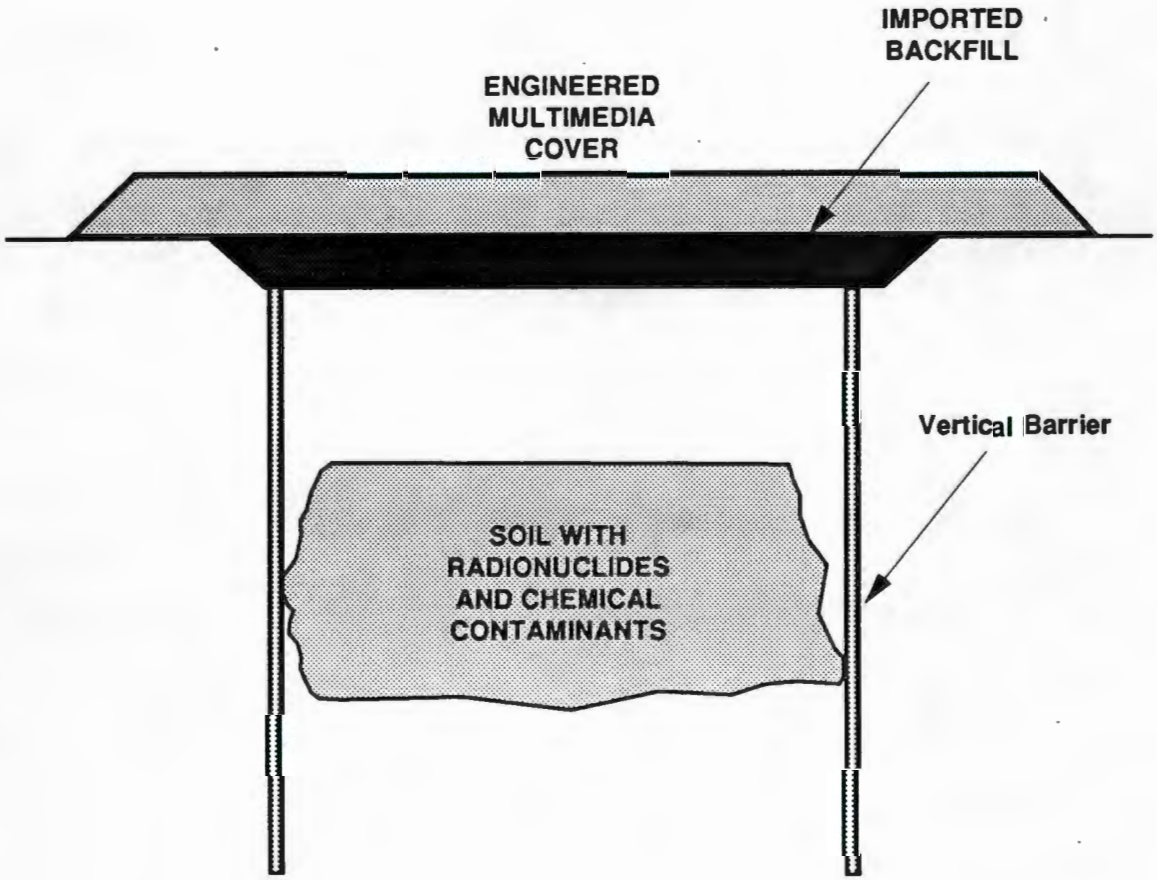

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Figure 7-3. Alternative 2: In Situ Grouting of Soil.

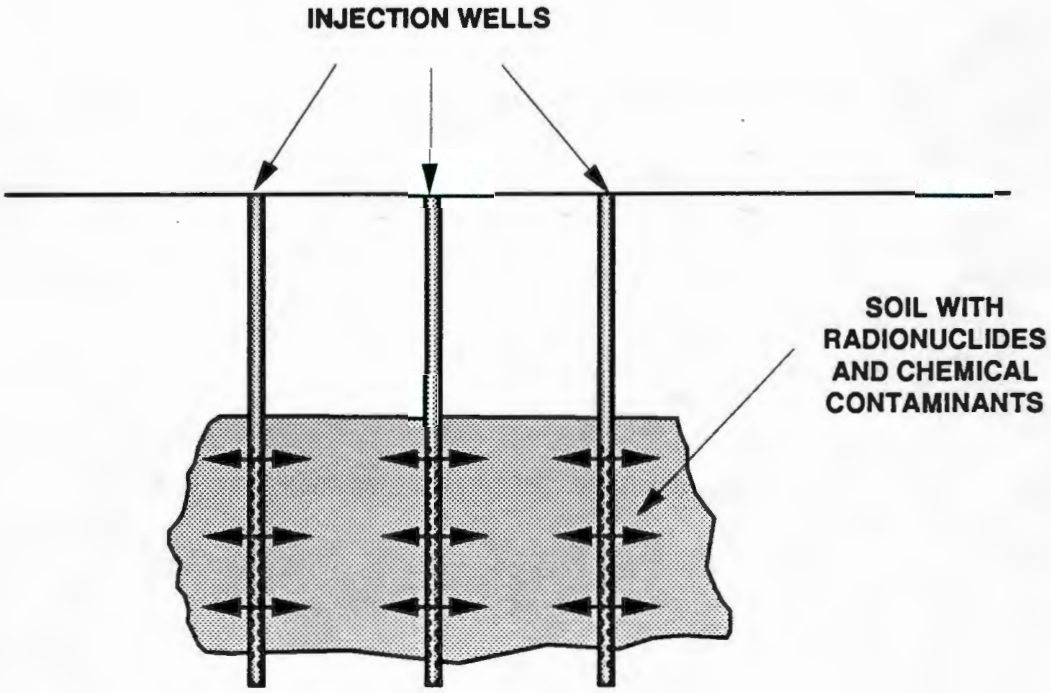

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Figure 7-4. Alternative 3: Excavation, Treatment, and Disposal.

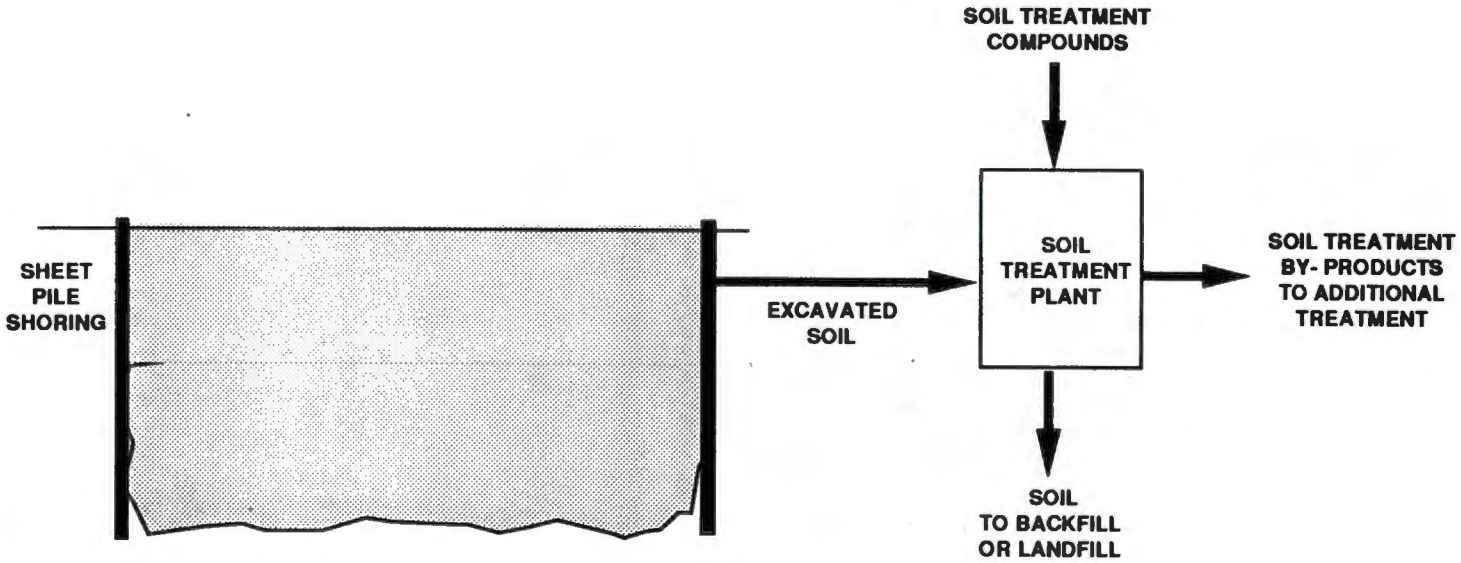


Figure 7-5. Alternative 4: In Situ Vitrification of Soil.

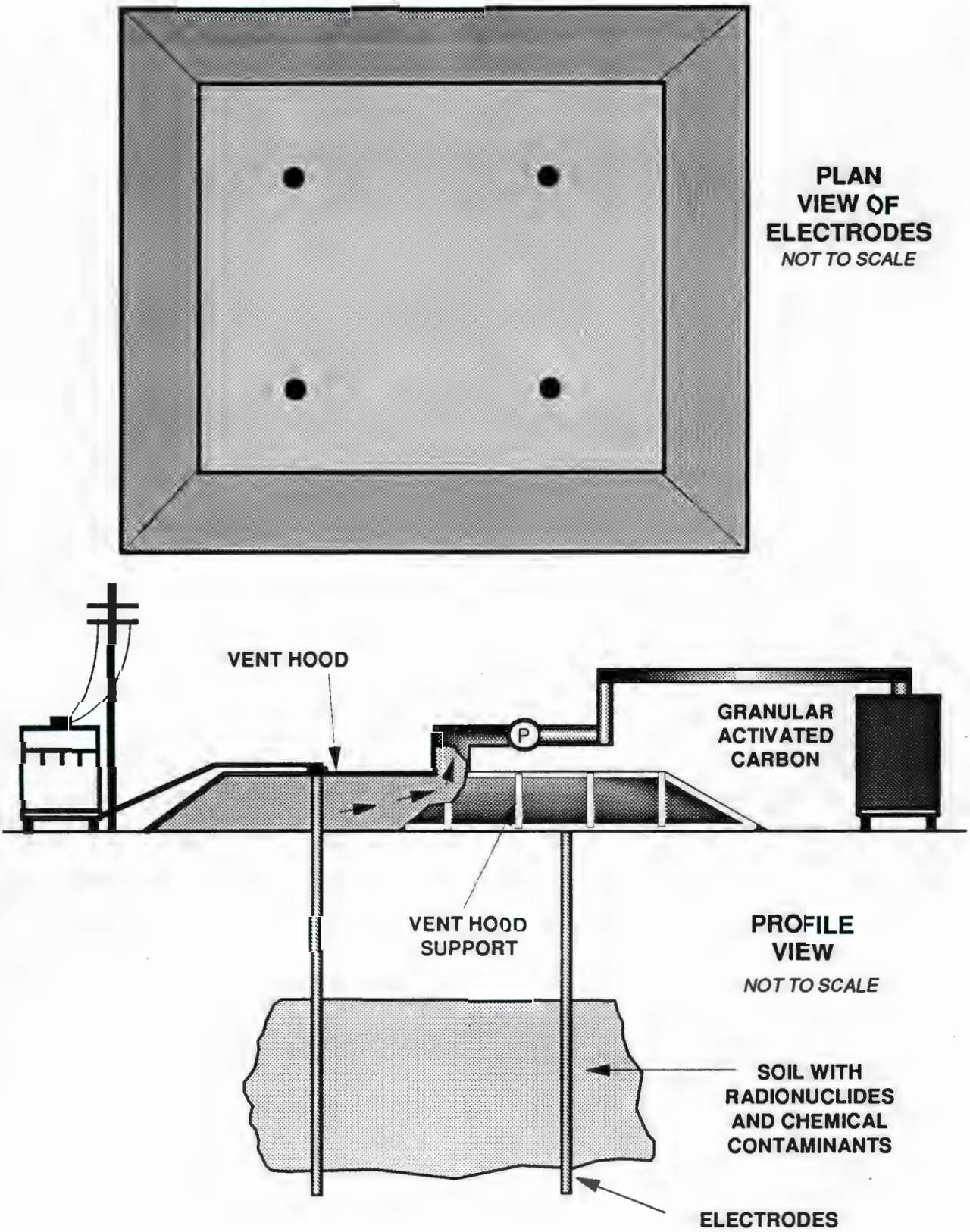
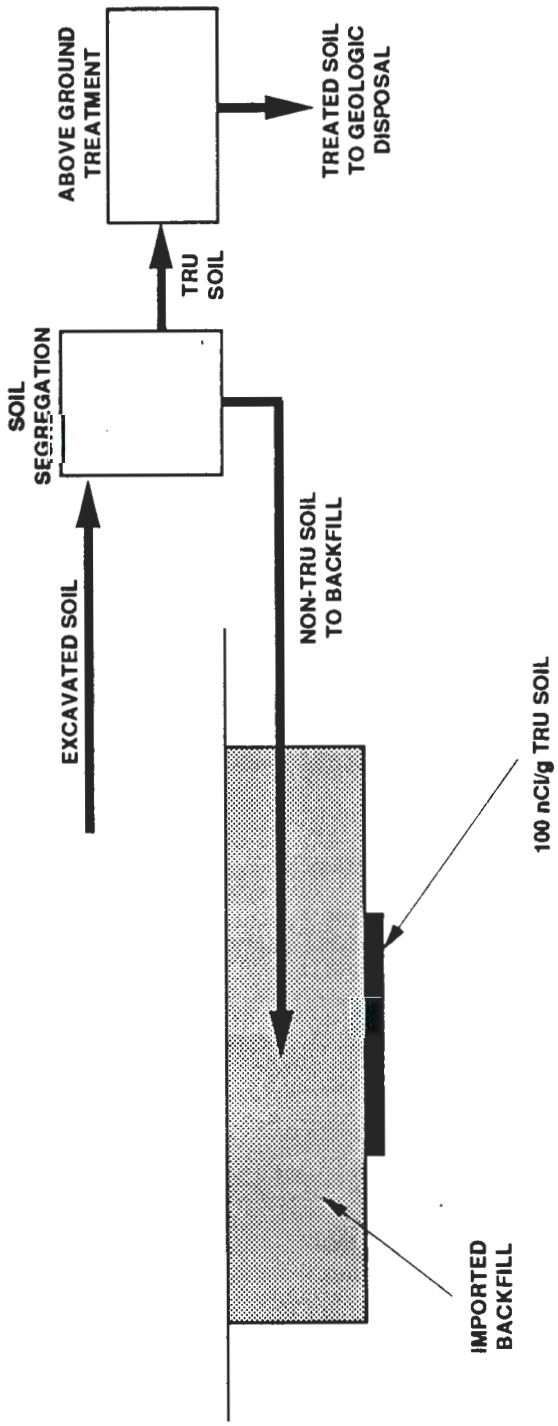


Figure 7-6. Alternative 5: Excavation, Vitrification, and Geologic Disposal of Soil with TRU Radionuclides.



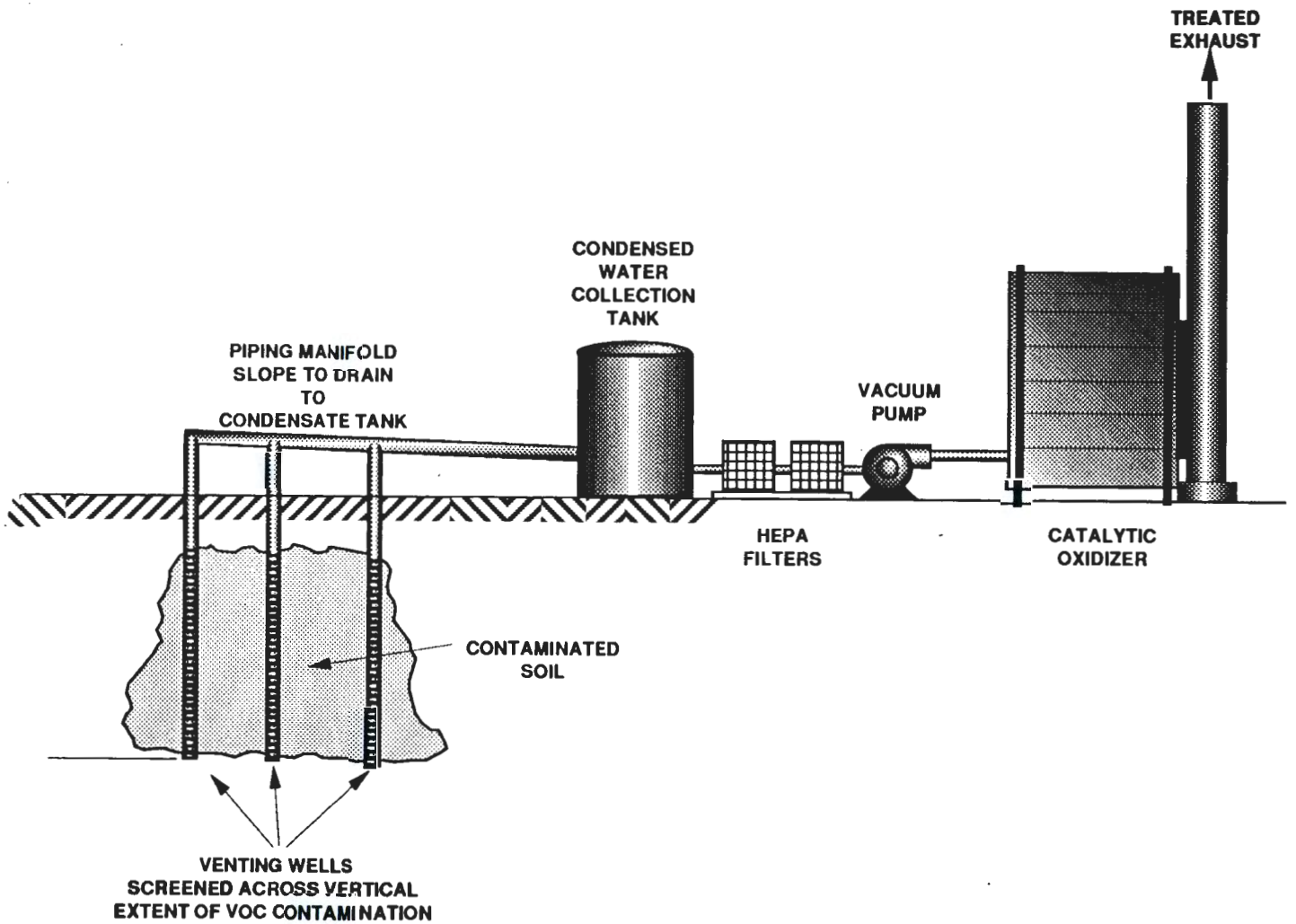


Figure 7-7. Alternative 6: Soil Vapor Extraction for VOC.

Table 7-1. Preliminary Remedial Action Objectives and General Response Actions.

Environmental Media	Remedial Action Objectives		General Response Actions
	Human Health	Environmental Protection	
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 • Containment • Excavation • Treatment • Disposal • 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 • Excavation • Treatment • Disposal • Containment • In Situ Treatment
Air[a]	• 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.	

[a] 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.

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	Multimedia	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
		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

Table 7-2. Preliminary Remedial Action Technologies.

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
		Biological Treatment	Aerobic (Landfarming)	O
			Anaerobic	O
	Disposal	Landfill Disposal	On-site Landfill	I,M,R,O
			Off-site Landfill	I,M,O
			Offsite RCRA 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
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

Table 7-2. Preliminary Remedial Action Technologies.

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
	Excavation	Excavation	Standard Construction Equipment	I,M,R,O
	Disposal	Landfill Disposal	Landfill Disposal	I,M,R,O
	Containment	Capping	Multimedia	I,M,R,O

I = Other Inorganics contaminants applicability
M = Heavy Metals contaminants applicability
R = Radionuclide contaminants applicability
O = Organic contaminants applicability
NA = Not Applicable
T = TRU Radionuclides Applicability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
SOIL TECHNOLOGIES:						
No Action	No Action	Do nothing to cleanup the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as farming.	Depends on continued implementation. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of soil contamination.	Effective if the fence and signs are maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to prevent people from becoming exposed.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Analyze soil and soil gas samples for contaminants and scan with radiation detectors.	Does not reduce the contamination, but is very effective in tracking the contaminant levels.	Easily implemented. Standard technology.	Low	Retained to be used in conjunction with other process options.
Capping	Multimedia	Fine soils over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective on all types of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Retained because of potential effectiveness and implementability.
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.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Cryogenic Walls	Circulate refrigerant in pipes surrounding the contaminated site to create a frozen curtain with the pore water.	Effective in blocking lateral movement of all types of soil contamination.	Specialized engineering design required. Requires ongoing freezing.	Medium	Rejected because it is difficult to implement.
Dust and Vapor Suppression	Membranes/ Sealants/ Wind Breaks/ Wetting Agents	Using membranes, sealants, wind breaks, or wetting agents on top of the contaminated soil to keep the contaminants from becoming airborne.	Effective in blocking the airborne pathways of all the soil contaminants, but may require regular upkeep.	Commonly used practice and very easy to implement, but land restrictions will be necessary.	Low	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.
Thermal Treatment	Above-ground Vitrification	Convert soil to glassy materials by application of electric current.	Effective in destroying organics and immobilizing the inorganics and radionuclides. Off-gas treatment for volatiles may be required.	Commercial units are available. Laboratory testing required to determine additives, operating conditions, and off gas treatment. Must pre-treat soil to reduce size of large materials.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	Incineration	Destroy organics by combustion in a fluidized bed, kiln, etc.	Effectively destroys the organic soil contaminants. Some heavy metals will volatilize. Radionuclides will not be treated.	Technology is well developed. Mobile units are currently available for relatively small soil quantities. Off-site treatment is available. Air emissions and wastewater generation should be addressed.	High	Rejected because of potential air emissions and wastewater generation.
	Thermal Desorption	Organic volatilization at 150 to 400°C (300 to 800°F) by heating contaminated soil followed by off gas treatment.	Effectively destroys the organic soil contaminants. Heavy metals less likely to volatilize than in high temperature treatments. Radionuclides will not be treated.	Successfully demonstrated on a pilot-scale level. Full-scale remediation yet to be demonstrated. Pilot testing essential.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	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.	Virtually untested on treating soils. Competing reactions may reduce efficiency.	Medium	Rejected because of limited applicability and implementation problems.
	Hydrolysis	Acid- or base-catalyst reaction in water to break down contaminants to less toxic components.	Very effective on compounds generally classified as reactive. Limited effectiveness on stable compounds. Radioactivity will not be reduced.	Common industrial process. Use for treatment of soils not well demonstrated.	Medium	Rejected because of limited effectiveness and unproven on soils.
	Chemical Dechlorination	Detoxify chlorinated organic chemicals by reaction with organic reagents.	Not commonly used on the chlorinated compounds that have been identified at T Plant.	Difficult to implement. Requires soil washing or solvent extraction before use.	High	Rejected because of limited effectiveness and difficult implementation.
	Chemical Dechlorination	Detoxify chlorinated organic chemicals byreaction 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.
Physical Treatment	Soil Washing	Leaching of waste constituents from contaminated soil using a washing solution.	Effectiveness is contaminant specific. Generally more effective on contaminants that partition to the fine soil fraction. Radioactivity will not be reduced.	Treatability tests are necessary. Well developed technology and commercially available.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Solvent Extraction	Contacting a solvent with contaminated soils to preferentially dissolve the contaminants into the solvent.	The selected solvent is often just as hazardous as the contaminants presented in the waste. May lead to further contamination. Radioactivity will not be reduced.	Laboratory testing necessary to determine appropriate solvent and operating conditions. Not fully demonstrated for hazardous waste applications.	Medium	Rejected because the solvent may lead to further contamination.
	Physical Separation	Separating soil into size fractions.	Effective as a concentration process for all contaminants that partition to a specific soil size fraction.	Most often used as a pretreatment to be combined with another technology. Equipment is readily available.	Low	Retained because of potential effectiveness and implementability.
	Fixation/ Solidification/ Stabilization	Form low permeability solid matrix by mixing soil with cement, asphalt, or polymeric materials.	Effective in reducing inorganic and radionuclide soil contaminant mobility. Effectiveness for organic stabilization is highly dependent on the binding agent.	Stabilization has been implemented for site remediations. Treatability studies are needed. Volume of waste is increased.	Medium	Retained because of potential effectiveness and implementability.
	Containerization	Enclosing a volume of waste within an inert jacket or container.	Effective for difficult to stabilize, extremely hazardous, or reactive waste. Reduces the mobility of radionculides.	May be implemented for low concentration waste. Disposal or safe storage of containers required. Regulatory constraints may prevent disposal of containers of certain waste types.	Low	Retained because of potential effectiveness and implementability.
Biological Treatment	Aerobic (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.	Various options are commercially available to produce contaminant degradation. Treatability tests are required to determine site-specific conditions.	Medium	Rejected because of limited applicability and difficult implementation.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Anaerobic	Microbial degradation in an oxygen deficient environment.	Effectiveness is very contaminant and concentration specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides.	Various options are commercially available to produce contaminant degradation. Treatability tests are required to determine site-specific conditions.	Medium	Rejected because of limited applicability and difficult implementation.
Disposal	Landfill Disposal	Place contaminated soil in an existing onsite landfill.	Does not reduce the soil contamination but moves all of the contamination to a more secure place.	Easily implemented if sufficient storage is available in an on-site landfill area.	Medium	Retained because of potential effectiveness and implementability.
	Geologic Repository	Put the contaminated soil in a safe geologic repository.	Does not reduce the soil contamination, but is a very effective and long-term way of storing radionuclides. Probably unnecessary for nonradioactive waste.	Not easy to implement because of limited site availability, and permits for transporting radioactive wastes are hard to get.	High	Retained because of effectiveness on TRU 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.

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 hydrology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex solvents of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problem.
	Vapor Extraction	Vacuum is applied by use of wells inducing a pressure gradient that causes volatiles to flow through air spaces between soil particles to the extraction wells.	Effective for volatile organics. Ineffective for inorganics and radionuclides. Emission treatment required.	Easily implementable for proper site conditions. Requires emission treatment for organics and capture system for radionculides 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.
	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.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
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 at proper conditions. Ineffective for inorganics and radionuclides.	Difficult to implement. Treatability studies and thorough subsurface characterization required.	Low	Rejected because of limited applicability and difficult implementation.
	Anaerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by addition of nutrients.	Effective for volatile and complex organics. Not effective for inorganics and radionuclides.	Difficult to implement. Anoxic ground conditions required. Treatability studies and thorough subsurface characterization necessary.	Low	Rejected because of limited applicability and difficult implementation.
BIOTA TECHNOLOGIES:						
No Action	No Action	Do nothing to clean-up the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline"case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as agriculture.	Effective if implementation is continued. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of contamination to keep people out and the biota in.	Effective if fencing is maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to eliminate people from coming in contact with the contamination.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel are easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Take biota samples and test them for contaminants.	Does not reduce the contamination, but is very effective tracking the contaminant levels.	Easily implemented. Standard Technology.	Low	Retained to be used in conjunction with other process options.
Capping	Multimedia	Fine soils over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective in reducing the uptake of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will also be necessary.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options.

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Excavation	Standard Excavating Equipment	Remove affected biota and load it onto process system equipment.	Effective in moving and transporting biota to vehicles for transportation.	Equipment and workers are readily available.	Low	Retained because of potential effectiveness and implementability.
Disposal	Landfill Disposal	Place contaminated biota in an existing landfill.	Does not reduce the biota contamination but moves all of the contamination to a more secure place.	Easily implemented if sufficient storage is available in an offsite landfill area.	Medium	Retained because of potential effectiveness and implementability.

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt 1. With or Without Vertical Barriers	Alt 2. In Situ Grouting or Stabilization	Alt 3. Excavation and Treatment	Alt 4. In Situ Vitrification	Alt 5. Excavation, Treatment, and Geologic Disp. of TRU Soil	Alt 6. In Situ Soil Vapor Extraction for VOCs
Cribs and Drains						
216-S-1 & -2 Cribs	•	•		•		
216-S-5 Crib	•	•	•	•	•	
216-S-6 Crib	•	•	•	•	•	
216-S-7 Crib	•	•	•	•	•	
216-S-9 Crib	•	•	•	•	•	
216-S-13 Crib	•	•	•	•	•	
216-S-20 Crib	•	•	•	•	•	
216-S-22 Crib	•	•	•	•	•	
216-S-23 Crib	•	•	•	•		
216-S-25 Crib	•	•	•	•		
216-S-26 Crib	•	•	•	•		
216-S-3 French Drain	•	•	•	•	•	
Ponds, Ditches, and Trenches						
216-S-10P Pond	•		•	•	•	
216-S-11 Pond	•		•	•	•	
216-S-15 Pond	•	•	•	•	•	
216-S-16P Pond	•	•	•	•	•	
216-S-17 Pond	•	•	•	•	•	
216-S-19 Pond	•	•	•	•	•	
216-S-10D Pond	•		•	•	•	•

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt 1. With or Without Vertical Barriers	Alt 2. In Situ Grouting or Stabilization	Alt 3. Excavation and Treatment	Alt 4. In Situ Vitrification	Alt 5. Excavation, Treatment, and Geologic Disp. of TRU Soil	Alt 6. In Situ Soil Vapor Extraction for VOCs
216-S-16D Pond	•	•	•	•	•	•
216-U-9 Ditch	•	•	•	•	•	•
216-S-8 Trench		•	•		•	
216-S-12 Trench		•	•	•	•	•
216-S-14 Trench		•	•	•	•	•
216-S-18 Trench	•	•	•	•	•	•
Septic Tanks and Associated Drain Fields						
2607-W6 Septic Tank and Tile Field	•	•	•			
2607-WZ Septic Tank	•	•	•			
Sanitary Crib	•	•	•	•		
Transfer Facilities, Diversion Boxes, and Pipelines						
216-S-172 Control Structure	•	•	•			
2904-S-160 Control Structure	•		•			
2904-S-170 Control Structure	•		•			
2904-S-171 Control Structure	•		•			
Basins						
207-S-Retention Basin	•	•	•			
207-SL Retention Basin	•	•	•			
Burial Sites						
218-W-7 Burial Ground	•	•	•			
218-W-9 Burial Ground	•	•	•	•	•	•

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites.

Waste Management Unit or Unplanned Release	Alt 1. With or Without Vertical Barriers	Alt 2. In Situ Grouting or Stabilization	Alt 3. Excavation and Treatment	Alt 4. In Situ Vitrification	Alt 5. Excavation, Treatment, and Geologic Disp. of TRU Soil	Alt 6. In Situ Soil Vapor Extraction for VOCs
Unplanned Releases						
UN-200-W-32	•	•	•			
UN-200-W-34	•	•	•			
UN-200-W-35	•	•	•			
UN-200-W-41	•	•	•			
UN-200-W-42	•		•			
UN-200-W-43	•	•	•			
UN-200-W-52	•	•				
UN-200-W-56	•					
UN-200-W-61	•	•	•			
UN-200-W-69	•	•	•			
UN-200-W-83	•	•	•			
UN-200-W-108	•	•	•			
UN-200-W-109	•	•	•			
UN-200-W-116	•	•	•			
UN-200-W-123	•	•	•			
UN-200-W-127	•	•	•			
UN-216-W-30	•	•	•			

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" that 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 S 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 S Plant AAMS.

8.1.1 Data Users

The data users for the S Plant AAMS and subsequent investigations such as LFIs, RI/FSs, and Resource Conservation and Recovery Act (RCRA) Facility, Investigations (RFI)/Corrective Measures Studies (CMS) 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), EPA, and the 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 Operations 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 S 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.

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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 S 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)
- Issue 3: Sampling events of waste effluents and affected media (Section 4.1)
- Issue 4: Site conditions including the site physiography, topography, geology, hydrology, meteorology, ecology, demography, and archaeology (Section 3.0)
- Issue 5: Environmental monitoring data for affected media including air, surface water, sediment, soil, groundwater and biota (Section 4.1, except that groundwater data is presented in the separate 200 West Groundwater Aggregate Area Management Study Report, AAMSR).

A major requirement for adequate characterization of many of these issues is identification of chemical and radiological constituents associated with the sites, with a view to determine the contaminants of concern there and the extent of their distribution in the soils beneath each of the waste management units in the S 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 S Plant Aggregate Area (See Section 4.1 and Tables 4-1, 4-2, and 4-3) have been found to describe:

- Inventory: generally estimated from chemical process data and emphasizing radionuclides (Issues 1 and 2). These data are especially limited regarding reconstruction of early operations activities, and even the most recent data are based on very few sampling events, possibly non-representative of the long-term activity of the waste management units. In some cases (e.g., for 218-W-9 Burial Ground even the location of the facility is not adequately understood.

- Surface radiological surveys: undifferentiated radiation levels, without identification of radionuclides present, presented in terms of extent of radiation and maximal levels (Issue 5). These historical data are extremely difficult to relate to the present-day distribution and nature of the radioactive contamination they purport to measure because of the lack of radionuclide identification and the likelihood that changes have occurred (at least to surface soils) since the time of these surveys.

- External radiation monitoring: similar to the surface radiological surveys but provide even less information because with a fixed-point thermoluminescent dosimeter (TLD) no spatial distribution is provided. In addition, data are also available for some TLDs placed at points not associated with specific waste management units. The TLD data also do not differentiate radionuclide species.

- Waste, soil, or sediment sampling--these include waste sampling in single-shell tanks (in the 241-S and 241-SX Tank Farms), wastes in the 207-SL Retention Basin; sediments from the 216-S-10D Ditch were collected and analyzed for radionuclide contamination, and soil samples in the vicinity of the 216-S-1 and 2 Cribs were collected and analyzed for radionuclides. The quality of these data will be addressed based on the criteria presented in Section 8.3. Changes at the release sites since the time of the sampling may make the data inapplicable to determination of the present-day distribution of contamination. Such changes might include cleanup activities which could alter the location of waste or cause soil particle fractionation, chemical leaching of contaminants, or contaminant reactions in the environment which could alter the nature of the contamination.

  There is also a set of data of soil sampling and analysis that was conducted for several years on a grid pattern, and cannot be assigned to a particular waste management unit. These data would indicate impacts of historical operations at the Hanford Site, and in the vicinity of the grid points, but the impacts cannot be ascribed to a particular unit and so do not assist in decision making on a unit-by-unit basis but may be used to estimate background contamination levels.

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- Biota sampling--only in the 216-S-10D Ditch. These data could assist assessment of bio-uptake and bio-transfer pathways from this unit (Issue 5).

