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Semiworks Source Aggregate Area Management Study Report

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SEMI-WORKS SOURCE AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the Semi-Works 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 of 1980 (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 Semi-Works 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.

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 U.S. Environmental Protection Agency (EPA), Washington State Department of Ecology (Ecology), 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 Semi-Works Aggregate Area is located within the 200 East Area, near the middle of the Hanford Site. There is one operable unit within the Semi-Works Aggregate Area.

The 201-C Semi-Works Process Building and the Critical Mass Laboratory are the two central features and key operational facilities of the aggregate area. The 201-C Process Building was constructed in 1949 as a pilot plant for reprocessing reactor fuel using the REDOX process. It was converted to a pilot plant for the PUREX process in 1954 and continued in this capacity until it was shut down in 1956. The 201-C Process Building and associated structures were put back into operation for the recovery of strontium from fission product waste. It has been inactive since 1967 and decommissioning activities began in 1983.

Criticality experiments and research were conducted at the Critical Mass Laboratory from 1960 to 1983. Currently, the laboratory is closed, although the administrative offices are in use.

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

- 2 (No. of waste management units) Plants, Buildings, and Storage Areas
- 3 Tanks and Vaults
- 7 Cribs and Drains
- 1 Reverse Well
- 2 Ponds, Ditches, and Trenches
- 2 Septic Tanks and Associated Drain Fields
- 3 Transfer Facilities, Diversion Boxes, and Pipelines
- 1 Burial Site
- 5 Unplanned Releases.

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

There are several active programs that may potentially affect buildings and waste management units in the Semi-Works Aggregate Area (Section 2.7). These programs are RCRA and the Hanford Decommissioning and RCRA Closure Program. Their applicability is not yet determined for four of the waste management units listed above whose status in RCRA-related closure processes is not firmly established. Three units are single-shell tanks which have or will be covered by a RCRA Part A permit. One of the tanks has been cleaned and stabilized while the other two tanks are still contaminated. Plans had been made to sample and clean these tanks but recently-identified safety concerns have led to a proposal that the tank sampling and cleanup be postponed to the CERCLA process. The fourth facility is a diversion box identified but not yet evaluated as a potential RCRA unit.

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 East Area and vicinity. Groundwater of the 200 East Area is described in detail in a separate 200 East Groundwater AAMSR.

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

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

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

Potential ARARs to be used in developing and assessing various remedial action alternatives at the Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area are developed in Section 9.1. As a result of the data evaluation process, no waste management units were recommended for ERA or IRM, 7 units were recommended for LFIs which could lead to IRMs, and 18 units were recommended for final remedy selection. A discussion of the data evaluation process is provided in Section 9.2. Table ES-1 provides a summary of the results of the data evaluation assessment of each unit. Table ES-2 provides the decision matrix patterns each unit followed in reaching the recommendation. Recommendations for redefining operable unit boundaries and prioritizing operable units for work plan development are provided in Section 9.3. Included in Section 9.3 are the interactions with RCRA required to disposition the facilities. 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 and treatability studies, respectively.

Table ES-1. Summary of the Results of Remediation Process Path Assessment. (sheet 1 of 3)

Waste Management Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Plants, Buildings, and Storage Areas							
201-C Process Building					X		Structures have been stabilized under Hanford Surplus Facilities Program.
291-C Ventilation System					X		
Tanks and Vaults							
241-CX-70 Storage Tank					X		Tanks to be decontaminated and decommissioned under the Hanford Decommissioning and RCRA Closure Program. Evaluations for post-closure care or remediation to be performed under Final Remedy Selection Path.
241-CX-71 Storage Tank					X		
241-CX-72 Storage Tank					X		
Cribs and Drains							
216-C-1 Crib		X	X				All cribs included under one analogous group. 216-C-1 Crib to be investigated as analogue site, with supplemental LFIs at 216-C-7 and 216-C-10 Cribs.
216-C-3 Crib		X	X				
216-C-4 Crib		X	X				
216-C-5 Crib		X	X				
216-C-6 Crib		X	X				
216-C-7 Crib		X	X				
216-C-10 Crib		X	X				
Reverse Wells							
216-C-2 Reverse Well					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.

Table ES-1. Summary of the Results of Remediation Process Path Assessment. (sheet 2 of 3)

Waste Management Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Ponds, Ditches, and Trenches							
216-C-9 Pond					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
200 East Powerhouse Ditch					X		To be removed from the Semi-Works operable unit and included as a waste management unit under B Plant AAMS.
Septic Tanks and Associated Drain Fields							
2607-E-5 Septic Tank and Drain Field					X		
2607-E-7A Septic Tank and Drain Field					X		
Transfer Facilities, Diversion Boxes, and Pipelines							
Semi-Works Valve Pit					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
Critical Mass Laboratory Valve Pit					X		To be decommissioned under Hanford Decommissioning and RCRA Closure Program, then evaluated under Final Remedy Selection Path.
241-C-154 Diversion Box					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
Burial Sites							
218-C-9 Burial Ground					X		
Unplanned Releases							
UN-200-E-36				X			
UN-200-E-37				X			

Table ES-1. Summary of the Results of Remediation Process Path Assessment. (sheet 3 of 3)

Waste Management Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
UN-200-E-98					X		
UN-200-E-141					X		

ERA = Expedited Response Action
IRM = Interim Remedial Measure
LFI = Limited Field Investigation
RA = Risk Assessment
RI = Remedial Investigation
OPS = Operational Programs

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Table ES-2. Semi-Works Aggregate Area Data Evaluation Decision Matrix. (sheet 1 of 2)

	ERA Evaluation Pathway								IRM Evaluation Pathway			LFI Path	Final Remedy
Waste Management Unit	Hanford Site Past-Practice Strategy Criteria?	Release?	Path-way?	Quan-tity?	Concen-tration?	Treat-ment Available?	Adverse Conse-quences?	Opera-tional Pro-grams?	High Priority?	Data Ade-quate?	Adverse Conse-quences?	Collect Data?	Data Ade-quate?
Plants, Buildings, and Storage Areas													
201-C Process Building	N	—	—	—	—	—	—	—	N	—	—	—	N
291-C Ventilation System	N	—	—	—	—	—	—	—	N	—	—	—	N
Tanks and Vaults													
241-CX-70 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
241-CX-71 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
241-CX-72 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
Cribs and Drains													
216-C-1 Crib	Y	Y	N	—	—	—	—	—	Y	N	—	Y	—
216-C-3 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-4 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-5 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-6 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-7 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-10 Crib	Y	Y	N	—	—	—	—	—	Y	N	—	Y	—
Reverse Wells													
216-C-2 Reverse Well	Y	N	—	—	—	—	—	—	N	—	—	—	N
Ponds, Ditches, and Trenches													
216-C-9 Pond	Y	Y	N	—	—	—	—	—	N	—	—	—	N
200 East Powerhouse Ditch	N	—	—	—	—	—	—	—	N	—	—	—	N

Table ES-2. Semi-Works Aggregate Area Data Evaluation Decision Matrix. (sheet 2 of 2)

	ERA Evaluation Pathway								IRM Evaluation Pathway			LFI Path	Final Remedy
Waste Management Unit	Hanford Site Past-Practice Strategy Criteria?	Release?	Path-way?	Quan-tity?	Concen-tration?	Treat-ment Available?	Adverse Conse-quences?	Opera-tional Pro-grams?	High Priority?	Data Ade-quate?	Adverse Conse-quences?	Collect Data?	Data Ade-quate?
Septic Tanks and Associated Drain Fields													
2607-E-5 Septic Tank and Drain Field	N	—	—	—	—	—	—	—	N	—	—	—	N
2607-E-7A Septic Tank and Drain Field	N	—	—	—	—	—	—	—	N	—	—	—	N
Transfer Facilities, Diversion Boxes, and Pipelines													
Semi-Works Valve Pit	N	—	—	—	—	—	—	—	N	—	—	—	N
Critical Mass Laboratory Valve Pit	Y	N	—	—	—	—	—	—	N	—	—	—	N
241-C-154 Diversion Box	N	—	—	—	—	—	—	—	N	—	—	—	N
Burial Sites													
218-C-9 Burial Ground	N	—	—	—	—	—	—	—	N	—	—	—	N
Unplanned Releases													
UN-200-E-36	N	—	—	—	—	—	—	—	N	—	—	—	Y
UN-200-E-37	N	—	—	—	—	—	—	—	N	—	—	—	Y
UN-200-E-98	Y	Y	N	—	—	—	—	—	N	—	—	—	N
UN-200-E-141	Y	Y	N	—	—	—	—	—	N	—	—	—	N

N = No
Y = Yes
* Evaluated as high priority site because of proximity and/or similarity to other high priority sites.
ERA = Expedited Response Action
IRM = Interim Remedial Measure
LFI = Limited Field Investigation

ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
AAMSR	aggregate area management study reports
ARARs	applicable or relevant and appropriate requirements
ASIL	acceptable source impact level
BDAT	best demonstrated available treatment technologies
BWIP	Basalt Waste Isolation Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	Corrective Measures Studies
DOD	Department of Defense
DOE	U.S. Department of Energy
DOE/RL	U.S. Department of Energy, Richland Operations Office
DQO	data quality objective
Ecology	Washington State Department of Ecology
EDTA	ethylenediamine tetraacetic acid
EPA	U.S. Environmental Protection Agency
ERA	expedited response actions
FFS	focused feasibility study
FS	feasibility study
FWQC	Federal Water Quality Criteria
GTR	Grout Treatment Facility
Health	State of Washington Department of Health
HEPA	high efficiency particulate air
HRS	Hazard Ranking System
HSDB	Hazardous Substance Database
HVAC	heating, ventilation, air conditioning
IRM	interim remedial measure
LFI	limited field investigation
MCL	maximum contaminant levels
MEPAS	Multimedia Environmental Pollutant Assessment System
mHRS	modified Hazard Ranking System
MIBK	methyl isobutyl ketone (hexone)
MSL	mean sea level
MTCA	Model Toxics Control Act
NAAQS	National 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
OSM	Office of Sample Management
PA	preliminary assessment

ACRONYMS AND ABBREVIATIONS (Continued)

PARCC	Precision, Accuracy, Representativeness, Comparability, and Completeness
PA/SI	preliminary assessment/site inspection
PNL	Pacific Northwest Laboratory
PUREX	plutonium uranium extraction
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
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 and oxidation
RI	remedial investigation
RFI	RCRA Facility Investigation
RLS	Radionuclide Logging System
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
TBC	to-be-considered
TCLP	toxicity characteristic leaching procedure
TFSA&S	Tank Farm Surveillance Analysis & Support Group
TLD	thermoluminescent dosimeter
TRAC	Tracks Radioactive Components Inventory Program
TRU	Transuranic
TSD	treatment, storage or disposal
USC	U.S. Code
USGS	United States Geological Survey
WAC	Washington Administrative Code
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant
WPPSS	Washington Public Power Supply System
Westinghouse Hanford	Westinghouse Hanford Company
WHC	Westinghouse Hanford Company

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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 of 1980* (CERCLA). 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 Semi-Works Aggregate Area located in the 200 Areas. The study provides the basis for initiating RI/FS under CERCLA or under the Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI) and Corrective Measures Studies (CMS). This report also integrates RCRA treatment, storage, or disposal (TSD) closure activities with CERCLA and RCRA past-practice investigations.

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

1.1 OVERVIEW

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

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

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

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

1.1.1 Tri-Party Agreement

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

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

1.1.2 Hanford Site Past-Practice Strategy

The *Hanford Site Past-Practice Strategy* was developed between Ecology, EPA, and DOE to streamline the existing RI/FS and RFI/CMS processes. A primary objective of this strategy is to develop a process to meet the statutory requirements and integrate CERCLA RI/FS and RCRA past-practice RFI/CMS guidance into a singular process for the Hanford Site that ensures protection of human health and welfare and the environment. The strategy refines the existing past-practice decision-making process as defined in the Tri-Party Agreement. The fundamental principle of the strategy is a bias-for-action by optimizing the use of existing data, integrating past-practice with RCRA TSD closure investigations, focusing the RI/FS process, conducting interim remedial actions, and reaching early decisions to initiate and complete cleanup projects on both operable-unit and aggregate-area scale. The ultimate goal is the comprehensive cleanup or closure of all contaminated areas at the Hanford Site at the earliest possible date in the most effective manner.

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

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

- Expedited response action (ERA) path, where an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem

- Interim remedial measure (IRM) path, where existing data are sufficient to indicate that the site poses a risk through one or more pathways and additional investigations are not needed to screen the likely range of remedial alternatives for interim actions; if a determination is made that an IRM is justified, the process proceeds to select an IRM remedy and a focused feasibility study (FFS), if needed, to select a remedy

- Limited field investigation (LFI) path, where minimum site data are needed to support IRM or other decisions, and are obtained in a less formal manner than that needed to support a final Record of Decision (ROD). Data generated from a LFI may be sufficient to directly support an interim ROD. Regardless of the scope of the LFI, it is a part of the RI process, and not a substitute for it.

The process of final remedy selection must be completed for the aggregate area to reach closure. The aggregation of information obtained from LFI and interim actions may be sufficient to perform the cumulative risk assessment and to define the final remedy for the aggregate area or associated operable units. If the data are not sufficient, additional investigations and studies will be performed to the extent necessary to support final remedy selection. These investigations would be performed within the framework and process defined for RI/FS or RFI/CMS programs.

1.2 200 NPL SITE AGGREGATE AREA MANAGEMENT STUDY PROGRAM

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

1.2.1 Overall Approach

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

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

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

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

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

1.2.2 Process Overview

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

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

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

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

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

- U Plant Geologic and Geophysics Data Package
- Z Plant Geologic and Geophysics Data Package
- S Plant Geologic and Geophysics Data Package
- T Plant Geologic and Geophysics Data Package
- PUREX Geologic and Geophysics Data Package
- B Plant Geologic and Geophysics Data Package
- 200 North Geologic and Geophysics Data Package
- Semi-Works Geologic and Geophysics Data Package
- Hydrologic Model for the 200 West Groundwater Aggregate Area
- Hydrologic Model for the 200 East Groundwater Aggregate Area
- Unconfined Aquifer Hydrologic Test Data Package for the 200 West Groundwater Aggregate Area
- Unconfined Aquifer Hydrologic Test Data Package for the 200 East Groundwater Aggregate Area
- Confined Aquifer Hydrologic Test Data Package for the 200 Groundwater Aggregate Area Management Studies
- Groundwater Field Characterization Report

- 200 West Area Borehole Geophysics Field Characterization
- 200 East Area Borehole Geophysics Field Characterization.

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

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

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

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

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

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

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

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

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

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

1.3 PURPOSE, SCOPE, AND OBJECTIVES

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

Specific objectives of the AAMS include the following:

- Assemble and interpret existing data including operational and environmental data
- Describe site conditions
- Conduct limited new site characterization work if data or interpretation uncertainty could be reduced by the work (results from this work may not be available for the AAMSR, but will be included in subsequent topical reports)
- Develop a preliminary conceptual model
- Identify contaminants of concern, and their distribution
- Identify potential ARARs
- Define preliminary remedial action objectives, screen potential remedial technologies, and if possible provide recommendations for 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.

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 Satement of Work for Organic Analysis* (EPA 1991c) 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 a screening process for determining the relative priority of follow-up action at each waste management unit.

- Section 6.0, Potentially Applicable or Relevant and Appropriate Requirements, identifies federal and state standards, requirements, criteria, or limitations that may be considered relevant to the aggregate area.

- Section 7.0, Preliminary Remedial Action Technologies, identifies and screens potential remedial technologies and establishes remedial action objectives for environmental media.

- Section 8.0, Data Quality Objectives, reviews QA criteria on existing data, identifies data gaps or deficiencies, and identifies broad data needs for field characterization and risk assessment. The DQO and data priorities are established.

- Section 9.0, Recommendations, provides guidance for future past-practice activities based on the results of the AAMS. Recommendations are provided for ERA at problem sites, IRM, LFI, refining operable unit boundaries, prioritizing work plans, and conducting field investigations and treatability studies.

- Section 10.0, References, list reports and documents cited in the AAMSR.

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

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

- Appendix B: Health and Safety Plan

- Appendix C: Project Management Plan

- Appendix D: Information Management Overview.

Community relations requirements for the Semi-Works 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.

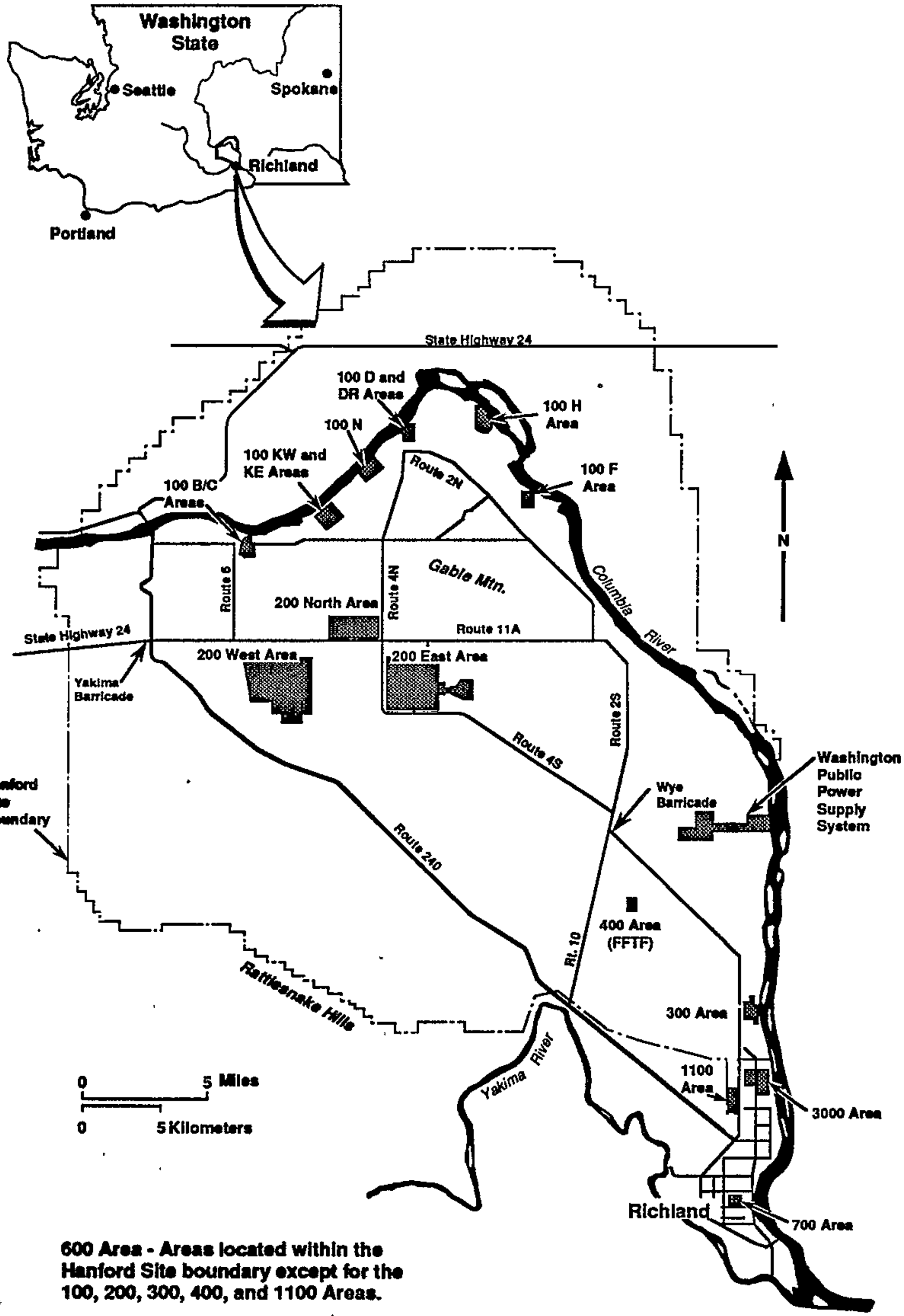
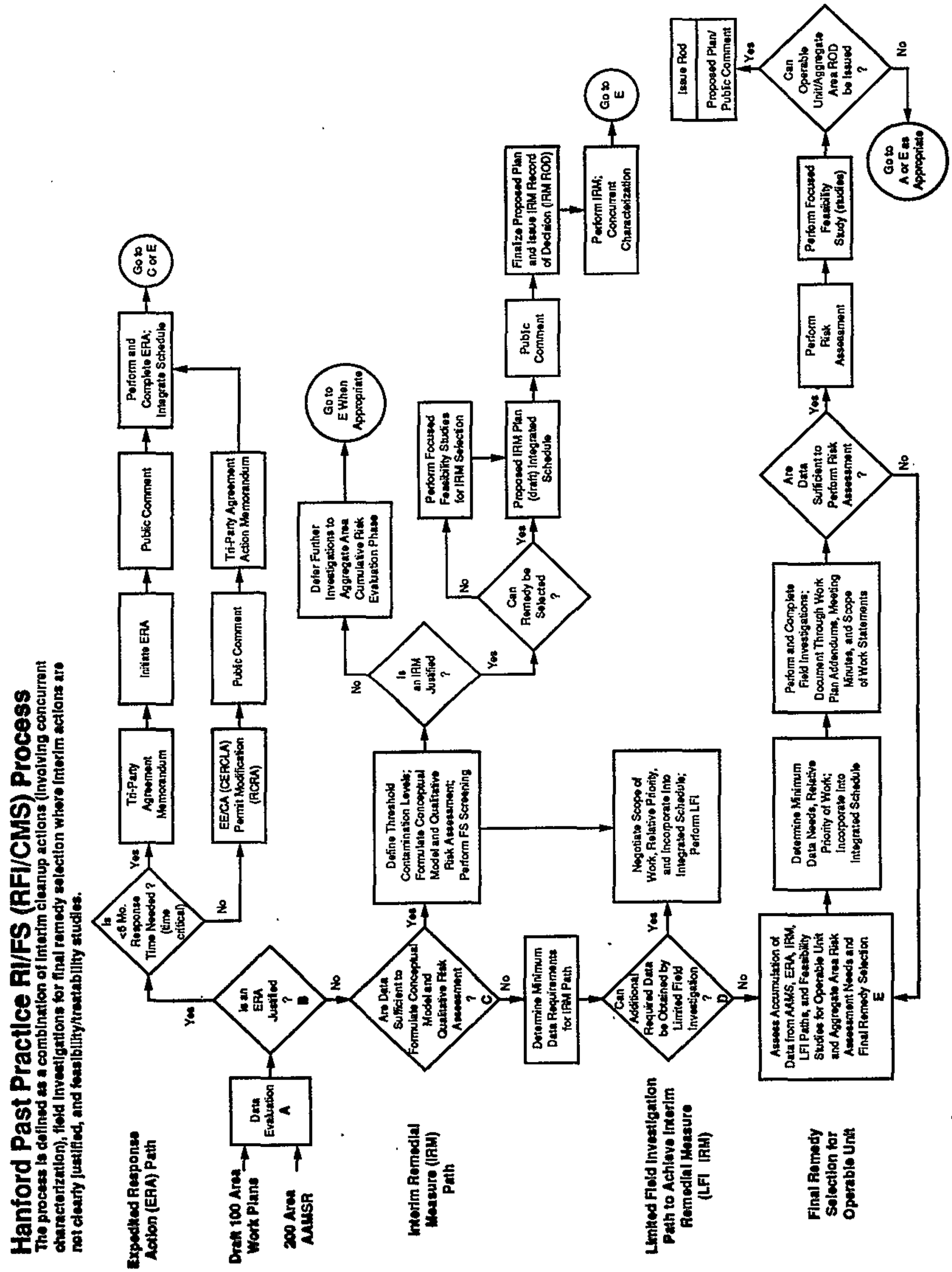


Figure 1-2. Hanford Past-Practice Strategy Flow Chart.

9 3 1 2 9 0 6 3 7 4 2



9312906?743

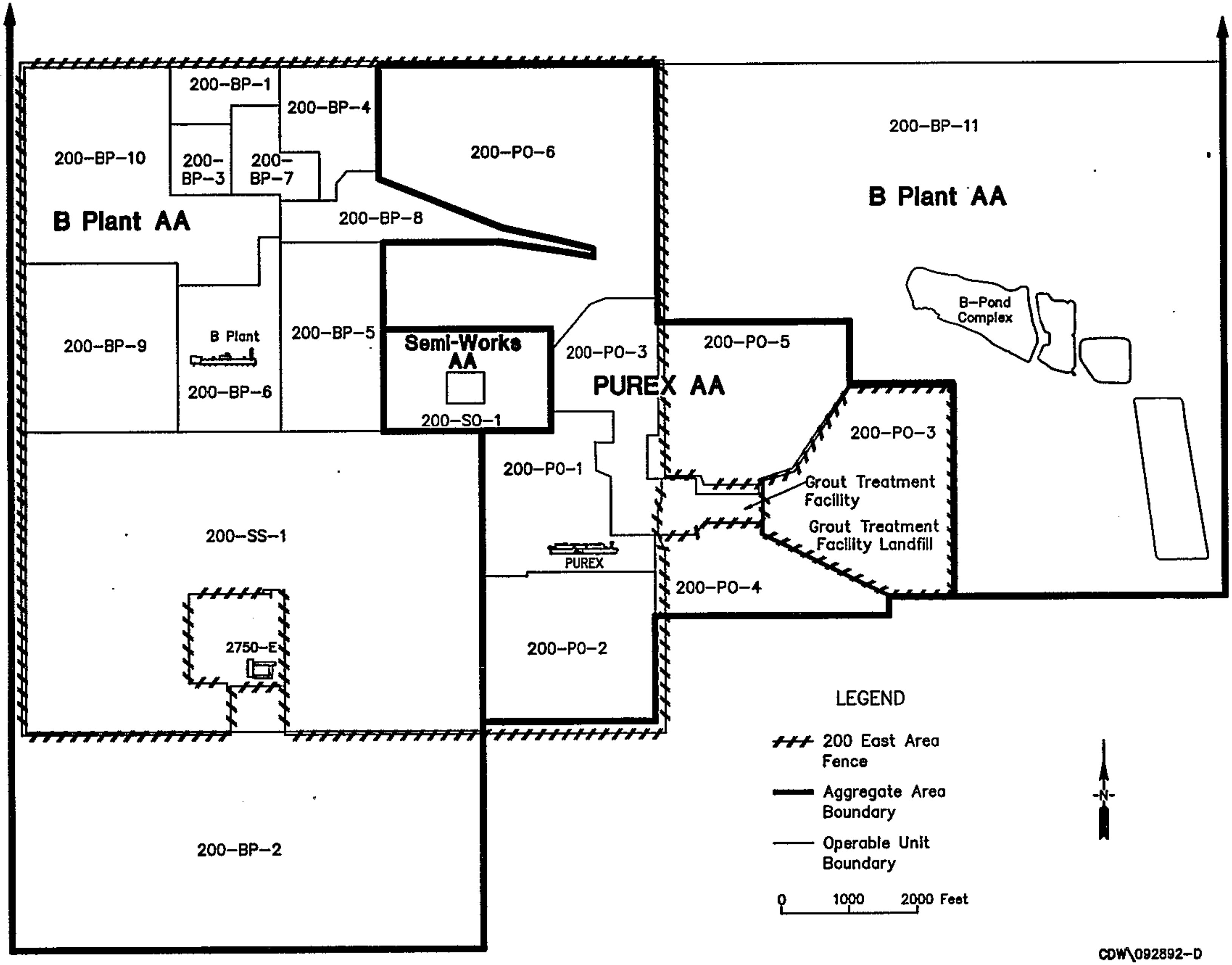


Figure 1-3. 200 East Aggregate Areas.

Figure 1-4. 200 West Aggregate Areas.

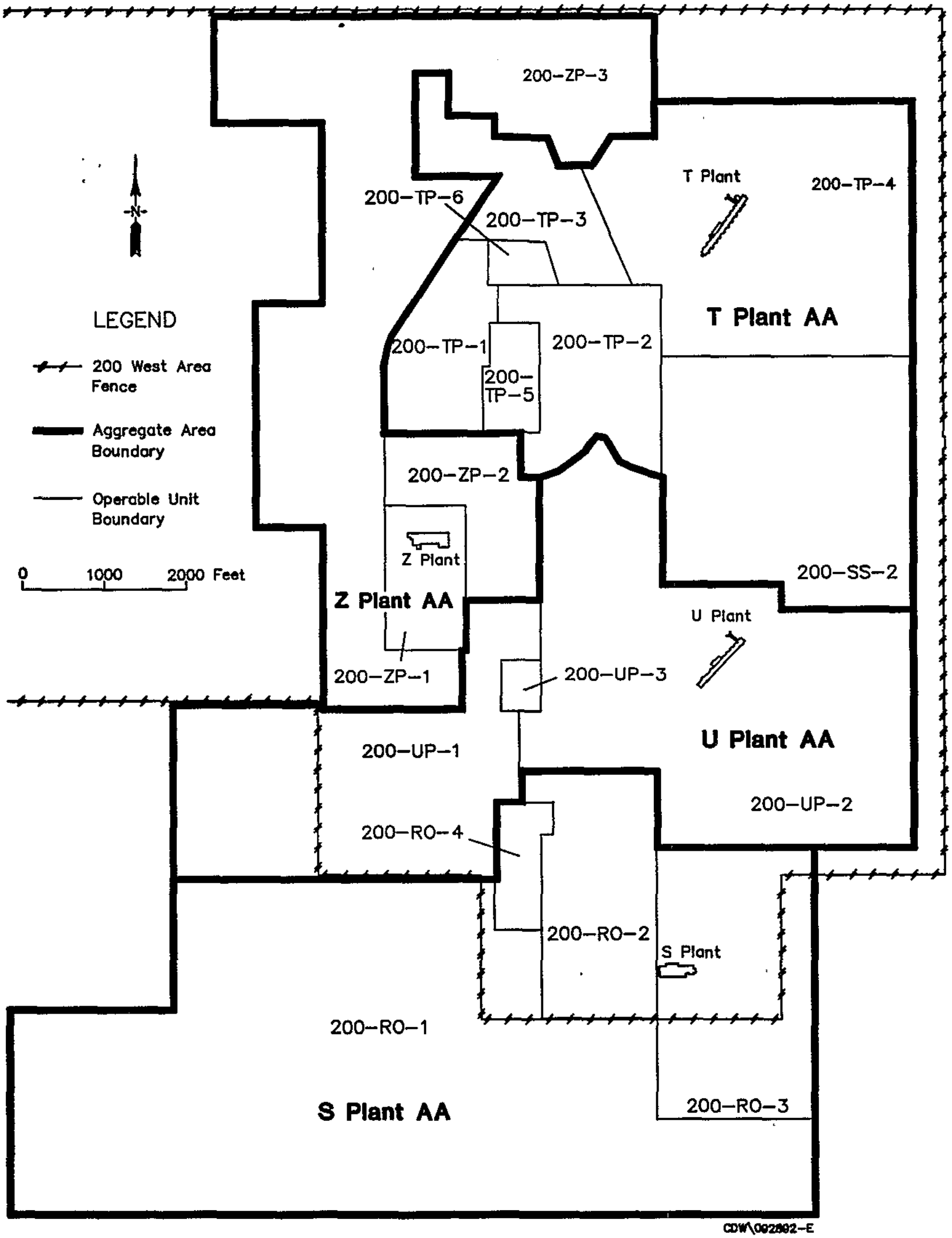
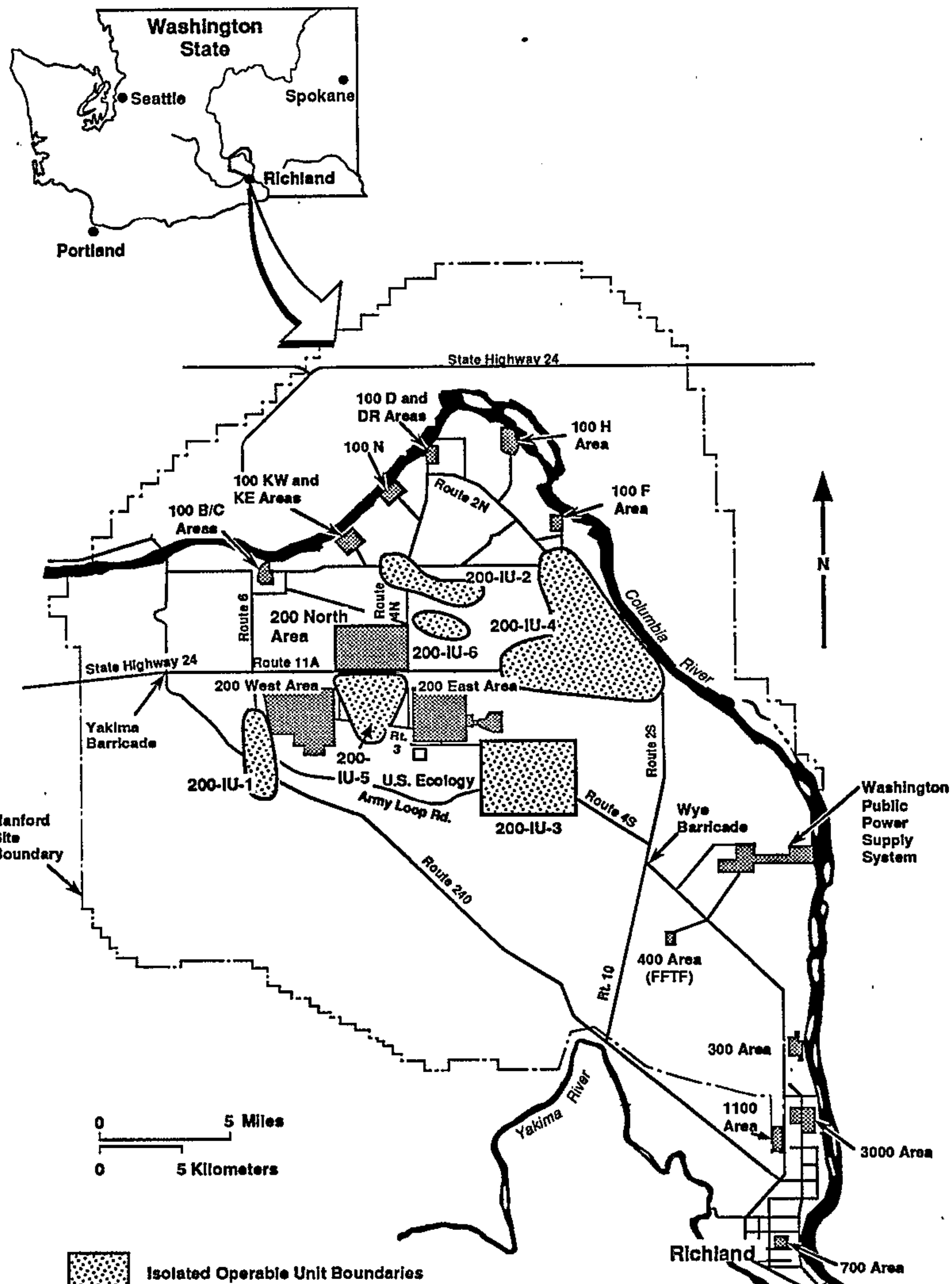


Figure 1-5. 200 NPL Site Isolated Operable Units.



H9106036.3

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

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

2.0 FACILITY, PROCESS, AND OPERATIONAL HISTORY DESCRIPTIONS

Section 2.0 of this Aggregate Area Management Study (AAMS) presents historical data on the Semi-Works 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 site in Section 4.0. Data from these three sections are used to identify contaminants of concern (Section 4.0), waste management units with a high priority for remediation (Section 5.0), potential ARARs (Section 6.0), and current data gaps (Section 8.0).

This section describes the location of the Semi-Works Aggregate Area (Section 2.1), summarizes the history of operations (Section 2.2), describes the facilities, buildings, and structures of the Semi-Works Aggregate Area (Section 2.3), and describes the Semi-Works 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 RCRA program and other Hanford programs.

2.1 LOCATION

The Hanford Site, operated by the U.S. Department of Energy (DOE), occupies about 1,450 km^2 (560 mi^2) of the southeastern part of Washington State north of the confluence of the Yakima and Columbia Rivers (Figure 1-1). The 200 East Area is a controlled area of approximately 15 km^2 (5.8 mi^2) near the middle of the Hanford Site. The 200 East Area is about 10 km (6 mi) from the Columbia River and 20 km (12 mi) from the nearest Hanford boundary. There are 20 operable units grouped into three aggregate areas in the 200 East Area (Figure 1-3). The locations of the buildings and waste management units and the topography of the Aggregate Area are shown in Plate 1. The media sampling locations are shown on Plate 2. The Semi-Works Aggregate Area lies in the central portion of the 200 East Area and consists of one operable unit (200-SO-1) comprising the entire aggregate area (Figure 2-1). The Semi-Works Aggregate Area has a rectangular shape and is approximately 82 acres in area. The waste management units are located within a 20 acre area at the center of the Aggregate Area. In documentation reviewed for this report, the Semi-Works is sometimes referred to as the Hot Semi-Works, Strontium Semi-Works, 201-C Area, or C Plant (DeFord 1992).

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 production reactors were built (H, DR, C, KW, KE, and N Reactors). Beginning in the 1950s, waste management, 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 shutdown 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 heading 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 spent nuclear fuel separation. Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The 200 East Area consists of three main former processing areas (Figure 1-3):

- 221-B Building (B Plant), where plutonium was separated from uranium and the bulk of the fission product separation took place
- 202-A Building (PUREX Plant), where recovery of uranium and plutonium from N Reactor fuels took place separated plutonium from spent uranium fuel rods
- 201-C Process Building (Semi-Works Complex), where plutonium separation technology was developed (now decommissioned).

The 200 Areas also contain nonradioactive support facilities, including transportation maintenance buildings, service stations, 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 (DOE/RL 1988a).

The Semi-Works Aggregate Area was composed of two primary facilities; the 201-C Process Building and the Critical Mass Laboratory (209-E Building). The 201-C Process Building was constructed in 1949 as a pilot plant for reprocessing reactor fuel using first, the REDOX (S-Plant) chemical process and then the PUREX chemical process. In 1961 it was again converted to recover strontium from fission product waste. This facility operated until 1967. The facility remained in safe storage mode until decommissioning began in 1983 (DeFord 1992).

The Critical Mass Laboratory (209-E Building) was operated from 1960 to 1987 by PNL. Criticality experiments and research were conducted at this location. Currently the laboratory is closed, and the facility has been transferred to WHC for use by Waste Tank Management (DeFord 1992).

2.3 FACILITIES, BUILDINGS, AND STRUCTURES

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

- 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.

- Transuranic Waste is defined as: without regard to source or form, radioactive waste that; at the end of institutional control, 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 transuranic waste.

- Low-Level Waste is defined as: radioactive waste, not classified as high-level waste, transuranic waste, spent nuclear fuel, or IIe(2) byproduct material as defined by this Order. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic is less than 100 nCi/g.

- Byproduct Material is defined as: (a) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident or to the process of producing or utilizing special nuclear material. For purposes of determining the applicability of the RCRA to any radioactive waste, the term "any radioactive material" refers only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous waste component of the waste substance will be subject to regulation under the RCRA. (b) The tailings or waste produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content. Ore bodies depleted by uranium solution extraction operations and which remain underground do not constitute "byproduct material."

Based on construction, purpose, or origin, the Semi-Works 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 (Sections 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 Semi-Works Aggregate Area. In addition, the aggregate area contains several unplanned release sites. The locations of these waste management units are shown on separate figures for each waste management group and on Plate 1. 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 WIDS (WHC 1992a) inventory sheets and other sources (Cummings 1988 and 1989, DeFord 1992, and Maxfield 1979) reviewed for this report. The waste inventories reported in Tables 2-2 and 2-3 reflect the materials handled or disposed of at the facilities listed, but not all of these facilities released radionuclide or chemical constituents to the environment. Figures 2-1 through 2-9 show the physical location of the waste management units and unplanned releases. Years of operations for Semi-Works Aggregate Area operating processes and waste management units are shown on Figure 2-10 and Figure 2-11, respectively. Figures 2-12 through 2-14 show representative construction details of individual waste management units.

In the following sections each waste management unit is described within the context of one of the aforementioned subgroups. Hanford coordinate information presented in these sections was reported by DeFord (1992) and in WIDS (WHC 1992a).

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 Hanford Decommissioning and RCRA Closure Programs. The program is responsible for the surveillance, maintenance, and decommissioning of surplus facilities within the Environmental Restoration Program. Section 2.7 details interaction of the Hanford programs. However, the Semi-Works Aggregate Area is unique among the aggregate areas because of the decommissioning activities initiated in 1983 for the Semi-Works Complex which contains the 201-C Process Building along with several support buildings and waste management units. In general, decommissioning efforts involved removal of contaminated equipment and materials, decontamination of radioactive surface contamination, and dismantling of the above-ground portions of some structures and stabilizing underground portions in place by filling voids with grout. Since the entombed portions of the structures may contain radioactive and/or hazardous material contamination, they will be considered as waste management units.

Section 2.3.1.1 provides an overview of the decommissioning program at Semi-Works Aggregate Area. The primary buildings in this aggregate area, including the Critical Mass Laboratory, are also discussed individually. The locations of former and existing structures are presented on Figure 2-1.

2.3.1.1 Decommissioning Activities and Building Descriptions. The decommissioning of the Semi-Works Complex included the following structures:

- 201-C Process Building
- 291-C Ventilation System
- 276-C Solvent Handling Facility
- 2707-C Storage and Change House
- 215-C Gas Preparation Building
- 271-C Aqueous Makeup and Control Building.

In addition, three underground storage tanks were also slated for decommissioning under this program, as discussed in Section 2.3.2.

The major objective of the Semi-Works decommissioning program was to minimize the potential spread of radioactive materials from the facility (DeFord 1992). The strategy involved decontaminating and dismantling the above-ground portions of the structures and entombing underground portions with concrete grout. Subsequently the entombed facilities were to be covered with an engineered earthen barrier providing a minimum cover of 4.6 m

(15 ft) over all contaminated materials and surfaces. This barrier was to consist of a base layer of bottom ash from the 200 East Steam Plant beneath a four-foot thickness of soil and a surface soil stabilizing mat. The side slopes were to be armored and the stable surface areas vegetated.

The present status of this program is as follows: the 276-C Solvent Handling Facility and the 215-C Gas Preparation Building have been decontaminated for reuse. The 2707-C Storage and Change House and the 271-C Aqueous Makeup & Control Building have been decontaminated and dismantled. Portions of the 201-C Process Building and the 291-C Ventilation System have been dismantled, while other portions have been entombed on site. The initial base layer of bottom ash has been put in place; however, construction was suspended when CERCLA activities superceded decommissioning activities at Semi-Works. Barrier completion or any other remedial activities will be based on conclusions drawn from completion of the CERCLA process.

2.3.1.1.1 201-C Process Building. The 201-C Process Building was the main processing facility for the Semi-Works Aggregate Area. During its history the 201-C Process Building went through three distinct operational modes. It was originally built in 1949 as a pilot plant for the REDOX process, then was converted to a pilot plant for the PUREX process in 1954. Additional conversions took place in 1961 primarily for recovery of strontium from process wastes. Cerium, technetium, and promethium as well as minor amounts of americium and curium in the final production run were also extracted (Figure 2-10). The fission products were from wastes generated in B-Plant and other process buildings and were stored in the Tank Farms.

The building was located at Hanford coordinates N422000/W50300 and was approximately 42.7 m (140 ft) in length and 24.4 m (80 ft) wide. The building extended approximately 9.1 m (30 ft) above ground and 9.1 m (30 ft) below ground (WHC 1992a). The 201-C Process Building consisted of 3 integrated cells (A, B, and C), seven process galleries, a gallery exhaust system, a hot shop, and an air treatment room. In addition, two cells (D and E) were connected to the east side of the building (DeFord 1992). The date of addition of these cells to the 201-C Process Building was not available in the documents reviewed. The building/cells were largely constructed of concrete. The process equipment in the 201-C Process Building consisted of approximately 38 stainless steel tanks, 19 solvent exchange columns, 13 centrifugal pumps, and a large amount of primarily stainless steel process and service piping (WHC 1992a).

The 201-C Process Building cell areas were used for materials processing, handling, and storage. Product (plutonium) and high-level waste handling were conducted primarily in A Cell which was equipped with welded process and service lines. Reprocessed reactor fuel, purified plutonium, and recovered strontium, cerium, technetium, and promethium were products obtained during various stages of operations at the 201-C Process Building. The original concrete floor of this cell was contaminated by spilled process solution containing plutonium. The B Cell contained solvent extraction columns and an ion exchange column. C Cell was used for radioactive solvent handling and limited batch rework processing. The

D Cell was used for loading strontium product into shipping casks. The E Cell was used as a strontium storage vault and contained four stainless tanks which stored megacurie quantities of strontium. The hot shop and air treatment room were located adjacent to the south wall of B Cell. These rooms served as a maintenance area for contaminated equipment and provided a controlled area for opening the doors into the A, B, and C Cells.

Decommissioning of the building was initiated in 1983 and completed in 1987. Efforts included decontaminating and dismantling the building by removing piping, small equipment, the outer walls, roof, superstructure, large equipment, and floors from the top down. Contaminated portions of the structure were disposed of in the 218-C-9 Burial Ground located in the Semi-Works Aggregate Area, while uncontaminated portions were taken to the Central Landfill south of the 200 East Area (DeFord 1992). The building was dismantled to 3 m (10 ft) above grade. The remaining portions of the building, including the process cells and equipment, were filled with grout and partially covered over with 3 m (10 ft) of ash, the initial component of a proposed engineered cover (DeFord 1992). Estimated radionuclide and lead shielding inventories for this unit are presented in Table 2-2.

2.3.1.1.2 215-C Gas Preparation Building. The 215-C Gas Preparation Building was constructed for use as a support facility to the 201-C Process Building. The original construction date of the 215-C Gas Preparation Building was not reported in the documents reviewed. It provided compressed air for pneumatic equipment and instruments. It also provided inert gas for use in the 201-C Process Building when flammable solvents were in use.

The building is located north of the former 201-C Process Building at Hanford coordinates N42500/W50200. The 215-C Gas Preparation Building has two rooms on a single level and dimensions of approximately 10.7 m (35 ft) in length, 6.4 m (21 ft) in width, and 4 m (13 ft) in height. These rooms provided storage for equipment, compressors, and gas cylinders. There is a lean-to on the south side of the building, which protected three compressed air storage tanks.

The 215-C Gas Preparation Building previously contained radioactively contaminated structures and equipment. As part of decommissioning operations, all equipment was removed from in and around the building. In 1985, the building was decontaminated and is currently used to store miscellaneous equipment (DeFord 1992). It is, however, still within the radiation control area for the complex.

2.3.1.1.3 271-C Aqueous Makeup and Control Building. The 271-C Aqueous Makeup and Control Building was the control center for the 201-C Process Building operations. It included an aqueous makeup area for "cold" (non-radioactive) solutions. This three-story building occupied an area of 295 m^2 (3,200 ft^2) and was constructed of steel frame on a concrete pad with metal siding and a steel deck roof. The building was divided into three separate sections, including a control room for the process cells and different areas for aqueous "cold" solutions (DeFord 1992). Portions of this building, primarily the control room, were contaminated by overpressurization of process tanks in 201-C forcing radioactive solutions up instrument lines which subsequently leaked onto the floor. The building previously contained 26 tanks, mostly stainless steel, 13 pumps, piping, tubing, and control panels. Waste discharges from this building were acidic process wastes and process cooling water.

The building was initially decontaminated and subsequently dismantled by removing all piping, equipment, the outer walls, roof, superstructure, and the floors. Contaminated portions of the structure were disposed of in the 218-C-9 Burial Ground. Uncontaminated portions of the building were taken to the Central Landfill. The large tanks were removed for reuse. The building foundation remains at the site, but is partially covered with an ash barrier (DeFord 1992).

2.3.1.1.4 291-C Ventilation System. The 291-C Ventilation System contained air filter and ventilation equipment used to provide exhaust air ventilation for operation cells and process vessel vents from the 201-C Process Building. The building complex is also identified as the 291-C Filter/Fan House. Information describing when the system began operations was not found in the documents reviewed. The 291-C Ventilation System Buildings were located northeast of the 201-C Building at Hanford coordinates N42340/W50050.

The 291-C Ventilation System was composed of the following structures:

- 291-C Fan House
- 291-C Stack
- Fiberglass Filter Building
- HEPA Filter 1
- HEPA Filter 2
- Air Tunnel.

The 291-C Fan House and the HEPA Filter 2 were located above ground, while the Fiberglass Filter Building and the HEPA Filter 1 were below grade. The air tunnel connecting the system with the 201-C Process Building was about 61 m (200 ft) long, with the first 30.5 m (100 ft) of the tunnel situated approximately 6 m (20 ft) below grade. The remaining 30.5 m (100 ft) were 1.5 m (5 ft) below grade.

The 291-C Stack was located just west of the 291-C Fan House Building. The unit was a double-shell, reinforced concrete structure lined with brick, approximately 61 m (200 ft) high. It was used to exhaust discharge air from the plant process cells after the air passed through the various filters (Louie and Speer 1989). The stack has been inactive since 1967 and was demolished in 1988.

The radionuclide inventory reported for the ventilation systems was located primarily in the fiberglass filters and HEPA Filter 1 (DeFord 1992). The inside of the stack also contained radiological contamination.

Decommissioning activities included dismantling and removal of the 291-C Fan House and the HEPA Filter 2. The HEPA Filter 1, the Fiberglass Filter Building, and the Air Tunnel were filled with grout and left in place.

The stack was demolished during decommissioning activities. Prior to demolition, the interior surfaces were partially decontaminated using remote-controlled sandblasting. The interior was subsequently painted to stabilize remaining contaminants, and the stack was felled using explosives into a prepared trench running south from the stack base. The stack rubble was further demolished to minimize void spaces and ash was used to fill the voids (DeFord 1992). The stack base was filled with concrete. Subsequently, the entombed portions of the 291-C Ventilation System were covered with the ash barrier.

The radionuclide inventory reported for 291-C, primarily ^{90}Sr and ^{90}Y (Deford 1992) was concentrated in the fiberglass filters, HEPA filters, and the inside of the exhaust stack. No exact inventories are known.

2.3.1.1.5 2707-C Storage and Change House. The 2707-C Storage and Change House was a one-level wood frame structure containing maintenance and instrument shops, and locker rooms with restroom facilities for personnel. The personnel decontamination room contained a shower and sink. The building also contained office space and a lunch room. Sanitary waste water and shower water from 2707-C Charge House was sent to 2607-E5 Septic Tank and the associated drain field.

During decommissioning activities, the sink and shower in the decontamination room were removed and their common drain grouted. The water and steam lines were isolated, the transite siding removed, and the building and concrete slab were demolished. The site was then backfilled and graded to match existing terrain (DeFord 1992).

2.3.1.1.6 276-C Solvent Handling Facility. The 276-C Solvent Handling Facility contained equipment and tanks for the treatment and storage of process solvents used in the 201-C Process Building operations. The 276-C Solvent Handling Facility is a four-story structure extending approximately 14 m (46 ft) above grade with a total floor area of 213.5 m^2 (2,300 ft^2) (DeFord 1992). The building is steel framed with metal siding, concrete floors, and a concrete roof. All of the exposed steel framework is covered with one inch of heat-resistant plaster. No information regarding the type of solvent treatment was available in the documents reviewed.

Equipment used for solvent treatment was located on the first level. The chemical addition tanks were located on the second level mezzanine. Head tanks and storage tanks for clean solvents were located on the third and fourth levels. Removable panels on the top two levels allowed large equipment to be removed from the building. The head tanks delivered organic feeds by gravity to the 201-C Process Building. In addition, a large heating, ventilation, and air conditioning (HVAC) unit was located on the second level. The power control room was attached to the south side of the building. Contamination in the 276-C building was limited to a diluent vessel on the third floor and in the filter housings.

In 1984, the facility was partially decommissioned by removing all radioactively contaminated equipment within the building and decontaminating all exposed surfaces. The building was subsequently used for a period of time as an equipment storage area unrelated to Semi-Works, but is now inactive (DeFord 1992).

2.3.1.1.7 Additional Structures Associated with the Semi-Works Complex. Hanford drawings and figures in DeFord (1992) indicate other structures are, or were at one time, located in the Semi-Works Complex. In the documents reviewed for this study, limited information was available regarding these structures. The location of the structures are presented on Figure 2-1. The following paragraphs present a brief summary of the additional structures.

The 2715-C Storage Building was located along the south side of Seventh Street, approximately 23 m (75 ft) west of the 2704-C Office Building. No other information was found in the documents reviewed regarding its specific use. The building has been removed.

The 2704-C Office Building is also located along the south side of Seventh Street, immediately west of the main entrance gate to the 201-C Process Building. The building was the guard house for the Semi-Works Complex and is not currently occupied.

A Control Building was associated with, and located immediately north of, the 241-CX-72 Storage Tank. The building was used as a process control facility for the 241-CX-72 Storage Tank. The building was removed as part of the decommissioning of the 241-CX-72 Storage Tank (DeFord 1992).

The 272-C Building is referred to as a maintenance shop on Westinghouse Hanford drawings. It was located immediately north of the 276-C Solvent Handling Facility and immediately west of the decommissioned 2707-C Storage and Change House. The building has been removed.

2.3.1.1.8 Critical Mass Laboratory (209-E Building). The Critical Mass Laboratory is located west of the 201-C Process Building. The Critical Mass Laboratory is an L-shaped concrete block structure. One wing houses offices, control room shops, and common facilities. The other wing houses an equipment room, change room, mixing laboratory, and a two-story reactor hall. The reactor hall is heavily shielded (DeFord 1992).

Criticality experiments were conducted in the Critical Mass Room from 1960 to 1983 using plutonium nitrate and enriched uranium solutions. Criticality research was also conducted with solid special nuclear materials and fuels (DeFord 1992) such as plutonium blocks, uranium blocks and slabs, and fuel assemblies from the Fast Flux Test Facility and other reactors.

The laboratory is currently closed but not decommissioned. No research has occurred there since 1983. The administrative offices were transferred to WHC in January 1992 and occupied in April 1992, by Westinghouse Hanford Tank Farm Waste Management.

The 2718 Storage Building is an existing structure located adjacent to the southwest corner of the Critical Mass Laboratory. It serves as a small storage building in which containers of uranyl nitrate were at one time stored. It was the site of the Unplanned Release UN-200-E-141 in 1984. This facility is posted as a radiologically controlled area.

2.3.2 Tanks and Vaults

Tanks and vaults were constructed to handle and store liquid wastes generated by processing operations. Three storage tanks are located within the boundaries of the Semi-Works Aggregate Area at the Hanford Facility; the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks (Figure 2-2). Processes that were associated with and descriptions of these three tanks are provided below. High level wastes were also transferred to the 241-C and other tank farms.

2.3.2.1 241-CX-70 Storage Tank. The 241-CX-70 Storage Tank was used to store high-level process waste from pilot studies. It is located south of the former 201-C Process Building at Hanford coordinates N42100/W50200. A schematic diagram of the 241-CX-70 Storage Tank is presented on Figure 2-12.

The tank has a 113,500 liter (30,000 gallon) design capacity. It is 4.6 m (15 ft) deep, 6.1 m (20 ft) in diameter, and is buried approximately 3.4 m (11 ft) below grade. It is constructed of 0.6 cm (0.25 in.) stainless steel plate inside of a poured concrete covering. The concrete thickness on the tank top and sides is 0.3 m (1 ft), while the bottom thickness varies from 0.25 to 0.6 m (0.8 to 2 ft). Two fill pipes enter the side of the tank near its top, and nine riser pipes extend out of the tank to above grade (Deford 1992).

In 1979 the tank was partially pumped out by an overground transfer to the CR vault and the tank farms, leaving approximately 38,986 liters (10,300 gallons) of sludge containing $^{239/240}Pu$, ^{137}Cs, ^{90}Sr, $NaNO_3$, $NaNO_2$, NaF, $Al_2(SO_4)_3$, and Na_2CrO_4 in place.

Removal activities for the remaining waste in the 241-CX-70 Storage Tank were initiated in the summer of 1987 with the construction of a sluicing/pumping system. The sluicing/pumping system used large volumes of water to sluice/pump the sludge from the 241-CX-70 Storage Tank to Tank Farms. Sluicing was intended to loosen and suspend the waste sludge in water. Approximately 529,900 liters (140,000 gallons) of water was used to sluice the original waste volume of 38,986 liters (10,300 gallons) down to 2,839 liters

(750 gallons). Wastes from the tank were analyzed for classification as a RCRA waste. The waste was classified as a RCRA waste because of corrosivity (D002) based on the presence of sodium hydroxide. The mixed waste was also classified as a RCRA toxicity characteristic waste due to detection of chromium (D007) and as a toxic state-only waste (WT02, dangerous waste). The remaining 2,839 liters (750 gallons) were drummed and transferred to the Hanford Central Waste Complex in May 1992 and the tank is now empty. The site is covered with a temporary plywood containment structure called a "greenhouse."

2.3.2.2 241-CX-71 Storage Tank. The 241-CX-71 Storage Tank operated as a flow-through tank to help neutralize the acidic 201-C Process Building condensate, and the coil and condensate cooling water stream before the liquid was discharged to the 216-C-1 Crib. It may have also received process condensates from REDOX, plutonium-uranium extraction (PUREX) pilot plant operations, decontamination flushes following the completion of PUREX pilot plant operations, and Hot Shop sink wastes. The 241-CX-71 Storage Tank is located south of the former 201-C Process Building. A schematic diagram of the 241-CX-71 Storage Tank is presented on Figure 2-13. This tank was partially filled with a bed of limestone aggregate to promote neutralization. To renew the limestone bed as it was dissolved by the acid, limestone was periodically added through the large central riser pipe. Cummings (1989) and others indicate that there is little reliable historical information concerning this tank.

The tank has a 3,785 liter (1,000 gallon) design capacity. Available documentation, including the Dangerous Waste Part A Permit Application for the 241-CX Tank System (1992) and DeFord (1992) indicate that the 241-CX-71 Storage Tank is a cylindrical, single-shell, stainless steel tank which is approximately 1.5 m (5 ft) in diameter and 2.1 m (6.85 ft) deep, and is buried approximately 1.1 m (3.5 ft) below grade.

The tank void and risers were filled with grout in 1986 in accordance with the decommissioning plan. The tank was subsequently sampled in the fall of 1990 to determine what chemical constituents were within the tank. The estimated radionuclide inventory for this tank are presented in Table 2-2. No chemical waste inventory was found for this tank.

2.3.2.3 241-CX-72 Storage Tank. The 241-CX-72 Storage Tank began operation in 1957 and was used experimentally as a "complex waste self-concentrator" for Semi-Works PUREX pilot plant operations waste (DeFord 1992 and Cummings 1989). Records indicate that this tank was in operation for less than one year. It is located southeast of the former 201-C Process Building at Hanford coordinates N41900/W50100. A schematic diagram of the 241-CX-72 Storage Tank is presented on Figure 2-14.

The 241-CX-72 Storage Tank is an upright, cylindrical single-shell carbon steel tank, approximately 1.0 m (40 in.) in diameter, 11 m (36 ft) deep, and is buried approximately 4.3 m (14 ft) below grade. The tank walls are reinforced with five stiffener rings that extend nearly out to the walls of its caisson enclosure. Three rows of vertical guides connect the stiffener rings. It has a 8,800 liter (2,300 gallon) design capacity and was constructed in association with the 241-CX Vault (discussed at the end of this section) and a sampling pit. A 7.6 cm (3 in.) diameter drywell is mounted on the inner wall of the tank. The tank rests inside a 1.8 m (6 ft) diameter carbon steel caisson which has a cylindrical electric heater mounted above each stiffener ring. According to DeFord (1992) four pipes extend above grade and two pipes enter the tank underground via the 241-CX Vault. In addition, a manually operated system of agitator rods originally extended from within the tank to above ground. Cummings (1989) reports this tank was not directly associated with any other cribs or tanks.

Although there is no supporting documentation, the 241-CX-72 Storage Tank most likely received high level waste from the PUREX pilot plant process. This process used tributylphosphate in a kerosene solvent to extract plutonium and uranium from acidic solutions of irradiated uranium. Nitric acid was used to promote the extraction of plutonium and uranium.

The tank was grouted in 1986 as part of the decommissioning process. Approximately 4.6 m (15 ft) of the internal system of actuator rods was pulled from the tank by heavy equipment sometime between 1986 and 1988 resulting in contamination to the ash material covering this area and the discovery that the tank still contained waste (Griffin and Ludowise 1989). After discovery of the remaining waste, Griffin and Ludowise (1989) concluded that the contents of the 241-CX-72 Storage Tank could be considered transuranic waste and should be retrieved, and that the retrieval of the waste from the 241-CX-72 Storage Tank was feasible using existing technology and methods. More recently, however, plans to drill out the grout cap have been abandoned and Decontamination and Decommissioning has recommended deferring sampling or cleanup of the tank to the CERCLA operable unit activities.

Currently, the sludge in the tank is believed to contain approximately 200 grams of plutonium 239/240 (WHC 1992a). Summaries of the estimated radionuclide waste inventories for this tank are presented in Table 2-2.

The 241-CX-72 Vault is located below grade directly north of the 241-CX-72 Storage Tank. The vault is constructed of reinforced concrete and is divided into an instrument section, mechanical section, and a small sample pit. Exterior walls and floor are 0.3 m (1 ft) thick concrete with a 0.75 m (2.5 ft) thick dividing wall. The control building, located north of the tank and vault, has been removed. The vault's floor drain was connected via pipeline to the 216-C-6 Crib. The 241-CX-72 Vault was filled with grout as part of the decommissioning project.

2.3.3 Cribs and Drains

The cribs and drains were designed to percolate wastewater into the ground without exposure to the atmosphere. The locations of cribs and drains in the aggregate area are shown on Figure 2-3. Cribs are shallow excavations that are either backfilled with medium to coarse gravel material or held open by wooden structures. Both types of cribs are covered with an impermeable vapor barrier made of either sisalkraft paper (a natural fiber media) or polyethylene which is then covered with soil to grade. Water flows directly into the backfilled material or covered open space and percolates into the vadose zone soils. French drains are generally constructed of steel or concrete pipe and may be either open or filled with gravel. The Semi-Works Aggregate Area contains 7 cribs, as well as 4 newly identified french drain type structures.

The cribs and drains received low-level waste for disposal. Most cribs, drains, and trenches were designed to receive liquid until the unit's specific retention or radionuclide capacity was met. The term "specific retention" is defined as that volume of waste liquids 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 the percent of 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 wee allowed to receive until they were shut down (Fecht et al. 1977). The following sections describe each crib and drain in the Semi-Works Aggregate Area.

2.3.3.1 216-C-1 Crib. The 216-C-1 Crib began operating in 1953 and was retired in 1957. The crib is located 76 m (250 ft) south of the 2704-C Building at Hanford coordinates N42069/W50235 (WHC 1992a). This crib is constructed with concrete ties, spacer blocks, and roof slab, and measures 7 m (23 ft) long, 1.7 m (5.5 ft) wide, and 2.4 m (8 ft) wide. Sources reviewed for this report indicate that the crib was set in an excavation 4 to 5.2 m (13 to 17 ft) deep, and was covered with a layer of gravel and then soil. Until it was stabilized in the mid-1980s, the crib location was marked by a 1.5 m (5 ft) depression in the ground surface. Per Maxfield (1979), this crib and the 216-C-3, 216-C-4, and 216-C-5 Cribs were stabilized in 1979 by (1) blading off 10 cm (4 in.) of ground and placing the soil in the 216-C-1 Crib depression, (2) covering the ground with a 10 cm (4 in.) sand pad, (3) applying a herbicide, (4) installing a 10 mil plastic sheet over the entire surface, (5) placing a 30 cm (12 in.) sand pad over the plastic, and (6) stabilizing the area with 10 cm (4 in.) of pit run gravel.

Two pipes protrude from the roof of the structure to a height of approximately 0.9 m (3 ft) above grade. A 20 cm (8 in.) diameter steel well casing extends vertically through the center of the crib from 1.2 m (4 ft) above the structure to 7.6 m (25 ft) below the structure (WHC 1992a). The bottom 1.5 m (5 ft) of the casing are perforated. A 1 cm (0.5 in.) steel water level indicator pipe extends down approximately 0.9 m (3 ft) below the crib's roof (DeFord 1992).

The 216-C-1 Crib received 23,400,000 liters (6,180,000 gallons) of liquid waste. Up until September 1955, the crib received REDOX and PUREX high salt waste, process condensate from the 201-C Process Building, and material described as "cold-run" waste from the REDOX and PUREX Processes by DeFord (1992). From September 1955 to

June 1957, the crib also received the high salt cold-run waste from the 201-C Process Building (WHC 1992a and Cummings 1989). A summary of the radionuclide and chemical waste inventories for the 216-C-1 Crib are presented in Tables 2-2 and 2-3, respectively. The WIDS (WHC 1992a) estimated there is approximately 153 m^3 (200 yd^3) of contaminated soil at this site.

When the site was retired in June of 1957, it was stabilized by blocking off the effluent piping and filling in the depression above the crib with layers of sand and gravel on either side of 10 mil plastic sheeting.

2.3.3.2 216-C-3 Crib. This drain field-type crib received waste during 1953 and 1954. The crib is located 122 m (400 ft) south of 7th Street and 114 m (375 ft) south/southwest of the 2704-C Building, at Hanford coordinates N42055/W50390. It consists of 10 cm (4 in.) diameter open jointed drain tiles placed in a 41 cm (16 in.) gravel bed at the bottom of a 15 m (50 ft) long, 3 m (10 ft) wide, and 3 m (10 ft) deep excavation. The excavation was only partially backfilled during use and completely backfilled when deactivated (DeFord 1992). The boundaries of this site are not delineated with a barrier, although the crib is marked by one concrete marker post.

The 216-C-3 Crib received 5,000,000 liters (1,320,000 gallons) of liquid acidic REDOX Process waste during its period of operation from the 201-C Process, 215-C Gas Preparation, and 271-C Aqueous Makeup and Control Buildings. This waste management unit was also known as the 201-C Leach Pit. A summary of the radionuclide and chemical waste inventories for the 216-C-3 Crib are presented in Tables 2-2 and 2-3, respectively (WHC 1992a). There is an estimated 31 m^3 (40 yds^3) of contaminated soil at this site.

The site was deactivated by blanking off the pipeline to the crib and backfilling the excavation with layers of sand and gravel on either side of 10 mil plastic sheeting. Currently, a 1-ft thick temporary gravel road runs across part of this crib site to provide access to the 241-CX-70 and 241-CX-72 Storage Tanks.

2.3.3.3 216-C-4 Crib. The 216-C-4 Crib is a liquid waste drain field-type crib which was used from July 1955 until May 1965. It is situated just west of the 216-C-3 Crib and is approximately 115 m (375 ft) southwest of the 2704-C Building between the two security fences at Hanford coordinates N42060/W50430. The crib is 3 m (10 ft) by 6 m (20 ft), with piping arranged in an H pattern in plan view. It consists of two 6 m (20 ft) lengths of 15 cm (6 in.) diameter galvanized, corrugated, perforated steel pipe connected in the middle with a 2 m (6 ft) length of pipe. The piping system was buried approximately 3 m (10 ft) below grade in a bed of gravel, which was covered with tar paper. The excavation was backfilled with gravel (DeFord 1992).

The 216-C-4 Crib received 170,000 liters (45,000 gallons) of radioactive-contaminated organic waste from the 276-C Solvent Handling Facility. This liquid waste was characterized as low salt and neutral/basic from the PUREX process and the strontium, promethium, cerium, and technetium recovery process. Radionuclide and chemical inventories of the waste are presented in Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The WIDS (WHC 1992a) estimated that there is 93 m^3 (112 yds^3) of contaminated soil present at this site.

The site was deactivated by valving out the effluent pipeline and covering the crib area with successive layers of sand, 10 mil plastic sheeting, sand, and gravel. Currently, two 7.6 cm (3 in.) metal pipes extend above grade from this crib area (DeFord 1992).

2.3.3.4 216-C-5 Crib. The 216-C-5 Crib is a liquid waste drain field-type crib which operated from March to June 1955. It is located 114 m (375 ft) south-southwest of the 2704-C Building and 137 m (450 ft) south of 7th Street, at Hanford coordinates N42030/W50360. This crib was constructed with 15 cm (6 in.) diameter galvanized, corrugated, perforated steel pipe with the same dimensions and H-pattern (plan view) as the 216-C-4 Crib (3 m [10 ft] long by 6.1 m [20 ft] wide by 4.9 m [16 ft] deep). It is situated approximately 3 m (10 ft) below grade in a bed of gravel, covered with two layers of tar paper and backfill material (WHC 1992a and DeFord 1992).

During its short operational period, the 216-C-5 Crib received 37,900 liters (10,000 gallons) of PUREX high salt and cold-run waste from the 201-C Process Building. High salt wastes were high in sodium content and cold-run wastes were saline solutions left over from testing system integrity. Radionuclide and chemical waste inventories for this crib are presented in Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The contaminated soil volume of this crib is estimated to be 86 m^3 (112 yds^3).

The site was deactivated by valving out the effluent pipeline and covering the crib area with successive layers of sand, 10 mil plastic sheeting, sand, and gravel (WHC 1992a and DeFord 1992). On April 1, 1992, the 216-C-5 Crib was backfilled with ash and the posting was downgraded to Underground Radioactive Material.

2.3.3.5 216-C-6 Crib. The 216-C-6 Crib is a liquid waste drain field-type crib which operated from September 1955 to September 1964. It is located 137 m (450 ft) south of 7th Street, at Hanford coordinates N42015/W50066. This crib was constructed with 15 cm (6 in.) diameter galvanized, corrugated, perforated 6.1 m (20 ft) length steel pipe with the same dimensions and H-form as the 216-C-4 and 216-C-5 Cribs. It is situated approximately 3 m (10 ft) below grade in a bed of gravel, covered with two layers of tar paper and backfill material. The site dimensions are 6.1 m (20 ft) long by 6.1 m (20 ft) wide by 4.9 m (16 ft) deep (WHC 1992a and DeFord 1992).

The 216-C-6 Crib received 530,000 liters (140,000 gallons) of PUREX, REDOX, and strontium recovery process condensate from the 201-C Process Building and the 241-CX Vault floor drain. The waste is acidic. Radioactive process condensate wastes derived from REDOX and PUREX operation contained cesium-137, ruthenium-106, strontium-90, plutonium-239, and uranium based on WIDS information. Non-radioactive constituents in PUREX process condensates included dilute nitric acid and other inorganic constituents. Radionuclide and chemical waste inventories for this crib are presented in

Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The WIDS (WHC 1992a) estimates the contaminated soil volume at this site as 86 m^3 (112 yd^3).

The site was deactivated by sealing the effluent pipelines. Currently, four metal vents with vent covers extend approximately 1 m (3 ft) above grade (WHC 1992a and DeFord 1992).

2.3.3.6 216-C-7 Crib. The 216-C-7 Crib is an inactive liquid waste site. It is a drain field-type crib constructed in 1961 about the same time as the Critical Mass Laboratory, to receive waste streams from the laboratory. It received waste through 1987 but is now inactive. The unit is located approximately 15.2 m (50 ft) southwest of the Critical Mass Laboratory, at Hanford coordinates N42000/W50672.

The crib was constructed in an H-pattern (plan view) with two 6.1 m (20 ft) lengths of 15 cm (6 in.) diameter vitrified clay pipe and one 4.6 m (15 ft) connecting cross pipe. It is buried approximately 3.7 m (12 ft) below grade in a bed of gravel. The gravel bed is separated from backfill material by 6 mil polyethylene sheeting (DeFord 1992). The site dimensions are 6.1 m (20 ft) long by 6.1 m (20 ft) wide by 3.7 m (12 ft) deep (WHC 1992a).

During its period of operation, the 216-C-7 Crib received 60,000 liters (16,000 gallons) of Critical Mass Laboratory liquid waste. Nielsen (1990) described the waste as reflector tank water from two tanks located in the laboratory. Radionuclide and chemical waste inventories for this crib are presented in Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The WIDS (WHC 1992a) estimated the contaminated soil volume at this site to be 130 m^3 (170 yds^3).

Currently, four vitrified clay vent pipes extend approximately 1 m (3 ft) above the ground at the site. DeFord (1992) indicates that these vent pipes extend upward from the four tips of the H-configuration.

2.3.3.7 216-C-10 Crib. The 216-C-10 Crib is an inactive drain field-type crib which received waste from the 201-C Process Building from 1964 to 1967. The crib is located southeast of the 201-C Process Building at Hanford coordinates N42100/W49870. The 216-C-10 Crib is constructed of a single 9.8 m (32 ft) length of perforated 7.5 cm (3 in.) diameter stainless steel pipe placed in a 1 m (3 ft) deep gravel bed at the bottom of a 2 m (7 ft) deep excavation. A 30.5 cm (12 in.) diameter vitrified clay pipe vent extends from the end of the distribution pipe to approximately 1.5 m (5 ft) above grade. A 20 cm (8 in.) vitrified clay pipe gage well extends from the bottom of the crib to about 1 m (3 ft) above grade (WHC 1992a and DeFord 1992). The site dimensions are 9.8 m (32 ft) long by 1.5 m (5 ft) wide by 2.1 m (7 ft) deep.

The 216-C-10 Crib received 897,000 liters (237,000 gallons) of acidic process condensate from the strontium recovery process at the 201-C Process Building. Radionuclide and chemical inventories of the waste are presented in Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The contaminated soil volume at this site is estimated by WIDS (WHC 1992a) to be 66 m^3 (86 yds^3).

2.3.3.8 Newly Identified Drains. During the preparation of the Semi-Works AAMS, four additional drains were identified in the Semi-Works Aggregate Area. In general, the information found for these sites was limited, and the sites have not been officially documented, listed as formal waste management units, nor included under the Tri-Party Agreement. More information will be compiled on these drains in the future to assess their historical use and any environmental impact. A formal evaluation of the regulatory status of these drains will be made in accordance with WHC-CM-7-7, EII 1-10 (WHC 1988d). Based on results of this evaluation, the drains may be submitted for listing as official waste management units. The identified drains are described below.

2.3.3.8.1 Critical Mass Laboratory Dry Well North. Site inspection shows a 1.2 m (4 ft) dry well approximately 7.6 m (25 ft) north of the Critical Mass Laboratory. No other information was available on this dry well.

2.3.3.8.2 Critical Mass Laboratory Dry Well South. Site inspection shows a 1.2 m (4 ft) dry well located approximately 7.6 m (25 ft) southeast of the Critical Mass Laboratory. No other information was available on this dry well.

2.3.3.8.3 Critical Mass Laboratory Dry Well East. Site inspection shows a dry well located approximately 7.6 m (25 ft) northeast of the office wing in the Critical Mass Laboratory. No other information was available on this dry well.

2.3.3.8.4 Gatehouse French Drain. Site inspection shows a french drain located approximately 3 m (10 ft) southwest of the 2704-C Building. The drain cover is currently painted yellow and is posted to indicate the presence of radioactive contamination. No other information was available on this drain.

2.3.4 Reverse Wells

Reverse wells are encased drill holes with the lower end of the casing perforated or open to allow liquid to seep into the vadose zone at a depth greater than that for cribs and drains. The location of the 216-C-2 Reverse Well identified at the Semi-Works Aggregate Area is shown on Figure 2-4.

2.3.4.1 216-C-2 Reverse Well. The 216-C-2 Reverse Well is an Ecology-registered underground injection well which received waste from 1953 to 1988 (WHC 1992a). The waste management unit is located approximately 30 m (100 ft) southeast of the former 291-C Stack at Hanford coordinates N42300/W50000 and received condensate from the stack and seal water from the fiberglass filter assembly. The well was constructed of 30.5 cm (12 in.) diameter steel pipe which extended approximately 0.3 m (1 ft) above grade and 12.2 m (40 ft) below grade. The lower 7.6 m (25 ft) of the pipe is perforated (DeFord 1992).

Condensate from the 291-C Stack drained into the 216-C-2 Reverse Well through a 10 cm (4 in.) diameter pipe which entered the reverse well at about 3 m (10 ft) below grade. The reverse well also received seal water drainage from the stack ventilation filter through a 5 cm (2 in.) diameter line entering the well at about 3.6 m (12 ft) below grade. The liquid waste is characterized as low salt and neutral/basic. The volume of waste received by this reverse well is unknown (WHC 1992a and DeFord 1992).

The unit was decommissioned in 1988 by cutting and capping the two influent lines, thus isolating it, sealing the wellhead in concrete, and covering it with a 0.9 m (3 ft) ash "barrier" (DeFord 1992).

2.3.5 Ponds and Ditches

The pond and ditch in the Semi-Works 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. The locations of the pond and ditch are shown on Figure 2-5. A pond is a relatively broad, shallow unlined structure intended to percolate large volumes of slightly contaminated wastewater into the soil column. A ditch is a long, open, unlined excavation used to transfer low-level liquid wastes from process facilities to ponds or trenches. Ditches are also used as soil column disposal sites for low-level waste streams. Trenches are unlined temporary (typically 1-3 months lifespan) excavations used for disposing material from the process facilities by infiltration in the subsurface. Quantities are usually limited as compared to cribs or ponds. Many of Hanford's trenches are designated "specific retention" trenches as defined in Section 2.3.3. Generally, for soil column disposal, a target of 6% of the specific retention capacity of the unit was utilized after 1958 in an effort to ensure that liquid did not reach groundwater (Haney and Honstead 1958). There is one ditch and one pond in the Semi-Works Aggregate Area.

2.3.5.1 216-C-9 Pond. The 216-C-9 Pond was the foundation excavation for the planned 221-C Canyon Building which was never completed. The pond began operation in 1953 as a receiving site for process cooling water from Semi-Works facilities and operated until 1985. The pond was situated north of 7th Street and was approximately 7,432 m^2 (80,000 ft^2) in area, with dimensions of 244 m (800 ft) in length, 30.5 m (100 ft) in width, and 7.6 m (25 ft) in depth (DeFord 1992). The pond was divided by berms into several lobes. Wastewater was fed to the pond via several diversion boxes and six pipes from facilities in the Semi-Works Aggregate Area. These include the 201-C Process Building, the 215-C Gas Preparation Building, the 291-C Ventilation System, the 2707-C Storage and Change House, and the Critical Mass Laboratory (209-E Building). Liquid waste from the Semi-Works Complex appears to have been directed to the eastern end of the pond while liquid waste from the Critical Mass Laboratory appears to have been directed to the west lobe.

The 216-C-9 Pond received a total waste volume of 1,030,000,000 liters (272,000,000 gallons). The waste receiving history is as follows:

- Until August 1960, the site received process cooling water from the 201-C Process Building and the other Hot Semi-Works facilities.
- From August 1960 to October 1969, the site received the effluents mentioned above plus miscellaneous wastewater from the Critical Mass Laboratory.
- From October 1969 to December 1985, the pond received miscellaneous wastewater from the 201-C Process Building and the Critical Mass Laboratory.

The 209-E miscellaneous wastewater stream consisted mostly of effluent from equipment and floor drains in the utility and change rooms. One source of waste cooling water came from the mixing room and was potentially contaminated with radionuclides. During its operational history, the 216-C-9 Pond received liquids with cesium, ruthenium, strontium, plutonium, and alpha and beta contamination. No radioactivity was found along the pond perimeter in a survey performed on June 22, 1978. Radionuclide and chemical waste inventories for this unit are presented in Table 2-2 and 2-3, respectively (WHC 1992a and DeFord 1992). The volume of contaminated soil is estimated in WIDS (WHC 1992a) to be 2,609 m^3 (3,400 yds^3).

After the 216-C-9 Pond was shut down in 1985, it dried up and was eventually backfilled with 0.9 m (3 ft) of gravel. The eastern portion of the former pond was then converted into the 218-C-9 Burial Ground and subsequently the whole excavation was backfilled to grade with ash.

2.3.5.2 200 East Powerhouse Ditch. The 200 East Powerhouse Ditch runs along the southern boundary of the Semi-Works Aggregate Area. This active ditch drains non-radioactive wastewater from the active 284-E Power Plant located about 1.6 km (1 mile) southwest of the Semi-Works Aggregate Area. DeFord (1992) reports the 200 East Powerhouse Ditch is approximately 762 m (2,500 ft) in length, has a 6.1 m (20 ft) bottom width, and is 3 m (10 ft) deep. The ditch flows to the west into a 76 cm (30 in.) diameter corrugated metal pipe that carries water to the 216-B-3 Pond Complex in the B Plant Aggregate Area.

DeFord (1992) reports that the process associated with the 284-E Power Plant is steam production. Purified water from the 283-E Water Treatment facility is heated in coal-fired boilers to produce steam. During this process, three major discharges of waste water occur to the 200 East Powerhouse Ditch:

- The largest discharge is associated with purified water used to cool various components of the 284-E Power Plant and averages a flow rate of about 12,300,000 liters (3,250,000 gallons) per month.

- The second flow of wastewater—the waste brine solution used to regenerate the zeolite water softener columns in the 283-E plant—contains the most concentrated single discharge in terms of dissolved solids. This water contains about 9 percent by weight sodium chloride and has an average monthly flow rate of 1,135,000 liters (300,000 gallons).

- The third discharge comes from the blowdown of scale from inside the 284-E boilers. This flow is about 378,000 liters (100,000 gallons) per month. This discharge contains dissolved boiler scale and residual oxygen scavenging chemicals.

2.3.6 Septic Tanks and Associated Drain Fields

Septic tanks and associated drain fields accept sanitary sewer effluent from the buildings in the Semi-Works Aggregate Area. The location of the two septic tank drainfield systems associated with the Semi-Works Aggregate Area are shown on Figure 2-6. Both systems are included in the Tri-Party Agreement (DeFord 1992).

2.3.6.1 2607-E-5 Septic Tank and Drain Field. The 2607-E-5 Septic Tank and associated drain field is an active waste site for sanitary wastes from the Critical Mass Laboratory and mobile offices. This septic tank also received sanitary wastewater from the 2707-C Storage and Change House. The septic system is located north of the 209-E Building and south of 7th Street at Hanford coordinates N42400/W50850. Although WIDS (WHC 1991a) reports the system was constructed in 1944, DeFord (1992) suggests a more likely construction date of 1949 when the Semi-Works Plant was built.

The 2607-E-5 Septic Tank is a 6.4 m (21 ft) long, 2.7 m (9 ft) wide, and 3.7 m (12 ft) deep reinforced concrete structure with a metal manhole cover. The design capacity was 292 persons (132 liters/day [35 gallons/day]) with a 24-hour detention time. The original drain field is located southwest of the tank and was constructed of 10 cm (4 in.) diameter pipe (WHC 1992a). According to DeFord (1992), the original drain field was disconnected and abandoned around 1963, and the 2607-E-5 Septic Tank was connected in tandem with the 2607-E-7A Septic Tank and Drain Field.

There are no radioactive or hazardous wastes reported for the 2607-E-5 Septic Tank and drain field in the documents reviewed.

2.3.6.2 2607-E-7A Septic Tank and Drain Field. The 2607-E-7A Septic Tank and associated drain field is an active, sanitary waste site constructed in 1983. The unit is located immediately west of, and is operated in conjunction with, the 2607-E-5 Septic Tank at Hanford coordinates N42400/W51199. The 2607-E-7A Septic Tank consists of two 3.7 m (12 ft) long, 1.5 m (5 ft) wide, and 1.5 m (5 ft) deep concrete tanks connected in tandem. The associated drain field is located west of the tanks.

There are no radioactive or hazardous wastes reported for the 2607-E-7A Septic Tank and drain field in the documents reviewed.

2.3.7 Transfer Facilities, Diversion Boxes, and Pipelines

High-level waste transfer lines (also referred to as process lines) connect the major processing facilities with each other and with the various waste disposal and storage facilities. Most lines are 7.6 cm (3 in.) diameter stainless steel pipes with welded joints. Process lines are generally enclosed in steel reinforced concrete encasements and are set below grade. The process lines are not waste management units according to the Tri-Party Agreement and will be addressed in detail under separate programs (e.g., Hanford Decommissioning and RCRA Closure Program). However, because of their age and construction, there is a possibility of leakage for some of the process lines along their rights-of-way.

Pipelines connecting the liquid waste stream generating facilities to their soil column disposal sites (e.g., cribs, ditches) are sometimes constructed of sectional vitreous clay or corrugated metal pipes; these types of lines are expected to have leaked to some degree. The pipeline rights-of-way, therefore, may be contaminated to levels comparable to the soil column sites. 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 part of their respective units.

Process transfer lines cross the Semi-Works Aggregate Area both north and south of Semi-Works connecting facilities within the PUREX and B Plant Aggregate Areas. There are also steam lines, raw and sanitary water lines, and electrical lines crossing and connected to Semi-Works and the Critical Mass Laboratory facilities.

Diversion boxes house the switching facilities where waste can be routed from one process line to another. They are concrete boxes that were designed to contain any waste that leaks from the waste transfer line connections. The diversion boxes generally drain by gravity to nearby catch tanks where any spilled waste is stored.

2.3.7.1 Semi-Works Valve Pit. The Semi-Works Valve Pit is also identified as the Hot Semi-Works Valve Pit (WHC 1992a). The unit is a cylindrical stainless steel pit, with a 1.7 m (5.5 ft) inside diameter. It is placed below grade and is located adjacent to the east wall of the 201-C Process Building at Hanford coordinates N43220/W51760. The valve pit connected lines from sources within the 201-C Process Building to discharge locations at the 244-CR Vault in the PUREX Aggregate Area, the 241-C Tank Farm, and the 241-CX-70 Storage Tank.

DeFord (1992) reports the pit was decommissioned in the late 1980's as part of the general Semi-Works decommissioning effort. The lines were sealed, isolated, and the box was filled with concrete. Currently, the site is buried beneath the ash barrier which was placed over the decommissioned 201-C Process Building.

2.3.7.2 Critical Mass Laboratory Valve Pit. The Critical Mass Laboratory Valve Pit is a concrete structure that abuts the south wall of the 209-E Building. It is approximately 1.8 m (6 ft) by 2.4 m (8 ft) and stands about 1 m (3 ft) above grade. It has a steel lid and is posted with 'Radioactive Contamination' warning signs.

DeFord (1992) suggests that the line running to the 216-C-7 Crib originates in this pit. The ventilation stack and fan assembly for the Critical Mass Laboratory are also located at this point. Reportedly radioactive contamination is associated with the valve pit sump, although no specific waste inventories for this unit were found in the documents reviewed. The valve pit and ventilation hardware were integral to the Critical Mass Laboratory and until recently were considered active.

2.3.7.3 241-C-154 Diversion Box. The 241-C-154 Diversion Box operated until 1967 in support of the promethium recovery phase of the Semi-Works operations. The unit is a 2.4 m (8 ft) cube, steel reinforced concrete diversion box located about 9.1 m (30 ft) southeast of the southeast corner of the 201-C Process Building at Hanford coordinates N42175/W50140. The unit was associated with a promethium transfer line which connected promethium lines from B Plant to various Semi-Works locations. A floor drain was connected from this diversion box into the Semi-Works Valve Pit (DeFord 1992).

DeFord (1992) reports that this site was decommissioned in 1985 as part of the general Semi-Works decommissioning effort. The decommissioning effort included isolating the lines, sealing, filling the diversion box with concrete, and covering the area with ash.

No waste characterization or hazardous material inventory is available on the 241-C-154 Diversion Box.

2.3.8 Basins

Retention basins are concrete lined ponds used for intermittent storage of liquid waste before being transferred to ponds, ditches, or cribs. There are no basins in the Semi-Works Aggregate Area.

2.3.9 Burial Sites

There is one burial site, the 218-C-9 Burial Ground, located in the Semi-Works Aggregate Area. The burial ground generally consists of trenches that received radiologically contaminated building rubble and related material, and then were backfilled. The location of the burial ground is shown on Figure 2-8.

2.3.9.1 218-C-9 Burial Ground. The 218-C-9 Burial Ground, also called Dry Waste No. OC9, is a low-level solid waste burial ground which began receiving wastes in 1985. The WIDS (WHC 1992a) suggests that this is an active site, while DeFord (1992) indicates, and field inspection confirms, the site was filled to grade with an ash "barrier" after the 201-C Process Building was decommissioned. The site is situated north of 7th Street in the eastern portion of the old 216-C-9 Pond area, and covers an area of approximately 16,982 m^2 (182,800 ft^2). The pond had dried up by 1985, and was subsequently stabilized with 1 m (3 ft) of fresh gravel before beginning to receive waste.

According to DeFord (1992), the burial grounds received 2,266 m^3 (80,000 ft^3) of rubble from the decommissioning of the 201-C Process Building. The radiological inventory for the Burial Ground is reported in WHC (1991c) and is shown in Table 2-2. No chemical inventory was located for this waste unit.

2.3.10 Unplanned Releases

Four unplanned releases are included in the Semi-Works Aggregate Area. In addition, two other unplanned releases were identified during the course of the study. Their locations are shown on Figure 2-9. Unplanned releases designated with a "UPR" are releases from or within the operations of specific waste management units and are considered part of that unit for remediation purposes. Releases designated with a "UN" are a distinct waste management unit for remediation purposes. Many of the releases are not included as independent sites in the Tri-Party Agreement because they are closely associated with existing waste management units. These unplanned releases and their associated waste management units will be addressed together in this study.

Table 2-4 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 (WHC 1992a). In addition to the unplanned releases, there is considerable surface contamination around the 201-C Process Building site.

2.3.10.1 UN-200-E-36. Unplanned Release UN-200-E-36 occurred on July 24, 1967, at the A-Cell of the 201-C building cell. The release covered a fan-shaped area 137 m (450 ft) wide and 275 m (900 ft) long extending north of the A-Cell at the 201-C building, and across 7th Street into the desert. The release occurred while two pumps, identified as P-5 and P-7, were being removed from the below-ground cell, in preparation for a planned processing campaign.

The exact cause was undetermined and the release could not be detected until the A-Cell cover blocks were replaced and the background levels dropped. The most likely reason for the contamination spread was attributed to a ventilation fan being left on during pump removal and drawing contaminated particles up a stack and out of the A-Cell area and/or the pumps. Alternate and possibly contributory explanations include wind gusts during the pump movement or the use of a block yoke to tamp waste material into the burial box, thereby spreading particles. The typical method of contaminated equipment removal was to pull the device into a hanging plastic cover, wrapping it up and installing it in a burial box, located in this instance at the surface. Contamination was also blown into the A-Cell valve and pipe ways.

Beta/gamma readings of 30,000 to 60,000 ct/min were measured in the desert area north of the Semi-Works, including 7th Street. Particulate contamination of up to 80,000 ct/min was found on adjacent roadways. No personnel contamination resulted. The roads were blocked-off and washed off by the fire department. Additional unspecified decontamination procedures were instigated to remove contamination from the facility and surrounding area. The roadway was later removed from surface contamination status.

2.3.10.2 UN-200-E-37. This unplanned release is associated with the Unplanned Release, UN-200-E-36 and was reported a week afterward. In Unplanned Release UN-200-E-37, more contamination was found on July 31, 1967 east of the 201-C building with additional random spots found north of the 201-C building. Beta/gamma readings were measured at up to 200 mrem/hr. The spread was attributed to the failure to clean up the original spread and was likely augmented by strong winds drying up and spreading the contamination. The WIDS (WHC 1992a) and Deford (1992) report that the area was roped off, sprinklers were set up to flush the contamination below ground, and roads were cleaned. After removal of the contaminated soil, the area was removed from surface contamination status in 1990.

2.3.10.3 UN-200-E-98. Unplanned Release UN-200-E-98 occurred in September 1980 on the east side of the 291-C Stack, near the 216-C-2 Reverse Well. The WIDS (WHC 1992a) speculates that particulate matter containing ^{90}Sr was inadvertently released to the ground surface. DeFord (1992) reports that although some of the contamination was removed, some residual contamination still remains. The site is currently buried beneath the ash barrier placed over the decommissioned 201-C Process Building.

2.3.10.4 UN-200-E-141. DeFord (1992) reports that Unplanned Release UN-200-E-141 occurred in September of 1984 in the 2718 Storage Building located adjacent to the southwest side of the Critical Mass Laboratory. Approximately 208 liters of a 450 gm/L solution of uranyl nitrate (84 percent ^{235}U) was released onto the concrete floor when one of the storage containers failed due to corrosion (WHC 1992a). All liquids were subsequently removed from the building along with contaminated soil and asphalt. The concrete floor was reportedly decontaminated to background levels.

2.3.10.5 Newly Identified Unplanned Releases. During the course of the Semi-Works AAMS, two additional unplanned releases were identified in the Semi-Works Aggregate Area. In general, the information found for these unplanned releases was limited, and the sites have not been officially documented, listed as formal waste management units, nor included under the Tri-Party Agreement. More information will be compiled on these unplanned releases in the future to assess their potential impacts to the environment. A formal evaluation of the regulatory status of these sites will be made in accordance with WHC-CM-7, EII 1-10 (WHC 1988e). Based on results of this evaluation, the sites may be submitted for listing as official unplanned releases. The identified unplanned releases are described below.

2.3.10.5.1 241-C Waste Line Unplanned Release No. 1. Immediately east of and abutting the 201-C Process Building in an area called the A Courtyard, is an area of reported underground contamination roughly 39.6 m (130 ft) by 18.3 m (60 ft) identified in 1957. A leak is believed to have originated from a teflon gasket in the flange on the 241-C Waste Line running from the 201-C Process Building to the 241-C Tank Farm in the PUREX Aggregate Area. Piping was eventually installed to bypass the flanged section of the line. No waste inventory information on this release was available in the documents reviewed. This area is covered with ash.

2.3.10.5.2 241-C Waste Line Unplanned Release No. 2. Approximately 45.7 m (150 ft) east of the 201-C Process Building a second area of underground contamination was identified in 1957. The approximate size of the area is 39.6 m (130 ft) by 9.1 m (30 ft). This release is also believed to have occurred at a flange (with failed teflon gasket) in the 241-C Waste Line. That section of the line was eventually bypassed. No waste inventory information was available for this release.

2.4 WASTE GENERATING PROCESSES

The primary waste generating activities at the Semi-Works Aggregate Area include historical operations in the 201-C Process Building (Semi-Works Complex) and the Critical Mass Laboratory (209-E Building). Other waste-generating facilities include:

- 276-C Solvent Handling Facility
- 291-C Ventilation System Stack
- 215-C Gas Preparation Building
- 271-C Aqueous Makeup and Control Building.

For the facilities listed, the following subsections describe the waste generating processes, the resulting waste streams, and waste stream disposition and disposal. The discussions incorporate information from reference sources reviewed for this report, including DeFord (1992), Anderson (1990), Nielsen (1990), Cummings (1989), and Evans and Tomlinson (1954). Additional information regarding the nature of waste generating processes and resulting waste streams was not found during document review. Semi-Works waste producing processes and waste stream characteristics are summarized on Table 2-5. Table 2-6 lists chemicals that are known to have been used during processing activities in the Semi-Works Aggregate Area.

2.4.1 201-C Process Building (Semi-Works Complex) REDOX, PUREX, and Strontium Recovery Process Descriptions

The REDOX process was used for the separation of uranium and plutonium from fission products and from each other. The basis of the process was the extraction of uranium and plutonium from an aqueous, high-salt solution in an organic solvent (hexone). This operation was conducted in a continuous, packed solvent extraction column through which the aqueous and organic phases were passed counter-currently. Uranium and plutonium were separated by converting the plutonium to a lower valence state, in which form it was preferentially extracted back into an aqueous phase of high salt content in a second column. Uranium was then returned to an aqueous phase of low salt content in a third column. The products were purified further in similar, additional cycles (Evans and Tomlinson 1954).

The PUREX process used tributylphosphate in kerosene solvent to extract plutonium and uranium from acid solutions of irradiated uranium. Nitric acid was used to promote extraction of plutonium and uranium.

The strontium recovery process was performed utilizing a complexant di-2-ethyl-hexyl phosphoric acid, to extract strontium from acid solutions of waste fuels (Cummings 1989).

2.4.1.1 201-C Process Building Waste Streams and Disposition. Liquid waste streams from the 201-C Process Building consisted of wastes from the pilot REDOX and PUREX recovery activities in the 1950's, and from strontium, cerium, promethium, and technetium recovery in the 1960's. Prior to commencing the actual pilot recovery activities, extensive "cold-run" trials were routinely conducted using nonradioactive materials to verify the operational status of the equipment. The following discussion summarizes the waste streams generated from these processes.

Wastes from the 201-C Process Building were chemically and radiologically contaminated, and their disposition was accomplished in accordance with their radiological content (DeFord 1992).

In general, high-level wastes were stored in underground tanks in the 200 East Area Tank Farms, and low-level wastes were routed to cribs in the Semi-Works Aggregate Area for disposal. Wastes from the 201-C Process Building were sent to several waste management units, including:

- 216-C-9 Pond received low-level process cooling water between 1957 and 1985
- 241-CX-70 and 241-CX-72 Storage Tanks received high-level process wastes between 1952 and 1957
- 241-CX-71 Storage Tank received acidic wastes from 201-C Process Building prior to discharge to the 216-C-1 Crib and unspecified wastes from the 201-C Process Building hot shop sink.

2.4.1.1.1 REDOX Process Waste Streams. Wastes generated during the REDOX process included coating wastes from decladding of aluminum fuels in a boiling sodium nitrate/sodium hydroxide solution. The waste stream was composed primarily of uranium, plutonium, sodium hydroxide, sodium aluminate, sodium nitrate and nitrite, and sodium silicate. The waste solution was transferred to a tank separate from the high-level waste. During the REDOX processes, zircaloy-clad fuels were declad in an ammonium nitrate-ammonium fluoride mixture. The REDOX waste stream was composed of large volumes of aluminum nitrate, and zirconium oxide, sodium fluoride, sodium nitrate, potassium fluoride, uranium, and plutonium. Other wastes associated with the REDOX process included chromate, sodium sulfate, and ferric hydroxide compounds in addition to many of the other compounds listed. Waste streams from the REDOX process were slightly acidic and contained fission products including cesium-137, ruthenium-106, strontium-90, plutonium-239, and uranium based on WIDS (WHC 1992a). Cummings (1989) reported the presence of additional radionuclides including tritium, cobalt-60, and uranium-238 in the waste stream. The coating wastes from the aluminum and zircaloy-clad fuels decladding were neutralized with caustic soda.

Wastes generated during the REDOX process were sent to several waste management units, including:

- 241-C and other tank farms received high level process waste between 1952 and 1953
- 216-C-1 Crib received acidic radioactive waste between 1953 and 1954
- 216-C-3 Crib received acidic radioactive wastes between 1953 and 1954.

2.4.1.1.2 PUREX Process Waste Streams. The PUREX process generated wastes from decladding of aluminum and zircaloy fuels which were reportedly identical to those generated from REDOX decladding. During the PUREX process, a potassium permanganate, sodium carbonate, and nitric acid wash were used to separate organic compounds from a process extraction solvent prior to reuse of the solvent. The PUREX organic wash wastes primarily included sodium nitrate, sodium carbonate, manganese oxide, and uranium. Acidic PUREX wastes were neutralized, high level wastes containing nitrate, sulfate, phosphate, sodium, iron, and aluminum. The radionuclides in the waste streams included cesium-137, ruthenium-106, strontium-90, plutonium-239, and uranium (WHC 1992a). Cummings (1989) reported the presence of additional radionuclides including tritium, cobalt-60, and uranium-238 in the waste streams.

The process condensate from PUREX was generated as a waste stream. This process condensate consisted of water that had been in intimate contact with process organics, tributyl phosphate, and normal paraffin hydrocarbons. Because these chemicals used were of technical grade, they contained a variety of trace impurities: butanol, butyraldehyde, acetone, methyl ethyl ketone, and others. In addition, degradation products are also expected from the breakdown of unstable compounds, such as tributyl phosphate.

Wastes generated during the PUREX process were sent to several waste management units, including:

- 241-CX-72 Storage Tank received waste during 1956
- 216-C-1 Crib received neutral to basic process condensate and cold oven wastes between 1954 to 1956
- 216-C-5 Crib received high salt, neutral to basic process condensate in 1955
- 216-C-6 Crib received acidic process condensates between 1955 and 1964
- 216-C-10 Crib received acidic process condensates from 1955 to 1956.

2.4.1.1.3 Strontium Recovery Waste Streams. Limited information from Cummings (1989) indicates that the strontium recovery process in the 201-C Process Building utilized an organic complexing agent, di-2-ethyl-hexyl phosphoric acid, to extract strontium from acid solutions of waste fuels. No information regarding specific characteristics of wastes derived from cerium, technetium, and promethium recovery were found in the documents reviewed.

Wastes from the strontium recovery were directed to several waste management units, including:

- 241-C and other tank farms received high-level process waste between 1955 and 1956
- 241-CX-72 Storage Tank received wastes with high levels of radioactivity
- 216-C-6 Crib received acidic process condensate wastes between 1961 and 1964
- 216-C-10 Crib received acidic process condensate wastes between 1964 and 1967.

2.4.1.1.4 Other Waste Streams. Limited information was obtained regarding the nature of cold-run wastes derived from startup trials for Semi-Works processing. Historical cold-run wastes are likely characterized by high salt content, low organics, and as neutral to basic.

Unspecified wastes were also derived from the 201-C Process Building systems decontamination which were conducted prior to conversion to new processes. Information regarding the waste management units receiving other waste streams is limited.

2.4.2 Critical Mass Laboratory

The Critical Mass Laboratory housed in the 209-E Building was in operation from 1960 to 1983 to conduct criticality experiments with plutonium nitrate and enriched uranium solutions. Experiments were also performed using solid special nuclear materials and fuels. During this time period, the number of experiments performed in the Critical Mass Laboratory averaged 15 per year with a maximum of 50 a year (Nielsen 1990).

The laboratory generated mostly acidic liquid waste (neutron reflector tank water) containing mainly cesium-137, ruthenium-106, strontium-90, plutonium, uranium, and some nitrates (Nielsen 1990). No high-level wastes were identified in available literature as having been generated at the Critical Mass Laboratory.

The 216-C-7 Crib received about 60,000 liters (16,000 gallons) of liquid waste from the Critical Mass Laboratory transferred through the Critical Mass Laboratory Valve Pit. No other waste management unit has been identified in the documents reviewed as having received process waste from the laboratory.

2.4.3 276-C Solvent Handling Facility

The 276-C Solvent Handling Facility discharged radiologically contaminated, low-level, low-salt neutral to basic organic wastes to the 216-C-4 Crib between 1955 and 1965.

2.4.4 291-C Ventilation System Stack

Between 1953 and 1988 low-salt, neutral to basic stack drainage and ventilation filter seal water drainage were discharged to the 216-C-2 Reverse Well. The 291-C Ventilation System discharged filtered exhaust air from the operation cell sand process vessel vents through the 291-C stack.

2.4.5 215-C Gas Preparation Building and 271-C Aqueous Makeup and Control Building

The 215-C Gas Preparation Building and 271-C Aqueous Makeup and Control Buildings discharged acid wastes to the 216-C-3 Crib (along with similar wastes from the 201-C Process Building) between 1953 and 1954. Process cooling water from these buildings was sent to 216-C-9 Pond as waste.

2.5 INTERACTIONS WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

This section discusses the interaction of the Semi-Works Aggregate Area with other 200 Areas facilities and aggregate areas. The 200 Areas have two distinct operational areas, 200 East and 200 West. These are dedicated to chemical separations and waste management.

The Semi-Works Aggregate Area is bordered by the PUREX Aggregate Area on the east and north, and by the B Plant Aggregate Area on the west and south.

During operation of the 201-C Process Building, the Semi-Works Complex received spent reactor fuel rods from the reactors at the Hanford Site for reprocessing. Here, the plutonium was separated, purified, loaded out, and shipped off site to the Z Plant as a plutonium nitrate solution. According to DeFord (1992), megacurie quantities of strontium were recovered, purified, and loaded into casks for shipment off site, reportedly to the Oak Ridge National Laboratory.

Waste management units within the Semi-Works Aggregate Area which received waste from other operable units or aggregate areas include the 200 East Powerhouse Ditch and several transfer lines and valve boxes. This ditch receives water from the 201 East Powerhouse (284-E Power Plant) located in the 200 East Area. This wastewater contains dissolved solids in the form of sodium chloride, and oxygen-scavengers and anti-scaling compounds such as sodium sulfate and ethylenediaminetetraacetic acid (EDTA).

The Semi-Works Aggregate Area was connected to several other operations within the 200 East Area by transfer lines. DeFord (1992) reports that the 241-C-154 Diversion Box connected promethium lines from B Plant to various Semi-Works locations. The function of the Semi-Works Valve Pit was to connect lines from the 201-C Process Building and the 241-CX-70 Storage Tank to the 244-CR Vault in the PUREX Aggregate Area.

High-level wastes from the REDOX process were sent to the 241-C Tank Farm.

2.6 INTERACTION WITH RESOURCE CONSERVATION AND RECOVERY ACT PROGRAM

Two waste management units located within the Semi-Works Aggregate Area boundaries are subject to RCRA (and corresponding Washington State) regulations. A third waste management unit is currently under consideration for inclusion under the RCRA program. These units include:

- The 241-CX-70 Storage Tank is a TSD facility. This tank is currently identified in a Part A permit application.
- The 241-CX-71 Storage Tank has been identified as a TSD facility. A modification to the 241-CX-70 Part A permit identifying this tank has been sent to DOE-RL for approval and has been submitted to Ecology.
- The 241-CX-72 Storage Tank has been identified as a TSD unit. Sampling activities that had been planned to characterize the waste have been halted due to safety-related concerns. Consequently, an amendment to the 241-CX-70 Part A Permit will need to be prepared for submittal to Ecology.

It is expected that after these tanks are decontaminated and decommissioned, they will be permanently closed under the RCRA program. Following RCRA closure, further remediation of these tanks, if necessary, would be assessed through the AAMS process under CERCLA. Thus, there will be a need for interaction between future RCRA closure actions and the remediation actions recommended later in this report for the other Semi-Works Aggregate Area waste management units and unplanned releases.

2.7 INTERACTIONS WITH OTHER HANFORD PROGRAMS

In addition to RCRA, there are several other ongoing programs that affect buildings and waste management units in the Semi-Works Aggregate Area. These programs include: the Hanford Surplus Facilities Program; the Radiation Area Remedial Action Program; and the Defense Waste Management Program.

The Hanford Surplus Facilities 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 Semi-Works Aggregate Area, and the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks are covered under this program.

The Radiation Area Remedial Action Program is conducted as part of the Surplus Facilities Program, and is responsible for the surveillance, maintenance, decontamination, and/or interim stabilization of inactive burial grounds, cribs, ponds, trenches, and unplanned releases at the Hanford Site. A major concern associated with these requirements is the management and control of surface soil contamination. All of the controlled access surface radiation zones and the cribs in the Semi-Works Aggregate Area are covered by this program.

The Defense Waste Management Program is responsible for all actively operating waste management units in the Semi-Works Aggregate Area. These facilities include all high-level waste process lines and their associated diversion boxes.

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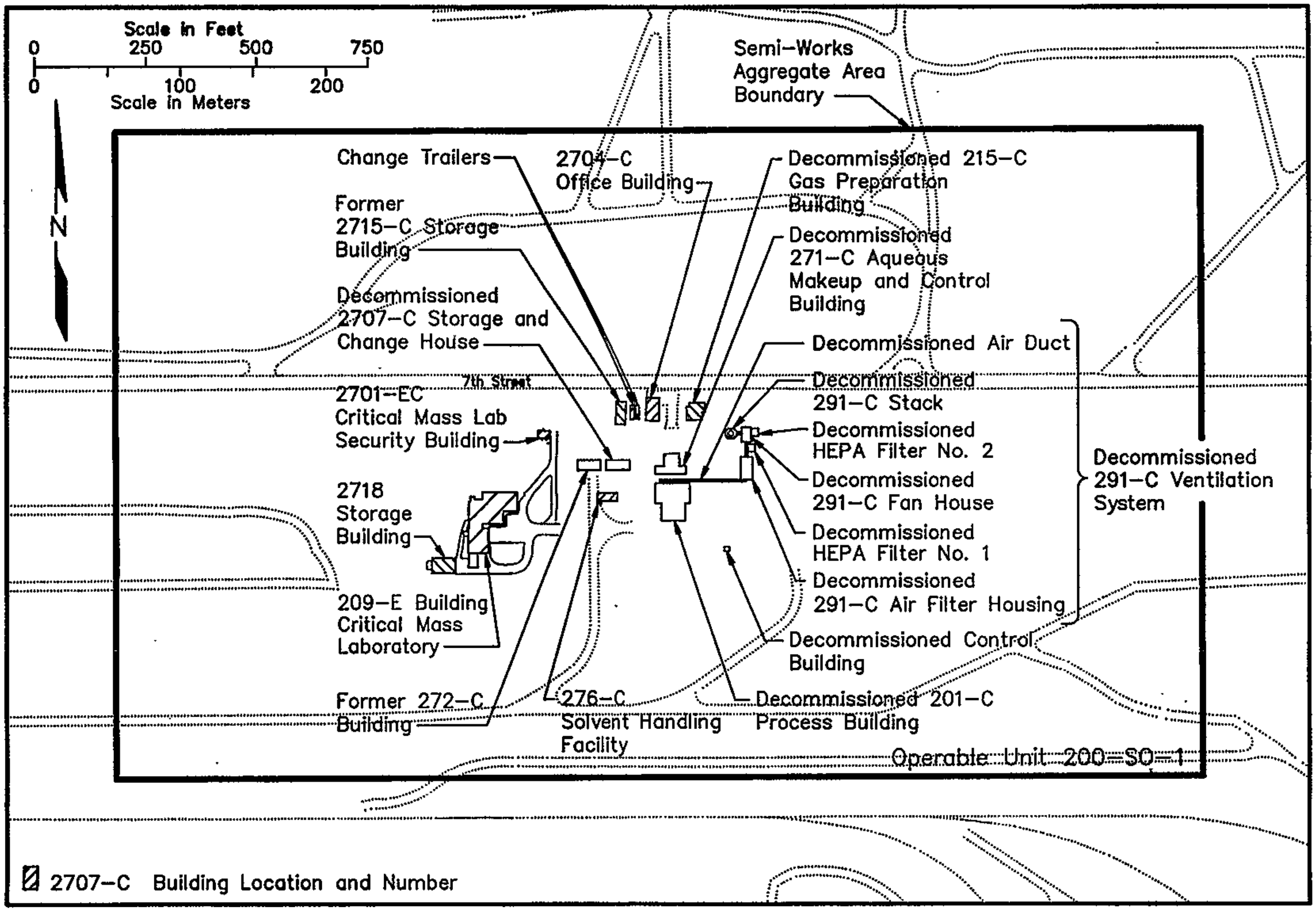

Figure 2-1. Location of Plants, Buildings, and Storage Areas in the Semi-Works Aggregate Area.

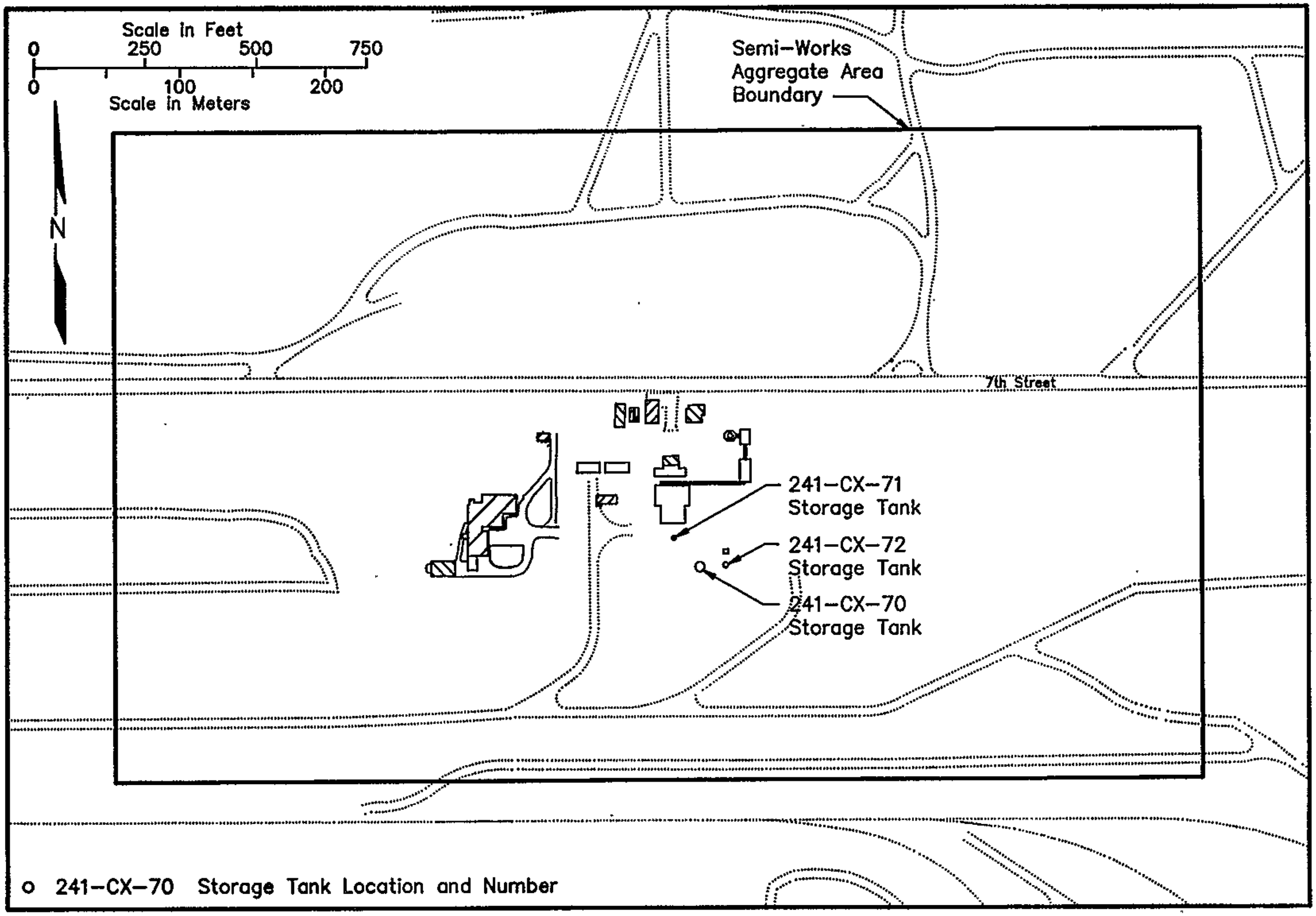

Figure 2-2. Location of Tanks and Vaults in the Semi-Works Aggregate Area.

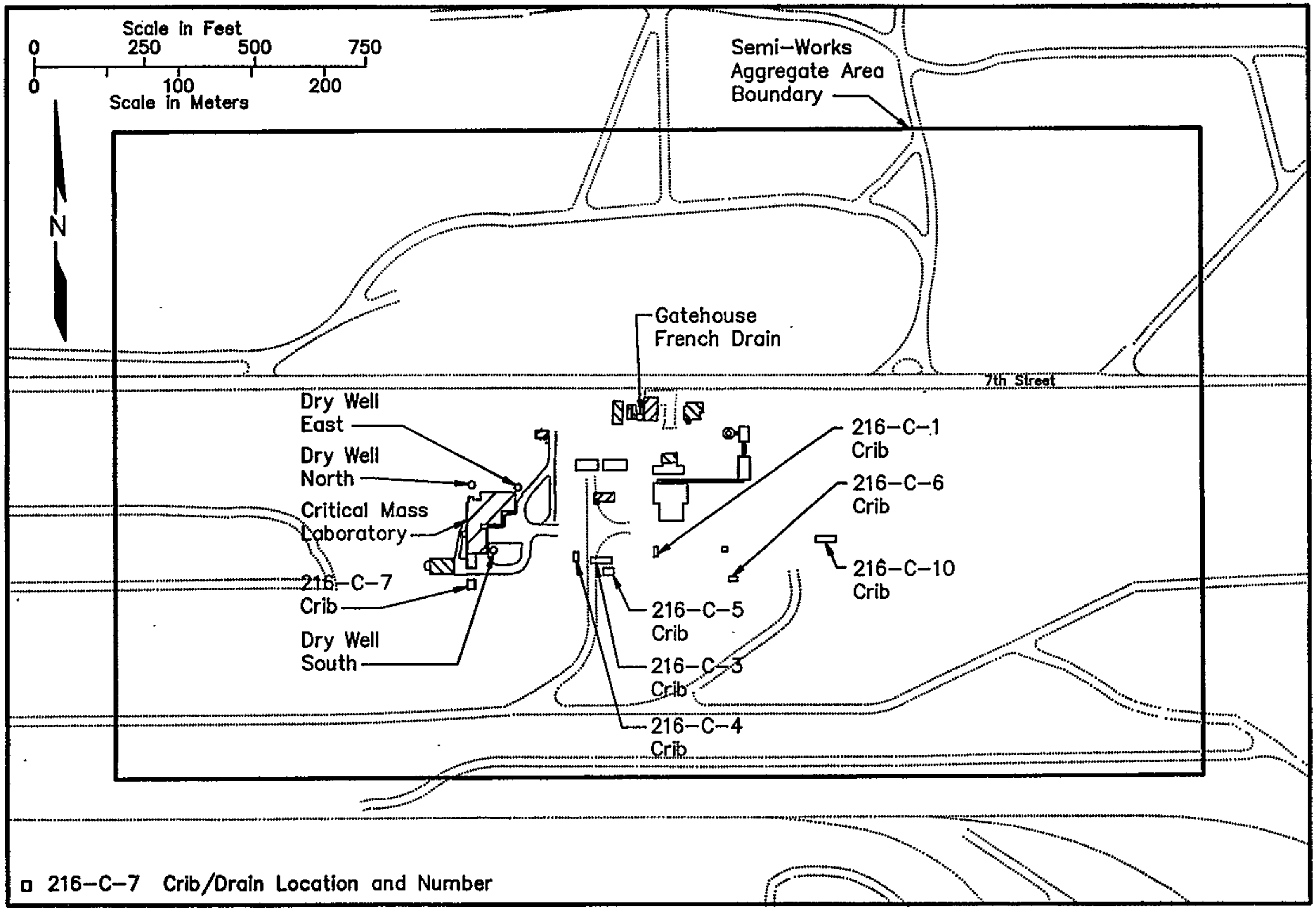

Figure 2-3. Location of Cribs and Drains in the Semi-Works Aggregate Area.

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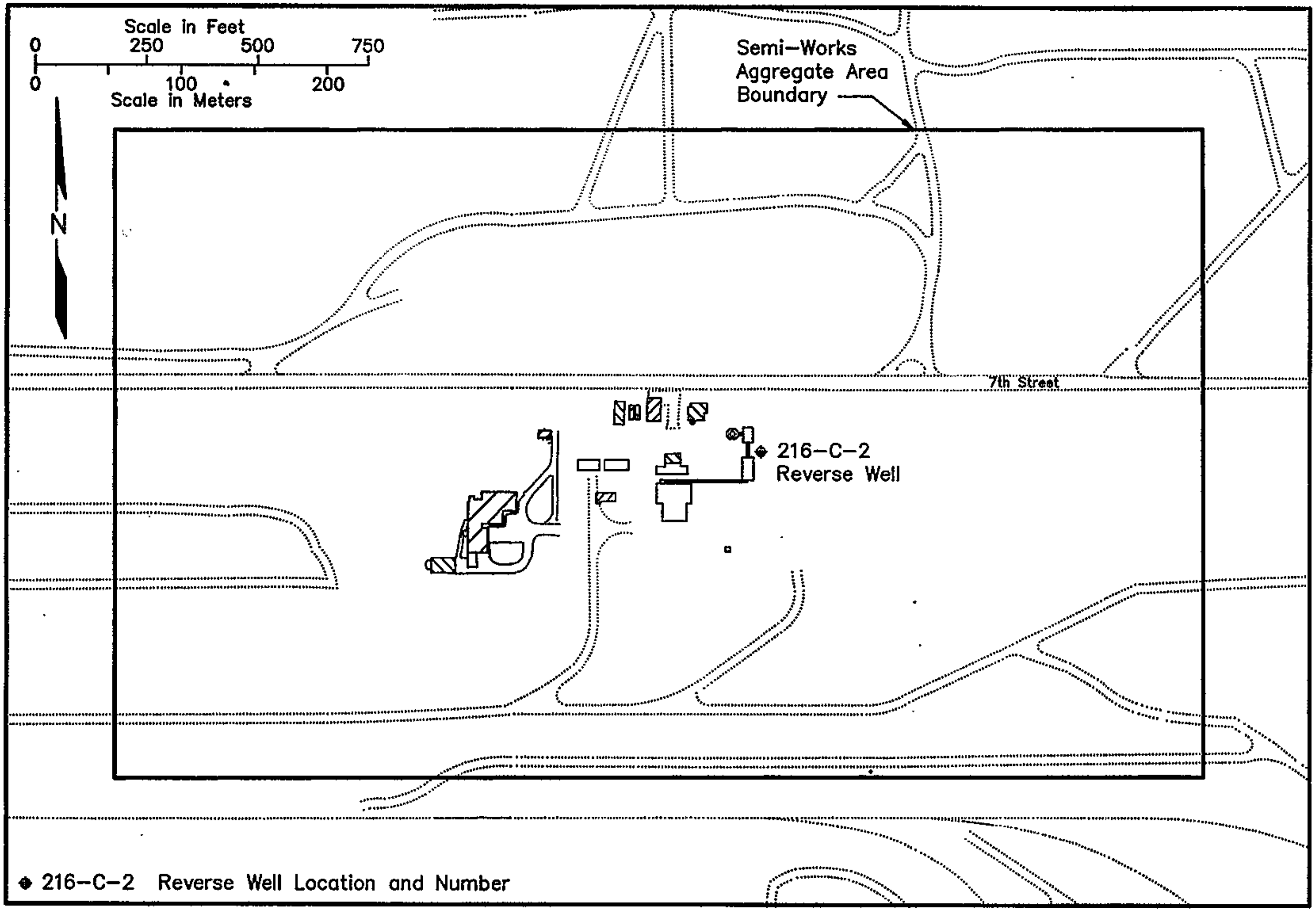

Figure 2-4. Location of Reverse Well in the Semi-Works Aggregate Area.

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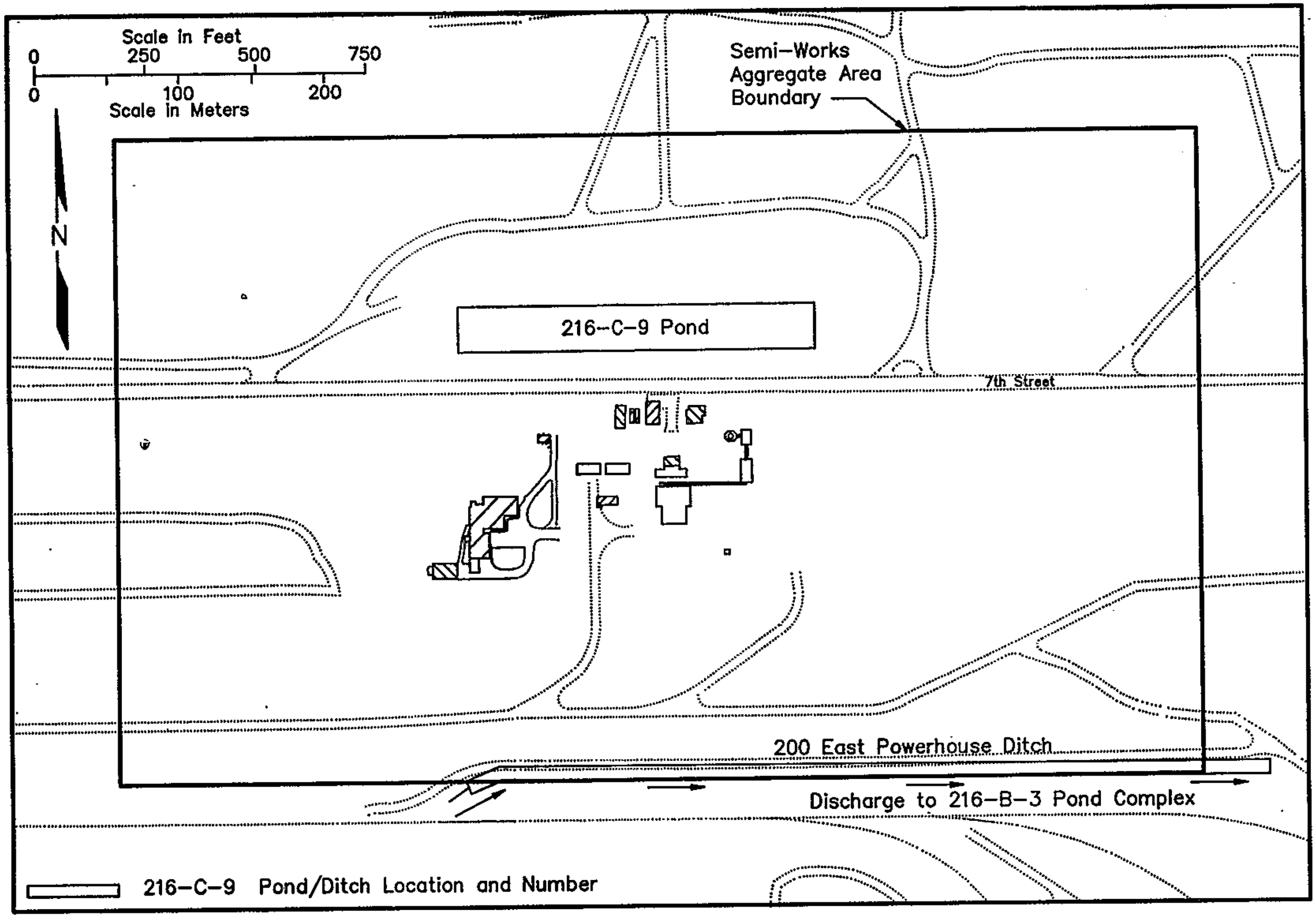

Figure 2-5. Location of Ponds, Ditches, and Trenches in the Semi-Works Aggregate Area.

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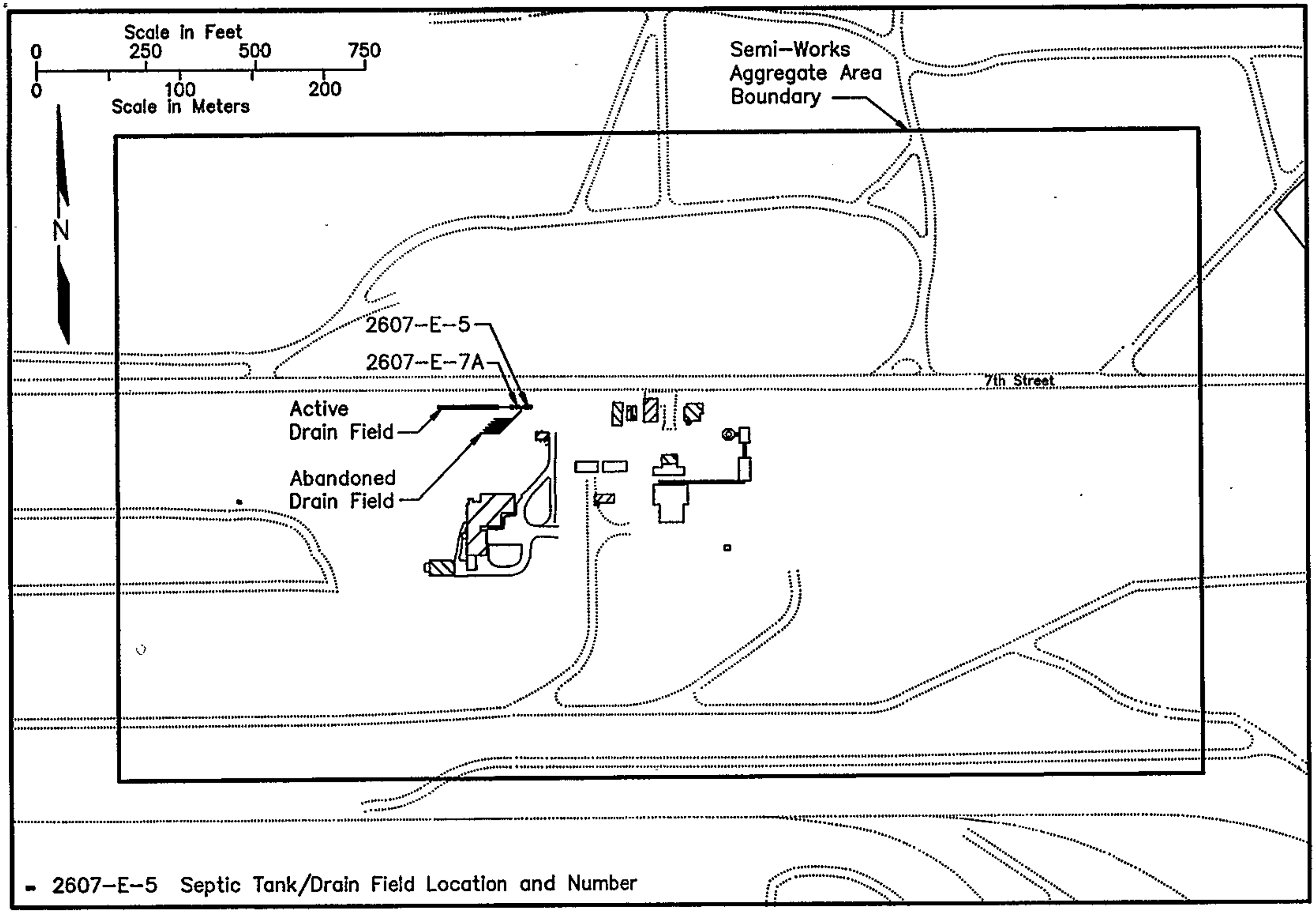


Figure 2-6. Location of Septic Tanks and Associated Drain Fields in the Semi-Works Aggregate Area.

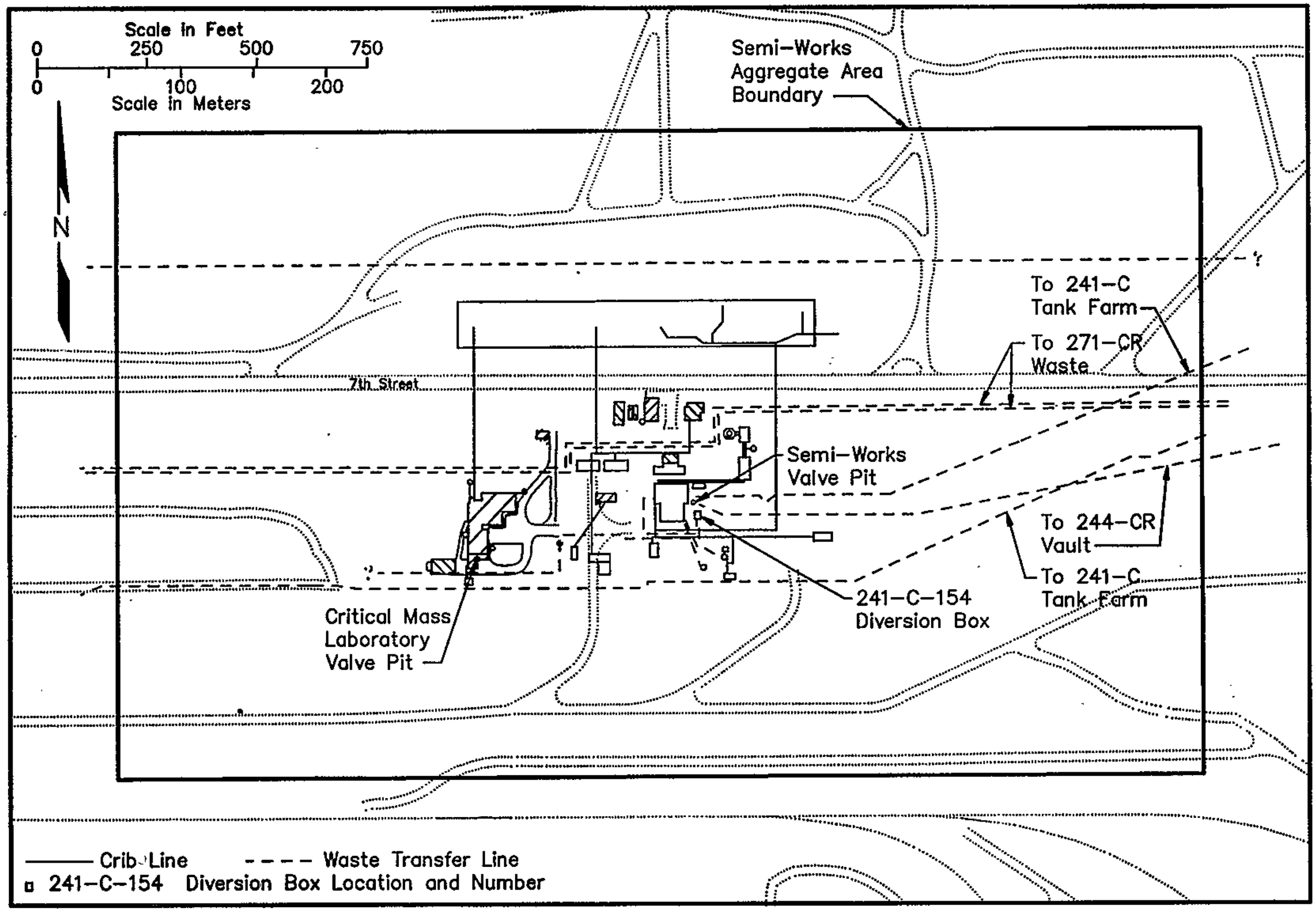


Figure 2-7. Location of Transfer Facilities, Diversion Boxes, and Pipelines in the Semi-Works Aggregate Area.

Figure 2-8. Location of Burial Sites in the Semi-Works Aggregate Area.