  There are also analytical data for grid-point samples of vegetation which cannot be assigned to a specific waste management unit but may be useful to indicate background contamination levels in vegetation.

- Borehole geophysics: these data, for a number of units discharged to the soil column (cribs, trenches, and ditches) and the single-shell tanks, were designed to detect the presence of radionuclides (by their gamma-ray radiation) in the subsurface and to indicate whether these materials are migrating vertically (Issue 5). A list of these surveys that have been conducted in the S Plant Aggregate Area is included in the Data Package Topical Report prepared for this study (Chamness et al. 1991). Most of the earlier data are limited by the method's inability to identify specific radionuclides and thus to differentiate naturally-occurring radioactive materials from possible releases. Variations in quality control further limit their comparability and possible use for estimation of concentrations.

  Besides these historic data, additional borehole geophysical data will be available through the Radionuclide Logging System (RLS), being carried out at the time of this report and in support of the AAMS process. Like the previous (gross gamma) logging conducted at waste management units in the S Plant Aggregate Area, the RLS depends on gamma rays and cannot detect some species of radionuclides. However, unlike the gross gamma surveys, the RLS is designed to identify individual radionuclide species through their characteristic gamma ray photon energy levels. It should thus be able to differentiate naturally-occurring radionuclides from those resulting from releases. It will also (like gross gamma logging) determine the vertical extent of the presence of the radionuclides. It will be conducted in about ten wells located in the S Plant Aggregate Area and will be available with completion of the AAMS process.

Based on the above summary, the data are considered to be of varying quality. These data have not been validated, a process generally required for risk assessment or final Record of Decision(ROD) purposes. Most of the data are based on field methods, which are generally applicable only for screening purposes and can be used to focus future activities (e.g., sampling and analysis plans).

They are considered to be deficient in one or more of the following ways:

- Methods which have been used in the past are unable to differentiate the various radionuclides which may have been present at the time of the survey.

- The release locations have been changed (especially by remediation activities) since the time of the survey or sampling, and it is likely that contaminant distributions have changed.

- The survey or sampling has been done at a location different from the waste management unit or release, and so would not be representative of the concentrations in the zone of the 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 S 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 2) that do not directly relate to the presence of environmental releases, but which will assist in the assessment of its potential migration if present. These data are generally summarized in the Topical Reports prepared for this AAMS. Those include the following:

- *S Plant Geologic and Geophysics Data Package for the 200 AAMS* (Chamness et al. 1991), which 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 S 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 S 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 S 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. 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 that was gathered in the general area of the 200 West Area, and therefore potentially appropriate to the S Plant Aggregate Area, is the result of a set of studies that 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 have been used for the stratigraphic interpretation presented in Section 3.4 (all the wells denoted with an alias "BH-.." were drilled for the BWIP) 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 S Plant (source area) AAMS. 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 S 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 very few features (and none in the S Plant Aggregate Area) which are interpreted as descriptive of the structure of the suprabasalt sediments.

- Lastly, some of the anomalies that 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 AAMS, 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 S 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 that 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 that 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 S 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 that are considered "valid."

  None of the data that have been previously gathered in the S 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 of 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 S 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 deficient in completeness, (the appropriate media, constituents, or locations were generally not sampled or analyzed). These data should, however, be used to the maximum extent to develop work plans for site field investigations, prioritize 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 sites in the S Plant Aggregate Area is presented and described in Section 4.2 (Figure 4-3). The model is based on best estimates of where contaminants were discharged and their potential for migration from release points. The conceptual model is designed to be conservatively inclusive in the face of a lack of data.

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This means that a migration pathway was included if there is any possibility of contamination travelling on it, historically or at present. In most cases there may not be a significant flux of such contamination migration for many of the pathways shown on the figure.

The one pathway in Figure 4-3 that has transported large amounts of water is undoubtedly the releases to soil from the 216-S-10D Ditch, through the vadose zone into the unconfined aquifer. Contamination can be demonstrated to have been present in the ditch according to results of sediment sampling. If significant levels of dissolved constituents were present in the ditch, the large quantities of water would have contributed to their mobilization and transport to the aquifer. The 216-S-16P and 216-S-17 Ponds have received and may have discharged even larger amounts of water through the vadose zone into the unconfined aquifer. However, there is little information about the contamination that actually has been transported along these pathways. The pathway from some of the cribs leading to adsorption of TRU elements on vadose-zone soils is possibly more significant. These and other pathways can be traced on the conceptual model. All are possible; only a few are likely because of the conservatism inherent in including all conceivable pathways. More importantly, even if a pathway carries significant levels of a contaminant, it still may not have carried contamination to the ultimate receptors, human or ecological. This can only be assessed by sampling at the exposure point on this pathway, or sampling at some other point and extrapolation to the exposure point, to indicate the dosage to the receptors.

There are, therefore, significant uncertainties in the contaminant levels in the contaminant migration pathways shown on the conceptual model, yet almost none of these pathways has been sampled to determine whether any contamination still exists in any of the locations implicated from the conceptual model, and if so which constituents, how much, and to what extent.

8.1.5 Aggregate Area Management Study Objectives and Decisions

The specific objectives of the S Plant AAMS are listed in Section 1.3. They include the following:

- Assemble site data (as described in Section 8.1.2)
- Describe site conditions (see Section 3.0)
- Conduct limited new site characterization work (see separate topical reports)
- Develop a preliminary site conceptual model (see Section 8.1.4)
- Identify contaminants of concern and their distribution (Section 4.0)

- Identify potential applicable, or relevant and appropriate, requirements (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 focused FS (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)

- 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.)

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Most of these decisions are actually a complicated mixture of many smaller questions, and will be addressed in Section 9.0 in a more detailed flowchart for assessing the need for remediation or investigation.

Similarly, the tasks that will need to be performed after the AAMS that drive the data needs for the study are found in the rectangular boxes on the flow chart. These include the following:

- ERA (if justified)
- Definition of threshold contamination levels, and formulation of conceptual model, performance of qualitative risk assessment, and FS screening (IRM preliminaries)
- FFS for IRM selection
- Determination of minimum data requirements for IRM path
- Negotiation of Scope of Work, relative priority, and incorporation into integrated schedule, performance of LFI
- Determination of minimum data needs for risk assessment and final remedy selection (preparation of RI/FS pathway).

These stages of the investigation must be considered in assessing data needs (Section 8.2.1).

8.2 DATA USES AND NEEDS (STAGE 2 OF THE DQO PROCESS)

Stage 2 of the DQO development process (EPA 1987) defines data uses and specifies the types of data needed to meet the project objectives. These data uses and needs are based on the Stage 1 results, but must be more specific. The elements of this stage of the DQO process include:

- Identifying data uses (Section 8.2.1)
- Identifying data types (Section 8.2.2.1)
- Identifying data quality needs (Section 8.2.2.2)
- Identifying data quantity needs (Section 8.2.2.3)
- Evaluating sampling/analysis options (Section 8.2.2.4)

- Reviewing data quality parameters (Section 8.2.2.5)
- Summarizing data gaps (Section 8.2.3).

Stage 2 is developed on the basis of the conceptual model and the project objectives. These following sections discuss these issues in greater detail.

8.2.1 Data Uses

For the purposes of the remediation in the S 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 determining and evaluating the physical and chemical properties of any wastes and contaminated media present at a site, and evaluating the nature and extent of contamination. This process normally involves the collection of basic geologic, hydrologic, and meteorologic data but more importantly for the S 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 S 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

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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 S Plant Aggregate Area is that a quantitative assessment of contaminant concentrations for purposes of risk assessment cannot 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 the 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 can be derived from the inventories for the sites (mainly for the cribs and other disposal facilities) as well as from the limited sampling that has been done at specific sites, such as the 216-S-10D Ditch.

- The likely depth of contaminants: this information is mainly obtained from the gross gamma borehole logging for many of the sites.

Two types of information are available for the purposes of worker health and safety, and will be used to develop health and safety documents:

- Levels of surface radiation: derived from the on-going periodic radiological surveys performed under the Environmental Surveillance program (Schmidt et al. 1992). Table 8-1 shows where surveys have indicated no detectable levels of surface radiation and so no additional survey is required before surface activities can be conducted.

- Expected maximum contaminant levels: these data can be used mainly on the results of subsurface soil sampling.

Table 8-1 also presents a first expression of the data needs for the individual waste management units in the S Plant Aggregate Area, which must be addressed for remediation approaches to be developed.

8.2.2 Data Needs

The data needs for the S 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 S 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 S Plant Aggregate Area are discussed in Section 8.3 to provide focus to investigatory methods that may be employed. The data type requirements for the preliminary remedial action alternatives developed in Section 7.4 are summarized in Table 8-2.

8.2.2.2 Data Quality Needs. The various tasks and phases of a CERCLA investigation may require different levels of data quality. Important factors in defining data quality include selecting appropriate analytical levels and validating 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 S Plant Aggregate Area. In general, increased 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 S Plant Aggregate Area (as developed in Section 5) are presented 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 for screening 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

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beta/gamma spectrometer probe locations can be based on results of surface geophysical and radiation surveys. These may help locate some subsurface features (such as the 218-W-9 Burial Ground), 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 S 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 1988b; EPA 1989a), *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. 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).

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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 that 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 characterizing 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 all 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 may not be 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 S 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 S 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 4.2, "Interim Control of Unknown Suspected Hazardous and Mixed Waste" (WHC 1988b).

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8.3.2 General Strategy

The overall objective of any field investigation (LFI, IRM, or RI) of the sites in the S 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 4.2, "Interim Control of Unknown Suspected Hazardous and Mixed 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 S 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 contaminants 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

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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 such as the 218-W-9 Burial Ground (Section 2.3.9.1), 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 such as cribs or where volatile organic compounds (VOCs) are suspected, as a screening method to identify compounds such as solvents that may have been used in processes. The soil gas survey should not be considered conclusive that VOCs 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 qualities of liquid waste received by the unit (Table 4-13) and the likelihood of the Plio-Pleistocene unit being present at the location (Section 3.4.3.3).

- Geologic data collected during the ongoing vadose zone soil (Section 8.3.3.4) and other (deeper) investigations (e.g., geologic and geophysical logs from groundwater well installations for groundwater AAMSs) will be compared, compiled, and evaluated.

8.3.3.3 Surface Water Sediment Investigation. A surface water sediment investigation should be conducted. The investigation will include:

- Radiation surveys along ditches, trenches, and ponds for health and safety purposes and to locate areas of elevated radiation for selection of specific sediment sampling locations

- Sampling of sediment in any ditches, ponds, and trenches that still contain water. This will probably be limited to the 216-S-10D Ditch.

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 VOCs) 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 on-site 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.

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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 S 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 S Plant Aggregate Area Waste Management Units.

Waste Management Unit	Type of Unit	Development of Sampling Plans			Health & Safety	
		Location	Possible Contam.	Depth Contam.	Surface Rad.	Expected Max. Level
Cribs and Drains						
216-S-1 & 2	Cribs	*	*	*	*	
216-S-5	Crib	*	*	*	*	
216-S-6	Crib	*	*	*	*	
216-S-7	Crib	*	*	*	*	
216-S-9	Crib	*	*	*	*	
216-S-13	Crib	*	*	*	*	
216-S-20	Crib	*	*	*	*	
216-S-22	Crib	*	*	*	*	
216-S-23	Crib	*	*	*	*	
216-S-25	Crib	*	*	*	*	
216-S-26	Crib	*	*	*	*	
216-S-3	French Drain	*	*	*	*	
Ponds, Ditches, and Trenches						
216-S-10P	Pond	*	*	*	*	
216-S-11	Pond	*	*	*	*	
216-S-15	Pond	*	*	*	*	
216-S-16P	Pond	*	*	*		
216-S-17	Pond	*	*	*	*	
216-S-19	Pond	*	*		*	
216-S-10D	Ditch	*	*	*	*	
216-S-16D	Ditch	*	*		*	
216-4-P	Ditch	*	*	*	*	
216-S-8	Trench	*	*	*	*	
216-S-12	Trench	*	*	*	*	
216-S-14	Trench	*	*	*	*	
216-S-18	Trench	*	*		*	

Table 8-1. Uses of Existing Data for S Plant Aggregate Area Waste Management Units.

Waste Management Unit	Type of Unit	Development of Sampling Plans			Health & Safety	
		Location	Possible Contam.	Depth Contam.	Surface Rad.	Expected Max. Level
Septic Tanks and Associated Drain Fields						
2607-W6	Septic Tank and Drain Field	*			*	
2607-WZ	Septic Tank and Drain Field	*			*	
	Sanitary Crib	*			*	
Transfer Facilities and Pipelines						
216-S-172	Control Structure	*	*			
2904-S-160	Control Structure	*	*		*	
2904-S-170	Control Structure	*	*		*	
2904-S-171	Control Structure	*	*		*	
Basins						
207-S	Retention Basin	*	*		*	
207-SL	Retention Basin	*			*	
Burial Sites						
218-W-7	Burial Ground	*				
218-W-9	Burial Ground	*			*	
Unplanned Releases						
UN-200-W-32	Unplanned Release	*	No	No	*	No
UN-200-W-34	Unplanned Release	*	No	No	No	No
UN-200-W-35	Unplanned Release	*	No	No	No	No
UN-200-W-41	Unplanned Release	*	No	No	No	No
UN-200-W-42	Unplanned Release	*	No	No	No	No
UN-200-W-43	Unplanned Release	*	No	No	No	No
UN-200-W-52	Unplanned Release	*	No	No	No	No
UN-200-W-56	Unplanned Release	*	No	No	No	No
UN-200-W-61	Unplanned Release	*	No	No	No	No
UN-200-W-69	Unplanned Release	*	No	No	No	No
UN-200-W-83	Unplanned Release					
UN-200-W-108	Unplanned Release	*	No	No	*	No
UN-200-W-109	Unplanned Release	*	No	No	*	No

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Table 8-1. Uses of Existing Data for S Plant Aggregate Area Waste Management Units.

Waste Management Unit	Type of Unit	Development of Sampling Plans			Health & Safety	
		Location	Possible Contam.	Depth Contam.	Surface Rad.	Expected Max. Level
UN-200-W-116	Unplanned Release	*	No	No	No	No
UN-200-W-123	Unplanned Release	*	No	No	No	No
UN-200-W-127	Unplanned Release	*	No	No	No	No
UN-216-W-30	Unplanned Release	*	No	No	*	No

Table 8-2. Data Needs for Preliminary Remedial Action Technologies S 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 contact • voids	• 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

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Table 8-2. Data Needs for Preliminary Remedial Action Technologies S Plant Aggregate Area.

Alternative	Physical Attribute	Chemical/Radiochemical Attribute
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 Past-Practice Strategy* (DOE/RL 1992a)

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Table 8-3. Analytical Levels for the S 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. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES								
Gross Alpha	900.0 M	TBD	±30	±25	900.0	10	±25	±25
Gross Beta	900.0 M	TBD	±30	±25	900.0	5	±25	±25
Gamma Scan	D3699 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Actinium-225	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Actinium-227	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-241	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Americium-242	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-242m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-243	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Antimony-126	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Antimony-126m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Barium-137m	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Bismuth-210	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-213	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Carbon-14	C-01 M	TBD	±30	±25	TBD	TBD	±25	±25
Cesium-134	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Cesium-135	901.0 M	TBD	±30	±25	901.0	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
Curium-244	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Curium-245	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Europium-152	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Europium-154	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Europium-155	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Francium-221	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Iodine-129	902.0 M	TBD	±30	±25	902.0	TBD	±25	±25
Lead-209	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-210	Pb-01 M	TBD	±30	±25	Pb-01	TBD	±25	±25
Lead-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-212	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Lead-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Neptunium-237	907.0 M	TBD	±30	±25	907.0	TBD	±25	±25
Neptunium-239	D35649 M	TBD	±30	±25	D3649 M	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
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
Promethium-137	Pm-02M	TBD	±30	±25	Pm-01	TBD	±25	±25
Protactinium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Protactinium-234m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Radium-225	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radium-226	Ra-04	TBD	±30	±25	Ra-05	TBD	±25	±25
Radium-228	Ra-05M	TBD	±30	±25	Ra-05	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Ruthenium-106	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Samarium-151	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Selenium-79	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Sodium-22	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25
Strontium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Technetium-99	Tc-01 M	TBD	±30	±25	Tc-01	TBD	±25	±25
Thallium-207	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Thallium-208	D3649M	TBD	±30	±25	D3649	TBD	±25	±25
Thorium-227	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-229	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-230	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Tritium	906.0 M	TBD	±30	±25	906.0	300	±25	±25
Uranium	U-04	TBD	±30	±25	U-04	TBD	±25	±25
Uranium-233	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-234	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-235	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-236	U	TBD	±30	±25	908.0	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
RADIONUCLIDES (cont.)								
Uranium-238	U	TBD	±30	±25	908.0	TBD	±25	±25
Yttrium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Zirconium-93	TBD	TBD	±30	±25	TBD	TBD	±25	±25
INORGANICS								
Arsenic	7061	0.02	±25	±30	7061	10	±20	±25
Barium	6010	0.02	±25	±30	6010	20	±20	±25
Boron	6010	TBD	±25	±30	6010	TBD	±20	±25
Cadmium	6010	0.09	±25	±30	6010	1	±20	±25
Chromium	6010	0.07	±25	±30	6010	10	±20	±25
Copper	6010	0.06	±25	±30	220.2	10	±20	±25
Cyanide	9010	TBD	±25	±30	335.3	50	±20	±25
Fluoride	300 M	TBD	±25	±30	300	50	±20	±25
Iron	6010	20	±25	±30	6010	70	±20	±25
Lead	6010	0.45	±25	±30	6010	450	±20	±25
Manganese	6010	0.02	±25	±30	6010	20	±20	±25
Mercury	7471	0.02	±25	±30	245.2	2	±20	±25
Nickel	6010	1.5	±25	±30	6010	50	±20	±25
Nitrate	300 M	TBD	±25	±30	300	130	±20	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a/] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
INORGANICS (cont.)								
Nitrite	300 M	TBD	±25	±30	300	40	±20	±25
Selenium	6010	0.75	±25	±30	270.2	20	±20	±25
Silver	6010	2	±25	±30	272.2	10	±20	±25
Titanium	6010	TBD	±25	±30	6010	TBD	±20	±25
Vanadium	6010	0.08	±25	±30	286.2	40	±20	±25
Zinc	6010	0.02	±25	±30	6010	20	±20	±25
ORGANICS								
Acetone	8240	0.1	±25	±30	8240	100	±20	±25
Carbon tetrachloride	8240	0.005	±25	±30	8240	1	±20	±25
Chloroform	8240	0.005	±25	±30	8240	5	±20	±25
Hydrazine	TBD	TBD	±25	±30		200	±30	±25
Kerosene	8015	20	±35	±30	8015	500	±35	±25
Methylene chloride	8240	0.005	±25	±30	8240	5	±20	±25
MIBK	8015	0.5	±25	±30	8015	5	±20	±25
1,1,1-Trichloroethane	8240	0.005	±25	±30	8240	5	±20	±25
Toluene	8240	0.005	±25	±30	8240	5	±20	±25
Tributyl phosphate	TBD	TBD	±25	±30	TBD	TBD	±30	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses.

	Soil/Sediment				Water			
	Analysis Method	Practical Quantitation Limit[a] (pCi/g, mg/kg)	Precision (RPD)	Accuracy (%)	Analysis Method	Practical Quantitation Limit[a] (pCi/g, µg/L)	Precision (RPD)	Accuracy (%)
ORGANICS (cont.)								
Xylene	8020	2.0	±30	±30	8020	0.2	±25	±25

TBD = To Be Determined
M = Method modified to include extraction from the solid medium, extraction method is matrix and laboratory-specific
RPD = Relative Percent Difference

Prescribed Procedures for Measurement of Radioactivity in Drinking Water (EPA 1980a)
Test Methods for Evaluation Solid Waste (SW 846) Third Edition (EPA 1986)
Methods for Chemical Analysis of Water and Waste (EPA 1983)
Radionuclide Method for the Determination of Uranium in Soil and Air (EPA 1980b)
EML Procedures Manual (DOE/EML 1990)
Eastern Environmental Radiation Facility RadioChemistry Procedures Manual (EPA 1984)
High-Resolution Gamma-Ray Spectrometry of Water (ASTM 1985)

Precision and accuracy are goals. Since these parameters are highly matrix dependent they could vary greatly from the goals listed.

[a]pCi/g and pCi/L apply to radionuclides, mg/kg and µg/L apply to organic and inorganic constituents.

Table 8-5. Data Gaps by Site Category.

Site Category	Identified Data Gaps
Tanks and Vaults	• Contaminant concentrations in waste management units other than single-shell tanks • Distribution of contaminants in subsurface soils released in leaks • Constituents concentrations in related surface contamination
Cribs and Drains	• Contaminant concentrations in cribs • Contaminant concentrations in soils beneath cribs • Specific constituents (especially organic chemicals) • Distribution and vertical/lateral extent of contamination
Ponds, Ditches, and Trenches	• Distribution/extent of subsurface contamination • Buried contaminant concentrations in stabilized portions/units
Septic Tanks and Associated Drain Fields	• Actual discharge levels • Possible discharge and presence/level of non-sanitary wastes (e.g., laboratory drains)
Transfer Facilities, Diversion Boxes, and Pipelines	• Contamination constituents and concentrations • Direct radiation levels in facilities • Constituents/concentrations in related surface contamination • Integrity of transfer lines
Unplanned Releases	• Surface soil constituents and concentrations • Buried contamination constituents and concentrations

9 3 1 2 8 2 9 1 1 7 7

Table 8-6. Applicable Characterization Investigation Methods at S Plant Aggregate Area Waste Management Units.

Waste Mangement Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	Remarks
Tanks and Vaults									
240-S-302 Catch Tank	--	--	--	--	--	--	--	--	--
241-S-302A Catch Tank	--	--	--	--	--	--	--	--	--
241-S-302B Catch Tank	--	--	--	--	--	--	--	--	--
241-SX-302 Catch Tank	--	--	--	--	--	--	--	--	--
244-S Receiver Tank	--	--	--	--	--	--	--	--	--
Cribs and Drains									
216-S-1 and 216-S-2 Crib	X	A	--	--	X	--	X	--	--
216-S-5 Crib	X	X	--	--	X	--	X	--	--
216-S-6 Crib	X	X	--	--	X	--	X	X	--
216-S-7 Crib	--	A	--	--	--	--	A	X	--
216-S-9 Crib	--	A	--	--	--	--	A	--	--
216-S-13 Crib	--	A	--	--	--	--	A	--	--
216-S-20 Crib	--	A	--	--	X	--	X	--	--
216-S-22 Crib	--	A	--	--	--	--	A	--	--
216-S-23 Crib	--	A	--	--	--	--	A	--	--
216-S-25 Crib	X	A	--	--	--	--	X	X	--
216-S-26 Crib	--	A	--	--	--	--	X	--	--
216-S-3 French Drain	--	A	--	--	--	--	X	--	--
Ponds, Ditches, and Trenches									
216-S-10P Pond	--	X	--	--	X	--	X	--	--
216-S-11 Pond	--	X	--	--	X	--	X	--	--
216-S-15 Pond	X	X	--	X	X	--	X	--	--
216-S-16P Pond	X	X	--	--	X	--	X	--	--

Table 8-6. Applicable Characterization Investigation Methods at S Plant Aggregate Area Waste Management Units.

Waste Mangement Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	Remarks
216-S-17 Pond	X	X	--	--	X	--	X	--	--
216-S-19 Pond	--	X	--	X	X	--	X	--	--
216-S-8 Trench	--	X	X	--	X	--	X	--	--
216-S-12 Trench	--	X	X	--	--	--	X	--	--
216-S-14 Trench	--	--	--	X	--	--	X	--	--
216-S-18 Trench	--	--	--	--	--	--	X	--	--
216-S-10D Ditch	X	X	X	--	X	X	X	X	--
216-S-16D Ditch	--	X	--	--	--	--	X	--	--
216-U-9 Ditch	X	X	--	--	X	--	X	--	--
Septic Tanks and Associated Drain Fields									
2607-WZ Septic Tank	X	X	X	X	--	--	X	--	--
2607-W6 Septic Tank	X	X	X	X	--	--	X	--	--
Sanitary Crib	X	X	--	--	--	--	X	--	--
Transfer Facilities, Diversion Boxes, and Pipelines									
241-S-151 Diversion Box	--	--	--	--	--	--	X	--	--
240-S-151 Diversion Box	--	--	--	--	--	--	X	--	--
240-S-152 Diversion Box	--	--	--	--	--	--	X	--	--
241-S-152 Diversion Box	--	--	--	--	--	--	X	--	--
241-SX-151 Diversion Box	--	--	--	--	--	--	X	--	--
241-SX-152 Diversion Box	--	--	--	--	--	--	X	--	--
241-SX-A Valve Pit	--	--	--	--	--	--	X	--	--
241-SX-B Valve Pit	--	--	--	--	--	--	X	--	--
241-SY-A Diversion Box	--	--	--	--	--	--	X	--	--
241-SY-B Diversion Box	--	--	--	--	--	--	X	--	--

Table 8-6. Applicable Characterization Investigation Methods at S Plant Aggregate Area Waste Management Units.

Waste Mangement Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	Remarks
216-S-172 Control Structure	--	--	--	--	--	--	X	--	--
2904-S-160 Control Structure	--	--	--	--	--	--	X	--	--
2904-S-170 Control Structure	--	--	--	--	--	--	X	--	--
2904-S-171 Control Structure	--	--	--	--	--	--	X	--	--
241-S-A Valve Pit	--	--	--	--	--	--	X	--	--
241-S-B Valve Pit	--	--	--	--	--	--	X	--	--
241-S-C Valve Pit	--	--	--	--	--	--	X	--	--
241-S-D Valve Pit	--	--	--	--	--	--	X	--	--
Basins									
207-S Retention Basin	--	X	--	--	X	X	X	--	--
207-SL Retention Basin	--	A	--	--	--	X	X	--	--
Burial Sites									
218-W-7 Burial Ground	--	--	--	--	--	--	X	--	--
218-W-9 Burial Ground	--	X	X	--	X	--	X	--	--
Unplanned Releases									
UN-200-W-10 Unplanned Release	X	--	--	--	X	--	--	--	--
UN-200-W-30 Unplanned Release	--	--	--	--	--	--	--	--	--
UN-200-W-32 Unplanned Release	--	--	--	--	--	--	X	--	--
UN-200-W-34 Unplanned Release	X	--	--	--	X	--	X	--	--
UN-200-W-35 Unplanned Release	X	--	--	--	X	--	X	--	--
UN-200-W-41 Unplanned Release	--	--	--	--	X	--	--	--	--
UN-200-W-42 Unplanned Release	X	--	--	--	X	--	--	--	--
UN-200-W-43 Unplanned Release	X	--	--	--	X	--	--	--	--
UN-200-W-49 Unplanned Release	X	--	--	--	X	--	--	--	--

Table 8-6. Applicable Characterization Investigation Methods at S Plant Aggregate Area Waste Management Units.

Waste Mangement Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	Remarks
UN-200-W-50 Unplanned Release	X	–	–	–	X	–	–	–	–
UN-200-W-52 Unplanned Release	X	X	–	–	X	–	X	–	–
UN-200-W-56 Unplanned Release	X	–	–	–	X	–	–	–	–
UN-200-W-61 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-69 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-80 Unplanned Release	X	–	–	–	X	–	–	–	–
UN-200-W-81 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-82 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-83 Unplanned Release	X	–	–	–	X	–	–	–	–
UN-200-W-108 Unplanned Release	–	X	–	–	X	–	X	X	–
UN-200-W-109 Unplanned Release	–	X	–	–	X	–	X	–	–
UN-200-W-114 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-116 Unplanned Release	–	–	–	–	X	–	–	–	–
UN-200-W-123 Unplanned Release	X	–	–	–	X	–	–	–	–
UN-200-W-127 Unplanned Release	X	X	–	–	X	–	X	–	–
UN-216-W-25 Unplanned Release	X	–	–	–	–	–	–	–	–
UN-216-W-30 Unplanned Release	X	–	–	–	X	–	–	–	–
UPR-200-W-13 Unplanned Release	–	–	–	–	–	–	–	–	–
UPR-200-W-15 Unplanned Release	–	–	–	–	–	–	–	–	–
UPR-200-W-20 Unplanned Release	X	X	–	–	X	–	X	–	–
UPR-200-W-36 Unplanned Release	–	–	–	–	–	–	–	–	–
UPR-200-W-47 Unplanned Release	X	–	–	–	X	–	X	–	–
UPR-200-W-51 Unplanned Release	X	–	–	–	X	–	–	–	–
UPR-200-W-59 Unplanned Release	X	–	–	–	X	–	–	–	–

Table 8-6. Applicable Characterization Investigation Methods at S Plant Aggregate Area Waste Management Units.

Waste Mangement Unit	Surface Radiation Survey	Subsurface Spectral Geophysics	Surface Geophysics	Soil Gas Survey	Surface Soil Sampling	Surface Water Sediment Sampling	Subsurface Soil Sampling	Perched Zone Monitoring Wells	Remarks
UPR-200-W-95 Unplanned Release	--	--	--	--	--	--	--	--	--
UPR-200-W-96 Unplanned Release	--	--	--	--	X	--	X	--	--
UPR-200-W-124 Unplanned Release	X	--	--	--	--	--	X	--	--
UPR-200-W-139 Unplanned Release	X	--	--	--	--	--	X	--	--
UPR-200-W-140 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-141 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-142 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-143 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-144 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-145 Unplanned Release	--	X	--	--	--	--	X	--	--
UPR-200-W-146 Unplanned Release	--	X	--	--	--	--	X	--	--

* = Investigation at each individual site.
A = Investigation at representative of several analogous units.

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 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA). The existing body of pertinent knowledge regarding S 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 measures, 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 Sections 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 each unit followed.

This section presents recommended assessment paths for the waste management units and unplanned releases at the S 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.

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 (e.g., LFI). Several units and releases assessed within the ERA path were recommended for actions that fall within the scope of existing operational programs. Wooden cribs with collapse potential and sites with elevated levels of surface radionuclide contamination are addressed by the Radiation Area Remedial Action (RARA) Program.

Waste management units and unplanned releases which are addressed entirely by other programs were not subjected to the data evaluation process. This includes units and unplanned release which 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 unit not included in the evaluation.

A majority of waste management units not addressed in the data evaluation fall within the scope of the Single-Shell Tank Closure Program. The activities associated with closure of the 200-RO-4 Operable Unit single-shell tanks have separate Tri-Party Agreement milestones and any recommendations for disposition of these units and associated unplanned releases will be developed as part of the ongoing program addressing the single-shell tanks. The Waste Management Program will completely address the active 216-S-25 and -26 Cribs, and the active 207-SL Retention Basin.

A discussion of the four decision-making paths shown in Figure 9-1: ERA, IRM, LFI, and final remedy selection, is provided in Section 9.1. Section 9.2 provides a discussion of the waste management units grouped under each of these paths. A discussion of regrouping and prioritization of the waste management units is provided in Section 9.3. Recommendations for redefining operable unit boundaries and prioritizing operable units for work plan development are also provided in Section 9.3. No additional aggregate area-based field characterization activities are recommended to be undertaken as a continuation of the AAMS. All recommendations for future characterization needs (see Section 8.0) will be more fully developed and implemented through work plans. Plan development and submittal will be accomplished in accordance with requirements of the *Hanford Site Past-Practice Strategy* and the Tri-Party Agreement and could include remedial investigation/feasibility study (RI/FS) RCRA facility investigation/corrective measures study (RFI/CMS), or LFI work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility and treatability studies, respectively.

9 3 1 2 8 6 9 1 1 8 4

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 candidate 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 a 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.

Specific criteria used to develop initial recommendations for ERAs, LFIs, and IRMs for units and unplanned releases within the S Plant 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 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:

- 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 judgement 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 the 216-S-25 and 216-S-26 Cribs and the 207-SL Retention Basin. Generally, active waste management units will not be included in past-practice investigations unless operation is discontinued prior to initiation of the investigation. The Decommissioning and RCRA Closures 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 S Plant Aggregate Areabased, at least in part, on the recommendation provided in this AAMSR and the results of a supporting LFI.

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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 Sections 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

Six waste management units meet all the criteria for an ERA prior to determining whether the proposed action was within the scope of an operational program. None of the candidate units were recommended for an ERA. Four candidate ERA units (cribs with collapse potential) were recommended for disposition under RARA. Two candidate units (active waste management units) were recommended for disposition under the Waste Management Program. The six units area:

- 216-S-1 and 216-S-2 Cribs
- 216-S-7 Crib
- 216-S-13 Crib
- 216-S-20 Crib
- 216-S-25 Crib
- 216-S-26 Crib

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 sites, all units will be included for further data evaluation in the assessment paths.

9.2.1.1 Cribs With Collapse Potential. Four of the older cribs are open wooden structures that could collapse and potentially expose workers. A sudden collapse could bring contaminated dust from the buried crib to the surface. Based on crib inventory data, dust derived from the bottom of the cribs would be expected to contain radionuclides at several orders of magnitude above reportable quantities and quality standards. The 216-S-1 and 216-S-2, 216-S-7, 216-S-13, and 216-S-20 Cribs all have collapse potential.

Maintenance and contamination control measures for cribs with collapse potential are implemented under the RARA Program. Therefore, actions to mitigate environmental releases from these facilities will be performed under the RARA Program. An engineering study is planned under the RARA Program for 1993 to evaluate the potential for crib collapse.

Response actions such as the addition of clean fill material over the cribs or pressure grouting void areas within the crib to prevent collapse may be considered for these waste management units. Evaluation and recommendation of response actions for these facilities will be performed under the RARA Program.

9.2.1.2 Active Waste Management Units. Two active liquid effluent units operate within the S Plant Aggregate Area; the 216-S-25 Crib, and the 216-S-26 Crib. Operation of these units provides a potential for migration of radioactive contaminants to groundwater. Efforts are currently underway to evaluate an alternative that could be implemented that would result in deactivation of these units by June 1995. In the interim, hazardous wastes will not be discharged to these units. Evaluation and deactivation of these facilities will remain with the operational program and will not be included as part of the past practices investigation. In addition, investigation of contamination associated with the facilities will be deferred until after deactivation of the facilities.

9.2.1.3 Non-ERA Sites. The primary reason most waste management units and unplanned releases were not recommended for ERAs was because of the lack of driving force to an exposure pathway. Inactive cribs, ponds, ditches, and trenches are no longer receiving waste and, therefore, no longer have artificial recharge as a driving force to move subsurface contaminants. Natural recharge from local precipitation was not considered a significant short-term driving force. Specifics for each waste management unit or unplanned release are provided in Table 9-2.

A majority of the unplanned release sites either will be addressed by the RARA Program to eliminate the airborne release pathway or had insufficient quantity and concentration to qualify as an ERA.

9.2.2 Proposed Sites for Interim Remedial Measures

Twenty-six of the 53 waste management units addressed in the S Plant Aggregate Area data evaluation process were identified as high priority units (refer to Section 5.0) and were assessed as candidates for IRMs. Ten of the 26 units were designated as high priority because of high HRS and mHRS scores. Eight additional units were included as candidate IRM units because they received qualitative high HRS scores. The remaining eight units were designated as high priority because of surface radiation measurements. In addition, six low priority units were assessed as IRM candidates because they had similar operations and waste disposal histories as other high priority units or were ancillary equipment. The Environmental Protection Group rankings did not add to the high priority sites because they had been included on the list because of the other criteria. Septic tanks and drain fields and unplanned releases were two primary classes of units not considered in the IRM path.

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All of the 32 candidate IRM units met the criteria for IRM designation, with the exception of having adequate data. No direct sampling data exist for any of the 32 waste management units and unplanned releases. It was determined that an LFI could gather sufficient data for 25 of the 32 units; therefore, 25 units remain IRM candidates. The remaining 7 waste management units and unplanned releases (1 basin, 1 burial site, and 5 unplanned release sites) are recommended for direct inclusion in the final remedy selection path discussed in Section 4.2.4.1. A discussion of the LFIs is provided in Section 9.2.3.

9.2.3 Proposed Sites for Limited Field Investigation Activities

Twenty-five waste management units are recommended to undergo LFIs. The initial decision point in the IRM path is to assess whether data are adequate to conduct an IRM. For each of the twenty-five units, only screening level field data and inventory estimates are available. No data are available describing the nature and extent of contamination, so LFIs are required before IRMs may be implemented. The rationale for IRM and LFI will be more completely developed in work plans; however, the following addresses possible considerations during work plan development.

Possible LFI objectives would be to:

- Evaluate the potential for releases from the waste management unit to impact underlying groundwater quality.
- Determine if contamination exists in the soil beneath the waste management unit, and if so, assess the extent.
- Assess the nature and extent of contaminant migration from the waste management unit in support of focused feasibility studies.

Each waste management unit that is recommended for an LFI will be studied as part of an analogous group. The analogous site concept is presented in the *Hanford Site Past-Practice Strategy*.

This concept emphasizes that characterization activities can be reduced by identifying select sites (analogue sites) for characterization that are representative of a group sites (analogous groups). This concept is particularly applicable to operable units which contain a number of waste management units that are similar in design, disposal history, and geology. Appropriate confirmatory characterization, as necessary to support remedial action, can then be performed at the sites within each analogous group during remediation. Collection of confirmatory data can again be reduced during remediation activities by emphasizing in work plans the use of the observational approach discussed in the *Hanford Site Past-Practice Strategy*.

To facilitate the implementation of these strategies in work plans, individual LFIs are assembled into analogous groups for study. Two primary analogous groups have been identified in the S Plant Aggregate Area: (1) cribs and french drains and (2) ditches and ponds. Specific waste management units are then identified that are considered to be representative on the analogous groups. Considerations used to select an analogue site for an analogous group include, but are not limited to, the following:

- Disposal history (including type and quantity of waste received)
- Physical and chemical setting.

Generally the selection process favored as analogue sites are those units or releases that received the most waste and were considered as conservative samples in terms of release mechanism, media of concern, exposure routes, and receptors.

9.2.3.1 Cribs, French Drains, and Control Structure. Thirteen waste management units have been assigned to this analogous group based on their design and type of waste received. These units include:

- 216-S-1 and -2 Cribs
- 216-S-5 Crib
- 216-S-6 Crib
- 216-S-7 Crib
- 216-S-9 Crib
- 216-S-13 Crib
- 216-S-20 Crib
- 216-S-22 Crib
- 216-S-23 Crib
- 216-S-25 Crib (active)
- 216-S-26 Crib (active)
- 216-S-3 French Drain
- 2904-S-171 Control Structure.

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The 216-S-3 French Drain is included in this group because of its construction is more similar to a crib than to a french drain. The 2904-S-171 Control Structure is included in this group since it is ancillary equipment to the 216-S-6 Crib.

A comparison of the crib inventories indicates that the 216-S-1 and 216-S-2 Cribs received the highest quantity of plutonium than any of the other cribs. Only one other crib (216-S-7) exceeds the level of ^{90}Sr and total uranium than these cribs and only by a slight amount. The crib that received the highest total volume was the 216-S-6 Crib, 4,470,000 L (1,182,500 gal).

The physical and chemical settings for the releases from these waste management units are generally similar:

- Relatively large scale liquid releases (98,000 L to 4,470,000,000 L) occurred at these waste management units and wastewater probably reached the unconfined aquifer beneath the units (Table 4-13).

- The waste management units were completed at about the same depths and in the same stratigraphic horizons. The depth to groundwater is also similar for all of the units (49 to 61 m, 162 to 199 ft).

- The vadose zone stratigraphy is generally uniform beneath the aggregate area and would tend to favor the downward movement of fluid with little lateral spreading. The caliche layer, the primary vadose zone aquitard, occurs beneath each waste management unit.

- The 216-S-5, 216-S-19, 216-S-22, and 216-S-26 Cribs are all reported to have received acidic waste which could aid in the vertical migration of contamination. The other waste management units are not reported to have received materials that could aid in contaminant migration.

The 216-S-1 and 216-S-2 Cribs and the 216-S-6 Crib are proposed for analog study because they have either the largest contaminant inventory or total waste volume. They also represent two distinct waste streams: process condensate (216-S-1 and 216-S-2) and cooling water and steam condensate (216-S-6).

The cribs and french drain were high priority units with the exception of the 216-S-13, -22, and -23 Cribs, which do not have high HRS scores. However, the waste types and disposal methods for these low priority sites are similar enough to other high priority sites to justify their inclusion in this path. The two active cribs will be included in investigation activities if they are deactivated prior to preparation of investigation plans.

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9.2.3.2 Ditches and Ponds. Eleven waste management units have been assigned to this analogous group. These units are:

- 216-S-10D Ditch
- 216-S-10P Pond
- 216-S-11 Pond
- 216-S-15 Pond
- 216-S-16D Ditch
- 216-S-16P Pond
- 216-S-17 Pond
- 216-S-19 Pond
- 216-S-172 Control Structure
- 2904-S-160 Control Structure
- 2904-S-170 Control Structure.

The three control structures (216-S-172, 2904-S-160, and 2904-S-170) are included in this analogous group because they are ancillary equipment to the pond and ditch systems.

The 216-U-9 Trench is recommended for transfer to the U Plant Aggregate Area and so is not included in the pond and ditch analogous unit.

The 216-S-10P Pond and the 216-S-10D Ditch will be investigated under RCRA. Selection of these units as group analogs will allow for utilization of the data produced by the RCRA investigation in the CERCLA investigations. Any additional data requirements of the CERCLA investigation can be integrated into the RCRA investigation. This approach will maximize efficiencies and minimize costs, while securing data that is applicable to all the units in this analogous group.

The physical and chemical settings for the releases from these waste management units are generally similar:

- Relatively large scale liquid releases (10,000 L to 40,7000,000,000 L) occurred at these waste management units and wastewater probably reached the unconfined aquifer beneath the units (Table 4-15).

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- The waste management units were completed at about the same depths and in the same stratigraphic horizons. The depth to groundwater is also similar for all of the units (49 to 61 m, 162 to 199 ft).

- The vadose zone stratigraphy is generally uniform beneath the aggregate area and would tend to favor the downward movement of fluid with little lateral spreading. The caliche layer, the primary vadose zone aquitard, occurs beneath each waste management unit.

- All ponds and ditches generally received low-activity non-process liquid wastes.

These units have been grouped because of similarity in design and purpose along with the fact that the wastes from all the facilities commingled in this system.

9.2.4 Proposed Sites for Final Remedy Selection

A number of unplanned releases, along with several diverse waste management units which are unique because of design, contaminants received, or operational history, have been proposed for the final remedy selection path. Section 9.2.4.2 discusses the sites proposed for direct inclusion in the final remedy selection risk assessment. Direct inclusion in the final remedy selection RI is recommended for the remainder of the waste management units and unplanned releases due to the lack of information to perform a risk assessment 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. An RI has been recommended for the S Plant Aggregate Area which includes several groups of waste management units and unplanned releases. The first group consists of generally low priority disposal trenches which were in use for a short period of time and received relatively small volumes of waste. The second group contains septic tanks and the sanitary crib which require confirmatory sampling to show that the sites do not contain hazardous or radioactive substances. The third group contains two retention basins, one of which was assessed in the IRM path and had insufficient data to conduct an IRM. The fourth group consists of burial sites, one of which was assessed in the IRM path but had insufficient data to conduct an IRM. The fifth group consists of unplanned releases which have unique contamination histories.

9.2.4.1.1 Trenches. Four trenches have been grouped as a single class because of their similarity. These trenches are basically excavations which were opened for a short duration of time and then filled in. The trenches include:

- 216-S-8 Trench
- 216-S-12 Trench
- 216-S-14 Trench
- 216-S-18 Trench.

The trenches are low priority units which were assessed in the final remedy selection path only. All the trenches are unique in the types of waste received. Most of them were in use for a short period of time and received relatively small volumes of waste.

The units were grouped and risk assessment possibilities were examined. No data exists to determine the nature and extent of contamination at these sites. Therefore, a RI which includes each unit was recommended to provide data adequate to perform a risk assessment and select a final remedy for the units. The unique nature of the units will not allow for investigation of a representative unit and applying the information to the other sites.

9.2.4.1.2 Septic Tanks and Sanitary Cribs. Confirmatory investigation levels should be performed at the following waste management units: the 2607-W6 Septic Tank and Drain Field, the 2607-WZ Septic Tank and Drain Field, and the Sanitary Crib. These units have low HRS scores.

There are no sampling or inventory data for any of the units and so a risk assessment (RA) cannot be performed. Therefore, these units are recommended for inclusion in the aggregate area RI to conduct confirmatory sampling. The purpose of a limited sampling program is to confirm that no contamination exists in the tanks and drain fields. If no contamination were to be found, than no further action would likely be recommended.

9.2.4.1.3 Basins. The 207-S Retention Basin is a high priority unit which has been assessed in the IRM path. Sufficient data does not exist to proceed with the IRM, and no similar high priority units exist. The 207-SL Retention Basin is a low priority unit which was directly included in the final remedy selection path. These units are recommended for inclusion in the aggregate area RI to provide data adequate to perform a risk assessment and select a final remedy.

9.2.4.1.4 Burial Sites. The 218-W-9 Burial Grounds are high priority units that have been assessed in the IRM path. Sufficient data does not exist to proceed with the IRMs, and no similar units exist. The 216-W-9 Burial Ground is a low priority unit which was directly included in the final remedy selection path. These units received unique wastes,

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and cannot be grouped together for an LFI. The 218-W-7 Burial Ground is steel caisson, and received dry laboratory wastes from the 222-S Laboratory from 1952 to 1960. The 218-W-9 Burial Ground was an excavation which received scrap metal during September 1954. Therefore, inclusion in the aggregate area RI was recommended for each waste management unit to provide data adequate to perform a risk assessment and select a final remedy.

9.2.4.1.5 Unplanned Releases. Seventeen unplanned release sites with known contamination are candidates for inclusion in an aggregate area or operable unit RI. These sites are:

UN-200-W-32	UN-200-W-83
UN-200-W-34	UN-200-W-108
UN-200-W-35	UN-200-W-109
UN-200-W-41	UN-200-W-116
UN-200-W-42	UN-200-W-123
UN-200-W-43	UN-200-W-127
UN-200-W-49	
UN-200-W-52	
UN-200-W-56	
UN-200-W-61	
UN-200-W-69	

Confirmatory sampling is recommended for these unplanned releases, including all those which will first be addressed by the RARA Program. The majority of unplanned releases have low HRS scores; or are described as having been cleaned up or released as radiation zones as contamination decayed to background levels, and are therefore assumed to have low HRS scores. Five of the unplanned releases were high priority but had insufficient information to proceed with an IRM and also were unique and could not be grouped for an LFI. These sites do not have any data to support a risk assessment. Confirmatory sampling is recommended for these unplanned releases to provide enough data to confirm that contamination does not exist at these locations, and to perform a risk assessment. If no contamination is found, no further action would likely be recommended.

9.2.4.2 Proposed Sites for Risk Assessment. No waste management units or unplanned release sites had sufficient information for direct inclusion in the final RA under the final remedy selection path.

9.3 SOURCE OPERABLE UNIT REDEFINITION AND PRIORITIZATION

The investigation process can be made more efficient if units with similar histories and waste constituents are studied together. The data needs and remedial actions required for similar waste management units are generally the same. It is much easier to ensure a

consistent level of effort and investigation methodology if like units are grouped together. Economies of scale also make the investigation process more cost effective if similar units are studied together.

9.3.1 Units Addressed by Other Aggregate Areas or Programs

The investigation of one unit should be transferred from the S Plant Aggregate Area to the U Plant Aggregate Area. Although the 216-U-9 Ditch is physically within the S Plant Aggregate Area, the ditch was used to transfer overflow from the 216-U-10 Pond which received waste from the facilities within U Plant Aggregate Area. Transfer of this unit to the U Plant Aggregate Area would allow it to be investigated with other units having similar waste characteristics.

Several units are recommended to be fully investigated by existing programs. The programs include the Decommissioning and RCRA Closure Program, the Waste Management Program, and the Single-Shell Tank Closure Program. These units included the single-shell and double-shell tanks and the auxiliary units supporting tank farm operations such as diversion boxes, catch tanks, and transfer lines Table 9-3 lists the waste management units and unplanned releases that are to remain in the existing programs. Recommendations were developed for RARA units that will be only partially remediated by the program (for example, recommendations need to be developed for the remaining contaminant at a crib stabilized under the RARA Program). There are no previously identified ERAs within the S Plant operable units.

Deactivation of active liquid effluent units should remain within the existing Waste Management Program. The active facilities include the 216-S-25 Crib, 216-S-26 Crib, and 207-SL Retention Basin. Investigation of these facilities will be deferred until after deactivation.

9.3.2 S Plant Operable Unit Redefinition

Redefinition of the 200-RO-1, -2, -3, and -4 Operable Units are suggested based on the data evaluation in this report. In general, it is recommended that:

- Investigation of groundwater should be removed from the scope and included in a 200 West Groundwater Operable Unit Groundwater beneath the source operable unit interacts with all surrounding operable units since it is not confined by the geographic boundaries. Contamination from nearby operable units has migrated beneath the 200-UP Operable Units. Similarly, the contamination originating from the operable units has migrated outside the boundaries of the operable units. These interactions with other operable units will necessitate the integration of groundwater response actions throughout the

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200 West Area. This integration would likely be best handled in a combined groundwater operable unit, rather than in individual source operable units. A 200-UP-1 groundwater operable unit has been defined which includes the hydraulic regime south of the 216-U-10 Pond mound, including groundwater beneath the U Plant and S Plant Aggregate Areas. Perched water will remain a part of the source AAMS, since this generally is a localized phenomena within the unsaturated zone attributed to specific waste management units.

- High-level waste transfer facilities and pipelines should remain within the scope of the Waste Management Program and Decommissioning and RCRA Closure Program. The facilities are also structures with no unplanned releases and can be dealt with more efficiently in these existing Hanford programs. The Tri-Party Agreement does not include these lines within the scope of the past-practices investigations. Effluent transfer lines associated with individual waste management units will be investigated with the respective units.

- The 200-RO-1 Operable Unit boundary should be redefined to include the 216-S-4 French Drain and the 216-S-21 Crib. These units are currently part of the 200-UP-1 Operable Unit of the U Plant Aggregate Area.

- The 216-U-9 Ditch should be included in the U Plant Aggregate Area. This ditch was an overflow for the 216-U-10 Pond and, therefore, should have similar contaminant profile as the U Pond System.

9.3.3 Investigation Prioritization

Very little if any data exist to rank the waste management units and unplanned releases within the S Plant Aggregate Area on a risk-related basis. The HRS and surface contamination data which were used to sort the waste management units and unplanned releases into either high or low priority are indicators of potential risk but are not suitable to develop a risk-related ranking. The most useful data for indicating potential risk are probably the waste inventories and facility construction or operation information.

Based on inventories of contaminants, the cribs and french drain received the largest quantities of contamination and should be investigated first. The S Pond system received the next largest quantity of contamination and should be evaluated second. Based on this ranking, the 200-RO-2 Operable Unit should be investigated prior to the 200-RO-1 Operable Unit, which should be investigated prior to the 200-RO-3 Operable Unit. The 200-RO-4 Operable Unit will be dispositioned under the Single-Shell Closure Tank Program. Unit-specific priorities will be developed in subsequent work plans.

9.3.4 Resource Conservation and Recovery Act Facility Interface

A number of RCRA waste management units exist in the S Plant Aggregate Area. They include:

- 276-S-141 and 276-S-142 Hexone Tanks
- 216-S-10P Pond and 216-S-10D Ditch
- 222-S Storage Pad and 222-S Tanks 102 and 103
- 241-S and 241-SX Single-Shell Tank Farm Systems
- 241-SY Double-Shell Tank Farm Systems
- 244-S Receiver Tank
- 2727-S Nonradioactive Dangerous Waste Storage Facility

9.3.4.1 Active RCRA TSD Facilities. The 241-SY-101 through 241-SY-103 Double-Shell Tanks (3 total), the 244-S Receiver Tank, and the 222-S Storage Pad and tanks 102 and 103 are active facilities under the control of the Waste Management Program. These units have a current RCRA operating permit. All of the units will continue to be active, operating facilities. Closure is not anticipated to occur for some time. Thus, there will be no need to interface with the past practices program for these units at this time. In the event that any of these RCRA TSD facilities are closed while past practices investigation or remediation activities are still occurring, it will be necessary at that time for the RCRA TSD closure activities to interface with the past practices program.

9.3.4.2 RCRA Clean Closures. The 2727-S Nonradioactive Dangerous Waste Storage Facility and the 276-S-141 and 276-S-142 Hexone Tanks will undergo RCRA clean closure. The closure plan for 2727-S Facility was submitted to Ecology and EPA in January 1992. The closure plan for the Hexone Tanks is currently being prepared and will be submitted to Ecology and EPA by November 1992. It is recommended that closure and, if necessary, future remediation of these units remain completely under the RCRA Program.

9.3.4.3 RCRA Single-Shell Tanks. The RCRA regulated 241-S and 241-SX Tank Farms and associated facilities will be addressed under the Single-Shell Tank Closure Program and are administered under a separate Tri-Party Agreement 30-year schedule. Therefore, although there will be RCRA interfaces on these tanks, these interfaces are not addressed under this AAMS.

9.3.4.4 216-S-10P Pond and 216-S-10D Ditch. The 216-S-10P Pond and the 216-S-10D Ditch have been recommended for consideration under the IRM path. To be successful, the LFIs/IRMs should be integrated with ongoing RCRA closure activities to ensure maximum efficiency, compatibility of remedial measures, and minimal duplication of efforts. Recommendations for such integration are discussed in detail below.

The 216-S-10P Pond and the 216-S-10D Ditch are scheduled to undergo closure, and are expected to be subject to post-closure care. A closure plan is scheduled for submission to Ecology and EPA by May 1996. It is recommended that TSD facility closure activities and the RFI/CMS investigation and remediation activities for past-practice units be integrated. To accomplish the integration, it is recommended that prior to submittal the closure plan will include the past-practice program requirements. The resulting document would be a combined closure plan and RFI/CMS work plan.

It is recommended that risk assessment and determination of clean closure be performed in a consistent manner for all the analagous group units. To accomplish this, the units would be evaluated in accordance with the risk assessment methodology being developed and agreed to between DOE, EPA, and Ecology under Tri-Party Agreement milestone M-29-03. The latest presentation of the risk assessment protocols appear in *The Hanford Site Baseline Risk Assessment Methodology*. It is expected that these risk assessment protocols will be at least as conservative as the guidelines established under the proposed 40 CFR Part 264 Subpart S EPA regulations published in the July 27, 1990 Federal Register. The Subpart S guidelines will provide the bases for closing RCRA units in a manner that will prevent future threats to human health and the environment. Use of the milestone M-29-03 methodology would both satisfy the past practices risk assessment procedures and allow evaluation of whether or not clean closure of RCRA TSD units had been accomplished.

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 FSSs 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 record of decision. Insufficient data exists to prepare either a focused or final FS for any units or group of units within the S 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 S 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 judgment, and/or new characterization data such as that generated by an LFI.

Recommendations for the FFS in support of IRMs are not provided in this report because of limited data availability. In most cases, LFIs will be conducted at sites initially identified for IRMs. The information gathered is considered necessary prior to making a final determination whether an IRM is actually necessary or whether a remedy can be selected.

Rather than being driven by an IRM, the FFS will also be prepared to evaluate select remedial alternatives. In this case, the FFS focuses on technologies or alternatives that are considered to be viable based on their implementibility, 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.

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- 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 S 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 volitale 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 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.

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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.

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- 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.

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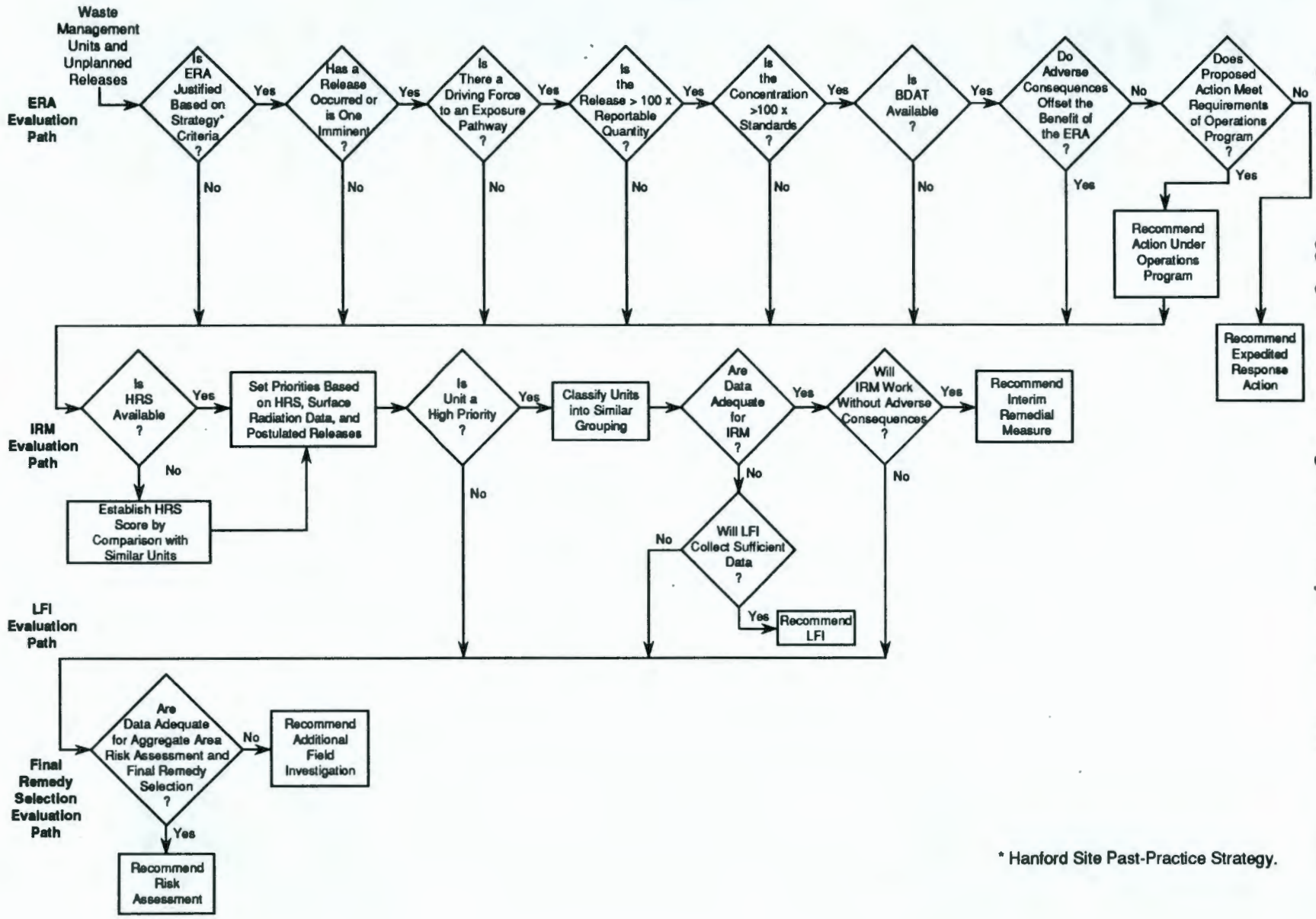
- In situ soil vapor extraction of volatile organic compounds--Development and testing of methods to characterize, retrieve, and treat waste from VOC contaminated soil will be required. The DOE has established the VOC-Arid Integration Demonstration to resolve these issues. The Z Plant Aggregate Area 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.



* Hanford Site Past-Practice Strategy.

Figure 9-1. 200 Aggregate Area Management Study Data Evaluation Process.

Table 9-1. Summary of the Results of Remediation Process Path Assessment.

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
Cribs and Drains							
216-S-1 & -2 Crib		X	X			X	RARA-Collapse Potential
216-S-5 Crib		X	X				
216-S-6 Crib		X	X				
216-S-7 Crib		X	X			X	RARA-Collapse Potential
216-S-9 Crib		X	X				
216-S-13 Crib		X	X			X	RARA-Collapse Potential
216-S-20 Crib		X	X			X	RARA-Collapse Potential
216-S-22 Crib		X	X				
216-S-23 Crib		X	X				
216-S-25 Crib		X	X			X	WMP-Active
216-S-26 Crib		X	X			X	WMP-Active
216-S-3 French Drain		X	X				
Ponds, Ditches, and Trenches							
216-S-10P Pond		X	X				
216-S-11 Pond		X	X				
216-S-15 Pond		X	X				
216-S-16P Pond		X	X				

Table 9-1. Summary of the Results of Remediation Process Path Assessment.

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
216-S-17 Pond		X	X				
216-S-19 Pond		X	X				
216-S-10D Ditch		X	X				
216-S-16D Ditch		X	X				
216-U-9 Ditch		X	X				Redefined to U Plant Aggregate Area
216-S-8 Trench					X		
216-S-12 Trench					X		
216-S-14 Trench					X		
216-S-18 Trench					X		
Septic Tanks and Associated Drain Fields							
2607-W6 Septic Tank					X		
2607-WZ Septic Tank					X		
Sanitary Crib					X		
Transfer Facilities, Diversion Boxes, and Pipelines							
216-S-172 Control Structure		X	X				
2904-S-160 Control Structure		X	X				
2904-S-170 Control Structure		X	X				
2904-S-172 Control Structure		X	X				

Table 9-1. Summary of the Results of Remediation Process Path Assessment.

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
Basins							
207-S Retention Basin					X		
207-SL Retention Basin					X		
Burial Sites							
218-W-7 Burial Ground					X		
218-W-9 Burial Ground					X		
Unplanned Releases							
UN-200-W-32 Unplanned Release					X		
UN-200-W-34 Unplanned Release					X		
UN-200-W-35 Unplanned Release					X		
UN-200-W-41 Unplanned Release					X		
UN-200-W-42 Unplanned Release					X		
UN-200-W-43 Unplanned Release					X		
UN-200-W-52 Unplanned Release					X		
UN-200-W-56 Unplanned Release					X		
UN-200-W-61 Unplanned Release					X		
UN-200-W-69 Unplanned Release					X		
UN-200-W-83 Unplanned Release					X		

Table 9-1. Summary of the Results of Remediation Process Path Assessment.

Waste Management Unit Name or Unplanned Release Site	Recommended Actions						Remarks
	ERA	IRM	LFI	RA	RI	OPS	
UN-200-W-108 Unplanned Release					X		
UN-200-W-109 Unplanned Release					X		
UN-200-W-116 Unplanned Release					X		
UN-200-W-123 Unplanned Release					X		
UN-200-W-127 Unplanned Release					X		
UN-216-W-30 Unplanned Release					X		

Key:

ERA = Expedited Response Action
RI = Remedial Investigation/Feasibility Study (RCRA Facility Investigation/Corrective Measures Study)
LFI = Limited Field Investigation
RA = Risk Assessment
IRM = Interim Remedial Measure
OPS = Operational Programs
RARA = Radiation Area Reduction Action Program
WMP = Waste Management Program

Table 9-2. S Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority ?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
Cribs and Drains													
216-S-1 & -2 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-5 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-6 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-7 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	-	Y	-
216-S-9 Crib	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-13 Crib	Y	Y	Y	Y	Y	Y	N	Y	N[a]	N	-	Y	-
216-S-20 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-22 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-23 Crib	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-25 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-26 Crib	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-3 French Drain	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
Ponds, Ditches, and Trenches													
216-S-10P Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-11 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-15 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-16P Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-17 Pond	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-19 Pond	Y	Y	N	-	-	-	-	-	N[a]	N	-	Y	-
216-S-10D Ditch	Y	Y	Y	Y	Y	Y	N	Y	Y	N	-	Y	-
216-S-16D Ditch	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-

Table 9-2. S Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority ?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
216-U-9 Ditch	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
216-S-8 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-S-12 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-S-14 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
216-S-18 Trench	Y	Y	N	-	-	-	-	-	N	-	-	-	N
Septic Tanks and Associated Drain Fields													
2607-W6 Septic Tank	N	-	-	-	-	-	-	-	N	-	-	-	Y
2607-WZ Septic Tanks	N	-	-	-	-	-	-	-	N	-	-	-	Y
Sanitary Crib	N	-	-	-	-	-	-	-	N	-	-	-	Y
Transfer Facilities, Diversion Boxes, and Pipelines													
216-S-172 Cont. Struct.	N	-	-	-	-	-	-	-	N[04]	N	-	Y	-
2904-S-160 Cont. Struct.	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
2904-S-170 Cont. Struct.	Y	Y	N	-	-	-	-	-	Y	N	-	Y	-
2904-S-171 Cont. Struct.	N	-	-	-	-	-	-	-	N[04]	N	-	Y	-
Basins													
207-S Retention Basin	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
207-SL Retention Basin	N	-	-	-	-	-	-	-	N	-	-	-	N
Burial Sites													
218-W-7 Burial Ground	Y	Y	N	-	-	-	-	-	N	-	-	-	N
218-W-9 Burial Ground	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
Unplanned Releases													
UN-200-W-32	Y	Y	N	-	-	-	-	-	Y	N	-	N	N

Table 9-2. S Plant Aggregate Area Data Evaluation Decision Matrix.

Waste Management Unit	ERA Evaluation Path								IRM Evaluation Path			LFI Path	Final Remedy
	Is an ERA Justified?	Release?	Pathway?	Quantity?	Concentration?	Technology Available?	Adverse Consequences?	Operational Programs?	High Priority ?	Data Adequate?	No Adverse Consequences?	Collect Data	Data Adequate
UN-200-W-34	Y	Y	N	-	-	-	-	-	Y	N	-	N	N
UN-200-W-35	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-41	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-42	Y	Y	Y	N	-	-	-	-	Y	N	-	N	N
UN-200-W-43	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-52	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-56	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-61	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-69	Y	Y	Y	N	-	-	-	-	N	N	-	N	N
UN-200-W-83	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-108	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-109	Y	Y	Y	Y	N	-	-	-	Y	N	-	N	N
UN-200-W-116	Y	Y	Y	N	-	-	-	-	N	N	-	N	N
UN-200-W-123	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-200-W-127	N	-	-	-	-	-	-	-	N	-	-	-	N
UN-216-W-30	Y	Y	Y	N	-	-	-	-	Y	N	-	N	N

Y = Yes
N = No
\- = Decision point not reached on pathway. Evaluation branced to other path.
(a) = Addressed as on IRM candidate because of similarities with other units.
(b) = Addressed as an IRM candidate because unit is ancillary equipment to IRM candiate.