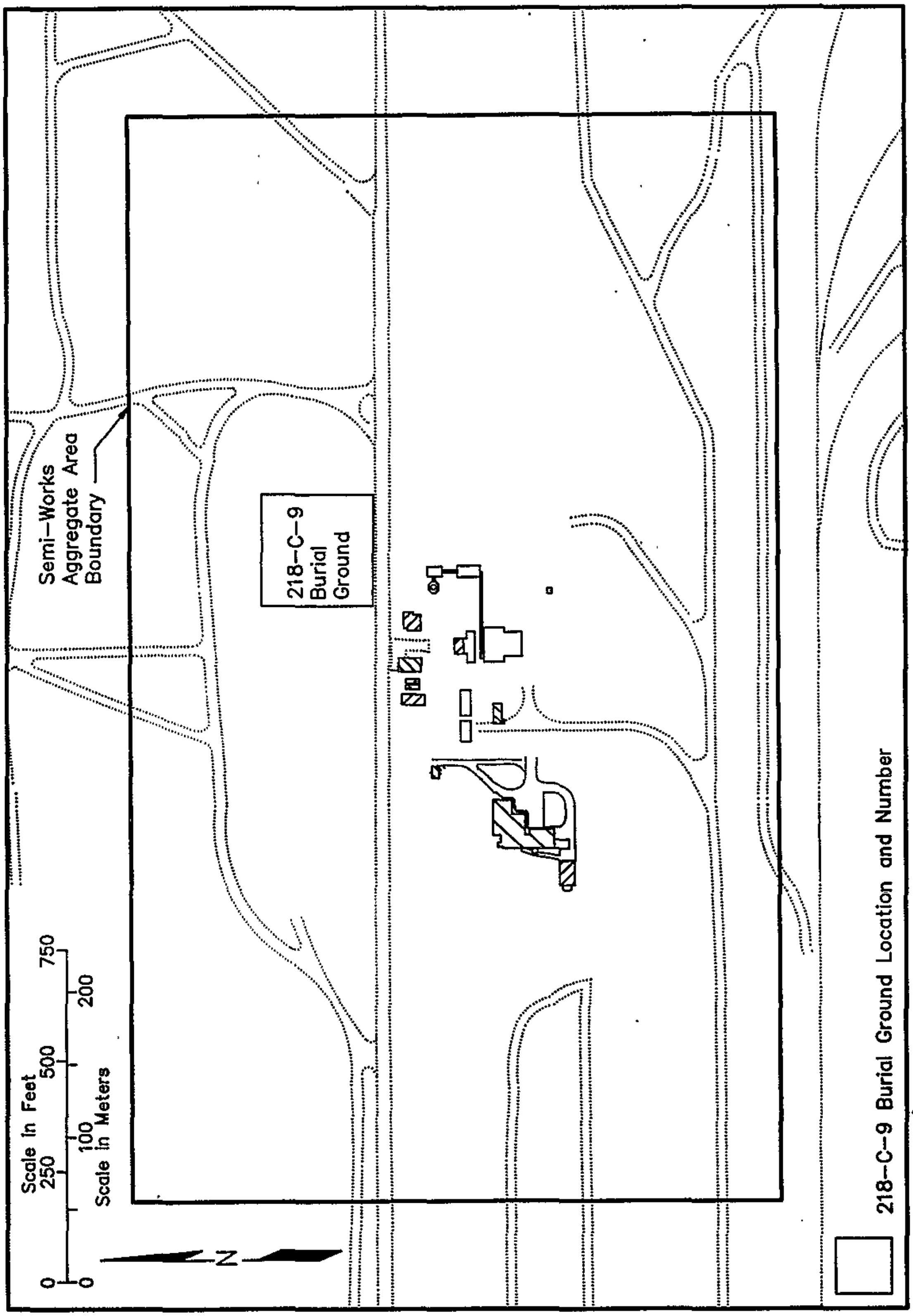
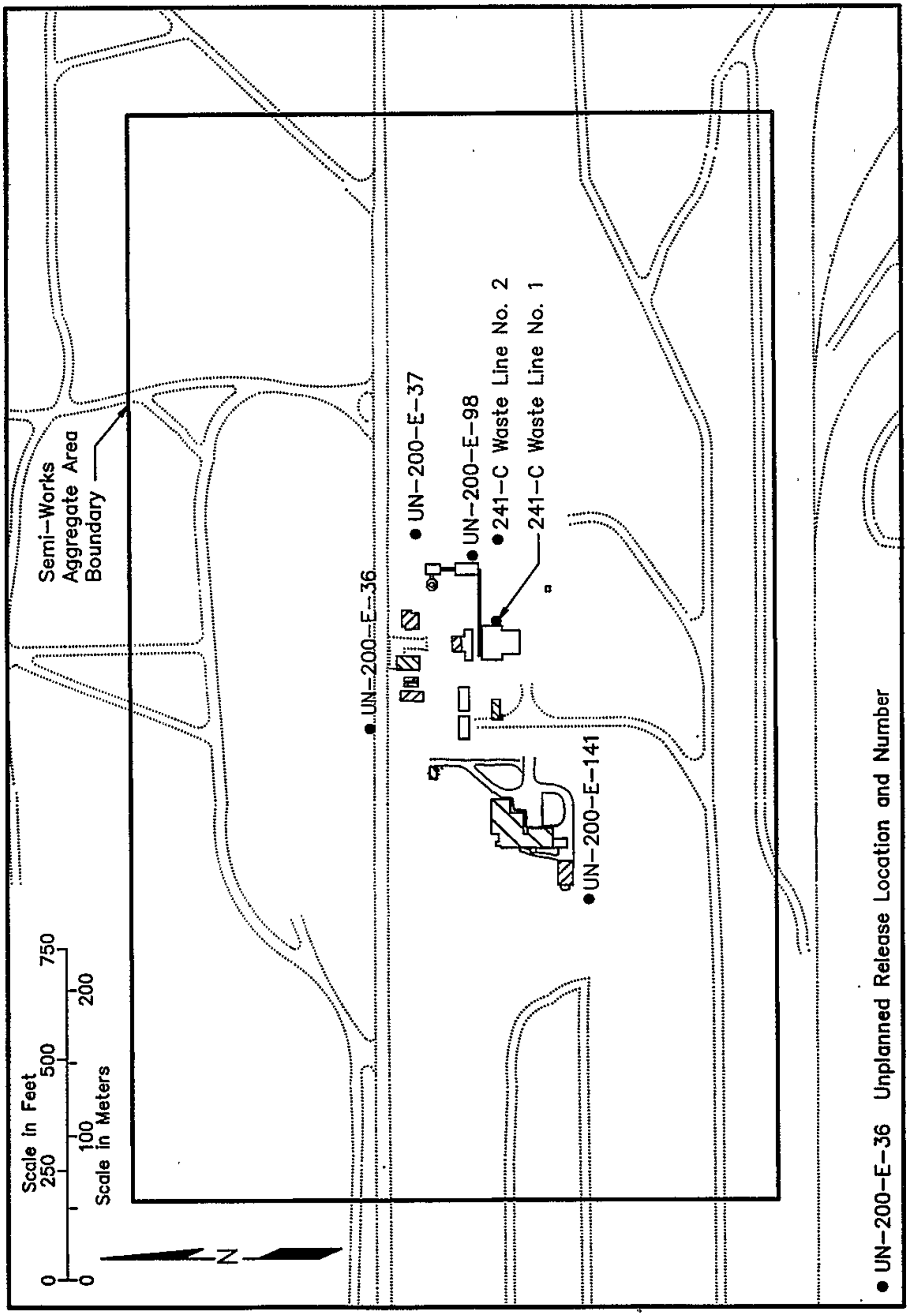


Figure 2-9. Location of Unplanned Releases in the Semi-Works Aggregate Area.



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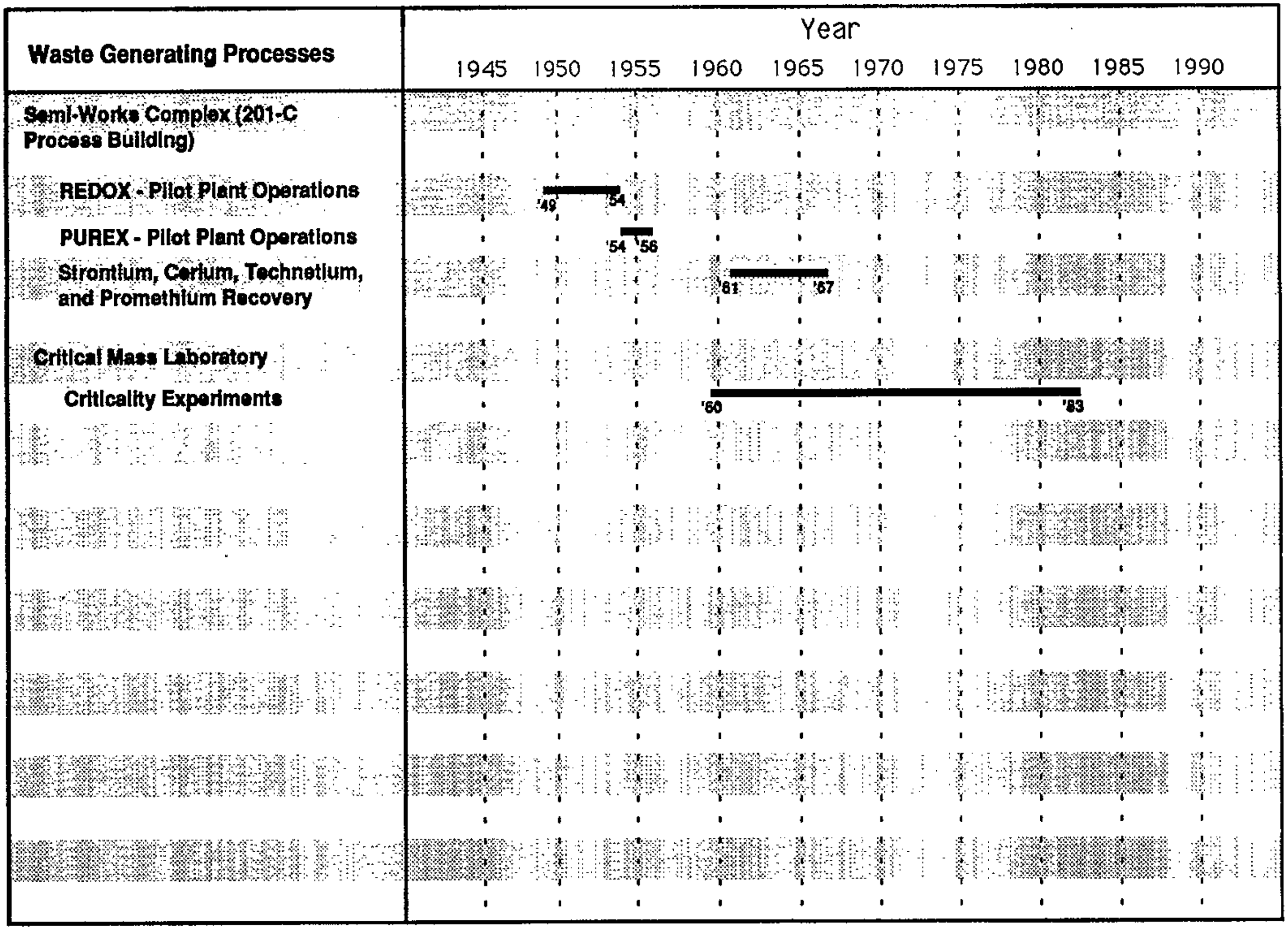

Figure 2-10. Semi-Works Process History.

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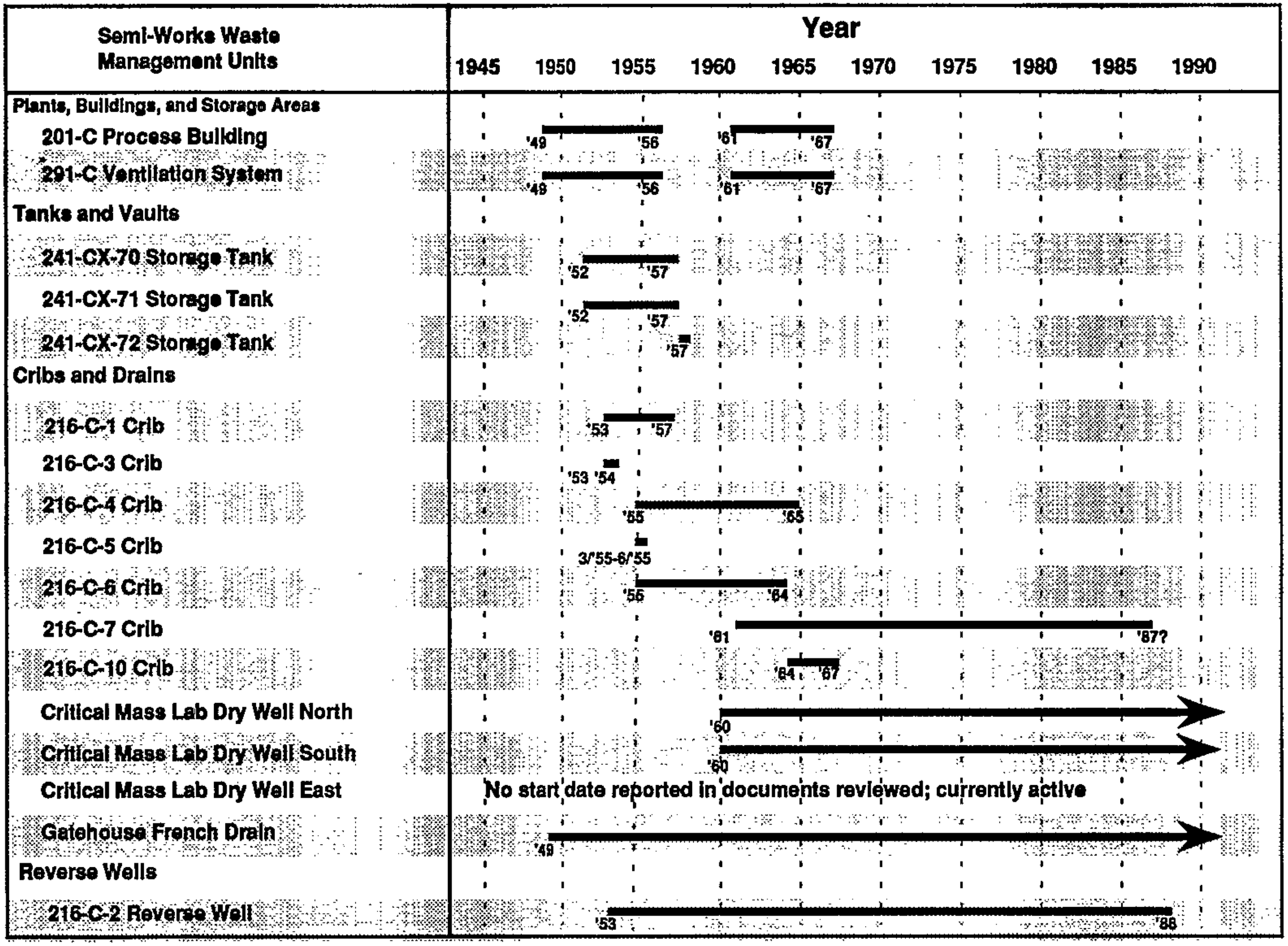

Figure 2-11. Waste Management Unit Operational History. (1 of 2)

Figure 2-12. Schematic Diagram of 241-CX-70 Storage Tank.

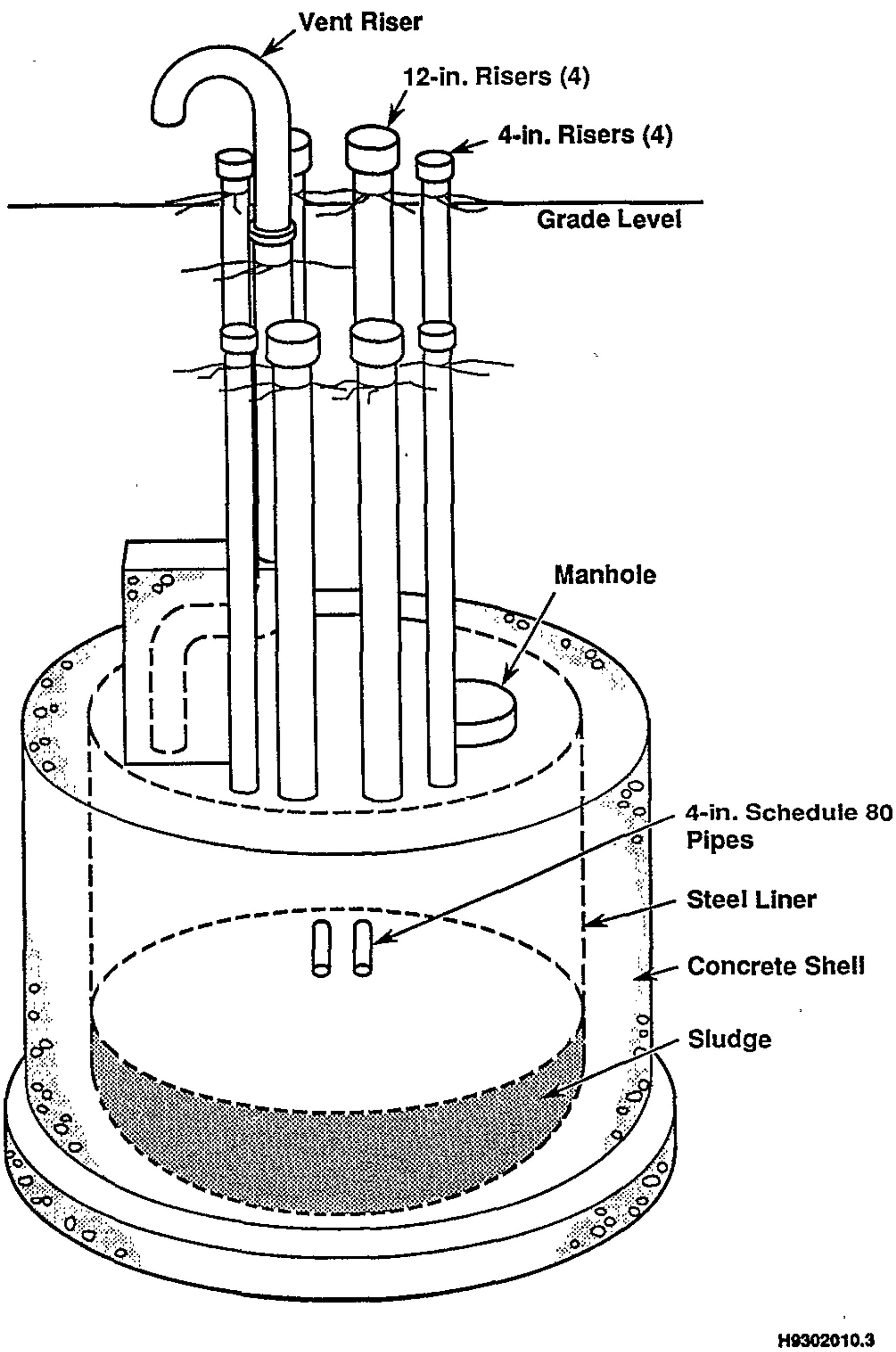

Figure 2-13. Schematic Diagram of 241-CX-71 Storage Tank.

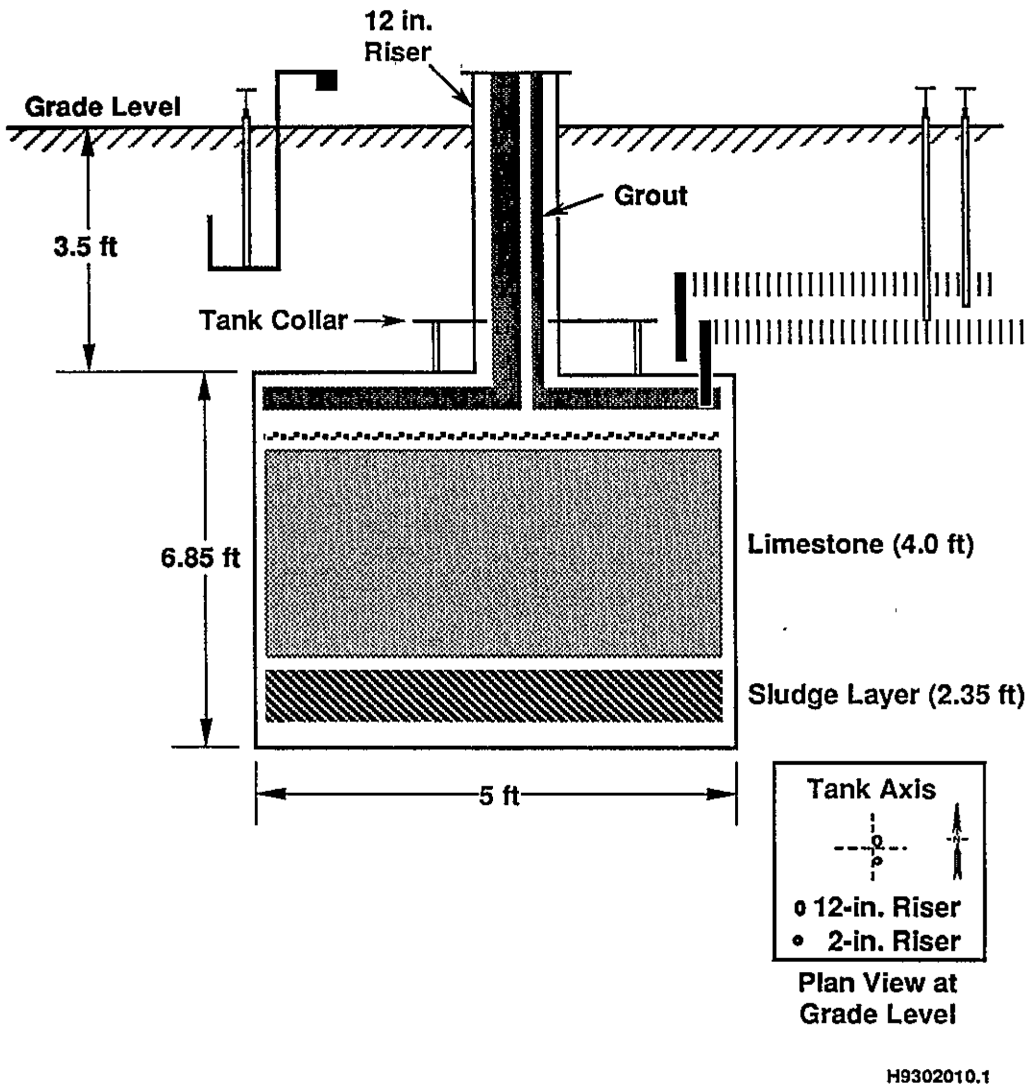

Figure 2-14. Schematic Diagram of 241-CX-72 Storage Tank.

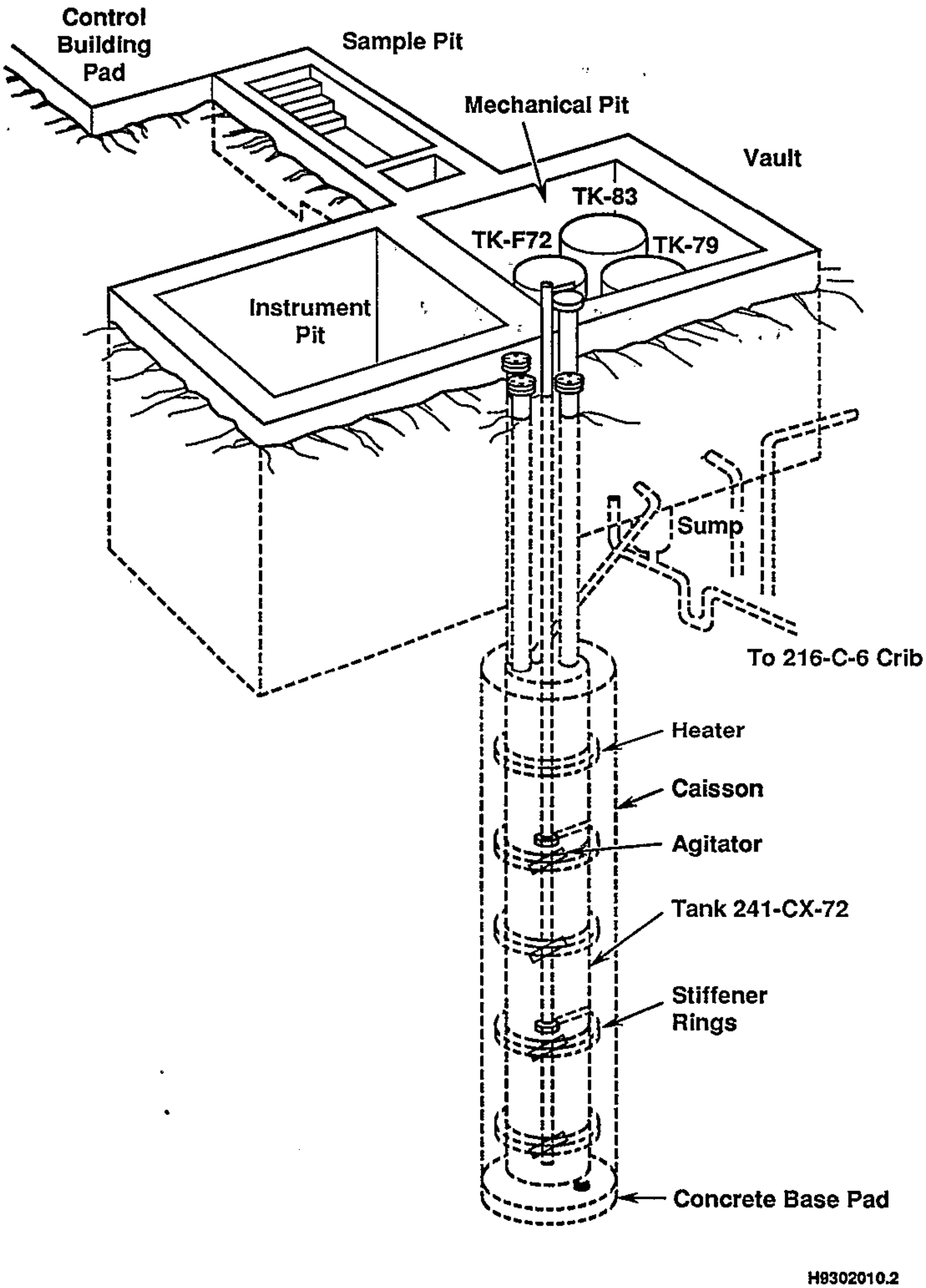

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Table 2-1. Summary of Semi-Works Aggregate Area Waste Management Units (Sheet 1 of 2).

Waste Management Unit	Years in Service	Source Description	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m³	Contaminated Soil Volume in m³	Operable Unit
		Plants, Buildings, and Storage Areas				
201-C Process Building	1949 - 1967	Processing Activities within 201-C Building	n/a	n/a		200-SO-1
291-C Ventilation System	1949 - 1967	Internal Filtering Activities	n/a	n/a		200-SO-1
		Tanks and Vaults				
241-CX-70 Storage Tank	1952 - 1957	High level process waste	40,000 sludge (3)	n/a		200-SO-1
241-CX-71 Storage Tank (1)	1952 - 1957	201-C Building, Hot Shop	5,700 (3)	8.70		200-SO-1
241-CX-72 Storage Tank	1957	PUREX Pilot Plant	7,500	n/a		200-SO-1
		Cribs and Drains				
216-C-1 Crib	1953 - 1957	201-C Building REDOX, PUREX Pilot Plant	23,400,000	n/a	150	200-SO-1
216-C-3 Crib	1953 - 1954	201-C Building, 215-C Building, 271-C Building	5,000,000	n/a	31	200-SO-1
216-C-4 Crib	1955 - 1965	276-C Building	170,000	n/a	86	200-SO-1
216-C-5 Crib	1955	201-C Building	37,900	n/a	86	200-SO-1
216-C-6 Crib	1955 - 1964	201-C Building, 241-CX vault floor drains	530,000	n/a	86	200-SO-1
216-C-7 Crib	1961 - 1987	Critical Mass Laboratory	60,000	n/a	130	200-SO-1
216-C-10 Crib	1964 - 1969	201-C Process Building	897,000	n/a	66	200-SO-1
Critical Mass Laboratory Dry Well North	1960 - present	209-E Critical Mass Laboratory				200-SO-1
Critical Mass Laboratory Dry Well South	1960 - present	209-E Critical Mass Laboratory				200-SO-1
Critical Mass Laboratory Dry Well East	? - present	209-E Critical Mass Laboratory				200-SO-1
Gatehouse French Drain	1949 - present	2704-C Office Building				200-SO-1
		Reverse Wells				
216-C-2 Reverse Well	1953 - 1988	291-C Stack		n/a		200-SO-1

Table 2-1. Summary of Semi-Works Aggregate Area Waste Management Units (Sheet 2 of 2).

Waste Management Unit	Years in Service	Source Description	Total Fluid Volume Received in Liters	Solid Waste Volume Received in m^3	Contaminated Soil Volume in m^3	Operable Unit
		Ponds, Ditches, and Trenches				
216-C-9 Pond	1953 - 1985	209-E Building, 226-C, 201-C, 215-C, 209-C	1,030,000,000	n/a	2,600	200-SO-1
200 East Powerhouse Ditch (2)	? - present	284-E Power Plant	12,300,000 mo	n/a		200-SO-1
		Septic Tanks and Associated Drain Fields				
2607-E-5 Septic Tank and Drain Field (2)	1949 - present	Critical Mass Laboratory, mobile offices		n/a		200-SO-1
2607-E-7A Septic Tank and Drain Field (2)	1983 - present	Critical Mass Laboratory		n/a		200-SO-1
		Transfer Facilities, Diversion Boxes, and Pipelines				
Semi-Works Valve Pit (1)	? - late 1980s	201-C Process Building		n/a		200-SO-1
Critical Mass Laboratory Valve Pit (1)(2)	? - present	Critical Mass Laboratory		n/a		200-SO-1
241-C-154 Diversion Box (1)	? - 1985	Promethium transfer line from B Plant		n/a		200-SO-1
		Burial Sites				
218-C-9 Burial Ground	1985 - 1989	Decommissioning rubble from 201-C Process Building		2,265		200-SO-1
		Unplanned Releases				
UN-200-E-36	July 1967	Beta/gamma spill during transport				200-SO-1
UN-200-E-37	July 1967	Beta/gamma spill				200-SO-1
UN-200-E-98	Sept. 1980	Strontium 90 source				200-SO-1
UN-200-E-141	Sept. 1984	Uranyl nitrate spill	208.2	n/a		200-SO-1
241-C Waste Line Unplanned Release No. 1	prior to 1957	241-C Waste Line from 241-C Process Building to 241-C Tank Farm				200-SO-1
241-C Waste Line Unplanned Release No. 2	prior to 1957	241-C Waste Line from 241-C Process Building to 241-C Tank Farm				200-SO-1

Notes: (1) This waste management unit is not included in the Tri-Party Agreement (Ecology et al. 1991).
(2) Reported as active by DeFord (1992).
(3) Volume remaining after partial waste removal.
Blank entries indicate no applicable data found during document review.
n/a - not applicable.

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Table 2-2. Semi-Works Aggregate Area Radionuclide Waste Inventory Summary. (Sheet 1 of 2)

		Quantity of Reported Radionuclides in Ci											
Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{154}Eu	^{90}Sr	^{60}Co	^{3}H	^{14}C	^{155}Eu	Other Radionuclides	^{238}Pu	^{239}Pu	^{240}Pu
Plants, Buildings, and Storage Areas													
201-C Process Building	60.5				9000(6)					^{241}Am = 0.2(6)	3.7(6)	4.9(6)	
201-C Ventilation System (5)													
Tanks and Vaults													
241-CX-70 Storage Tank													
241-CX-71 Storage Tank (1)		0.0908(6)	0.0496(6)		93(6)	0.002(6)	70.0(6)					0.4579(6)	0.1230(6)
241-CX-72 Storage Tank	200	5.33E-7(4)	15000 0		2.8E-6(4)								
Cribs and Drains													
216-C-1 Crib	8.0	0.0908(3)	0.0455 0.0496(3)	1.00E-08	85.5 93.8(3)	0.002	70.0					0.4579	0.1230
216-C-3 Crib	1.0	0.0153(3)	0.0424 0.0924(3)	8.30E-11	8.04 8.83(3)	0.0014(3)							
216-C-4 Crib	1.0	0.0011(3)	0.0433 0.0472(3)	5.35E-10	11.8 13.0(3)	0.0018(3)							
216-C-5 Crib	1.0	0.0182(3)	0.0444 0.484(3)	1.30E-10	4.20 4.610(3)	0.0018(3).							
216-C-6 Crib	0.1	0.0001(3)	0.0465 0.0507(3)	2.73E-08	28.8 31.6(3)	0.0025							
216-C-7 Crib (2)	1.1	n/a	0.0534	1.06E-08	0.0512								
216-C-10 Crib	0.15	0.00001(3)	0.0855 0.0932(3)	8.95E-08	3.45 37.8(3)	0.0113(3)							
Critical Mass Laboratory Dry Well North													
Critical Mass Laboratory Dry Well South													
Critical Mass Laboratory Dry Well East													
Gatehouse French Drain													
Reverse Wells													
216-C-2 Reverse Well													

Table 2-2. Semi-Works Aggregate Area Radionuclide Waste Inventory Summary. (Sheet 2 of 2)

	Quantity of Reported Radionuclides in Ci												
Ponds, Ditches, and Trenches													
216-C-9 Pond	0.338		0.703	8.66E-08	2.43								
200 East Powerhouse Ditch (2)													
Septic Tanks and Associated Drain Fields													
2607-E-5 Septic Tank and Drain Field (2)													
2607-E-7A Septic Tank and Drain Field (2)													
Transfer Facilities, Diversion Boxes, and Pipelines													
Semi-Works Valve Pit (1)													
Critical Mass Laboratory Valve Pit (1)(2)													
241-C-154 Diversion Box (1)													
Burial Sites													
218-C-9 Burial Ground	1E-04(7)		8.1(7)	5.4E-06(7)				1E-06(7)					
Unplanned Releases													
UN-200-E-36													
UN-200-E-37													
UN-200-E-98													
UN-200-E-141													
241-C Waste Line Unplanned Release No. 1													
241-C Waste Line Unplanned Release No. 2													

Notes: Unless otherwise noted, data are obtained from WHC 1992.
(1) This waste management unit is not included in the Tri-Party Agreement (Ecology et al. 1991).
(2) This is an active unit.
(3) Cummings 1989
(4) Griffin and Ludowise 1989
(5) DeFord 1992 reports an entombed inventory of 4.6 ci alpha and 6000 ci beta/gamma in the HEPA filter unit 1 and fiberglass filters.
(6) DeFord 1992
(7) WHC 1991c
Blank entry indicates no applicable data found during document review.
Data is representative of decayed material.

Table 2-3. Semi-Works Aggregate Area Chemical Waste Inventory Summary. (Sheet 1 of 2)

	Quantity of Reported Chemical in Unit in kg				
Waste Management Unit	Tributyl Phosphonate	Nitrate	Sodium	Nitric Acid	Normal Paraffin Hydrocarbons
Plants, Buildings, and Storage Areas					
201-C Process Building (4)					
291-C Ventilation System					
Tanks and Vaults					
241-CX-70 Storage Tank (3) (5) (6)					
241-CX-71 Storage Tank (1) (8)					
241-CX-72 Storage Tank (7)					
Cribs and Drains					
216-C-1 Crib				15,000	
216-C-3 Crib		20			
216-C-4 Crib	14,000				24,000
216-C-5 Crib		8,000	3,000		
216-C-6 Crib		330			
216-C-7 Crib (2)		1			
216-C-10 Crib					
Critical Mass Laboratory Dry Well North					
Critical Mass Laboratory Dry Well South					
Critical Mass Laboratory Dry Well East					
Gatehouse French Drain					
Reverse Wells					
216-C-2 Reverse Well					
Ponds, Ditches, and Trenches					
216-C-9 Pond					
200 East Powerhouse Ditch (2)					
Septic Tanks and Associated Drain Fields					
2607-E-5 Septic Tank and Drain Field (2)					
2607-E-7A Septic Tank and Drain Field (2)					

Table 2-3. Semi-Works Aggregate Area Chemical Waste Inventory Summary. (Sheet 2 of 2)

	Quantity of Reported Chemical in Unit in kg				
Waste Management Unit	**Tributyl Phosphonate**	**Nitrate**	**Sodium**	**Nitric Acid**	**Normal Paraffin Hydrocarbons**
Transfer Facilities, Diversion Boxes, and Pipelines					
Semi-Works Valve Pit					
Critical Mass Laboratory Valve Pit (1)					
241-C-154 Diversion Box (1)					
Burial Sites					
218-C-9 Burial Ground					
Unplanned Releases					
UN-200-E-36					
UN-200-E-37					
UN-200-E-98					
UN-200-E-141					
241-C Waste Line Unplanned Release No. 1					
241-C Waste Line Unplanned Release No. 2					

Notes:
(1) This waste site is not included in the Tri-Party Agreement (Ecology et al. 1991).
(2) This is an active unit.
(3) Also 7.8 ton $NaNO_3$; 1.1 ton $NaNO_2$; 1.2 ton NaF; 0.5 ton $Al_2(SO_4)_3$; 0.2 ton Na_2CrO_4.
(4) 201-C Process Building has 2.5 tons of lead entombed.
(5) This tank is now empty. However, according to Holmes, 1988, an analysis was conducted on the sludge and yielded the following (in gms): Al = 7.06E+6; Fe = 9.13E+5; Na = 3.01E+6; Ni = 1.92E+5; NO_3 = 3.29E+6; Mg = 2.0E+4; Mn = 6.74E+5; PO_4 = 3.88E+5; Si = 4.59E+5.
(6) This waste unit received wastes from PUREX, REDOX, and decontamination flushes but no information is available as to the inventory of the tank contents.
(7) This waste unit received wastes from PUREX and decontamination flushes but no information is available as to the inventory of the tank contents.
(8) This waste unit received wastes from PUREX and decontamination flushes. Sample results are available as to the inventory of the tank contents, but a waste volume has not been calculated.

Blank entry indicates no applicable data found during document review.

Table 2-4. Summary of Unplanned Releases. (Sheet 1 of 2)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
UN-200-E-36	200-SO-1	July 24, 1967	201-C Process Building	▸ Two pumps being removed from the 201-C Process Building released air-borne contaminant into ventilation systems and contaminated the 7th Street roadway near the Hot Semi-Works plant, the North part of the Semi-Works area and north of 7th Street. ▸ The spill covered 274 m (900 ft) in length and 137 m (450 ft) in width. Beta/gamma readings of 30,000 to 80,000 ct/min were measured. ▸ For remedial measures, the roadways were flushed with water and a program for decontamination was initiated.
UN-200-E-37	200-SO-1	July 31, 1967	201-C Process Building	▸ This unplanned release is attributed to and was detected during cleanup efforts for the UN-200-E-36 Unplanned Release. The location was an area east of Semi-Works Aggregate Area on a road outside the east fence. ▸ The dimensions of the area impacted by the spill were 183 m (600 ft) in length. Beta/gamma readings to 200 mRem/hr were measured. ▸ For remedial measures, sprinklers were set in the contaminated areas and the blacktop was cleaned.
UN-200-E-98	200-SO-1	September 1980	201-C Process Building	▸ Radioactive particulate matter from the hot semi-works building ventilation was inadvertently spread to the ground surface near the base of the 291-C-1 Stack and around the 216-C-2 Reverse Well. ▸ The actual area impacted was unknown. The waste type identified was primarily strontium. ▸ WIDS indicates that the contamination was removed and the area was stabilized.
UN-200-E-141	200-SO-1	September 1984	2718-E Building	▸ A release occurred from a container failure due to erosion of the container. The release occurred in the storage area near the 2718-E Building. ▸ The waste volume released was 208 liters. The release consisted of 450 g/L solution of uranyl nitrate (corrosive), 84% ^{235}U. ▸ For remedial measures, all liquids were removed from the storage area in the 2718-E Building. The contaminated asphalt and soil were removed until background levels of contamination were reached.

Table 2-4. Summary of Unplanned Releases. (Sheet 2 of 2)

Unplanned Release No.	Location (Operable Unit)	Date	Associated Waste Management Unit	Reported Waste-Related History
241-C Waste Line Unplanned Release No. 1	200-SO-1	Prior to 1957	Immediately west of 201-C Process Building	▸ Release was a result of a flange leak in the 241-C Waste Line. Actual area impacted is unknown. ▸ Radiation readings of >100 Rad/hr were reported at a depth of 3.7 m (12 ft). ▸ No WIDS data, currently under ash barrier.
241-C Waste Line Unplanned Release No. 2	200-SO-1	Prior to 1957	241-CX Fence Line west of 201-C Process Building	▸ Release occurred as a result of a flange leak in the 241-C Waste Line. ▸ The release was reported to have contaminated subsurface soils along the fence. Actual area impacted is unknown. ▸ Radiation levels >100 Rad/hr were reported 4.6 m (15 ft) below the surface. ▸ No WIDS data or recent surveys are available.

Notes: n/a = Not applicable

Table 2-5. Summary of Waste Producing Processes in the Semi-Works Aggregate Area. (Sheet 1 of 3)

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
REDOX and PUREX Pilot Plants (201-C Process Building)	Aluminum coating waste	sodium hydroxide, sodium aluminate, sodium nitrate, sodium nitrite, sodium silicate, uranium, plutonium	High	neutralized acidic waste	Low	Low-High
	Zircaloy coating	aluminum nitrate zirconium oxide, sodium fluoride, sodium nitrate, potassium fluoride, uranium, plutonium	High	neutralized acidic waste	Low	Low-High
	Radioactive condensates	cesium-137, ruthenium-106, strontium-90, plutonium-239, uranium, tritium, cobalt-60, uranium-238, nitric acid, other inorganic contaminants	High	acidic (neutralized)	Low	Low-High
	Hot Shop sink wastes					
	Cold-run wastes		High	neutral/basic	Low	

Table 2-5. Summary of Waste Producing Processes in the Semi-Works Aggregate Area. (Sheet 2 of 3)

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
REDOX and PUREX Pilot Plants (cont.)	REDOX Spent solvent	Hexone	Low	neutral/basic	High	Low
	Other REDOX wastes	sodium aluminate, sodium hydroxide, sodium nitrate, chromate, sodium sulfate, ferric hydroxide, plutonium, uranium	Low		Low	Low-High
	PUREX Organic Wash waste	Sodium nitrate, sodium carbonate, manganese oxide, uranium	High	neutralized acidic waste	High	High
	PUREX acid process waste	Nitric acid, ferrous sulfate, ferrous phosphate, sodium, aluminum	High	acidic (neutralized)	Low	High
	PUREX Spent solvent waste	tributyl phosphate, kerosene	Low	neutral	High	Low
Strontium Recovery Pilot Plant (201-C Process Building)	Process waste	Hydrochloric acid, nitric acid, di-2-ethylhexyl-phosphoric acid		acidic (neutralized)	High	High
Critical Mass Laboratory (209-E Building)	Neutron reflector tank water	cesium-137, ruthenium-106, strontium-90, plutonium, uranium, nitrates		acidic		Low
276-Solvent Handling Facility			Low	neutral/basic	High	Low

Table 2-5. Summary of Waste Producing Processes in the Semi-Works Aggregate Area. (Sheet 3 of 3)

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
291-C Ventilation Stack	Condensate and seal water drainage		Low	neutral/basic	Low	Low
215-Gas Preparation Building, and 271-Aqueous Makeup and Control Building				acidic		

Notes: Blank spaces indicate no information was located in documents reviewed.

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Table 2-6. Partial List of Chemicals Used in the Semi-Works Aggregate Area. (Sheet 1 of 2)

COMPOUND NAME
Acetic acid
Aluminum sulfate
Aluminum nitrate nonahydrate (ANN)
Ammonium fluoride
Ammonium nitrate
Calcium nitrate
Caustic tartrate (CT)
Chromium nitrate
Citric acid
Di-2-ethylhexyl phosphoric acid
Ethylenediamine tetraacetate (EDTA)
Ferric nitrate
Ferric sulfate
Ferrous sulfamate
Glycolic acid
Hexone
Hydrazine
Hydrogen peroxide
Kerosene
Lead nitrate
Manganese oxide
Nickel nitrate
Nitric acid
Nitric ferrous ammonium sulfate
Nitrilotriacetic acid (NTA)
Nonylphenoxy polyethoxy ethanol
Normal paraffin hydrocarbon (NPH)
Oxalic acid
Pentasodium diethylene
Triamine penta acetate
Permanganate caustic
Phosphoric acid
Potassium bicarbonate
Potassium nitrate
Potassium permanganate
Potassium persulfate

Table 2-6. Partial List of Chemicals Used in the Semi-Works Aggregate Area. (Sheet 2 of 2)

COMPOUND NAME
Shell spray base
Shell E-2342®[1]
Silver nitrate
Sodium acetate
Sodium aluminate
Sodium carbonate
Sodium dichromatic
Sodium hexametaphosphate
Sodium fluoride
Sodium hydroxide
Sodium nitrate
Sodium nitrite
Sodium persulfate
Sodium phosphate
Sodium silicate
Sodium sulfate
Sodium sulfide
Soltrol-170®[2]
Sugar
Sulfamic acid
Sulfuric acid
Tartaric acid
Tetrasodium ethylene diamine-tetra acetate (EDTA)
Tributyl phosphate (TBP)
Trisodium hydroxyethyl ethylene-diamine triacetate (HEDTA)
Trisodium phosphate
Turco 4128A®[3]
Zirconium oxide

[1]Trademark of Shell Oil Company.
[2]Trademark of Phillips Petroleum Company.
[3]Trademark of Turco Products Incorporated.

Table 2-7. Estimated Quantity of Chemicals Disposed of in Semi-Works Aggregate Area Cribs.

Crib	NO_3	TBP	Kerosene	HNO_3	Na	MIBK
216-C-1	0	0	0	15,000	0	NA
216-C-3	0	0	0	NA	0	NA
216-C-4	0	14,000	24,000	0	0	NA
216-C-5	8,000	0	0	0	3,000	NA
216-C-6	330	0	0	0	0	NA
216-C-7	NA	NA	NA	NA	NA	NA
216-C-10	0	0	0	600	0	NA

NA = No information available.
Quantities in kg based on Cummings (1989).

Table 2-8. Estimated Quantity of Radionuclide Inventory in Semi-Works Aggregate Area Cribs.

Crib	^{3}H	^{60}Co	^{90}Sr	^{137}Cs	^{239}Pu	^{240}Pu	^{238}U
216-C-1	70.00	0.0020	93.800	0.0496	0.4570	0.1230	0.0988
216-C-3	0	0.0014	8.830	0.0463	0.0571	0.0154	0.0153
216-C-4	0	0.0018	13.000	0.0472	0.0571	0.0154	0.0011
216-C-5	0	0.0018	4.610	0.0484	0.0571	0.0154	0.0182
216-C-6	0	0.0025	31.600	0.0507	0.0571	0.0154	0.00001
216-C-7	NA	NA	NA	NA	NA	NA	NA
216-C-10	0	0.0113	37.800	0.0932	0.0086	0.0023	0.00001

NA = No information available.
Quantities in Curies (Ci) based on Cummings (1989).

3.0 SITE CONDITIONS

The following sections describe the physical nature and setting of the Hanford Site, the 200 East Area, and the Semi-Works 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 East 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 East Area is generally flat (Figure 3-6). The elevation in the vicinity of the Semi-Works Aggregate Area ranges from approximately 214 m (701 ft) in the southwest part of the unit to about 203 m (644 ft) above msl in the northeastern part. A detailed topographic map of the area is provided as Plate 1. There are no natural surface drainage channels within the area.

3.2 METEOROLOGY

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

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

3.2.1 Precipitation

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

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

3.2.2 Winds

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

Figure 3-7 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 East 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 to -6 °C (-27 to +22 °F), and maximum summer temperatures vary from 38 to 46 °C (100 to 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 Semi-Works 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 3-8). 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 1.1×10^{11} m^3 (8.7×10^7 acre-ft) at the USGS gage and 1.6×10^{11} m^3 (1.3×10^8 acre-ft) at the McNary Dam gage (DOE 1988b).

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

3.3.2 Surface Hydrology of the Hanford Site

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

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

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

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

3.3.3 Semi-Works Aggregate Area Surface Hydrology

No natural surface water bodies exist in the Semi-Works Aggregate Area. This aggregate area lies within the Columbia River drainage system. The only existing man-made surface water body is the 200 East Powerhouse Ditch located along the southern boundary of the aggregate area. As discussed in Section 2, the ditch is 760 m (2,500 ft) long, 2.5 to 3.5 m (8 to 11.5 ft) deep, and approximately 6 m (20 ft) wide at the bottom (DeFord 1992). The ditch receives cooling brines from batch processes and boiler blowdown rinseate from the 200 East Power Plant. The flow rate from the powerhouse facility to the ditch is estimated at 12,300,000 L/month (3,198,000 gal/month). Ditch effluent is also dispersed by evaporation and infiltration to the soil column along the ditch. Ditch effluent flows westward and is discharged to an approximately 76 cm (30 in.) diameter corrugated metal pipe connected to the 216-B-3 Pond system.

In addition to the Powerhouse Ditch the Semi-Works Aggregate Area is the site of the former 216-C-9 Pond, a 250 m by 30 m (800 ft by 100 ft) liquid waste disposal site north of the former Semi-Works Complex (201-C Process Building). The 216-C-9 Pond, which occupied a 7.5 m (25 ft) deep excavation, was divided into several lobes and filled to a water depth of approximately 2 m (6.5 ft) with cooling water and other process waste water from the 201-C Process Building. Discharge ceased in 1985 and a portion of the pond was converted into a solid waste disposal site. The entire excavation has been backfilled to grade.

The 200 East Area, and specifically the Semi-Works Aggregate Area, is not in a designated floodplain. Calculations of probable maximum floods for the Columbia River and the Cold Creek Watershed indicate that the 200 East Area is not expected to be inundated under maximum current flood conditions. Given the effluent volumes conveyed, limited amount of precipitation, the Powerhouse Ditch dimensions, and the flat nature of the surrounding topography, the potential for flooding in the Powerhouse Ditch is low.

3.4 GEOLOGY

The following sections provide information pertaining to geologic characteristics of southcentral Washington, the Hanford Site, the 200 East Area, and the Semi-Works Aggregate Area. Topics included are the regional tectonic framework (Section 3.4.1), regional stratigraphy (Section 3.4.2), and 200 East Area and Semi-Work Aggregate Area geology (Section 3.4.3).

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

3.4.1 Regional Tectonic Framework

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

3.4.1.1 Regional Geologic Structure. The Columbia Plateau is a part of the North American continental plate and lies in a back-arc setting east of the Cascade Range. It is bounded on the north by the Okanogan Highlands, on the east by the Northern Rocky Mountains and Idaho Batholith, and on the south by the High Lava Plains and Snake River Plain (Figure 3-9).

The Columbia Plateau can be divided into three informal structural subprovinces (Figure 3-10): 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 Subprovince.

The principal characteristics of the Yakima Fold Belt (Figure 3-11) 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 3-12). The Pasco Basin is divided by the Gable Mountain anticline, the easternmost extension of the Umptanum Ridge anticline, into the Wahluke syncline in the north, and Cold Creek syncline in the south. Both the Cold Creek and Wahluke synclines are asymmetric and relatively flat-bottomed structures. The north limbs of both synclines dip gently (approximately 5°) to the south and the south limbs dip steeply to the north. The deepest parts of the Cold Creek syncline, the Wye Barricade depression, and the Cold Creek depression are approximately 12 km (7.5 mi) southeast of the Hanford Site 200 Areas, and to the west-southwest of the 200 East Area, respectively. The deepest part of the Wahluke syncline lies just north of Gable Gap.

The 200 East 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 East Area.

3.4.1.3 Regional and Hanford Site Seismology. Eastern Washington, especially the Columbia Plateau region, is a seismically inactive area when compared to the rest of the western United States (DOE 1988b). The historic seismic record for eastern Washington began in approximately 1850, and no earthquakes large enough to be felt had epicenters on the Hanford Site. The closest regions of historic moderate-to-large earthquake generation are in western Washington and Oregon and western Montana and eastern Idaho. The most significant event relative to the Hanford Site is the 1936 Milton-Freewater, Oregon, earthquake that had a magnitude of 5.75 and that occurred more than 90 km (54 mi) away. The largest Modified Mercalli Intensity for this event was felt about 105 km (63 mi) from the Hanford site at Walla Walla, Washington, and was VII.

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

3.4.2 Regional Stratigraphy

The following sections summarize regional stratigraphic characteristics of the Columbia River Basalt and suprabasalt sediments. Specific references to the Hanford Site and 200 East 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 3-13). 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 3-14). 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 East 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 3-13) 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 3-13), 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 reworked 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 3-13. 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 3-13 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 1987; DOE 1988b) and was deposited in alluvial and lacustrine environments (Bjornstad 1985; Fecht et al. 1987; Lindsey 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 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 bedding, wide, shallow channels, and large-scale cross-bedding are found in outcrops. The association was deposited in a gravelly fluvial system characterized by wide, shallow shifting channels.

- Fluvial sand--Quartzo-feldspathic sands displaying cross-bedding and cross-lamination in outcrop dominate this association. These sands usually contain less than 15% basalt lithic fragments, although basalt contents as high as 50% may be encountered. Intercalated strata consist of lenticular silty sands and clays up to 3 m (10 ft) thick and thin (<0.5 m, 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--This association dominantly consists of laminated to massive silt, silty fine-gained sand, and paleosols containing variable amounts of pedogenic calcium carbonate. Overbank deposits occur as thin lenticular interbeds (<0.5 m to 2 m, <1.6 ft to 6 ft) in the fluvial gravel and fluvial sand associations and as thick (up to 10 m, 33 ft) laterally continuous sequences. These sediments record deposition in a floodplain under proximal levee to more distal floodplain conditions.

- Lacustrine deposits--Plane laminated to massive clay with thin silt and silty sand interbeds displaying some soft-sediment deformation characterize this association. Coarsening upwards packages less than 1 m (3.3 ft) to 10 m (33 ft) thick are common in the association. Strata comprising the association were deposited in a lake under standing water to deltaic conditions.

- Alluvial fan--Massive to crudely stratified, weathered to unweathered basaltic detritus dominates this association. These basaltic deposits generally are found around the periphery of the basin. This association was deposited largely by debris flows in alluvial fan settings.

The lower half of the Ringold Formation contains five separate stratigraphic intervals dominated by fluvial gravels. These gravels, designated units, A, B, C, D, and E (also called FSA, FSB, FSC, FSD and FSE [Lindsey and Gaylord 1989; Lindsey et al. 1991]) (Figure 3-14), are separated by intervals containing deposits typical of the overbank and lacustrine facies associations. The lowermost of the fine-grained sequences, overlying unit A, is designated the lower mud sequence. The uppermost gravel unit, unit E, grades upwards into interbedded fluvial sand and overbank deposits. These sands and overbank deposits are overlain by lacustrine-dominated strata.

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

3.4.2.4 Plio-Pleistocene Unit. Unconformably overlying the Ringold Formation in the western Cold Creek syncline in the vicinity of 200 West Area (Figures 3-12, 3-13, and 3-14) is the laterally discontinuous Plio-Pleistocene unit (DOE 1988b). The unit is up to 25 m (82 ft) thick and divided into two facies: (1) sidestream alluvium and (2) calcic paleosol (Stage III and Stage IV) DOE 1988b). The calcic paleosol facies consists of massive calcium carbonate-cemented silt, sand, and gravel (caliche), to interbedded caliche-rich and caliche-poor silts and sands. The basaltic detritus facies consists of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluvium, and sidestream alluvium. Where the unit occurs, it unconformably overlies the Ringold Formation. The Plio-Pleistocene unit appears to be correlative to other sidestream alluvial and pedogenic deposits found near the base of the ridges bounding the Pasco Basin on the north, west, and south. These sidestream alluvial and pedogenic deposits are inferred to have a late Pliocene to early Pleistocene age on the basis of stratigraphic position and magnetic polarity of interfingering loess units.

3.4.2.5 Pre-Missoula Gravels. Quartzose to gneissic clast-supported pebble to cobble gravel with a quartzo-feldspathic sand matrix underlies the Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area (Figures 3-12, 3-13, and 3-14). These gravels, called the pre-Missoula gravels (PSPL 1982), are up to 25 m (82 ft) thick, contain less basalt than underlying Ringold gravels and overlying Hanford deposits, have a distinctive white or bleached color, and sharply truncate underlying strata. The nature of the contact between the pre-Missoula gravels and the overlying Hanford formation is not clear. In addition, it is unclear whether the pre-Missoula gravels overlie or interfinger with the early "Palouse" soil and Plio-Pleistocene unit. Magnetic polarity data indicates the unit is no younger than early Pleistocene in age (>1 Ma) (Baker et al. 1991).

3.4.2.6 Early "Palouse" Soil. The early "Palouse" soil consists of up to 20 m (66 ft) of massive, brown yellow, and compact, loess-like silt and minor fine-grained sand (Tallman et al. 1979, 1981; DOE 1988b). These deposits overlie the Plio-Pleistocene unit in the western Cold Creek syncline around the 200 West Area (Figures 3-12, 3-13, and 3-14). 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 the 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 107 m (350 ft) thick (Figures 3-12, 3-13, 3-14, and 3-32). The Hanford formation was deposited by cataclysmic flood waters that drained out of glacial Lake Missoula (Fecht et al. 1987; DOE 1988b; and Baker et al. 1991). Hanford deposits are absent on ridges above approximately 385 m (1,263 ft) above sea level. The following sections describe the three Hanford formation facies.

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

3.4.2.7.1 Pasco Gravels. The Pasco Gravels consist of two facies, a gravel-dominated 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 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, 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 consists 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; Baker et al. 1991). The 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 East Area and Semi-Works Aggregate Area Geology

The following subsections describe the occurrence of the uppermost basalt unit and the suprabasalt sediments in the 200 East Area. The subsection discusses notable stratigraphic characteristics, thickness variations, and the geometric relationships of the sediments, Stratigraphic variations pertinent to the Semi-Works Aggregate Area are presented in the overall context of stratigraphic trends throughout the 200 East Area.

Geologic cross-sections depicting the distribution of basalt and sedimentary units within and near the Semi-Works Aggregate Area are presented on Figures 3-15 through 3-18. Figure 3-15 illustrates the cross-sections locations. A legend for symbols used on the cross-sections is provided on Figure 3-16. The cross-sections are based on geologic information from wells shown on the figures, as interpreted in Lindsey et al. (1992). To develop these stratigraphic interpretations, logs for all the wells in the Semi-Works Aggregate Area were reviewed and a selection was made of the most relevant to the Semi-Works Aggregate Area. Chamness et al. (1992) provides a compilation of a number of geologic logs from the Semi-Works Aggregate Area and a listing of other logs which are available and additional geological, geochemical and geophysical, data available from these and other boreholes. The cross-sections depict subsurface geology in the Semi-Works Aggregate Area. For each cross-section, locations of Semi-Works Aggregate Area waste management units are identified for reference. Figures 3-19 through 3-32 present structure maps of the top of the sedimentary units, and isopach maps illustrating the thickness of each unit in the 200 East Area and Semi-Works Aggregate Area. The structure and isopach maps are included from Lindsey et al. (1992). Plate 1 should be consulted to identify locations of Semi-Works 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 most of the 200 East Area (Figure 3-19). At one location north of the 200 East Area, the Elephant Mountain Member is absent due to erosion by cataclysmic flooding, and the uppermost basalt encountered is the Pomona Member. Where the Elephant Mountain Member is absent the Rattlesnake Ridge Interbed, the sedimentary unit that commonly separates the Elephant Mountain and Pomona Members, is in direct contact with overlying suprabasalt sediments.

3.4.3.2 Ellensburg Formation. The Rattlesnake Ridge Interbed of the Ellensburg Formation is found beneath the entire 200 East Area (Reidel and Fecht 1981). Mapping on Gable Mountain indicates it is absent at many localities on this structural high (Fecht 1978). Three units comprise the Rattlesnake Ridge interbed; (1) a lower clay or tuffaceous sandstone, (2) a middle, micaceous-arkosic and/or tuffaceous sandstone, and (3) an upper, tuffaceous siltstone or sandstone. In the 200 Area East, the unit thickens from 6 m (20 ft) in the north to approximately 24 m (79 ft) in the south. The upper contact of the interbed with the overlying Elephant Mountain Member generally is baked from contact with the Elephant Mountain Basalt (Fecht 1978).

3.4.3.3 Ringold Formation. Within the 200 East 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 sand and minor muds of the upper unit. These strata are found throughout the southern two-thirds of the 200 East Area where it disconformably overlies basalt. The Ringold Formation is absent from the north-central part of the area where sediment of the overlying Hanford formation directly overlie basalt or sedimentary interbeds in the basalt. Ringold units B, C, and D are not found in the immediate vicinity of the 200 East Area.

The lowest Ringold unit in the 200 East Area, the fluvial gravels of unit A, thicken and dip to the south and southwest towards the axis of the Cold Creek syncline. Unit A generally pinches out in the central part of the area against structural highs in the underlying basalt. Thin, lenticular occurrences of unit A are found locally in the area between the northeast 200 East Area and Gable Mountain. Most of the Ringold gravels encountered in the central part of the 200 East Area probably belong to unit A (Lindsey et al. 1992). The top of the unit is a relatively flat surface that dips to the south into the Cold Creek syncline. Intercalated lenticular sand and silt of the fluvial sand overbank facies associations are found locally in the middle part of the unit in the southeastern part of the area. In the Semi-Works Aggregate Area, the Ringold unit A is present throughout the area (Figures 3-20 and 3-21). Unit A ranges in thickness from approximately 40 m (130 ft) in the southwest corner of the Semi-Works Aggregate Area to approximately 9 m (28 ft) in the northeast corner of the Semi-Works Aggregate Area.

The overbank and lacustrine deposits of the lower mud sequence thicken and dip to the south and southwest in a manner similar to the Ringold unit A gravels. However, unlike unit A, the line along which the lower mud sequences pinches out is very irregular. In the area between the 200 East Area and Gable Mountain the lower mud sequence can be found directly overlying the Elephant Mountain basalt at a number of locations where unit A is absent. Within the central part of the 200 East Area the lower mud sequence is largely absent. The nature of the pinchout of the lower mud sequence varies from location to location. At some locations it pinches out against uplifted basalt while at other locations the sequence is truncated by overlying deposits (either Ringold gravel unit E or Hanford gravels). In the area between Gable Mountain and the 200 East Area and in the vicinity of the B Pond complex, the lower mud sequence forms the uppermost part of the Ringold Formation and is overlain by the Hanford formation. Throughout the rest of the 200 East Area, the lower mud sequence is overlain by the gravels of Ringold unit E. In the Semi-Works Aggregate Area (Figures 3-22 and 3-23), the lower mud unit is probably not present, and has not been identified from the well logs reviewed.

Ringold unit E thickens to the south and southwest in the 200 East Area. Like the lower mud sequence, the line along which unit E pinches out is very irregular. In the 200 East Area, unit E is largely restricted to the southwest corner of the area and the GTF. It is absent in the B Pond area, the central and northern part of the area, and from the area between 200 East and Gable Mountain. Based on the stratigraphic relationships shown in Figure 3-13, most of the Ringold gravels encountered beneath the central part of the 200 East Area are part of gravel unit A and not gravel unit E (Figure 3-26). Ringold unit E dominantly consists of fluvial gravels. Strata typical of the fluvial sand and overbank facies associations may be encountered locally. However, predicting where intercalated lithologies will occur is very difficult. In the Semi-Works Aggregate Area (Figures 3-24 and 3-25), the Ringold unit E is probably not present, and has not been identified from the well logs reviewed.

3.4.3.4 Plio-Pleistocene Unit and Early "Palouse" Soil. The Plio-Pleistocene unit and early "Palouse" soil are not found within or near the 200 East Area or the Semi-Works Aggregate Area. They are encountered only near the eastern boundary of the 200 West Area approximately 5 km (3 mi) from the 200 East Area.

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) the 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 distribution of the facies types and similarities in lithologic succession across the 200 East Area indicates that the Hanford formation can be divided into three stratigraphic sequences which are designated as: (1) lower gravel, (2) sand, and (3) upper gravel. However, because of the variability of Hanford deposits, contacts between the sequences can be difficult to identify.

The sequences are composed mostly of the gravel-dominated and sand-dominated facies. The silt-dominated facies is relatively rare except in the southern part of the 200 East Area. Two of the sequences are dominated by deposits typical of the gravel-dominated facies and they are designated the upper and lower gravel sequences. The third sequence consists of deposits of the sand-dominated facies with lesser intercalated occurrences from both the gravel-dominated and silt-dominated facies. This sequence, designated the sandy sequence, generally is situated between the upper and lower gravel sequences.

The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies. Local intercalated intervals of the sand-dominated facies are also found. The lower gravel sequence ranges form 0 to 41 m (0 to 133 ft) thick and is found throughout most of the 200 East Area. In the Semi-Works Aggregate Area (Figures 3-27 and 3-28), the lower gravel sequence is not differentiated from the upper gravel sequence due to the absence of the sandy sequence which is used to distinguish the two gravel sequences from one another. The contact between the lower coarse sequence and the overlying sandy sequence is placed at the top of the first thick (> 6 m, >20 ft) gravel interval encountered below the sand-dominated strata of the sandy sequence. The lower gravel sequence is not present in the Semi-Works Aggregate Area.

The sandy sequence consists of a heterogenous mix of sands typical of the sand-dominated facies. Deposits of the silt-dominated facies are present, but less abundant. The sandy sequence ranges from 0 to 84 m (0 to 275 ft) thick. This sequence is dominated by the sand-dominated facies in the north, and the silt-dominated facies becomes more common towards the south. Gravels, occurring as single clasts and as interbeds are common in the sandy sequence, especially towards the north. The sandy sequence probably contains the greatest concentration of clastic dikes and it is laterally equivalent with lower fine sequence in the 200 West Area (Lindsey et al. 1991). Where the sandy sequence pinches out it commonly interfingers with gravels of the overlying and underlying gravel sequences. Where this occurs the contact separating the sandy sequence from the other intervals is difficult to place. The sandy sequence is differentiated from the gravelly strata of the upper and lower gravel sequences on the basis of sand content. The base of the sandy sequence is placed at the top of the highest gravelly interval and underlies sand-dominated strata. The top of the sequence is placed at the top of the highest thick, sand-dominated interval. In the Semi-Works Aggregate Area, the sandy sequence ranges in thickness from 86 m (282 ft) in the southwest to approximately 60 m (197 ft) in the northeast corner (Figures 3-29 and 3-30) and generally thickens to the southwest.

The third Hanford formation stratigraphic sequence consists of gravel-dominated strata referred to as the upper gravel sequence. This sequence is dominated by deposits typical of the gravel-dominated facies. Lesser occurrences of the sand-dominated facies are encountered locally. The sequence thins from as much as 55 m (180 ft) in the north to zero near the southern border of the 200 East Area (Figure 3-31). In addition, at one location, northwest of the 200 East Area, the sequence thins more than surrounding localities and at another location, in the central part of the 200 East Area, the unit is completely absent. Where the upper gravel sequence is thickest, in the north, it is found to form an elongated northwest to southeast oriented body. The upper gravel and lower gravel sequences are not differentiated in this area where the intervening sandy sequence is absent.
Figure 3-32 depicts variations in thickness of the Hanford formation throughout the 200 East

Area. In the Semi-Works Aggregate Area, the upper coarse gravel sequence is locally absent (Figure 3-32) or forms a thin sheet (<4 m ([<13 ft]) around the perimeter of the area.

3.4.3.6 Surficial Deposits. Surficial deposits in the 200 East Area are dominated by very fine- to medium-grained to occasionally silty eolian sheet 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 sheets (<3 m, 10 ft) that cover the ground. Longitudinal (southwest to northeast trending) dunes are well developed in the southern part of the 200 East Area. The Holocene-age surficial deposits are not differentiated on cross-sections and maps because they are relatively thin and because of the lack of definition on so many of the borehole geologic logs available for the 200 East Area and the Semi-Works Aggregate Area. Holocene surficial deposits are found in thin sheets (±5 m [±16 ft]) covering parts of the Semi-Works Aggregate Area (Lindsey et al. 1992).

3.5 HYDROGEOLOGY

Regional hydrogeology and hydrogeology of the 200 East Area are summarized in the following sections. Where sufficient data exists, interpretations of the hydrogeology beneath the Semi-Works 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 southwest Pasco Basin is generally within the Ringold fluvial gravels of unit E. In the northern and eastern Pasco Basin the water table is generally within the Hanford formation. Table 3-1 presents hydraulic parameters for various water-bearing geologic units at the Hanford Site.

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

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

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

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

3.5.2 Hanford Site Hydrogeology

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

3.5.2.1 Hydrostratigraphy. The hydrostratigraphic units of concern in the 200 Areas are (1) the Rattlesnake Ridge interbed (confined water-bearing zone), (2) the Elephant Mountain Basalt Member (confining horizon), (3) the Ringold Formation (unconfined and confined water-bearing zones and lower part of the vadose zone), (4) the Plio-Pleistocene unit and early "Palouse" soil (primary vadose zone perching horizons and/or perched groundwater zones) and (5) the Hanford formation (vadose zone) (Figure 3-32). 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. In the 200 East Area the Plio-Pleistocene and early "Palouse" soil are absent. The unconfined aquifer water table (discussed in Section 3.5.2.1.3) lies within the Ringold unit E and the Hanford formation.

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 3-33 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 that predict the conductivity from measured soil moisture retention data (Van Genuchten et al. 1991).

Thirty-five soil samples from the 200 West Area have had moisture retention data measured. These samples were collected from Wells 299-W18-21, 299-W15-16, 299-W15-2, 299-W10-13, 299-W7-9, and 299-W7-2. Eleven of these samples were reported by Bjornstad (1990). The remaining 24 were analyzed as part of an ongoing performance assessment of the low-level burial grounds (Connelly et al. 1992). For each of these samples saturated hydraulic conductivity was measured in the laboratory. Van Genuchten's computer program RETC was then used to develop wetting and drying curves for the Hanford, early "Palouse" soil, Plio-Pleistocene, upper Ringold, and Ringold gravel lithologic units. An example of the wetting and drying curves, and corresponding grain size distributions, is provided on Figure 3-33.

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 waste management unit, the detailed layering of the lithologic units 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 et al. (1989) used the UNSAT-H one-dimensional finite-difference unsaturated zone water flow computer code to predict the precipitation infiltration for several different soil horizon combinations and characteristics. The researchers used statistically generated precipitation values that 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 low 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. The potential for perched water zones in the Semi-Works Aggregate Area is 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. As discussed earlier, the Plio-Pleistocene unit and the early "Palouse" soil do not occur in the 200 East Area. Therefore, the potential for perched water occurring in the Semi-Works Aggregate Area is low.