Table 9-3. Waste Management Units and Unplanned Releases Addressed by Other Programs. Page 1 of 2

Site Name	Site Type	Program	Active/Inactive	Operable Unit
Tanks and Vaults				
241-S-101	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-102	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-103	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-104	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-105	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-106	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-107	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-108	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-109	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-110	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-111	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-S-112	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-101	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-102	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-103	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-104	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-105	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-106	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-107	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-108	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-109	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-110	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-111	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-112	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-113	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-114	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SX-115	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SY-101	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SY-102	Single-Shell Tank	SSTCP	Inactive	200-RO-4
241-SY-103	Single-Shell Tank	SSTCP	Inactive	200-RO-4
240-S-302	Catch Tank	WMP	Inactive	200-RO-3
241-S-302A	Catch Tank	WMP	Inactive	200-RO-2
241-S-302B	Catch Tank	WMP	Inactive	200-RO-4
241-SX-302	Catch Tank	WMP	Inactive	200-RO-2
244-S	Receiver Tank	WMP	Active	200-RO-2
Transfer Facilities, Diversion Boxes, and Pipelines				
241-S-151	Diversion Box	WMP	Active	200-RO-2
241-S-151	Diversion Box	SSTCP	Inactive	200-RO-3
241-S-152	Diversion Box	SSTCP	Inactive	200-RO-3
241-S-152	Diversion Box	SSTCP	Inactive	200-RO-4
241-SX-151	Diversion Box	SSTCP	Inactive	200-RO-4
241-SX-152	Diversion Box	SSTCP	Inactive	200-RO-4
241-SY-A	Diversion Box	WMP	Active	200-RO-4

Table 9-3. Waste Management Units and Unplanned Releases Addressed by Other Programs. Page 2 of 2

Site Name	Site Type	Program	Active/Inactive	Operable Unit
241-SY-B	Diversion Box	WMP	Active	200-RO-4
241-S-A	Valve Pit	WMP	Active	200-RO-4
241-S-B	Valve Pit	WMP	Active	200-RO-4
241-S-C	Valve Pit	WMP	Active	200-RO-4
241-S-D	Valve Pit	WMP	Active	200-RO-4
241-SX-A	Valve Pit	SSTCP	Inactive	200-RO-4
241-SX-B	Valve Pit	SSTCP	Inactive	200-RO-4
Unplanned Releases				
UN-200-W-10	Unplanned Release	SSTCP	–	200-RO-2
UN-216-W-25	Unplanned Release	SSTCP	–	200-RO-2
UN-200-W-49	Unplanned Release	SSTCP	–	200-RO-2
UN-200-W-50	Unplanned Release	SSTCP	–	200-RO-2
UN-200-W-80	Unplanned Release	SSTCP	–	200-RO-4
UN-200-W-81	Unplanned Release	SSTCP	–	200-RO-4
UN-200-W-82	Unplanned Release	SSTCP	–	200-RO-2
UN-200-W-114	Unplanned Release	SSTCP	–	200-RO-2

SSTCP - Single-Shell Closure Program
WMP - Waste Management Program
D&RCP - Decommissioning and RCRA Closure Program

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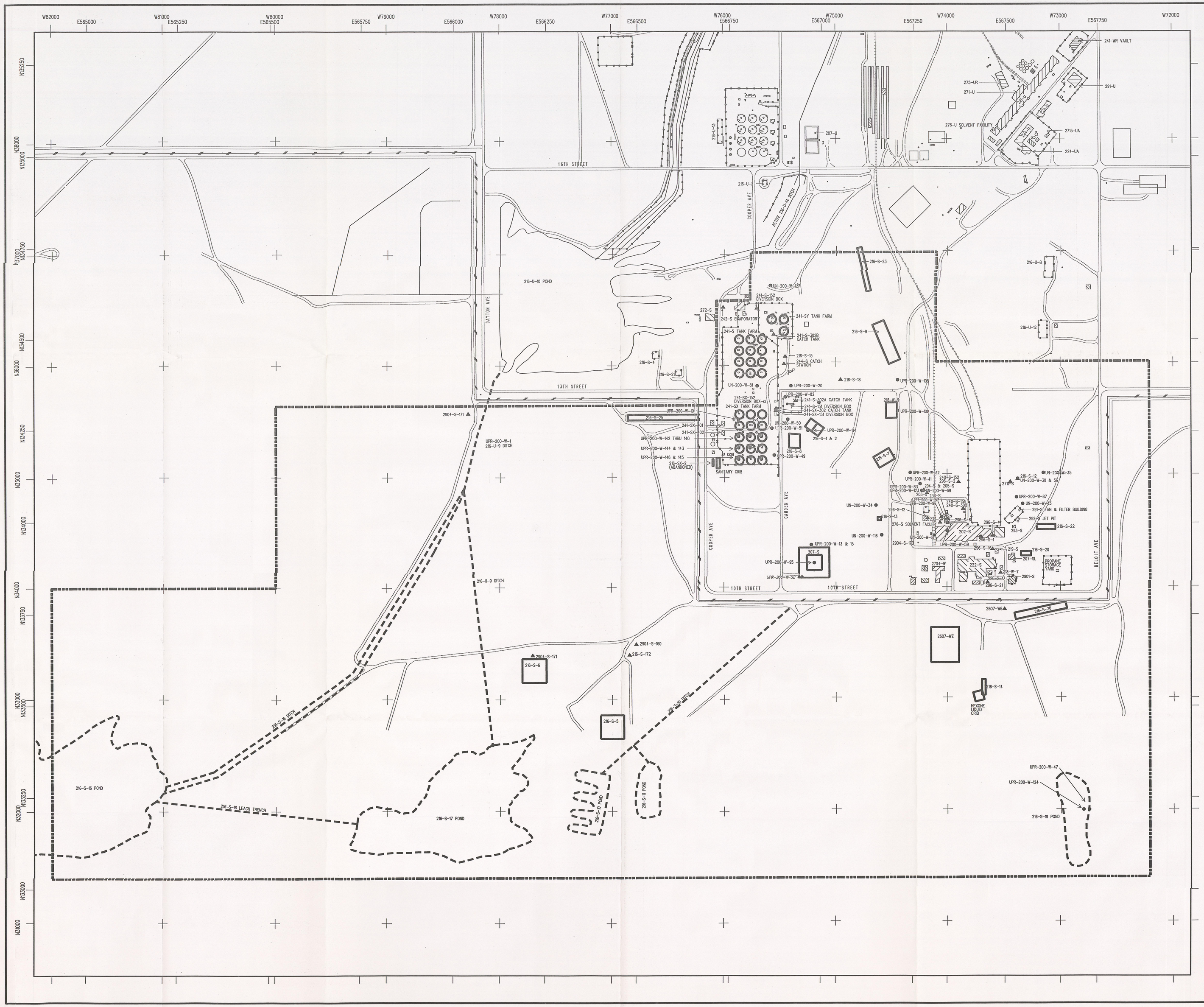
APPENDIX A

SUPPLEMENTAL DATA

9 1 1 2 8 . 9 1 2 7 0

APPENDIX A.1

GEOPHYSICAL DATA



Westinghouse Hanford Company
Aggregate Area Management Studies

S PLANT AGGREGATE AREA
PLATE 1 – Facilities, Sites, & Unplanned Releases

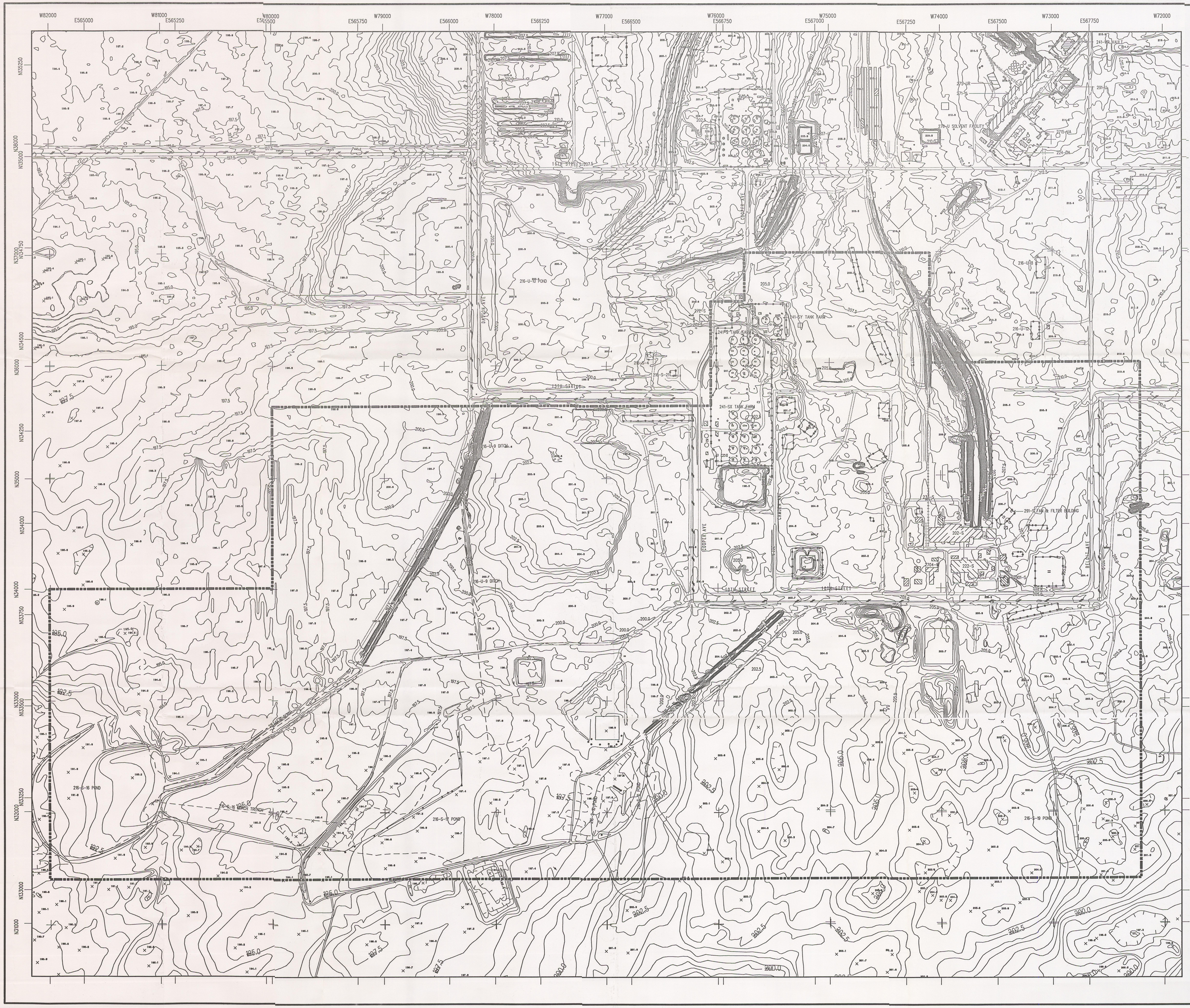
LEGEND

- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings
- Waste Management Units
- Unplanned Releases
- Other Waste Mgmt Units
- Waste Mgmt Units (Approx)

N

Scale in Feet
0 1000 2000

Scale in Meters
0 100 500



Westinghouse Hanford Company
Aggregate Area Management Studies

S PLANT AGGREGATE AREA
PLATE 2 – Topography

LEGEND

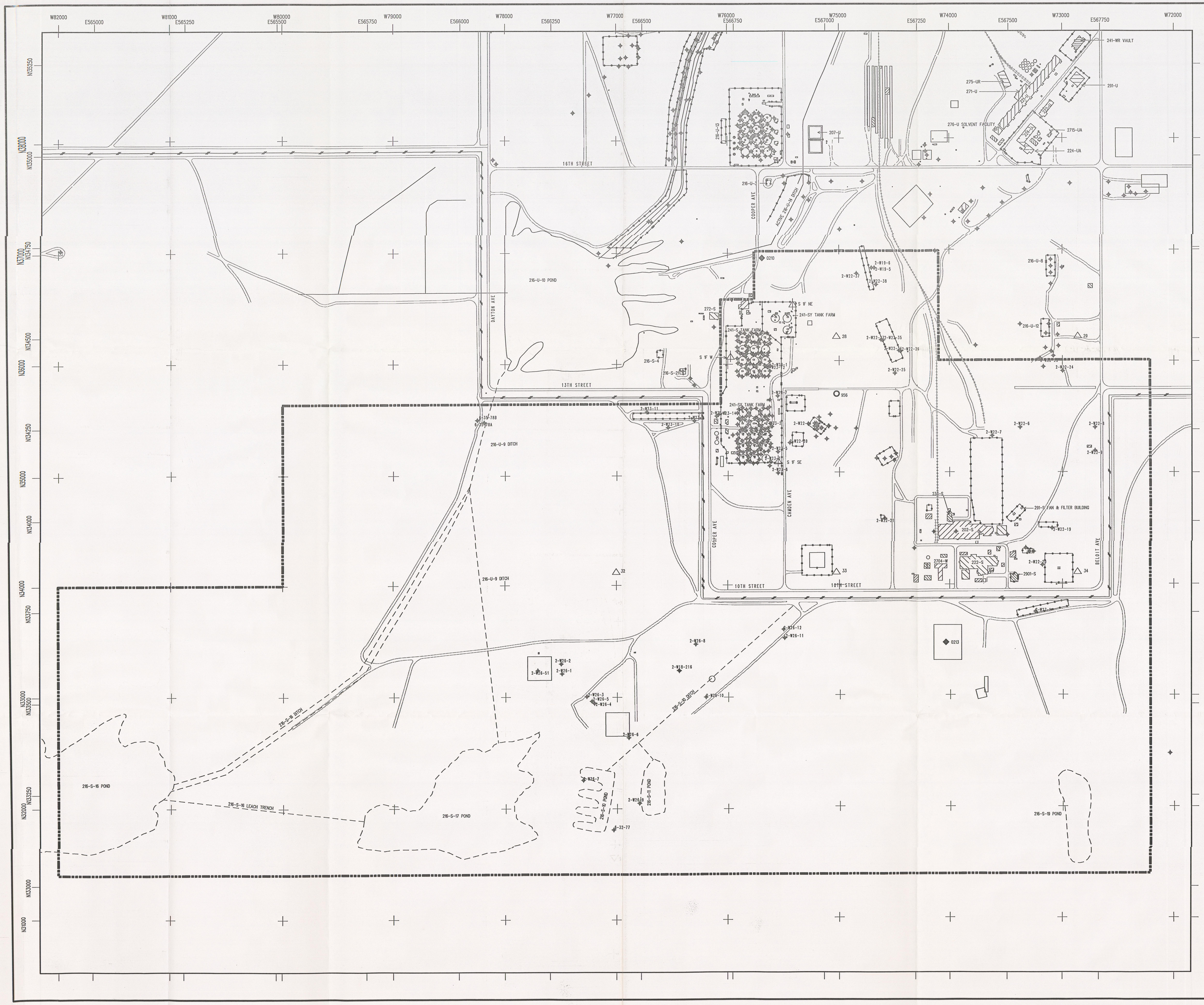
- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings

Contour Interval .5 Meter

N

Scale in Feet
0 1000 2000

Scale in Meters
0 100 500



Westinghouse Hanford Company
Aggregate Area Management Studies

S PLANT AGGREGATE AREA
PLATE 3 – Monitor Wells & Sample Locations

LEGEND

- Aggregate Area Boundary
- Security Systems/Fences
- Perimeter Boundary
- Buildings
- Monitoring Wells

SAMPLING LOCATIONS (Approximate)

Soil Sampling Locations

- Former Locations (to 1989) --including TLDs
- New Sampling Locations (1990 and following)
- Fenceline Sampling Locations

Surface Water Sampling Locations

Air Sampling Locations

New TLD Sampling Locations

Scale in Feet
0 1000 2000

Scale in Meters
0 100 500

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9 3 1 2 8 6 9 1 2 3 6

A-1.1 INTRODUCTION

Geophysical well logging has been conducted in monitoring wells located within the 200 East and West Areas since 1954 and in the S Plant Aggregate Area since at least as early as 1958. Such logging can be used to map lithologic boundaries (Addition et al. 1978; Last et al. 1989; Brodeur and Koizumi 1989), soil moisture content (Lane 1990) and to evaluate the location and extent of radionuclides in the subsurface due to waste disposal activities (Fecht et al. 1977; Addition et al. 1978; Lane 1990). The geophysical borehole logging techniques which have been used include density, neutron, temperature and gross gamma radiation logging. The most successful of these for mapping lithologic boundaries and monitoring radionuclides in the subsurface has been the gross gamma logging. The other techniques have been less successful either because they are not suitable for use in cased holes or they do not measure radiation (Lane 1990).

Previous studies based on the gross gamma logs collected from wells monitoring various waste management units in the 200 East and West Areas were conducted in 1964, 1969, 1977, 1978, and 1986. The tank farms located in the 200 East and West Areas were not considered in these reports. Addition et al. (1978) report that the 1964 study (Raymond and McGhan 1964) discusses the disposition of radionuclides beneath most of the waste management units active between 1945 and 1963. The 1969 study (Tillson and McGhan 1969) is reported by Addition et al. (1978) to be a discussion of the waste management units where significant changes in the gamma logs were observed after 1963. The report by Fecht et al. (1977) is a qualitative study of the distribution, redistribution and decay of radionuclides beneath approximately 100 waste management units in the 200 East and West Areas. Fecht et al. (1977) included a summary of the waste disposal history of each facility evaluated and based their conclusions on approximately 300 selected gross gamma logs collected between 1954 and 1976. Plots of the logs used were provided with the report. Addition et al. (1978) provide a complete summary of the logging systems used and a discussion of the limitations of using gross gamma logs to evaluate the distribution and composition of radionuclides in the subsurface. The methodologies employed to qualitatively evaluate the gross gamma logs collected from wells monitoring the waste disposal facilities in the 200 East and West Areas were also summarized. Plots of the gross gamma logs collected from 154 monitoring wells outside the tank farms in the 200 East Area was included in the report by Addition et al. (1978). Chamness (1986) reviewed gross gamma logs available from selected wells in the 200 area and qualitatively summarized any changes in the logs between 1976 and 1986.

Fifteen active and inactive waste management units in the S Plant Aggregate Area which are monitored by wells in which gross gamma logs are collected were evaluated in this study. These waste management units were qualitatively evaluated in terms of the location and extent of radionuclides in the subsurface, any evidence of vertical or lateral migration, and the potential for radionuclides reaching the ground water). The results of the evaluations for these waste management units are summarized in Table A-1.1.

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, but has not yet reached the stage of practical application (Lane 1990).

The bulk of the gamma logs available for the S 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; Addition et al. 1978; Brodeur and Koizumi 1989; Arthur 1990).

The accuracy and precision of gamma activity measurements in the subsurface is determined by details of the logging system instrumentation, the field data acquisition methodology, the surrounding media and the radionuclides present. The relationship between the gamma activity detected by a scintillation probe and the actual activity, the distance gamma radiation may travel through geologic materials before being completely attenuated and the vertical resolution of changes in activity by the logging systems used will be discussed below.

The time required for the logging system to process a detected gamma photon, or "dead time", is an important limitation in the measurement of gamma activity (Brodeur and Koizumi 1989; Arthur 1990). During this short span of time, no other photons will be processed by the instrument. The "dead time" computed for the PNL system currently in use is 17.8 microseconds (Arthur 1990). Based upon this value, the maximum count rate this logging system is capable of is about 56,000 ct/sec. If the activity is above that level, the system will become "paralyzed" and read 0 ct/sec until it resets itself. The maximum count rate of the TFSA&S system currently in use is about 100,000 ct/sec with Probe #4 (Strong 1980). This suggests that the "dead time" of their logging system is about 10 microseconds. There is no evidence that TFSA&S's system will become paralyzed if this activity level is exceeded.

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The actual gamma activity on an interval may be computed by multiplying the "dead time" corrected activity by a factor consistent with the amount of attenuation due to well construction. The amount of attenuation the gamma radiation experiences in penetrating well casing is significant. A single string of casing reduces the count rate measured by the scintillation probe by about 25%, groundwater in an uncased hole reduces the observed count rate by 11%, and groundwater in a cased hole reduces the observed count rate by about 33% (Brodeur and Koizumi 1989; Arthur 1990).

The relationship between the gamma activity observed with a scintillation probe and the actual activity is linear over much of the system's range. However, above some threshold activity level, the relationship between the observed and actual activity becomes non-linear. At this point the tool is said to be saturated. The gross gamma logging system currently in use by PNL becomes saturated around 14,500 ct/sec (Brodeur and Koizumi 1989; Arthur 1990), and that currently in use by TFSA&S with Probe # 4 becomes saturated around 70,000 ct/sec (Strong 1980).

Where the relationship between the observed and actual gamma activity is linear, and complete details of well construction are available, the activity may be converted to standard units related to decay rates or to concentrations of specific radionuclides (thorium or uranium for example). Such conversions allow the direct comparison of data collected by different logging systems and quantitative analyses of the concentrations of gamma emitters with depth. To achieve this, it is necessary to calibrate the scintillation probes used with a model bore hole containing intervals with known activities (Strong 1980; Brodeur and Koizumi 1989; Arthur 1990). The rigorous procedures and facilities necessary for calibrating scintillation probes have not yet been completed.

A scintillation probe is calibrated by periodically adjusting the components of the system to meet established specifications and by logging a test well with intervals of known activity under standard conditions. The probe's calibration is then verified in the field before and after each logging run using portable equipment and procedures which are correlated with those of the calibration procedure. Standard conditions are established by constructing the test bore hole 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 bore hole, 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 bore hole in sedimentary rocks. The radius of investigation is larger on intervals where there are high concentrations of radionuclides since higher intensities of gamma radiation will penetrate a greater thickness of a given material. The radius of investigation is decreased by well casing, grout, and groundwater since they increase the effective density of sediments. Another factor in determining the radius of investigation is the tool response to low energy (frequency) gamma photons. The

scintillation probe currently used by PNL has a low energy cutoff of between 46.5 and 59.5 keV (Arthur 1990). Gamma radiation with energies below this value will not be detected by that probe. The low energy cutoff for the probes used by TFSA&S is unknown.

The vertical resolution and apparent location of a change in the gamma activity measured by a scintillation probe depends upon details of how the probe signal is processed by the rate meter and the logging speed. The rate meter used in PNL's logging system differs from that used by TFSA&S. The rate meter used by PNL smooths its output using an electronic circuit (an RC circuit). The amount of smoothing is determined by the time constant of the circuit used. This removes statistical variations in the signal detected by the scintillation probe and improves the reproducibility and sensitivity of the data. However, a "lag" is introduced between the depth at which a change in the gamma activity is first encountered by the scintillation probe and the depth at which it is plotted. The size of this "depth lag" is the distance traveled before half of the amplitude of the change in activity is recorded. One time constant is required to reach 63% 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. Before 1989, the logging speed used by PNL was 4.6 m/min (15 ft/min) (0.25 ft/sec) and the time constant used was 3 seconds. This results in a depth lag of 0.2 m (0.75 ft). The thinnest interval of elevated activity which can be resolved is also 0.2 m (0.75 ft) on these older profiles. In 1989, the logging speed was reduced to 1.5 m (5 ft/min) (1 in./sec) and the time constant to 1 second. The expected vertical resolution and "depth lag" of these logs is 2.5 cm (1 in.). The rate meter used by TFSA&S sums the pulses over the period of time required for the probe to ascend through 0.3 m (1 ft) and averages the reading over time. This process does not remove the statistical variations from the data so the data are less reproducible. 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. However, the vertical resolution of changes in activity on these logs is 0.3 m (1 ft), the distance over which the activity is averaged.

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A-1.3 TECHNICAL APPROACH

Scintillation probe profiles collected periodically from monitoring wells within the S 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. Each analysis is accompanied by a summary of the types and sources of wastes handled, the service dates and the volume of wastes disposed of or stored at a given facility. 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. It is assumed that the activity detected on the gamma logs represent diffuse, continuous sources of radiation.

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 here have not been normalized.

There has been no attempt to quantitatively compare the activity levels detected by different vintages of scintillation probes in the evaluations presented here. If gross changes in the profiles are evident, they have been noted in a qualitative sense. The criteria used to identify radionuclide decay are the significant, consistent decline of activity levels and the "narrowing" of the features representing elevated radiation on the logs over time. However, such changes may also be indicative of lateral migration of radionuclides away from a particular well. Identification of lateral migration is generally uncertain. The most reliable criteria for identifying lateral migration of radionuclides is the notable increase of activity on an interval in a well that is down gradient (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 5 feet have been noted between these logs. This error is due in part to the "depth lag" of the PNL logging system. This "depth lag" will place equivalent features on PNL logs (collected before 1989) 0.2 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 (0.2 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 references 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 logs used in these evaluations which were collected before 1976, and some of the 1976 vintage logs had been previously digitized by PNL, who provided text files of the information. The cross sections are not scaled horizontally. To obtain a true picture of the spacial relationship between the wells used in the cross sections, the reader is instructed to inspect the location map provided on each figure containing cross sections.

Isopach maps showing the thickness of the interval of elevated gamma radiation were constructed from the cross sections and gross gamma logs. Although such maps do not give any indication of gamma activity, they do provide a reasonable representation of the potential extent of gamma emitters. Use of activity data was avoided since the data are not suitable to be used in such a quantitative fashion.

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A-1.4 EVALUATION OF WASTE MANAGEMENT UNITS

A-1.4.1 216-S-1 and -2 Cribs

Waste Description:
Received cell drainage from D-1 Receiver Tank and redistilled condensate from D-2 Receiver Tank in 202-S Building.

Service Dates:
January 1952 - January 1956.

Waste Volume:
160,000,000 L (42,000,000 gal).

Evaluation of Scintillation Probe Profiles

The 216-S-1 and 216-S-2 Cribs are located in the 200-RO-2 Operable Unit 100 m (300 ft) east of the 241-SX Tank Farm. The cribs are monitored by Wells 299-W22-1, 299-W22-2, 299-W22-5, 299-W22-6, 299-W22-10, 299-W22-11, 299-W22-15, 299-W22-16, 299-W22-17, 299-W22-18, 299-W22-29, 299-W22-30, 299-W22-31, 299-W22-36, and 299-W22-67. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

Scintillation probe profiles for wells monitoring the 216-S-1 and -2 Cribs have been evaluated by Fecht et al. (1977) and Chamness (1986). These studies concluded that radionuclides from the cribs had reached the groundwater and that gamma activity may have decreased due to decay. This evaluation is consistent with the findings of these previous studies.

Wells 299-W22-1, 299-W22-2, 299-W22-29, 299-W22-30, 299-W22-31, and 299-W22-36 have elevated gamma activity throughout the vadose zone beneath the crib. All of these wells are located immediately adjacent to the crib. Peripheral wells 299-W22-5, 299-W22-6, 299-W22-10, 299-W22-16, and 299-W22-17 all have gamma activity at background levels. Other peripheral wells, wells 299-W22-11, 299-W22-15, 299-W22-18, and 299-W22-67, have elevated gamma activity between 42 and 66 feet (13 and 20 m). The scintillation probe profiles from wells 299-W22-6, 299-W22-11, 299-W22-1, 299-W22-18, and 299-W22-5 were used to construct a cross-section through the cribs and compared to the geology from Well 299-W22-1 (Figure A-1.1). The highest elevated gamma activity corresponds with the boundary of the upper coarse and lower fine units of the Hanford Formation. This lithologic boundary is at a depth of about 45 ft (14 m) beneath the cribs. The areal extent and thickness of elevated gamma activity is shown in Figure A-1.2. The lateral extent of elevated gamma activity is limited to an area immediately adjacent to the cribs.

Wells 299-W22-2, 299-W22-5, 299-W22-6, 299-W22-10, 299-W22-15, 299-W22-16, 299-W22-17, 299-W22-18, 299-W22-29, 299-W22-30, 299-W22-31, 299-W22-36, and 299-W22-67 have all been geophysically logged for gross gamma since 1977. Examination of these logs showed only one major change. In 1986, Well 299-W22-6 recorded a peak above background from 46 to 48 ft (14-15 m). A relog of this well in 1987 showed gamma activity had returned to background levels. This transient elevated activity corresponds to elevated gamma activity in Wells 299-W22-11, 299-W22-15, 299-W22-18, and 299-W22-67 and the contact between the upper coarse and lower fine units of the Hanford Formation. This lithologic boundary may have facilitated lateral migration of radionuclides in the past.

The data indicates that breakthrough of gamma emitters to the groundwater occurred in the past and that long-lived radionuclides are present throughout the vadose zone beneath the cribs. The top of the lower fine unit of the Hanford Formation has vacilitated some limited lateral spreading of radionuclides.

A-1.4.2 216-S-5 Crib

Waste Description:
Radioactive, acidic process vessel cooling water and steam condensate from the 202-S Building.

Service Dates:
March 1954 - March 1957.

Waste Volume:
4,100,000,000 L (1,100,000,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-5 Crib is located in the 200-RO-1 Operable Unit 100 m (300 ft) north of the 216-S-10P Pond. The crib is monitored by Wells 299-W26-1, 299-W26-3, 299-W26-4, and 299-W26-5. The location of Well 299-W26-1 is uncertain. Fecht et al. (1977) locate the well within the crib. The GIS coordinates listed for the well locate it to the northwest of the crib closer to the 216-S-6 Crib. This evaluation uses the location of Fecht et al. (1977).

The 216-S-5 Crib was previously evaluated by Fecht et al (1977). They concluded that radionuclides were held high in the sediment beneath the crib and that breakthrough to the groundwater has not occurred at this site. This evaluation concurs with Fecht et al. (1977).

The wells monitoring the 216-S-5 Crib have not been logged since 1976. Gross gamma logs from Well 299-W26-1 show elevated gamma activity from 5 to 38 ft (1.5 to 12 m) below the ground surface. Peripheral wells, 299-W26-3, 299-W26-4, and 299-W26-5, have gamma activity at background levels. These three wells are located to the northwest of the crib. If any lateral migration of gamma emitters occurred in directions other than to the northwest, they would not be detected.

A-1.4.3 216-S-6 Crib

Waste Description:
Received process vessel cooling water and steam condensate from 202-S Building and steam condensate from the D-12 and D-14 waste concentrators in the S Plant complex.

Service Dates:
November 1954 - July 1972.

Waste Volume:
4,470,000,000 L (1,180,000,000 gal).

9 3 1 2 8 6 9 1 2 4 4

Evaluation of Scintillation Probe Profiles:

The 216-S-6 Crib is located in the 200-RO-1 Operable Unit 200 m (600 ft) northwest of the 216-S-5 Crib. The crib is monitored by Wells W26-51 and W26-2. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

The 216-S-6 Crib has previously been evaluated by Fecht et al. (1977). They concluded that breakthrough to the groundwater has not occurred at this site. This evaluation is consistent with Fecht et al. (1977).

The 1987 gross gamma log for Well 299-W26-51 indicates elevated gamma activity from just beneath the surface to a depth of approximately 50 ft (15 m). The scintillation probe profile for Well 299-W26-51 is shown in Figure A-1.3. Well 299-W26-2 located to the east of the crib was last logged in 1976. This gross gamma log detected only background radiation levels.

These data indicated that radionuclides have been retained high in the sediment and that breakthrough to the groundwater is not indicated.

A-1.4.4 216-S-7 Crib

Waste Description:
Received cell drainage from the D-1 Receiver Tank, process condensate from the D-2 Receiver Tank, and condensate from the H-6 Condenser in the 202-S Building.

Service Dates:
January 1956 - July 1965.

Waste Volume:
390,000,000 L (100,000,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-7 Crib is located in the 200-RO-2 Operable Unit northwest of S Plant. The Crib is monitored by Wells 299-W22-12, 299-W22-13, 299-W22-14, 299-W22-32, and 299-W22-33. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

Fecht et al. (1977) previously evaluated the gross gamma logs from the wells monitoring the 216-S-7 Crib. This study indicated that radionuclides had broken through to the groundwater and that gamma activity in the vadose zone was declining. The results of this evaluation are consistent with the findings of Fecht et al. (1977).

Older gross gamma logs for all five monitoring wells indicate elevated gamma activity from 8 feet (2.5) below the surface to the water table. Since crib activity ceased in 1965, no

measurable movement in intervals of elevated gamma in the vadose zone has occurred. Wells 299-W22-13, 299-W22-14, and 299-W22-33 were geophysically logged occasionally up to 1987. Peaks in gamma activity have remained at the same depth as in previous logs. Most of the elevated gamma activity below 45 ft (14 m) has declined to near background levels.

The 1987 scintillation probe profiles from Wells 299-W22-13, 299-W22-14, and 299-W22-33 have been compiled into a cross-section and compared to the geology of Lindsey et al. (1991) (Figure A-1.4). These gross gamma profiles show that elevated gamma activity is limited to between a depth of 22 to 42 ft (7 to 13 m). The lateral extent of this interval of elevated gamma is not known due to a lack of peripheral wells located beyond the area of elevated gamma activity.

In the past, elevated gamma activity extended to the groundwater indicating that breakthrough of radionuclides occurred. The decline of gamma activity in the vadose zone is probably due to radionuclide decay.

9 3 1 2 8 5 9 1 2 4 6

A-1.4.5 216-S-8 Trench

Waste Description:
Unirradiated startup waste from 202-S Building.

Service Dates:
November 1951 - February 1952.

Waste Volume:
10,000,000 L (2,640,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-8 Trench is located in the 200-RO-2 Operable Unit 50 m (150 ft) east of the 241-SX Tank Farm. The trench is monitored by Well 299-W22-39. Details of this monitoring well and the scintillation profiles used in this evaluation are given in Table A-1.2.

Figure A-1.5 shows the 1991 scintillation probe profile of Well 299-W22-39. This profile shows no elevated gamma activity. The well is located just to the west of the trench.

A-1.4.6 216-S-9 Crib

Waste Description:
Received process condensate from the D-2 Receiver Tank in the 202-S Building. Waste is radioactive and acidic, mainly composed of nitric acid.

Service Dates:
July 1965 - January 1969.

Waste Volume:
50,300,000 L (13,300,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-9 Crib is located in the 200-RO-2 Operable Unit east of the 241-S and 241-SY Tank Farms. The crib is monitored by Wells 299-W22-25, 299-W22-26, 299-W22-35, and 299-W22-36. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

The 216-S-9 Crib has been previously evaluated by Fecht et al. (1977) and Chamness (1986). Fecht et al. (1977) indicated that breakthrough to the groundwater may have occurred. These previous evaluations noted that gamma activity was declining due to radionuclide decay. This evaluation is in agreement with these previous evaluations.

Gross gamma profiles recorded in 1970 from Wells 299-W22-25 and 299-W22-26 indicate elevated gamma activity from 28 ft (10 m) to the water table. More recent gross gamma logs of the all four wells indicates that gamma activity has been declining due to radionuclide decay. Gross gamma profiles from Wells 299-W22-25, 299-W22-34, and 299-W22-35 have been compiled into a cross-section and correlated with the geology from Well 299-W22-25 (Figure A-1.6). The profiles from Wells 299-W22-25 and 299-W22-34 indicate elevated gamma activity from 28 ft to 62 ft (9 m to 19 m). The profile from Well 299-W22-35 shows gamma activity at near background levels. The cross-section indicates that most of the waste disposed of in the crib percolated into the vadose zone at the southern end of the crib.

The areal extent of the interval of elevated gamma activity is not known due to a lack of wells further from the crib than Wells 299-W22-25 and 299-W22-26. The data from wells 299-W22-25 and 299-W22-26 indicate that breakthrough to the groundwater occurred in the past and that current intervals of elevated gamma activity have been declining due to radionuclide decay.

A-1.4.7 216-S-10D Ditch, 216-S-10P Pond, and 216-S-11 Pond

Waste Description:

216-S-10D:	Received hazardous waste salts and received chemical sewer waste from the 202-S Building, 241-S Tank Farm, 211-S Station, 276-S Solvent Handling facility drains, and overflow from the high water tower.
216-S-10P:	Received chemical sewer waste from the S Plant Complex and overflow from the high water tower via the 216-S-10D Ditch. Also received bearing cooling water from the S Plant Complex.
216-S-11:	Received waste from air conditioning drains and chemical sewer waste from 202-S Building via the 216-S-10 Ditch.

Service Dates:

216-S-10D:	August 1951 - October 1991.
216-S-10P:	February 1954 - October 1984.
216-S-11:	May 1954 - August 1965.

Waste Volume:

216-S-10D:	8,604,000,000 L (2,280,000,000 gal).
216-S-10P:	7,100,000 L (1,900,000 gal).
216-S-11:	2,230,000,000 L (589,000,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-10 Ditch and 216-S-10P and -11 Ponds are located in the 200-RO-1 Operable Unit. The ponds and ditch are monitored by Wells 299-W26-8, 299-W26-9, 299-W26-11, and 699-32-77. Details of these wells and the scintillation profiles used in this evaluation are given in Table A-1.2. The gamma activity in these wells is at background levels.

A-1.4.8 216-S-13 Crib

Waste Description:
Received liquid waste from the 203-5 Decontaminated Metal Storage Facility, the 204-S Uranyl Nitrate Hexahydrate Lag Storage Facility, and the 276-S Organic Solvent make-up Facility. Also received occasional waste from the 204-S Uranyl Nitrate Hexahydrate Facility. Waste is low-salt and neutral/basic.

Service Dates:
January 1952 - July 1972.

Waste Volume:
5,000,000 L (1,300,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-13 Crib is located in the 200-RO-2 Operable Unit directly west of the 202-S Building. The crib is monitored by Well 299-W22-21. Details of the monitoring well and the scintillation profiles used in this evaluation are given in Table A-1.2.

The 216-S-13 Crib has previously been evaluated by Fecht et al. (1977). They noted that breakthrough to groundwater had not occurred at this site and that radioactive contaminants were held high in the sediment column. This evaluation concurs with the findings of Fecht et al. (1977).

Well 299-W22-21 has not been geophysically logged since 1976. The 1976 scintillation profile showed that elevated gamma activity from 6 to 107 ft (2 to 33 m) seen in the 1968 log had declined to near background levels due to radionuclide decay.

9 3 1 2 8 6 9 1 2 4 8

A-1.4.9 216-S-20 Crib

Waste Description:
Received miscellaneous waste from laboratory hoods and decontamination sinks in the 222-S Laboratory via the 219-S Retention Building. Also received above waste via the 207-SL Retention Basin and the 219-S Retention Building and 300 Area laboratory waste via the manhole. Received miscellaneous waste from laboratory hoods and decontamination sinks in 222-S laboratory via 219-S Retention Building.

Service Dates:
January 1952 - May 1973.

Waste Volume:
135,000,000 L (35,700,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-20 Crib is located in Operable Unit 200-RO-3 100 m (300 ft) southeast of the 222-S Laboratory. The crib is monitored by Wells 299-W22-20 and 299-W22-74. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

Fecht et al. (1977) evaluated the gross gamma logs from Well 299-W22-20. They concluded that breakthrough of contaminants had not occurred at this site and that gamma activity had declined to near background levels. This evaluation concurs with the findings of Fecht et al. (1977).

Well 299-W22-20 has not been geophysically logged since 1976. The 1976 log for this well showed that a previous zone of elevated gamma activity at a depth of 150 ft (50 m) had declined to background levels. The 1984 scintillation probe profile from Well 299-W22-74 is shown in Figure A-1.7. This profile shows gamma activity at or near background levels. The small peak at 38 ft (11.5 ,) may be due to natural activity or it may represent a zone of elevated gamma activity that has declined to near background levels due to radionuclide decay. The 299-W22-74 and 299-W22-20 scintillation probe profiles do not indicate that breakthrough to groundwater has occurred at this site.

A-1.4.10 216-S-22 Crib

Waste Description:
Received liquid waste containing nitrate and sodium from the acid recovery facility in the 293-S Building.

Service Dates:
October 1957 - June 1967.

Waste Volume:
98,000 L (26,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-22 Crib is located in the 200-RO-3 Operable Unit approximately 200 m (600 ft) east of the 202-S Building. The crib is monitored by Well 299-W22-19. Details of this monitoring well and the scintillation profiles used in this evaluation are given in Table A-1.2.

Fecht et al. (1977) evaluated the 216-S-22 Crib and noted that the data did not indicate breakthrough to the groundwater and that no elevated gamma activity was apparent in the vadose zone. This evaluation is consistent with the findings of Fecht et al. (1977).

Figure A-1.8 shows the 1984 scintillation probe profile and geologic log from Well 299-W22-19. This profile shows that gamma activity is at background levels throughout the vadose zone.

A-1.4.11 216-S-23 Crib

Waste Description:
Received S Plant Complex process condensate from the D-2 Receiver Tank in the 202-S Building. Waste is low salt and neutral/basic.

Service Dates:
January 1969 - July 1972.

Waste Volume:
34,100,00 L (9,000,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-23 Crib is located in the 200-R-2 Operable Unit northeast of the 241-SY Tank Farm and north of the 216-S-9 Crib. The crib is monitored by Wells 299-W19-5, 299-W19-6, 299-W19-7, 299-W22-37, and 299-W22-38. Details of these monitoring wells and the scintillation profiles used in the evaluation are given in Table A-1.2.

Fecht et al. (1977) evaluated the 216-S-23 Crib and concluded that the data did not indicate breakthrough to the groundwater and that scintillation probe profiles for all of the monitoring wells were at near background gamma activity. This evaluation concurs with the findings of Fecht et al. (1977).

None of the five monitoring wells have been geophysically logged since 1976. The 1976 scintillation probe profiles for these wells were at background levels.

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A-1.4.12 216-S-25 Crib

Waste Description:
Received 241-S evaporator process steam condensate, and 241-SX Tank Farm cooling water.

Service Dates:
November 1973 - present.

Waste Volume:
300,000,000 L (80,000,000 gal).

Evaluation of Scintillation Probe Profiles:

The 216-S-25 Crib is located in the 200-RO-1 Operable Unit 850 m (2,800 ft) northwest of the 202-S Building. The crib is monitored by Wells 299-W23-9, 299-W23-10, and 299-W23-11. Details of these monitoring wells and the scintillation profiles used in this evaluation are given in Table A-1.2.

Fecht et al. (1977) evaluated the 216-S-25 Crib and concluded that the data did not indicate breakthrough to the groundwater and that the scintillation probe profiles for all of the monitoring wells were at near background gamma activity. This evaluation concurs with the findings of Fecht et al. (1977).

None of the three monitoring wells have been geophysically logged since 1976. The 1976 scintillation probe profiles for these wells were at background levels.

A-1.4.13 S Plant Tank Farms

There are three tank farms located in the S Plant Aggregate Area, the 241-S, -SX and -SY Tank Farms. All three tank farms are located immediately adjacent to one another within the 200-R0-2 Operable Unit (Figure 2-4). The 241-S Tank Farm contains 12 single-shell, steel-lined, reinforced concrete tanks with individual capacities of 2,800,000 L (750,000 gal). The 241-SX Tank Farm contains 15 single-shell, steel-lined, reinforced concrete tanks with individual capacities of 3,785,000 L (1,000,000 gal). The 241-SY Tank Farm contains 3 double-shell, double steel-lined tanks within reinforced concrete tanks with individual capacities of 3,785,000 L (1,000,000 gal). All of the tanks contain salt cake, sludge, and/or drainable interstitial liquid (Hanlon 1991). All of the 241-S Tanks and the 241-SX-101 through -106 Tanks have been partially interim isolated. The 241-SX-107 through -115 Tanks have been interim isolated. The 241-SY Tanks have not been isolated. Eleven of the tanks are assumed leakers, the 241-S-104 Tank, 241-SX-104 Tank, and 241-SX-107 through -115 Tanks.

Scintillation probe profiles from selected drywells used to monitor the 241-S, -SX and -SY Tanks were examined and general conclusions reached about the distribution of

radionuclides in the subsurface beneath the tanks. All of the scintillation probe profiles used were generated by TFSA&S, which logs the monitoring wells in the tank farms on a periodic basis.

Elevated levels of gamma activity are detected within the backfill material around the tanks, near the surface and within the upper coarse unit of the Hanford Formation beneath the tanks. The surface elevated gamma activity is not necessarily directly related to tank leakage; it may be partly due to gamma emitters contained within near surface utilities. Elevated gamma activity at the base of the backfill and extending into the underlaying sediments occurs near tanks 241-S-104, 241-S-105, 241-S-110, 241-SX-101, 241-SX-102, 241-SX-103, 241-SX-107, 241-SX-108, 241-SX-109, 241-SX-110, 241-SX-111, 241-SX-112, 241-SX-114, and 241-SX-115.

Downward migration and gamma emitters is indicated beneath the 241-SX-107 and 241-SX-109 Tanks. Downward migration is indicated by increasing levels of gamma activity in boreholes 41-08-07 near the 241-SX-107 Tank and 41-10-01 near the 241-SX-109 Tank.

Because of the limited depth of the wells, the possibility that gamma emitters may have reached the groundwater cannot be ruled out.

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9 3 1 2 8 9 1 2 5 3

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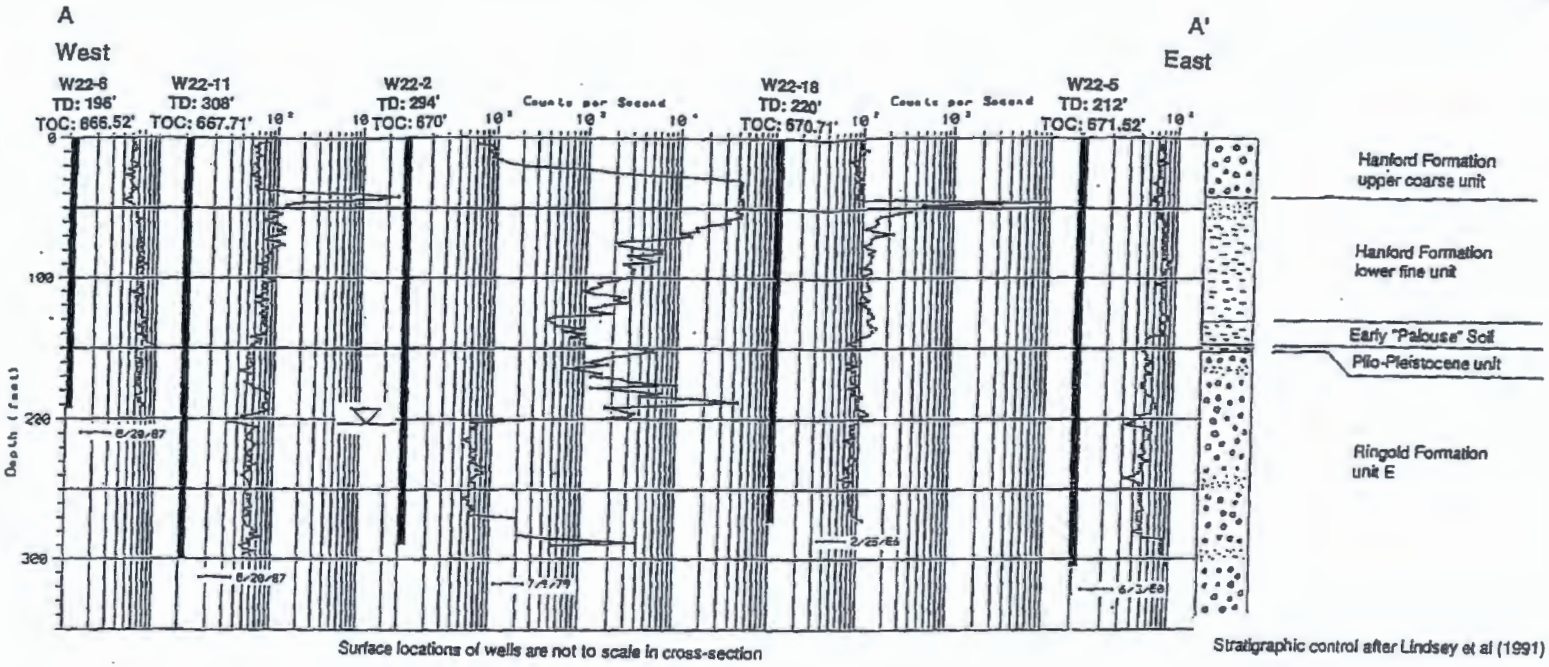
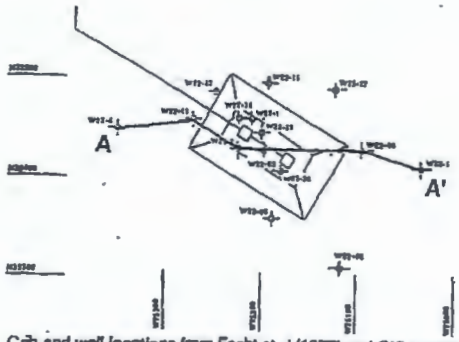


Surface locations of wells are not to scale in cross-section

Stratigraphic control after Lindsey et al (1991)



Crib and well locations from Fecht et al (1977) and GIS coordinates

Figure A1-1. 216-S-1 and 216-S-2 Cribs: Scintillation Probe Profile Cross-section A-A'.

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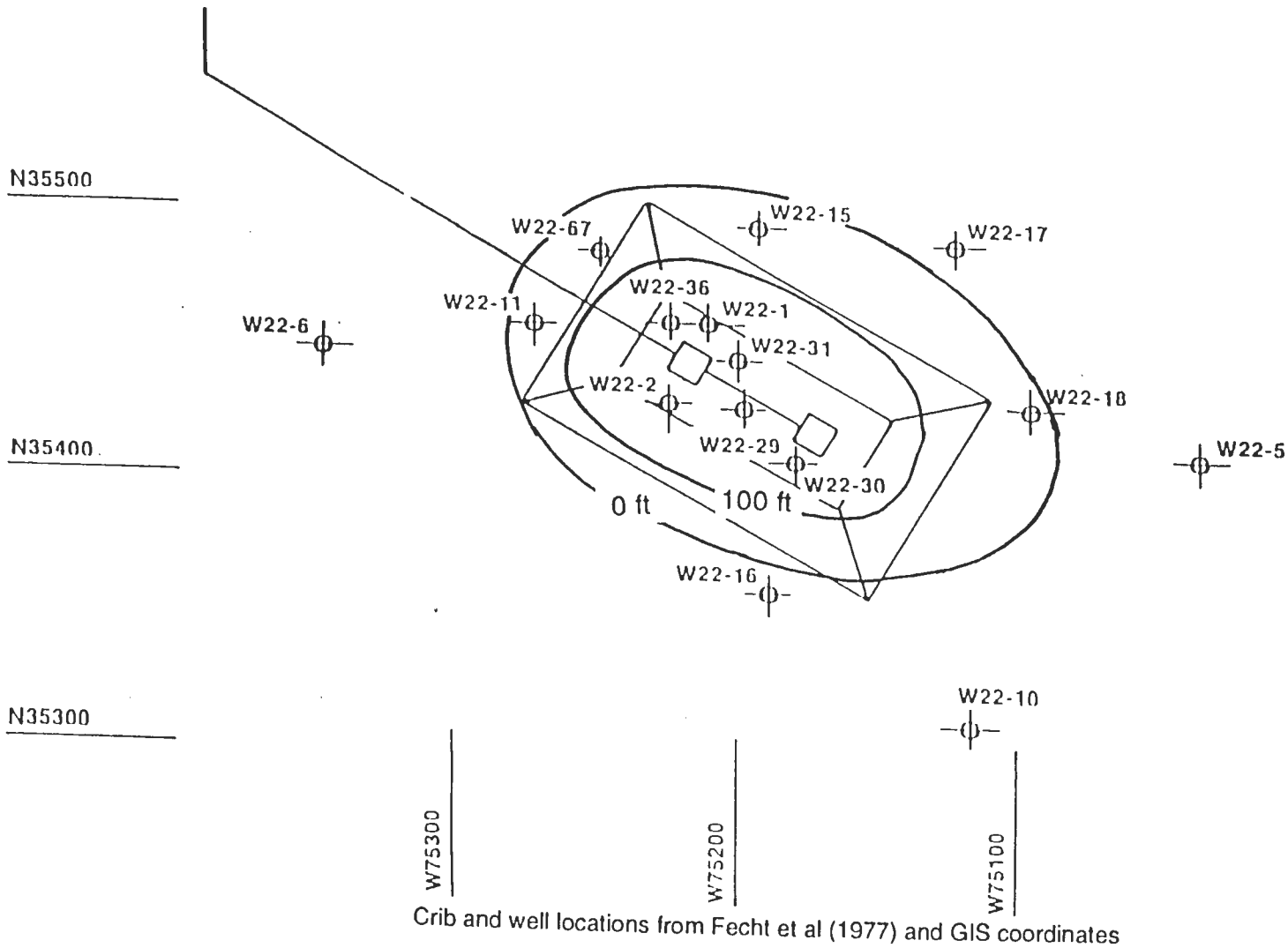
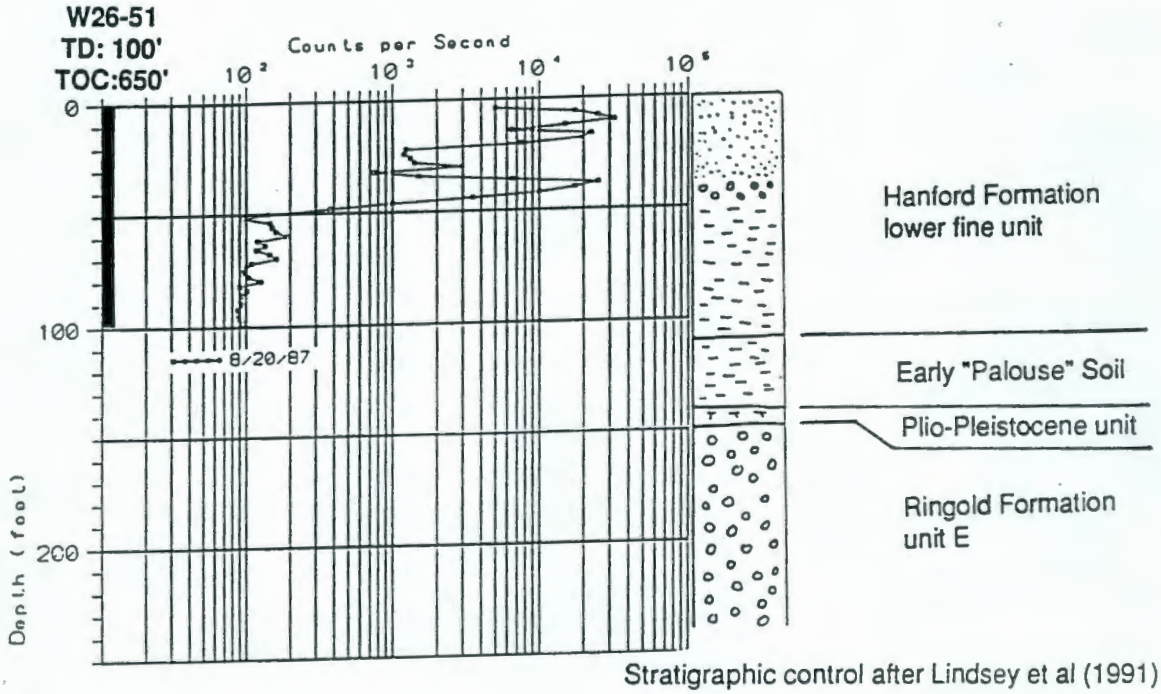
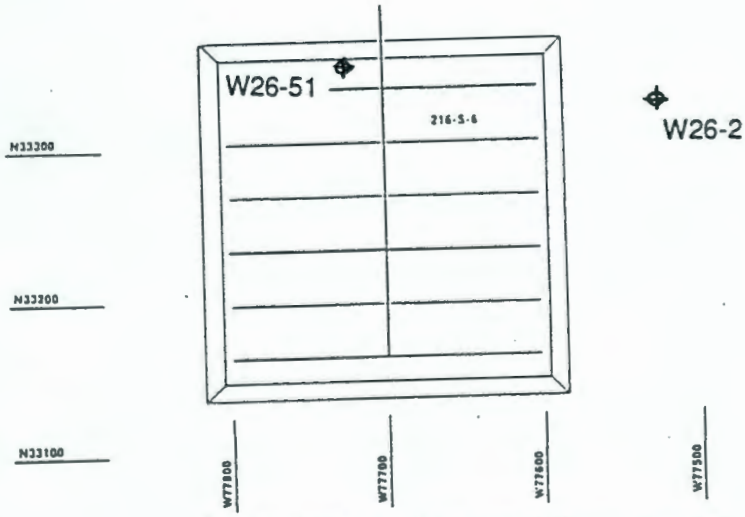


Crib and well locations from Fecht et al (1977) and GIS coordinates

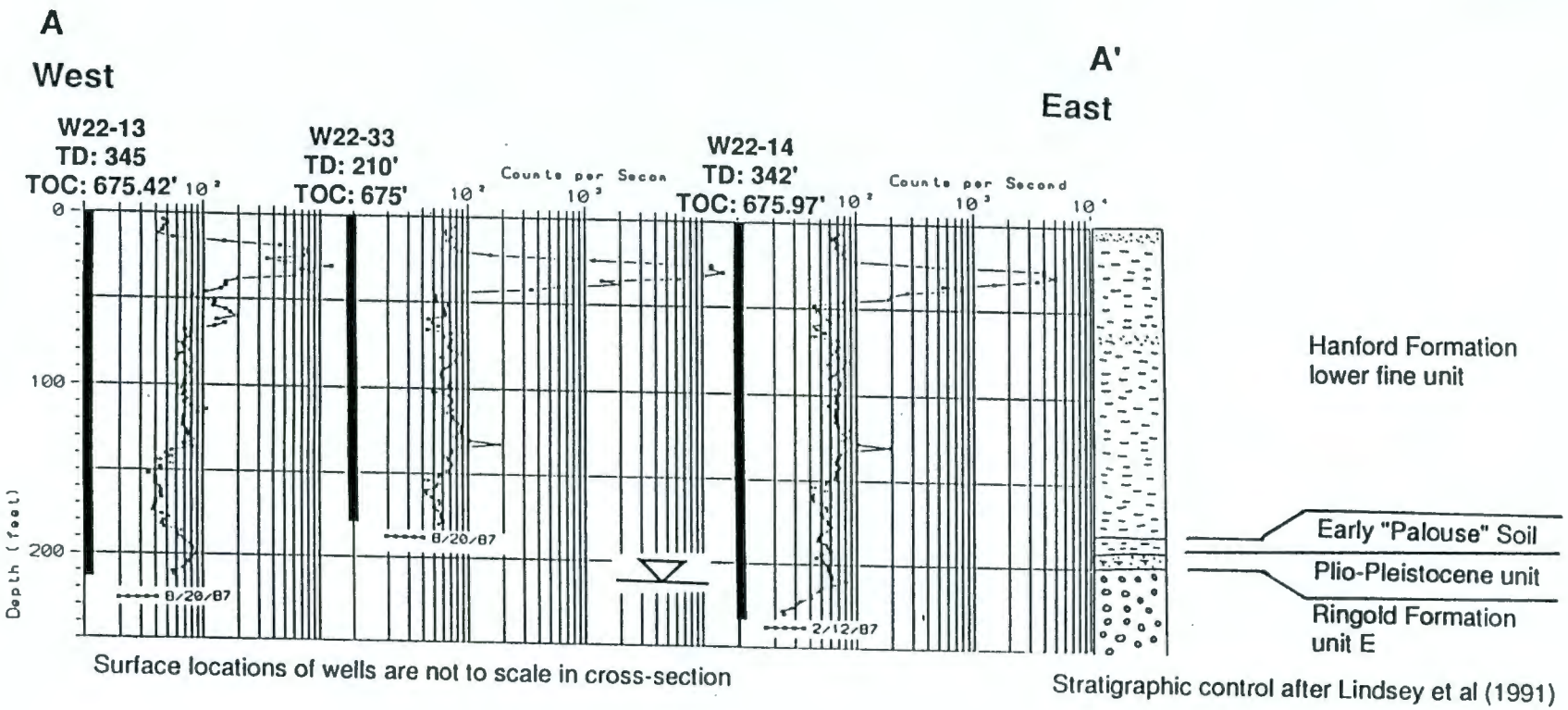
Figure A1-2. 216-S-1 and 216-S-2 Cribs: Elevated Gamma Radiation Isopach Map.

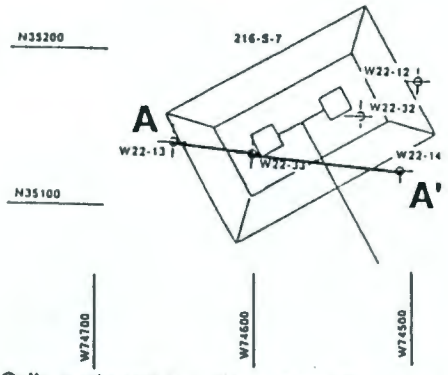




Crib and well locations from GIS coordinates

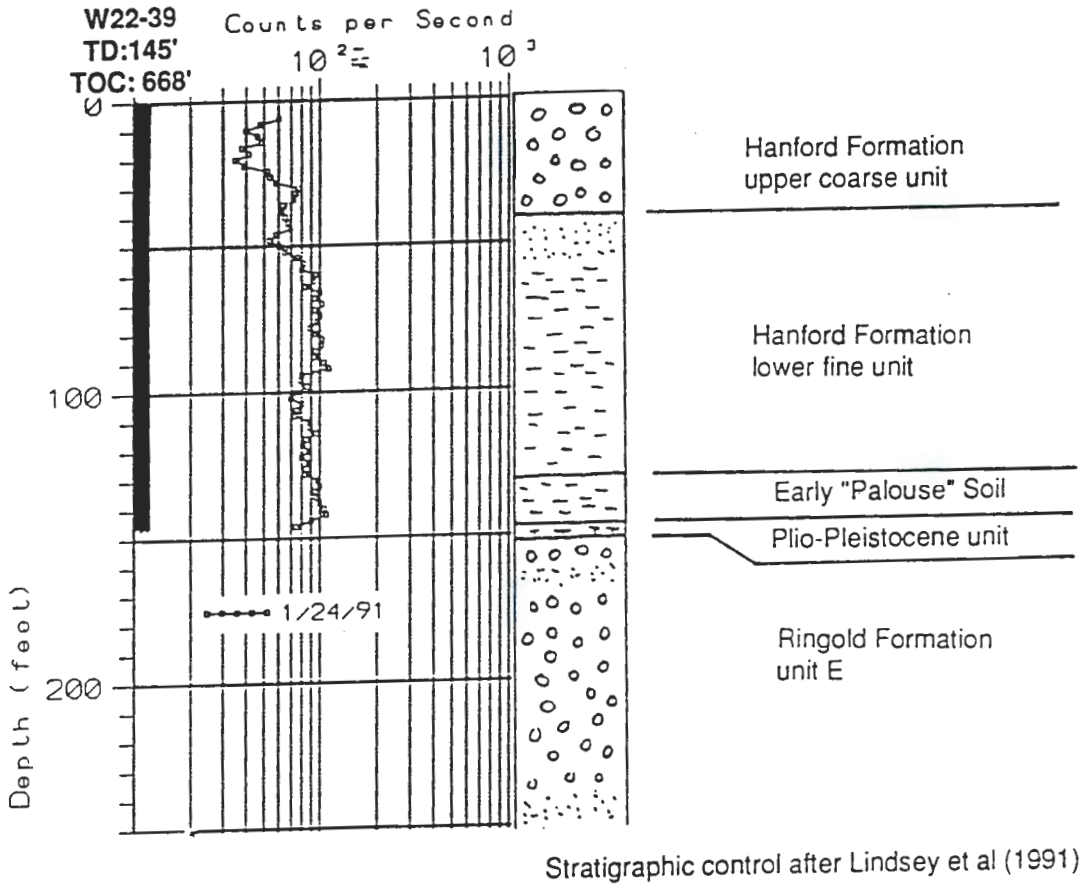
Figure A1-3. 216-S-6 Crib: Scintillation Probe Profile of Well 299-W26-51.

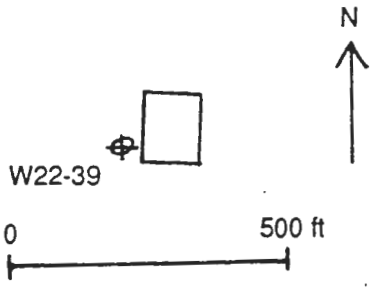




Crib and well locations from Fecht et al (1977)

Figure A1-4. 216-S-7 Crib: Scintillation Probe Profile Cross-section A-A'.





Trench and well locations from GIS coordinates

Figure A1-5. 216-S-8 Trench: Scintillation Probe Profile of Well 299-W22-39.

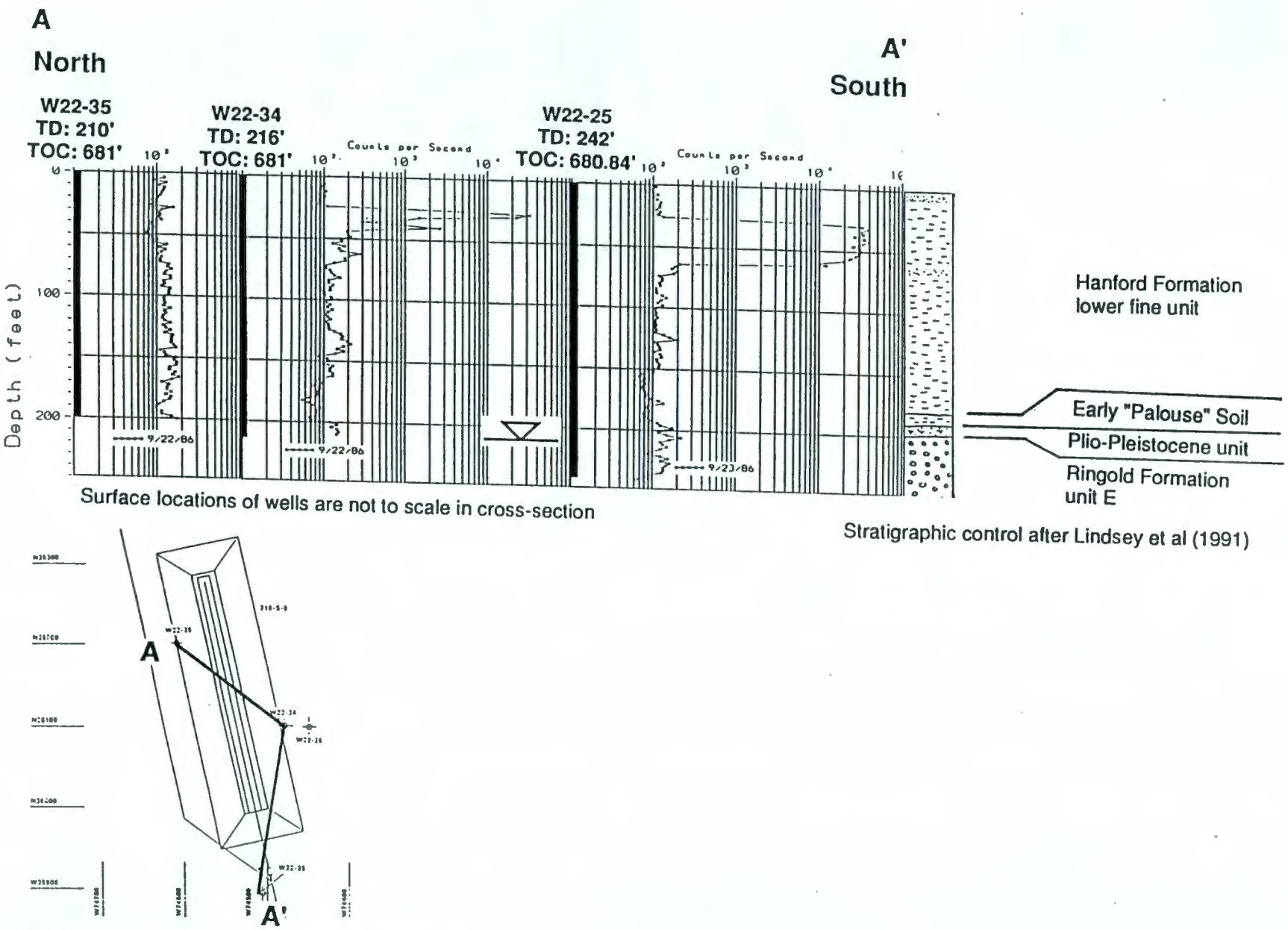


Figure A1-6. 216-S-9 Crib: Scintillation Probe Profile Cross-section A-A'.