3.5.2.1.3 Unconfined Aquifer. The uppermost aquifer system in the 200 Areas occurs primarily within the sediments of the Ringold Formation and Hanford formation. In the 200 West Area the upper aquifer is contained within the Ringold Formation and displays unconfined to locally confined or semiconfined conditions. In the 200 East Area the upper aquifer occurs in the Ringold Formation and Hanford formation. The depth to groundwater in the upper aquifer underlying the 200 Areas ranges from approximately 60 m (197 ft) beneath the former 216-U-10 Pond in the 200 West Area to approximately 105 m (340 ft) west of the 200 East Area to approximately 103 m (338 ft) near the 202-A Building in the 200 East Area. The saturated thickness of the unconfined aquifer ranges from approximately

67 to 112 m (220 to 368 ft) in the 200 West Area and approximately 61 m (200 ft) in the southern 200 East Area to nearly absent in the northeastern 200 East Area where the aquifer thins out and terminates against the basalt located above the water table in that area.

The upper part of the uppermost aquifer in the 200 East Area consists of a generally unconfined water-bearing zone within the Ringold unit E. In the northern part of the Semi-Works Aggregate Area the Ringold Formation has been eroded and the water-bearing zone is found within the Hanford formation. The lower part of the uppermost aquifer consists of a confined to 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.

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 East Groundwater Aggregate Area Management Study Report (AAMSR).

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

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

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

Examples of precipitation recharge studies include:

- 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 3-34. 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.

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

- An assessment of precipitation recharge involving the redistribution of ^{137}Cs in vadose zone soil also reported by Routson and Johnson (1990). In this study, split-spoon soil samples were collected beneath a solid waste burial trench in the T Plant Aggregate Area. The trench, located just south and west of the 218-W-3AE Burial Ground, approximately 6 km (3.7 mi) west of the 200 East Area, 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) 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 x 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) was conducted at the 200 East Area Lysimeter Site, approximately 1 km (1.6 mi) south of the 200 East Area. Water contents below the 4.88 m (16 ft) depth in the closed-bottom lysimeter have not changed reasonably between 1972 and 1988, implying that significant recharge has not occurred. Data are insufficient to conclude whether the presence of a plant community on the lysimeter is the reason for the lack of water increase.

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 for the unconfined aquifer showed little variation and were generally around 133 m (405 ft) (Kasza et al. 1990).

Temporary reversal of groundwater flow entering the Columbia River may occur during transient, high-river stages. This occurrence is known as bank storage. Correlations were made between groundwater level and river-stage fluctuations along a 81 km (50 mi) reach of the Columbia River adjacent to the Hanford Site by Newcomb and Brown (1961). They concluded that a 260 km^2 (100 mi^2) area within the Hanford Site was affected by bank storage. During a 45 day rise in river stage, it was estimated that water infiltrated at an average rate of 4,600,000 m^3/day (3,700 acre-ft/day) versus 1,200,000 m^3/day (1,000 acre-ft/day) during the 165 day recession period. Since this study was conducted, dam control on the Columbia River has reduced the magnitude of bank storage on the groundwater system.

Natural groundwater inflow to the unconfined aquifer primarily occurs along the western boundary of the Hanford Site. Historically, much greater recharge occurred from a number of waste management units in the 200 Areas. Man-made recharge probably substantially exceeded 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). Generally, groundwater flow is from the west towards the east-southeast. Artificial recharge from the 216-B-3 Pond System in the neighboring B Plant Aggregate Area has produced a groundwater mound which has altered the hydraulic gradients and groundwater flow direction throughout the 200 East Area. The result of this flow convergence in the development of a large groundwater "saddle" beneath the 200 East Area. The overall effect of the "saddle" is that groundwater flow is partitioned in two primary directions: north through the Gable Gap area and southeast towards Richland. Locally, within the 200 East Area groundwater, flow direction is difficult to determine and can be variable due to extremely low hydraulic gradient and effects of variable discharges to the 216-B-3 Pond System.

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 East Area was on the order of 0.0003 (Delaney et al. 1991). Prior to disposing liquid waste to the soil column in the 200 Areas, groundwater elevations in the 200 East Area may have been as much as 18 m (55 ft) lower in 1944 than at present. As seen in Figure 3-35, a distinct groundwater mound is still apparent east of the 200 East Area near the B Pond. The B Pond has caused the groundwater flow direction to change to a northwest-southeast flow pattern.

3.5.3 Semi-Works Aggregate Area Hydrogeology

This section presents additional hydrogeologic information identified with specific application to the Semi-Works Aggregate Area.

3.5.3.1 Hydrostratigraphy. As shown on Figure 3-36, the hydrostratigraphic units of concern beneath the Semi-Works Aggregate Area are (1) the Rattlesnake Ridge interbed, (2) the Elephant Mountain Basalt Member, (3) the Ringold Formation units A and E, and (4) the Hanford formation. The hydrogeologic designations for the Semi-Works Aggregate Area were determined by examination of borehole logs from Lindsey et al. (1992) and Chamness et al. (1992) and integration of these data with stratigraphic correlations from existing reports. For the purposes of the PUREX 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 can be found in the 200 East Groundwater AAMSR.

3.5.3.1.1 Vadose Zone. The vadose zone beneath the Semi-Works Aggregate Area is approximately 87 m (285 ft) thick with minor variations. 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.

3.5.3.1.2 Perched Water Zones. Unlike the 200 West Area, the likelihood of perched water occurring in the 200 East Area is low. In the 200 West Area, perched water is found predominantly in the Plio-Pleistocene and the early "Palouse" soil. Those stratigraphic units are not present in the 200 East Area. However, because of the large quantity of liquid waste disposed of and the variability of grain size/stratigraphy and the occurrence of intercalated lenses, perched water zones are possible.

3.5.3.2 Natural Groundwater Recharge. As discussed in Section 3.3.3, no natural surface water bodies exist within the Semi-Works Aggregate Area. Therefore, the potential for natural groundwater recharge within the Semi-Works Aggregate Area is limited to precipitation infiltration. No precipitation infiltration data were identified with specific reference to the Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area. As indicated on Figure 3-35, the Semi-Works Aggregate Area is located between groundwater mounds from the 200 West Area and B-Pond to the east. Consequently, there is very little gradient to the groundwater table beneath the site. Based on the December 1990 Hanford wells groundwater data (Kasza et al. 1990), flow away from the B-Pond mound likely produces a very gradual west to south west flow beneath the Semi-Works Aggregate Area.

3.5.3.4 Historical Effects of Operations. Artificial recharge from waste management facilities within the 200 East Area has caused significant changes to the water levels of the unconfined aquifer since operations began in 1943. Historically, the majority (greater than 90%) of wastewater discharged from the 200 East Area has been routed to the B or Gable Mountain Ponds (Zimmerman et al. 1986). Between 1943 and 1980 approximately 3.433×10^{11} L (9.082×10^{10} gal) of wastewater had been discharged to these ponds. The B Pond received greater than 90% of the wastewater discharged from the 200 East Area between 1945 and 1955. In 1957 the Gable Mountain Pond began receiving wastewater.

From 1956 to 1980 these ponds received over 90% of the wastewater generated from the 200 East Area. This discharging has created elevated groundwater levels, or mounding of the groundwater, in the vicinity of the B and Gable Mountain Ponds.

Between 1950 and 1955 small groundwater elevation increases occurred south of Gable Mountain in response to wastewater discharges from the B Plant. Groundwater mounding in the vicinity of the B Pond continued in response to the startup of the PUREX in 1956 and new discharges to the Gable Mountain Pond. During this time, the artificial recharge caused elevations to reach approximately 10 m (32 ft) above the natural groundwater elevations.

During the 1960's, the groundwater mound grew at a much slower rate and reached near equilibrium conditions during the 1970's. During the 1980's, three expansion ponds were created near the B Pond to receive wastewater redirected from the Gable Mountain Pond and the PUREX Plant which resumed production in 1983. This increased discharge amount has elevated groundwater levels in the vicinity of the B Pond approximately 1.5 m (5 ft) between December 1979 and December 1989. Groundwater elevations in the vicinity of the Gable Mountain Pond have decreased approximately 1 m (3 ft) during this same time.

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 milkvetch 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 the Natural Heritage Program [1990]). Of concern to the Hanford Site, there are two

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

Of the two Endangered taxa, Persistantsepal yellowcress is well documented along the banks of the Columbia River throughout the 100 Areas, it is unlikely to occur in the 200 Areas. The northern wormwood (*Artemisia campestris spp. borealis*) is known in the State of Washington by only two populations, one across from The Dalles, Oregon, and the other near Beverly, Washington, just north of the Hanford Site. This taxon has not been found on the Hanford Site, but would probably occur only on rocky areas immediately adjacent to the Columbia River if it were present. Neither of the Threatened taxa listed in Table 3-3 have been observed on the Hanford Site. The Columbia milkvetch (*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 tubersoum*) 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. bruria*) 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 B Pond, the 216-A-24 Crib, and 100-H Area. Bristly cryptantha (*Crypthantha interrupta*), and 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 arractus*) and coyote tobacco (*Nicotiana attenuata*) are not as well documented but are known to inhabit dry sandy areas such as the 200 Areas Plateau.

In addition to the three classifications for species of concern listed above, the Natural Heritage Program also maintains a "Monitor" list, which is divided into three groups. Group 1 consists of taxa in need of further field work before a formal status can be assigned. The tooth-sepal dodder (*Cuscuta denticulata*), which has been found in the state of Washington only on the Hanford Site is the only taxon in this group that is of concern to Hanford operations. This parasitic species has been found in the area west of McGee Ranch. Group 2 of the Monitor list includes species with unresolved taxonomic questions. Thompson's sandwort (*Arenaria franklinii* var. *thompsonii*) is of concern to Hanford operations. However, the representatives of this species in the state of Washington are now believed to all be variety *franklinii* which is not considered particularly rare. Group 3 of the

Monitor list includes taxa that are either more abundant or less threatened than previously believed. There are approximately 15 taxa on the Hanford Site that are included on this list.

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

3.6.1.3.1 Mammals. The largest mammal occurring on the 200 Areas Plateau is the mule deer (*Odocoileus hemionus*). Although mule deer are much more common to riparian sites along the Columbia River, they are frequently observed foraging throughout the 200 Areas. Elk (*Cervus elaphus*) also occur at Hanford but they have only been observed at the Arid Lands Ecology Reserve. Other mammal species common to the 200 Areas include badgers (*Taxidea taxus*), coyotes (*Canis latrans*), blacktail jackrabbits (*Lepus californicus*), Townsend ground squirrels (*Spermophilus townsendii*), Great Basin pocket mice (*Perognathus parvus*), pocket gophers (*Thomomys talpoides*), and deer mice (*Peromyscus maniculatus*). Badgers are known for their digging capability and have been implicated several times for encroaching into inactive burial grounds throughout the 200 Areas. The majority of the badger excavations in the 200 Areas are a result of badgers searching for prey (mice and ground squirrels). Coyotes are the principal predators, consuming such prey as rodents, insects, rabbits, birds, snakes and lizards. The Great Basin pocket mouse is the most abundant small mammal, which thrives in sandy soils and lives entirely on seeds from native and revegetated plant species. Townsend ground squirrels are not abundant in the 200 Areas but they have been seen at several different sites. Other small mammals that occur in low numbers include the Western harvest mouse (*Reithrodontomys megalotis*) and the Grasshopper mouse (*Onychomys leucogaster*). Mammals associated more closely with buildings and facilities include Nuttall's cottontails (*Sylvilagus nuttallii*), house mice (*Mus musculus*), Norway rats (*Rattus norvegicus*), and some bat species. Bats probably play a minor role in the 200 Areas' ecosystem but no documentation is available on bat populations at Hanford. Mammals such as skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), weasels (*Mustela* spp.), porcupines (*Erethizon dorsatum*), and bobcats (*Lynx rufus*) have only been observed on very few occasions.

3.6.1.3.2 Birds. Over 235 species of birds have been documented to occur at the Hanford Site (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*), rufflehead (*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 that 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 that inhabit the Hanford Site have been given special status designations by the state and federal government. Some of these designations include state and federal threatened and endangered species, federal candidate, state monitor, state sensitive, and state candidate species. Species listed in Table 3-3 as state and/or federal threatened and endangered such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), American white pelican (*Pelecanus 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 Semi-Works Aggregate Area is the location of the 201-C Building, the Critical Mass Laboratory, and its attendant facilities and structures. In the past, the 201-C Building and related facilities served as a pilot plant for both the REDOX and PUREX processes and later was used for the recovery of strontium from fission product waste. Three of these buildings (215-C, 2704-C, and 276-C), are still in use (Deford 1992). The 201-C Process Building was decommissioned in 1987. There are no active waste management units associated with this building.

The Critical Mass Laboratory (209-E Building) was used for criticality experiments through 1983. Since then, its associated administrative offices have been used intermittently. Two waste management units (2607-E-5 Septic Tank, 2607-E-7A Septic Tank) are still active. In addition, the Critical Mass Laboratory Valve Pit has not been decommissioned.

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

3.6.3 Water Use

There is no consumptive use of groundwater within the Semi-Works Aggregate Area. Water for drinking and emergency use, and facilities process water is drawn from the Columbia River, treated, and imported to the 200 East Area. The nearest wells used to supply drinking water are located at the Yakima Barricade (Well 699-40-100-C) about 7 km (4 mi) west of the 200 East Area; at the Hanford Safety Patrol Training Academy (Well 699-528-E0) about 40 km (24 mi) to the southeast; at an Arid Lands Ecology field station building near Rattlesnake Springs (Well 699-24-95) about 10 km (6 mi) west southwest of the 200 West Area; 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 (19 mi) to the southeast. There is one well, 299-E26-6, used by the 241-A Tank Farm as an emergency water supply for the tank farm vent cooling system. This well is located approximately 240 m (800 ft) north of the 241-A-701 Building. Two wells for emergency cooling water supply are located near the B Plant. 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.

3.7 HUMAN RESOURCES

The environmental conditions at the Semi-Works 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 18 km (11 mi) north of the Semi-Works 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 East Area by the Hanford Cultural Resources Laboratory. Isolated artifacts and sites of interest were identified in the 200 East Area but not within the Semi-Works Aggregate Area. The closest site of interest is the remains of the White Bluffs Road, located approximately 15 km (9 mi) northwest of the aggregate area, which was previously an Indian trail. More information is available in Rice (1980) and Chatters (1989).

3.7.3 Historical Resources

The only historic site in 200 East Area is the old White Bluffs freight road which is located to the northwest. 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 that includes any potentially affected community with respect to the PUREX 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.

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

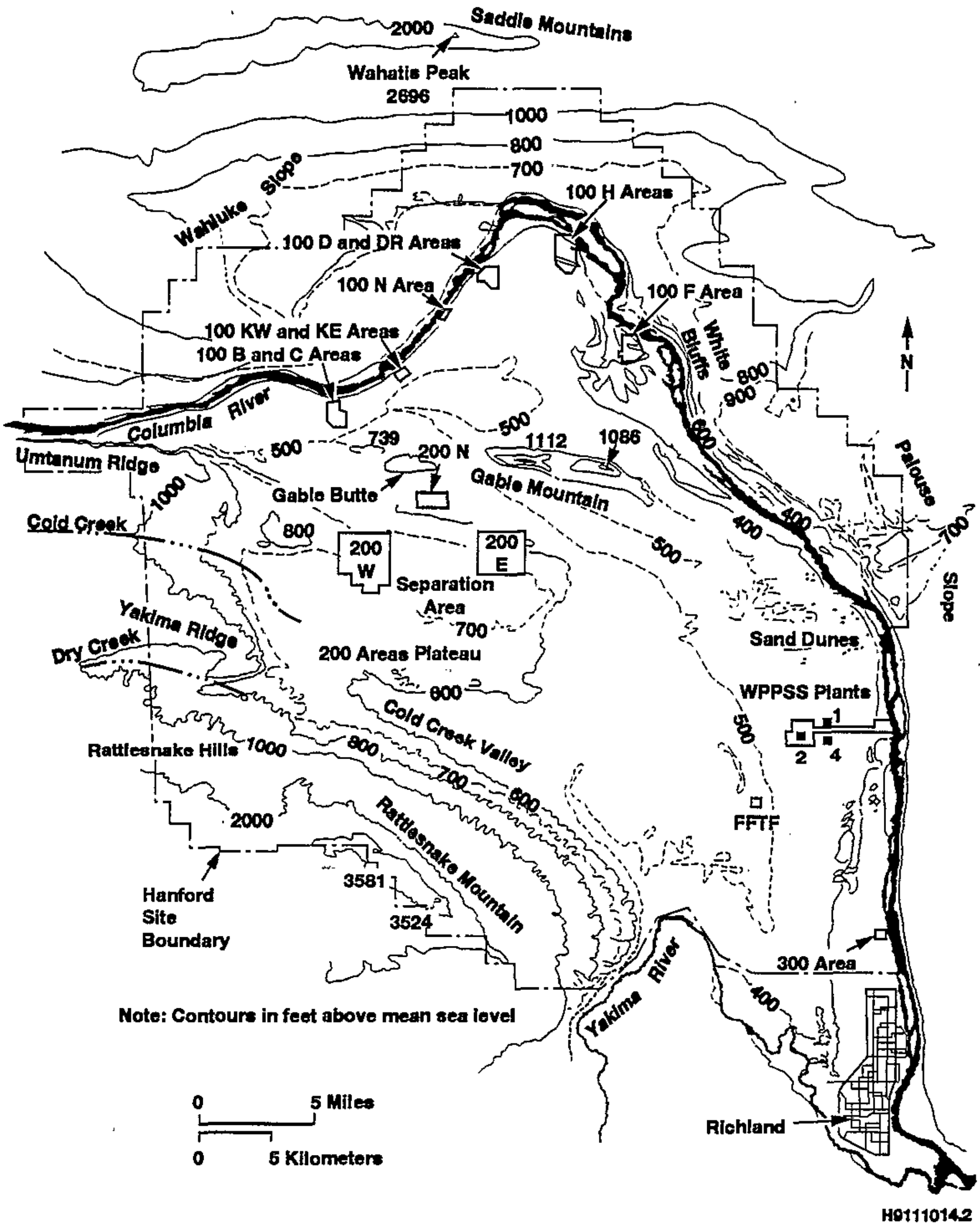


Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province. (DOE 1988a)

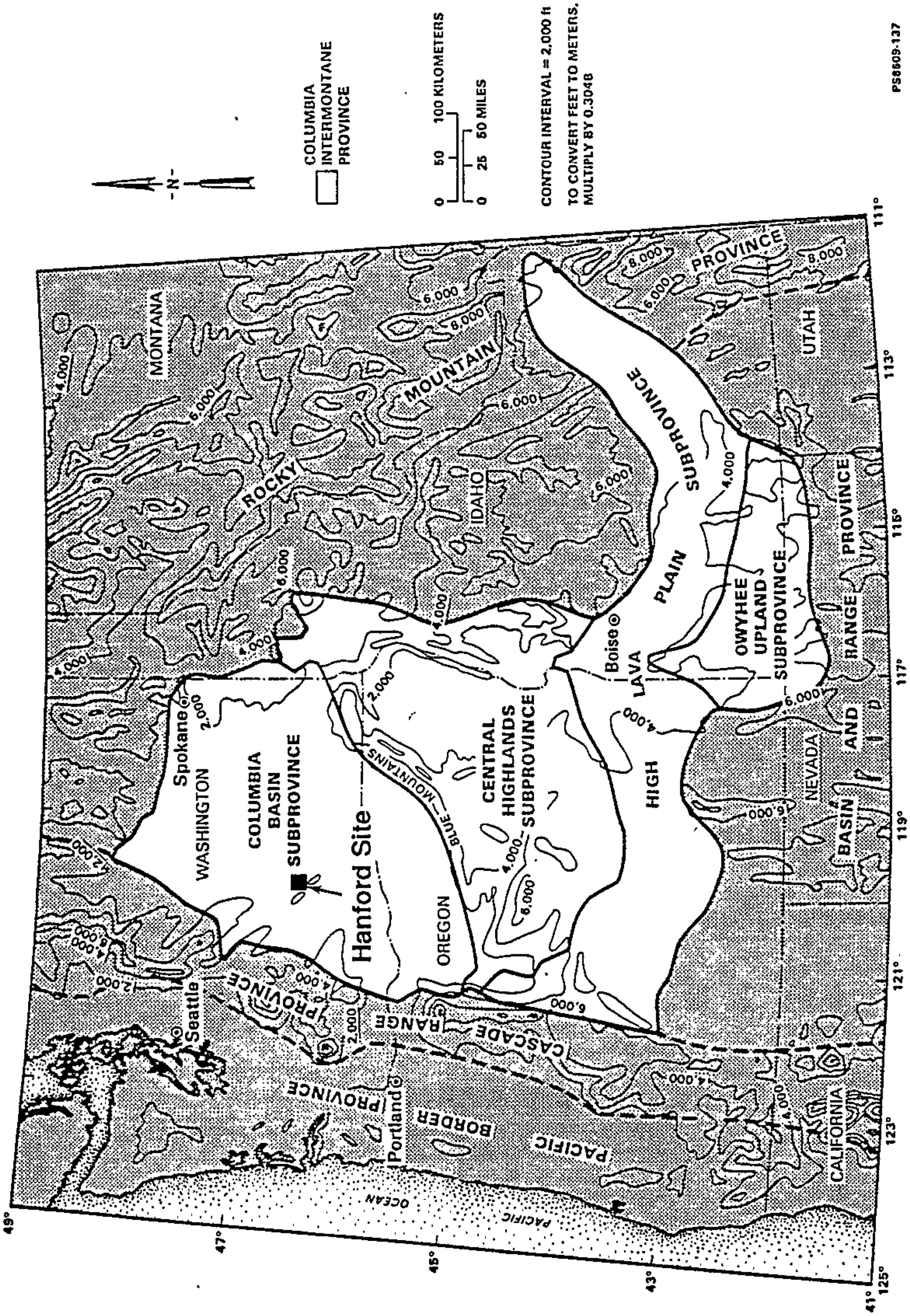
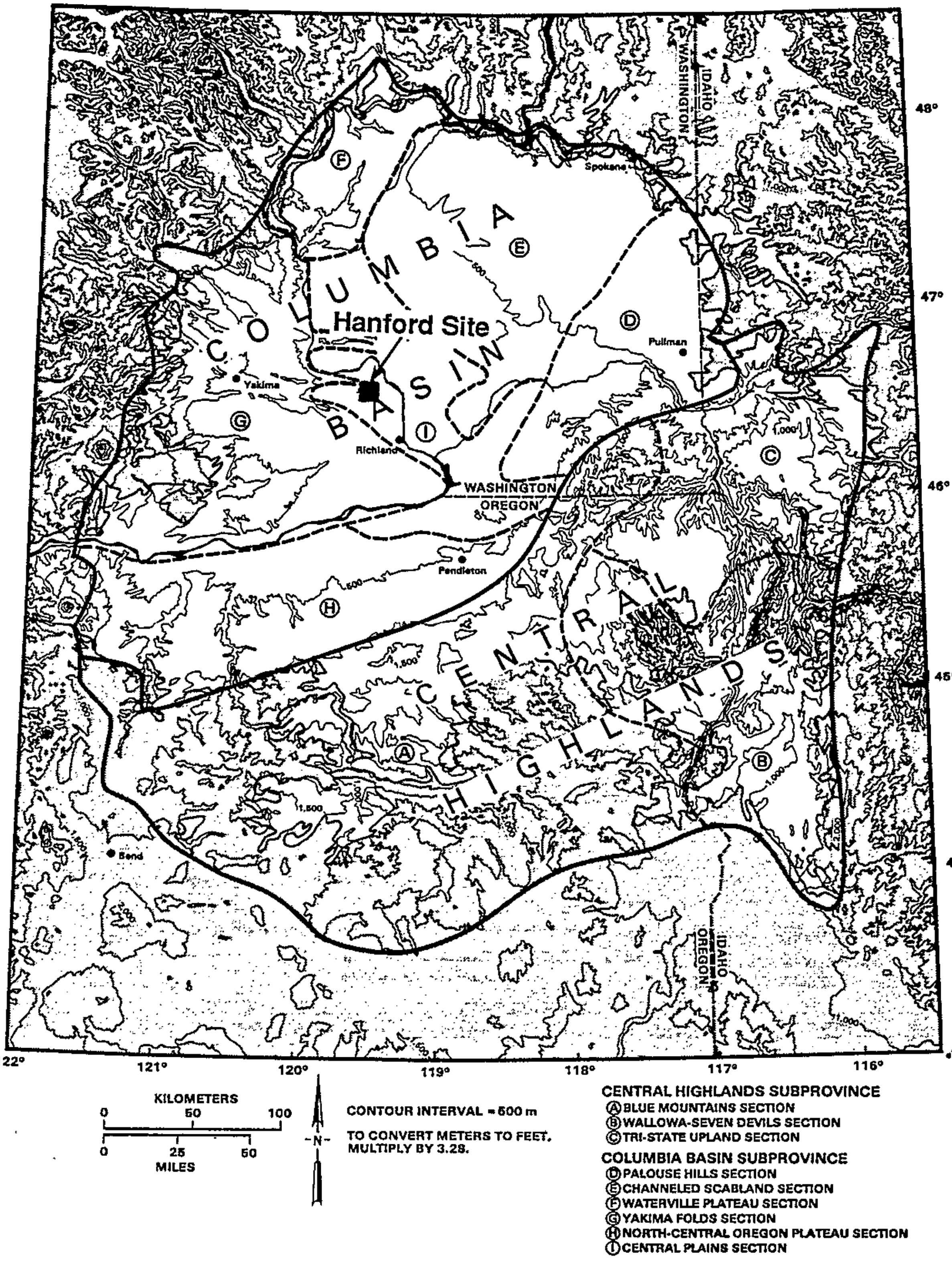
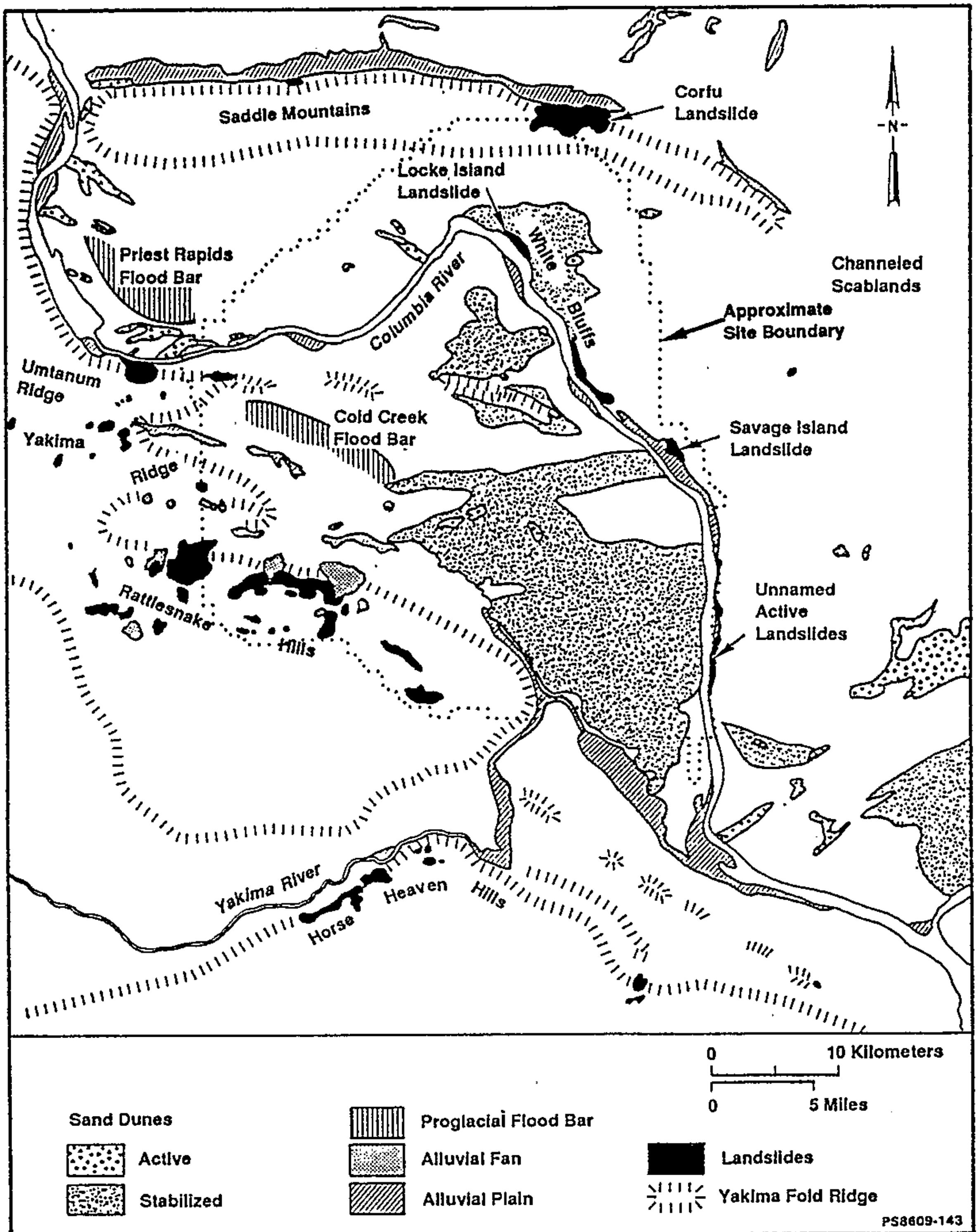


Figure 3-3. Geomorphic Units Within the Central Highlands and Columbia River Subprovinces that Contain the Columbia River Basalt Group. (DOE 1988a)



9 3 1 2 9 0 6 1 3 4 7

Figure 3-4. Landforms of the Pasco Basin and the Hanford Site. (DOE 1988a)



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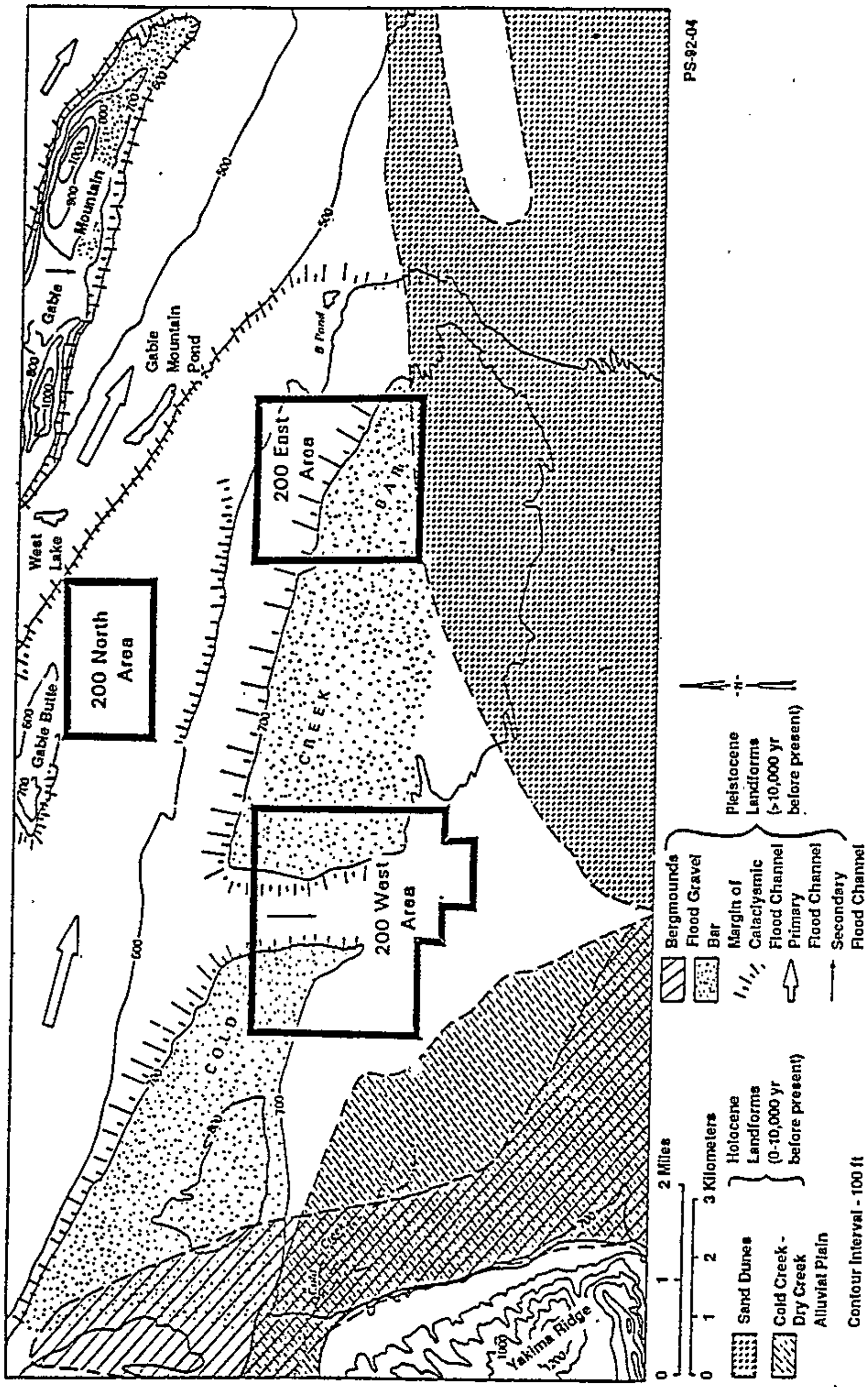
9 3 1 2 9 0 5 0 9 4 8

Figure 3-5. Geomorphic Features Surrounding the 200 Areas. (DOE 1988a)



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

93129050349

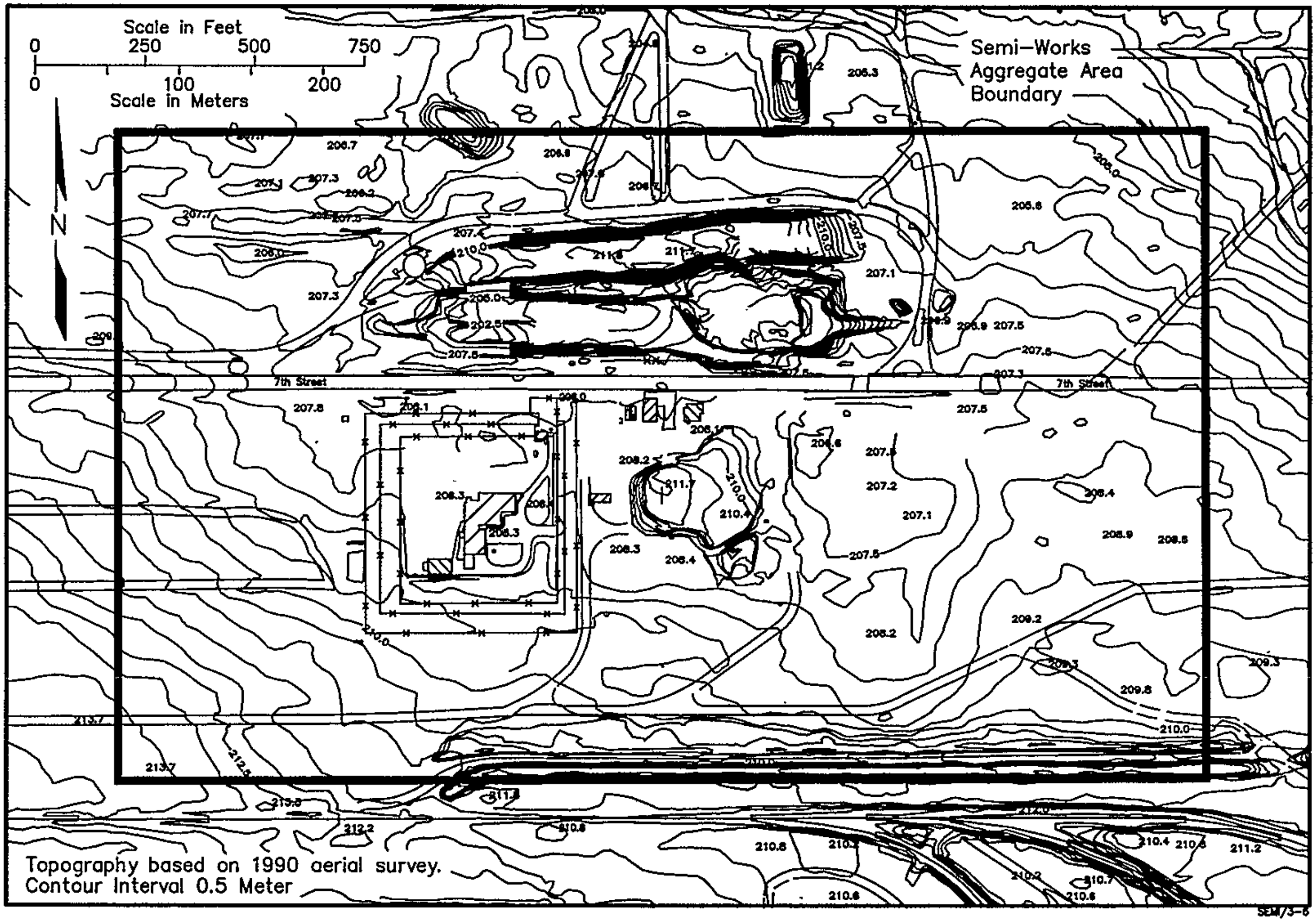
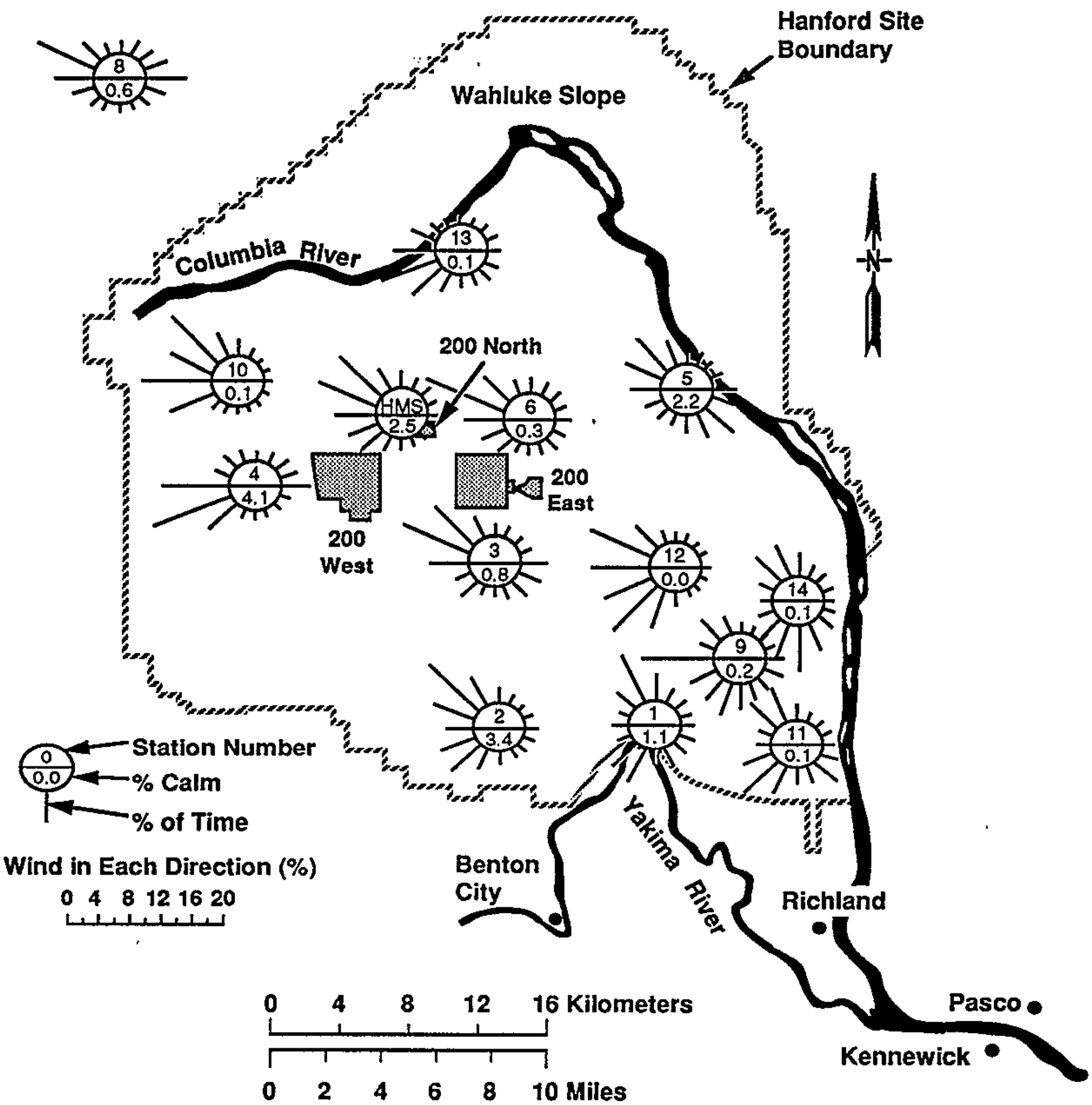


Figure 3-6. Topographic Map of the Semi-Works Aggregate Area.

Figure 3-7. Hanford Site Wind Roses, 1979 through 1982. (Stone et al. 1983)



HMS = Hanford Meteorological Station

H9206024.1

Figure 3-8. Hydrologic Basins Designated for the Washington Staate Portion of the Columbia Plateau. (DOE 1988a)

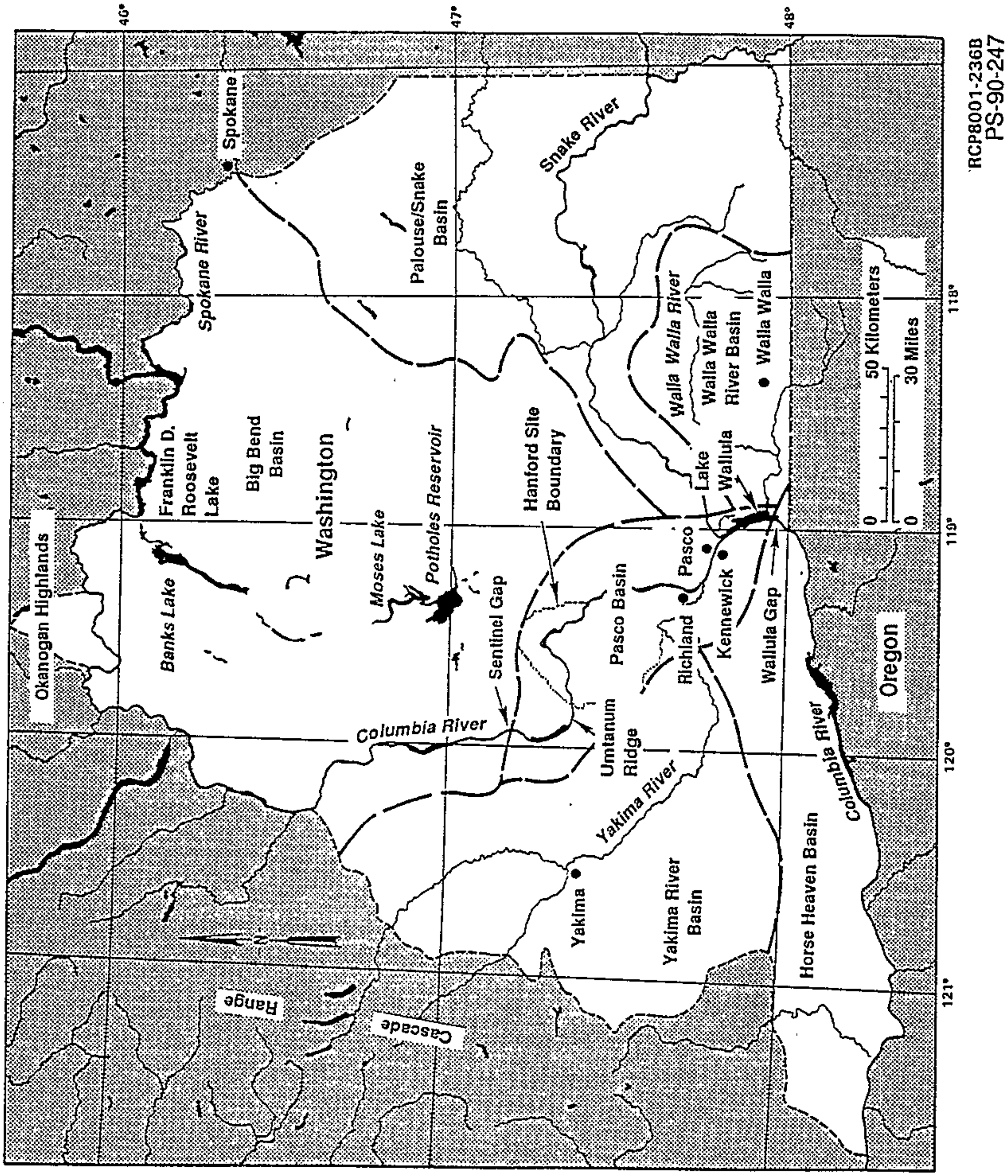
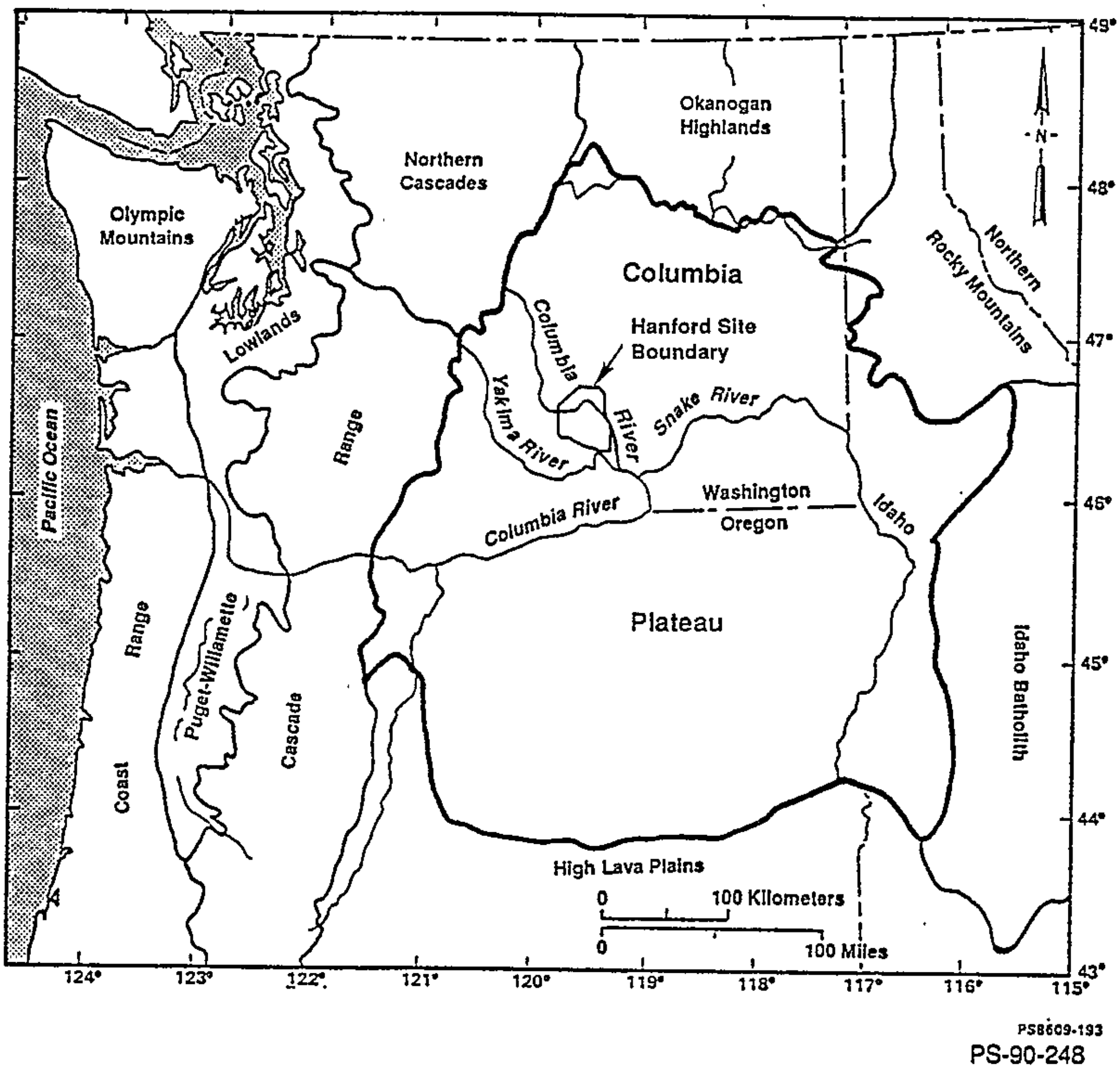
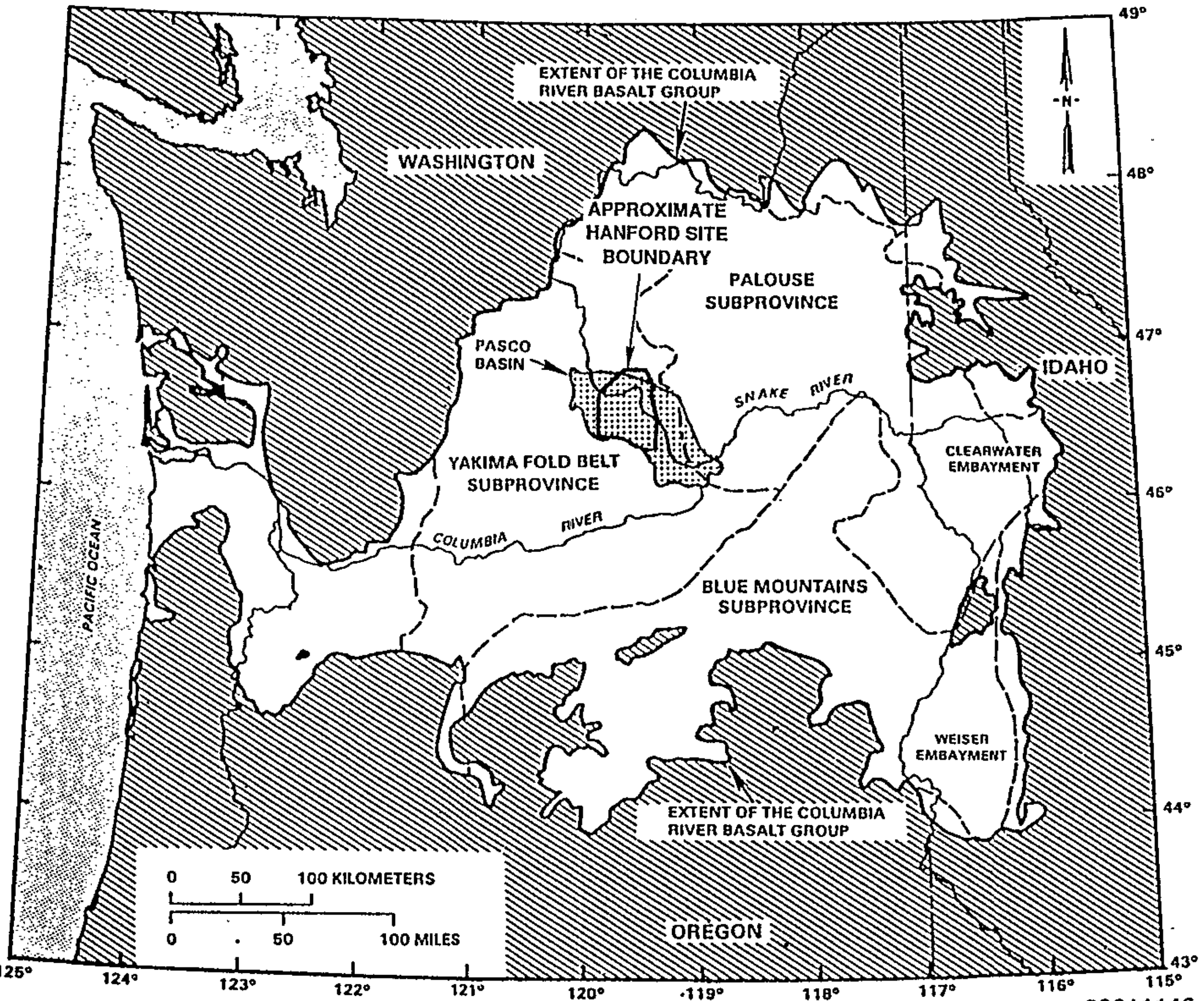


Figure 3-9. Structural Provinces of the Columbia Plateau.



9 3 1 2 9 0 5 3 3 5 3

9312906-9854



38811146.6

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Figure 3-10. Structural Subprovinces of the Columbia Plateau. (DOE 1988a)

Figure 3-11. Structural Elements of the Yakima Fold Belt Subprovince. (DOE 1988a)

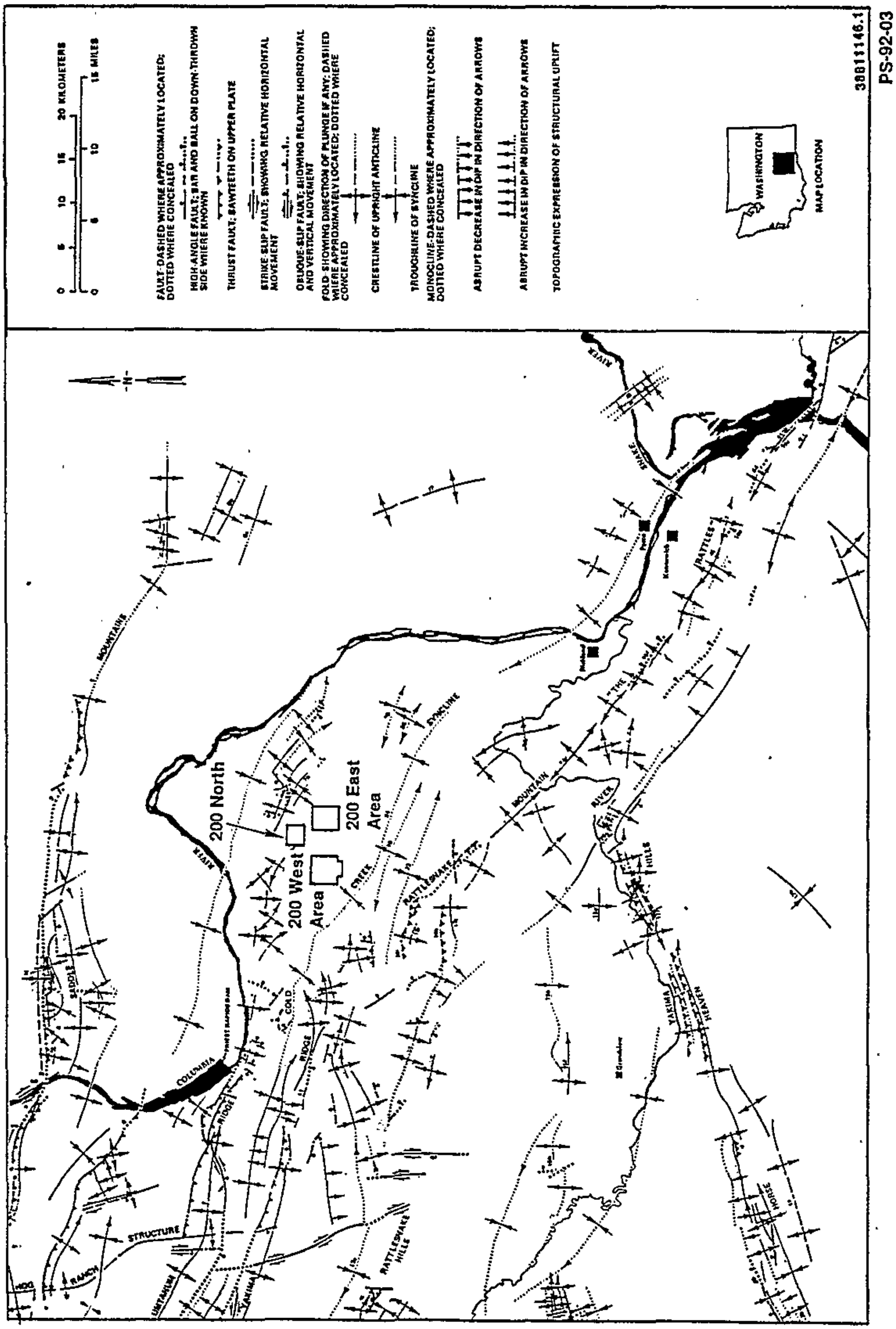
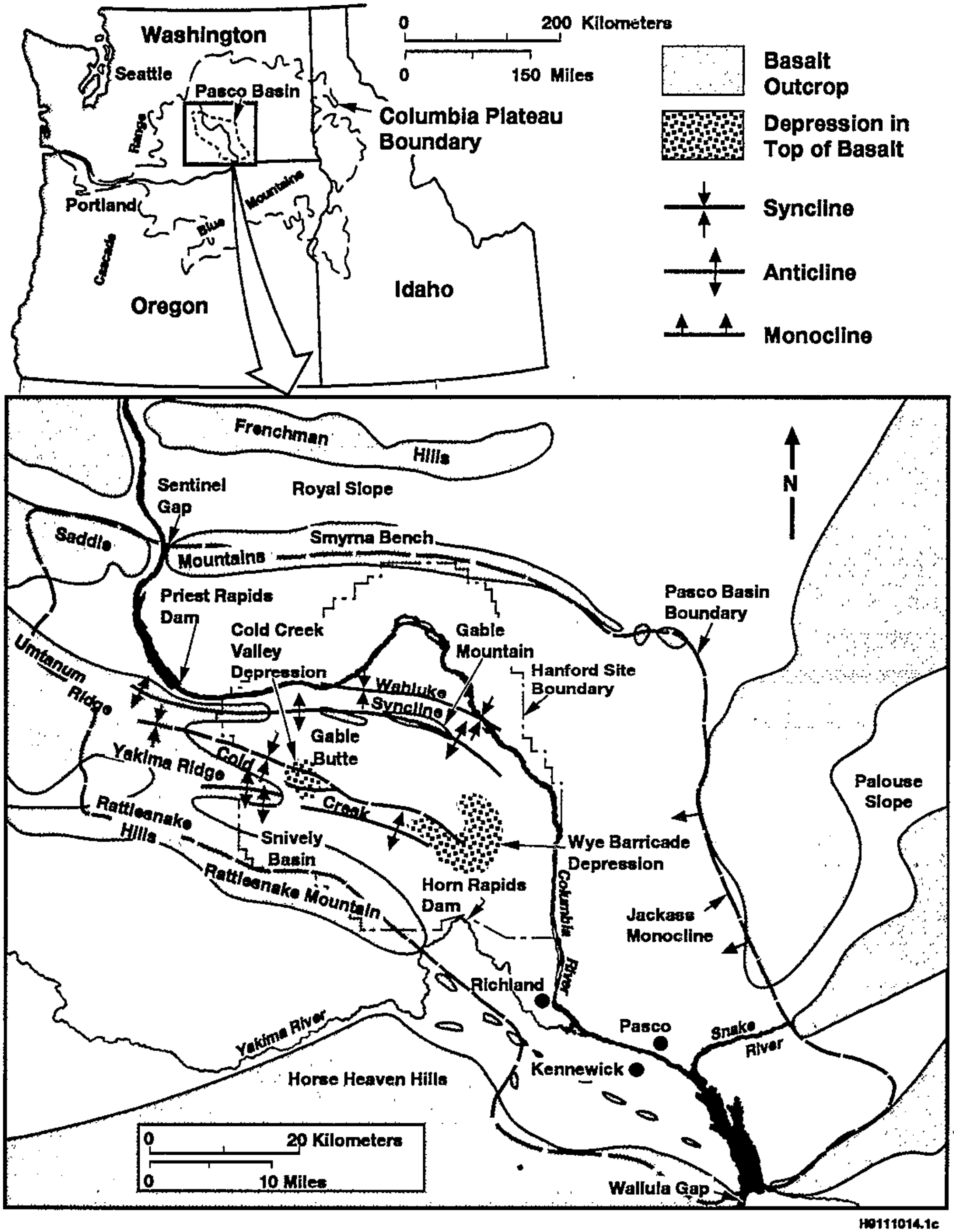


Figure 3-12. Geologic Structures of the Pasco Basin and the Hanford Site. (Reidel et al. 1989a)



9 3 1 2 9 0 6 0 9 5 6

Figure 3-13. Generalized Stratigraphy of the Hanford Site.

Period	Epoch	Group	Formation	Isotopic Age Dates Years x 10^6	Member (Formal and Informal)	Sediment Stratigraphy or Basalt Flows	
QUATERNARY	Holocene				Surficial Units	Loess, Sand Dunes, Alluvium and Alluvial Fans, Land Slides, Talus, Colluvium	
QUATERNARY	Pleisto-cene		Han-ford		Touchet beds / Pasco gravels		
QUATERNARY	Pleisto-cene					Plio-Pleistocene unit	
TERTIARY	Plio-cene		Ringold Formation				
TERTIARY	Miocene	Columbia River Basalt Group	Saddle Mountains Basalt	8.5	Ice Harbor Member	basalt of Goose Island	Ellensburg Formation
						basalt of Martindale	
						basalt of Basin City	
						Levey Interbed	
				10.5	Elephant Mountain Member	basalt of Ward Gap	
						basalt of Elephant Mountain	
						Rattlesnake Ridge interbed	
				12.0	Pomona Member	basalt of Pomona	
						Selah interbed	
					Esquatzel Member	basalt of Gable Mountain	
						Cold Creek interbed	
				13.5	Asotin Member	basalt of Huntzinger	
					Wilbur Creek Member	basalt of Lapwai	
						basalt of Wahluke	
					Umatilla Member	basalt of Sillusi	
						basalt of Umatilla	
				14.5		Mabton Interbed	
			Wanapum Basalt		Priest Rapids Member	basalt of Lolo	
						basalt of Rosalia	
						Quincy interbed	
					Roza Member	basalt of Roza	
						Squaw Creek interbed	
					Frenchman Springs Member	basalt of Lyons Ferry	
						basalt of Sentinel Gap	
						basalt of Sand Hollow	
						basalt of Silver Falls	
						basalt of Ginkgo	
						basalt of Palouse Falls	
				15.6		Vantage interbed	
			Grande Ronde Basalt*		N_2 Sentinel Bluffs Unit	basalt of Museum	
						basalt of Rocky Coulee	
						basalt of Levering	
						basalt of Cohassett	
						basalt of Birkett	
						basalt of McCoy Canyon	
				16.5	N_2 Umtanum Unit	basalt of Umtanum	
					N_2 Slack Canyon Unit		
					N_2 Ortley Unit	basalt of Benson Ranch	
					R_2 Grouse Creek Unit		
					R_2 Wapshilla Ridge Unit		
					R_2 Mt. Horrible Unit		
					N_1 China Creek Unit		
					R_1 Teepee Butte Unit		
					R_1 Buckhorn Springs Unit		
			Imnaha	17.5	Rock Creek Unit		
					American Bar Unit		

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

H9102029.6a

Figure 3-14. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site. (Lindsey and Gaylord 1989)

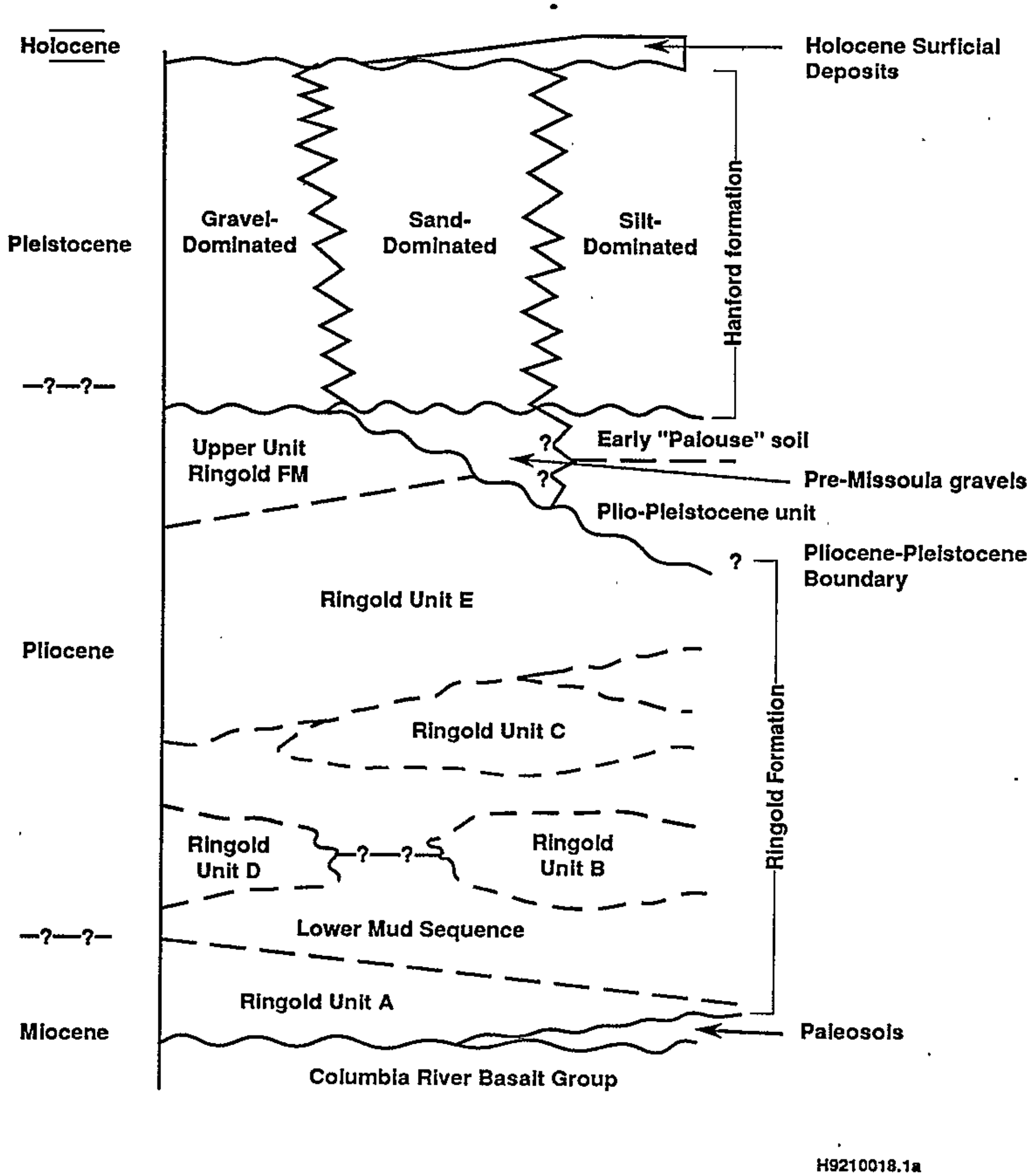


Figure 3-15. Location of the Cross Sections.