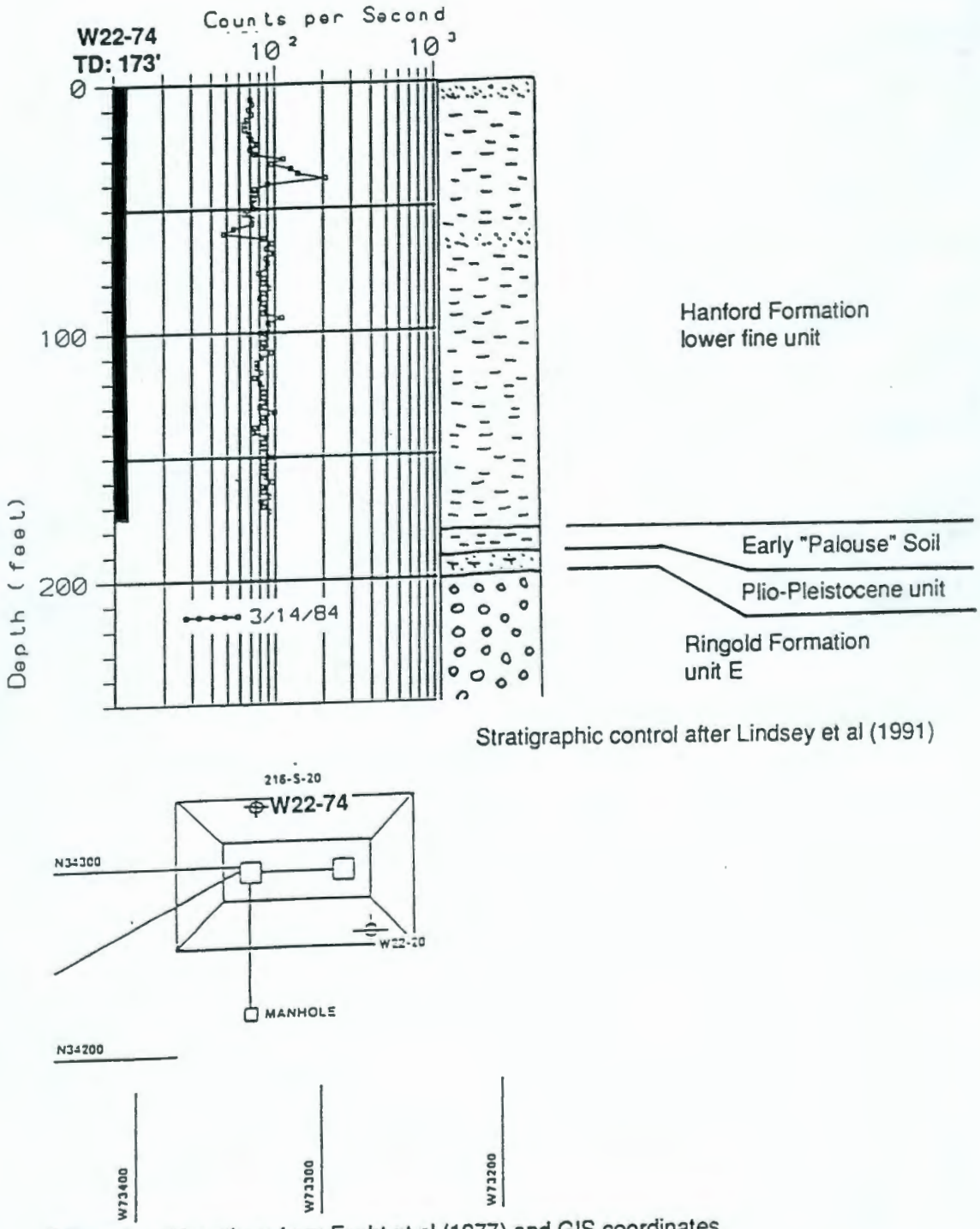
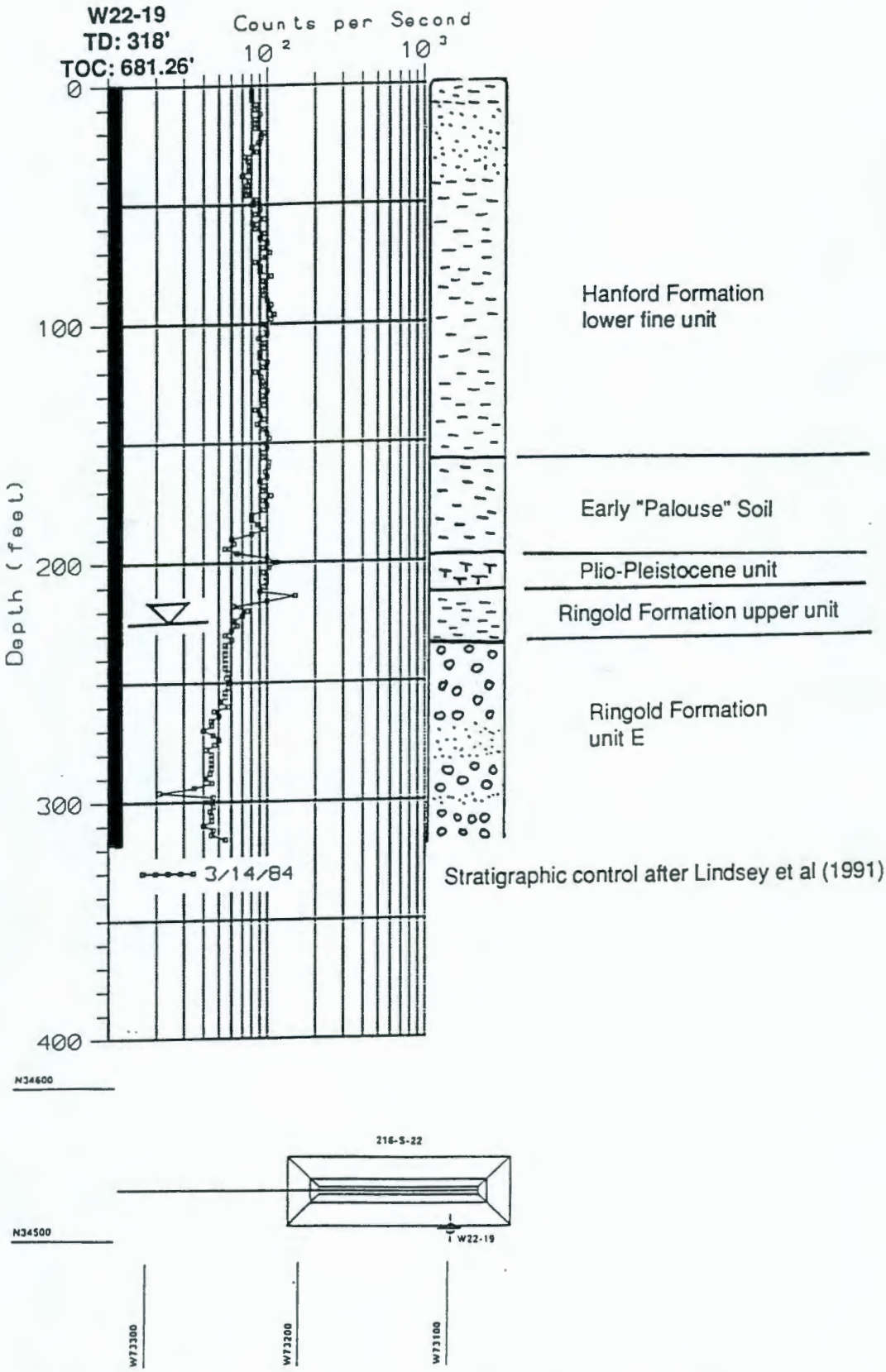


Figure A1-7. 216-S-20 Crib: Scintillation Probe Profile of Well 299-W22-74.

9 3 1 2 8 4 9 1 2 6 1



Crib and well locations from Fecht et al (1977)

Figure A1-8. 216-S-22 Crib: Scintillation Probe Profile of Well 299-W22-19.

9 3 1 2 8 9 1 2 6 2

APPENDIX A.2

SAMPLE DATA

9 3 1 2 3 0 9 1 2 5 3

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W28											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	<7.60E-03	4.40E-02	--	--	1.48E-02	8.19E-02	1.12E-02
Ce-144	--	--	--	--	<7.40E-03	1.30E-01	--	--	-4.21E-02	1.01E-01	2.48E-02
Co-58	*	--	--	--	<-5.20E-03	2.10E-02	--	--	-1.99E-02	2.58E-02	1.26E-02
Co-60	4.00E-02	3.00E-02	--	--	<-2.40E-03	1.50E-02	<3.60E-03	1.40E-02	3.76E-03	1.36E-02	1.24E-02
Cs-134	7.00E-02	4.00E-02	3.00E-02	3.00E-02	2.90E-02	2.00E-02	--	--	-4.52E-03	1.73E-02	3.34E-02
Cs-137	2.10E+01	1.34E+00	3.68E+00	3.90E-01	5.80E+00	5.90E-01	5.30E+00	5.40E-01	3.99E+00	4.11E-01	7.95E+00
Eu-152	9.00E-02	8.00E-02	1.90E-01	1.00E-01	1.20E-01	7.60E-02	1.00E-01	6.60E-02	6.31E-02	5.99E-02	1.13E-01
Eu-154	1.10E-01	7.00E-02	--	--	<5.40E-02	5.50E-02	<4.10E-03	4.70E-02	7.58E-03	4.20E-02	4.39E-02
Eu-155	*	--	--	--	<6.40E-02	7.30E-02	<5.40E-02	5.40E-02	3.38E-02	5.24E-02	5.06E-02
I-129	--	--	--	--	--	--	--	--	-1.37E-01	5.78E-01	1.37E-01
K-40	--	--	--	--	--	--	--	--	1.17E+01	1.36E+00	1.17E+01
Mn-54	*	--	4.00E-02	2.00E-02	<-1.30E-03	1.60E-02	<-8.50E-05	1.40E-02	3.59E-04	1.74E-02	1.04E-02
Nb-95	*	--	--	--	--	--	<-2.00E-02	1.60E-02	-3.57E-02	5.98E-02	2.79E-02
Pb-212	--	--	--	--	--	--	--	--	5.89E-01	7.29E-02	5.89E-01
Pb-214	--	--	--	--	--	--	4.80E-01	7.10E-02	4.96E-01	8.39E-02	4.88E-01
Pu-238	1.10E-03	5.00E-04	2.00E-03	8.00E-04	1.50E-03	5.60E-04	1.80E-03	4.60E-04	3.52E-03	7.65E-04	1.98E-03
Pu-239	1.00E-02	1.00E-02	2.00E-02	0.00E+00	2.00E-02	2.70E-03	3.50E-02	4.00E-03	1.96E-02	2.57E-03	2.09E-02
Ru-106	6.00E-01	4.90E-01	--	--	<-6.50E-02	1.80E-01	<2.20E-02	1.40E-01	6.05E-02	1.61E-01	1.87E-01
Sr-90	6.80E-01	1.30E-01	6.90E-01	1.30E-01	1.00E+00	2.50E-01	1.60E+00	3.00E-01	1.28E+00	2.61E-01	1.05E+00
Tc-99	--	--	--	--	--	--	--	--	2.17E-01	1.17E+00	2.17E-01
U (total)	6.20E-01	1.90E-01	3.00E-01	1.00E-01	2.40E-01	7.20E-02	2.70E-01	8.20E-02	3.05E-01	9.66E-02	3.47E-01
Zn-65	*	--	--	--	3.90E-02	3.70E-02	--	--	-3.19E-02	3.93E-02	3.55E-02
Zr-95	*	--	--	--	<-1.70E-02	3.70E-02	<-7.50E-03	2.50E-02	3.18E-03	4.85E-02	9.23E-03

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W29											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	–	–	–	–	<-1.80E-02	4.20E-02	–	–	–	–	1.80E-02
Ce-144	–	–	2.70E-01	2.30E-01	<-7.60E-02	1.00E-01	–	–	–	–	1.73E-01
Co-58	*	–	–	–	<5.20E-03	1.60E-02	–	–	–	–	5.20E-03
Co-60	*	–	–	–	2.60E-02	1.50E-02	<6.70E-03	1.70E-02	–	–	1.64E-02
Cs-134	*	–	4.00E-02	3.00E-02	<1.60E-02	2.10E-02	–	–	–	–	2.80E-02
Cs-137	2.43E+00	2.30E-01	1.54E+00	1.80E-01	1.10E+00	1.20E-01	1.40E+00	1.50E-01	–	–	1.62E+00
Eu-152	*	–	–	–	1.00E-01	6.90E-02	1.10E-01	6.80E-02	–	–	1.05E-01
Eu-154	*	–	–	–	<4.10E-02	5.50E-02	<2.50E-02	5.10E-02	–	–	3.30E-02
Eu-155	*	–	–	–	<1.20E-02	5.60E-02	6.80E-02	5.80E-02	–	–	4.00E-02
I-129	–	–	–	–	–	–	–	–	–	–	–
K-40	–	–	–	–	–	–	–	–	–	–	–
Mn-54	*	–	–	–	<-2.90E-03	1.90E-02	<7.90E-03	1.60E-02	–	–	5.40E-03
Nb-95	*	–	–	–	–	–	<-1.30E-02	2.20E-02	–	–	1.30E-02
Pb-212	–	–	–	–	–	–	–	–	–	–	–
Pb-214	–	–	–	–	–	–	6.50E-01	8.90E-02	–	–	6.50E-01
Pu-238	1.00E-02	1.70E-03	4.70E-03	1.10E-03	2.40E-03	6.10E-04	5.00E-03	9.10E-04	–	–	5.53E-03
Pu-239	6.00E-02	1.00E-02	5.00E-02	1.00E-02	5.00E-02	5.80E-03	1.20E-01	1.30E-02	–	–	7.00E-02
Ru-106	9.50E-01	3.90E-01	–	–	<2.50E-02	1.40E-01	<-7.50E-02	1.20E-01	–	–	3.50E-01
Sr-90	1.18E+00	2.20E-01	4.90E-01	1.00E-01	4.60E-01	1.20E-01	8.10E-01	1.50E-01	–	–	7.35E-01
Tc-99	–	–	–	–	–	–	–	–	–	–	–
U (total)	4.20E-01	1.40E-01	5.70E-01	1.90E-01	2.70E-01	8.00E-02	3.10E-01	9.40E-02	–	–	3.93E-01
Zn-65	–	–	–	-	<-6.80E-03	4.40E-02	–	–	–	–	6.80E-03
Zr-95	*	–	–	–	<-2.60E-02	3.80E-02	<2.60E-02	3.10E-02	–	–	2.60E-02

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W31											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	–	–	–	–	<-7.80E-03	3.70E-02	–	–	–	–	7.80E-03
Ce-144	–	–	–	–	<-6.00E-02	1.00E-01	–	–	–	–	6.00E-02
Co-58	–	–	–	–	<5.40E-03	1.50E-02	–	–	–	–	5.40E-03
Co-60	–	–	–	–	1.70E-02	1.40E-02	<7.70E-03	1.70E-02	–	–	1.24E-02
Cs-134	–	–	–	–	2.60E-02	2.00E-02	–	–	–	–	2.60E-02
Cs-137	–	–	–	–	3.50E-01	4.70E-02	1.20E+00	1.40E-01	–	–	7.75E-01
Eu-152	–	–	–	–	<1.60E-02	7.30E-02	1.20E-01	7.00E-02	–	–	6.80E-02
Eu-154	–	–	–	–	7.40E-02	4.80E-02	<-1.20E-02	6.00E-02	–	–	4.30E-02
Eu-155	–	–	–	–	<1.30E-02	6.30E-02	<2.30E-02	6.80E-02	–	–	1.80E-02
I-129	–	–	–	–	<-8.30E-02	4.90E-01	–	–	–	–	8.30E-02
K-40	–	–	–	–	–	–	–	–	–	–	–
Mn-54	–	–	–	–	2.40E-02	1.70E-02	<6.90E-03	1.70E-02	–	–	1.55E-02
Nb-95	–	–	–	–	–	–	<-1.40E-02	2.20E-02	–	–	1.40E-02
Pb-212	–	–	–	–	–	–	–	–	–	–	–
Pb-214	–	–	–	–	–	–	5.70E-01	8.10E-02	–	–	5.70E-01
Pu-238	–	–	–	–	1.40E-03	4.10E-04	6.10E-03	1.10E-03	–	–	3.75E-03
Pu-239	–	–	–	–	4.80E-02	5.20E-03	2.40E-01	2.60E-02	–	–	1.44E-01
Ru-106	–	–	–	–	1.50E-01	1.20E-01	<6.80E-02	1.30E-01	–	–	1.09E-01
Sr-90	–	–	–	–	1.60E-01	4.20E-02	3.00E-01	5.90E-02	–	–	2.30E-01
Tc-99	–	–	–	–	<-1.30E-01	9.80E-01	–	–	–	–	1.30E-01
U (total)	–	–	–	–	2.60E-01	7.80E-02	2.00E-01	6.60E-02	–	–	2.30E-01
Zn-65	–	–	–	–	<-3.50E-02	4.50E-02	–	–	–	–	3.50E-02
Zr-95	–	–	–	–	1.20E-03	3.30E-02	<2.80E-02	3.10E-02	–	–	1.46E-02

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W32											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	–	–	–	–	–	–	–	–	–	–	–
Ce-144	–	–	–	–	–	–	–	–	–	–	–
Co-58	–	–	–	–	–	–	–	–	–	–	–
Co-60	–	–	–	–	–	–	<-9.80E-03	1.60E-02	–	–	9.80E-03
Cs-134	–	–	–	–	–	–	–	–	–	–	–
Cs-137	–	–	–	–	–	–	6.60E-01	7.90E-02	–	–	6.60E-01
Eu-152	–	–	–	–	–	–	1.40E-01	6.70E-02	–	–	1.40E-01
Eu-154	–	–	–	–	–	–	<2.50E-02	5.50E-02	–	–	2.50E-02
Eu-155	–	–	–	–	–	–	7.20E-02	5.50E-02	–	–	7.20E-02
I-129	–	–	–	–	–	–	–	–	–	–	–
K-40	–	–	–	–	–	–	–	–	–	–	–
Mn-54	–	–	–	–	–	–	<3.70E-03	1.60E-02	–	–	3.70E-03
Nb-95	–	–	–	–	–	–	<-3.10E-02	2.10E-02	–	–	3.10E-02
Pb-212	–	–	–	–	–	–	–	–	–	–	–
Pb-214	–	–	–	–	–	–	6.50E-01	8.30E-02	–	–	6.50E-01
Pu-238	–	–	–	–	–	–	1.00E-03	4.50E-04	–	–	1.00E-03
Pu-239	–	–	–	–	–	–	4.30E-02	5.10E-03	–	–	4.30E-02
Ru-106	–	–	–	–	–	–	<2.70E-02	1.30E-01	–	–	2.70E-02
Sr-90	–	–	–	–	–	–	3.20E-01	6.10E-02	–	–	3.20E-01
Tc-99	–	–	–	–	–	–	–	–	–	–	–
U (total)	–	–	–	–	–	–	2.60E-01	8.10E-02	–	–	2.60E-01
Zn-65	–	–	–	–	–	–	–	–	–	–	–
Zr-95	–	–	–	–	–	–	<1.40E-02	2.60E-02	–	–	1.40E-02

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W33											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	<2.30E-02	3.50E-02	--	--	-1.35E-02	8.62E-02	1.83E-02
Ce-144	--	--	--	--	<5.30E-02	9.50E-02	--	--	-2.07E-02	1.06E-01	3.69E-02
Co-58	*	--	--	--	<-6.00E-03	1.60E-02	--	--	1.83E-02	2.53E-02	1.22E-02
Co-60	*	--	2.00E-02	2.00E-02	<-3.60E-03	1.40E-02	<1.50E-02	1.80E-02	1.48E-02	1.68E-02	1.34E-02
Cs-134	4.00E-02	4.00E-02	3.00E-02	2.00E-02	5.50E-02	2.00E-02	--	--	-3.92E-02	2.00E-02	4.11E-02
Cs-137	1.91E+00	1.90E-01	1.26E+00	1.40E-01	2.00E+00	2.10E-01	1.70E+00	1.80E-01	1.93E+00	2.04E-01	1.76E+00
Eu-152	*	--	1.40-01	8.00E-02	1.40E-01	6.40E-02	<2.10E-02	9.30E-02	4.79E-02	7.58E-02	8.72E-02
Eu-154	*	--	--	--	<2.60E-02	4.90E-02	9.80E-02	6.30E-02	-4.30E-02	5.92E-02	5.57E-02
Eu-155	*	--	--	--	<3.20E-02	4.80E-02	<5.90E-03	8.00E-02	3.78E-02	5.33E-02	2.52E-02
I-129	--	--	--	--	<-3.10E-01	5.60E-01	--	--	-3.95E-02	2.97E-01	1.75E-01
K-40	--	--	--	--	--	--	--	--	1.47E+01	1.63E+00	1.47E+01
Mn-54	*	--	--	--	<4.60E-03	1.60E-02	<1.30E-02	1.80E-02	1.95E-02	1.43E-02	1.24E-02
Nb-95	*	--	--	--	--	--	<-1.30E-02	2.40E-02	-1.87E-02	6.77E-02	1.59E-02
Pb-212	--	--	--	--	--	--	--	--	7.36E-01	8.48E-02	7.36E-01
Pb-214	--	--	--	--	--	--	6.40E-01	9.30E-02	5.40E-01	7.46E-02	5.90E-01
Pu-238	4.00E-03	9.00E-04	2.80E-03	9.00E-04	3.10E-03	6.70E-04	2.80E-03	6.50E-04	5.30E-03	8.85E-04	3.60E-03
Pu-239	8.00E-02	1.00E-02	9.00E-02	1.00E-02	1.20E-01	1.20E-02	1.40E-01	1.50E-02	1.27E-01	1.30E-02	1.11E-01
Ru-106	*	--	--	--	<4.00E-03	1.30E-01	<2.20E-02	1.60E-01	-2.28E-02	1.65E-01	1.63E-02
Sr-90	9.80E-01	1.80E-01	5.10E-01	1.00E-01	5.60E-01	1.40E-01	4.90E-01	9.30E-02	5.59E-01	1.10E-01	6.20E-01
Tc-99	--	--	--	--	<4.50E-02	9.80E-01	--	--	1.40E-01	1.17E+00	9.25E-02
U (total)	3.30E-01	1.10E-01	4.70E-01	1.60E-01	2.40E-01	7.40E-02	3.50E-01	1.10E-01	3.60E-01	1.11E-01	3.50E-01
Zn-65	*	--	--	--	<-7.80E-03	3.60E-02	--	--	-1.27E-01	5.43E-02	6.74E-02
Zr-95	*	--	--	--	<2.00E-02	3.40E-02	<-2.50E-02	3.60E-02	-8.27E-03	5.34E-02	1.79E-02

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W34											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	4.00E-02	3.70E-02	--	--	3.58E-02	6.89E-02	3.79E-02
Ce-144	--	--	--	--	<6.20E-02	8.80E-02	--	--	-4.20E-02	8.84E-02	5.20E-02
Co-58	*	--	--	--	<6.20E-04	1.60E-02	--	--	-1.53E-03	2.52E-02	1.08E-03
Co-60	5.00E-02	3.00E-02	--	--	<9.00E-03	1.60E-02	2.30E-02	1.50E-02	9.46E-03	1.24E-02	2.29E-02
Cs-134	6.00E-02	4.00E-02	6.00E-02	3.00E-02	3.70E-02	1.80E-02	--	--	9.89E-03	1.28E-02	4.17E-02
Cs-137	1.89E+00	2.00E-01	1.56E+00	1.80E-01	9.10E-01	1.00E-01	9.10E-01	1.00E-01	8.23E-01	9.50E-02	1.22E+00
Eu-152	1.50E-01	1.10E-01	1.00E-01	1.00E-01	1.10E-01	6.40E-02	1.40E-01	7.20E-02	5.31E-02	6.41E-02	1.11E-01
Eu-154	*	--	--	--	5.40E-02	4.50E-02	<1.40E-02	4.70E-02	-4.42E-03	4.55E-02	2.41E-02
Eu-155	1.70E-01	1.20E-01	--	--	<1.20E-02	5.30E-02	<4.30E-02	4.50E-02	5.89E-02	4.77E-02	7.10E-02
I-129	--	--	--	--	--	--	--	--	-3.70E-01	4.94E-01	3.70E-01
K-40	--	--	--	--	--	--	--	--	1.33E+01	1.50E+00	1.33E+01
Mn-54	*	--	2.00E-02	2.00E-02	<-5.80E-03	1.70E-02	<8.40E-04	1.50E-02	9.41E-04	1.59E-02	6.90E-03
Nb-95	*	--	4.00E-02	4.00E-02	--	--	<-2.00E-02	1.60E-02	-5.20E-02	5.95E-02	3.73E-02
Pb-212	--	--	--	--	--	--	--	--	7.42E-01	8.50E-02	7.42E-01
Pb-214	--	--	--	--	--	--	5.40E-01	7.30E-02	5.27E-01	7.27E-02	5.34E-01
Pu-238	3.56E-01	3.38E-02	3.52E-01	3.49E-02	3.90E-01	4.30E-02	3.90E-01	3.90E-02	2.81E-01	2.78E-02	3.54E-01
Pu-239	1.70E-01	2.00E-02	2.00E-01	2.00E-02	6.10E-02	7.20E-03	1.70E-01	1.70E-02	8.25E-02	8.46E-03	1.37E-01
Ru-106	*	--	--	--	<-5.20E-02	1.30E-01	<3.40E-02	1.20E-01	8.89E-02	1.39E-01	5.83E-02
Sr-90	1.27E+00	2.30E-01	1.55E+00	2.80E-01	4.70E-01	1.20E-01	6.10E-01	1.20E-01	6.22E-01	1.19E-01	9.04E-01
Tc-99	--	--	--	--	--	--	--	--	-1.51E-01	1.14E+00	1.51E-01
U (total)	3.70E-01	1.20E-01	5.00E-01	1.70E-01	2.70E-01	8.00E-02	2.40E-01	7.70E-02	4.83E-01	1.44E-01	3.73E-01

Table A-2.1. Results of Grid Soil Sampling (pCi/g).

Location 2W34											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Zn-65	1.60E-01	9.00E-02	7.00E-02	5.00E-02	<3.40E-03	3.80E-02	--	--	-1.89E-02	3.91E-02	6.31E-02
Zr-95	*	--	--	--	<6.50E-03	3.10E-02	<-4.40E-04	2.50E-02	2.23E-02	5.07E-02	9.75E-03

NOTE: Negative values indicate concentrations at or near background levels or radioactivity.
A dashed line (--) indicates no data are available.
Shaded Areas indicate a positive detection, the result is larger than the error.
An asterisk (*) indicates that radionuclide concentration is less than detectable. The detection limits are as follows: mn-54=2.0E-02, Co-58=2.0e-02, Co-60+2.0e-02, Zn-65=4.0E-02, Sr-90=5.0E-03, Nb-95=3.0E-02, Zr-95=3.0E-02, Ru-106=1.7E-01, Cs-134=2.0E-02, Cs-137=2.0E-02, Eu-152=1.1E-01, Eu-154=5.0E-02, Eu-155=5.0E-02, Pu-238=6.0E-04, Pu-239+6.0E-04, and U total=1.0E-02.
Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.

Table A-2.2. 1990 Results of Grid Soil Sampling (pCi/g).

Radionuclide	Location 2W27		Location 2W28		Location 2W29		Location 2W31		Location 2W37	
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error
Be-7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	--	--	--	--
CePr-144	5.38E-01	1.39E+00	-1.61E+00	1.63E+00	-1.67+00	2.02E+00	-4.73E-01	1.91E+00	2.57E-01	1.75+00
Co-60	1.25-02	3.49E-02	7.43E-03	4.11E-02	0.00E+00	0.00E+00	4.16E-03	4.17E-02	-1.15E-02	3.91E-02
Cs-134	-9.92E-02	5.56E-02	-1.44E-01	6.16E-02	-9.54E-02	6.94E-02	-5.62E-02	6.20E-02	-1.53E-02	6.29E-02
Cs-137	4.89E-01	8.17E-02	2.03E+00	2.30E+00	8.24E+00	8.57E-01	6.27E+00	6.59E-01	5.46E+00	5.78E-01
Eu-154	-1.39E-02	1.22E-01	-2.95E-03	1.02E-01	-5.85E-02	1.24E-01	-7.97E-02	1.27E-01	8.28E-02	1.09E-01
Eu-155	1.13E-01	1.31E-01	7.40E-02	1.48E-01	5.99E-02	2.07E-01	7.75E-02	1.85E-01	1.69E-01	1.81E-01
K-40	1.24E+01	1.65E+00	1.30E+01	1.68E+00	1.54E+01	2.01E+00	1.28E+01	1.70E+00	1.39E+01	1.85+00
Pb-212	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--
Pu-238	4.81E-04	2.09E-04	1.03E-03	3.70E-04	1.21E-03	3.57E-04	5.99E-03	1.00E-03	9.93E-04	5.19E-04
Pu-239/240	6.14E-03	9.29E-04	2.42E-02	3.01E-03	2.92E-02	3.30E-03	3.07E-01	3.15E-02	4.17E-02	5.99E-03
Ra-225	--	--	--	--	--	--	--	--	--	--
Ru-106	-4.86E-01	7.04E-01	3.01E-01	7.76E-01	8.62E-02	1.12E+00	7.36E-01	9.86E-01	1.10E+00	1.01E+00
Sb-125	-2.26E-02	1.39E-01	-3.88E-03	1.41E-01	1.24E-01	2.50E-01	-5.65E-02	2.07E-01	4.23E-02	1.86E-01
Sr-90	1.38E-01	2.68E-02	6.17E-01	1.19E-01	2.60E-01	5.06E-02	6.25E-01	1.16E-01	1.87E+00	3.36E-01
U (total)	7.61E-01	1.44E-01	7.58E-01	1.08E-01	6.63E-01	9.99E-02	9.12E-01	1.31E-01	5.16E-01	9.37E-02
U-235	1.63E-02	2.07E-02	4.65E-02	2.11E-02	2.49E-02	1.73E-02	5.45E-02	2.86E-02	1.76E-02	1.60E-02
U-238	7.63E-01	1.43E-01	7.85E-01	1.10E-01	6.71E-01	9.93E-02	1.01E+00	1.45E-01	5.51E-01	9.59E-02
Zn-65	4.13E-02	3.85E-01	-1.79E-01	3.40E-01	0.00E+00	0.00E+00	7.26E-02	3.52E-01	-6.69E-01	4.40E-01
ZrNb-95	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	--	--	--	--

Table A-2.2. 1990 Results of Grid Soil Sampling (pCi/g).

Radionuclide	Location 2W38		Location 2W39		Location 2W41		Location 2W51		Location 2W52	
	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error
Be-7	--	--	-8.01E+00	5.88E+01	-1.50E+01	2.73E+01	-6.36E+00	2.38E+01	-7.39E-01	2.55E+01
CePr-144	-2.65E-02	1.40E+00	1.07E-01	7.42E-01	9.77E-02	4.70E-01	-3.49E-01	5.33E-01	-1.30E-01	4.76E-01
Co-60	-4.45E-02	4.19E-02	1.42E-02	2.32E-02	1.69E-02	2.12E-02	1.30E-02	1.76E-02	7.42E-03	1.88E-02
Cs-134	-5.64E-02	6.02E-02	-3.89E-02	3.25E-02	-4.78E-02	2.11E-02	-3.91E-02	2.01E-02	-3.17E-01	4.50E-02
Cs-137	6.03E-01	9.65E-02	9.85E+00	9.96E-01	1.03E+00	1.14E-01	3.79E-01	4.82E-02	1.92E-01	3.00E-02
Eu-154	-2.54E-02	9.97E-02	-3.12E-02	6.75E-02	3.80E-02	5.43E-02	4.46E-02	5.83E-02	3.39E-02	6.02E-02
Eu-155	1.08E-01	1.24E-01	1.08E-01	1.02E-01	7.25E-02	6.43E-02	7.27E-02	6.37E-02	6.25E-02	6.36E-02
K-40	1.54E+01	2.00E+00	1.36E+01	1.54E+00	1.32E+01	1.46E+00	1.36E+01	1.50E+00	1.40E+01	1.54E+00
Pb-212	--	--	6.39E-01	8.12E-02	6.68E-01	7.66E-02	6.57E-01	7.57E-02	7.18E-01	8.14E-02
Pb-214	--	--	6.07E-01	9.70E-02	5.74E-01	7.73E-02	5.77E-01	7.94E-02	6.28E-01	7.79E-02
Pu-238	7.36E-04	2.95E-04	3.93E-02	5.10E-03	3.60E-03	1.26E-03	2.19E-03	8.96E-04	6.50E-04	3.27E-04
Pu-239/240	2.85E-02	3.35E-03	1.16E+00	1.21E-01	6.05E-02	9.45E-03	3.58E-02	5.77E-03	1.32E-02	1.96E-03
Ra-225	--	--	5.29E-01	8.35E-02	5.44E-01	7.25E-02	4.9E-01	6.93E-02	5.43E-01	7.07E-02
Ru-106	3.07E-02	9.05E-01	7.80E-02	4.54E-01	-6.17E-02	2.60E-01	-6.75E-02	2.56E-01	-2.33E-00	2.66E-01
Sb-125	-2.86E-02	1.30E-01	6.88E-04	1.26E-01	2.48E-02	5.52E-02	2.96E-02	4.93E-02	4.57E-03	4.86E-02
Sr-90	3.47E-01	6.27E-02	2.88E+00	5.29E-01	7.11E-01	1.34E-01	1.84E-01	3.67E-02	4.57E-02	1.10E-02
U (total)	6.20E-01	1.75E-01	8.28E-01	1.21E-01	8.71E-01	1.19E-01	7.86E-01	1.13E-01	9.19E-01	1.24E-01
U-235	1.07E-02	2.76E-02	2.71E-02	1.86E-02	4.05E-02	1.99E-02	4.07E-02	2.08E-02	2.82E-02	1.74E-02
U-238	5.80E-01	1.67E-01	8.23E-01	1.19E-01	8.40E-01	1.14E-01	8.51E-01	1.18E-01	9.59E-01	1.26E-01
Zn-65	-5.78E-01	4.21E-01	-4.23E-01	1.55E-01	-4.82E-01	1.46E-01	-1.58E-01	1.15E-01	-4.58E-01	1.48E-01
ZrNb-95	--	--	-1.61E+00	3.34E+00	3.45E+00	2.95E+00	-1.42E+00	3.09E+00	-5.07E+00	2.96E+00

NOTE: Negative values indicate concentrations at or near background levels of radioactivity.
Shaded Areas indicate a positive detection, the result is larger than the error.
Source: Schmidt et al. 1991.

Table A-2.3. Results of Fenceline Soil Sampling (pCi/g).

Location S-TF-SE											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	–	–	–	–	<3.80E-02	<4.80E-02	<4.40E-02	5.70E-02	-8.91E-02	1.93E-01	5.70E-02
Ce-144	–	–	–	–	<-2.60E-02	1.60E-01	–	–	-2.37E-01	2.77E-01	1.32E-01
Co-58	*	–	–	–	<-9.20E-03	1.50E-02	–	–	-1.15E-02	2.86E-02	1.04E-02
Co-60	*	–	–	–	<-1.20E-02	1.70E-02	–	–	-6.60E-03	1.87E-02	9.30E-03
Cs-134	3.70E-02	1.80E-02	3.20E-02	2.30E-02	3.20E-02	2.00E-02	<1.80E-03	2.90E-02	-3.88E-02	3.67E-02	2.83E-02
Cs-137	1.22E+01	7.52E-01	7.19E+00	7.34E-01	2.00E+01	2.00E+00	3.70E+01	3.80E+00	4.64E+01	4.65E+00	2.46E+01
Eu-152	*	–	–	–	<4.70E-02	6.40E-02	<-4.40E-03	7.70E-02	1.45E-01	8.53E-02	6.55E-02
Eu-154	*	–	–	–	4.70E-02	4.60E-02	<2.90E-02	4.90E-02	1.33E-02	5.71E-02	2.98E-02
Eu-155	*	–	–	–	<2.30E-02	8.70E-02	<-9.90E-03	1.20E-01	4.13E-02	1.19E-01	2.47E-02
I-129	–	–	–	–	–	–	–	–	–	–	–
K-40	–	–	–	–	–	–	–	–	1.38E+01	1.58E+00	1.38E+01
Mn-54	2.90E-02	1.50E-02	–	–	<3.50E-03	1.50E-02	<6.80E-03	1.70E-02	1.52E-02	2.02E-02	1.36E-02
Nb-95	*	–	–	–	–	–	–	–	-7.43E-02	6.11E-02	7.43E-02
Pb-212	–	–	–	–	–	–	–	–	6.32E-01	1.08E-01	6.32E-01
Pb-214	–	–	–	–	–	–	–	–	5.07E-01	1.35E-01	5.07E-01
Pu-238	*	–	4.00E-04	3.00E-04	1.10E-03	8.40E-04	1.70E-02	2.20E-03	–	–	6.17E-03
Pu-239	3.90E-02	1.00E-02	9.00E-03	2.00E-03	2.40E-02	4.40E-03	4.90E-02	5.50E-03	–	–	3.03E-02
Ru-106	1.87E-01	1.86E-01	–	–	<-6.10E-02	2.00E-01	<-4.00E-01	3.00E-01	1.32E-01	3.76E-01	1.95E-01
Sr-90	3.12E+00	5.69E-01	2.25E+00	4.15E-01	3.80E+00	9.50E-01	9.80E+00	1.80E+00	–	–	4.74E+00
Tc-99	–	–	–	–	–	–	–	–	–	–	–
U (total)	3.34E-01	1.11E-01	3.87E-01	1.27E-01	2.50E-01	1.20E-01	2.80E-01	9.00E-02	–	–	3.13E-01
Zn-65	*	–	–	–	<5.80E-03	3.30E-02	–	–	-9.11E-03	4.53E-02	7.46E-03
Zr-95	*	–	–	–	<6.70E-03	2.60E-02	<2.80E-02	3.00E-02	-2.75E-02	5.28E-02	2.07E-02

Table A-2.3. Results of Fenceline Soil Sampling (pCi/g).

Location S-TF-NE											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	<-2.00E-03	3.30E-02	<-2.40E-03	3.40E-02	-1.64E-02	1.06E-01	6.93E-03
Ce-144	--	--	--	--	<3.00E-02	1.10E-01	--	--	4.17E-02	1.40E-01	3.59E-02
Co-58	*	--	--	--	<-2.70E-02	2.20E-02	--	--	4.47E-02	3.30E-02	3.59E-02
Co-60	1.70E-02	1.60E-02	3.50E-02	2.00E-02	3.00E-02	1.80E-02	--	--	9.62E-03	2.08E-02	2.29E-02
Cs-134	4.50E-02	2.10E-02	5.50E-02	2.70E-02	4.50E-02	2.30E-02	<9.90E-03	2.00E-02	-4.69E-02	2.33E-02	4.04E-02
Cs-137	7.80E+00	4.87E-01	3.59E+00	3.81E-01	2.60E+00	2.80E-01	4.20E+00	4.30E-01	8.00E-01	9.75E-02	3.80E+00
Eu-152	*	--	1.31E-01	8.80E-02	1.10E-01	5.90E-02	<-1.60E-03	9.10E-02	1.02E-01	9.67E-02	8.62E-02
Eu-154	*	--	--	--	<-2.80E-02	5.70E-02	<1.30E-02	5.60E-02	3.14E-02	6.88E-02	2.41E-02
Eu-155	1.04E-01	8.00E-02	--	--	<1.70E-02	6.60E-02	<1.80E-02	7.20E-02	2.77E-02	8.13E-02	4.17E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	1.45E+01	1.70E+00	1.45E+01
Mn-54	*	--	--	--	<1.10E-02	1.70E-02	<8.10E-03	1.90E-02	2.45E-02	2.39E-02	1.45E-02
Nb-95	*	--	--	--	--	--	--	--	6.43E-02	7.23E-02	6.43E-02
Pb-212	--	--	--	--	--	--	--	--	7.62E-01	9.31E-02	7.62E-01
Pb-214	--	--	--	--	--	--	--	--	5.08E-01	7.93E-02	5.08E-01
Pu-238	*	--	9.00E-04	5.00E-04	8.20E-04	4.50E-04	1.60E-03	6.50E-04	--	--	1.11E-03
Pu-239	4.00E-02	5.00E-03	1.20E-02	2.00E-03	1.20E-02	2.10E-03	2.20E-02	3.60E-03	--	--	2.15E-02
Ru-106	*	--	--	--	<-5.60E-03	1.70E-01	<-1.60E-02	1.80E-01	7.82E-02	1.95E-01	3.33E-02
Sr-90	2.86E+00	5.25E-01	4.24E+00	7.77E-01	1.20E+00	3.00E-01	1.90E+00	3.60E-01	--	--	2.55E+00
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U (total)	3.73E-01	1.22E-01	4.38E-01	1.44E-01	2.70E-01	1.30E-01	2.50E-01	8.10E-02	--	--	3.33E-01
Zn-65	*	--	--	--	<3.10E-02	4.80E-02	--	--	-1.96E-01	8.05E-02	1.14E-01
Zr-95	*	--	--	--	<5.50E-03	3.10E-02	<-7.80E-03	3.40E-02	2.51E-02	6.56E-02	1.28E-02

Table A-2.3. Results of Fenceline Soil Sampling (pCi/g).

Location S-TF-WE											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Ce-141	--	--	--	--	<-8.40E-04	3.30E-02	<5.00E-03	2.90E-02	-2.85E-02	9.03E-02	1.14E-02
Ce-144	--	--	--	--	<-4.60E-02	1.20E-01	--	--	6.16E-03	1.33E-01	2.61E-02
Co-58	5.10E-02	2.10E-02	--	--	<1.20E-02	1.30E-02	--	--	-1.58E-03	2.51E-02	2.15E-02
Co-60	2.50E-02	2.40E-02	--	--	<-5.20E-02	2.20E-02	--	--	-1.77E-02	1.80E-02	3.16E-02
Cs-134	4.80E-02	2.50E-02	3.80E-02	2.00E-02	3.70E-02	1.80E-02	<5.20E-03	1.90E-02	-1.19E-02	1.88E-02	2.80E-02
Cs-137	1.94E+00	1.40E-01	4.38E+00	4.54E-01	4.60E+00	4.70E-01	3.30E+00	3.40E-01	4.48E+00	4.59E-01	3.74E+00
Eu-152	*	--	1.18E-01	7.50E-02	<-3.70E-02	7.20E-02	<7.50E-02	7.60E-02	-1.36E-02	7.85E-02	6.09E-02
Eu-154	*	--	--	--	<-1.50E-02	4.80E-02	<2.60E-02	5.10E-02	6.92E-03	5.15E-02	1.60E-02
Eu-155	*	--	--	--	<-5.50E-03	6.60E-02	7.00E-02	6.50E-02	2.24E-02	7.23E-02	3.26E-02
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	1.36E+01	1.54E+00	1.36E+01
Mn-54	*	--	--	--	<-2.30E-03	1.50E-02	<-8.00E-03	1.60E-02	1.96E-02	1.73E-02	9.97E-03
Nb-95	*	--	--	--	--	--	--	--	-3.79E-02	5.28E-02	3.79E-02
Pb-212	--	--	--	--	--	--	--	--	5.90E-01	7.44E-02	5.90E-01
Pb-214	--	--	--	--	--	--	--	--	4.39E-01	7.23E-02	4.39E-01
Pu-238	9.00E-04	8.00E-04	1.30E-03	6.00E-04	7.60E-04	3.40E-04	3.60E-04	2.20E-04	--	--	8.30E-04
Pu-239	1.40E-02	3.00E-03	2.00E-02	3.00E-03	1.70E-02	2.40E-03	9.90E-03	1.50E-03	--	--	1.52E-02
Ru-106	--	--	--	--	<1.00E-01	1.40E-01	<2.70E-02	1.90E-01	1.40E-01	1.90E-01	8.90E-02
Sr-90	5.13E-01	9.90E-02	2.34E+00	4.24E-01	2.40E+00	5.90E-01	7.40E-01	1.40E-01	--	--	1.50E+00
Tc-99	--	--	--	--	--	--	--	--	--	--	--
U (total)	2.79E-01	9.60E-02	2.28E-01	7.60E-02	3.70E-01	1.70E-01	2.40E-01	7.80E-02	--	--	2.79E-01

Table A-2.3. Results of Fenceline Soil Sampling (pCi/g).

Location S-TF-WE											
	1985		1986		1987		1988		1989		Average Result
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Zn-65	*	--	--	--	<-1,80E-02	3.90E-02	--	--	-3.28E-02	5.05E-02	2.54E-02
Zr-95	*	--	--	--	<5.90E-03	3.10E-02	<1.60E-02	3.10E-02	1.13E-02	5.06E-02	1.11E-02

NOTE: Negative values indicate concentrations at or near background levels of radioactivity.
A dash (--) indicates that no data were available.
Shaded Areas indicated a positive detection, the result is larger than the error.
An asterisk (*) indicates that radionuclide concentration is less than detectable. The detection limits are as follows: Mn-54=2.0E-02, Co-58=2.0E-02, Co-60=2.0E-02, Zn-65=4.0E-02, Sr-90=5.0E-03, Nb-95=3.0E-02, Zr-95=3.0E-02, Ru-106=1.7E-01, Cs-134=2.0E-02, Cs-137=2.0E-02, Eu-152=1.1E-01, Eu-154=5.0E-02, Eu-155=5.0E-02, Pu-238=6.0E-04, Pu-239=6.0E-04, and U total=1.0E-02.
Source: Schmidt et al. 1990, Elder et al. 1986, 1987, 1988, 1989.

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W28.

Radionuclide	1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error		1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Be-7	–	–	–	–	–	–		–	–	1.84E+00	3.43E-01	1.84E+00
Ce-144	–	–	–	–	–	–		–	–	7.79E-03	3.06E-02	7.79E-03
Co-58	1.94E-01	9.3E-02	–	–	–	–		–	–	–	–	1.94E-01
Co-60	–	–	–	–	–	–		1.40E-02	1.40E-02	1.34E-02	1.95E-02	1.37E-02
Cs-134	–	–	–	–	–	–		–	–	–	–	–
Cs-137	2.09E+00	2.31E-01	–	–	–	–		1.40E+00	1.40E-01	7.63E-01	8.91E-02	1.40E+00
Eu-152	–	–	–	–	–	–	<	2.20E-02	6.1E-02	2.51E-02	9.19E-02	2.36E-02
Eu-154	2.49E-01	2.29E-01	–	–	–	–	<	-3.90E-02	5.00E-02	1.00E-02	5.96E-02	9.93E-02
Eu-155	–	–	–	–	–	–	<	1.00E-02	3.90E-02	-1.79E-02	3.93E-02	1.40E-02
I-129	–	–	–	–	–	–	<	5.50E-02	2.50E-01	7.81E-02	1.40E-01	6.66E-02
K-40	–	–	–	–	–	–		–	–	1.16E+01	1.38E+00	1.16E+01
Nb-95	–	–	–	–	–	–	<	5.80E-03	1.50E-02	-1.71E-02	2.99E-02	1.15E-02
Pb-212	–	–	–	–	–	–		–	–	2.31E-02	3.07E-02	2.31E-02
Pb-214	–	–	–	–	–	–		–	–	2.58E-02	3.01E-02	2.58E-02
Pu-238	–	–	–	–	–	–		–	–	1.46E-04	1.50E-04	1.46E-04
Pu-239	–	–	–	–	–	–		–	–	4.66E-03	8.09E-04	4.66E-03
Ru-103	–	–	–	–	–	–		–	–	–	–	–
Ru-106	–	–	–	–	–	–		–	–	–	–	–
Sr-90	–	–	–	–	–	–		5.80E-01	1.10E-01	3.55E-01	6.91E-02	4.68E-01
Tc-99	–	–	–	–	–	–	<	1.00E+00	1.80E+00	3.7E-01	1.07E+00	6.85E-01
Zn-65	3.91E-01	2.09E-01	–	–	–	–		–	–	–	–	–
Zr-95	–	–	–	–	–	–		–	–	-2.55E-02	3.68E-02	2.55E-02

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W29.

Radionuclide	1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--	--	--	--	--	--
Co-58	9.70E-02	4.60E-02	--	--	--	--	--	--	--	--	9.70E-02
Co-60	8.10E-02	4.30E-02	--	--	--	--	1.90E-02	1.50E-02	--	--	5.00E-02
Cs-134	--	--	9.00E-02	2.70E-02	--	--	--	--	--	--	9.00E-02
Cs-137	--	--	2.05E-01	4.00E-02	--	--	1.10E+00	1.20E-01	--	--	6.53E-01
Eu-152	--	--	1.18E-01	6.00E-02	--	--	1.10E-01	6.90E-02	--	--	1.14E-01
Eu-154	--	--	--	--	--	--	6.60E-02	4.70E-02	--	--	6.60E-02
Eu-155	--	--	--	--	--	--	< 3.70E-03	4.70E-02	--	--	3.70E-03
I-129	--	--	--	--	--	--	--	--	--	--	--
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	--	--	< -1.30E-02	4.00E-02	--	--	1.30E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	8.10E-02	5.70E-02	--	--	--	--	--	--	8.10E-02
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	4.20E-01	8.00E-02	--	--	4.20E-01
Tc-99	--	--	--	--	--	--	--	--	--	--	--
Zn-65	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	--	--	--	--	--	--	--

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W31

Radionuclide	1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Be-7	--	--	--	--	--	--	--	--	--	--	--
Ce-144	--	--	--	--	--	--	--	--	--	--	--
Co-58	--	--	--	--	--	--	--	--	--	--	--
Co-60	3.60E-02	3.20E-02	--	--	< 7.50E-03	1.40E-02	< 1.10E-02	1.80E-02	--	--	1.82E-02
Cs-134	--	--	--	--	2.90E-02	1.80E-02	--	--	--	--	2.90E-02
Cs-137	--	--	--	--	1.30E-01	2.70E-02	1.70E-01	2.90E-02	--	--	1.50E-01
Eu-152	--	--	--	--	< 1.60E-02	5.60E-02	< -1.30E-02	7.50E-02	--	--	1.45E-02
Eu-154	--	--	--	--	< -1.70E-02	4.80E-02	< 4.20E-02	5.30E-02	--	--	2.95E-02
Eu-155	--	--	--	--	--	--	< 2.50E-02	4.30E-02	--	--	2.50E-02
I-129	--	--	--	--	< -1.40E-01	2.80E-01	--	--	--	--	1.40E-01
K-40	--	--	--	--	--	--	--	--	--	--	--
Nb-95	--	--	--	--	< 6.40E-03	2.40E-02	< -5.30E-02	7.00E-02	--	--	2.97E-02
Pb-212	--	--	--	--	--	--	--	--	--	--	--
Pb-214	--	--	--	--	--	--	--	--	--	--	--
Pu-238	--	--	--	--	--	--	--	--	--	--	--
Pu-239	--	--	--	--	--	--	--	--	--	--	--
Ru-103	--	--	--	--	--	--	--	--	--	--	--
Ru-106	--	--	--	--	--	--	--	--	--	--	--
Sr-90	--	--	--	--	--	--	--	--	--	--	--
Tc-99	--	--	--	--	< 4.10E-01	8.50E-01	--	--	--	--	4.10E-01
Zn-65	--	--	--	--	--	--	--	--	--	--	--
Zr-95	--	--	--	--	4.60E-02	2.90E-02	--	--	--	--	4.60E-02

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W32

Radionuclide	1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Be-7											
Ce-144											
Co-58											
Co-60							< -3.80E-04	3.50E-02			3.80E-04
Cs-134											
Cs-137	8.90E-02	6.30E-02					5.10E-01	6.90E-02			3.00E-01
Eu-152							< -4.70E-03	1.50E-01			4.70E-03
Eu-154							< -4.80E-02	1.10E-01			4.80E-02
Eu-155							< 6.00E-02	9.10E-02			6.00E-02
I-129											
K-40											
Nb-95							1.60E-01	1.30E-01			1.14E-01
Pb-212											
Pb-214											
Pu-238											
Pu-239											
Ru-103											
Ru-106											
Sr-90							3.80E-01	7.30E-02			3.80E-01
Tc-99											
Zn-65	1.51E-01	8.40E-02									
Zr-95											

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W33

	1985		1986		1987		1988		1989		
Radionuclide	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	Average Result
Be-7									1.89E+00	3.19E-01	1.89E+00
Ce-144									-1.58E-02	2.75E-02	1.58E-02
Co-58											
Co-60	8.90E-02	5.60E-02			< 1.30E-02	1.70E-02	< 1.10E-02	1.60E-02	-1.24E-02	1.72E-02	3.14E-02
Cs-134	1.31E-01	5.90E-02	9.60E-02	2.50E-02							
Cs-137	3.13E-01	9.50E-02	2.79E-01	4.40E-02							
Eu-152	4.31E-01	2.74E-01	7.80E-02	6.20E-02							
Eu-154											
Eu-155											
I-129											
K-40											
Nb-95											
Pb-212											
Pb-214											
Pu-238											
Pu-239											
Ru-103			1.54E-01	6.00E-02							
Ru-106											
Sr-90											
Tc-99											
Zn-65	2.36E-01	1.89E-01									
Zr-95											

Table A-2.4. Results of Vegetation Soil Sampling (pCi/g)
Location 2W34

Radionuclide	1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Be-7											
Ce-144											
Co-58											
Co-60											
Cs-134											
Cs-137											
Eu-152											
Eu-154											
Eu-155											
I-129											
K-40											
Nb-95											
Pb-212											
Pb-214											
Pu-238											
Pu-239											
Ru-103											
Ru-106											
Sr-90											
Tc-99											
Zn-65											
Zr-95											

Table A-2.5. Results of Vegetation Soil Sampling for 1990 (pCi/g).

	Location 2W37		Location 2W41	
Radionuclide	Result	Error	Result	Error
Be-7	1.31E-01	1.92E-01	3.13E-02	2.12E-01
CePr-144	7.79E-02	1.19E-01	9.72E-02	1.31E-01
Co-60	7.56E-03	1.37E-02	9.43E-03	1.44E-02
Cs-137	5.22E-01	6.08E-02	1.69E-01	2.80E-02
Eu-154	9.92E-04	4.64E-02	8.18E-03	4.73E-02
Eu-155	--	--	4.11E-02	3.63E-02
K-40	1.55E+01	1.67E+00	9.38E+00	1.09E+00
Pb-212	2.11E-02	2.08E-02	--	--
Pb-214	--	--	--	--
Pu-238	6.11E-04	4.46E-04	8.25E-04	3.46E-04
Pu-234/240	1.14E-02	2.37E-03	6.46E-03	1.21E-03
Ru-106	1.87E-02	1.20E-01	3.85E-02	1.3E-01
Sb-125	1.03E-02	3.25E-02	6.24E-03	3.48E-02
Sr-90	1.60E-01	3.14E-02	6.34E-02	1.33E-02
U	1.49E-02	6.04E-03	1.99E-02	7.44E-03
Zn-65	-3.63E-03	3.88E-02	-4.04E-03	4.40E-02
ZrNb-95	5.17E-02	4.31E-02	1.67E-02	4.16E-02

Source: Schmidt et al. 1991
Negative values indicated concentrations at or near background levels of radioactivity.
Shaded areas indicate a positive detection, the result is greater than the error.
A dash (--) indicates that radionuclide concentration is less than detectable. The detection limits are as follows: Mn-54 = 2.0E-02, Co-58 = 2.0E-02, Co-60 = 2.0E-02, Zn-65 = 4.0E-02, Sr-90 = 5.0E-03, Nb-95 = 3.0E-02, Zr-95 = 3.0E-02, Ru-106 = 1.7E-01, Cs-134 = 2.0E-02, Cs-137 = 2.0E-02, Eu-152 = 1.1E-01, Eu-154 = 5.0E-02, Eu-155 = 5.0E-02, Pu-238 = 6.0E-04, Pu-239 = 6.0E-04, and U total = 1.0E-02.

9 3 1 2 8 4 9 1 2 8 3

Table A-2.6. Results of Air Monitoring (pCi/m3)
Location N956

Radionuclide		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sr-90	max	1.10E-02		2.96E-03		2.03E-04		2.30E-04	1.20E-04	2.82E-04	1.29E-04	2.94E-03
	min	1.28E-04		1.49E-04		9.74E-05		< 6.80E-06	6.30E-05	1.26E-05	4.94E-05	7.88E-05
	avg	2.94E-03	1.08E-02	9.12E-04	2.74E-03	1.40E-04	9.61E-05	9.30E-05	1.00E-04	9.99E-05	8.23E-05	8.37E-04
Cs-137	max	1.42E-03		2.37E-03		2.58E-03		1.10E-03	6.10E-04	1.63E-03	4.62E-04	1.82E-03
	min	4.05E-04		-3.61E-04		-4.02E-04		< -1.90E-04	5.40E-04	-2.86E-05	6.53E-04	2.77E-04
	avg	9.66E-04	8.38E-04	6.22E-04	2.41E-03	1.46E-03	2.58E-03	5.40E-04	5.50E-04	7.33E-04	5.45E-04	8.64E-04
Pu-239	max	3.38E-05		2.61E-05		8.77E-06		1.20E-05	6.20E-06	8.03E-06	3.99E-06	1.77E-05
	min	3.09E-06		8.42E-06		3.12E-06		< 9.30E-07	2.50E-06	1.75E-06	2.09E-06	3.46E-06
	avg	1.72E-05	3.13E-05	1.44E-05	1.59E-05	5.29E-06	4.95E-06	6.90E-06	5.20E-06	3.95E-06	2.97E-06	9.55E-06
U(total)	max	8.90E-04		8.29E-05		2.47E-05		< -1.30E-05	1.80E-05	3.62E-05	1.73E-05	2.09E-04
	min	3.22E-05		2.34E-05		-1.38E-06		< -2.00E-06	1.90E-05	0.00E+00	2.09E-05	1.18E-05
	avg	2.76E-04	8.32E-04	4.96E-05	5.14E-05	1.05E-05	2.51E-06	-7.30E-06	5.80E-06	1.43E-05	1.80E-05	7.15E-05

Table A-2.6. Results of Air Monitoring (pCi/m3)
Location N963

Radionuclide		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sr-90	max	1.50E-02		3.23E-04		1.07E-04		1.80E-04	1.30E-04	2.58E-05	6.39E-05	3.13E-03
	min	1.15E-04		7.50E-05		9.31E-06		< 3.10E-05	8.30E-05	9.65E-06	8.24E-05	4.80E-05
	avg	3.86E-03	1.49E-02	2.00E-05	2.14E-04	5.99E-05	8.30E-05	1.10E-04	6.40E-05	1.75E-05	7.83E-05	8.13E-04
Cs-137	max	3.20E-04		1.68E-03		2.37E-04		6.60E-04	5.80E-04	-3.82E-04	5.47E-04	6.56E-04
	min	4.04E-05		-2.52E-04		-4.12E-04		< 5.00E-05	4.40E-04	1.20E-04	5.55E-04	1.75E-04
	avg	2.43E-04	2.71E-04	4.23E-04	1.73E-03	-1.15E-04	5.70E-04	1.00E-04	4.10E-04	1.20E-04	5.55E-04	2.00E-04
Pu-239	max	2.77E-05		1.23E-05		3.82E-05		5.20E-05	1.40E-05	1.01E-05	4.80E-06	2.81E-05
	min	7.38E-06		4.97E-06		6.38E-06		< 1.00E-06	1.90E-06	2.20E-06	2.28E-06	4.39E-06
	avg	1.56E-05	1.75E-05	8.76E-06	6.18E-06	2.01E-05	2.83E-05	1.60E-05	2.50E-05	7.32E-06	4.01E-06	1.36E-05
U(total)	max	1.37E-04		3.46E-05		4.93E-05		< -4.60E-06	1.80E-05	6.28E-05	2.63E-05	5.77E-05
	min	2.62E-05		2.77E-05		1.67E-06		< 1.80E-06	2.10E-05	3.77E-06	2.00E-05	1.22E-05
	avg	7.11E-05	1.04E-04	3.13E-05	5.80E-06	3.33E-05	4.43E-05	-1.90E-06	2.90E-06	3.54E-04	2.54E-05	9.83E-05

Source: Schmidt et al. 1990; Elder et al. 1986, 1987, 1988, 1989.
Negative values indicate concentrations at or near background levels of radioactivity.
Shaded areas indicate a positive detection, the result is greater than the error.
A dash (-) indicates that radionuclide concentration is less than detectable. The detection limits are as follows: Mn-54 = 2.0E-02, Co-58 = 2.0E-02, Co-60 = 2.0E-02, Zn-65 = 4.0E-02, Sr-90 = 5.0E-03, Nb-95 = 3.0E-02, Zr-95 = 3.0E-02, Ru-106 = 1.7E-01, Cs-134 = 2.0E-02, Cs-137 = 2.0E-02, Eu-152 = 1.1E-01, Eu-154 = 5.0E-02, Eu-155 = 5.0E-02, Pu-238 = 6.0E-04, Pu-239=6.0E-04, and U total = 1.0E-02.

Table A-2.7. Results of Air Monitoring for 1990 (pCi/m^3).

Radionuclide		Location N956		Location N963	
		Result	Error	Result	Error
Sr-90	Quarter 1	1.30E-05	5.78E-05	9.65E-06	8.24E-05
	Quarters 2-4	1.64E-04	6.70E-05	1.04E-05	6.10E-05
	Average	8.85E-05	6.24E-05	1.00E-05	7.17E-05
Cs-137	Quarter 1	4.62E-04	3.92E-04	3.11E-04	4.61E-04
	Quarters 2-4	9.58E-04	8.10E-04	9.30E-05	6.30E-04
	Average	7.10E-04	6.01E-04	2.02E-04	5.46E-04
Pu-239	Quarter 1	8.03E-06	3.99E-06	9.99E-06	4.98E-06
	Quarters 2-4	8.53E-06	6.20E-06	1.18E-06	4.00E-06
	Average	8.28E-06	5.10E-06	1.09E-05	4.49E-06
U (total)	Quarter 1	1.81E-05	1.36E-05	6.28E-05	2.63E-05
	Quarters 2-4	1.66E-05	1.90E-06	1.77E-05	4.40E-06
	Average	1.74E-05	7.75E-06	4.03E-05	1.54E-05

Source: Schmidt et al. 1991
Negative values indicated concentrations at or near background levels of radioactivity.
Shaded areas indicate a positive detection, the result is greater than the error.
The detection limits are as follows: Mn-54 = 2.0E-02, Co-58 = 2.0E-02, Co-60 = 2.0E-02, Zn-65 = 4.0E-02, Sr-90 = 5.0E-03, Nb-95 = 3.0E-02, Zr-95 = 3.0E-02, Ru-106 = 1.7E-01, Cs-134 = 2.0E-02, Cs-137 = 2.0E-02, Eu-152 = 1.1E-01, Eu-154 = 5.0E-02, Eu-155 = 5.0E-02, Pu-238 = 6.0E-04, Pu-239 = 6.0E-04, and U total = 1.0E-02.

Table A-2.8. Results of Vegetation Soil Sampling for 1991 (pCi/g).

Radionuclide	Location 105		Location 106	
	Result	Error	Result	Error
Be-7	5.8E+00	8.2E+00	-1.7E+00	1.1E+01
CePr-144	3.9E-01	1.0E+00	-2.9E-01	1.2E+00
Co-60	-3.1E-02	9.0E-02	2.7E-02	7.6E-02
Cs-134	2.9E-02	7.2E-02	7.9E-04	8.1E-02
Cs-137	9.9E-02	9.0E-02	-1.6E-03	9.0E-02
Eu-154	-5.4E-02	2.2E-01	3.3E-01	2.5E-01
Eu-155	-1.8E-01	1.9E-01	1.1E-01	1.9E-01
K-40	1.2E+01	2.7E+00	9.1E+00	2.7E+00
Pu-238	1.4E-04	1.2E-04	1.5E-04	1.6E-04
Pu-234/240	8.5E-03	1.2E-03	2.1E-03	5.9E-04
Ru-106	-8.0E-01	9.1E-01	5.6E-01	9.2E-01
Sb-125	2.0E-02	1.9E-01	7.4E-02	2.1E-01
Sr-90	1.1E-02	4.5E-03	6.0E-03	3.4E-03
U-234	4.4E-02	7.5E-03	-1.5E-05	2.7E-03
U-235	4.8E-03	2.6E-03	6.5E-04	2.3E-03
U-238	2.1E-02	4.9E-03	-2.1E-03	3.3E-03
Zn-65	-3.1E-01	2.8E-01	2.4E-01	2.6E-01
ZrNb-95	-3.2E-01	1.5E+00	8.0E-01	1.3E+00

Source: Schmidt et al. 1991.
Negative values indicate concentrations at or near background levels of radioactivity.
Shaded areas indicate a positive detection, the result is greater than the error.
The detection limits are as follows: Mn-54=2.0E-02, Co-58=2.0E-02, Co-60=2.0E-02, Zn-65=4.0E-02, Sr-90=5.0E-03 Nb-95=3.0E-02, Zr-95=3.0E-02, Ru-106=1.7E-01, Cs-134=2.0E-02, Cs-137=2.0E-02, Eu-152=1.2E-01, Eu-154=5.0E-02, Eu-155=5.0E-02, Pu-238=6.0E-04, Pu-239=6.0E-04, and U total=1.0E-02.

Table A-2.9. Results of Air Monitoring for 1991 (pCi/m³).

Radionuclide		Location N959 Result	Location N959 Error	Location N963 Result	Location N963 Error
Be-7	Quarters 1-2	7.2E-02	4.6E-02	5.5E-02	7.0E-02
	Quarters 3-4	7.5E-02	2.0E-02	9.9E-02	2.0E-02
	Average	7.3E-02	3.3E-02	7.7E-02	4.5E-02
CePr-144	Quarters 1-2	1.5E-03	2.9E-03	5.3E-04	2.2E-03
	Quarters 3-4	-4.1E-04	2.1E-03	-2.6E-03	2.1E-03
	Average	5.6E-04	2.5E-03	-1.0E-03	2.2E-03
Co-60	Quarters 1-2	0.0E+00	3.0E-04	-1.2E-04	3.3E-04
	Quarters 3-4	1.4E-04	1.7E-04	5.9E-05	1.9E-04
	Average	6.8E-05	6.8E-05	-2.8E-05	2.6E-04
Cs-134	Quarters 1-2	8.3E-04	2.7E-04	-1.5E-04	2.3E-04
	Quarters 3-4	-1.9E-04	2.5E-04	-1.2E-04	2.3E-04
	Average	-8.8E-05	2.6E-04	-1.4E-04	2.3E-04
Cs-137	Quarters 1-2	2.2E-04	2.6E-04	-2.5E-04	1.8E-04
	Quarters 3-4	9.8E-04	3.2E-04	6.8E-05	2.2E-04
	Average	6.0E-04	2.9E-04	-8.9E-05	2.0E-04
Eu-154	Quarters 1-2	-3.7E-04	1.0E-03	-3.8E-05	6.6E-04
	Quarters 3-4	3.1E-04	6.4E-04	3.4E-05	5.3E-04
	Average	-3.0E-05	8.3E-04	-2.3E-06	5.9E-04
Eu-155	Quarters 1-2	-4.2E-04	5.1E-04	5.8E-05	3.1E-04
	Quarters 3-4	-1.7E-04	4.6E-04	5.2E-05	4.5E-04
	Average	-3.0E-04	4.8E-04	5.5E-05	3.8E-04
K-40	Quarters 1-2	2.0E-03	2.7E-03	8.1E-03	3.7E-03
	Quarters 3-4	3.7E-03	3.1E-03	7.3E-03	2.8E-03
	Average	2.8E-03	2.9E-03	7.7E-03	3.2E-03
Pu-238	Quarters 1-2	2.1E-08	2.9E-07	1.4E-06	9.8E-07
	Quarters 3-4	4.0E-07	4.9E-07	3.2E-06	1.6E-06
	Average	2.1E-07	3.9E-07	2.3E-06	1.3E-06
Pu-234/240	Quarters 1-2	4.8E-06	1.7E-06	2.8E-06	1.4E-06
	Quarters 3-4	1.5E-05	3.1E-06	9.6E-06	2.9E-06
	Average	1.0E-05	2.4E-06	6.2E-06	2.2E-06

Table A-2.9. Results of Air Monitoring for 1991 (pCi/m³).

Radionuclide		Location N959 Result	Location N959 Error	Location N963 Result	Location N963 Error
Ru-106	Quarters 1-2	-2.2E-03	2.8E-03	-3.4E-04	2.4E-03
	Quarters 3-4	3.4E-04	2.2E-06	-6.1E-04	2.1E-03
	Average	-9.2E-04	2.5E-03	-4.8E-04	2.3E-03
Sb-125	Quarters 1-2	0.0E+00	6.9E-04	1.6E-04	5.6E-04
	Quarters 3-4	2.8E-04	5.1E-04	-3.0E-04	5.6E-04
	Average	1.4E-04	6.4E-04	-7.1E-05	5.6E-04
Sr-90	Quarters 1-2	3.6E-05	2.5E-04	-5.4E-06	2.1E-05
	Quarters 3-4	1.5E-03	3.4E-04	9.3E-04	3.2E-05
	Average	7.7E-04	1.6E-04	4.4E-05	2.6E-05
U-234	Quarters 1-2	9.3E-06	3.4E-06	1.1E-05	5.0E-06
	Quarters 3-4	7.8E-06	2.6E-06	5.0E-06	1.9E-06
	Average	8.5E-06	3.0E-06	8.1E-06	3.4E-06
U-235	Quarters 1-2	8.4E-07	1.0E-06	1.4E-06	2.7E-06
	Quarters 3-4	7.0E-07	7.3E-07	-1.3E-07	1.4E-07
	Average	7.7E-07	8.8E-07	6.1E-07	1.4E-06
U-238	Quarters 1-2	9.1E-06	3.3E-06	1.1E-05	6.8E-06
	Quarters 3-4	6.0E-06	2.2E-06	6.0E-06	1.9E-06
	Average	7.6E-06	2.8E-06	8.4E-06	4.4E-06
Zn-65	Quarters 1-2	-1.9E-04	7.7E-04	4.0E-04	4.6E-04
	Quarters 3-4	-2.6E-04	6.5E-04	-1.2E-04	5.3E-04
	Average	-2.2E-04	7.1E-04	1.4E-04	5.0E-04
ZrNb-95	Quarters 1-2	1.6E-03	4.2E-03	3.9E-03	3.9E-03
	Quarters 3-4	2.3E-06	1.9E-03	1.2E-03	1.5E-03
	Average	1.8E-03	3.0E-03	2.5E-03	2.7E-03

Source: Schmidt et al. 1991.
Negative values indicated concentrations at or near background levels of radioactivity.
Shaded areas indicate a positive detection, the result is greater than the error.