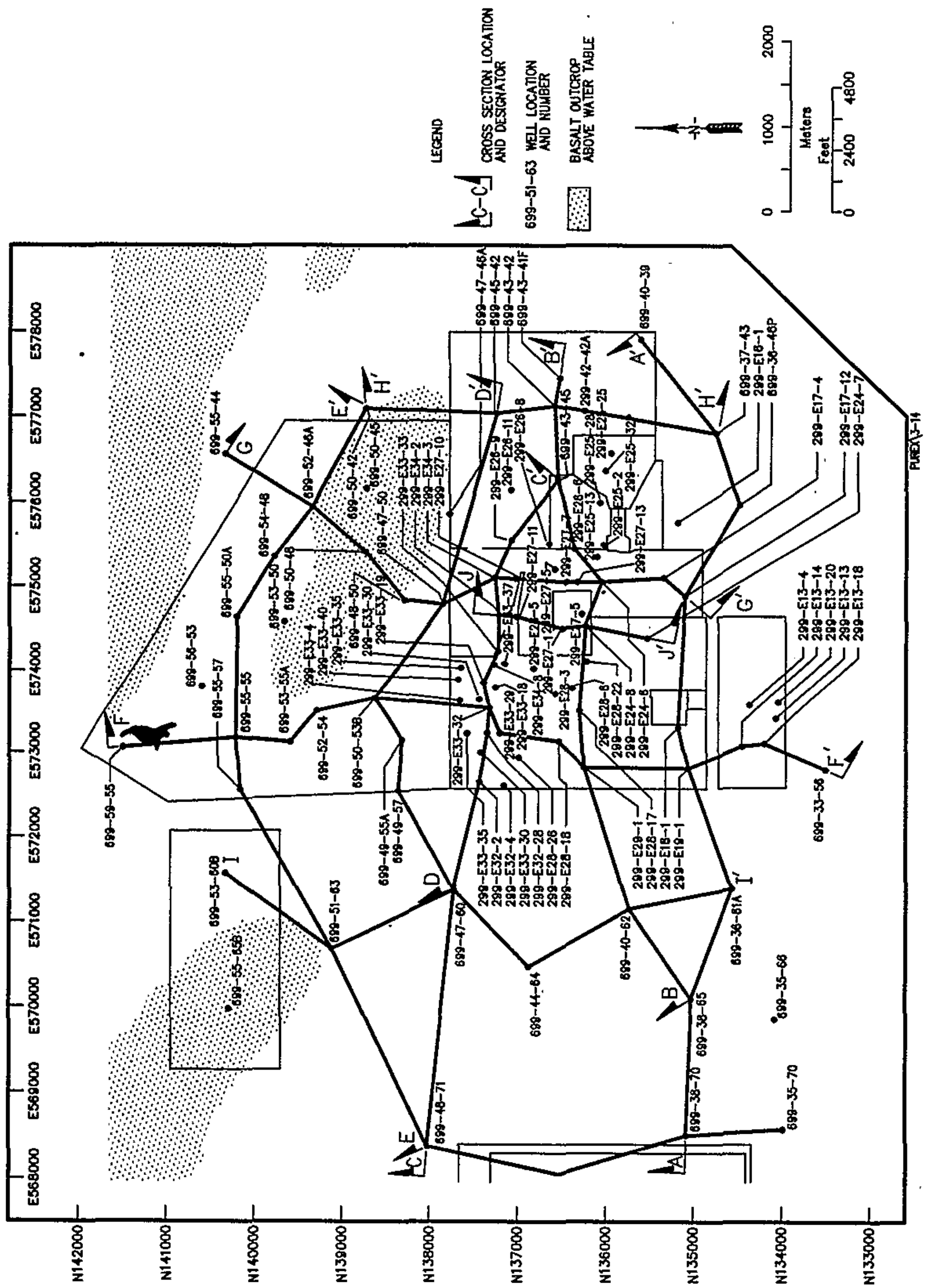


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Figure 3-16. Legend for Cross Sections.

Explanation

Additional Lithologic Symbols, Includes Subordinate Lithologies

- Clay rich
- Silt rich
- Sandy
- Pebbly to cobbly
- Bouldery
- Calcium carbonate present
- Paleosol
- Basalt
- Cemented

Scales

100 ft

874 ft

Vertical Exaggeration 8.7 X

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

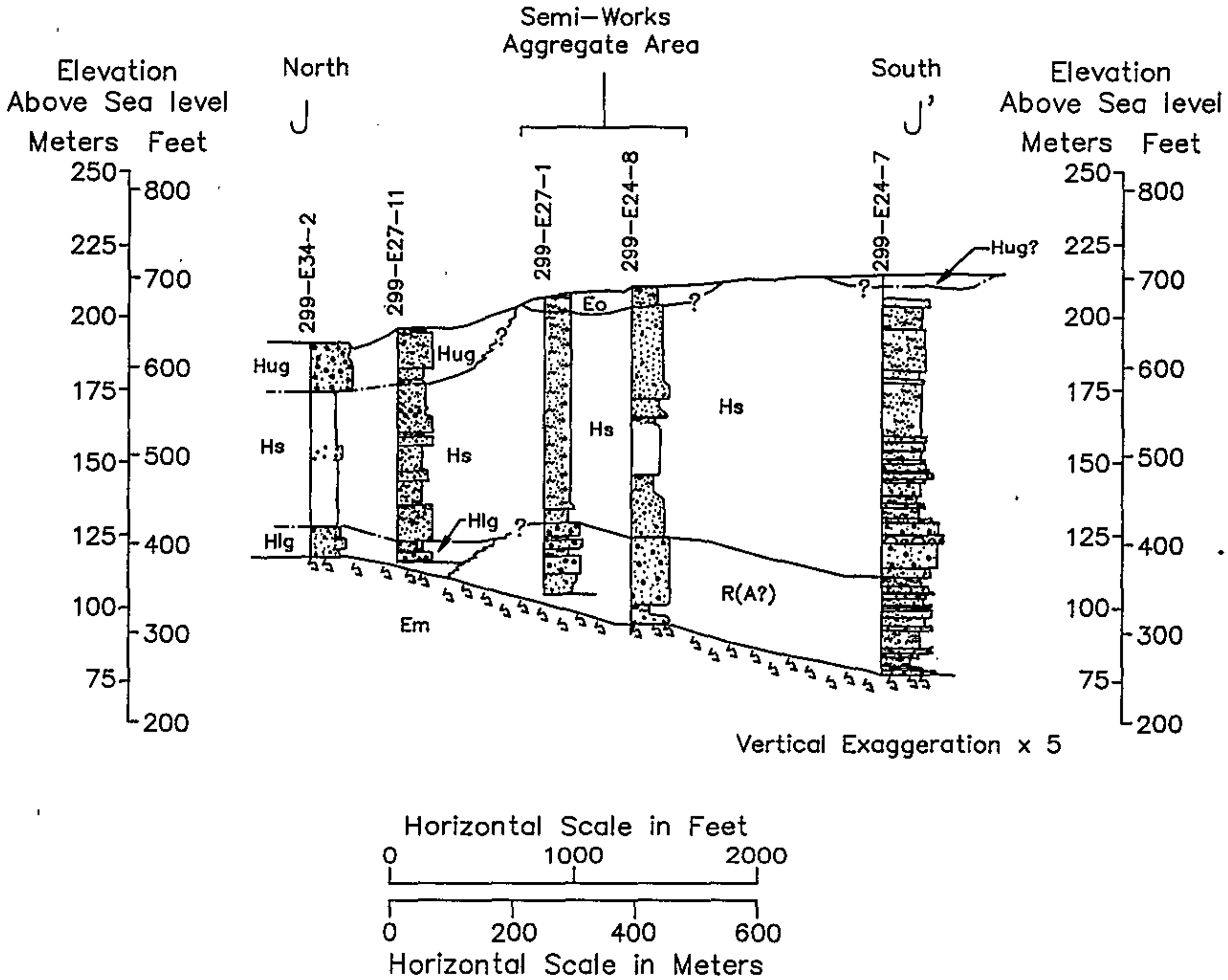
Other Symbols

- Formational contact, ? where inferred
- Unit or sequence contact, ? where inferred
- Major facies contact
- Interval absent

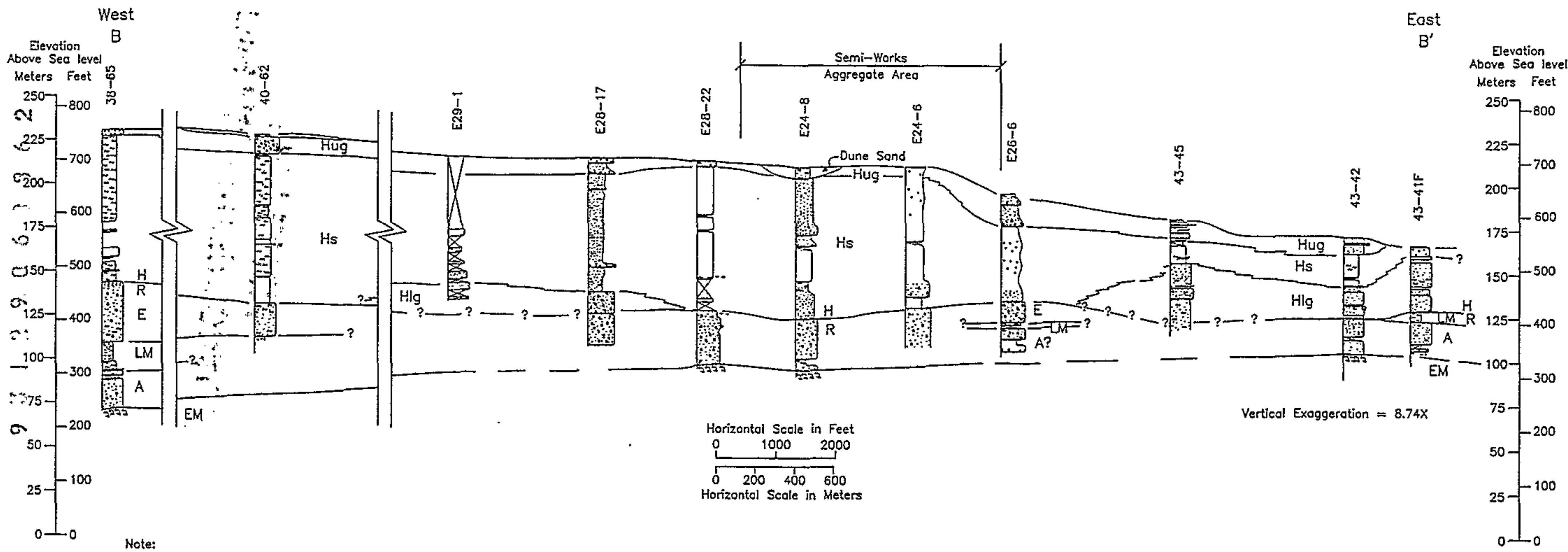
Stratigraphic Abbreviations

Eo — Eolian (Holocene) deposits
Hug — Upper gravel sequence, Hanford formation
Hs — Sandy Sequence, Hanford formation
Hlg — Lower gravel sequence, Hanford formation
H/R — Hanford/Ringold contact
E — Gravel Unit E, Ringold Formation
LM — Lower mud sequence, Ringold Formation
A — Gravel unit A, Ringold Formation
EM — Elephant Mountain Basalt Member, Saddle Mountains Basalt

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



Note:
Based on borehole information from Chamness et al. (1992) and Lindsey et al. (1992).
Refer to Figure 3-15 for cross section location and Figure 3-16 for legend.



Note:
Based on Lindsey et al. (1992)
Refer to Figure 3-15 for cross section location and 3-16 for Legend.

Figure 3-18. Geologic Cross Section B-B.

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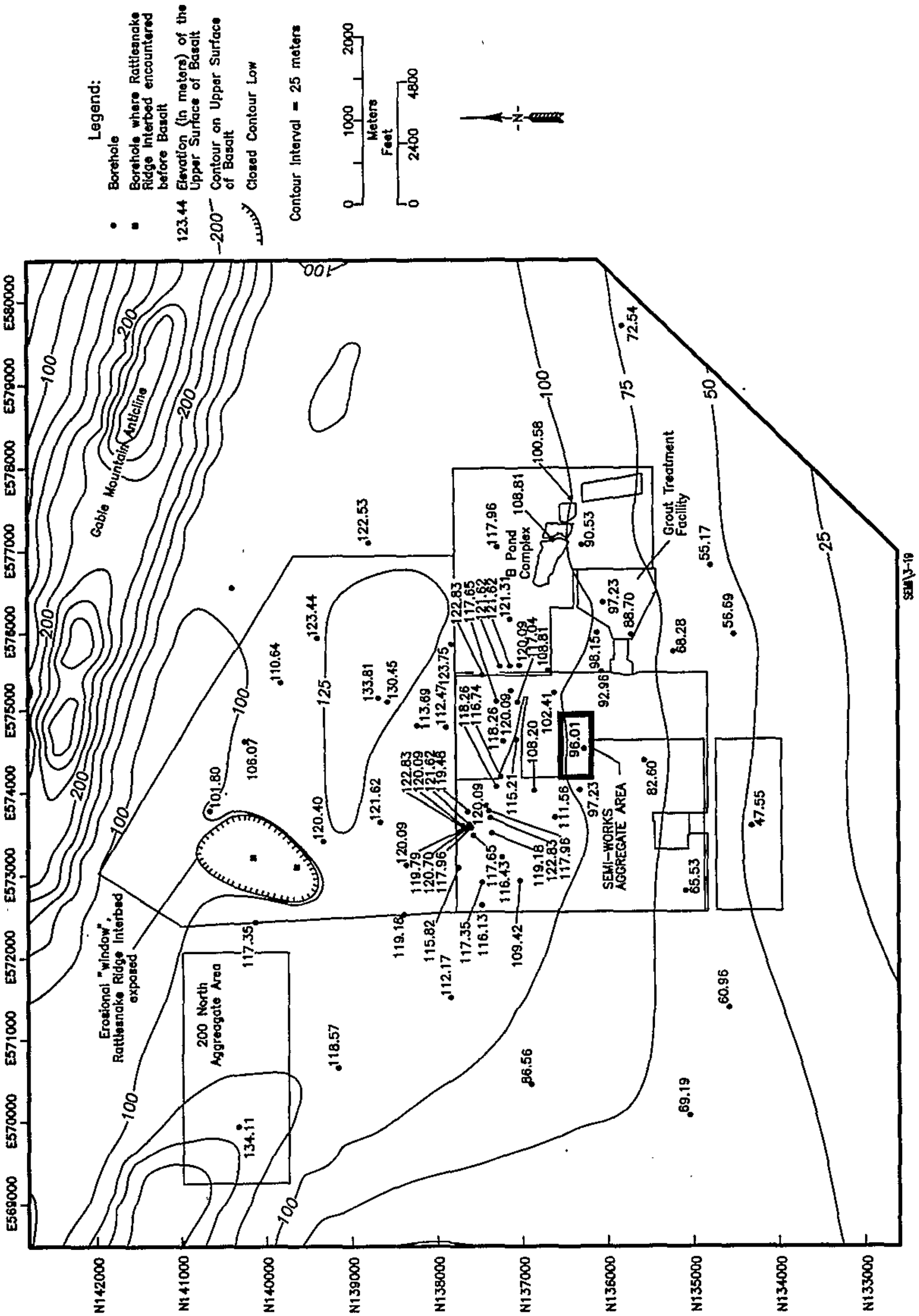
Figure 3-19. Structure Contour map of Surface of the Elephant Mountain Member Beneath 200 East Area.



9 5 1 2 9 0 3 1 3 6 4

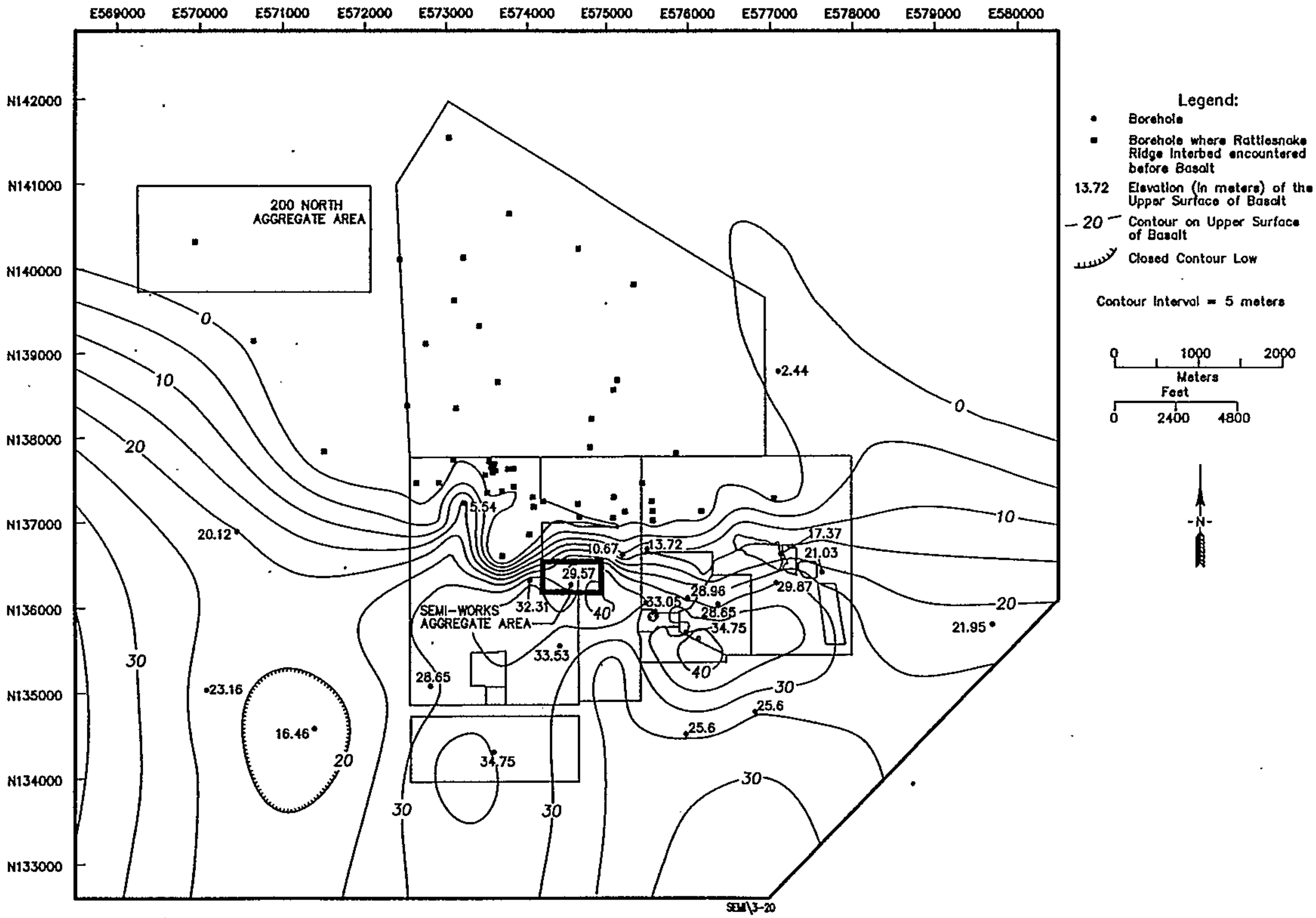
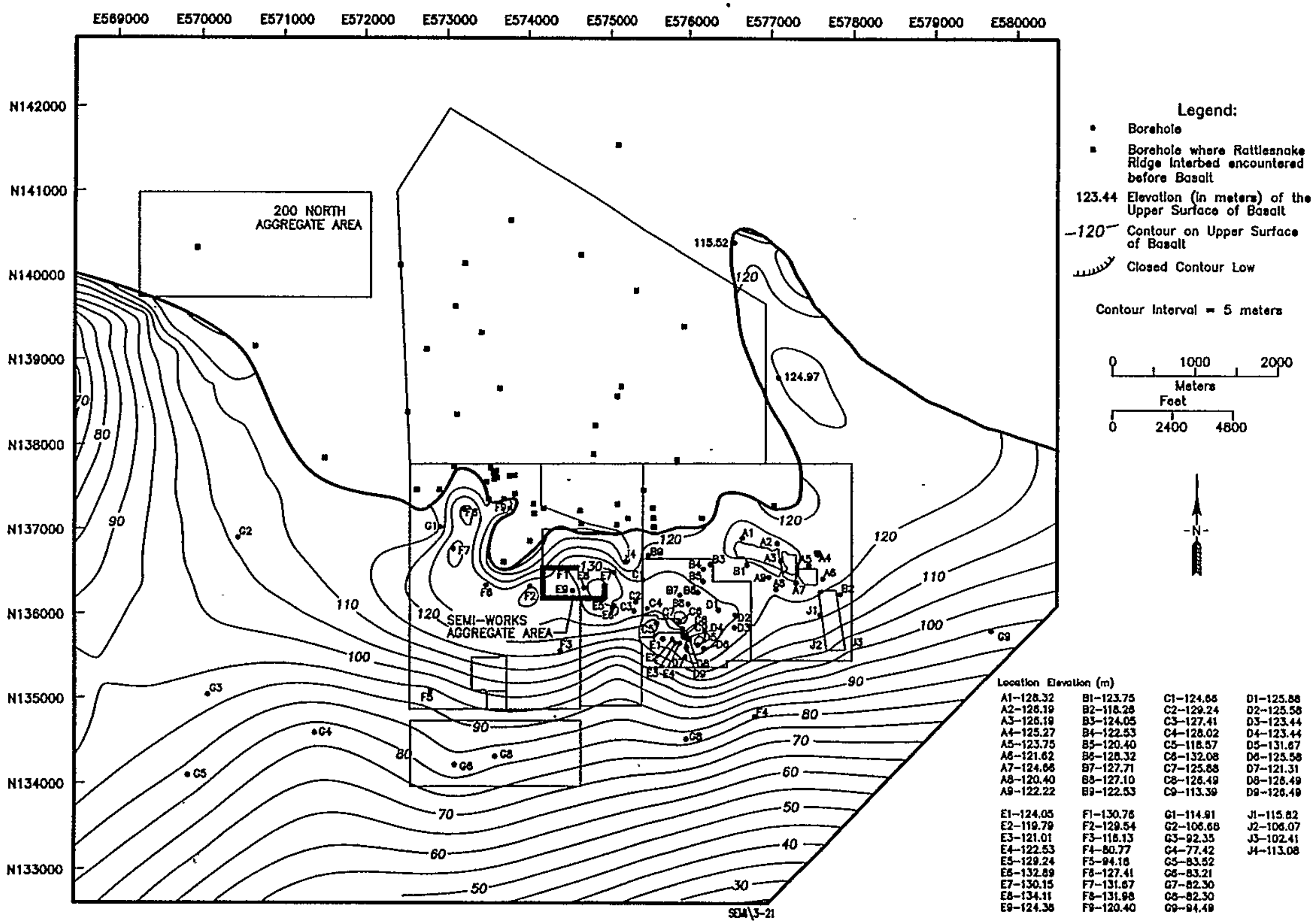


Figure 3-20. Isopach Map of the Ringold Gravel Unit A.



Location Elevation (m)

A1-128.32	B1-123.75	C1-124.66	D1-125.88
A2-126.19	B2-118.28	C2-129.24	D2-125.58
A3-126.19	B3-124.05	C3-127.41	D3-123.44
A4-125.27	B4-122.53	C4-128.02	D4-123.44
A5-123.75	B5-120.40	C5-118.57	D5-131.67
A6-121.62	B6-128.32	C6-132.08	D6-125.58
A7-124.66	B7-127.71	C7-125.88	D7-121.31
A8-120.40	B8-127.10	C8-126.49	D8-126.49
A9-122.22	B9-122.53	C9-113.39	D9-126.49
E1-124.05	F1-130.76	G1-114.91	J1-115.82
E2-119.79	F2-129.54	G2-106.68	J2-106.07
E3-121.01	F3-116.13	G3-92.35	J3-102.41
E4-122.53	F4-80.77	G4-77.42	J4-113.08
E5-129.24	F5-94.18	G5-83.52	
E6-132.89	F6-127.41	G6-83.21	
E7-130.15	F7-131.67	G7-82.30	
E8-134.11	F8-131.98	G8-82.30	
E9-124.36	F9-120.40	G9-94.49	

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

9 3 1 2 9 0 5 1 3 6 6

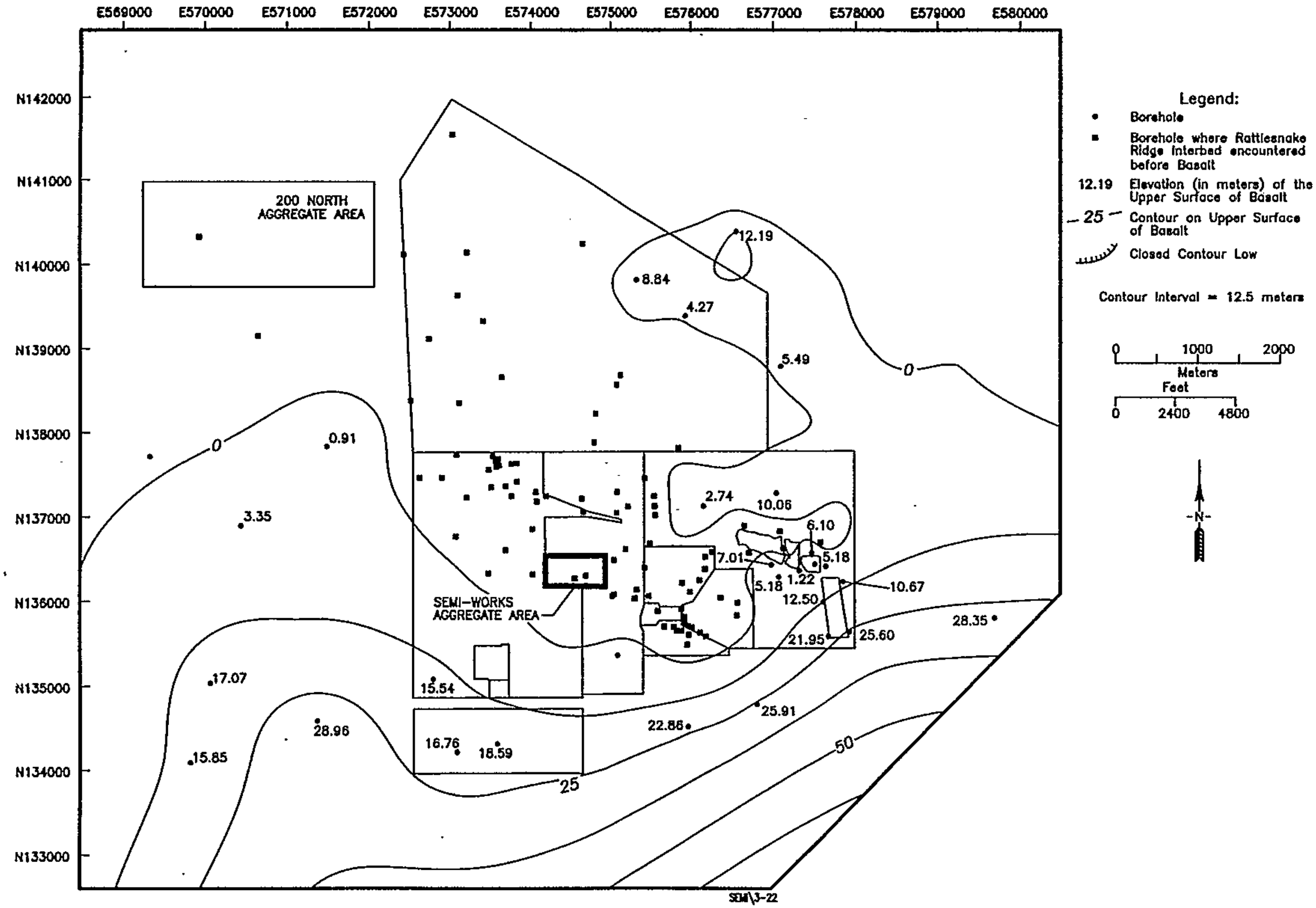
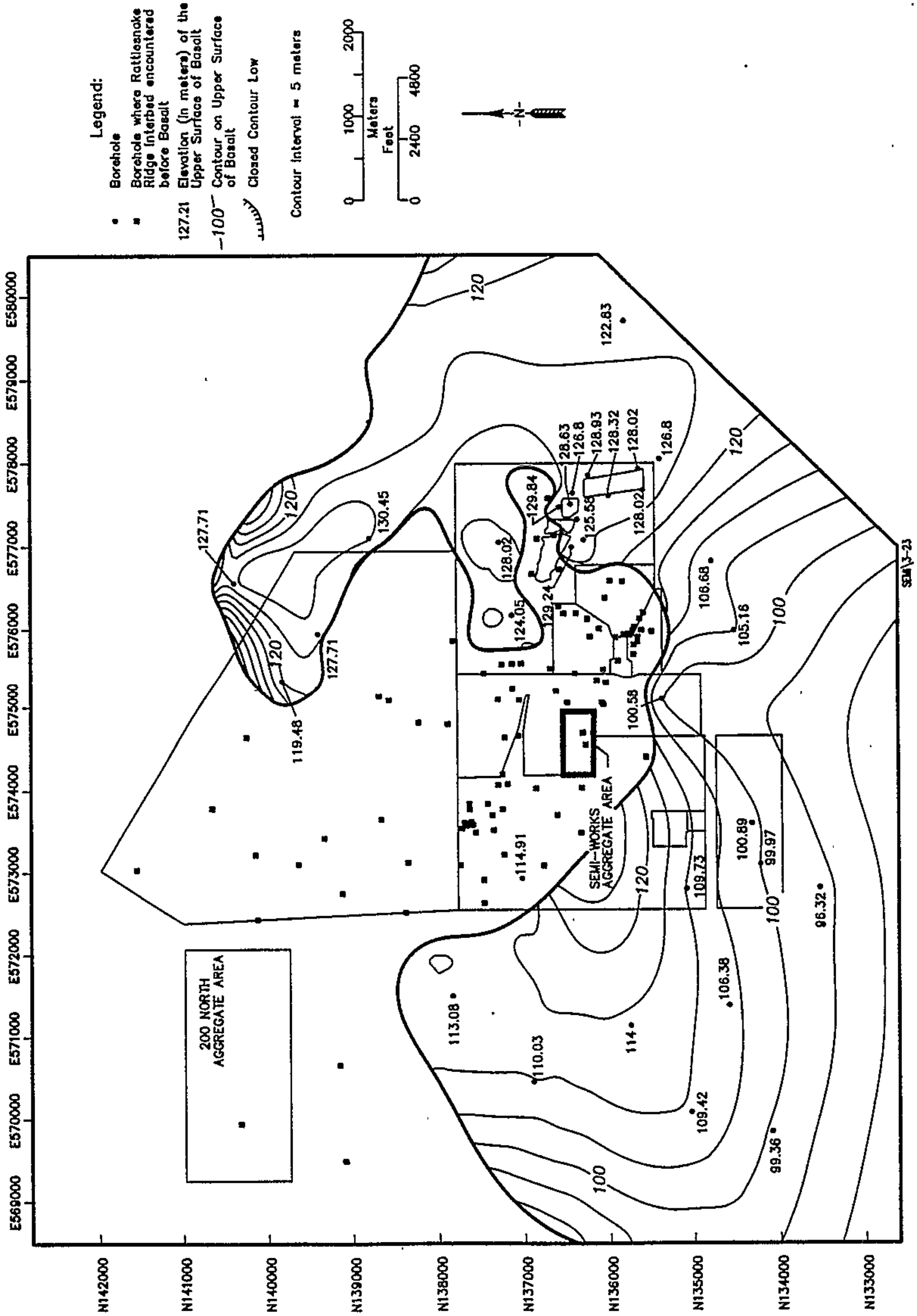


Figure 3-22. Isopach Map of the Lower Mud Sequence, Ringold Formation.

Figure 3-23. Structure Contour Map of the Top of the Lower Mud Sequence, Ringold Formation.



9 3 1 2 9 0 5 1 1 6 8

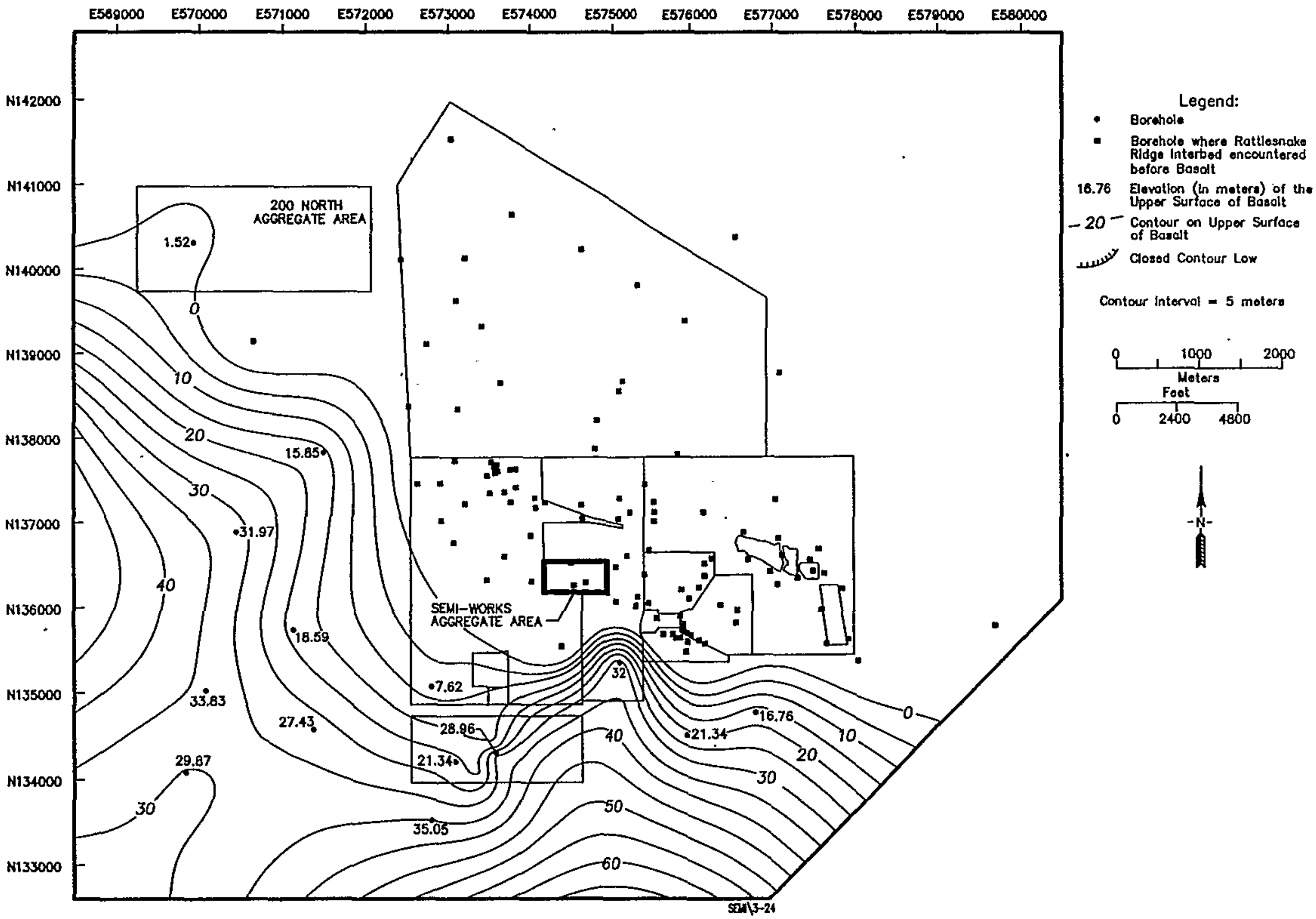


Figure 3-24. Isopach Map of the Ringold Gravel Unit E.

9 3 1 2 9 0 5 1 9 6 9

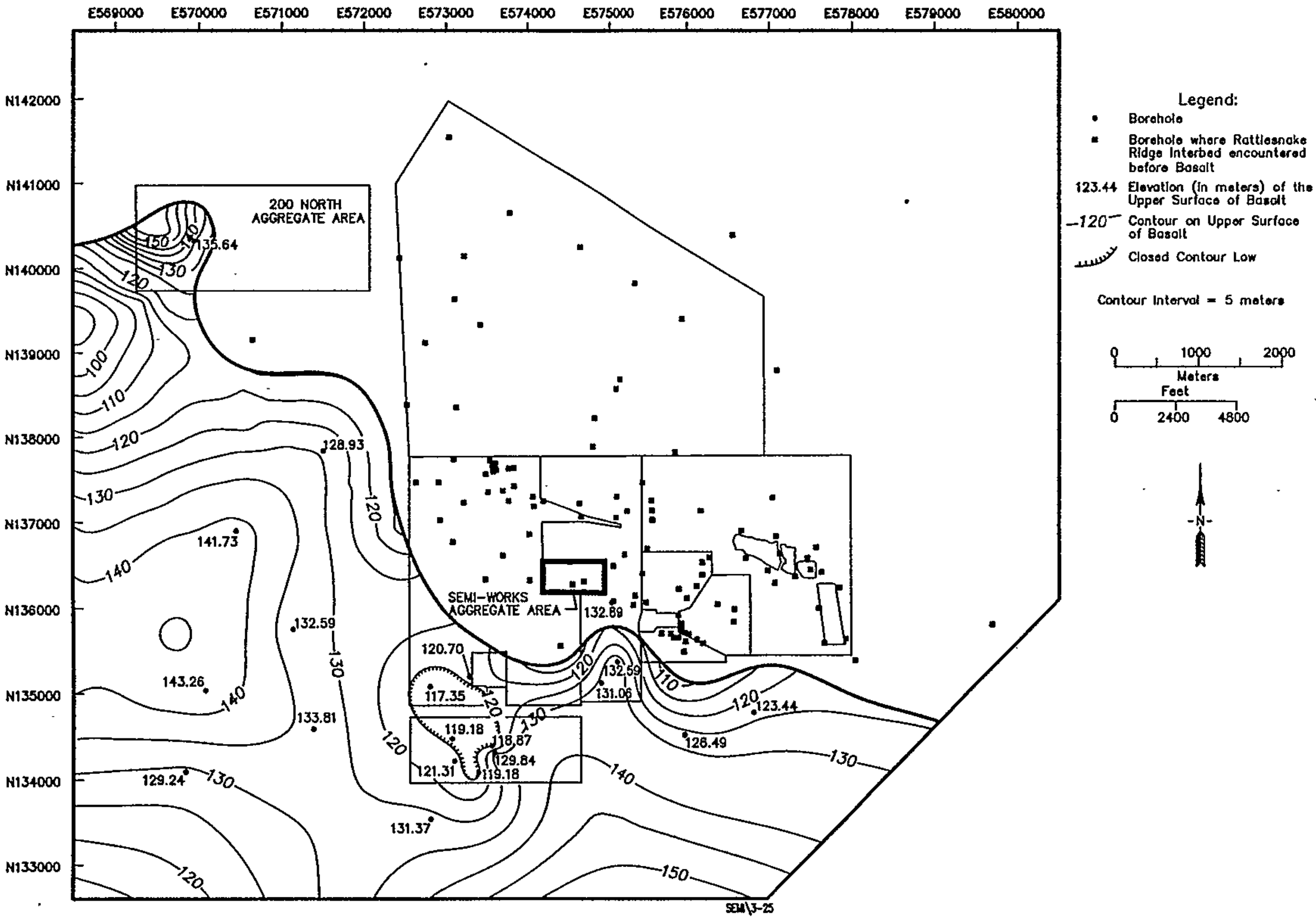


Figure 3-25. Structure Contour Map of the Ringold Gravel Unit E.

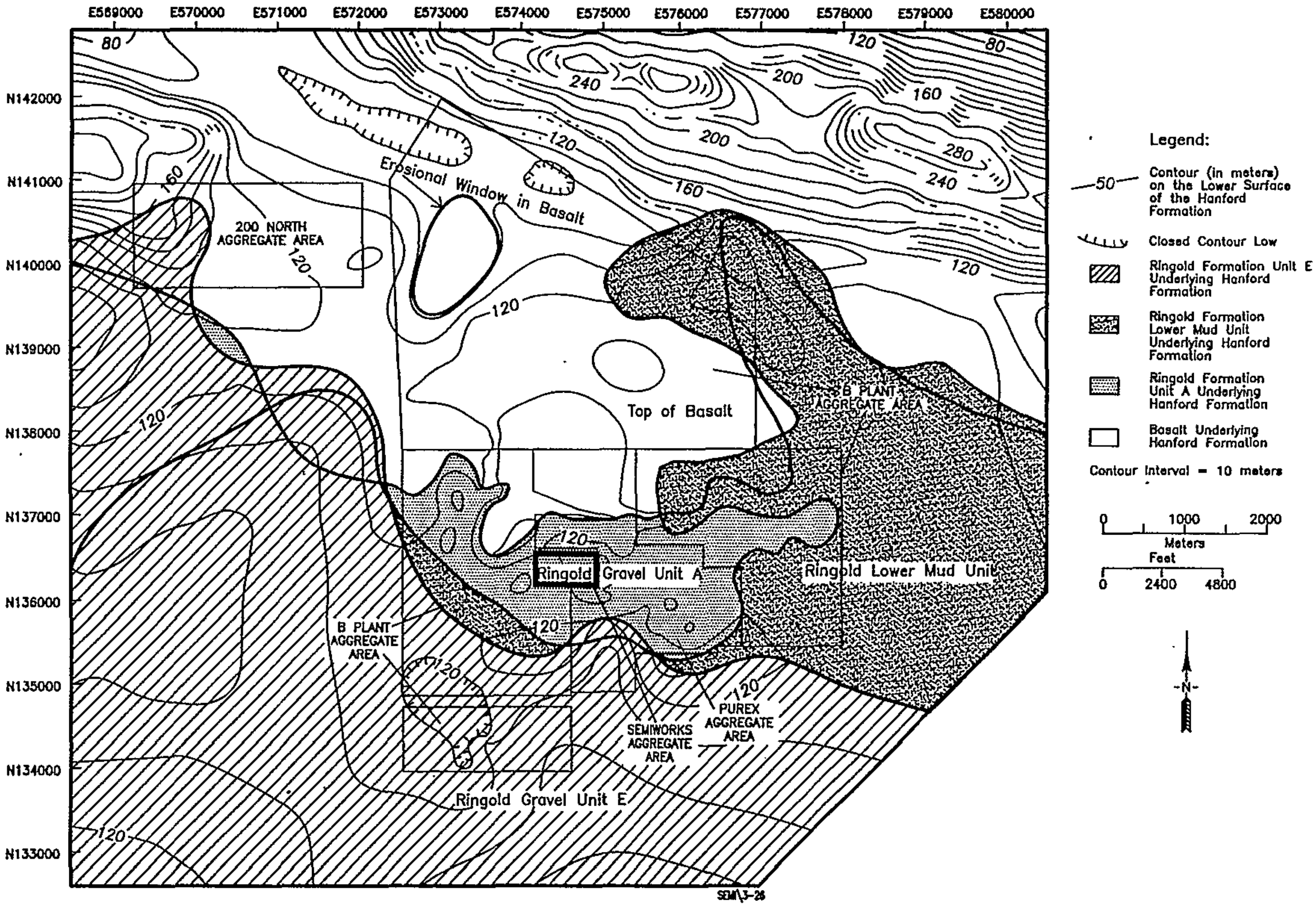


Figure 3-26. Structure Contour Map of the Top of the Ringold Formation.

Figure 3-27. Isopach Map of the Lower Gravel Sequence, Hanford Formation.

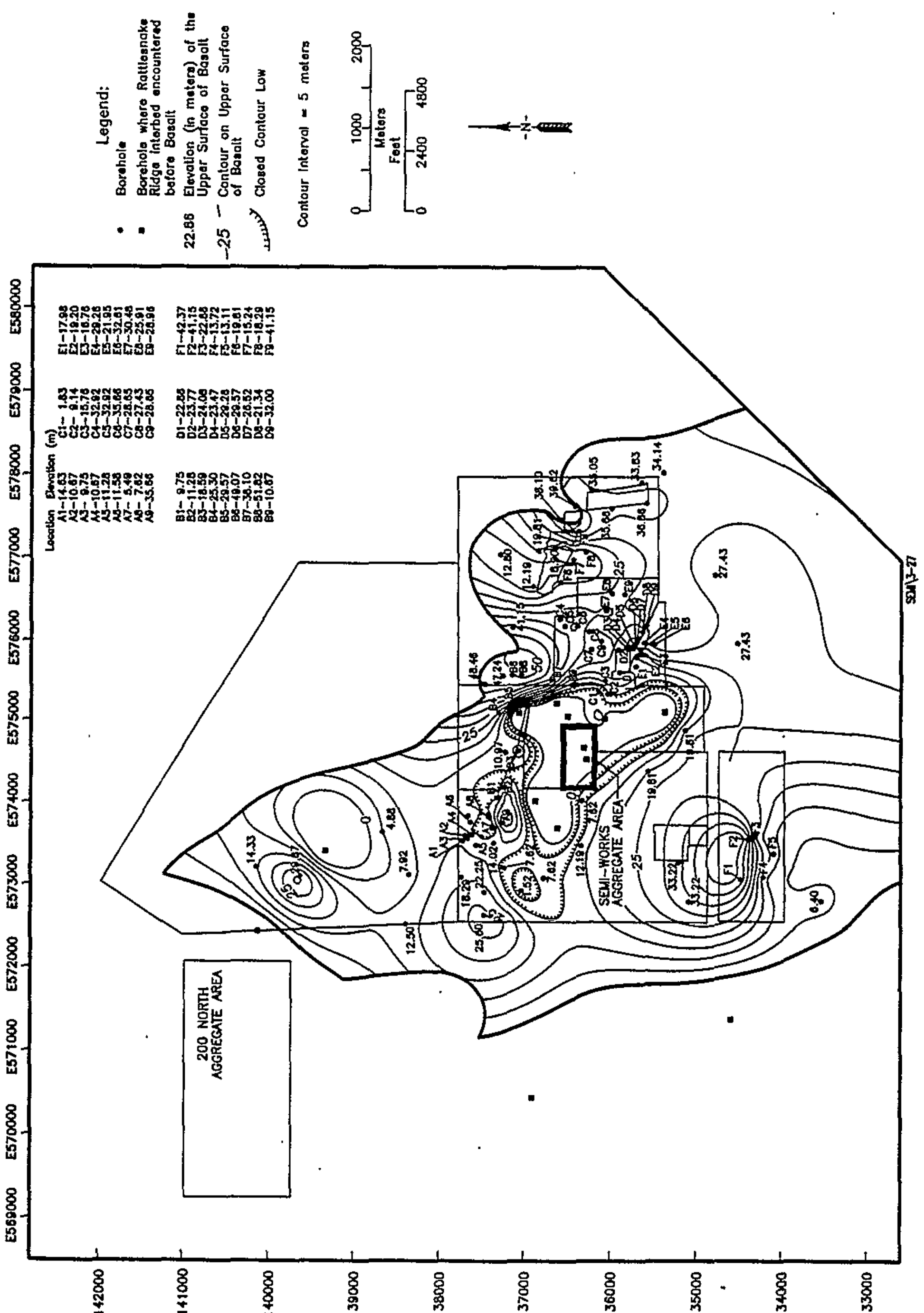


Figure 3-28. Structure Contour Map of the Top of the Lower Gravel Sequence, Hanford Formation.

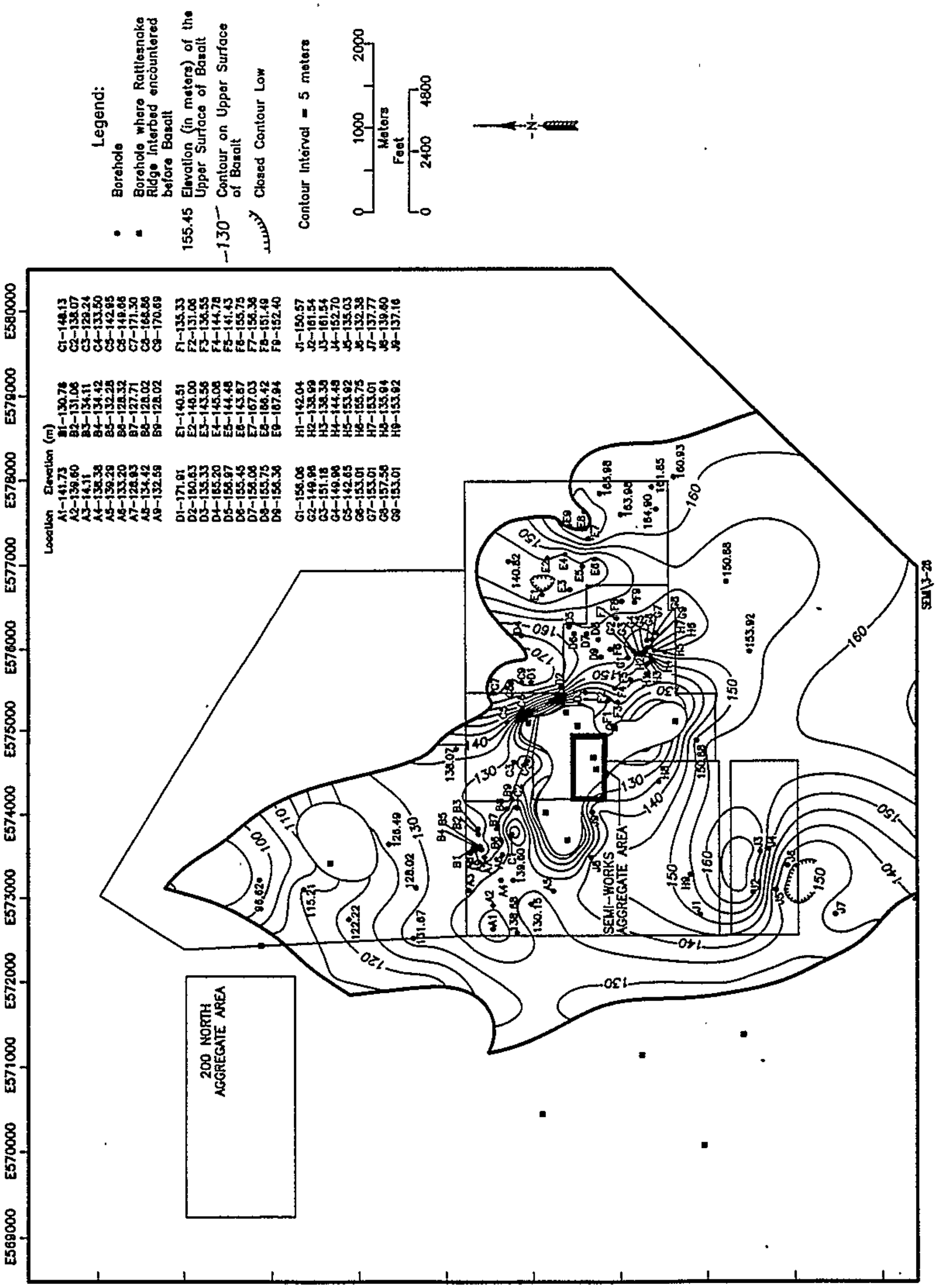


Figure 3-29. Isopach Map of the Sandy Sequence, Hanford Formation.

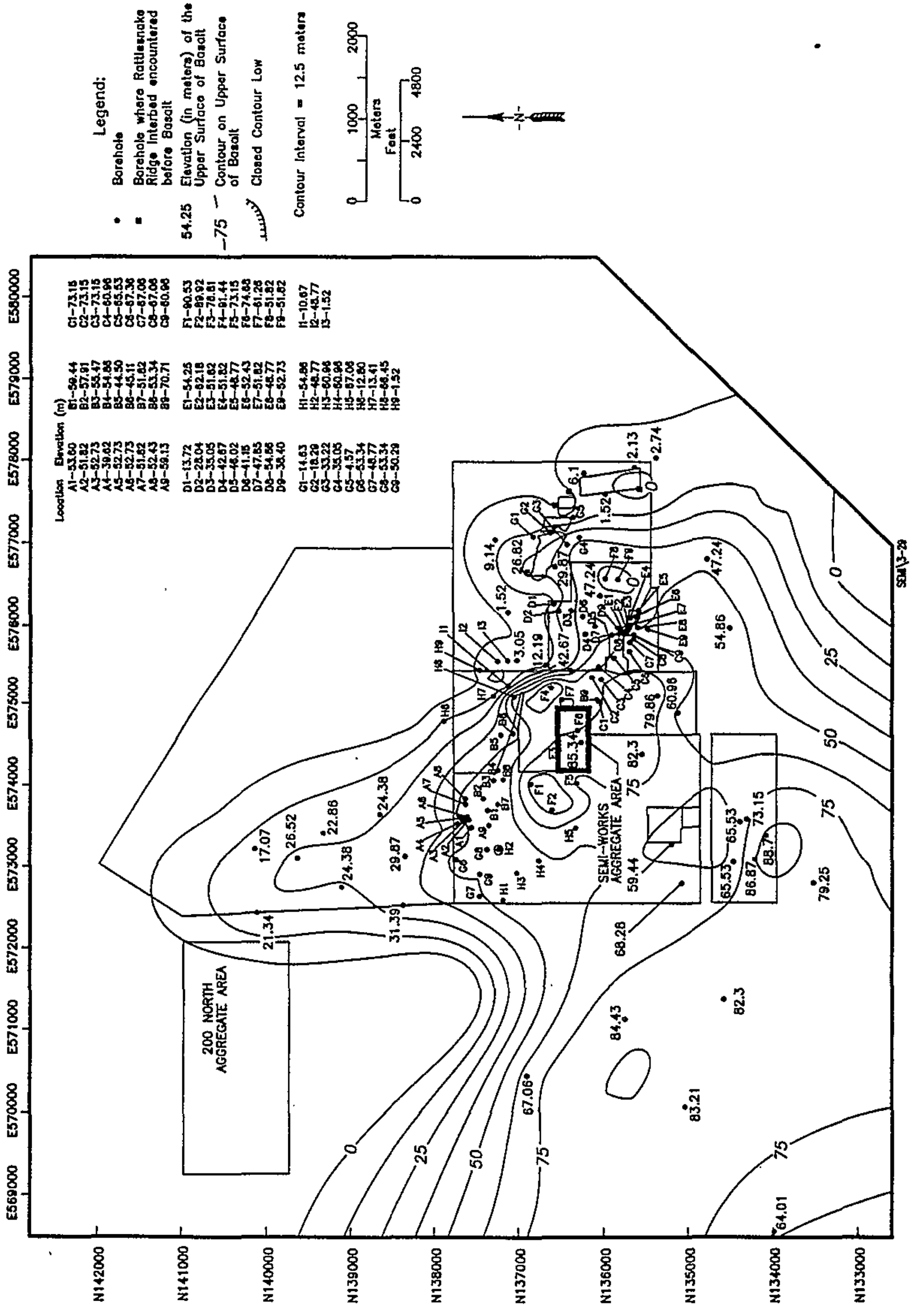


Figure 3-30. Structure Contour Map of the Top of the Sandy Sequence, Hanford Formation.

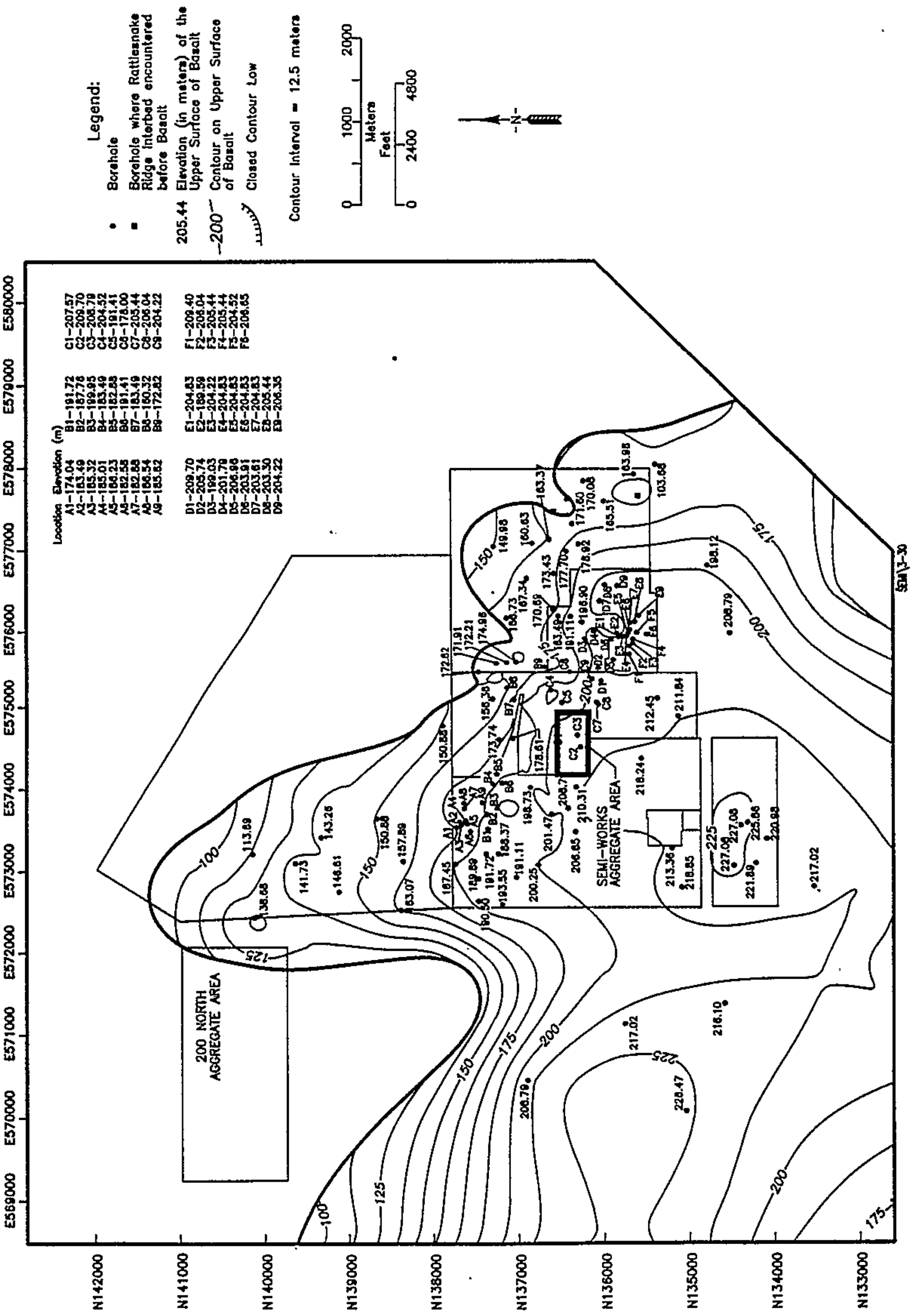
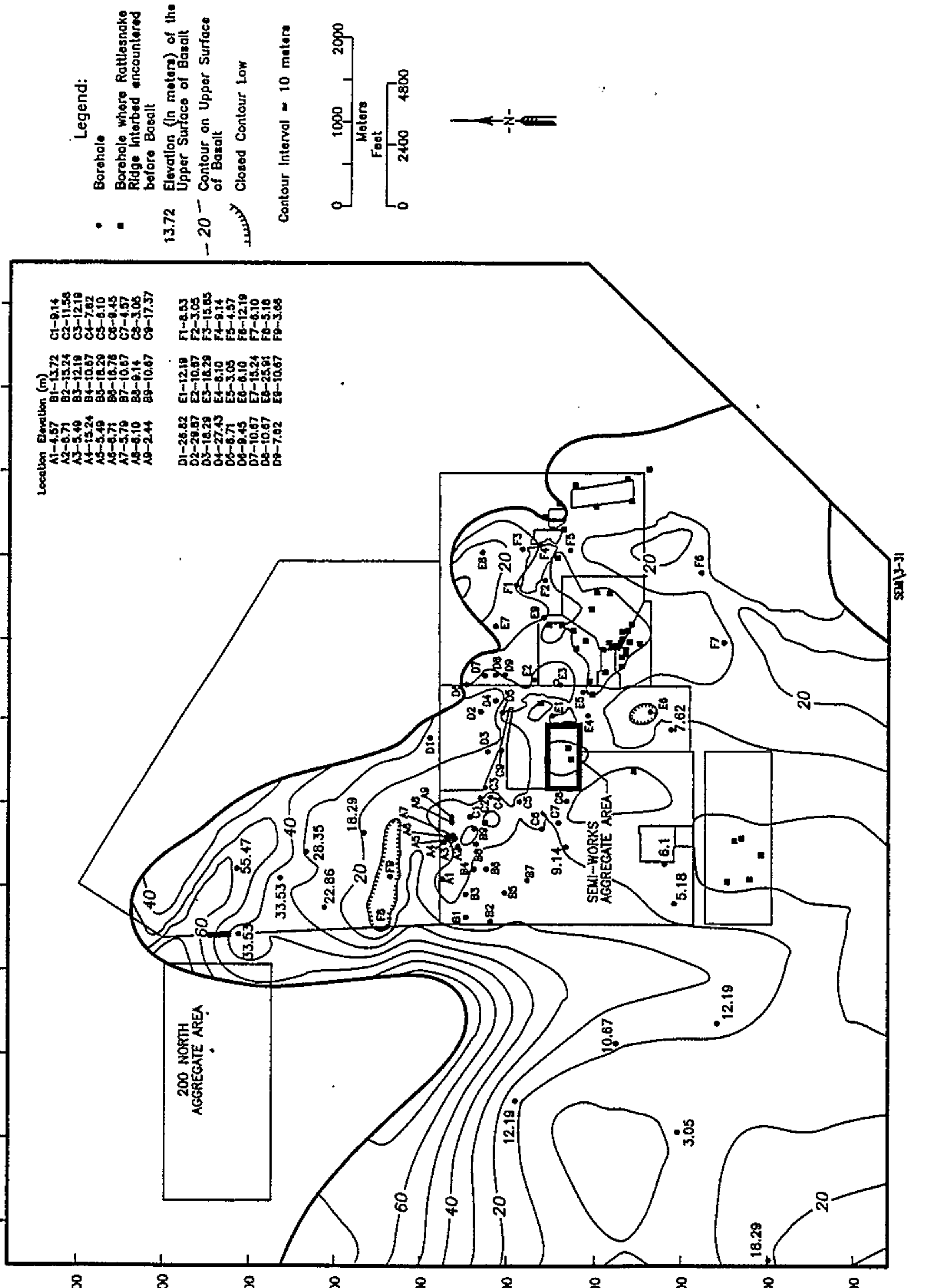


Figure 3-31. Isopach Map of the Upper coarse Gravel Sequence, Hanford Formation.



9 3 1 2 9 0 5 1 3 7 6

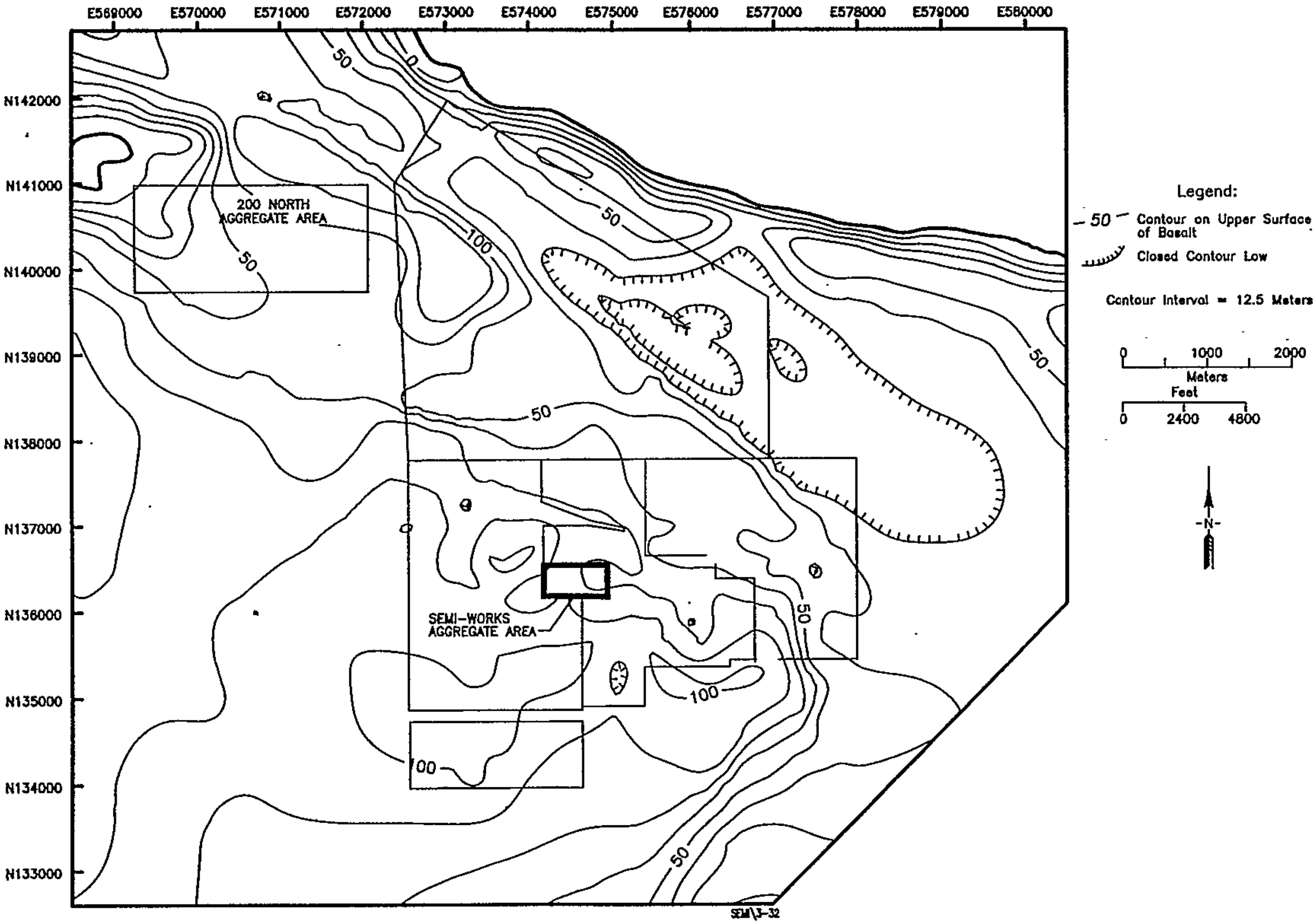


Figure 3-32. Isopach Map of the Entire Hanford Formation.