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 Regulation
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 S Plant Aggregate Area Management Study (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 S 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.

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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 Instructions (EII) 1.1 and Appendix B to EII 1.1 (WHC 1988b).

All visitors shall be informed of potential hazards and emergency procedures by their escorts and shall conform to EII 1.1 (WHC 1988b).

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.

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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 1.2 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.

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- 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 S 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, <u>including any test pit</u>, 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.

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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 S Plant AAMS background and known and suspected contamination are described in Chapters 2.0 through 10.0 of the plan. The S Plant Aggregate Area is situated within the 200 West Area of the U.S. Department of Energy's (DOE) 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 S Plant Area at the Hanford Site was used by the U.S. Government as a chemical separations area in the process to produce plutonium for nuclear weapons. These operations resulted in the release of chemical and radioactive wastes into the soil, air, and water of the area. Each waste site in the aggregate area is described separately in this document. Close relationships between waste units, such as overflow from one to another, are also discussed.

4.0 SCOPE OF WORK AND POTENTIAL HAZARDS

While the information presented in Chapters 2.0 through 10.0 of the plan are believed to be representative of the constituents and quantities of wastes at the time of discharge, the present chemical nature, location, extent, and ultimate fate of these wastes in and around the liquid disposal facilities are largely unknown. The emphasis of the investigation in the S 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.

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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 1988a).

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.

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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, "1760 KE Laboratory Decontamination of Equipment for RCRA/CERCLA Sampling" (WHC 1988b), 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.

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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
QAPP	quality assurance project plan
RCRA	Resource Conservation Recovery Act
RI	remedial investigation
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
Westinghouse Hanford	Westinghouse Hanford Company

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1.0 INTRODUCTION

This Project Management Plan (PMP) defines the administrative and institutional tasks necessary to support the S 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) Action Plan dated August 1990. Any revisions to the Tri-Party Agreement Action Plan that would result in changes to the project management requirements would supersede the provisions of this chapter.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 INTERFACE OF REGULATORY AUTHORITIES AND THE U.S. DEPARTMENT OF ENERGY

The S Plant Aggregate Area consists of active and inactive waste management units to be remedied under either *Resource Conservation Recovery Act* (RCRA) or *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). The Washington State Department of Ecology (Ecology) has been designated as the lead regulatory agency, as defined in the Tri-Party Agreement. Accordingly, Ecology is responsible for overseeing remedial action activity at this aggregate area and ensuring that the applicable authorities of both the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) are applied. The specific responsibilities of EPA, Ecology, and DOE are detailed in the Tri-Party Agreement Action Plan.

2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization for implementing remedial activities at the S 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 Action Plan. The responsibilities of the project managers are given in Section 4.1 of the Tri-Party Agreement Action Plan.

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 S Plant Aggregate Area.

The unit manager from Ecology will serve as the lead unit manager. The Ecology unit manager will be responsible for regulatory oversight of all activities required for the S Plant Aggregate Area.

The unit manager from EPA will be responsible for making decisions related to issues for which the supporting regulatory agency maintains authority. All such decisions will be made in consideration of recommendations made by the Ecology unit manager.

The unit manager from DOE will be responsible for maintaining and controlling the schedule and budget and keeping the EPA and Ecology unit managers informed as to the status of the activities at the S 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 Company (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 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 S 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 Action Plan. The process for document review and comment will be as described in Section 9.2 of the Tri-Party Agreement Action Plan. Revisions, should they become necessary after finalization of any document, will be in accordance with Section 9.3 of the Tri-Party Agreement Action Plan. Changes in the work schedule, as well as minor field changes, can be made without having to process a formal revision. The process for making these changes will be as stated in Section 12.0 of the Tri-Party Agreement Action Plan. 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 Action Plan.

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 S 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 Action Plan 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.

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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 Action Plan.

Unit managers shall meet monthly to discuss progress, address issues, and review near-term plans pertaining to their respective operable unit 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 S 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 S 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 Action Plan.

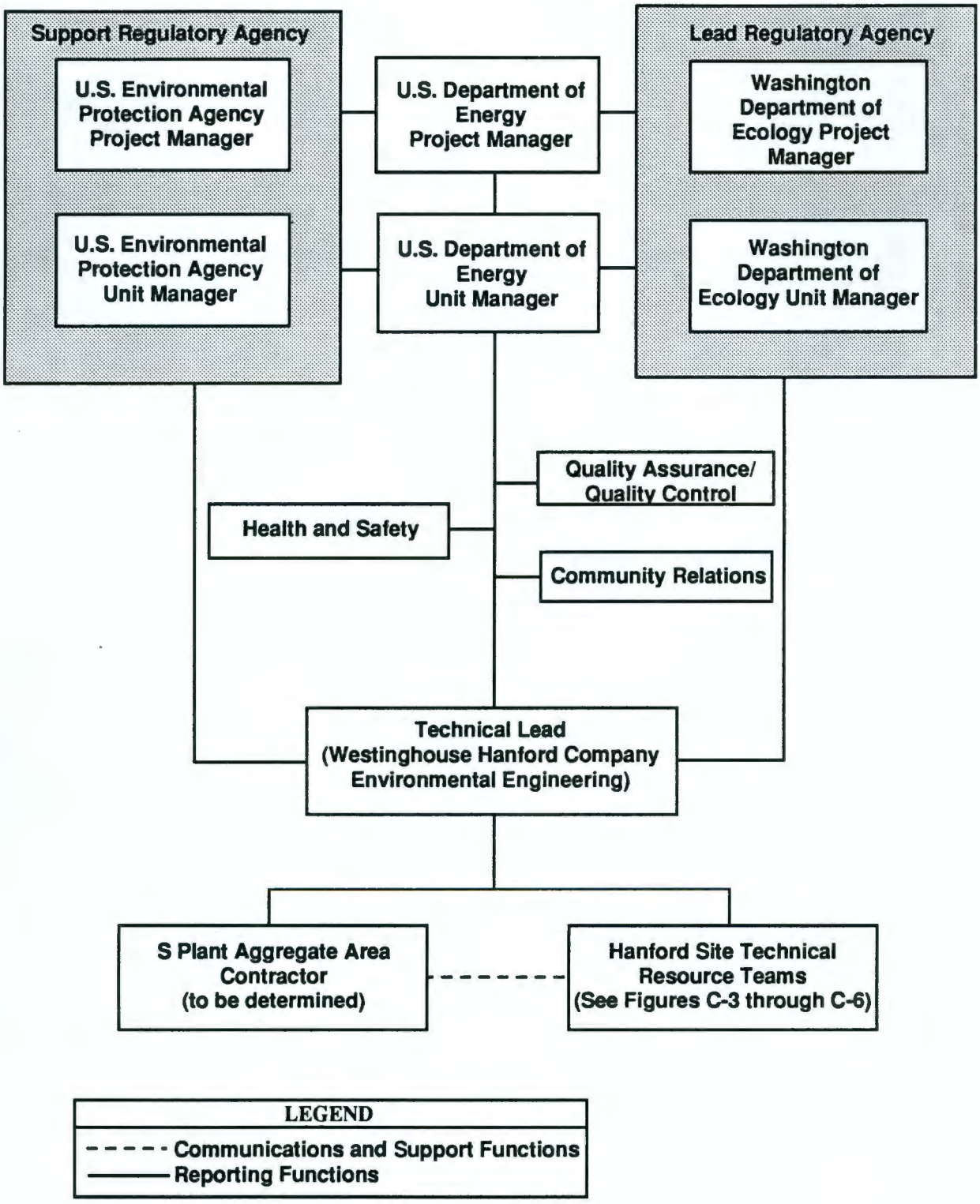
Project coordinators for each operable unit also will meet on a monthly basis to share information and to discuss progress and problems.

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 Action Plan. 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).

Figure C-1. Project Organization for the S Plant Aggregate Area Project.



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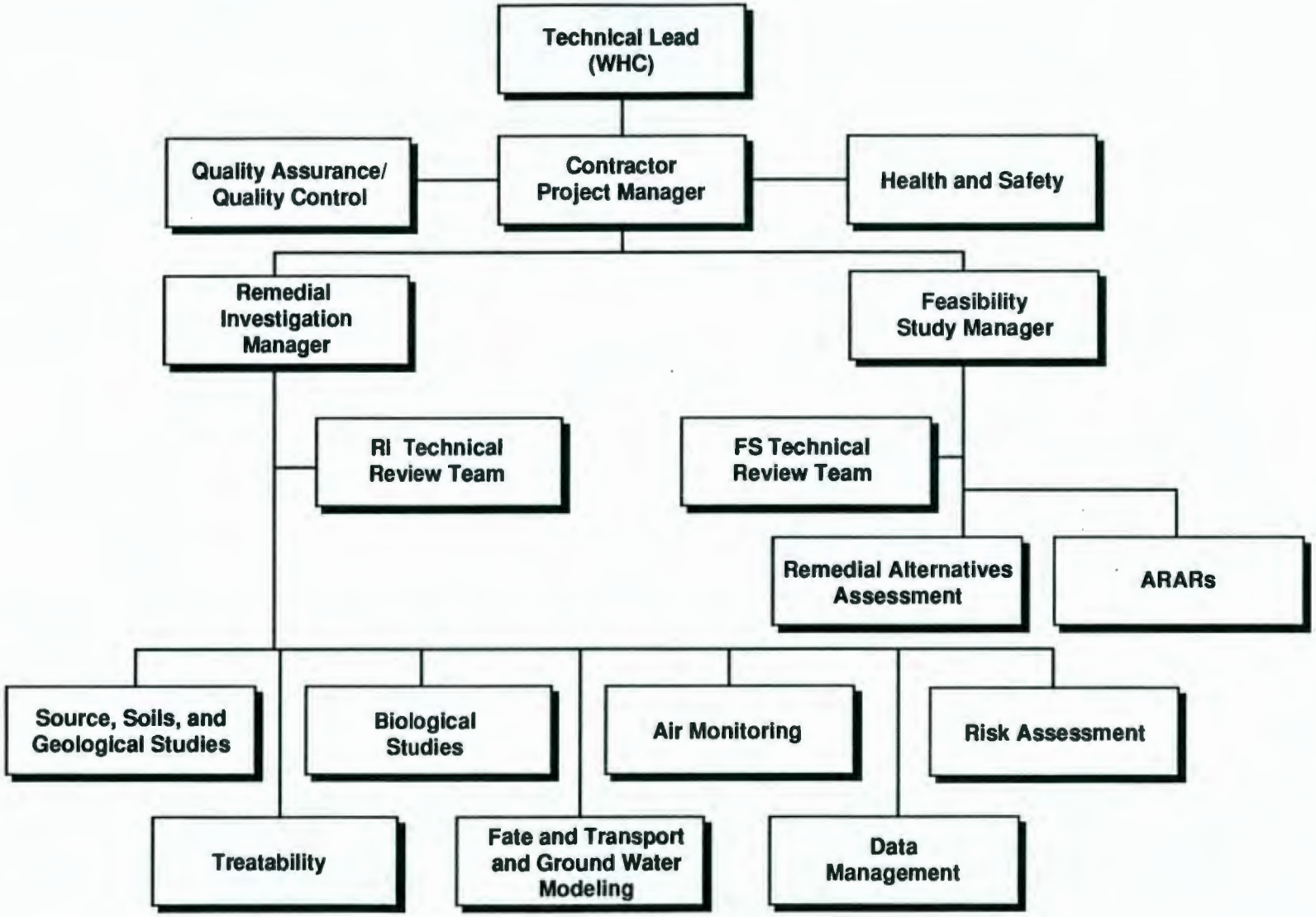

Figure C-2. Example Project Organization for the S Plant Aggregate Area.

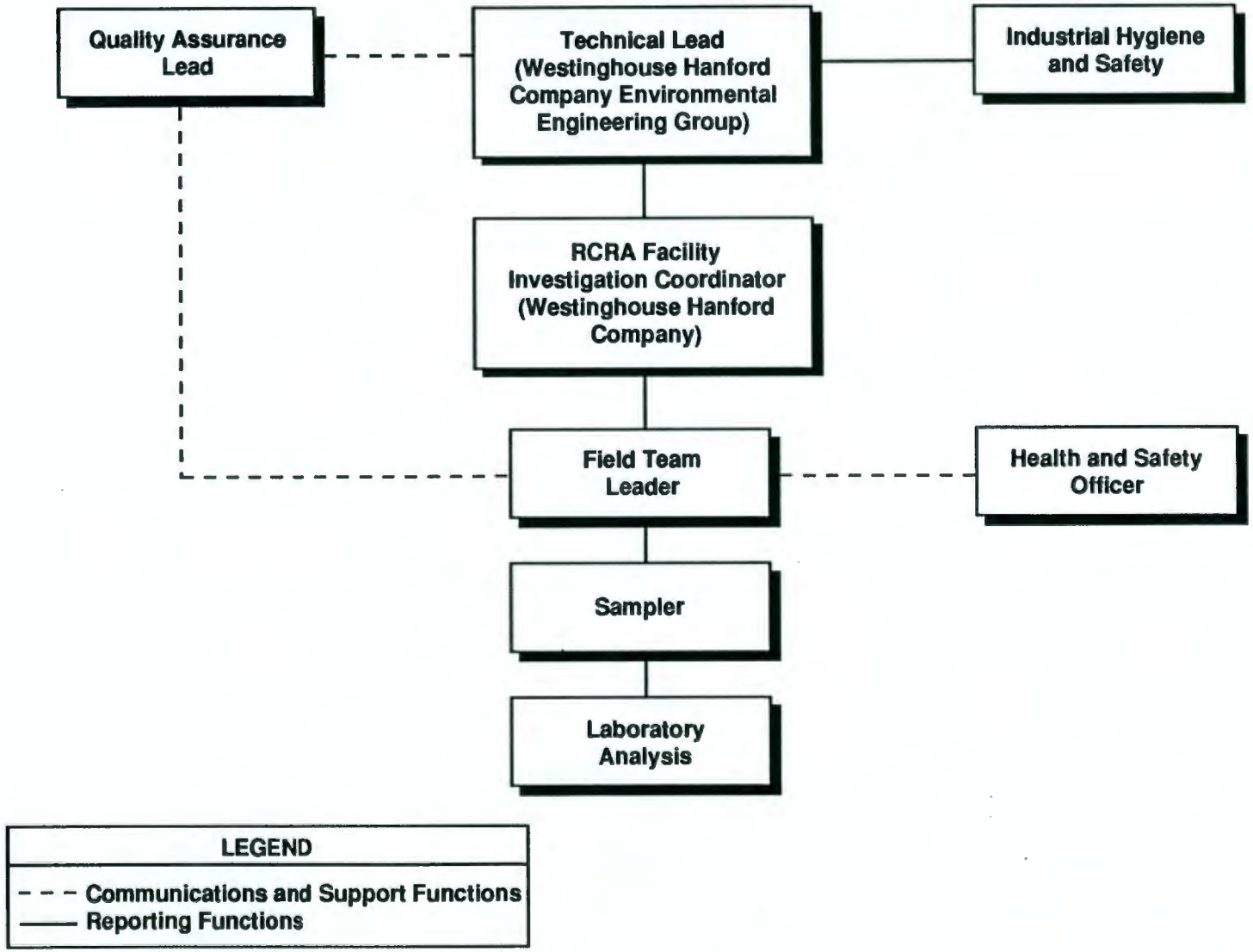

Figure C-3. The Hanford Site Soil Sampling Team.

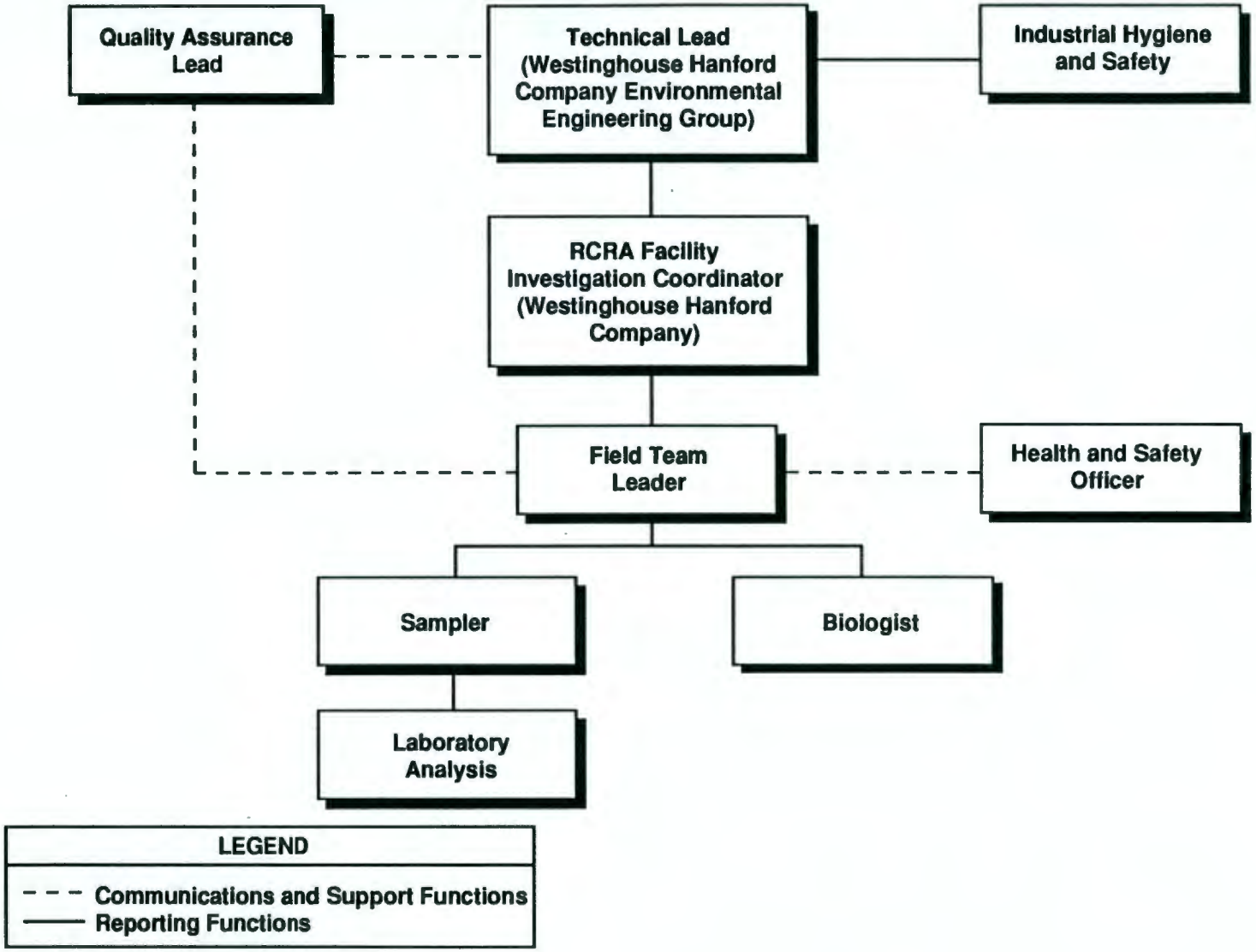

Figure C-4. The Hanford Site Biological Sampling Team.

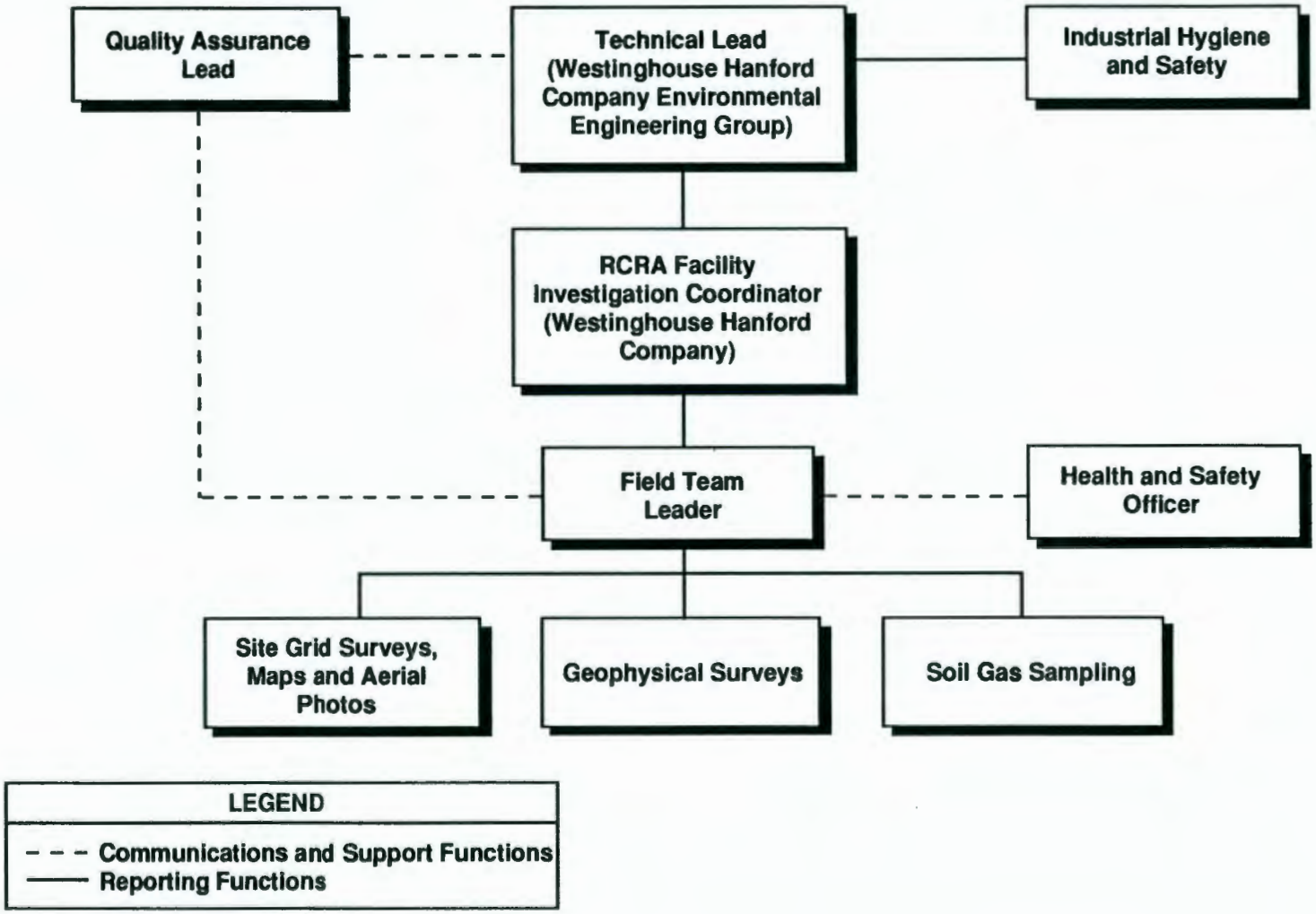

Figure C-5. The Hanford Site Physical and Geophysical Survey Team.

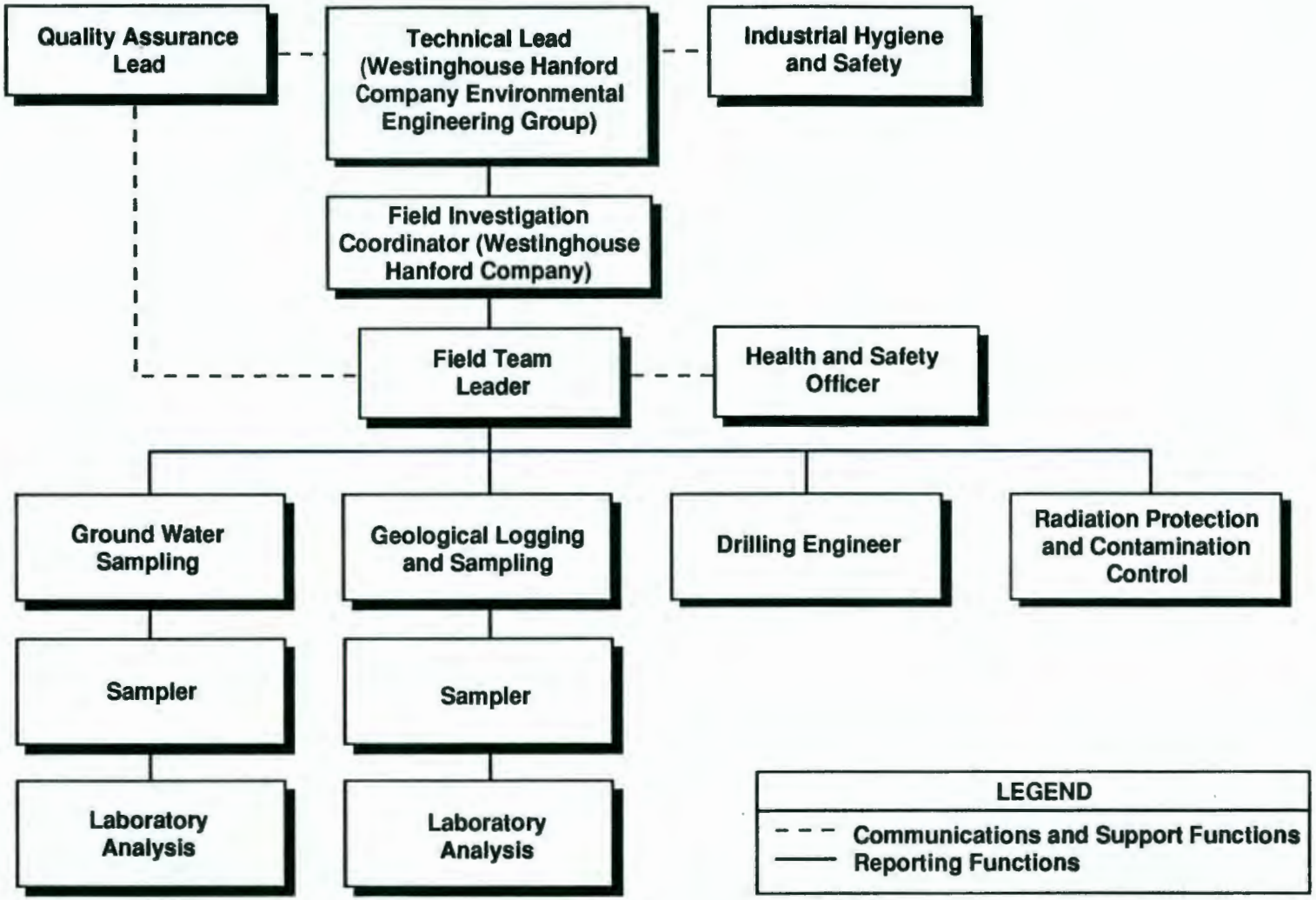

Figure C-6. Drilling, Sampling, and Well-Development Team.

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

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Table C-1. Hanford Site RI/FS Technical Resources.

Subject/Activity	Technical Resources	
	RI	FS
Soil and water sampling and analysis	Westinghouse Hanford/ Environmental Engineering Westinghouse Office of Sampling Management PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center	NA
Drilling and well installation	Westinghouse Hanford/ Geosciences Environmental Field Services Kaiser Engineers	NA
Radiation monitoring	Westinghouse Hanford/ Operational Health Physics	NA

NA = Not applicable.

APPENDIX D

INFORMATION MANAGEMENT OVERVIEW

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.

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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.

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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 S 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).

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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.

9 3 1 2 8 6 9 1 3 3 4

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.

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3.3.4 Training Records

Training records for Westinghouse Hanford and subcontractor personnel are managed by the Westinghouse Hanford Technical Training Support Section. Other Hanford Site contractors (PNL and KEH) maintain their own personnel training records. Training records for non-Westinghouse personnel are entered into the Westinghouse (soft reporting) database to document compliance.

Training records include:

- Initial 40-h hazardous waste worker training
- Annual 8-h hazardous waste worker training update
- Hazardous waste generator training
- Hazardous waste site specific training
- Radiation safety training
- Cardiopulmonary resuscitation
- Scott air pack
- Fire extinguisher
- Noise control
- Mask fit.

3.3.5 Environmental Information/Administrative Record

Environmental information and the AR are managed by Westinghouse Hanford EDMC personnel. They provide an index and key information on all data transmitted to the EDMC. This database is used to assist in data retrieval and to produce index lists as required.

3.3.6 Sample Status Tracking

The OSM maintains the sample status tracking database. This database contains information about each sample. Information maintained includes sample number, ship date, receipt date, and laboratory identification.

4.0 ENVIRONMENTAL INFORMATION AND RECORDS MANAGEMENT PLAN

This section briefly discusses the EIMP (Michael et al. 1990) that was developed to provide an overview of an integrated approach to managing Hanford Site environmental data, and the *Environmental Restoration Remedial Action Program Records Management Plan* (WHC 1991b).

4.1 ENVIRONMENTAL INFORMATION MANAGEMENT PLAN

The EIMP provides an overview of how information is managed throughout the lifetime of Hanford Site environmental programs.

The Environmental Division of Westinghouse Hanford is responsible for the protection and improvement of the Hanford Site environment. To fulfill responsibility, the Environmental Division has assumed a management role with respect to Hanford Site environmental information. This management role includes (1) establishing standards for how data are validated and controlled, (2) developing and maintaining a supporting computer-based environment, and (3) sustaining a centralized file management system.

Hanford Site environmental information is defined as data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990) (Tri-Party Agreement).

Environmental information falls into several overlapping categories, such as administrative versus technical and electronic versus manual or hard copy. A considerable amount of data are recorded in documents, which are governed by company-wide document and records control practices. Other data are collected or generated by computer and, therefore, exist in electronic form. The name ENCORE has been given to the combination of administrative, hardware, and software systems that serve to integrate the management of this electronic data.

Administrative information (e.g., budgets and schedules) is subject to accounting and other standard business practices. Scientific and technical data are subject to a different set of legal, classification, release, and engineering requirements.

Superimposed over these categories is the files management system for environmental information. This management system, has been developed to meet a number of Environmental Division needs, including requirements for compilation of AR files. The AR files are compilations of all material related to environmental restoration and remedial action records of decision (ROD) for each operable unit and treatment, storage, and disposal (TSD) group described in the Tri-Party Agreement.

Data in electronic form flows from information systems in the ENCORE realm to both scientific/technical and administrative documents. Environmental documents distributed within the Hanford Site and from regulatory agencies are received by the EDMC for storage and future processing.

Part I of the EIMP describes the overall Westinghouse Hanford systems that are generally applied to documents and records. Part I also describes, in greater detail, the files management system developed to manage the AR file information. The EDMC compiles the

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.

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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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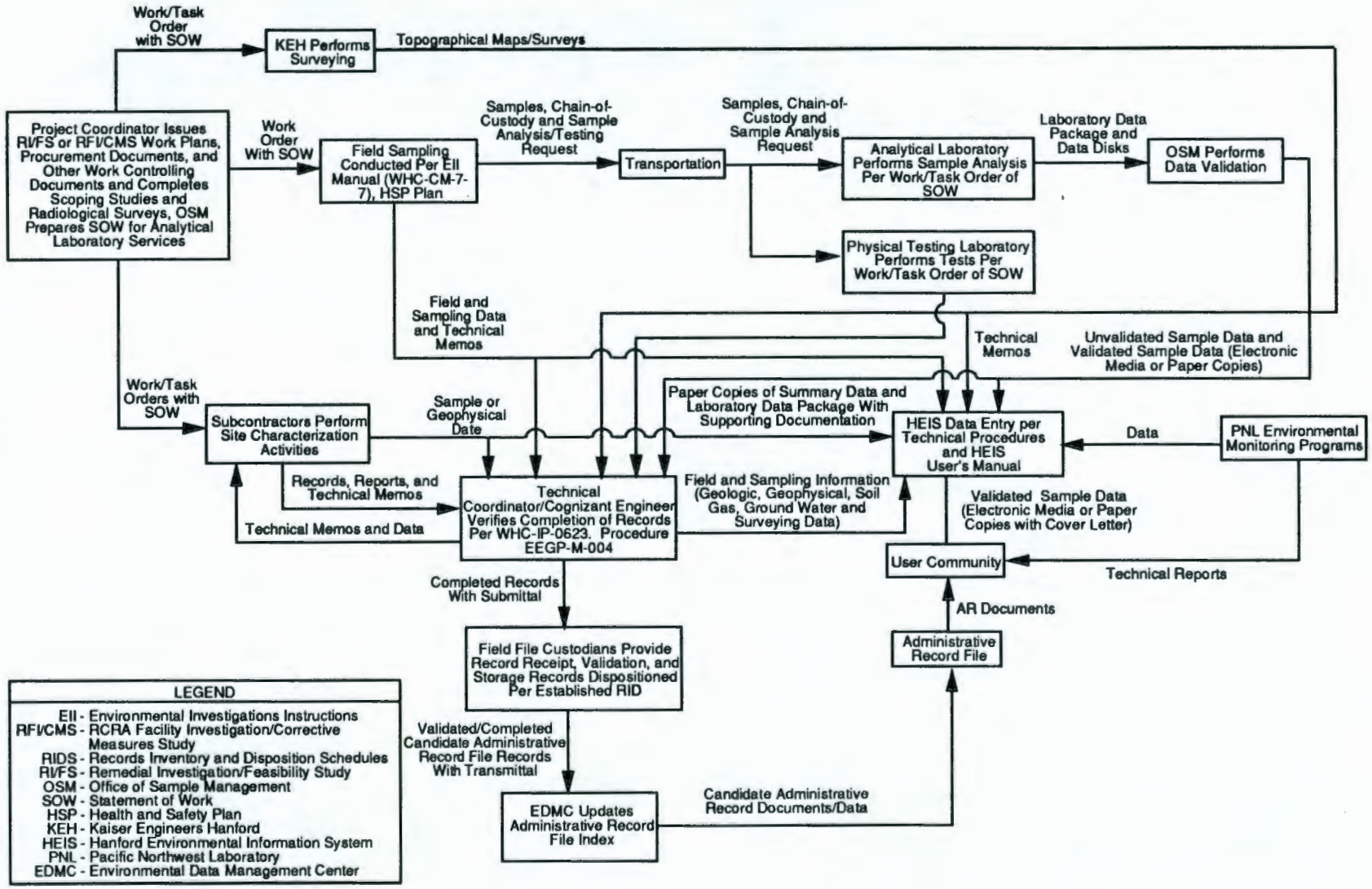

Figure D-1. Environmental Engineering, Technology and Permitting Data Management Model.

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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