9 3 1 2 9 0 5 1 3 7 7

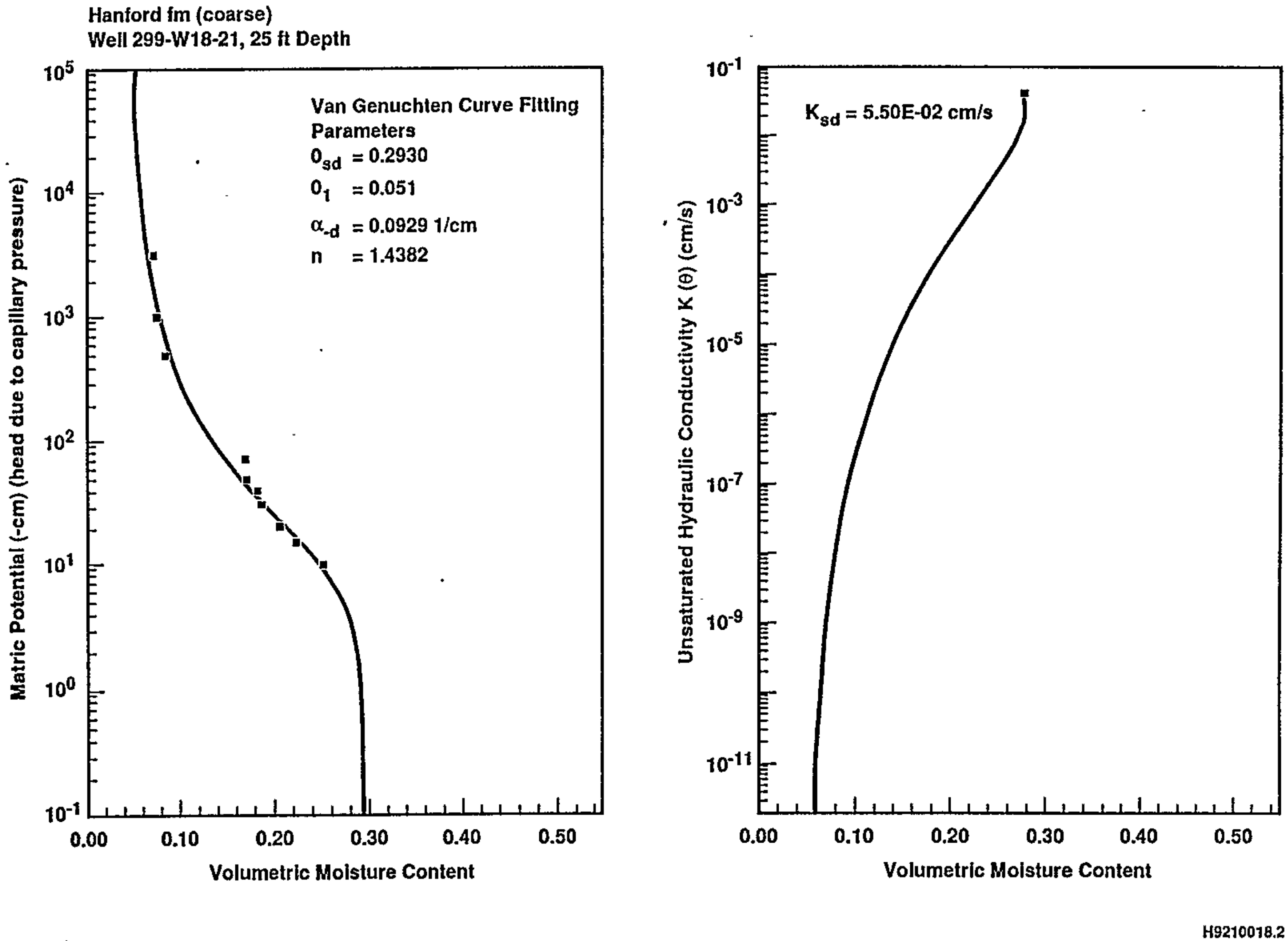
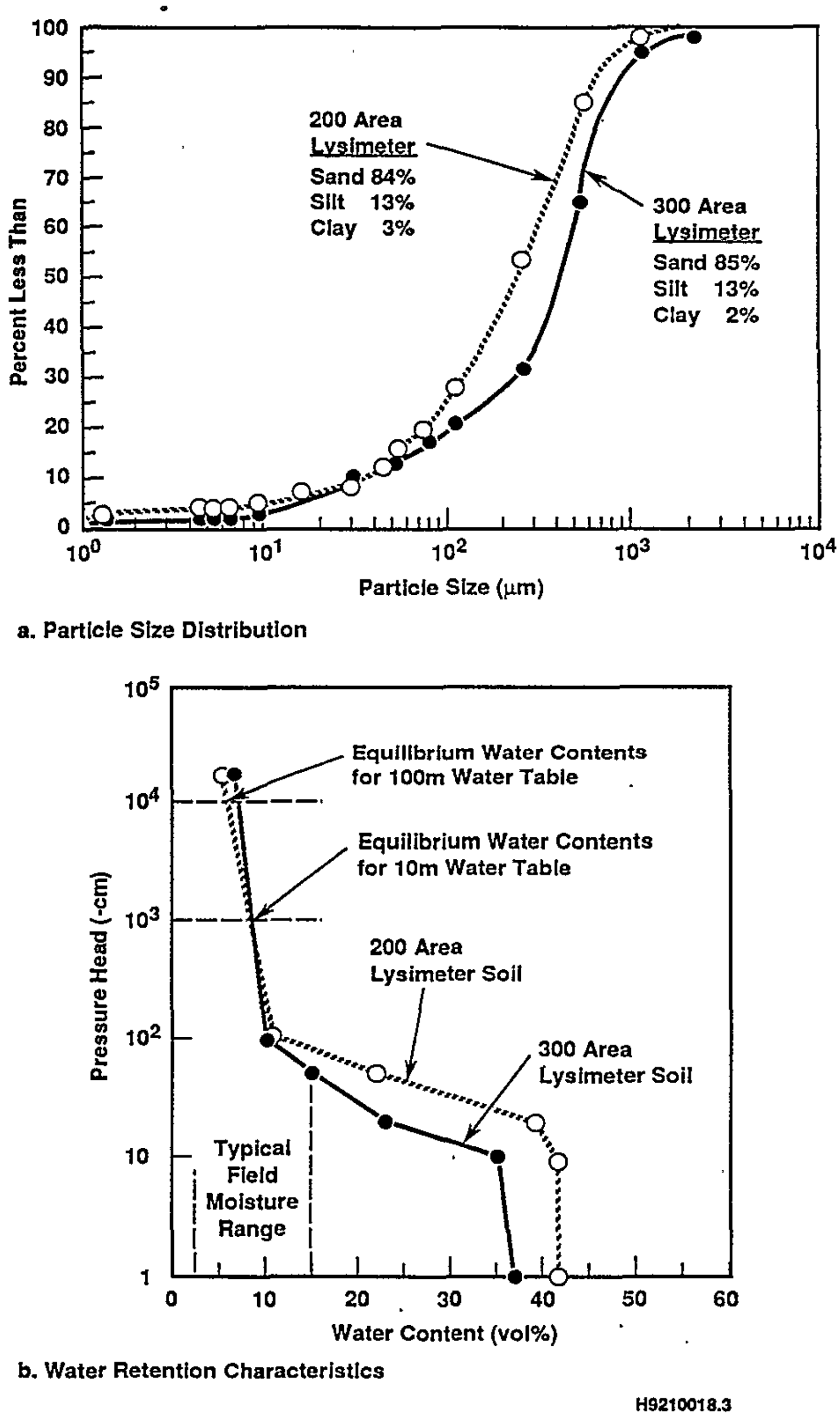


Figure 3-33. Wetting and Drying Curves for Well 299-W18-21.

Figure 3-34. Particle Size Distribution and Water Retention Characteristics of Soils from Hanford Site Lysimeters.



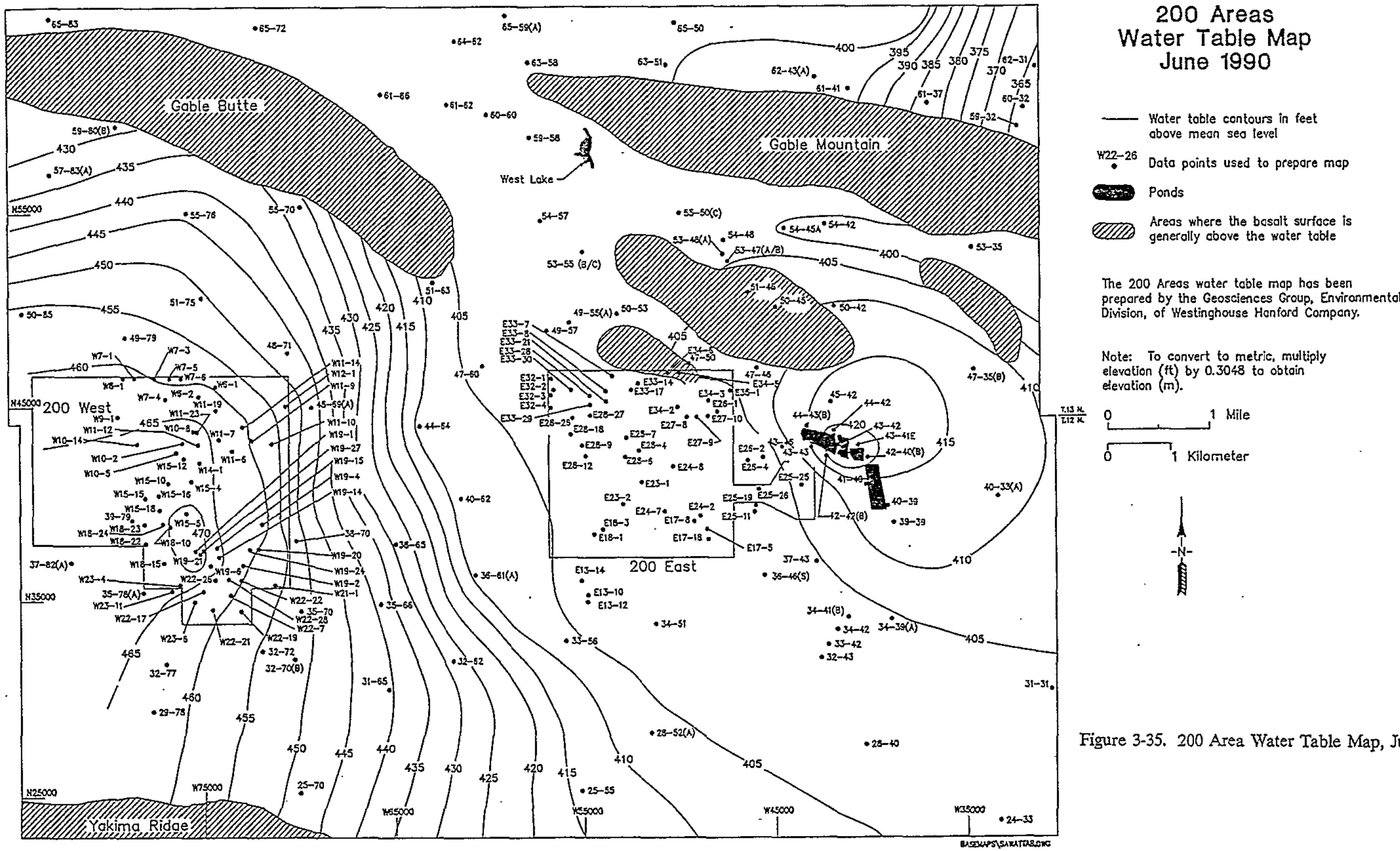


Figure 3-35. 200 Area Water Table Map, June 1990.

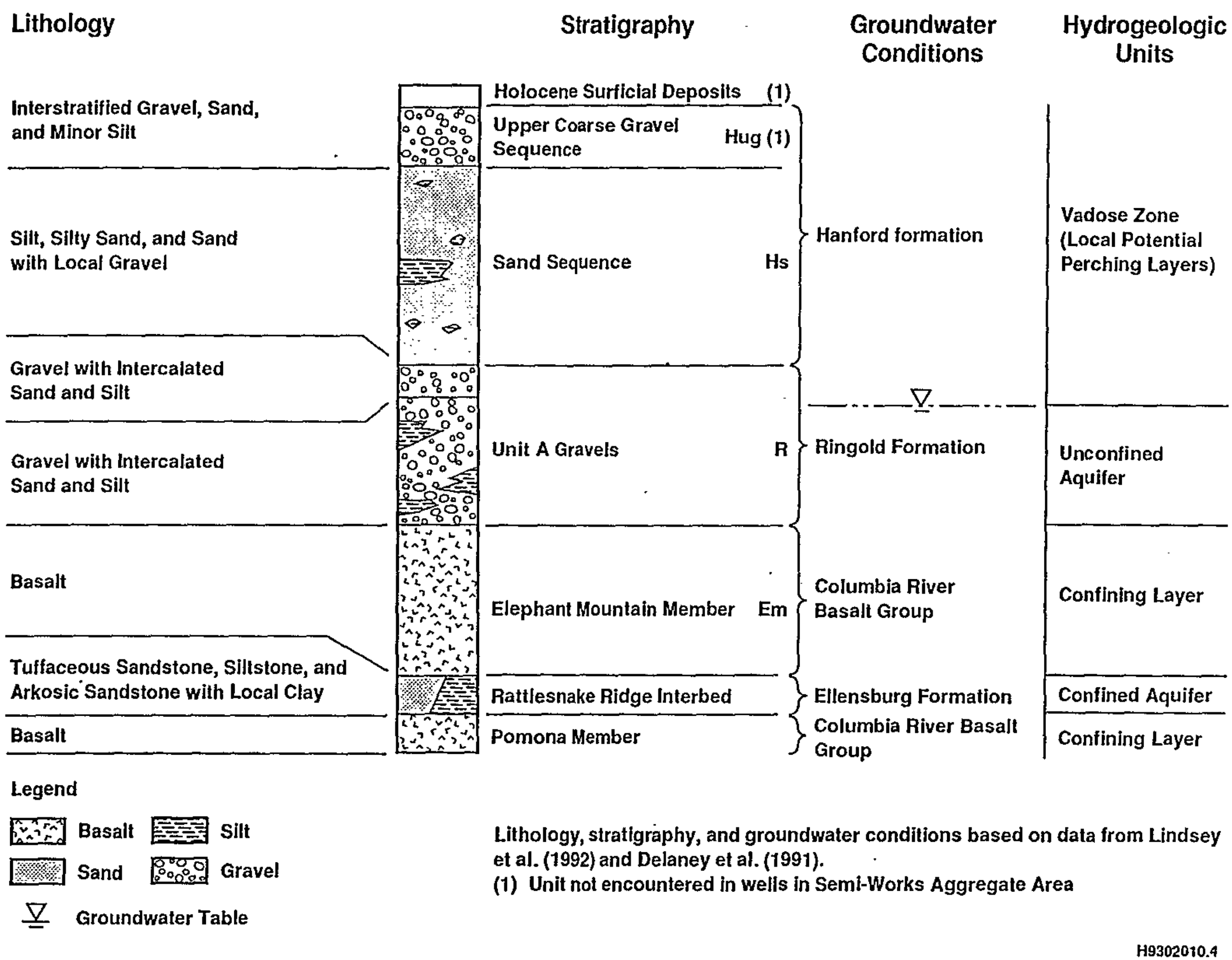


Figure 3-36. Conceptual Hydrogeologic Column for the Semi-Works Aggregate Area. (Lindsey et al. 1992, Delaney et al. 1991)

4.0 PRELIMINARY CONCEPTUAL MODEL

Section 4.1 presents the chemical and radiological data available for each waste management unit. These chemical data, along with physical descriptions of the waste management units (Section 2.0) and descriptions of the surrounding environment (Section 3.0) are evaluated in Sections 4.2 and 5.0 in order to qualitatively assess the potential impacts of the contamination to human health and to the environment. The quality and sufficiency of the existing data are assessed in Section 8.0. This information is also used to identify potential applicable or relevant and appropriate requirements (ARARs) (Section 6.0). Contaminant information is assessed in Section 7.0 to provide a basis for selecting technologies which can be implemented at the 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 Semi-Works 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 4-2 for radionuclide contamination and Table 4-3 for chemical contamination.

4.1 KNOWN AND SUSPECTED CONTAMINATION

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

Some waste management units and unplanned releases have been the subject of chemical and radiological studies in the past. However, most of these studies were limited in scope and did not provide a comprehensive analysis of the character and distribution of the contamination at each 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 4-1 summarizes the types of unit-specific data available for each of the waste management units. It should be emphasized that the table only summarizes what types of data are available; it does not indicate the sufficiency of the data, either in terms of quality or quantity. These concerns are addressed in Section 8.0. The unit-specific information is presented for each waste management unit in Section 4.1.2.

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

In addition to these unit-specific data, there are area-wide data not directly applicable to any waste management unit within the Semi-Works 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 Semi-Works 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 East 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 that are 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 Semi-Works Aggregate Area on a media-specific basis (air, surface soil, surface water, biota, and vadose zone soil). The text summarizes sources of chemical and radiological sampling information. Section 4.1.1 presents data on a media-specific basis. Section 4.1.1.1 presents results of air quality sampling data. Surface soil data are described in Section 4.1.1.2. Results of surface water sampling are presented in Section 4.1.1.3. Results of vegetation and other biota sample analyses are presented in Section 4.1.1.4. Available vadose zone sampling data are presented in Section 4.1.1.5. Section 4.1.1.5 also discusses evidence for contamination migration within the vadose zone to the unconfined aquifer underlying the site. Additional assessment of the nature and extent of groundwater contamination is presented in the 200 East Groundwater Aggregate Area Management Study Report (AAMSR).

To supplement available radiological and chemical analytical data, historical waste inventory information for the Semi-Works 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 Semi-Works Aggregate Area waste management unit. Table 4-2 summarizes available information regarding known or suspected radionuclide contamination at the Semi-Works Aggregate Area. Table 4-3 summarizes available information regarding known and suspected chemical contamination. In Tables 4-2 and 4-3, 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. Four high volume air samplers (N001, N002, N003, and N004) are stationed within or adjacent to the Semi-Works Aggregate Area (Figure 4-1 and Plate 2). The air samples are collected by drawing samples through a 47-mm, open-face $3\mu m$ filter at about 1 m (3 ft) above the ground with a flowrate of 0.2 m^3/min (2 ft^3/min). 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. The initial analysis serves as an indicator of potential environmental problems. 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. None of the airborne monitoring samples collected in the Semi-Works Aggregate Area revealed any unusual or exceptional airborne contamination for the period reviewed (Elder et al. 1986, 1987, 1988, 1989; Schmidt et al. 1990, 1992).

The filters are analyzed quarterly for ^{90}Sr, ^{137}Cs, ^{239}Pu, and U total. Data typically take one to two years to process and validate. Data are typically reported in yearly surveillance reports such as Schmidt et al. (1990). The results have shown a general decline in the concentration of these radionuclides from 1985 to 1989, throughout the 200 East Area

(Schmidt et al. 1990). Air samples were measured only during 1988 and 1989; in 1989 only sampling location was reported. The last 5 years of data for the Semi-Works Aggregate Area have been averaged and the values are summarized in Table 4-4.

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 sections 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 East 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 4-2 presents the gross count data (counts per second) on an isoradiation contour map that covers the entire 200 East 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 Semi-Works Aggregate Area were between 70,000 and 220,000 ct/s measured from unplanned releases and contaminated equipment on the nearby TC-4 railroad spur in the PUREX Aggregate Area (site number 4 on Figure 4-2). However, a bulge in the 7,000 to 22,000 ct/s isoradiation contour centered above the Semi-Works production area appears to indicate that releases from waste management units are contributing to overall gamma readings in this area.

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. A photopeak is the specific energy or wavelength that can be associated with the emissions from a specific radionuclide. Also, aerial systems integrate radiation levels over an area whose diameter may be ten times the height of the platform above the ground. Because of the large-area integration of the airborne system, localized anomalies will appear to be spread over a larger area with lower activities than actually exist on the ground (Reiman and Dahlstrom 1988). 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 4-3 shows areas of known surface contamination, underground contamination and migration identified from surface surveys (Huckfeldt 1991b).

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 Area Remedial Action (RARA) 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 a series of grid points that covers the 200 East Area with 36 sampling points. The sample point locations have never been exactly surveyed, but are located close to the intersections of Hanford Site coordinate lines at 610 m (1,000 ft) spacings. Two of the grid points are located within or adjacent to the Semi-Works Aggregate Area (see Figure 4-1). Location 2E22, which is sited just south of the Semi-Works Aggregate Area boundary, was included because it is likely to be impacted by surface contamination released from Semi-Works unplanned releases. Two additional grid locations just beyond the northeast and southeast corners of the Semi-Works Aggregate Area were not included in this discussion, because these samples are in close proximity to the 241-C Tank Farm and PUREX facility, respectively, and are not likely to be representative of conditions within the Semi-Works Aggregate Area. The results of measurements made from 1985 to 1988 are presented in Table 4-6. Sample locations were changed in 1989; none of the new locations are within the Semi-Works Aggregate Area. 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 penetrating radiation sources including cosmic radiation, naturally occurring radioactivity, fallout from nuclear weapons testing, and contributions from other Hanford Site activities. The TLD measurements have ranged from 64 to 114 mrem/yr. The average reading for the two sites in 1988 was 102 mrem/yr.

4.1.1.2.3 Surface Soil Sampling. Between 1978 and 1989, surface soil samples were collected annually from the same two grid locations discussed for the external dose rate measurements. In addition, between 1984 and 1989, soils were sampled along fences enclosing the 200 East Area. None of the fenceline soil sampling locations are within or close to the Semi-Works Aggregate Area.

The results of the grid soil sampling program from 1985 through 1989 are summarized in Table 4-7. A complete list of the data collected during this period is presented in Table A-2 in Appendix A. Counting errors are included with each analytical result and those values that are higher than the accompanying counting errors are denoted with shading.

The most commonly detected radionuclides were ^{90}Sr, ^{137}Cs, U total, ^{238}Pu, ^{239}Pu, and ^{152}Eu. These species were found consistently at concentrations above counting errors.

Grid point 2E22 was not sampled in 1987 or 1989. Neither grid point was sampled in 1989. In 1990, one surface soil sample was collected at a location north of the Semi-Works Complex, north of 7th Street. Analytical results for this sample are shown in Table 4-8.

4.1.1.3 Surface Water. Surface water currently is present in the Semi-Works Aggregate Area only in the 200 East Powerhouse Ditch. The 216-C-9 Pond no longer contains water and has been backfilled and converted to a solid waste burial ground. No surface water sampling data was available in the documents reviewed for these waste units.

The source of water entering the 200 East Powerhouse Ditch is the 284-E Power Plant located south of the Semi-Works Aggregate Area. Water entering the Powerhouse Ditch was characterized in the *284-E Power Plant Wastewater Stream-Specific Report* (WHC 1990b). The most concentrated single contributor to the wastewater is a waste brine solution containing about 9 percent by weight of sodium chloride. It also contains several minor constituents that elevate the dissolved solids content to 10 percent by weight. Other sources of discharge to this ditch include boiler blowdown water containing dissolved boiler scale, a scaling agent (ethylenediaminetetraacetic acid [EDTA]) and sodium sulfite, which is used as an oxygen scavenger. A summary of chemical and radiological measurements of the wastewater is presented in Table 4-9.

4.1.1.4 Biota. Westinghouse Hanford and PNL have conducted various biota sampling activities beginning in 1971 through 1990 inside and outside the Hanford Site. The most recent biota sampling is reported in the document "Hanford Site Environmental Report for Calendar Year 1990" (PNL 1991). None of the samples referenced in this document were collected within the Semi-Works Aggregate Area. Analytical results for biota samples were similar to levels reported in earlier years and were far below applicable standards for radiation dose (PNL 1991). No upward trends in radionuclide concentrations were detected for any of the wildlife species examined. However, a significant downward trend was noted for many sample analytes, particularly ^{137}Cs. Levels of ^{137}Cs observed (e.g., in deer muscle tissue) were in the range of concentrations generally attributed to worldwide fallout (PNL 1991). 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 1985 from two sites within the Semi-Works Aggregate Area, namely 2E16 and 2E22. Vegetation samples were collected from the same locations as the grid soil samples described in Section 4.1.1.2 (see Figure 4-1 and Plate 2). Average analytical results from 1985 through 1989 are summarized in Table 4-10. Grid point 2E22 was not sampled in 1987, and neither grid location was sampled in 1989. In 1990, new sampling locations were established. A vegetation sample was obtained at location 63 but results from this sample were not yet available. The complete data set from these sampling events is presented in Table A-3 in Appendix A.

Vegetation samples have generally exhibited detectable levels of radionuclides. The most commonly detected radionuclides at grid point 2E16 are ^{137}Cs and ^{134}Cs. Other species detected at this location are ^{60}Co, ^{152}Eu, ^{103}Ru, and ^{106}Ru. In addition to the above radionuclides, ^{154}Eu and ^{95}Zr were also detected at grid point 2E22. There have been no statistically significant differences for the ^{137}Cs in vegetation from 1985 onwards. The Semi-Works Aggregate Area is an area where tumble weeds blow in from other Hanford Site areas and some of the detected contaminants may originate from other areas of surface radioactivity. Although the prevailing winds tend to blow from the northeast, that is, from the direction of B Plant, the facility does not track migration of tumbleweeds; thus, the source of contaminated vegetation generally is uncertain.

In addition to the routine vegetation sampling, additional biotic samples were collected for radiological evaluation during some years. A sample of mouse feces collected from an open field within the Semi-Works Aggregate Area in 1987 had a reading of 100,000 ct/min and 10 mrem/hr. The radionuclides analyzed for and the analytical results in pCi/gm dry weight were as follows:

^{60}Co	Not detected
^{90}Sr	Not reported
^{137}Cs	760,000
^{154}Eu	3,120
^{155}Eu	3,880
^{239}Pu	Not reported

The source of the contaminated material identified in the mouse feces is indeterminant because of the mobility of the animal. The contaminated mouse feces may be due to an animal contacting sources within or near the main Semi-Works Complex; however, the source was not specifically identified in the annual environmental report.

4.1.1.5 Vadose Zone. The extent of contamination in the vadose zone has been most studied by limited geophysical borehole logging, which has been conducted in the Semi-Works Aggregate Area since the late 1950's. Gross gamma-ray logs have been used since that time to evaluate radionuclide migration in the vadose zone beneath selected waste management units. However, very little gross gamma data have been published. Table 4-11 lists the logs that were located and reviewed during this study. The gamma log interpretation consisted of identifying zones with anomalously high gamma-ray counts that could be indicative of radionuclide contamination. The depth, thickness, and intensity of these zones were then compared with previous logs from these same holes if existing. 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 not been consistent. Attempts made to normalize data collected at different times have met with limited success, and quantitative interpretations were not possible. To attempt normalizing the data would necessitate determining the specific instruments shielding, logging rates, logging procedures, and calibration history of the equipment used. No equipment-specific information is available in the documents reviewed to achieve this.

Three monitoring wells, 299-E24-8, 299-E27-1, 299-E27-5 and a vadose zone boring, 299-E27-133, are located within the Semi-Works Aggregate Area (Figure 4-1).

Well 299-E24-8, located 20 m (65.6 ft) south of the 216-C-5 Crib, showed an elevated gamma response in the most recent logging in 1968 and 1976 at depths of 0 to 3 m (0 to 9.8 ft) below ground surface. This result has been attributed to a waste transfer line between the B Plant and the 244-AR Vault (Fecht et al. 1977).

Well 299-E27-1, located 50 m (164 ft) north of the 216-C-9 Pond and the 218-C-9 Burial Ground, and well 299-E27-5, located 3 m (9.8 ft) north of the 216-C-10 Crib, showed no elevated response. Soil boring 299-E27-133, located 5 m (16.4 ft) east of the 216-C-1 Crib, is a shallow vadose zone well that showed an elevated gamma response near the surface which decreased to near background approximately 12 m (39.3 ft) below land surface.

The gamma log interpretations are discussed in detail and presented on Figure A-1 in Appendix A. The results of the log interpretations are also summarized with the appropriate waste management units in Section 4.1.2.

No data resulting from sampling and analyses of vadose zone soils for chemical or radiological contaminants were located for the Semi-Works Aggregate Area. However, one sample of sediment taken from within the casing of the 216-C-2 Reverse Well was analyzed for radionuclide content. The methodology used to obtain this sample was not reported. The results of analysis of this sample by two analytical laboratories are presented in Table 4-12. Radionuclides detected in the sample were ^{137}Cs, ^{154}Eu, ^{155}Eu, ^{241}Am, ^{90}Sr, and ^{239}Pu.

Limited information about contaminants that could potentially have entered the vadose zone can be obtained from analysis of the waste streams that discharged to the units. Constituents present in the 284-E Power Plant wastewater, which discharges to the 200 East Powerhouse Ditch, are shown in Table 4-9.

The composition of wastewater from the 209-E Critical Mass Laboratory, which was discharged to the 216-C-7 Crib, is shown in Table 4-13. According to the *209-E Laboratory Reflector Wastewater Stream-Specific Report* (WHC 1990c), the only constituents that are elevated more than two times above the levels in the supply water are copper, zinc, and manganese.

Additional information on the potential for contaminants to migrate to groundwater can be inferred from the waste inventories of the waste management units (see Tables 2-1, 2-2, and 2-3). Those 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 4-14. They are based on several conservative assumptions: (1) the discharged water does not spread out laterally from the point of discharge (i.e., the volume of affected vadose zone is equal to the depth to groundwater times the plan-view cross-sectional area of the base of the waste management unit); (2) there is no significant change in liquid volume being introduced to the soil column due to evapotranspiration or precipitation; and (3) the average pore volume of the soil column is between 0.1 and 0.3 (the lower and upper pore volume estimates shown in Table 4-14). If the amount of waste received was greater than the most conservative porosity (0.1) then the waste management unit was considered to have the potential to contribute contaminants to the groundwater. According to these calculations, six waste management units have the potential for migration of liquid discharges to the unconfined aquifer from past operations: the 216-C-1, 216-C-3, 216-C-4, 216-C-6, and 216-C-10 Cribs and the 216-C-9 Pond. This analysis does not take into account long-term drainage which may be occurring at all sites which received liquid waste.

4.1.2 Site-Specific Data

This section presents sampling and analysis data regarding possible releases for individual Semi-Works Aggregate Area waste management units and unplanned releases. The information presented was obtained from reference documents reviewed for the current report. For many of the waste management units and unplanned releases the information is limited, and the lack of more comprehensive information may constitute significant data gaps.

4.1.2.1 Plants, Buildings, and Storage Areas. Buildings at the Semi Works Aggregate Area included the 201-C Process Building and supporting buildings: 276-C Solvent Handling Facility, 2707-C Storage and Change House, 271-C Aqueous Makeup Building, 215-C Gas Preparation Building, 2704-C Office Building and 291-C Ventilation System Building. The other building is the Critical Mass Laboratory Building which was run by the PNL, and is currently occupied by Westinghouse Hanford Tank Farm Waste Management.

Monitoring conducted at the above buildings was limited to surface radiation surveys; no sampling results of environmental media for chemical or radiological contamination were located during our review.

4.1.2.1.1 Plants and Buildings. The only building-specific data located during our review were surface radiation surveys conducted at the 2704-C and 276-C Buildings. The 2704-C Office Building, located due north of the 201-C Process and 271-C Aqueous Makeup Buildings, housed the offices of the Semi-Works Complex. Radiation surveys conducted by Hanford personnel around the 2704-C Office Building in 1989 and 1990 detected up to 6,000 disintegrations per minute (dis/min) of beta radiation. A 1989 survey of all accessible areas inside the building showed nondetectable levels of contamination.

A survey conducted around the 276-C Solvent Handling Building in 1990 detected up to 25,000 dis/min of beta and gamma radiation in two areas east and southeast of the building. The readings were due to contaminated tumbleweeds and were remediated by removing the vegetation. Information was not located to indicate whether the tumbleweed originated on or off of the Semi-Works Aggregate Area.

Four unplanned releases and one newly identified release are associated with plants and buildings at the Semi-Works Aggregate Area:

- Unplanned Releases UN-200-E-36 and UN-200-E-37 involved leakage of radioactive material from two pumps removed from the 201-C Process Building in 1967.
- Unplanned Release U-200-E-98 involved detection of ^{90}Sr around the 291-C Stack in 1980.
- Unplanned Release UN-200-E-141 is associated with the 2718 Storage Building in the Critical Mass Laboratory Area. This release involved a spill or uranyl nitrate onto a concrete floor.
- A release of radioactive waste from the 241-C Waste Line at the point where it enters the 201-C Process Building was reported in 1957. Soil from this leak was buried at the southeast corner of the "A Courtyard" on the east side of the 201-C Process Building. This unplanned release is not listed in WIDS.

4.1.2.2 Tanks and Vaults. The tanks and vaults in the Semi-Works Aggregate Area include the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks. Data available for evaluating the contents of the tanks include results of sampling and analysis of the 241-CX-70 and 241-CX-71 tank contents and waste disposal inventories for 241-CX-70.

4.1.2.2.1 241-CX-70 Storage Tank. No specific sampling and analysis information of soil and other potentially affected media associated with this waste unit was found in the documents reviewed. However, in 1988, a radiation survey conducted by Hanford personnel showed 1,000,000 dis/min of beta radiation in the bricks and concrete in the ash pile adjacent to this tank. This survey does not reflect the current status of the tank area, which is covered by a plastic "greenhouse" building used for radiation containment while excavating through the ash barrier to the tank. An analysis of the tank sludge solids from the 241-CX-70 Storage Tank was performed in 1991. Results of chemical and radiological analyses on the waste material are shown in Table 4-15. No monitoring wells are located near the tank.

Wastes from the tank were analyzed for classification as a RCRA waste. The waste was classified as a RCRA waste due to corrosivity (D002) due to the presence of sodium hydroxide. The mixed waste was also classified as a RCRA toxicity characteristic waste due to detection of chromium (D007) and as a toxic state-only waste (WT02, dangerous waste).

4.1.2.2.2 241-CX-71 Storage Tank. High levels of radioactivity were reportedly detected in soils overlying the tank during an investigation of the tank contents in 1991. Results of this investigation were not reported in the documents reviewed. An analysis of the tank sludge solids from the 241-CX-71 Storage Tank was performed in 1990. Results of chemical and radiological analyses on the waste material are shown in Table 4-16. No monitoring wells are located near the tank.

4.1.2.2.3 241-CX-72 Storage Tank. This waste unit was surveyed for surface radiation in 1990. The results of this survey indicated 15,000 dis/min of beta radiation in a "speck" within the ash pile. The results of this survey do not reflect the current surface conditions at the site, which has since been covered by a 6.2 m by 12.4 m (20 ft by 41 ft) temporary concrete slab to support sampling equipment. An excavation was made through the slab in 1991 to access the tank for sampling. No specific sampling and analysis information regarding soil and other potentially affected media associated with this waste unit was found in the documents reviewed. There are no monitoring wells located near the tank.

4.1.2.3 Cribs and Drains The Semi-Works Aggregate Area waste management units in this category are the 216-C-1, 216-C-3, 216-C-4, 216-C-5, 216-C-6, 216-C-7, and 216-C-10 Cribs.

4.1.2.3.1 216-C-1 Crib. Soil boring 299-E27-133 was drilled 5 m (16 ft) east of the 216-C-1 Crib to conduct gamma logging. This boring was logged only once, in 1984. A review of the log indicates an elevated gamma response, potentially due to radionuclide contamination, at depths between 2 and 12 m (6.5 and 39.3 ft) below the ground surface.

The boring is thought to be located outside the boundaries of the crib, thus the elevated response cannot be related directly to either the buried waste or the backfill that was used to fill the upper 1.5 m (4.9 ft) depression which formerly existed at this crib. A surface radiation survey conducted in 1987 indicated that radiation levels were below detection. Radiation surveys have not been conducted at the unit since the crib was decommissioned in 1988.

4.1.2.3.2 216-C-3 Crib. In the documents reviewed, no specific sampling and analysis information regarding soil and other potentially affected media associated with this waste management unit was located. No monitoring wells were identified near this waste management unit. This waste unit is posted for surface radiation; however, a surface radiation survey conducted in 1991 found no radiation above detection limits.

4.1.2.3.3 216-C-4 Crib. No specific sampling and analysis information regarding soil and other potentially affected media associated with this waste unit was found in the documents reviewed. No monitoring wells were identified near this waste management unit. A surface radiation survey conducted in 1988 found no radiation above detection limits.

4.1.2.3.4 216-C-5 Crib. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this waste unit. Monitoring well 299-E24-8 is located 20 m (65 ft) south of the crib. Gamma scintillation logs indicated a natural gamma response in 1963 but an elevated gamma response from 0 to 3.1 m (0 to 10 ft) below the ground surface in 1968 and 1976. This result was attributed to the presence of a waste transfer line at a distance of 3.1 m (10 ft) from the monitoring well. A surface radiation survey conducted in 1992 found no radiation above detection limits.

4.1.2.3.5 216-C-6 Crib. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this unit. No monitoring wells were identified near this waste management unit. A surface radiation survey conducted in 1988 found no radiation above detection limits.

4.1.2.3.6 216-C-7 Crib. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this waste unit. As discussed in Section 4.1.1.5, wastewater discharged to the crib from the 209-E Critical Mass Laboratory was analyzed. Results of this analysis are presented in Table 4-13. No monitoring wells were identified near this waste management unit. A surface radiation survey conducted in 1988 found no radiation above detection limits.

4.1.2.3.7 216-C-10 Crib. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this unit. Well 299-E27-5, located 3 m (10 ft) north of this unit, monitors this crib. Gamma scintillation logs made between 1963 and 1976 suggest a natural gamma response. A surface radiation survey conducted in 1992 found no radiation above detection limits.

4.1.2.3.8 Critical Mass Laboratory Dry Well North. No information was available on this site in the documents reviewed.

4.1.2.3.9 Critical Mass Laboratory Dry Well South. No information was available on this site in the documents reviewed.

4.1.2.3.10 Critical Mass Laboratory Dry Well East. No information was available on this site in the documents reviewed.

4.1.2.3.11 Gatehouse French Drain. No information was available on this site in the documents reviewed.

4.1.2.4 216-C-2 Reverse Well. Results of radiological analysis of a sediment sample from within this well are shown in Table 4-12. No monitoring wells were identified near this waste management unit. A surface radiation survey was conducted at the unit in 1987. The results showed a reading of 500 ct/min of alpha radiation and nondetectable levels of beta radiation. This survey does not reflect current surface conditions at the site, which has since been covered by an ash barrier.

4.1.2.5 Ponds, Ditches, and Trenches. The waste management units in this category in the Semi-Works Aggregate Area are the 200 East Powerhouse Ditch and the 216-C-9 Pond.

4.1.2.5.1 200 East Powerhouse Ditch. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this waste unit. However, analytical results from samples of wastewater discharged to the ditch are shown in Table 4-9. No monitoring wells were identified near this waste management unit. This ditch is not posted as a surface radiation site. No surface radiation survey was located for this ditch.

4.1.2.5.2 216-C-9 Pond. Monitoring well 299-E27-1 was completed 50 m (164 ft) north of this pond. The gamma scintillation data reviewed suggested a natural gamma response in all logs completed from 1959 to 1976. No specific sampling or analysis results for soil or other media were found in the documents reviewed. No recent surface radiation survey was located for this pond, and a 1978 survey also detected no contamination.

4.1.2.6 Septic Tanks and Associated Drain Fields. The waste units in this category are the 2607-E-5 and 2607-E-7A Septic Tanks and Drain Fields. These tanks supported the Critical Mass Laboratory and Mobile Offices. The two septic tanks operate in tandem.

4.1.2.6.1 2607-E-5 Septic Tank and Drain Field. No sampling or analysis information regarding soil and other potentially affected media was located for this unit. No monitoring wells have been constructed for this unit. This waste management unit is not posted as a surface radiation area. No surface radiation survey was located for this unit.

4.1.2.6.2 2607-E7A Septic Tank and Drain Field. No sampling or analysis information regarding soil and other potentially affected media was located for this unit. No surface radiation survey was located for this unit. No monitoring wells have been constructed for this unit. This waste management unit is not posted as a surface radiation area.

4.1.2.7 Transfer Facilities, Diversion Boxes, and Pipelines. This category of waste management units in the Semi-Works Aggregate Area includes Semi-Works Valve Pit, the Critical Mass Laboratory Valve Pit, and the 241-C-154 Diversion Box.

4.1.2.7.1 Semi-Works Valve Pit. No monitoring wells were identified near this waste management unit. No surface radiation surveys were located for this waste unit.

4.1.2.7.2 Critical Mass Laboratory Valve Pit. No monitoring wells were identified near this waste management unit. No surface radiation surveys were located for this valve pit.

4.1.2.7.3 241-C-154 Diversion Box. No monitoring wells were identified near this waste management unit. No surface radiation surveys were located for this unit.

4.1.2.8 Basins

No basins were identified in the Semi-Works Aggregate Area.

4.1.2.9 Burial Sites

4.1.2.9.1 218-C-9 Burial Ground. This category includes only the 218-C-9 Burial Ground. No specific sampling or analysis results for soil or other media were found in the documents reviewed for this burial ground. Monitoring well 299-E27-1 was constructed 50 m (164 ft) north of this burial ground. A natural gamma response was obtained from this monitoring well in all logs completed between 1959 and 1976. Based on a 1990 fitness-for-use evaluation, this well is no longer usable due to damage to the casing and should be abandoned or remediated. A surface radiation survey conducted on this waste management unit in 1991 found no radiation above detection limits. The burial ground is posted for underground radiation.

4.1.2.10 Unplanned Releases. These unplanned release sites include UN-200-E-36, UN-200-E-37, UN-200-E-98, and UN-200-E-141 and two newly identified unplanned releases not included in WIDS data. These two unplanned releases are referred to as the 241-C Waste Line Unplanned Release No. 1 and 241-C Waste Line Unplanned Release No. 2.

4.1.2.10.1 UN-200-E-36. Beta/gamma readings up to 80,000 ct/min were registered. The roadway was flushed with water to remediate the contamination. No monitoring wells were identified near this unplanned release. No specific sampling and analysis information regarding soil and other potentially affected media associated with this unplanned release were located in the documents reviewed. A surface radiation survey conducted in 1990 showed a beta radiation level of 4,000 dis/min and nondetectable levels of smearable alpha.

4.1.2.10.2 UN-200-E-37. This release was located east and north of the Semi-Works Complex. Beta/gamma readings at the time of release registered 200 mrem/hr. The release was reportedly remediated by sprinkling the roadway with water. No monitoring wells were identified near this unplanned release. No specific sampling and analysis information regarding soil and other potentially affected media associated with this unplanned release was located in the documents reviewed. A surface radiation survey performed in May 1992 reported no detectable radiation at this location. All posting requirements were removed.

4.1.2.10.3 UN-200-E-98. The WIDS (WHC 1992a) concludes that particulate matter containing ^{90}Sr was inadvertently spread to the ground surface. No specific sampling and analysis information regarding soil and other potentially affected media associated with this unplanned release was located in the documents reviewed. No monitoring wells were identified near this unplanned release. No recent surface radiation survey was located for this unplanned release. The area surrounding the 216-C-2 Reverse Well is currently covered by an ash barrier.

4.1.2.10.4 UN-200-E-141. A uranyl nitrate leakage in 1984 within the 2718 Storage Building resulted in this unplanned release. This unplanned release was reportedly remediated to background levels. No monitoring wells were identified near this unplanned release. No specific sampling and analysis information regarding soil and other potentially affected media associated with this unplanned release was not located in the documents reviewed. No surface radiation survey was located for this unplanned release.

4.1.2.10.5 241-C Waste Line Unplanned Release No. 1. A release of radioactive waste from the 241-C Waste Line valve flange was reported in 1957. This leak, which occurred just west of the 201-C Process Building, contaminated soils below the ground surface. Radiation readings of greater than 100 Rad/hr were measured at a depth of 3.7 m (12 ft) below the surface. Contaminated soils excavated while repairing the flange leak were reportedly buried at the southeast corner of the "A Courtyard" of 201-C Process Building. This release is within the area currently covered by the ash barrier. No monitoring wells are located near this unplanned release. No recent surface radiation surveys were located for this release.

4.1.2.10.6 241-C Waste Line Unplanned Release No. 2. A second release from the 241-C waste line occurred at a flange near the 241-CX fence at the east side of the Semi-Works Complex. This release, which was also reported in 1957, contaminated subsurface soils along the fence. Radiation levels greater than 100 Rad/hr were reported at a depth of 4.6 m (15 ft). No monitoring wells are located in this area. No recent surface radiation surveys were located for this unplanned release.

4.2 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

This preliminary assessment is intended to provide a qualitative evaluation of potential human health hazards associated with the known and suspected contaminants at the Semi-Works Aggregate Area. The assessment includes a discussion of release mechanisms and potential transport pathways, develops a conceptual model of human 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 in groundwater is a primary route for potential future exposures to many of the chemicals disposed of at the Hanford Site, this pathway (i.e., travel time, receptors) will be addressed in the 200 East Groundwater AAMS.

It is important to note that these evaluations do not attempt to quantify potential human health risks associated with exposure to Semi-Works Aggregate Area waste management unit and unplanned release contaminants. Such risk assessments cannot be performed until additional waste unit characterization data are acquired. Risk assessment activities will be performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* document (DOE/RL 1992b) prepared in response to the M-29 milestone. This method 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).

4.2.1 Release Mechanisms

The Semi-Works Aggregate Area waste management units can be divided into two general categories based on the nature of the waste released: (1) units where waste was discharged directly to the environment and (2) units where waste was discharged 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, cribs and ditches, ponds, and reverse wells. Also in this group are unplanned releases that involved waste material released to the soil. For this group of waste management units, if discharges contained contaminants of concern, it can be assumed that soils under the waste management unit are contaminated. The first task in developing a conceptual model for these units is to determine whether contaminants of concern are retained in soil near the waste management unit, or are likely to migrate to the underlying aquifer and then to receptor points such as drinking water wells or surface water bodies. Factors affecting migration of chemicals away from the point of release will be discussed in the following section.

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

The ability of this report to evaluate the efficacy of engineered barriers is limited by the lack of vadose zone soil sampling data and air sampling data for many waste management units. Available sampling information for the waste management units and unplanned releases has been summarized in Section 4.1. Vadose zone sampling or gamma logging information was available only for the 216-C-1, 216-C-5, and 216-C-10 Cribs; the 216-C-2 Reverse Well; and the 216-C-9 Pond and 218-C-9 Burial Ground.

For the 218-C-9 Burial Ground, which received only dry construction debris from the decommissioning of Semi-Works buildings, the potential for release is expected to be low. However, due to the earlier use of this location as a waste disposal pond, it is probable that soils beneath portions of the 218-C-9 Burial Ground are contaminated.

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 of the engineered waste management units have some type of barrier to releases to the surface; however, barriers can fail over time or may not be designed to prevent migration by certain transport pathways (e.g., volatilization).

The primary route for potential migration of contaminants from waste management units to air appears to be via vent pipes. Cribs in the Semi-Works Aggregate Area are constructed with buried perforated pipe covered by a layer of gravel and backfill. Likewise, the three storage tanks are below ground and only fill pipes and risers extend above the surface. No data were located to evaluate the potential for airborne releases from these vents and pipes.

4.2.2 Transport Pathways

Transport pathways that could potentially occur within the Semi-Works 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 from soils by animals via direct contact with soils or surface water or ingestion of soil, vegetation, surface water, and other animals
- Direct radiation.

In addition, transport within the saturated zone and subsequent release to groundwater wells or to offsite 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 East 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 Semi-Works 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 87 m (285 ft) below ground surface. These factors are discussed in the following sections.

4.2.2.1.1 Depth of Release. As a general rule, for a given volume waste management units that released wastes at a greater depth below the surface have a higher potential to contaminate groundwater than waste management units where the release was shallow. Other factors, however, such as rate of discharge, underlying geology, and many others will all significantly impact contaminant movement. The 216-C-2 Reverse Well is a primary example of a deep release at the Semi-Works Aggregate Area. This unit discharged wastes to the vadose zone approximately 12 m (39 ft) below the surface.

4.2.2.1.2 Liquid Volume or Recharge Rate. For waste constituents to migrate to the underlying water table, some source of recharge must be present. In the Semi-Works Aggregate Area, the primary sources of moisture for mobilizing contaminants are waste management units that discharge liquid waste to the soil column and precipitation recharge.

As discussed in Section 3.5.2, a number of studies have estimated natural precipitation recharge in a range from 0 to 10 cm/yr (0 to 3.9 in./yr), primarily depending on surface soil type, vegetation, and topography. The upper value in the range was a computer model generated estimation rather than actual measurement. The actual natural precipitation recharge for Semi-Works is likely to fall at the lower end of this range. Gravelly surface soils with no or minor shallow rooted vegetation appear to facilitate precipitation recharge. One modelling study (Smoot et al. 1989) indicated that some radionuclide (^{137}Cs and ^{106}Ru) transport could occur with as little as 5 cm/yr (1.95 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-C-1 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 (Table 4-14). 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 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. There are no known cases of this occurring in the Semi-Works Aggregate Area; however, the potential exists. A known example of this process occurred at the U Plant Aggregate Area 216-U-16 Crib, where lateral migration of acidic waste above a caliche layer mobilized radionuclides in the 216-U-1 and 216-U-2 Cribs (Baker et al. 1988).

It is also thought that septic fields may have the potential to mobilize contaminants. In the Semi-Works area, there are no known areas of vadose zone contamination within 31 m (100 ft) of the septic tanks or the powerhouse ditch.

4.2.2.1.3 Soil Moisture Transport Properties. The moisture flux in the vadose zone is dependent on hydraulic conductivity as well as gradients of moisture content or matrix suction. Higher unsaturated hydraulic conductivities are associated with higher moisture contents. However, higher unsaturated hydraulic conductivities may be associated with fine-grained soils compared to coarse-grained soils at low moisture contents. Due to the stratified nature of the Hanford Site vadose zone soils and the moisture content dependence of unsaturated hydraulic conductivity, vertical anisotropy is expected i.e., vadose zone soils are likely to be more permeable in the horizontal direction than in the vertical. This vertical anisotropy may substantially 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 clay minerals, organic matter, and iron and aluminum oxyhydroxides. In general, Hanford Site surface soils are characterized as sandy or gravelly with very low organic content (<0.1 percent) and low clay content (<12 percent) (Tallman et al. 1981). Thus, site-specific adsorption factors are likely to be lower, and rate of transport higher, than the average for soils nationwide.

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

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

- **Ionic Strength of Waste.** For some inorganics, the dominant mechanism leading to desorption from the soil matrix is ion exchange. Leachate having high ionic strength (high salt content) can bias the sorption equilibrium toward desorption, leading to higher concentrations of the contaminant in the soil pore water. Examples of wastes within the Semi-Works Aggregate Area that can be considered high ionic strength include liquid Coating Waste from the REDOX and PUREX pilot projects and process condensate from the 201-C Process Building.

- **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 Semi-Works Aggregate Area generally have carbonate contents in the range of 0.1 to 5 percent. Higher carbonate contents up to 20 percent are observed in finer-grained layers of the Hanford formation.

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

  - The remobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs in the U Plant Aggregate Area is believed to have occurred in part because of the introduction of low pH solutions.
  - Leaching of americium from the Z Plant Aggregate Area 216-Z-9 Crib sediments was found to be solubility controlled and correlated to solution pH.

4.2.2.1.5 Complexation by Organics. Certain organic materials disposed of at the Semi-Works Aggregate Area are known to form complexes with inorganic ions, which can enhance their solubility and mobility. Complexing agents known to have been constituents of process wastes at the Semi-Works Aggregate Area include tributylphosphate, EDTA, tetrasodium-EDTA, trisodium hydroxyethyl-EDTA, and nitrilotriacetic acid. In addition, surfactants known to have been used at the site, such as nonylphenoxy polyethoxy ethanol, could affect the migration of inorganic species in the subsurface.

4.2.2.1.6 Contaminant Loss Mechanisms. Processes that can lead to loss of chemicals from soils, and thus decrease the amount of chemical available for leaching to groundwater, include:

- **Radioactive Decay.** Radioactivity decays over time, generally decreasing the quantities and concentrations of radioactive isotopes.

- **Biotransformation.** Microorganisms in the soil may degrade organic contaminants such as kerosene and inorganic chemicals such as nitrate. They may also affect the mobility of metals through reduction-oxidation chemistry and complexation with metabolic products.

- **Chemical Transformation.** Hydrolysis, oxidation, reduction, radiolytic degradation and other chemical reactions are possible degradation mechanisms for contaminants.

- **Vegetative Uptake.** Vegetation may remove chemicals from the soil, bring them to the surface, and introduce them to the food web.

- **Volatilization.** Organic chemicals and volatile radionuclides can be transported in the vapor phase through open pores in soil either to adjacent soil or to the atmosphere. These volatilized compounds could include hexone, radon (a decay product of uranium), and tritium in water (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 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 or unplanned releases where volatile organics (e.g., chloroform) or volatile radionuclides (^{129}I or ^{3}H) have been released. Transport mechanisms include evaporation/volatilization, diffusion down a concentration gradient and gas-driven flow. Situations where the latter process may occur include production of methane gas from degradation of organic compounds in soil, or production of hydrogen and oxygen gases by radiolytic hydrolysis of water.

In 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 units. The processes by which biota may expose contaminated soils are discussed in Section 4.2.2.4.

The contribution of the Semi-Works Aggregate Area to the overall fugitive dust emissions at the Hanford Site is expected to be relatively minor, based on results of air monitoring downwind of the Semi-Works Aggregate Area waste management units.

4.2.2.3 Transport from Soils to Surface Water. The only surface water currently identified in the Semi-Works Aggregate Area is at the 200 East Powerhouse Ditch, which receives discharges from the 284-E Power Plant. The former 216-C-9 Pond has not contained water since before 1985 and has been filled in.

Transport of contaminants to surface water bodies outside of the Semi-Works 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 East Groundwater AAMS.

4.2.2.4 Transport from Soils 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 Semi-Works Aggregate Area waste management units or resulting in damage to affected ecosystems is unclear. The currently available data, as described in Section 3.6 and 4.1 are too general and do not adequately evaluate biotic transport or ecological risk. This data gap is discussed further in Sections 5.0 and 8.0. The future acquisition of additional data will be guided by the requirements for human health and ecological risk assessments in the Hanford Baseline Risk Assessment Methodology (DOE/RL 1992b) being proposed in response to the M-29 milestone.

4.2.2.4.1 Uptake by Vegetation. Release of radioactivity to the surface by growth of vegetation is an ongoing problem at Semi-Works Aggregate Area waste management units and unplanned releases. 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. No examples of this transport mechanism occurring within the Semi-Works Aggregate Area were located; however, one sample of mouse feces collected in the Semi-Works Aggregate Area in 1981 was radioactively contaminated.

4.2.3 Conceptual Model

Figure 4-4 presents a graphical summary of the physical characteristics and mechanisms that have occurred at the site either historically or at present which could potentially affect the generation, transport, and impact of contamination in the Semi-Works Aggregate Area on humans and biota (conceptual model).

The sources of contamination include discharges (condensates, cooling water, sewage) from Semi-Works facilities; process wastes from the 201-C Process Building and the Critical Mass Laboratory; drainage from diversion boxes; stack drainage and emissions; debris from decommissioning efforts; low level liquid wastes; low level waste; and waste material that was spilled during transit.

Contaminants from these sources have been discarded at the waste management units and unplanned releases that are under investigation. These include the 200 East Powerhouse Ditch, cribs, the 216-C-9 Pond, the 218-C-9 Burial Ground, the 216-C-2 Reverse Well, storage tanks, septic tanks and drain fields, the Tank Storage Area, diversion boxes and valve pits, 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 units and are shown on Figure 4-4 as dashed lines with "U" designations.

From these waste management units, various release mechanisms may have transported contamination to the potentially affected media. Volatilization could release chemicals from surface waters into the atmosphere. Chemicals in the 200 East Powerhouse Ditch (and formerly, the 216-C-9 Pond) may have seeped into the vadose zone, or been deposited into the sediments in the ditch. Biota may have taken up contaminants from the surface water and near-surface contaminated soils (via deep roots or burrowing animals).

Waste transfers via intermediate facilities such as transfer lines and between waste units within the Aggregate Area are shown by the arrows to the column marked "Transfer Facilities" and by the vertical arrows in the column marked "Waste Sites", respectively. The primary examples of waste transfer between waste storage and treatment units is the routing of process wastes to the 216-C-1 Crib after neutralization in the 216-CX-71 Tank.

Many waste management units discharge their waste effluents directly to the near-surface (vadose zone) soils. The cribs provide seepage discharge and similarly the reverse well and septic system drain fields directly inject their effluents into the subsurface sediments. The unplanned releases have mainly impacted surface soils although some contamination may have also taken place on building surfaces. Fugitive dust from sediment and surface soils has also been released or resuspended due to wind effects or surface disturbances, and some surface soils have been buried or removed to offsite disposal.

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

Figure 4-5 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 Semi-Works Aggregate Area are dominated by cribs. Table 4-14 identifies those units that had liquid discharges large enough to reach the unconfined aquifer.

Contaminant distributions near the burial ground type units in the Semi-Works 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 Semi-Works 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 Semi-Works 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) Most chemical contaminants of concern have distributions that tend to mimic radionuclide contaminant distributions in the vadose zone.

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

- Inhalation of airborne volatiles or fugitive dusts with adsorbed contamination
- Ingestion of surface water, fugitive dust, surface soils, biota (either directly or through the food chain), or groundwater
- Direct contact with the waste materials (such as those exhumed by burrowing animals), contaminated surface soils, buildings, or plants
- Direct radiation from waste materials, surface soils, building surfaces, pipelines and other facilities, or fugitive dusts.

4.2.4 Characteristics of Contaminants

Table 4-17 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 Semi-Works Aggregate Area. Table 4-18 summarizes the types of known or suspected contamination that are thought to exist at the individual waste management units. Known contaminants have been proven to exist from sampling and inventory data (Tables 2-3 and 2-4). Suspected contaminants are those which could have occurred at a unit based upon historical practices, chemical associations Given the large number of chemicals known or suspected to be present, it is appropriate to focus this assessment on those contaminants that have been detected through sampling efforts and which pose the greatest risk to human health or the environment.

The EPA Region 10 guidance on risk-based contaminant screening (EPA 1991a), as summarized in the *Hanford Baseline Risk Assessment Methodology* (DOE/RL 1992b), was consulted to establish the Semi-Works 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 Semi-Works 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 Semi-Works 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 4-19 lists the contaminants of potential concern for the Semi-Works Aggregate Area. This list was developed from Table 4-17 and includes only those contaminants which meet the following criteria:

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

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

- Contaminants that are known or suspected carcinogens or have a U.S. Environmental Protection Agency (EPA) noncarcinogenic toxicity factor.

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

The following characteristics will be discussed for the contaminants listed in Table 4-19:

- 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 Semi-Works 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 East Groundwater AAMS, it will not be discussed further here. Surface soil and biota samples have been collected from locations on a regular rectangular grid. These sampling locations do not correspond to any of the waste management units but are intended to characterize the Semi-Works Aggregate Area as a whole. Air and external radiation samples have been collected at several locations within or adjacent to the Semi-Works 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 for any of the units.

4.2.4.2 Historical Association with Semi-Works Activities. Radionuclides and other chemicals that are known components of Semi-Works are listed in Table 2-5. This list also 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 via cribs, it is probable that the chemicals on this list have affected environmental media.

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

- ^{90}Sr
- ^{137}Cs
- Pu (total)
- ^{3}H.

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

Nonradioactive chemicals reportedly released into Semi-Works Aggregate Area waste management units in large quantities include nitric acid, various metallic nitrates, sodium aluminate, sodium nitrate, kerosene, tributylphosphate, and sodium.

4.2.4.3 Mobility. Since most wastes at the Semi-Works 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 4-19 varies widely and depends on site-specific factors as well as the intrinsic properties of the contaminant. These site-specific factors include site stratigraphy, hydraulic conductivity, porosity, and other factors. Much of the site-specific information needed to characterize mobility is not available and will need to be obtained during future field investigations. However, it is possible to make general statements about the relative mobility of the candidate contaminants of concern.

4.2.4.3.1 Transport to the Subsurface. The mobility of radionuclides and other inorganic elements in groundwater depends on the chemical form and charge of the element or molecule, which in turn depends on site-related factors such as the pH, redox state, and ionic composition of the groundwater. Cationic species (e.g., Cd^{2+}, Pu^{4+}) generally are retarded in their migration relative to groundwater to a greater extent than anionic species such as nitrate (NO_3^-). The presence in groundwater of complexing or chelating agents can increase the mobility of metals by forming neutral or negatively charged compounds.

The chemical properties of radionuclides are essentially identical to the nonradioactive form of the element; thus, discussions of the chemical properties affecting the transport of contaminants can apply to both radionuclides and nonradioactive chemicals.

A soil-water distribution coefficient (K_d) can be used to predict mobility of inorganic chemicals in the subsurface. Table 4-20 presents a summary of soil-water distribution coefficients that have been developed for many of the inorganic chemicals of concern at the Semi-Works 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 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 the use of K_d that have not been verified by experimentation with site soils.

Serne and Wood (1990) recommended K_d for use with Hanford waste assessments for a limited number of important radionuclides (americium, cesium, cobalt, iodine, plutonium, ruthenium, strontium, and tritium) based on soil column or batch desorption studies, and have proposed conservative average values for a more extensive list of elements based on a review of the literature. An assumed K_d value of <1 is recommended for americium, cesium, plutonium, and strontium under acidic conditions.

Strenge and Peterson (1989) developed default K_d for a large number of elements for use in the Multimedia Environmental Pollution Assessment System (MEPAS), a computerized waste management unit evaluation system. The K_d 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 4-20 are for conditions of neutral waste pH and less than 10 percent adsorbent material, which is likely to be most representative of Hanford Site soils.

The mobility of inorganic species in soil can be divided roughly into three classes, using site-specific values (Serne and Wood 1990) where available and generic values otherwise: high mobility ($K_d<5$), moderate mobility ($5<K_d<100$), and low mobility chemicals ($K_d>100$). Table 4-21 lists the mobility class 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 Semi-Works Aggregate Area are listed in Table 4-22. Chemicals with low K_{oc} values are weakly adsorbed 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.

The density of an organic chemical also has an impact on the transport behavior of the chemical. Compounds that are denser than water, such as halogenated solvents (e.g., chloroform), will tend to migrate to the bottom of an aquifer, while compounds that are less dense than water will tend to migrate near the water table.

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 fugitive dust emissions. Chemicals subject to transport via airborne dust dispersion are those that are non-volatile and persistent on the soil surface, including most radionuclides and inorganics, and some organics such as creosote and coal tar.

Chemicals subject to volatilization are mostly organic compounds; however, some of the radionuclides detected at the site are subject to evaporation and could be lost from shallow soils to the ambient air. The most important species in this category are ^{14}C, ^{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 mole of chemical per cubic meter. Henry's Law Constants of the organic candidate contaminants of concern are presented in Table 4-22. 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 for the Semi-Works Aggregate Area that fall into this class include:

- Chloroform
- Tributylphosphate.

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 Semi-Works Aggregate Area contaminants of concern are discussed below.

The persistence of radionuclides depends primarily on their half-lives. A comparison of the half-lives and specific activities for most radionuclide candidate contaminants of concern for the Semi-Works Aggregate Area is presented in Table 4-23. 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 4-23 range from seconds to over one billion years. Also listed are the decay mechanisms of primary concern for the radionuclide. Note that radionuclides often undergo several decay steps in quick succession (e.g., an alpha decay followed by release of one or more gamma rays). The daughter products of these decays are themselves often radioactive.

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

Nonradioactive inorganic chemicals detected at the site are generally persistent in the environment, although they may decline in concentration due to transport processes or change their chemical form due to chemical or biological reactions. Nitrate undergoes chemical and biological transformations that may lead to its loss to the atmosphere (as N_2) or incorporation into living organisms, depending on the redox environment and microbiological communities present in the medium.

Biotransformation rates for organics vary widely and are highly dependent on site-specific factors such as soil moisture, redox conditions, and the presence of nutrients and of organisms capable of degrading the compound. Ketones, such as methyl ethyl ketone, are easily degraded by microorganisms in soil and thus would tend not to persist. Chlorinated solvents (e.g., chloroform) may undergo slow biotransformation in the subsurface under anoxic conditions. Volatile aromatics such as toluene are generally intermediate in their biodegradability.

4.2.4.5 Toxicity. Contaminants may be of potential concern for impacts to human health if they are known or suspected to have carcinogenic properties, or if they have adverse noncarcinogenic health effects. The toxicity characteristics of the chemicals detected at the aggregate area are summarized below.

4.2.4.5.1 Radionuclides. All radionuclides are classified by EPA as known human carcinogens based on their property of emitting ionizing radiation and on the evidence provided by epidemiological studies of radiation-induced cancers in humans. Non-carcinogenic health effects associated with radiation exposure include genetic and teratogenic effects; however, these effects generally occur at higher exposure levels than those required to induce cancer. Thus, the carcinogenic effect of radionuclides is the primary identified health concern for these chemicals (EPA 1989b).

Risks associated with radionuclides differ for various routes of exposure depending on the type of ionizing radiation emitted. Nuclides that emit alpha or beta particles are hazardous primarily if the materials are inhaled or ingested, since these particles expend their energy within a short distance after penetrating body tissues. Gamma-emitting radioisotopes, which deposit energy over much larger distances, are of concern as both external and internal hazards. A fourth mode of radioactive decay, neutron emission, is generally not of major health concern, since this mode of decay is much less frequent than other decay processes. In addition to the mode of radioactive decay, the degree of hazard from a particular radionuclide depends on the rate at which particles or gamma radiation are released from the material.

Excess cancer risks for exposure to the primary radionuclide contaminants of concern by inhaling air, drinking water, ingesting soil, and by external irradiation are shown in Table 4-24. 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). 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 (1991b) risk factors, the *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1992b) will be consulted. This document proposes to consult the EPA office of Radiation Programs to request the development of a slope factor or to use the dose conversion factors developed by the International Commission on Radiological Protection to calculate a risk value. Any Hanford Site risk assessments will be performed in accordance with the Hanford Baseline Risk Assessment Methodology document (DOE-RL 1992b) which includes the guidance established in the Risk Assessment Guidance for Superfund (EPA 1989a) and the EPA Region 10 Supplement Risk Assessment Guidance for Superfund (EPA 1991a).

The unit risk factors for different radionuclides are roughly proportional to their specific activities, but also incorporate factors to account for distribution of each radionuclide within various body organs, the type of radiation emitted, and the length of time that the radionuclide is retained in the organ of interest.

Based on the factors listed in Table 4-24, the highest risk for exposure to 1 pCi/m^3 in air is from plutonium, americium, and uranium isotopes, which are alpha emitters. Among the radionuclide contaminants of concern for the Semi-Works Aggregate Area, the highest risks from ingestion of soil at 1 pCi/g are for ^{227}Ac, ^{241}Am, ^{238}Pu, ^{129}I, ^{231}Pa, ^{210}Pb, ^{210}Po, ^{223}Ra, ^{225}Ra, ^{226}Ra, ^{229}Th, and the uranium isotopes. The primary gamma-emitters are ^{214}Bi, ^{60}Co, ^{134}Cs, ^{137m}Ba, ^{152}Eu, ^{154}Eu, and ^{214}Pb. It is important to note that this table only presents unit risk factors for the listed radionuclides and does not include potential contributions from daughter products.

The standard EPA risk assessment methodology assumes that the probability of a carcinogenic effect increases linearly with dose at low dose levels, i.e., there is no threshold for carcinogenic response. The EPA methodology also assumes that the combined effect of exposure to multiple carcinogens is additive without regard to target organ or cancer mechanism. However, the additive risk resulting for radionuclide 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 4-25. The basis for these potential health effects are described in the respective reference documents and may be associated with either human or animal data. Health effects were developed according to the hierarchy established in the Risk Assessment Guidance for Superfund (EPA 1989a). References were consulted in the following order: IRIS (Integrated Risk Information System), 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, kerosene, tributyl phosphate, and uranium.

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).

Table 4-1. Types of Data for the Semi-Works Aggregate Area Waste Management Units. (sheet 1 of 2)

Waste Management Unit	Waste Inventory Database (WIDS)[a]	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
Plants, Buildings, and Storage Areas						
201-C Process Building	R					
291-C Ventilation System	R					
Tanks and Vaults						
241-CX-70 Storage Tank	C,R		R			
241-CX-71 Storage Tank	C,R		R			
241-CX-72 Storage Tank	R		R			
Cribs and Drains						
216-C-1 Crib	C,R		R			R
216-C-3 Crib	C,R		R			
216-C-4 Crib	C,R		R			
216-C-5 Crib	C,R		R			R
216-C-6 Crib	C,R		R			
216-C-7 Crib	C,R		R			
216-C-10 Crib	R		R			R
Critical Mass Laboratory Dry Well North						
Critical Mass Laboratory Dry Well South						
Critical Mass Laboratory Dry Well East						
Gatehouse French Drain						
Reverse Wells						
216-C-2 Reverse Well			R			

Table 4-1. Types of Data for the Semi-Works Aggregate Area Waste Management Units. (sheet 2 of 2)

Waste Management Unit	Waste Inventory Database (WIDS)[a]	Surface Soil/Sediment Data	External Radiation Monitoring Data	Biota Sampling Data	Subsurface Vapor/Soil Sampling Data	Borehole Geophysics Data
Ponds, Ditches, and Trenches						
216-C-9 Pond	R					R
200 East Powerhouse Ditch						
Septic Tanks and Associated Drain Fields						
2607-E-5 Septic Tank and Drain Field						
2607-E-7A Septic Tank and Drain Field						
Transfer Facilities, Diversion Boxes, and Pipelines						
Semi-Works Valve Pit						
Critical Mass Laboratory Valve Pit						
241-C-154 Diversion Box						
Burial Sites						
218-C-9 Burial Ground	R		R			R
Unplanned Releases						
UN-200-E-36			R			
UN-200-E-37			R			
UN-200-E-98						
UN-200-E-141						
241-C Waste Line Unplanned Release No. 1						
241-C Waste Line Unplanned Release No. 2						

NOTES:
C Nonradioactive organic or inorganic constituents.
R Radiological constituents.
[a] or other sources of waste inventory information.
Blank entry indicates no applicable data found during document review.

9 1 2 9 0 5 1 9 1 7

Table 4-2. Summary of Radionuclide Contamination in Various Affected Media for the Semi-Works Aggregate Area. (sheet 1 of 2)

Waste Management Unit	Air	Surface Soil (0 to 1 m) (0 to 3.2 ft)	Surface Water	Biota	Vadose Zone	Remarks
Plants, Buildings, and Storage Areas						
201-C Process Building		S				Surface radiation in ash pile
291-C Ventilation System		S				Surface radiation in ash pile
Tanks and Vaults						
241-CX-70 Storage Tank						
241-CX-71 Storage Tank					S	
241-CX-72 Storage Tank						
Cribs and Drains						
216-C-1 Crib		nc		s	k	Elevated gamma to 12 m (39 ft)
216-C-3 Crib		nc		s	k	
216-C-4 Crib		nc		s	k	
216-C-5 Crib		nc		s	k	
216-C-6 Crib		nc		s	k	
216-C-7 Crib		nc				Received reflector tank water
216-C-10 Crib		nc		s	k	
Critical Mass Laboratory Dry Well North						
Critical Mass Laboratory Dry Well South						
Critical Mass Laboratory Dry Well East						
Gatehouse French Drain		S			S	Drain is labeled as radioactive
Reverse Wells						
216-C-2 Reverse Well		k			k	Elevated external radiation

Table 4-2. Summary of Radionuclide Contamination in Various Affected Media for the Semi-Works Aggregate Area.
(sheet 2 of 2)

Ponds, Ditches, and Trenches						
216-C-9 Pond					k	
200 East Powerhouse Ditch						Received 200 E Power Plant wastewater
Septic Tanks and Associated Drain Fields						
2607-E-5 Septic Tank and Drain Field					nc	Sanitary wastes only
2607-E-7A Septic Tank and Drain Field					nc	Sanitary wastes only
Transfer Facilities, Diversion Boxes, and Pipelines						
Semi-Works Valve Pit						
Critical Mass Laboratory Valve Pit						
241-C-154 Diversion Box						
Burial Sites						
218-C-9 Burial Ground		nc			s	
Unplanned Releases						
UN-200-E-36		k			s	Elevated surface radiation in 1990
UN-200-E-37		k			s	Elevated surface radiation (historical)
UN-200-E-98		s, r?			s	Elevated surface radiation (historical)
UN-200-E-141		r				Elevated surface radiation (historical)
241-C Waste Line Unplanned Release No. 1					s	Elevated underground radiation (historical)
241-C Waste Line Unplanned Release No. 2					s	Elevated underground radiation (historical)

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

9 1 1 2 9 0 5 1 9 1 9

Table 4-3. Summary of Chemical Contamination for Various Affected Media for the Semi-Works Aggregate Area. (sheet 1 of 3)

Waste Management Unit	Air	Surface Soil (0 to 1 m) (0 to 3.2 ft)	Surface Water	Biota	Vadose Zone Soil (0 to 5 m) (0 to 16 ft)	Remarks
Plants, Buildings, and Storage Areas						
201-C Process Building					S	2.5 tons of lead is entombed in the site
291-C Ventilation System						
Tanks and Vaults						
241-CX-70 Storage Tank						
241-CX-71 Storage Tank						
241-CX-72 Storage Tank						
Cribs and Drains						
216-C-1 Crib					k	
216-C-3 Crib					k	
216-C-4 Crib					k	
216-C-5 Crib					k	
216-C-6 Crib					k	
216-C-7 Crib					k	Received reflector tank water
216-C-10 Crib					k	
Critical Mass Laboratory Dry Well North						
Critical Mass Laboratory Dry Well South						

Table 4-3. Summary of Chemical Contamination for Various Affected Media for the Semi-Works Aggregate Area. (sheet 2 of 3)

Waste Management Unit	Air	Surface Soil (0 to 1 m) (0 to 3.2 ft)	Surface Water	Biota	Vadose Zone Soil (0 to 5 m) (0 to 16 ft)	Remarks
Critical Mass Laboratory Dry Well East						
Gatehouse French Drain						
Reverse Wells						
216-C-2 Reverse Well					k	
Ponds, Ditches, and Trenches						
216-C-9 Pond					k	
200 East Powerhouse Ditch			s	s	s	
Septic Tanks and Associated Drain Fields						
2607-E-5 Septic Tank and Drain Field						Sanitary wastes only
2607-E-7A Septic Tank and Drain Field						Sanitary wastes only
Transfer Facilities, Diversion Boxes, and Pipelines						
Semi-Works Valve Pit						
Critical Mass Laboratory Valve Pit						
241-C-154 Diversion Box						
Burial Sites						
218-C-9 Burial Ground						
Unplanned Releases						
UN-200-E-36						
UN-200-E-37						
UN-200-E-98						

Table 4-3. Summary of Chemical Contamination for Various Affected Media for the Semi-Works Aggregate Area. (sheet 3 of 3)

Waste Management Unit	Air	Surface Soil (0 to 1 m) (0 to 3.2 ft)	Surface Water	Biota	Vadose Zone Soil (0 to 5 m) (0 to 16 ft)	Remarks
UN-200-E-141						
241-C Waste Line Unplanned Release No. 1		s			s	
241-C Waste Line Unplanned Release No. 2		s			s	

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

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

Radionuclide in pCi/m³	Sampling Location Number			
	N001	N002	N003	N004
Strontium-90	6.0E-04	3.7E-04	6.8E-04	4.2E-04
Cesium-137	9.0E-06	9.0E-06	3.5E-04	7.9E-04
Plutonium-239	6.5E-06	2.4E-05	3.3E-06	7.9E-06
Uranium (Total)	1.2E-05	4.7E-07	1.3E-05	5.6E-05

NOTES:
Table values are annual averages for radionuclide concentrations in air from 1985 through 1989 in pCi/m^3.
Shaded values indicate a positive detection result greater than measurement error.
See Table A-1 for complete data set.
See Figure 4-1 for sampling locations.

Table 4-5. Radiation and Dose Rate Surveys at the Semi-Works Aggregate Area Waste Management Units. (sheet 1 of 3)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
			Plants, Buildings, and Storage Areas				
201-C Process Building	2	1983	NA	NA	2.5 to 1500	NA	α, β, γ in cells at ground level covered by ash barrier
291-C Ventilation System	2	1988	350	NA	NA	NA	α, β, γ in entombed filter unit and housing currently covered by ash barrier
			Tanks and Vaults				
241-CX-70 Storage Tank	1	4/16/91	NA	17,000	NA	420	β, bricks & concrete in ash pile; does not reflect current surface conditions
241-CX-71 Storage Tank							
241-CX-72 Storage Tank	1	12/5/90	NA	15,000	ND	NA	β, "speck" in ash pile area; does not reflect curent surface conditions
			Cribs and Drains				
216-C-1 Crib	1	3/30/87	ND	ND	NA	ND	Decommissioned in 1988. No longer surveyed.
216-C-3 Crib	1	2/27/91	ND	ND	ND	ND	
216-C-4 Crib	1	8/30/88	NA	ND	ND	ND	
216-C-5 Crib	1	2/27/92	NA	ND	NA	NA	
216-C-6 Crib	1	3/30/88	NA	ND	NA	ND	
216-C-7 Crib	1	8/30/88	NA	ND	ND	ND	
216-C-10 Crib	1	2/28/92	NA	ND	ND	NA	
Critical Mass Laboratory Dry Well North							

Table 4-5. Radiation and Dose Rate Surveys at the Semi-Works Aggregate Area Waste Management Units. (sheet 2 of 3)

Waste Management Unit	Ref.	Inspection Date	Radiation Survey ct/min	Radiation Survey dis/min	Radiation Survey mrem/hr	Radiation Survey Smearable Alpha in dis/min	Radiation Type, Notes
Critical Mass Laboratory Dry Well South							
Critical Mass Laboratory Dry Well East							
Gatehouse French Drain							Drain is labeled as radioactive - type unknown
Reverse Wells							
216-C-2 Reverse Well	1	3/30/87	500	ND	ND	ND	Currently covered by ash barrier
Ponds, Ditches, and Trenches							
216-C-9 Pond	2	1978	ND	ND	NA	NA	
200 East Powerhouse Ditch							
Septic Tanks and Associated Drain Fields							
2607-E-5 Septic Tank and Drain Field							
2607-E-7A Septic Tank and Drain Field							
Transfer Facilities, Diversion Boxes, and Pipelines							
Semi-Works Valve Pit							
Critical Mass Laboratory Valve Pit							
241-C-154 Diversion Box							

Table 4-5. Radiation and Dose Rate Surveys at the Semi-Works Aggregate Area Waste Management Units. (sheet 3 of 3)

			Radiation Survey				
Waste Management Unit	Ref.	Inspection Date	ct/min	dis/min	mrem/hr	Smearable Alpha in dis/min	Radiation Type, Notes
			Burial Sites				
218-C-9 Burial Ground	1	4/12/91	NA	ND	NA	NA	
			Unplanned Releases				
UN-200-E-36	3	11/15/90	NA	ND	ND	ND	β, γ, remediation attempted
UN-200-E-37	1	5/20/92	NA	ND	NA	ND	β, γ, remediation attempted
UN-200-E-98	2	1980	NA	NA	NA	NA	Unknown level of ^{90}Sr, partially remediated
UN-200-E-141	2	1984	NA	NA	NA	NA	Spill of ^{235}U, level unknown. Remediated to background.
241-C Waste Line Unplanned Release No. 1		1957	to 80,000	NA	NA	NA	Underground pipe leak, >100 rem at 3 m (12 ft) depth
241-C Waste Line Unplanned Release No. 2		1957	to 80,000	NA	NA	NA	Underground pipe leak, >100 rem at 5 m (15 ft)

NOTES:

Refs: 1) Compilation of Radiation Survey Data for the Semi-Works Aggregate Area.
2) Technical Baseline Report.
3) March 1992 Survey.

ND Measured but not detected.
NA Parameter was not available (not measured) in most recent survey.
ct/min Counts per minute.
dis/min Disintegrations per minute.
mrem/hr Millirem per hour.

Table 4-6. Results of External Radiation Monitoring: TLD Readings.

Sample Location	Readings in mrem/yr						
	1985	1986	1987	1988	1989	1990[b]	Annual Average
2E16							
max	83	106	103	114	a	— —	102
min	64	70	87	93	a	— —	79
total	74	83	93	107	a	— —	89
2E22							
max	a	104	102	113	a	— —	106
min	a	81	83	70	a	— —	78
total	a	88	94	98	a	— —	93

NOTES:
[a]Sample not taken at this location.
[b]Sample locations were changed in 1990. None of the new locations were within the Semi-Works Aggregate Area.
Monthly/quarterly dose rates normalized to annual dose rate equivalent.
max = Maximum quarterly value reported.
min = Minimum quarterly value reported.
total = Annual average value reported.
Data Sources: Elder et al. 1986 through 1989, Schmidt et al. 1990 and 1992.
See Figure 4-1 and Plate 2 for sample locations.

Table 4-7. Summary of Grid Soil Sampling Results (1985-1989).

Radionuclide Average Concentration in pCi/g	Sample Location	
	2E16	2E22
Cerium-141	6.7E-03	
Cerium-144	-6.0E-02	-1.1E-02
Cobalt-58	6.8E-03	4.4E-03
Cobalt-60	1.2E-02	8.6E-03
Cesium-134	2.8E-02	8.0E-03
Cesium-137	3.7E+00	2.3E+00
Europium-152	1.1E-01	1.1E-01
Europium-154	-5.0E-03	2.3E-02
Europium-155	-1.6E-02	6.9E-02
Iodine-129		
Potassium-40		
Manganese-54	2.2E-02	1.3E-02
Niobium-95		
Lead-212		
Lead-214	6.6E-01	7.8E-01
Plutonium-238	1.2E-03	1.2E-03
Plutonium-239	9.4E-02	1.6E-01
Ruthenium-106	1.1E-01	-8.8E-02
Strontium-90	1.8E+00	5.2E-01
Technetium-99		
Uranium	3.8E-01	3.9E-01
Zinc-65	-4.3E-02	-4.3E-02
Zirconium-95	4.4E-02	2.5E-02

NOTES:
Concentrations reported are averages for all years that the location was sampled.
Blanks indicate radionuclide not analyzed, or results not reported.
Shaded values indicate a positive detection, results are greater than the measurement error of the analytical method.
Negative values indicate concentrations at or near background levels of radioactivity.
Data Sources:

Rockwell Hanford Operations Environmental Surveillance Annual Monitoring Reports -- 200/600 Areas (1985 and 1986).

Westinghouse Hanford Operations Environmental Surveillance Annual Monitoring Reports -- 200/600 Areas (1987 through 1990).

Table 4-8. Results of Grid Soil Sampling, 1990 Sample Location 63.

Radionuclide in pCi/g Dry Weight	Result	Error
Antimony-125	6.54E-02	6.70E-02
Beryllium-7	-1.87E+01	2.99E+01
Cerium-144	3.61E-02	6.45E-01
Cobalt-60	-1.93E-02	2.71E-02
Cesium-134	-4.84E-02	2.67E-02
Cesium-137	5.50E-01	7.00E-02
Europium-154	-7.23E-03	7.14E-02
Europium-155	5.14E-02	7.88E-02
Potassium-40	1.48E+01	1.67E+00
Lead-212	8.14E-01	9.41E-02
Lead-214	8.47E-01	1.07E-01
Plutonium-238	3.07E-04	3.42E-04
Plutonium-239/240(1)	3.08E-02	4.41E-03
Radium-226	7.39E-01	9.98E-02
Ruthenium-106	3.68E-01	3.23E-01
Strontium-90	1.63E+00	3.02E-01
Uranium	9.21E-01	1.27E-01
Uranium-235	3.41E-02	1.91E-02
Uranium-238	8.28E-01	1.16E-01
Zinc-65	-4.74E-01	1.90E-01
Zirconium/Niobium-95(1)	2.25E-01	3.78E+00

NOTES:
(1)Radionuclides cannot be distinguished.
(2)Shaded values indicate a positive detection, results are greater than the counting error of the measurement.
(3)Negative values indicate concentrations at or near background levels of radioactivity.
Source: Schmidt et al. 1992.

Table 4-9. Analysis of 284-E Power Plant Wastewater.

Constituent	Mean Concentration	Maximum Concentration
Aluminum, in µg/liter	3.64E+02	8.74E+02
Arsenic (EP Toxic), µg/liter	<5.00E+02	<5.00E+02
Barium, in µg/liter	6.02E+01	9.60E+01
Barium (EP Toxic), in µg/liter	<1.00E+03	<1.00E+03
Boron, in µg/liter	5.25E+01	6.20E+01
Cadmium (EP Toxic), in µg/liter	<1.00E+02	<1.00E+02
Calcium, in µg/liter	1.96E+04	2.09E+04
Chloride, in µg/liter	3.70E+03	6.00E+03
Chromium (EP Toxic), in µg/liter	<5.00E+02	<5.00E+02
Fluoride, in µg/liter	1.57E+02	1.86E+02
Iron, in µg/liter	1.54E+02	3.30E+02
Lead (EP Toxic), in µg/liter	<5.00E+02	<5.00E+02
Magnesium, in µg/liter	4.34E+03	4.44E+03
Manganese, in µg/liter	5.50E+00	7.00E+00
Mercury (EP Toxic), in µg/liter	<2.00E+01	<2.00E+01
Nitrate, in µg/liter	5.25E+02	6.00E+02
Potassium, in µg/liter	8.56E+02	1.04E+03
Selenium (EP Toxic), in µg/liter	<5.00E+02	<5.00E+02
Silicon, in µg/liter	3.10E+03	4.06E+03
Silver (EP Toxic), in µg/liter	<5.00E+02	<5.00E+02
Sodium, in µg/liter	9.04E+03	1.38E+04
Strontium, in µg/liter	2.40E+02	2.65E+02
Sulfate, in µg/liter	1.71E+04	1.99E+04
Uranium, in µg/liter	4.72E-01	6.18E-01
Zinc, in µg/liter	7.25E+00	1.30E+01
Ammonia, in µg/liter	5.35E+01	5.80E+01
1-Butanol, in µg/liter	1.80E+01	1.80E+01
Trichloromethane, in µg/liter	1.55E+01	2.60E+01
Total alpha, in pCi/L	8.98E-01	1.22E+00
Total beta, in pCi/L	1.80E+00	2.75E+00

Table 4-10. Summary of Grid Vegetation Sampling Results (1985-1989).

Radionuclide Average Concentration in pCi/g	Sample Location	
	2E16	2E22
Cerium-141	-2.8E-02	4.2E-02
Cerium-144		
Cobalt-58		
Cobalt-60	6.3E-03	2.3E-02
Cesium-134	1.7E-01	2.5E-01
Cesium-137	3.7E-01	3.4E-01
Europium-152	4.5E-02	1.3E-02
Europium-154	6.7E-03	2.5E-02
Europium-155	1.2E-02	8.9E-03
Iodine-129		
Potassium-40		
Manganese-54		
Niobium-95	-3.8E-02	-1.8E-02
Lead-212		
Lead-214		
Plutonium-238		
Plutonium-239		
Ruthenium-103	3.3E-01	2.4E-01
Ruthenium-106	4.8E-01	7.8E-01
Strontium-90		
Technetium-99		
Uranium		
Zinc-65		
Zirconium-95	2.3E-02	1.5E-02

NOTES:
Concentrations reported are averages for all years that the location was sampled.
Blanks indicate radionuclide not analyzed, or results not reported.
Shaded values indicate positive detection, results are greater than measurement error of analytical method.
Negative values indicate concentrations at or near background levels of radioactivity.
Data Sources:

Rockwell Hanford Operations Environmental Surveillance Annual Monitoring Reports -- 200/600 Areas (1985 and 1986).
Westinghouse Hanford Operations Environmental Surveillance Annual Monitoring Reports -- 200/600 Areas (1987 through 1990).

9 1 1 9 0 5 3 9 3 1

Table 4-11. Summary of Gamma Scintillation Logging Results. (sheet 1 of 2)

Waste Management Unit	Well Number	Relative Location	Remarks
Plants, Buildings, and Storage Areas			
201-C Process Building	No monitoring wells		
291-C Ventilation System	No monitoring wells		
Tanks and Vaults			
241-CX-70 Storage Tank	No monitoring wells		
241-CX-71 Storage Tank	No monitoring wells		
241-CX-72 Storage Tank	No monitoring wells		
Cribs and Drains			
216-C-1 Crib	299-E27-133	5 meters east of crib	Elevated gamma response between 2 and 12 meters below land surface.
216-C-3 Crib	No monitoring wells		
216-C-4 Crib	No monitoring wells		
216-C-5 Crib	299-E24-8	20 meters south of crib	Elevated gamma between 0-3 m probably due to waste transfer line 3.2 m from well. (Fecht et al. 1977)
216-C-6 Crib	No monitoring wells		
216-C-7 Crib			
216-C-10 Crib	299-E27-5	3 meters north of crib	Natural gamma response.
Critical Mass Laboratory Dry Well North	No monitoring wells		
Critical Mass Laboratory Dry Well South	No monitoring wells		
Critical Mass Laboratory Dry Well East	No monitoring wells		
Gatehouse French Drain	No monitoring wells		

Table 4-11. Summary of Gamma Scintillation Logging Results. (sheet 2 of 2)

Waste Management Unit	Well Number	Relative Location	Remarks
		Reverse Wells	
216-C-2 Reverse Well	No monitoring wells		
		Ponds, Ditches, and Trenches	
216-C-9 Pond	299-E27-1	50 meters north of pond	Natural gamma response.
200 East Powerhouse Ditch	No monitoring wells		
		Septic Tanks and Associated Drain Fields	
2607-E-5 Septic Tank and Drain Field	No monitoring wells		
2607-E-7A Septic Tank and Drain Field	No monitoring wells		
		Transfer Facilities, Diversion Boxes, and Pipelines	
Semi-Works Valve Pit	No monitoring wells		
Critical Mass Laboratory Valve Pit	No monitoring wells		
241-C-154 Diversion Box	No monitoring wells		
		Burial Sites	
218-C-9 Burial Ground	299-E27-1	50 meters north of burial ground	Natural gamma response.
		Unplanned Releases	
UN-200-E-36	No monitoring wells		
UN-200-E-37	No monitoring wells		
UN-200-E-98	No monitoring wells		
UN-200-E-141	No monitoring wells		
241-C Waste Line Unplanned Release No. 1	No monitoring wells		
241-C Waste Line Unplanned Release No. 2	No monitoring wells		

Source: Fecht et al. 1977.

Table 4-12. Concentrations in 216-C-2 Reverse Well Sediments.

Element	Laboratory A	Laboratory B
Cesium-137 in μCi/g	0.10	0.098
Europium-154 in μCi/g	0.16	
Europium-155 in μCi/g	0.17	
Americium-241 in μCi/g	0.18	<0.1
Strontium-90 in μCi/g	628	280
Plutonium-239 in μCi/g	0.052	0.062

NOTES:
Sample collected March 13, 1984.

Lab A: Radiation Measurement Team of the Analytical Process Development Unit, Rockwell International.

Lab B: Analytical Laboratories - Rockwell International.

Blanks indicate no reported values.

Table 4-13. Analysis of 209-E Critical Mass Laboratory Reflector Wastewater.

Constituent	Mean Concentration	Maximum Concentration
Barium, in µg/L	3.80E+01	3.80E+01
Calcium, in µg/L	1.97E+04	2.07E+04
Chloride, in µg/L	1.06E+03	1.22E+03
Copper, in µg/L	2.90E+01	4.30E+01
Fluoride, in µg/L	1.28E+02	1.30E+02
Iron, in µg/L	1.11E+02	1.38E+02
Lead (EP Toxic), in µg/L	9.00E+00	9.00E+00
Magnesium, in µg/L	4.48E+03	4.62E+03
Manganese, in µg/L	3.07E+01	3.90E+01
Potassium, in µg/L	7.16E+02	7.31E+02
Sodium, in µg/L	2.13E+03	2.20E+03
Strontium, in µg/L	9.63E+01	9.70E+01
Sulfate, in µg/L	1.04E+04	1.06E+04
Uranium, in µg/L	6.03E-01	7.47E-01
Zinc, in µg/L	1.76E+02	2.08E+02
Total alpha, in pCi/L	7.88E-01	9.83E-01
Total beta, in pCi/L	1.81E+00	3.03E+00

Table 4-14. Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Range of Soil Column Pore Volumes in m^3 (2)	Liquid Effluent Volume Received in m^3	Potential Migration to Unconfined Aquifer
	Cribs and Drains		
216-C-1 Crib	260 to 785	23,400	Yes
216-C-3 Crib	404 to 1,211	5,000	Yes
216-C-4 Crib	161 to 484	170	Yes (1)
216-C-5 Crib	161 to 484	38	No
216-C-6 Crib	161 to 484	530	Yes (1)
216-C-7 Crib	323 to 967	60	No
216-C-10 Crib	129 to 387	897	Yes
	Ponds, Ditches, and Trenches		
216-C-9 Pond	64,500 to 193,700	1,030,000	Yes
200 East Powerhouse Ditch	40,000 to 120,000	(3)	— —
	Reverse Well		
216-C-2 Reverse Well	78 to 235	(3)	— —

Assumptions:

- Area for infiltration equal to the dimension of the base of crib/ditch/pond/reverse well
- No evapotranspiration
- No lateral flow assumed
- Decision regarding the potential for migration to the unconfined aquifer is based on a pore volume of 0.1.

(1)The pore volume of the soil column is roughly the same order of magnitude as the total known volume of the waste received. Given the high permeability of the soil column, it is possible that the discharge waste volume reached the groundwater.

(2)Pore volume calculation: (waste unit section area) x (nominal depth to groundwater) x (porosity). Pore volume based on nominal depth to groundwater of 87 m (285 ft) for all waste unit structures, except 216-C-2 Reverse Well where 75 m (245 ft) was used for depth to groundwater from bottom of reverse well. 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.

(3)Volume information was not located.

Table 4-15. Chemical Analysis of Solids Samples from Tank 241-CX-70.

Analyte	Sample ID Numbers			
	913-5	913-4	913-3	913.3[1]
pH	11.4	11.4	11.3	11.3
Cyanide, in mg/kg	<0.5	<0.5	<0.5	<0.5
Aluminum, in mg/kg	72,000	57,000	60,000	55,000
Calcium, in mg/kg	1,600	1,500	2,100	1,800
Chromium, in mg/kg	5,400	4,600	5,100	5,000
Iron, in mg/kg	3,200	2,800	2,900	2,700
Mercury, in mg/kg	<0.0004	<0.0005	<0.0005	<0.0005
Potassium, in mg/kg	320	240	240	250
Magnesium, in mg/kg	150	10	180	100
Manganese, in mg/kg	2,400	1,700	1,900	1,600
Sodium, in mg/kg	62,000	59,000	58,000	59,000
Nickel, in mg/kg	120	96	110	93
Selenium in mg/kg[2]	500	390	460	450
Selenium, in mg/kg[3]	<0.005	<0.005	<0.005	<0.005
Uranium, in mg/kg	18,000	17,000	17,000	19,000
Zinc, in mg/kg	70	49	100	60
Total alpha, in mCi/kg	0.46	0.35	<0.4	0.44
Total beta, in mCi/kg	96	75	88	84
Cesium-137, in mCi/kg	1.2	1.3	1.2	1.2
Strontium-90, in mCi/kg	30	24	25	26
Americium-241, in mCi/kg	0.13	0.40	0.14	0.18
Plutonium 239/240, in mCi/kg	<0.6	<0.7	<0.8	<0.8

NOTES:
Sampling date: September 13, 1991.
[1]Duplicate analysis of sample 913-3.
[2]Analysis by Inductively Coupled Plasma Spectroscopy.
[3]Analysis by Hydride Atomic Absorption Spectroscopy.
< Not detected above detection limit indicated.

Table 4-16. Chemical Analysis of Solids Sample from Tank 241-CX-71. (sheet 1 of 2)

Analyte	Concentration
Aluminum, in mg/kg	2,897
Arsenic, in mg/kg	152
Barium, in mg/kg	228
Cadmium, in mg/kg	35.2
Chloride, in mg/kg	388
Chromium, in mg/kg	2,822
Chromium (VI), in mg/kg	<0.024
Copper, in mg/kg	195
Cyanide, in mg/kg	21.5
Fluoride, in mg/kg	158
Iron, in mg/kg	116,500
Lead, in mg/kg	16,020
Magnesium, in mg/kg	4,258
Manganese, in mg/kg	1,010
Mercury, in mg/kg	148
Neodymium, in mg/kg	3,196
Nickel, in mg/kg	135
Nitrate, in mg/kg	106,000
Nitrite, in mg/kg	<720
Phosphate, in mg/kg	<720
Phosphorus, in mg/kg	31,860
Selenium, in mg/kg	<1.55
Silicon, in mg/kg	2,489
Sodium, in mg/kg	1,867
Strontium, in mg/kg	382
Sulfate, in mg/kg	668
Tin, in mg/kg	102

Table 4-16. Chemical Analysis of Solids Sample from Tank 241-CX-71. (sheet 2 of 2)

Analyte	Concentration
Titanium, in mg/kg	203
Zinc, in mg/kg	512
Total alpha, in mCi/kg	0.032
Total beta, in mCi/kg	2.45
Cesium-137, in mCi/kg	0.045
Plutonium 239/240, in mCi/kg	0.021
Strontium-90, in mCi/kg	0.63
Uranium (total), in mCi/kg	0.0013

NOTES:
Sampling date: October 25, 1990.
< Not detected above detection limit indicated.

Table 4-17. Candidate Chemicals of Potential Concern for the Semi-Works Aggregate Area[a]. (sheet 1 of 2)

TRANSURANICS

Americium-241
Plutonium-238
Plutonium-239
Plutonium-240
Plutonium-241

URANIUM

Uranium-233
Uranium-234
Uranium-235
Uranium-238

FISSION PRODUCTS

Actinium-225
Actinium-227
Astatine-217*
Barium-137m
Beryllium
Bismuth-210
Bismuth-211
Bismuth-213
Bismuth-214
Cerium-141*
Cerium-144*
Cesium-134
Cesium-137
Cobalt-58*
Cobalt-60
Europium-152
Europium-154
Europium-155
Francium-221
Iodine-129
Lead-209
Lead-210
Lead-211
Lead-214
Manganese-54*
Niobium-91
Niobium-95*
Polonium-210
Polonium-213*
Polonium-214
Polonium-215*
Polonium-218
Potassium-40
Promethium-147
Protactinium-231
Protactinium-234m*
Radium-223
Radium-225
Radium-226
Radon-219*
Radon-222
Ruthenium-106
Strontium-90
Tantalum-182*
Technetium-99
Thallium-207
Thallium-209
Thorium-227
Thorium-229
Thorium-230
Thorium-231
Thorium-234
Tritium
Yttrium-90
Zirconium-95*

METALS

Aluminum
Barium
Beryllium
Bismuth
Cadmium
Chromium
Copper
Gadolinium
Iron
Lead
Magnesium
Manganese
Molybdenum
Neodymium
Nickel
Palladium
Strontium
Silver
Titanium
Zinc

OTHER INORGANICS

Aluminum nitrate nonahydrate
Aluminum sulfate
Ammonia
Ammonium bicarbonate
Ammonium fluoride
Ammonium nitrate
Boron
Calcium nitrate
Carbonate
Chloride
Chromium nitrate
Ferric nitrate
Ferric sulfate
Ferrous sulfamate
Fluoride
Hydrazine
Hydrogen peroxide
Iron hydroxide
Lead nitrate
Manganese oxide
Nickel nitrate
Nitrate/nitrite
Nitric acid
Nitric ferrous ammonium sulfate
Permanganate caustic
Phosphoric acid
Potassium
Potassium bicarbonate
Potassium persulfate
Silica
Silver nitrate
Sodium
Sodium aluminate
Sodium carbonate
Sodium dichromate
Sodium fluoride
Sodium hexametaphosphate
Sodium hydroxide
Sodium nitrate
Sodium nitrite
Sodium persulfate
Sodium phosphate
Sodium silicate
Sodium sulfate
Sodium sulfide
Sulfamic acid
Sulfate
Sulfuric acid
Trisodium phosphate
Zirconium oxide

VOLATILE ORGANICS

Chloroform
Hexone (MIBK)
Tributyl phosphate

Table 4-17. Candidate Chemicals of Potential Concern for the Semi-Works Aggregate Area[a]. (sheet 2 of 2)

SEMIVOLATILE ORGANICS
Acetic acid
1-Butanol
Caustic tartrate (CT)
Citric acid
Di-2-ethylhexyl-phosphoric acid
Ethylenediamine tetraacetic acid (EDTA)
Glycolic acid
Kerosene
Nitrilotriacetic acid (NTA)
Nonylphenoxy polyethoxy ethanol
Normal paraffins
Oxalic acid
Pentasodium diethylene
Sodium acetate
Tartaric acid
Tetrasodium-EDTA
Triamine penta acetate (DTPA)
Trisodium hydroxyethyl-ethylenediamine triacetate (HEDTA)

[a]Candidate chemicals of concern are those that were reported in waste management unit inventories, detected at elevated levels in environmental media within the aggregate area, or are expected to occur based on historical association with waste processes.

[b]The radionuclide has a half-life of <1 year and, if it is a daughter product, the parent has a half-life of <1 year, or the buildup of the short-lived daughter would result in an activity of <1% of the parent radionuclide's initial activity.

Table 4-18. Summary of Known and Suspected Contamination Released from Each Waste Management Unit and Unplanned Release at the Semi-Works Aggregate Area. (sheet 1 of 2)

Waste Management Unit	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
Plants, Buildings, and Storage Areas							
201-C Process Building	S	S					
291-C Ventilation System							
Tanks and Vaults							
241-CX-70 Storage Tank							
241-CX-71 Storage Tank	S	S					
241-CX-72 Storage Tank							
Cribs and Drains							
216-C-1 Crib	K	K	K	S	K	S	S
216-C-3 Crib	K	S	K	S	K	S	S
216-C-4 Crib	S	S	S	S	S		S
216-C-5 Crib	K	S	K	S	K	S	S
216-C-6 Crib	K	S	K	S	K	S	S
216-C-7 Crib				K	K	S	S
216-C-10 Crib	K	S	K	S	S	S	S
Critical Mass Laboratory Dry Well North							
Critical Mass Laboratory Dry Well South							
Critical Mass Laboratory Dry Well East							
Gatehouse French Drain (1)		S					
Reverse Wells							
216-C-2 Reverse Well	K	K	K	S	S		S
Ponds, Ditches, and Trenches							
216-C-9 Pond	K	S	K	S	S	S	S
200 East Powerhouse Ditch				K	K		K

Table 4-18. Summary of Known and Suspected Contamination Released from Each Waste Management Unit and Unplanned Release at the Semi-Works Aggregate Area. (sheet 2 of 2)

Waste Management Unit	TRU	Fission Products	Uranium	Metals	Other Inorganics	Volatiles	Semi-volatiles
Septic Tanks and Associated Drain Fields							
2607-E-5 Septic Tank and Drain Field							
2607-E-7A Septic Tank and Drain Field							
Transfer Facilities, Diversion Boxes, and Pipelines							
Semi-Works Valve Pit							
Critical Mass Laboratory Valve Pit (2)							
241-C-154 Diversion Box							
Burial Sites							
218-C-9 Burial Ground		S	S	K	S		
Unplanned Releases							
UN-200-E-36	S	S		S	S		
UN-200-E-37	S	S		S	S		
UN-200-E-98		S					
UN-200-E-141			S		S		
241-C Waste Line Unplanned Release No. 1		S		S	S		
241-C Waste Line Unplanned Release No. 2		S		S	S		

NOTES:

K Contamination of environmental media is known to have occurred based on waste inventory or sampling data and knowledge of waste release mechanism.

S Contamination of environmental media is suspected to have occurred based on historical process information or indications from nonspecific sampling data (e.g., gamma logs).

(1) Unit is marked radioactive but no inventory information available in documents reviewed.

(2) No inventory information available in documents reviewed.

Table 4-19. Chemicals of Potential Concern for the Semi-Works Aggregate Area.

TRANSURANICS

Americium-241
Plutonium-238
Plutonium-239
Plutonium-240
Plutonium-241

URANIUM

Uranium-233
Uranium-234
Uranium-235
Uranium-238

FISSION PRODUCTS

Actinium-225
Actinium-227
Barium-137m
Bismuth-210
Bismuth-211
Bismuth-213
Bismuth-214
Cesium-134
Cesium-137
Cobalt-60
Europium-152
Europium-154
Europium-155
Francium-221
Iodine-129
Lead-209
Lead-210
Lead-211
Lead-214
Niobium-91
Polonium-214
Polonium-218
Potassium-40
Protactinium-231
Radium-225
Radium-226
Ruthenium-106
Strontium-90
Technetium-99
Thallium-207
Thorium-227
Thorium-229
Thorium-230
Thorium-231
Thorium-234
Tritium
Yttrium-90

METALS

Barium
Beryllium
Bismuth
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Molybdenum
Nickel
Palladium
Silver
Zinc

OTHER INORGANICS

Ammonia
Ammonium bicarbonate
Boron
Calcium nitrate
Chromium nitrate
Ferric hydroxide
Ferric nitrate
Ferric sulfate
Ferrous sulfamate
Fluoride
Hydrazine
Lead nitrate
Nickel nitrate
Nitrate/nitrite
Nitric acid
Nitric ferrous ammonium sulfate
Permanganate caustic
Silver nitrate
Sodium dichromate
Sodium fluoride
Sodium nitrate
Sodium nitrite

VOLATILE ORGANICS

Chloroform
Hexone (MIBK)

SEMIVOLATILE ORGANICS

1-Butanol
Tributyl phosphate

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Table 4-20. Soil-Water Distribution Coefficients (K_d) for Radionuclides[a] and Inorganics of Potential Concern for the Semi-Works Aggregate Area. (sheet 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	100 to 1,000 (<1 at pH 1-3)	100	82	Low
Ammonia				na
Barium		50	530	Moderate
Beryllium	-	-	70	Moderate
Bismuth		20		Moderate
Cadmium		15	14.9	Moderate
Cesium	200 to 1,000 1 to 200 (acidic waste)	50	51	Low
Chromium (VI)		0	16.8	Moderate-High
Cobalt	500 to 2,000	10	1.9	Low
Copper		15	41.9	Moderate
Europium		50	228	Moderate
Fluoride			0	High
Francium				na
Iodine	<1	0	0	High
Lead		30	234	Moderate
Manganese		20	16.5	Moderate
Molybdenum		0	40	Low
Nickel		15	12.2	Moderate
Niobium			50	Moderate
Nitrate/nitric acid			0	High
Palladium			0.4	High
Plutonium	100 to 1,000 < 1 at pH 1 to 3	100	10	Low
Polonium			5.9	Moderate
Potassium			0	High
Protactinium			0	High
Radium		20	24.3	Moderate
Ruthenium	20 to 700 (<2 at >1 M nitrate)		274	Moderate
Silver		20	0.4	Moderate

Table 4-20. Soil-Water Distribution Coefficients (K_d) for Radionuclides[a] and Inorganics of Potential Concern for the Semi-Works Aggregate Area. (sheet 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
Strontium	5 to 100 3 to 5 (acidic conditions) 200 to 500 (w/phosphate or oxalate)	10	24.3	Moderate
Technetium	0 to 1	0	3	High
Thorium		50	100	Moderate
Tritium	0	0	0	High
Uranium		0	0	High
Yttrium			278	Low
Zinc		15	12.7	Moderate

[a]Radionuclides with half-lives of greater than one year or short-lived products of long-lived precursors.
[b]Average K_ds for low salt and organic solutions with neutral pH.
[c]Default values for pH 6-9 and soil content of [clay + organic matter + metal oxyhydroxides] < 10% (Strenge and Peterson 1989).
Value was not provided for this element in this reference.
na K_d value was not provided in sources cited in this table.

Table 4-21. Mobility of Inorganic Species in Soil.

High mobility (K_d<5)	
Boron	Protactinium
Fluoride	Technetium
Iodine	Tritium
Molybdenum	Uranium
Nitrate/Nitrite	
Palladium	
Potassium	
Moderate mobility (5<K_d<100)	
Barium	Nickel
Beryllium	Niobium
Bismuth	Polonium
Cadmium	Radium
Cerium	Ruthenium
Chromium(VI)	Silver
Copper	Strontium
Europium	Thorium
Lead	Zinc
Manganese	
Low Mobility (K_d>100)	
Actinium	
Americium	
Cesium	
Molybdenum	
Plutonium	
Yttrium	

9 3 1 2 9 0 5 1 9 2 7

Table 4-22. Physical/Chemical Properties of Organic Compounds of Potential Concern at Semi-Works Aggregate Area.

Compound	Molecular Weight in g/mole	Water Solubility in mg/liter	Vapor Pressure in mm Hg	Henry's Law Constant (K_h) in atm-m^3/mo	Soil/Organic Matter Partition Coef. (K_{oc}) in ml/g
1-Butanol	74.12	79,000	24	$4.8x10^{-6}$	4.7
Chloroform (trichloromethane)	119	8,200	150	2.9×10^{-3}	31
Hexone (MIBK)	100.16	19,000	6	4.2×10^{-5}	19
Tributyl phosphate	266.3	280	15	1.9×10^{-2}	6,000

Sources: Strenge and Peterson 1989, except as noted in footnotes below.

[a] Values listed in Hazardous Substance Data Base (HSDB), National Library of Medicine database (HSDB 1991).
[b] Kerosene properties are represented by 2-methyl naphthalene.

Blank - Value not available from above sources.

Table 4-23. Radiological Properties of Candidate Radionuclides of Potential Concern for the Semi-Works Aggregate Area. (sheet 1 of 2)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{225}Ac	10 d	5.8×10^{4}	α
^{227}Ac	21.8 yr	7.2×10^{1}	β, α
^{241}Am	432 yr	3.4×10^{0}	α
^{217}At	0.032 sec	1.6×10^{12}	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
^{141}Ce	32.5 d	2.8×10^{4}	β, γ[c]
^{144}Ce	284.3 d	3.2×10^{3}	β, γ[c]
^{58}Co	70.8 d	3.2×10^{-4}	γ[c]
^{60}Co	5.3 yr	1.1×10^{3}	γ
^{134}Cs	2.06 yr	1.3×10^{3}	γ
^{137}Cs	30 yr	8.7×10^{1}	γ[c]
^{152}Eu	13.6 yr	1.7×10^{-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[c]
^{221}Fr	4.8 min	1.8×10^{8}	α
^{3}H	12.3 yr	9.7×10^{3}	β
^{129}I	1.6×10^{7} yr	1.7×10^{-4}	β
^{40}K	1.3×10^{9} yr	6.7×10^{-6}	β, γ[c]
^{54}Mn	312.7 d	7.7×10^{3}	γ[c], e^{-}
^{91}Nb	10,000 yr	3.9×10^{-1}	γ[c]
^{95}Nb	34.97 d	3.9×10^{4}	β, γ
^{231}Pa	32,800 yr	4.7×10^{-2}	α
^{234m}Pa	1.17 min	6.9×10^{8}	β
^{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
^{214}Pb	26.8 min	3.3×10^{7}	β, γ[c]
^{147}Pm	2.6 yr	9.3×10^{2}	β
^{210}Po	128 d	4.9×10^{3}	α
^{213}Po	4.2×10^{-6} sec	1.3×10^{16}	α

Table 4-23. Radiological Properties of Candidate Radionuclides of Potential Concern for the Semi-Works Aggregate Area. (sheet 2 of 2)

Radionuclide	Half-Life	Specific Activity[a] in Ci/g	Radiation of Concern[b]
^{214}Po	6×10^{-5} sec	8.8×10^{14}	α
^{215}Po	7.8×10^{-4} sec	2.9×10^{13}	α
^{218}Po	3.05 min	2.8×10^{8}	α
^{238}Pu	87.7 yr	1.7×10^{1}	α
^{239}Pu	24,400 yr	6.2×10^{-2}	α
^{240}Pu	6,560 yr	2.3×10^{-1}	α
^{241}Pu	14.4 yr	1.0×10^{2}	β
^{223}Ra	11.43 d	5.1×10^{4}	α
^{225}Ra	14.8 d	3.9×10^{4}	β
^{226}Ra	1,600 yr	9.9×10^{-1}	α
^{219}Rn	4.0 sec	1.3×10^{10}	α
^{222}Rn	3.8 d	1.5×10^{5}	α, γ
^{106}Ru	1.0 yr	3.4×10^{3}	β, γ[c]
^{90}Sr	28.5 yr	1.4×10^{2}	β
^{182}Ta	114.7 d	3.4×10^{-7}	β, γ[c]
^{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
^{234}Th	24.1 d	2.3×10^{-4}	β
^{207}Tl	4.77 min	1.9×10^{8}	β, γ
^{209}Tl	2.2 min	4.1×10^{8}	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
^{238}U	4.5×10^{9} yr	3.4×10^{-7}	α
^{90}Y	6.41 hr	5.4×10^{5}	β
^{95}Zr	64 d	2.1×10^{4}	β

[a]Source: DOE 1990.
[b]α - alpha decay; β - negative beta decay; γ - release of gamma rays.
[c]Gamma radiation due to daughter product.

Table 4-24. Relative Risks for Radionuclides of Potential Concern for the Semi-Works Aggregate Area. (sheet 1 of 2)

Radionuclide	Half-Life[a]	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}
^{137m}Ba	2.6 min	3×10^{-10}	1.2×10^{-10}	6.5×10^{-12}	3.4×10^{-4}
^{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}
^{60}Co	5.3 yr	8.1×10^{-5}	7.8×10^{-7}	4.1×10^{-8}	1.3×10^{-3}
^{134}Cs	2.06 yr	1.4×10^{-5}	2.1×10^{-6}	1.1×10^{-7}	8.9×10^{-4}
^{137}Cs	30 yr	9.6×10^{-6}	1.4×10^{-6}	7.6×10^{-8}	0
^{152}Eu	13.3 yr	6.1×10^{-3}	1.1×10^{-7}	5.7×10^{-9}	6.3×10^{-4}
^{154}Eu	8.8 yr	7.2×10^{-5}	1.5×10^{-7}	8.1×10^{-9}	6.8×10^{-4}
^{155}Eu	4.96 yr	na	na	na	
^{221}Fr	4.8 min	4.7×10^{-7}	3.0×10^{-9}	1.6×10^{-10}	1.9×10^{-5}
^{3}H	12.3 yr	4.0×10^{-8}	2.8×10^{-9}	1.5×10^{-10}	0
^{40}K	1.3×10^{9} yr	4.0×10^{-6}	5.7×10^{-7}	3.0×10^{-8}	7.8×10^{-5}
^{91}Nb	10,000 yr	na	na	na	na
^{231}Pa	32,800 yr	2.0×10^{-2}	9.7×10^{-6}	5.1×10^{-7}	2.0×10^{-5}
^{209}Pb	3.25 hr	3.6×10^{-8}	4.3×10^{-9}	2.3×10^{-10}	0
^{210}Pb	22.3 yr	8.7×10^{-4}	3.4×10^{-5}	1.8×10^{-6}	1.8×10^{-6}
^{211}Pb	36.1 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	2.9×10^{-5}
^{214}Pb	26.8 min	1.5×10^{-6}	9.2×10^{-9}	4.9×10^{-10}	1.5×10^{-4}
^{214}Po	6×10^{-5} sec	1.4×10^{-13}	5.1×10^{-16}	2.7×10^{-17}	4.7×10^{-8}
^{218}Po	3.05 min	3.0×10^{-7}	1.4×10^{-9}	7.6×10^{-11}	0
^{238}Pu	87.7 yr	2.1×10^{-2}	1.4×10^{-5}	7.6×10^{-7}	5.9×10^{-7}
^{239}Pu	24,400 yr	2.6×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	2.6×10^{-7}
^{239}Pu oxide	24,400 yr	2.6×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	2.6×10^{-7}

Table 4-24. Relative Risks for Radionuclides of Potential Concern for the Semi-Works Aggregate Area. (sheet 2 of 2)

Radionuclide	Half-Life[a]	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 $(pCi/g)^{-1}$
^{240}Pu	6,560 yr	2.1×10^{-2}	1.6×10^{-5}	8.4×10^{-8}	5.9×10^{-7}
^{240}Pu oxide	6,560 yr	2.1×10^{-2}	1.6×10^{-6}	8.4×10^{-8}	5.9×10^{-7}
^{241}Pu	14.4 yr	1.5×10^{-4}	2.5×10^{-7}	1.3×10^{-8}	0
^{225}Ra	14.8 d	8.2×10^{-4}	3.4×10^{-6}	1.8×10^{-7}	8.0×10^{-6}
^{226}Ra	1,600 yr	1.5×10^{-3}	6.1×10^{-6}	3.2×10^{-7}	4.1×10^{-6}
^{106}Ru	1.0 yr	2.3×10^{-4}	4.9×10^{-7}	2.6×10^{-8}	0
^{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}
^{234}Th	24.1 d	1.6×10^{-5}	2.0×10^{-7}	1.1×10^{-8}	5.6×10^{-6}
^{207}Tl	4.77 min	2.3×10^{-9}	6.6×10^{-10}	3.5×10^{-11}	1.2×10^{-6}
^{209}Tl	2.20 min	2.2×10^{-9}	7.2×10^{-10}	3.8×10^{-11}	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]Source: DOE 1990.
[b]Excess cancer risk associated with lifetime exposure to 1 pCi/m^3 (10^{-12} curies) per day in air (EPA 1991).
[c]Excess cancer risk associated with lifetime exposure to 1 pCi (10^{-12} curies) per day in drinking water (EPA 1991).
[d]Excess cancer risk associated with lifetime exposure to 1 pCi/g (10^{-12} curies/g) per day in soil (EPA 1991).
[e]Excess cancer risk associated with lifetime exposure to surface soils containing 1 pCi/g of gamma-emitting radionuclides (EPA 1991).

na = No information available.

Table 4-25. Potential Chronic Health Effects of Candidate Chemicals of Potential Concern for the Semi-Works Aggregate Area. (sheet 1 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
INORGANIC CHEMICALS		
Aluminum		
Aluminum nitrate nonahydrate	(see nitrate)	(see nitrate)
Aluminum sulfate		
Ammonia		decreased pulmonary function; degrades odor; taste of water
Ammonium bicarbonate	(see ammonia)	(see ammonia)
Ammonium fluoride	(see fluoride, ammonia)	(see fluoride, ammonia)
Ammonium nitrate	(see ammonia, nitrate)	(see ammonia, nitrate)
Barium		fetotoxicity; increased blood pressure
Beryllium	lung [B2]; tutal tumors [B2]	
Bismuth	NA;NA	NA;NA
Boron		NA; testicular lesions
Cadmium	respiratory tract [B1]; NA	cancer; renal damage
Calcium nitrate	(see nitrate)	(see nitrate)
Chloride		
Chromium	lung [A] - Cr(VI) only; NA	nasal mucosa atrophy (Cr(III)and (VI)); hepatotoxicity (Cr (III)
Chromium nitrate	(see chromium and nitrate)	(see chromium and nitrate)
Copper		NA; gastrointestinal irritation
Ferric nitrate	(see nitrate)	(see nitrate)
Ferric hydroxide		
Ferric sulfate		
Ferrous sulfamate		
Fluoride		NA; dental fluorosis at high levels
Hydrazine	nasal cavity [B2];liver[B2]	NA;NA
Hydrogen peroxide	NA;NA	NA;NA
Iron		
Lead	[B2][b]; [B2]	central nervous system (CNS) effects[b]; CNS effects
Lead nitrate	(see lead, nitrate)	(see lead, nitrate)
Magnesium		
Manganese		respiratory, psychomotor symptoms; no effect
Molybdenum		NA;changes in biochemical indices
Neodynium		
Nickel	respiratory tract [A]; NA	cancer; reduced weight gain

Table 4-25. Potential Chronic Health Effects of Candidate Chemicals of Potential Concern for the Semi-Works Aggregate Area. (sheet 2 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
Nickel nitrate	(see nickel, nitrate)	(see nickel, nitrate)
Nitrate/Nitrite		NA; methemoglobinemia in infants[e]
Nitric acid	(see nitrate)	(see nitrate)
Nitric ferrous ammonium sulfate	(see nitrate, ammonia)	(see nitrate, ammonia)
Palladium		
Permanganate caustic	(see manganese)	(see manganese)
Phosphate		
Phosphoric acid		
Potassium		
Potassium bicarbonate		
Potassium persulfate		
Silica		
Silver		NA; argyria
Silver nitrate	(see nitrate, silver)	(see nitrate, silver)
Sodium		
Sodium aluminate		
Sodium carbonate		
Sodium dichromate	(see chromium(VI))	(see chromium(VI))
Sodium fluoride	(see fluoride)	(see fluoride)
Sodium hexametaphosphate		
Sodium hydroxide		
Sodium nitrate	(see nitrate)	(see nitrate)
Sodium nitrite	(see nitrite)	(see nitrite)
Sodium persulfate		
Sodium phosphate		
Sodium silicate		
Sodium sulfate		
Sodium sulfide		
Strontium		
Sulfamic acid		
Sulfate		
Sulfuric acid		respiratory; NA
Titanium		
Trisodium phosphate		
Uranium		NA; body weight loss, nephrotoxicity
Zinc		NA; anemia

Table 4-25. Potential Chronic Health Effects of Candidate Chemicals of Potential Concern for the Semi-Works Aggregate Area. (sheet 3 of 3)

Chemical	Tumor Site Inhalation Route; Oral Route [Weight of Evidence Group[a]]	Non-carcinogenic Chronic Health Effects Inhalation Route; Oral Route
Zirconium oxide		
ORGANIC CHEMICALS		
Acetic acid		
1-Butanol	NA;NA	NA; effects on erythrocytes
Caustic tartrate		
Chloroform	liver [B2]; kidney [B2]	NA; liver lesions
Citric acid		
Dibutyl phosphate		
Di-2-ethylhexyl phosphoric acid		
Ethylenediamine tetraacetic acid (EDTA)		
Glycolic acid		
Hexone (MIBK)		liver and kidney effects; liver and kidney effects
Kerosene (n-paraffins)		
Nitrilotriacetic acid (NTA)		
Nonylphenoxy polyethoxy ethanol		
Oxalic acid		
Pentasodium diethylene		
Sodium acetate		
Sodium oxalate		
Tartaric acid		
Tetrasodium-EDTA		
Triamine pentaacetate		
Tributyl phosphate		
Trisodium hydroxyethyl-EDTA		

[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.

Source: EPA 1991 and 1992. A blank space means that no information was available from these sources.

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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 Semi-Works 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 Semi-Works 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 management 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 Semi-Works 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 4-17. 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 Semi-Works 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 Semi-Works 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 the 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 that are not available for most units.

The human health concerns, and various hazard ranking scores listed above, are used to establish whether or not a waste management 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 measure (IRM). "Low" priority sites are evaluated to determine what type of additional investigation is necessary to establish a final remedy. Further detail is presented in Section 9.0.

The data used for this evaluation are presented in the earlier sections of this report. The types of data that have been assessed include waste management units histories and physical descriptions (Section 2.0), descriptions of the physical environment of the study area (Section 3.0) and a summary of the available chemical and radiological data for each waste management unit (Section 4.0).

The quality and sufficiency of these data are assessed in Section 8.0. This information is also used to identify potentially applicable or relevant and appropriate requirements (ARARs) (Section 6.0).

5.1 CONCEPTUAL FRAMEWORK FOR RISK-BASED SCREENING

The range of potential human health and environmental exposure pathways at the Semi-Works 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 Semi-Works Aggregate Area contaminants is currently constrained by the lack of data. This gap in the Semi-Works Aggregate Area data is discussed in Section 8.2.3. As a result, the risk-based screening of waste management unit priorities discussed in this section is by necessity limited to potential human health risks.

The U.S. Environmental Protection Agency (EPA 1989a) considers a human exposure pathway to consist of four elements: (1) a source and mechanism for contaminant release, (2) a retention or transport medium (or media), (3) a point of potential human contact, and (4) an exposure route (e.g., ingestion) at the contact point. The probability of the existence of a particular pathway is dependent upon the physical and institutional controls affecting 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 Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works 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 East 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 to the waste management units and the integrity of engineered barriers.

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 Semi-Works Aggregate Area waste management units are presented in Table 5-1 from the available survey data.

For 11 of the 25 Semi-Works Aggregate Area waste management units, no radiation survey data are available. For those units that do have radiation survey data of some type, 4 were reported as having no contamination detected. Units where contamination was detected were the 291-C Ventilation System, the 241-CX-70, and 241-CX-72 storage tanks and the 216-C-2 Reverse Well.

Westinghouse Hanford manual WHC-CM-4-10, Section 7 (WHC 1988b) was used as the basis for setting one of the criteria that are used to identify waste management units that can be considered high priority sites. The manual indicates that waste management units with radiation levels of 2 mrem/h be posted with "Radiation Area" signs and undergo access controls for the purposes 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.

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 management 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. Available gross contamination survey data for the Semi-Works Aggregate Area waste management units are provided in Table 5-1.

The Westinghouse Hanford Environmental Protection Group policies state that the presence of any smearable alpha constitutes a potential threat to human health and qualifies a waste management unit for a high remediation priority (Huckfeldt 1991b). Waste management units that exhibit elevated alpha readings in radiological surveys can be presumed to have surface contamination, since alpha radiation cannot penetrate solids. As indicated in Table 4-5, smearable alpha was detected only at the 241-CX-70 Tank. This waste management unit is currently covered by the ash barrier and thus does not pose a hazard from contact with alpha radiation. Recent surveys indicate that no detectable levels of alpha contamination have been found on top of the ash barrier.

Westinghouse Hanford manual *Radiation Protection* (WHC 1988b) was also used to set criteria for identifying waste management units that can be considered high remediation priority sites. The manual indicates that 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 purposes 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%.

Waste management units that exceed the above criterion are the 241-CX-70 Storage Tank, the 241-CX-72 Storage Tank, and the 216-C-2 Reverse Well (see Table 5-1). The radiation measured at the tanks and reverse well was confined to discrete areas - bricks and concrete in the ash barrier material (storage tanks) and accessory piping (reverse well).

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.

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 Semi-Works Aggregate Area. Although several semivolatile compounds, such as tributyl phosphate and paraffin hydrocarbons, have been disposed of 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 can not 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 East Groundwater AAMSR, and thus, will not be discussed in the Semi-Works 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 units 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 management unit prioritization. The HRS ranking system evaluates sites based on their relative risk, taking into account the population at risk, the hazardous waste constituent toxicity and concentration at the facility, the potential for contamination of the environment, the potential risk of fire and explosion, and the potential for exposure associated with humans or animals that come into contact with the waste management unit inventory. The HRS is, thus, appropriate to consider for screening waste management units.

The PA/SI screening was performed using the EPA's HRS and the mHRS. The HRS (40 CFR 300) is a site ranking methodology that was designed to determine whether sites should be placed on the CERCLA National Priorities List (NPL) based on chemical contamination history. The EPA has established the criteria for placement on the NPL to be a score of 28.5 or greater. The HRS criteria used in 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 Semi-Works Aggregate Area waste management units were ranked in the PA/SI using both the HRS and mHRS. For those waste management units that were not ranked in the PA/SI, unit type and discharge history were evaluated in comparison with ranked units for the purpose of setting priorities. If a waste management unit that has been ranked exhibits similar characteristics (e.g., construction, waste type, and volume), the value for the ranked unit was applied to the unit without an HRS or mHRS score. If no ranked waste management units exhibit similar characteristics, then the unit was not ranked; however, a high or low score was determined qualitatively through evaluation of unit configuration and contamination history.

Table 5-1 lists the HRS and mHRS rankings, as well as scores that were assigned for unranked waste management units, based on their similarity to ranked units in terms of type, construction, and quantity of waste disposed. If no similar waste management units were available for comparison, the units were not ranked but were assigned a qualitative indicator of migration potential based on engineering judgement considering factors such as type of unit, waste characteristics, and volume of liquid received. 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, 2 units of the 25 Semi-Works Aggregate Area waste management units were given a score of 28.5 or greater. For the mHRS ranking, 2 units were given a score of 28.5 or greater (both of which had HRS scores greater than 28.5). No units received a qualitative "high" score and 16 units received a qualitative "low" score. The units that received "low" scores (2 process buildings, 3 tanks, 1 reverse well, 1 pond, 1 ditch, 2 septic tanks, 3 valve pits/diversion boxes, 1 burial ground, and 2 unplanned releases) were given such a ranking because there is no known history of liquid hazardous material disposal that could affect groundwater beneath the Semi-Works Aggregate Area.

None of the 25 units were assigned Westinghouse Environmental Protection Group scores of 7 or greater, indicating the need for remedial action.

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 Semi-Works Aggregate Area waste management units that exceeded one or more of the screening criteria identified in the preceding Sections. In total, 2 units were identified as high priority.

Radiation survey results (dose rate and/or contamination) were available for 9 of the 25 waste management units and unplanned releases. Four were reported as having no detectable results. Of the remaining 5 units, all 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, 2 waste management units were given scores of 28.5 or greater. For the mHRS, the same 2 units received a score of 28.5 or greater. No units received qualitative "high" scores. None of the 25 units were assigned Westinghouse Environmental Protection Group scores of 7 or greater, indicating the need for remedial action. Some of the sites were designated as high priority for 2 or more of the criteria, hence only 2 total units are designated high priority.

Table 5-1. Identification of High Priority Waste Management Units for the Semi-Works Aggregate Area. (sheet 1 of 2)

Waste Management Unit	HRS Rating	mHRS Rating	Radiation Surveys			Environmental Protection Score	Priority
			ct/min	dis/min	mrem/hr		
Plants, Buildings, and Storage Areas							
201-C Process Building	Low	Low	NA	NA	2.5 to 1,500		Low[c]
291-C Ventilation System	Low	Low	350	NA	NA		Low[c]
Tanks and Vaults							
241-CX-70 Storage Tank	Low	Low	NA	17,000	NA		Low[b]
241-CX-71 Storage Tank	Low	Low	NA	NA	NA		Low
241-CX-72 Storage Tank	Low	Low	NA	15,000	NA		Low[b]
Cribs and Drains							
216-C-1 Crib	50.34	39.23	ND	ND	NA		High
216-C-3 Crib	1.04	1.14	ND	ND	ND		Low
216-C-4 Crib	1.09	1.14	ND	ND	ND		Low
216-C-5 Crib	1.09	0.82	ND	ND	NA		Low
216-C-6 Crib	1.04	1.14	ND	ND	NA		Low
216-C-7 Crib	1.04[a]	1.14[a]	ND	ND	ND		Low
216-C-10 Crib	47.82	33.29	NA	ND	ND		High
Reverse Wells							
216-C-2 Reverse Well	Low	Low	500	ND	ND		Low[c]
Ponds, Ditches, and Trenches							
216-C-9 Pond	Low	Low	ND	ND	NA		Low
200 East Powerhouse Ditch	Low	Low	NA	NA	NA		Low

Table 5-1. Identification of High Priority Waste Management Units for the Semi-Works Aggregate Area. (sheet 2 of 2)

Waste Management Unit	HRS Rating	mHRS Rating	Radiation Surveys			Environmental Protection Score	Priority
			ct/min	dis/min	mrem/hr		
Septic Tanks and Associated Drain Fields							
2607-E-5 Septic Tank and Drain Field	Low	Low	NA	NA	NA		Low
2607-E-7A Septic Tank and Drain Field	Low	Low	NA	NA	NA		Low
Transfer Facilities, Diversion Boxes, and Pipelines							
Semi-Works Valve Pit	Low	Low	NA	NA	NA		Low
Critical Mass Laboratory Valve Pit	Low	Low	NA	NA	NA		Low
241-C-154 Diversion Box	Low	Low	NA	NA	NA		Low
Burial Sites							
218-C-9 Burial Ground	Low	Low	NA	NA	NA		Low
Unplanned Releases							
UN-200-E-36	1.25	1.30	ND	ND	ND		Low
UN-200-E-37	1.25	1.30	NA	ND	NA		Low
UN-200-E-98	Low	Low	NA	NA	NA		Low
UN-200-E-141	Low	Low	NA	NA	NA		Low

NOTES:
NA = No radiation survey measurement was located for this parameter.
ND = Radiation was measured but not detected.
Blank entries indicate no applicable data found during document review.
[a]Score assigned based on similarity to the 216-C-6 Crib.
[b]Radiation surveys of tanks do not reflect current status of tank areas. Tank 241-CX-70 is currently covered by a plastic structure to allow access to the tank through an excavation. Tank 241-CX-72 area was covered with a concrete slab. Radiation survey was not used to prioritize units.
[c]Radiation survey was performed before placement of ash barrier (1987). Radiation survey was not used to prioritize unit.

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 Semi-Works Aggregate Area. Specific requirements pertaining to hazardous and radiological waste management, remediation of contaminated soils, surface water protection, and air quality will be discussed.

The potential ARARs focus on federal or state statutes, regulations, criteria, and guidelines. The specific types of potential ARARs evaluated include the following:

- Contaminant-specific
- Location-specific
- Action-specific.

Potential contaminant-specific ARARs are usually health or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical contaminant values that are generally recognized by the regulatory agencies as allowable to protect human health and the environment. In the case of the Semi-Works Aggregate Area, potential contaminant-specific ARARs address chemical constituents and/or radionuclides. The potential contaminant-specific ARARs that were evaluated for the Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area. Specific TBC requirements are discussed in Section 6.5.

Potential contaminant- and location-specific ARARs will be refined during the aggregate area management study (AAMS) process. Potential action-specific ARARs are briefly discussed in this section, and will be further evaluated upon final selection of remedial alternatives. The points at which these ARARs must be achieved and the timing of the ARARs evaluations are discussed in Sections 6.6 and 6.7, respectively.

6.2 CONTAMINANT-SPECIFIC REQUIREMENTS

A contaminant-specific requirement sets concentration limits in various environmental media for specific hazardous substances, pollutants, or contaminants. Based on available information, some of the currently known or suspected contaminants that may be present in the Semi-Works Aggregate Area are outlined in Table 4-19. 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 Semi-Works Aggregate Area, as no natural surface water bodies exist. The only existing man-made surface water body at Semi-Works Aggregate Area is a waste management unit: the powerhouse ditch.

- **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 Semi-Works 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 potential 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 potential 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 OWSER 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 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 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 preconstruction 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 Semi-Works 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 Semi-Works Aggregate Area (groundwater will be addressed in the 200 East Groundwater Aggregate Area Management Study Report). 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 Semi-Works Aggregate Area. Method B and Method C cleanup standards can be calculated on a case-by-case basis in concert with Ecology. Method B and Method C should be used where Method A standards do not exist or cannot be met, or where routine cleanup actions cannot be implemented at a specific waste management unit.

- **State Hazardous Waste Management Act and Dangerous Waste Regulations (Chapter 173-303 WAC).** The State of Washington is a RCRA-authorized state for hazardous waste management, and has developed state-specific hazardous waste regulations under the authority of the State Hazardous Waste Management Act. Generally, state hazardous waste regulations (WAC 173-303) parallel the federal regulations. The state definition of a hazardous waste incorporates the EPA designation of hazardous waste that is based on the compound being specifically listed as hazardous, or on the waste exhibiting the properties of reactivity, ignitability, corrosivity, or toxicity as determined by the TCLP.

  In addition, Washington State identifies other waste as hazardous. Three unique criteria are established: toxic dangerous waste; persistent dangerous waste; and carcinogenic dangerous waste. These additional designation criteria may be imposed by Ecology as potential ARARs, for purposes of determining acceptable cleanup standards and appropriate waste management standards.

- **Ambient Air Quality Standards and Emission Limits for Radionuclides (Chapter 173-480 WAC).** These Ecology ambient air quality standards specify maximum accumulated dose limits to members of the public. Other Air Quality Standards potentially applicable include carbon monoxide, ozone, nitrogen dioxide (WAC 173-475), and volatile organic compounds (VOCs) (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 (Chapters 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. These standards apply to DOE facilities as provided in WAC 246-247-010 (2).

- **Controls for New Sources of Toxic Air Pollutants (Chapter 173-460 WAC).** In accordance with regulations recently promulgated by Ecology in Chapter 173-460 WAC, any new emission source will be subject to Toxic Air Pollutant emission standards. The regulations establish acceptable 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 Amendments to 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 additional 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.

These water quality standards do not constitute ARARs for purposes of establishing cleanup standards for the Semi-Works Aggregate Area.

Groundwater will be addressed in the 200 East Groundwater AAMSR in which pertinent groundwater-related potential ARARs will be covered. No surface water bodies exist within the Semi-Works 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 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 Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area. However, Wild and Scenic Rivers Act requirements may be potential ARARs for actions taken as a result of Semi-Works 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 offsite 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.

- **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 Semi-Works 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 Semi-Works 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 to 177).** The Department of Transportation standards contained in 49 CFR 171 to 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.

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 Semi-Works Aggregate Area. Solid waste standards include such requirements as follows:

  - 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 Semi-Works 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 Semi-Works 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 Semi-Works 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 173-303-170 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 TBC in determining the appropriate degree of remediation for the Semi-Works Aggregate Area. A myriad of resources may be potentially evaluated. The following represents an initial assessment of pertinent TBC provisions.

6.5.1 Health Advisories

The EPA Office of Drinking Water publishes advisories identifying contaminants for which health advisories have been issued.

6.5.2 International Commission 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 Semi-Works Aggregate Area. In particular, EPA included an appendix, "Appendix A - Examples of Concentrations Meeting Criteria for Action Levels," which presented recommended contaminant concentrations warranting corrective action. These contaminant-specific TBCs are included in Table 6-1 for the preliminary contaminants of concern.

6.5.4 Department of Energy Standards for Radiation Protection

A number of DOE Orders exist which could be TBCs. The DOE Orders that establish potential contaminant-specific or action-specific standards for the remediation of radioactive wastes and materials are discussed below.

- **DOE Order 5400.5 - DOE Standards for Radiation Protection of the Public and Environment.** The DOE Order 5400.5 establishes the requirements for DOE facilities to protect the environment and human health from radiation including soil and air contamination. The purpose of the Order is to establish standards and requirements for operations of the DOE and DOE contractors with respect to protection of members of the public and the environment against undue risk from radiation.

  The Order mandates that the exposure to members of the public from a radiation source as a consequence of routine activities shall not exceed 100 mrem/yr from all exposure sources due to routine DOE activities. In accordance with the Clean Air Act, exposures resulting from airborne emissions shall not exceed 10 mrem/yr to the maximally exposed individual at the facility boundary. The DOE Order 5400.5 provides Derived Concentration Guide (DCG) values for releases of radionuclides into the air or water. The DCG values are calculated so that, under conditions of continuous exposure, an individual would receive an effective dose equivalent of 100 mrem/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, 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 Semi-Works Aggregate Area remediation activities include those related to transuranic waste and low-level radioactive waste. These are summarized below.

- **Management of Transuranic Waste.** Transuranic (TRU) waste resulting from the Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area will be the determination of the point at which compliance with identified ARARs must be achieved (i.e., the point of a specific ARAR's applicability). These points of applicability are the boundaries at which the effectiveness of a particular remedial alternative will be assessed.

For most individual radioactive species transported by either water or air, Ecology and Health standards generally require compliance at the boundaries of the Hanford Site (e.g., Clean Air Act, Section 6.2.1). The assumed point of compliance for radioactive species is the point where a member of the public would have unrestricted access to live and conduct business, and, consequently, to be maximally exposed. Although Health is responsible for monitoring and enforcing the air standards promulgated by Ecology, and generally recognizes the site boundary as the point of applicability, Ecology has recently indicated that compliance may be required at the point of emission.

The point at which compliance with identified ARARs must be achieved will be a significant factor in evaluating appropriate remedial alternatives in the Semi-Works 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 Semi-Works 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 impractical.
- An alternative remedial action will attain the equivalent performance of the ARAR.
- For state ARARs, the state has not consistently applied (or demonstrated the intention to consistently apply) the requirements in similar circumstances.
- For CERCLA-financed actions under Section 104, compliance with the ARAR will not provide a balance between the need for protecting public health, welfare, and the environment at the facility, and the need for fund money to respond to other sites (this waiver is not applicable at the Hanford Site).

Once investigations have been completed and final remedies have been selected, the ARARs that must be met will be formally identified in the Record of Decision (ROD). Compliance with those ARARs specified in the ROD will be achieved through the remedial action. The ARARs may need to be reevaluated if unanticipated circumstances are encountered during remediation which prevent the ability to satisfy the identified ARARs.

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Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic and Organic Contaminants of Concern. (sheet 1 of 2)

	RCRA TCLP Designation Limits	RCRA Land Ban Limits Nonwastewater		MTCA Method A Cleanup Level Industrial Soil	WCAA Toxic Air Pollutants ASIL	RCRA Corrective Action Level (1) (Proposed)	
	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
METALS							
Barium	100.0	100.0	—	—	1.7	0.4	4000.0
Bismuth	—	—	—	—	—	—	—
Boron	—	—	—	—	—	—	—
Cadmium	1.0	1.0	—	10.0	0.00056	0.0006	40.0
Chromium (VI)	5.0	5.0	—	500.0	0.000083	0.00009	40.0
Chromium (III)	5.0	—	—	500.0	1.7	—	—
Copper	—	—	—	—	3.3	—	—
Iron	—	—	—	—	—	—	—
Lead	5.0	5.0	—	1000.0	—	—	—
Manganese	—	—	—	—	16.7	—	—
Molybdenum	—	—	—	—	33.3	—	—
Nickel	—	—	—	—	—	—	2000.0
Palladium	—	—	—	—	—	—	—
Silver	5.0	5.0	—	—	0.3	—	—
Zinc	—	—	—	—	—	—	—
OTHER INORGANICS							
Ammonia	—	—	—	—	59.9	—	—
Ammonium bicarbonate	—	—	—	—	—	—	—
Calcium nitrate	—	—	—	—	—	—	—
Chromium nitrate	—	—	—	—	1.7	—	—
Ferric hydroxide	—	—	—	—	—	—	—
Ferric nitrate	—	—	—	—	—	—	—
Ferric sulfate	—	—	—	—	—	—	—
Ferrous sulfamate	—	—	—	—	—	—	—
Fluoride	—	—	—	—	8.3	—	—
Hydrazine	—	—	—	—	—	—	—
Lead nitrate	—	—	—	—	—	—	—
Nickel nitrate	—	—	—	—	—	—	—
Nitrate (as Nitrogen)	—	—	—	—	—	—	—
Nitrite (as Nitrogen)	—	—	—	—	—	—	—
Nitric acid	—	—	—	—	16.7	—	—
Nitric ferrous ammonium sulfate	—	—	—	—	—	—	—
Permanganate caustic	—	—	—	—	—	—	—
Silver nitrate	—	—	—	—	—	—	—
Sodium dichromate	—	—	—	—	—	—	—
Sodium fluoride	—	—	—	—	—	—	—
Sodium nitrate	—	—	—	—	—	—	—
Sodium nitrite	—	—	—	—	—	—	—

Table 6-1. Potential Contaminant-Specific ARARs and TBCs for Preliminary Inorganic and Organic Contaminants of Concern. (sheet 2 of 2)

	RCRA TCLP Designation Limits	RCRA Land Ban Limits Nonwastewater		MTCA Method A Cleanup Level Industrial Soil	WCAA Toxic Air Pollutants ASIL	RCRA Corrective Action Level (1) (Proposed)	
ORGANICS							
1-Butanol	—	5.0	2.6	—	—	499.5	—
Chloroform	6.0	—	5.6	—	0.043	0.04	100.0
Methyl isobutyl ketone	—	0.33	33.0	—	682.7	70.0	4000.0
Tributyl phosphate	—	—	—	—	8.3	—	—

NOTES:
(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."
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.
ug/m3 = micrograms per cubic meter.

Table 6-2. Potential Location-Specific ARARs. (sheet 1 of 4)

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 disposal within 154 m (500 ft) of surface water (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
	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

Table 6-2. Potential Location-Specific ARARs. (sheet 2 of 4)

Location	Requirement	Prerequisite	Citation
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
GROUNDWATER			
Water codes 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 resources 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 173-303-402; WAC 173-304-130
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 reduction in water quality. Stat 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

Table 6-2. Potential Location-Specific ARARs. (sheet 3 of 4)

Location	Requirement	Prerequisite	Citation
DRINKING WATER SUPPLY			
Drinking water supply well	New solid waste disposal areas prohibited within 305 m (1000 ft) upgradient, or 90 days travel time, of drinking water supply well	New solid waste disposal within 305 m (1000 ft) of drinking water supply well	WAC 173-304-130
Watershed	New solid waste disposal areas prohibited within a watershed used by a public water supply system for municipal drinking water	New solid waste disposal in a public watershed	WAC 173-304-130
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 incinerator 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 ft) of state or national park	New solid waste disposal near state/national park	WAC 173-304-130
	Restrictions on activities in areas that are designated state parks, or recreation/conservation areas	Activities in state parks or recreation/conservation areas	Chapter 43.51 RCW; Chapter 352.32 WAC
Wilderness areas	Actions within designated wilderness areas must ensure area is preserved and not impaired	Activities within designated wilderness areas	16 USC 1131 *et seq*; 50 CFR 35.1 *et seq*
Wildlife refuge	Restrictions on actions in areas that are part of the National Wildlife Refuge System	Activities within designated wildlife refuges	16 USC 668dd *et seq*; 50 CFR Part 27
Natural areas preserves	Activities restricted in areas designated as having special habitat value (Natural Heritage Resources)	Activities within identified Natural Area Preserves	Chapter 79.70 RCW; Chapter 332-60 WAC

Table 6-2. Potential Location-Specific ARARs. (sheet 4 of 4)

Location	Requirement	Prerequisite	Citation
Wild, scenic, or recreational rivers	Avoid actions that would have adverse effects on designated wild, scenic, or recreational rivers	Activities near wild, scenic, and recreational rivers	16 USC 1271 *et seq*; 40 CFR 6.302; Chapter 79.72 RCW
Columbia River Gorge	Restrictions on activities that could affect resources in the Columbia River Gorge	Activities within the Columbia River Gorge	Chapter 43.97 RCW
<u>UNIQUE LANDS AND PROPERTIES</u>			
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
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 <u>et seq</u>; 36 CFR Parts 65 and 800; Chapters 27.34, 27.53 and 27.58 RCW
LAND USE			
Neighboring properties	No new solid waste disposal areas within 30.5 m (100 ft) of the facility's property line	New solid waste disposal within 30.5 m (100 ft) of facility property line	WAC 173-304-130
	No new solid waste disposal areas within 76 m (250 ft) of property line of residential zone properties	New solid waste disposal within 76 m (250 ft) of property line of residential property	WAC 173-304-130
Proximity to airports	Disposal of garbage that could attract birds prohibited within 3,050 m (10,000 ft) (turbojet aircraft)/1,524 m (5,000 ft) (piston-type aircraft) of airport runways	Garbage disposal near airport	WAC 173-304-130

7.0 PRELIMINARY REMEDIAL ACTION TECHNOLOGIES

Previous sections identified contaminants of concern at the Semi-Works 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 Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area waste management units, 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 (FFS). 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) Facility Investigation (RFI)/Corrective Measures Studies (CMS) are defined as the combination of interim remedial measures (IRMs), limited field investigations (LFIs) for final remedy selection where interim actions are not clearly justified, and focused or aggregate area feasibility/treatability studies for further evaluation of treatment alternatives. After completion of an IRM, data will be evaluated including concurrent characterization and monitoring data to determine if a final remedy can be selected.

A secondary purpose of the evaluation of preliminary remedial action alternatives is the identification of additional information needed to complete the evaluation. This information may include field data needs and treatability tests of selected technologies. Additional data will be developed for most waste management units or waste groups during future data gathering activities (e.g., LFIs, characterization supporting IRMs, or treatability studies). These data may be used to refine and supplement the RAOs and proposed alternatives identified in this initial study. Data needs are defined in Section 8.0. Alternatives involving technologies that are not well-demonstrated under the conditions of interest are identified in Sections 7.3 and 7.5. These technologies may require bench-scale and pilot-scale treatability studies. The intent is to conduct treatability studies for promising technologies early in the RI/FS process. Conclusions regarding the feasibility of some individual technologies may change after new data become available.

The bias-for-action philosophy of addressing contamination at the Hanford Site requires an expedited process for implementing remedial actions. Implementation of general response actions may be accomplished using an observational approach in which the implementation is redirected as information is obtained. This observational approach is an iterative process of data acquisition and refinement of the conceptual model. Data needs are determined by the model, and data collected to fulfill these needs are used as additional input to the model. Use of the observational approach while conducting response actions in the 200 Areas will allow integrating these actions with longer range objectives of final remediation of similar areas and the entire 200 Areas. Site characterization and remediation data will be collected concurrently with the use of LFIs, IRMs, and treatability testing. The knowledge gained through these different activities will be applied to similar areas. The overall goal of this approach is convergence on an appropriate response action as early as possible while continuing to obtain valuable characterization information during remediation phases.

7.1 PRELIMINARY REMEDIAL ACTION OBJECTIVES

The RAOs are remediation goals for protection of human health and the environment that specify the contaminants and media of concern, exposure pathways, and allowable contaminant levels. The RAOs discussed in this section are considered to be preliminary and may change or be refined as new data are acquired and evaluated.

The fundamental objective of the corrective action process at the Semi-Works 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 Semi-Works Aggregate Area and the 200 East Area. The RAOs also take into account the preference under the 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 East Area and Semi-Works Aggregate Area. The overall objective for the 200 East Area 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 Semi-Works Aggregate Area. The media of concern for the Semi-Works 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 directly or could degrade the integrity of other controls, such as caps thereby mobilizing contaminants.

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 is discussed in the 200-East 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 Semi-Works Aggregate Area, and are presented in Table 7-2. The following are the general response actions for the Semi-Works 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 (NEPA) and National Contingency Plan (NCP) [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 IRMs. 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 geologic disposal of transuranic (TRU) waste. If such soil was excavated, it would have to be temporarily stored at Hanford until a geologic repository disposal site was licensed and constructed or another disposal option is identified.

One potential problem with off-site radioactive waste disposal is the lack of an alternate disposal location that will decrease the potential human exposure over the long time required for many of the contaminants. Waste removal actions may not be needed, or only be required on a small scale, to protect human health or the environment for industrial uses of the 200 Areas.

Waste treatment involves the use of biological, thermal, physical, or chemical technologies. Typical treatment options include biological land farming, thermal processing, soil washing, and fixation/solidification/stabilization. As described in Section 7.3, some of the technologies that have been used as 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 biotreatment. The distinguishing feature of in-situ treatment technologies is the ability to attain RAOs without removing the wastes. The final waste form generally remains in place. This feature is advantageous when exposure during excavation would be significant or when excavation is technically impractical. In-situ treatment can be difficult because the process conditions may not be easily controlled.

In the next section, specific process options within these technology groups are evaluated.

7.3 TECHNOLOGY SCREENING

In this section, potentially applicable technology types and process options are identified. These process options are then screened using effectiveness, implementability, and relative cost as criteria to eliminate those process options that would not be feasible at the site. The remaining applicable processes are then grouped into remedial alternatives in Section 7.4.

The effectiveness criteria focuses on: (1) the potential effectiveness of process options in handling the areas or volumes of media and meeting the RAOs; (2) the potential impacts to human health and the environment during the construction and implementation phase; and (3) how proven and reliable the process is with respect to the contaminants and conditions at the site. This criteria also concentrates on the ability of a process option to treat a contaminant type (organics, inorganics, metals, radionuclides, etc.) rather than a specific contaminant (nitrate, cyanide, chromium, plutonium, etc.).

The implementability criteria places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of treatment, storage, and disposal services, and the availability of necessary equipment and skilled workers to implement the technology. It also focuses on the process option's developmental status, whether it is an experimental or established technology.

The relative cost criterion is an estimate of the overall cost of a process, including capital and operating costs. At this stage in the process, the cost analysis is made on the basis of engineering judgement, and each process is evaluated as to whether 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. 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 waste management 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 management units, 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 Semi-Works 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 Semi-Works Aggregate Area. Both no action and institutional control options are required to be considered as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS guidance. The purpose of including both of these alternatives is to provide decision makers with information on the entire range of available remedial actions.

For the containment alternative, an engineered multimedia cover, with or without vertical barriers (depending on the specifics of the remediation) was selected. Two alternatives were selected to represent the excavation and treatment strategy. One of these deals with disposal of TRU contaminated soils. Finally, three in-situ alternatives were identified. One deals with vapor extraction for VOCs, one with stabilization of soils and the other with vitrification of soils.

It is recognized that this does not represent an exhaustive list of all applicable alternatives. However, these do provide a reasonable range of remedial actions that are likely to be evaluated in future 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 multimedia cover may effectively contain radionuclides, heavy metals, inorganic compounds, and organic compounds simultaneously. It satisfies the RAO of protecting human health and the environment from direct exposures from contaminated soil, bio-mobilization, and airborne contaminants. In-situ soil vapor extraction is more 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 alternative 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 (FFS) 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 VOCs from the affected soil. This technology has not been proven to be effective for VOCs, so it is not recommended as the sole remedial action for VOC affected areas. Grouting may also be used to fill voids, such as in cribs, thereby reducing subsidence. Another variation of this alternative would be to stabilize the soil using in-situ mixing of soil with stabilizing compounds such as pozzolanics or fly ash.

There are two common methods of in-situ grout injection that have been used at industrial sites. In the first method (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, and 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 institutional controls might also be required.

7.4.4 Alternative 3--Excavation, Soil Treatment, and Disposal

Under Alternative 3, radioactive and hazardous soil would be excavated using conventional techniques, with special precautions to minimize fugitive dust generation. Depending on the configuration of the area to be excavated, shoring might be required to comply with safety requirements and to reduce the quantity of excavated soil. The 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 wold 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 test 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 the 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 would be effective in treating radionuclides, heavy metals, and inorganic contamination and may also destroy organic contaminants. This would reduce the potential for exposures by leaching to groundwater, windblown dust and direct dermal contact. However, this alternative would not reduce the mass or toxicity of the radionuclides present onsite. Also, in-situ vitrification may be limited to depths of less than about 30 m (100 ft), which may not be adequate to immobilize deep contamination.

If organic compounds are present in the affected area, they could migrate laterally and vertically during the vitrification process, as a result of the soil heating process. Therefore, this technology must include provisions for 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 in-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. Tests to date have not exceeded depths of 6 m (20 ft). Therefore, using this technology at the Hanford Site will likely require extensive pilot testing.

7.4.6 Alternative 5--Excavation, Above-Ground Treatment, and Geologic Disposal of Soil with Transuranic Radionuclides

Some of the waste management units in the Semi-Works Aggregate Area may contain isolated zones where the concentrations of TRU radionuclides exceed 100nCi/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 could contain TRU radionuclides at concentrations less than 100 nCi/g and could be treated using a combination of the technologies described in Section 7.3. After the non-TRU soil was treated to achieve appropriate cleanup standards, it could be backfilled into the original excavation. Alternatively, the non-TRU soil could be disposed of at an appropriate landfill. Imported fill material would be used to restore the 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 (BACT) in accordance with air toxics regulations. If the disposal site is considered a RCRA facility, then the offgas treatment system must also satisfy RCRA emission control standards. Destruction efficiencies exceeding 98% have often been achieved 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 Semi-Works Aggregate Area contain VOCs 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 units. Soil vapor extraction would reduce downward migration of the VOC vapors through the vadose zone, and thereby minimize potential cross-media migration into the groundwater. Soil vapor extraction would reduce upward migration of VOC through the soil column into the atmosphere, and thereby minimize inhalation exposures to the contaminants. In some cases the radionuclides were discharged to the 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 used in conjunction with other alternatives if contaminants other than VOCs are present. However, because of the limited number of Semi-Works Aggregate Area units that contain VOCs, the use of soil vapor extraction will not be extensive.

7.5 PRELIMINARY REMEDIAL ACTION ALTERNATIVES APPLICABLE TO WASTE MANAGEMENT UNITS AND UNPLANNED RELEASE SITES

The purpose of this section is to discuss which preliminary remedial action alternatives could be used to remediate each Semi-Works Aggregate Area waste management unit or unplanned release site. The criteria used for deciding this are as follows:

- Installing an engineered multimedia cover with or without vertical barriers (Alternative 1) could be used on any site where contaminants may be leached or mobilized by surface water infiltration or if surface/near-surface contamination exists.

- In-situ grouting or stabilization (Alternative 2) could be used on any waste management unit or unplanned release site that contain heavy metals, radionuclides, and/or other inorganic compounds. In-situ grouting could also be effective in filling voids for subsidence control.

- Excavation and soil treatment (Alternative 3) could be used at most waste management units or unplanned release sites that contain radionuclides, heavy metals, other inorganics compounds, semi-volatile organic compounds, and VOCs.

- In-situ vitrification (Alternative 4) could be used at most waste management units or unplanned release sites, although vapor extraction may be needed when VOCs are present. Waste management units or unplanned release sites where in-situ vitrification may not be effective include reverse wells and other sites where the contamination is present in a very narrow geometry. In-situ vitrification is also not considered for surface spills.

- Excavation, treatment, and geologic disposal of TRU-containing soils (Alternative 5) could only be used on those waste management units and unplanned release sites that contain TRU radionuclides. Since a geologic repository is likely to accept only TRU radioactive soils, the non-TRU radioactive soils will not be remediated using this alternative.

- In-situ soil vapor extraction (Alternative 6) could be used on any waste management unit or unplanned release site that contains volatile organic compounds. Such sites are not common in the Semi-Works Aggregate Area. Nonetheless, the 216-C-4 Crib, where tributyl phosphate and/or paraffin hydrocarbons were disposed, is one site at which soil vapor extraction would be an effective remedy.

Using these criteria, Table 7-4 was created showing possible preliminary remedial action alternatives that could be used to remediate each of the waste management units and unplanned release sites. 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.

Each waste management unit or unplanned release site may require just one alternative or a combination of many alternatives. Furthermore, similar sites may be remediated simultaneously. Also, more specific waste treatment alternatives could be identified and evaluated as more information is obtained.

Technology development studies will be needed for the in-situ vitrification process; and treatability studies will be needed for the in-situ grouting or stabilization process and for soil treatment processes to make sure that they will effectively remediate the contaminants. Specifically, organic waste mobility may be a problem for in-situ vitrification; grouting agents and the resulting reduction of contaminant leachability will need to be determined before in-situ grouting can be performed; and appropriate treatment protocols and systems will need to be identified before soil washing can be used. Capping, soil vapor extraction, and disposal options are all proven processes but may require site-specific performance assessment (treatability) studies.

The FFs, will be required to evaluate alternative designs for all of the alternatives evaluated, as they relate to the specific waste management unit being remediated. A site-by-site economic evaluation is also required before making a decision. This evaluation will require site-specific information obtained in LFIs and FFSs.

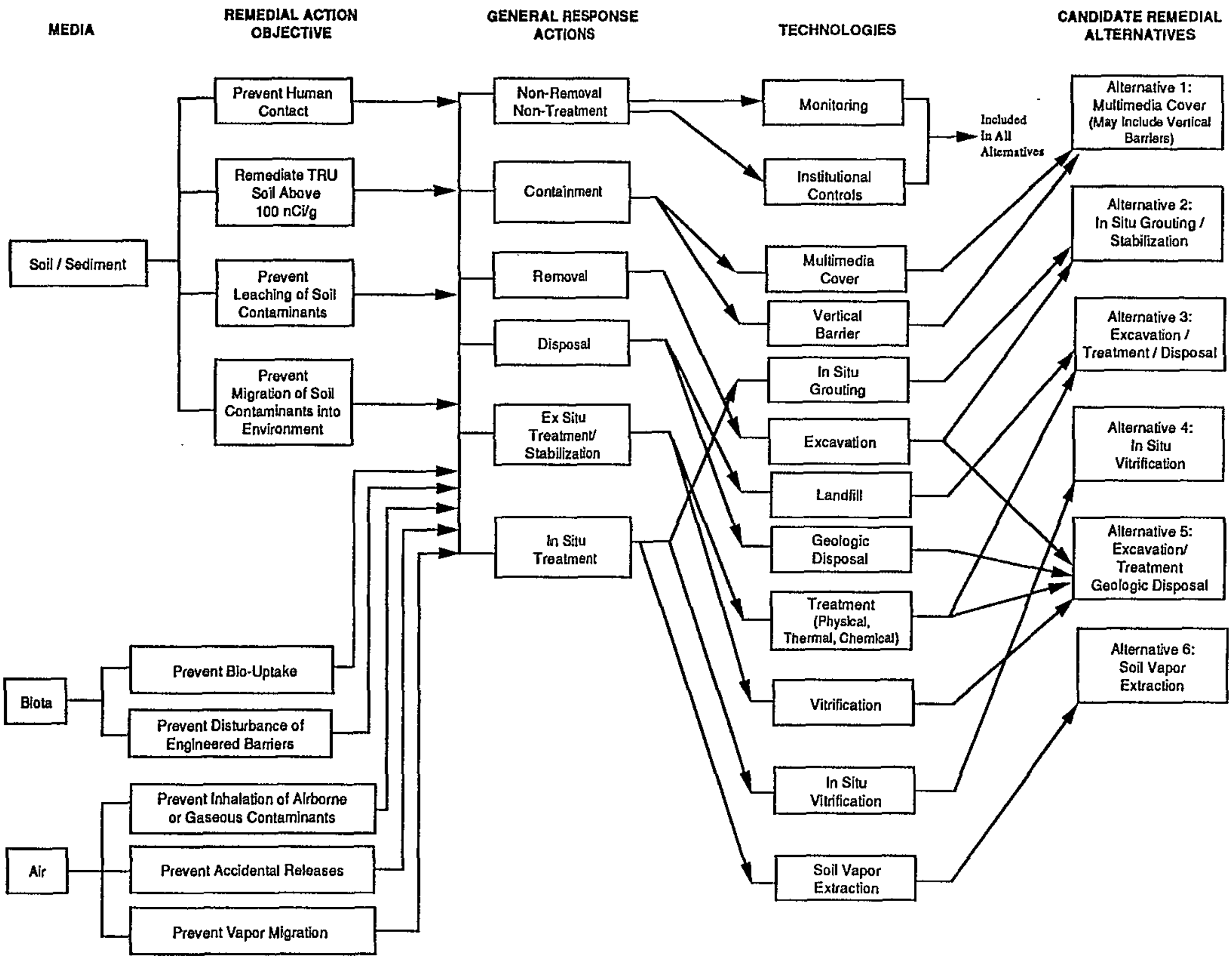


Figure 7-1. Development of Candidate Remedial alternatives for Semi-Works Aggregate Area.

Figure 7-2. Alternative 1 - Multi-Media Cover.

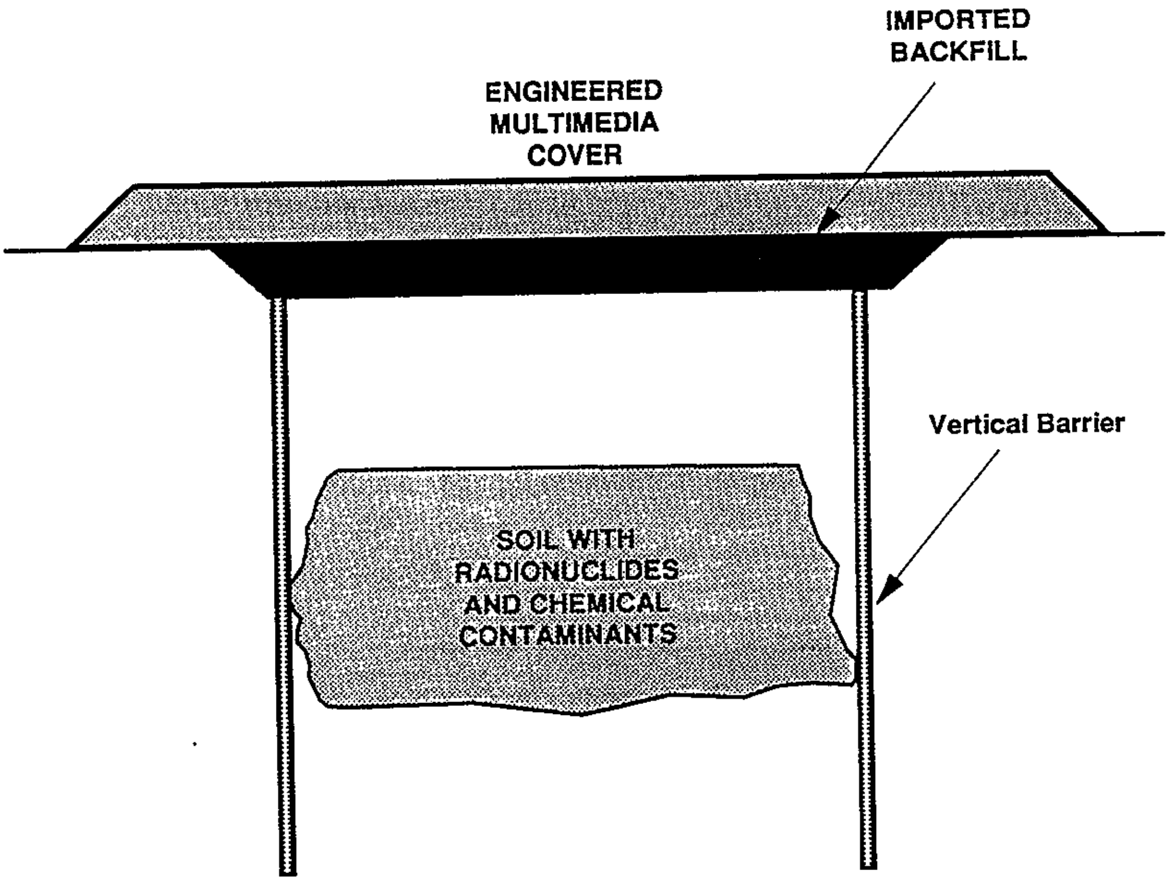


Figure 7-3. Alternative 2 - In situ Grouting of Soil.

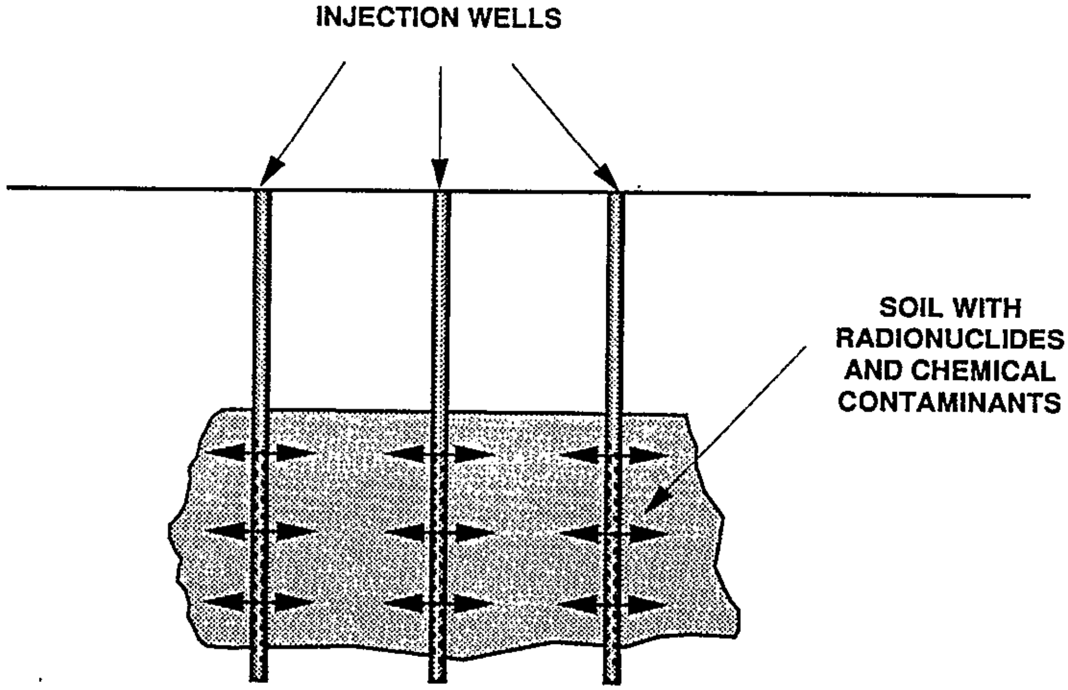


Figure 7-4. Alternative 3 - Excavation, Treatment, and Disposal.

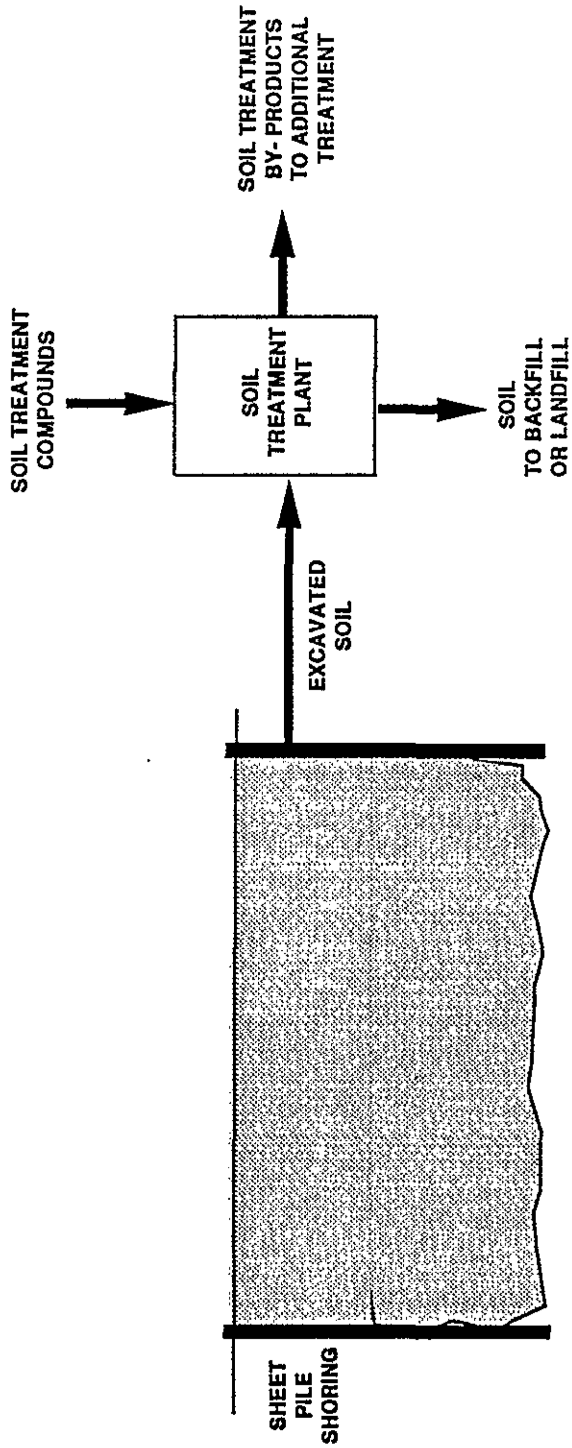


Figure 7-5. Alternative 4 - In Situ Vitrification of Soil.

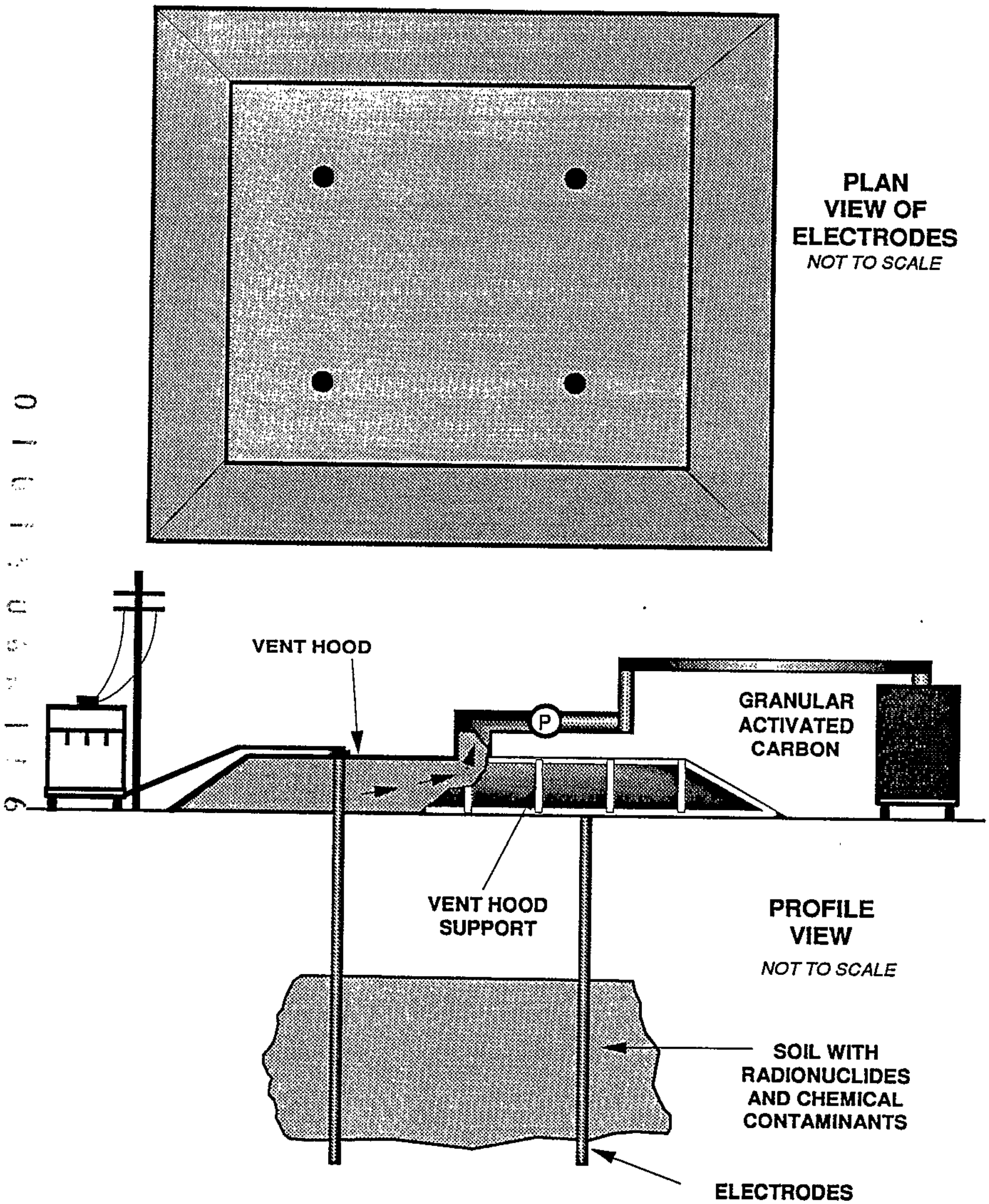
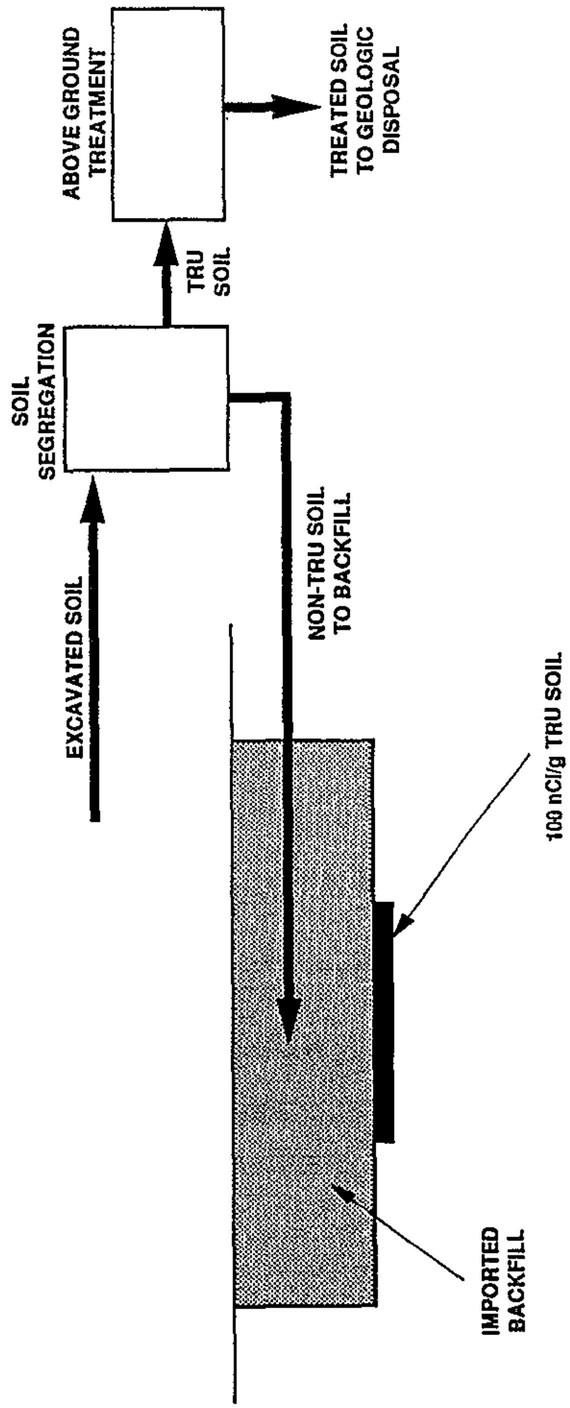


Figure 7-6. Excavation, Treatment, and Geologic Disposal of Soil with Transuranic Radionuclides.



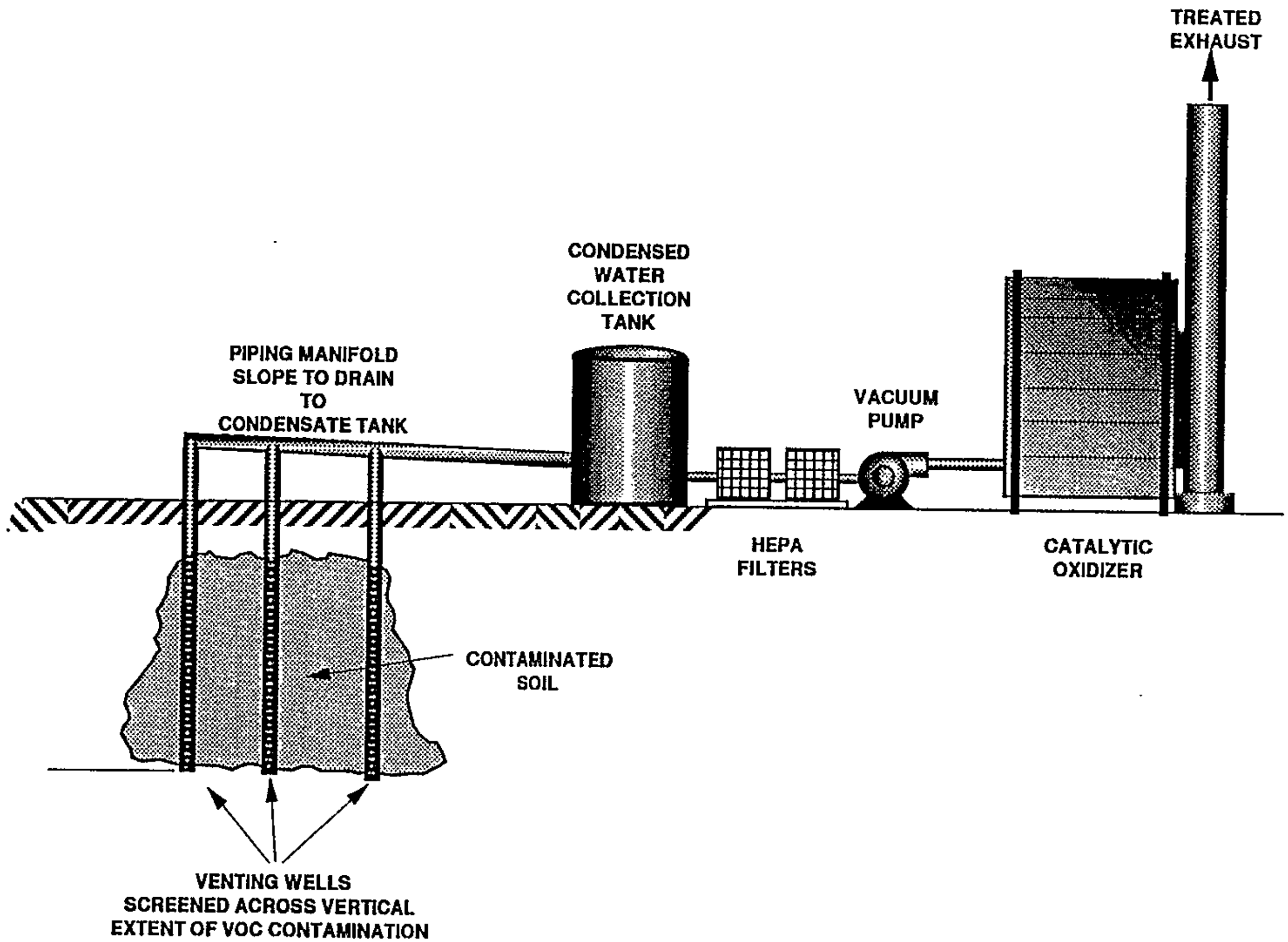


Figure 7-7. Alternative 6 - soil Vapor Extraction for Volatile Organic Compounds.

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Table 7-1. Preliminary Remedial Action Objectives and General Response Actions.

Environmental Media	Remedial Action Objectives: Human Health	Remedial Action Objectives: Environmental Protection	General Response Actions
Soils/ Sediments	• Prevent ingestion, inhalation, or direct contact with solids containing radioactive and/or hazardous constituents present at concentrations above MTCA and DOE standards for industrial sites (or subsequent risk-based standards).	• Prevent migration of radionuclides and hazardous constituents that would result in groundwater, surface water, air, or biota contamination with constituents at concentrations exceeding ARARs. • Remediate soils containing transuranic 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 (1)	• Prevent inhalation of contaminated airborne particulates and/or volatile emissions exceeding MTCA and DOE limits from soils/sediments.	• Prevent adverse environmental impacts on local biota. • Prevent accidental release from collapse of containment structures.	

NOTE: (1) No General Response Actions are required for the air because soil remediation will eliminate the air contamination source.

Table 7-2. Preliminary Remedial Action Technologies. (sheet 1 of 3)

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
Soil	No Action	No Action	No Action	NA
	Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
		Access Controls	Signs/Fences	NA
			Entry Control	NA
		Monitoring	Monitoring	NA
	Containment	Capping	Multi-Media	I,M,R,O
		Vertical Barriers	Slurry Walls	I,M,R,O
			Grout Curtains	I,M,R,O
			Cryogenic Walls	I,M,R,O
		Dust & Vapor Suppression	Membranes/Sealants/ Wind Breaks/Wetting Agents	I,M,R,O
	Excavation	Excavation	Standard Construction Equipment	I,M,R,O
	Treatment	Thermal Treatment	Vitrification	I,M,R,O
			Incineration	O
			Thermal Desorption	O
			Calcination	I,M,R,O
		Chemical Treatment	Chemical Reduction	M

Table 7-2. Preliminary Remedial Action Technologies. (sheet 2 of 3)

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
Soil			Hydrolysis	I,O
		Physical Treatment	Soil Washing	I,M,R,O
			Solvent Extraction	M,R,O
			Physical Separation	I,M,R,O
			Fixation/Solidification/ Stabilization	I,M,R,O
			Containerization	I,M,R,O
		Biological Treatment	Aerobic	O
			Anaerobic	O
	Disposal	Landfill Disposal	Onsite Landfill	I,M,R,O
			Offsite RCRA Landfill	I,M,O
		Geologic Repository	Geologic Repository	T (I,M,O non-TRU 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

Table 7-2. Preliminary Remedial Action Technologies. (sheet 3 of 3)

Media	General Response Action	Technology Type	Process Option	Contaminants Treated
Soil			Fixation/Solidification/ Stabilization	I,M,R,O
		Biological Treatment	Aerobic	O
			Anaerobic	O
Biota	No Action	No Action	No Action	NA
	Institutional Controls	Land Use Restrictions	Deed Restrictions	NA
		Access Controls	Signs/Fences	NA
			Entry Control	NA
		Monitoring	Monitoring	NA
	Excavation	Excavation	Standard Construction Equipment	I,M,R,O
	Disposal	Landfill Disposal	Landfill Disposal	I,M,R,O
	Containment	Capping	Multi-Media	I,M,R,O

I = Other Inorganics contaminants applicability.
M = Heavy Metals contaminants applicability.
R = Radionuclide contaminants applicability.
O = Organic contaminants applicability.
NA = Not Applicable.

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Table 7-3. Screening of Process Options. (sheet 1 of 7)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
SOIL TECHNOLOGIES:						
No Action	No Action	Do nothing to cleanup the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline" case.
Land Use Restrictions	Deed Restrictions	Identify contaminated areas and prohibit certain land uses such as farming.	Depends on continued implementation. Does not reduce contamination.	Administrative decision is easily implemented.	Low	Retained to be used in conjunction with other process options.
Access Controls	Signs/Fences	Install a fence and signs around areas of soil contamination.	Effective if the fence and signs are maintained.	Easily implemented. Restrictions on future land use.	Low	Retained to be used in conjunction with other process options.
	Entry Control	Install a guard/monitoring system to prevent people from becoming exposed.	Very effective in keeping people out of the contaminated areas.	Equipment and personnel easily implemented and readily available.	Low	Retained to be used in conjunction with other process options.
Monitoring	Monitoring	Analyze soil and soil gas samples for contaminants and scan with radiation detectors.	Does not reduce the contamination, but is very effective in tracking the contaminant levels.	Easily implemented. Standard technology.	Low	Retained to be used in conjunction with other process options.
Capping	Multi-Media	Fine soil over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective on all types of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will be necessary.	Medium	Retained because of potential effectiveness and implementability.
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. (sheet 2 of 7)

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	Retained because of potential effectiveness and implementability.
Excavation	Standard Excavating Equipment	Moving soil around the site and loading soil onto process system equipment.	Effective in moving and transporting soil to vehicles for transportation, and for grading the surface.	Equipment and workers are readily available.	Low	Retained because of potential effectiveness and implementability.
Thermal Treatment	Vitrification	Convert soil to glassy materials by application of electric current..	Effective in destroying organics and immobilizing the inorganics and radionuclides. Off-gas treatment for volatiles and gaseous radionuclides may be required.	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 and low organic content of soils..
	Thermal Desorption	Organic volatilization at 150 to 400°C (300 to 800°F) by heating contaminated soil followed by off gas treatment.	Effectively destroys the organic soil contaminants. Heavy metals less likely to volatilize than in high temperature treatments. Radionuclides will not be treated.	Successfully demonstrated on a pilot-scale level. Full-scale remediation yet to be demonstrated. Pilot testing essential.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options. (sheet 3 of 7)

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 for soils.
	Chemical Dechlorination	Detoxify chlorinated organic chemicals by reaction with organic reagents.	Not commonly used on the chlorinated compounds that have been identified at Z Plant.	Difficult to implement. Requires soil washing or solvent extraction before use.	High	Rejected because of limited effectiveness and difficult implementation.
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.
	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 present in the waste. May lead to further contamination. Radioactivity will not be reduced.	Laboratory testing necessary to determine appropriate solvent and operating conditions.	Medium	Rejected because the solvent may lead to further contamination.

Table 7-3. Screening of Process Options. (sheet 4 of 7)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	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 radionuclides.	May be implementable for low concentration waste. Disposal or safe storage of containers required. Regulatory constraints may prevent disposal of containers of certain waste types.	Low	Retained because of potential effectiveness and implementability.
Biological Treatment	Aerobic	Microbial degradation in an oxygen-rich environment.	Effectiveness is very contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides.	Various options are commercially available to produce contaminant degradation. Treatability tests are required to determine site-specific conditions.	Medium	Rejected because of limited applicability and difficult implementation.
	Anaerobic	Microbial degradation in an oxygen deficient environment.	Effectiveness is contaminant- and concentration-specific. Treatment has been demonstrated on a variety of organic compounds. Not effective on inorganics or radionuclides.	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 on-site landfill.	Does not reduce the soil contamination but moves all forms of contamination to a more secure place.	Easily implemented if sufficient storage is available in an on-site landfill area.	Medium	Retained because of potential effectiveness and implementability.

Table 7-3. Screening of Process Options. (sheet 5 of 7)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	Geologic Repository	Put the contaminated soil in a safe geologic repository.	Does not reduce the soil contamination, but is a very effective long-term method of storing radionuclides. Probably unnecessary for nonradioactive waste.	Not easy to implement because of limited site availability, and permits for transporting radioactive wastes are hard to get. Requires pretreatment of contaminated soils.	High	Retained because of effectiveness on transuranic wastes.
In Situ Thermal Treatment	Vitrification	Electrodes are inserted into the soil and a carbon/glass frit is placed between the electrodes to act as a starter path for initial melt to take place.	Effective in immobilizing radionuclides and most inorganics. Effectively destroys some organics through pyrolysis. Some volatilization of organics and inorganics may occur.	Potentially implementable. Implementability depends on site configuration, e.g., lateral and vertical extent of contamination. Treatability studies required.	High	Retained because of potential ability to immobilize radionuclides and destroy organics.
	Thermal Desorption	Soil is heated in situ by radio-frequency electrodes or other means of heating to temperatures in the 80 to 400°C (200 to 750°F) range thereby causing desorption of volatile and semivolatile organics from the soil.	Effective for removal of volatile and semi-volatile organics from soil. Ineffective for most inorganics and radionuclides. Contaminants are transferred from soil to air.	Implementable for shallow organics contamination. Not implementable for radionuclides and inorganics. Emission treatment and treatability studies required.	Medium	Rejected because of limited applicability.
In Situ Chemical Treatment	Chemical Reduction	Reducing agent is added to the soil to change oxidation state of target contaminant.	Effective for certain inorganics, e.g., chromium. Ineffective for organics. Limited applicability.	Difficult to implement in situ because of distribution requirements for reducing agent.	Low	Rejected because of limited applicability and implementation problems.
In Situ Physical Treatment	Soil Flushing	Solutions are injected through injection system to flush and extract contaminants.	Potentially effective for all contaminants. Effectiveness depends on chemical additives and hydrology. Flushing solutions posing environmental threat likely to be needed. Difficult recovery of flushing solution.	Difficult to implement. Not implementable for complex mixtures of contaminants. Flushing solution difficult to recover. Chemical additives likely to pose environmental threat.	Medium	Rejected because of implementation problems.

Table 7-3. Screening of Process Options. (sheet 6 of 7)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
	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 radionuclides and volatilized metals.	Medium	Retained for potential application to volatile organics.
	Grouting	Involves drilling and injection of grout to form barrier or injection to fill voids.	Effective in limiting migration of leachate, but difficult to maintain barrier integrity. Potentially effective in filling voids.	Implementable as barrier and for filling voids. Implementability depends on site conditions.	Medium	Retained because of ability to limit contaminant migration and potential use for filling void spaces.
	Fixation/ Solidification/ Stabilization	Solidification agent is applied to soil by mixing in place.	Effective for inorganics and radionuclides. Potentially effective for organics. Effectiveness depends on site conditions and additives used.	Implementable. Treatability studies required to select proper additives. Thorough characterization of subsurface conditions and continuous monitoring required.	Medium	Retained because of potential effectiveness and implementability.
In Situ Biological Treatment	Aerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by injection of or spraying with oxygen source and nutrients.	Effective for most organics under proper conditions. Ineffective for inorganics and radionuclides.	Difficult to implement. Treatability studies and thorough subsurface characterization required.	Low	Rejected because of limited applicability and difficult implementation.
	Anaerobic	Microbial growth utilizing organic contaminants as substrate is enhanced by addition of nutrients.	Effective for volatile and complex organics. Not effective for inorganics and radionuclides.	Difficult to implement. Anoxic ground conditions required. Treatability studies and thorough subsurface characterization necessary.	Low	Rejected because of limited applicability and difficult implementation.
BIOTA TECHNOLOGIES:						
No Action	No Action	Do nothing to cleanup the contamination or reduce the exposure pathways.	Not effective in reducing the contamination or exposure pathways.	Easily implemented, but might not be acceptable to regulatory agencies, local governments, and the public.	Low	Retained as a "baseline"case.
Land Use Restrictions	*Deed Restrictions*	*Identify contaminated areas and* prohibit certain land uses such as agriculture.	*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.

Table 7-3. Screening of Process Options. (sheet 7 of 7)

Technology Type	Process Option	Description	Effectiveness	Implementability	Relative Cost	Conclusions
Access Controls	Signs/Fences	Install a fence and signs around areas of contamination to keep people out and the biota in.	Effective 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	Multi-Media	Fine soil over synthetic membrane or other layers and covered with soil; applied over contaminated areas.	Effective in reducing the uptake of contaminants, not likely to crack. Likely to hold up over time.	Easily implemented. Restrictions on future land use will also be necessary.	Medium	Retained because of potential effectiveness and implementability.
Excavation	Standard Excavating Equipment	Remove affected biota and load it onto process system equipment.	Effective in moving and transporting biota to vehicles for transportation.	Equipment and workers are readily available.	Low	Retained because of potential effectiveness and implementability.
Disposal	Landfill Disposal	Place contaminated biota in an existing landfill.	Does not reduce the biota contamination but moves all of the contamination to a more secure place.	Easily implemented if sufficient storage is available in an offsite landfill area.	Medium	Retained because of potential effectiveness and implementability.

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Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (sheet 1 of 2)

Waste Management Unit or Unplanned Release	Alt 1. Multimedia Cover With or Without Vertical Barriers	Alt 2. In Situ Grouting	Alt 3. Excavation and Treatment	Alt 4. In Situ Vitrification	Alt 5. Excavation, Treatment, and Geologic Disp. of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
Plants, Buildings, and Storage Areas						
201-C Process Building	•		•		•	
291-C Ventilation System	•		•		•	
Tanks and Vaults						
241-CX-70 Storage Tank	•					
241-CX-71 Storage Tank	•		•			
241-CX-72 Storage Tank	•					
Cribs and Drains						
216-C-1 Crib	•	•	•	•	•	•
216-C-3 Crib	•	•	•	•	•	•
216-C-4 Crib	•	•	•	•		
216-C-5 Crib	•	•	•	•	•	•
216-C-6 Crib	•	•	•	•	•	•
216-C-7 Crib (2)	•	•	•	•		•
216-C-10 Crib	•	•	•	•	•	•
Critical Mass Laboratory Dry Well North	•	•	•	•		
Critical Mass Laboratory Dry Well South	•	•	•	•		
Critical Mass Laboratory Dry Well East	•	•	•	•		
Gatehouse French Drain	•	•	•	•		
Reverse Wells						
216-C-2 Reverse Well	•	•			•	
Ponds, Ditches, and Trenches						
216-C-9 Pond (2)	•	•	•	•	•	•

Table 7-4. Preliminary Remedial Action Alternatives Applicable to Waste Management Units and Unplanned Release Sites. (sheet 2 of 2)

Waste Management Unit or Unplanned Release	Alt 1. Multimedia Cover With or Without Vertical Barriers	Alt 2. In Situ Grouting	Alt 3. Excavation and Treatment	Alt 4. In Situ Vitrification	Alt 5. Excavation, Treatment, and Geologic Disp. of Transuranic Soil	Alt 6. In Situ Soil Vapor Extraction for Volatile Organic Compounds
200 East Powerhouse Ditch (2)	•	•	•	•		
Septic Tanks and Associated Drain Fields						
2607-E-5 Septic Tank and Drain Field (2)	•	•	•	•		
2607-E-7A Septic Tank and Drain Field (2)	•	•	•	•		
Transfer Facilities, Diversion Boxes, and Pipelines						
Semi-Works Valve Pit (1)	•	•	•	•		
Critical Mass Laboratory Valve Pit (1)	•	•	•	•		
241-C-154 Diversion Box (1)	•	•	•	•		
Burial Sites						
218-C-9 Burial Ground	•	•	•	•	•	
Unplanned Releases						
UN-200-E-36	•	•	•	•	•	
UN-200-E-37	•	•	•	•	•	
UN-200-E-98	•	•	•	•		
UN-200-E-141						
241-C Waste Line Unplanned Release No. 1	•	•	•	•	•	
241-C Waste Line Unplanned Release No. 2	•	•	•	•	•	

NOTES:
(1) This waste site is not included in the Tri-Party Agreement (Ecology et al. 1991)
(2) This is an active unit.
(3) Records indicate that all environmental contamination resulting from this unplanned release was removed and disposed of. Therefore, no applicable alternative(s) was identified.

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 (FFSs). 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 Semi-Works 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 Semi-Works AAMS.

8.1.1 Data Users

The data users for the Semi-Works AAMS and subsequent investigations such as LFIs, RI/FSs, and Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFI)/Corrective Measures Studies (CMSs) are the following:

- The decision makers for policies and strategies on remedial action at the Hanford Site. These are the signatories of the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1990) including the Washington State Department of Ecology (Ecology), EPA, and the U.S. Department of Energy (DOE).

  Nominally these responsibilities are assigned to the managers of these agencies (the Director of Ecology, the Administrator of EPA, and the Secretary of Energy for DOE), 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 Semi-Works Aggregate Area. Staff of these contractors will have to make the lower level (tactical) decisions about appropriate scheduling of activities and allocation of resources (funding, personnel, and equipment) to accomplish the recommendations of the AAMS.

- Concerned members of the wide community involved with the Hanford Site. These may include:

  - Other state (Washington, Oregon, and other states) and federal agencies

  - Affected Indian tribes

  - Special interest groups

  - The general public.

  These groups will be involved in the decision process through the implementation of the Community Relations Plan (Ecology et al. 1989), and will apply their concerns through the "primary" data users, the signatories of the Tri-Party Agreeme

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 Semi-Works 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 East 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 Semi-Works 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 Semi-Works 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.

- 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 the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks, a sediment sample from the 216-C-2 Reverse Well, and waste stream sampling specific for discharge to the 241-C-7 Crib and the 200 East Powerhouse Ditch (Issue 5).

  There are also sets of data of soil sampling and analysis that were conducted for several years on a grid pattern that cannot be assigned to a particular waste management unit. These data would indicate impacts of historical operations at the Hanford Site, and in the vicinity of the grid points, but the impacts cannot be ascribed to a particular unit and so do not assist in decision making on a unit-by-unit basis but may be used to estimate background contamination levels.

- Biota sampling: limited to non-waste unit-specific samples of vegetation taken in the vicinity of the Semi-Works Complex. These data could assist assessment of bio-uptake and 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 some units which discharged to the soil column (cribs, trenches, and ditches), 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 Semi-Works Aggregate Area is included in the *Semi-Works Geologic and Geophysics Data Package for the 200 Aggregate Area Management Study* prepared for this study (Chamness et al. 1992). 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 Semi-Works 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.

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 that may have been present at the time of the survey.

- The release locations have been changed (especially by remediation activities) since the time of the survey or sampling, and it is likely that contaminant distributions have changed.

- The survey or sampling has been done at a location different from the waste management unit or release, and so would not be representative of the concentrations in the zone of release. This deficiency applies to horizontal and vertical differences in location: the borehole geophysics data may be at the correct depths, but the distance of the borehole from the waste management unit can severely attenuate the gamma-radiation that 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).

- There has been virtually no measurement of non-radioactive hazardous constituents in the sampling and analysis of media in the Semi-Works 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 quality is provided in Section 8.1.3.

In addition to these data, there are also data regarding site conditions (Issue 4) 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:

- *Semi-Works Geologic and Geophysics Data Package for the 200 Aggregate Area Management Study* (Chamness et al. 1992), 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 Semi-Works 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 Semi-Works Aggregate Area.

- *Geologic Setting of the 200 East Area: An Update* (Lindsey et al. 1992) includes descriptions of regional stratigraphy, structural geology, and local (200 East Area) stratigraphy, with revised structure and isopach maps of the various unconsolidated strata found beneath the 200 East Area.

The data in these topical reports was obtained for the AAMS based on a review of driller's and geologist's logs for wells drilled in the Semi-Works Aggregate Area. A selection of those logs was made which best represented the geologic structures below the aggregate area and is presented in Chamness et al. (1992). Lindsey et al. (1992) then used these wells (and others from other aggregate areas in the 200 East Area) to develop cross-sections, structure maps, and isopach maps, which were in turn adapted to the specific needs of this report and presented in Section 3.0. Only existing logs were used; no new wells were drilled as part of this study. The quality of the data varies among the logs according to the time they were drilled and the scope of the study they were supporting, but generally these data are sufficient for the general geological characterization of the site. Issues involving the potential of contaminant migration at specific sites, based on stratigraphic concerns, may not be fully addressed through any existing borings or wells because appropriate borings may not be located in close proximity; these issues should be addressed during subsequent field investigations at locations where contaminant migration is considered likely.

Another class of data that was gathered in the general area of the 200 West Area, and is potentially appropriate to the Semi-Works Aggregate Area, is the result of a set of studies which were performed for the Basalt Waste Isolation Project (BWIP) (DOE 1988b), in the attempt to site a high-level radioactive waste geologic repository in the basalt beneath and in the vicinity of the Hanford Site. The proposed Reference Repository Site included the 200 West Area and some distance beyond it, mainly to the west. For this siting project, a number of geologic techniques were used, and some of the data generated by the drilling program has been used for the stratigraphic interpretation presented in Section 3.4 (all the wells denoted with an alias "BH-.." were drilled for the BWIP) 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 Semi-Works (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 Semi-Works Aggregate Area (or even the 200 East Area) only in passing. Some of the surveys (e.g., the grid of gravity stations) specifically avoided the 200 East 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 that were apparent in the data. All this is appropriate to a study of the basalt, but does not make the studies applicable to the current study.
- Even when features potentially caused by 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 very few features (and none in the Semi-Works Aggregate Area) which are interpreted as descriptive of the structure of the suprabasalt sediments.
- Lastly, some of the anomalies which are interpreted in terms of a sedimentary stratigraphic cause (e.g., "erosion of Middle Ringold") do not bear up under the more detailed stratigraphic interpretation carried out under the topical reports for the AAMS (Lindsey et al. 1992; Chamness et al. 1992).

However, these data will be reviewed in more detail for the purposes of the 200 East Groundwater AAMSR, since deeper features (including in the basalt) are of more concern for that study.

Other data, presented in Sections 2.0, 3.0, and 4.0, are broader-scale rather than site-specific such as contaminant concentrations. These include topography, meteorology, surface hydrology, environmental resources, human resources, and contaminant characteristics. These data are generally of acceptable quality for the purposes of planning remedial actions in the Semi-Works Aggregate Area.

8.1.3 Evaluation of Available Data

The EPA (1987) has specified indicators of data quality, the five "PARCC" parameters (precision, accuracy, representativeness, completeness, and comparability), which can be used to evaluate the existing data and to specify requirements for future data collection.

- Precision: the reproducibility of the data.

- Accuracy: the lack of a bias in the data.

  Much of the existing data are of limited precision and accuracy due to the analytical methods which have been used historically. The gross gamma borehole geophysical logging in particular is limited by methodological problems although reproducibility has been generally observed in the data. Conditions that have contributed to lack of precision and/or accuracy include: improvements in analytical instrumentation and methodology making older data incompatible; effects of background levels (particularly regarding radioactivity and inorganics); and lack of quality control on data acquisition.

  The limitations in precision and accuracy in existing data are mainly due to the progress of analytical methodologies and quality assurance (QA) procedures since the time they were collected. The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) recommends that existing data be used to the maximum extent possible, at two levels: first to formulate the conceptual model, conduct a qualitative risk assessment, and prepare work plans, but also as an initial data set 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 Semi-Works 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 East 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. 1992, Lindsey et al. 1992), the later, waste management unit specific, field sampling plans will require detailed consideration of more of the logs of wells drilled in the immediate vicinity, whatever their quality, as a starting point to conceptually model the geology specifically beneath that unit.

- Completeness: the fraction of samples which are considered "valid."

None of the data that have been previously gathered in the Semi-Works 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, at least as far as precision is concerned (accuracy requires proof of a lack of bias). This indicates that validity (completeness) is one of the less significant problems with the data.

- Comparability: the confidence that can be placed in the comparison to two data sets (e.g., separate samplings).

With varying levels of quality control and varying procedures for sample acquisition and analysis, this parameter is also generally poorly met. Much of this is due to the more recent development of QA procedures.

While these limitations cannot in most cases be quantified (and some such as representativeness are specifically only qualitative), most of the data gathered in the Semi-Works 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 in the development of work plans for site field investigations, prioritization of the various units, and to determine, to the extent possible, where contamination is or is not present.

In addition to these site-specific data, there are also a limited number of non site-specific sampling events that are being developed to determine background levels of naturally occurring constituents (Hoover and LeGore 1991). These data can be used to differentiate the effect of the environmental releases from naturally occurring background levels.

8.1.4 Conceptual Model

The initial conceptual model of the waste management units in the Semi-Works Aggregate Area is presented and described in Section 4.2 (Figure 4-4). The model is based on best estimates of where contaminants were discharged and their potential for migration from release points. The conceptual model is designed to be conservatively inclusive in the face of a lack of data. This means that a migration pathway was included if there is any possibility of contamination travelling on it, historically or at present. In most cases there may not be a significant flux of such contamination migration for many of the pathways shown on the figure.

The pathway from the cribs leading to adsorption of transuranic elements on vadose-zone soils is possibly the most 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 extrapolating to the exposure point, to indicate the dosage to the receptors.

There are 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 Semi-Works 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 ARARs (Section 6.0)
- Define preliminary remedial action objectives and screen potential remedial technologies to prepare preliminary remedial action alternatives (Section 7.0) and provide recommendations for FFS (Section 9.4.1) and treatability studies (Section 9.5)
- Define data needs, establish general DQOs, and set priorities
- Recommend ERA, IRM, LFI, or other actions (Section 9.0)
- Redefine and prioritize, as data allow, operable units, their boundaries, and work plan activities with emphasis on supporting early cleanup actions and records of decision (Sections 8.3 and 9.0)
- Integrate RCRA TSD closure activities with past-practice activities (Section 9.3.4).

The decisions that will have to be made on the basis of this AAMS can best be described according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart (Figure 1-2 in Section 1.0) that must be conducted on a site-by-site basis. Decisions are shown on the flow chart as diamond-shaped boxes, and include the following:

- Is an ERA justified?
- Is less than six months' response needed (is the ERA time critical)?
- Are data sufficient to formulate the conceptual model and perform a qualitative risk assessment?

- Is an IRM justified?
- Can the remedy be selected?
- Can additional required data be obtained by LFI?
- Are data (from field investigations) sufficient to perform risk assessment?
- Can an Operable Unit/Aggregate Area ROD be issued?

(The last two questions will only be asked after additional data are obtained through field investigations, and so are DQO issues only in assessing scoping for those investigations.)

Most of these decisions are actually a complicated mixture of many smaller questions, and will be addressed in Section 9.0 in a more detailed flowchart for assessing the need for remediation or investigation.

Similarly, the tasks that will need to be performed after the AAMS that drive the data needs for the study are found in the rectangular boxes on the flow chart. These include the following:

- ERA (if justified)
- Definition of the 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 path).

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 Semi-Works Aggregate Area, most data uses fall into one or more of four general categories:

- Site characterization
- Public health evaluation and human health and ecological risk assessments
- Evaluation of remedial action alternatives
- Worker health and safety.

Site characterization refers to a process that includes determination and evaluation of the physical and chemical properties of any wastes and contaminated media present at a site, and an evaluation of the nature and extent of contamination. This process normally involves the collection of basic geologic, hydrologic, and meteorologic data but more importantly for the Semi-Works 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 Semi-Works 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, 1989c). The EPA Region 10 has also developed its preferred methodology for these risk assessment activities (EPA 1989a, 1991a). The ecological and human health risk assessments will follow the guidance outlined in the approved M-29-03 milestone document, *Hanford Site Baseline Risk Assessment Methodology*. The data requirements for an ecological risk assessment include (1) identification of critical species, (2) identification of habitat within and surrounding the Hanford Site, (3) feeding relationships among species of concern, and (4) contaminant concentrations in environmental media and species of interest. The main deficiency in the data available for waste management units in the Semi-Works 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 waste management units and unplanned releases: many of the units or releases have surface expressions, markers, or have been surveyed in the past. The unplanned releases in particular are lacking in this information. Many of the unplanned releases are located by coordinates only and can be found on various site maps by a number of different names.
- Possible contamination found at the waste management units: these data are derivable from the inventories for the units (mainly for the cribs and other disposal facilities) as well as from the limited sampling that has been done at specific sites.
- The likely depth of contaminants: this information is mainly obtained from the gross gamma borehole logging for many of the units.

Two types of information are available for the purposes of worker health and safety, and will be used for the development of health and safety documents:

- Levels of surface radiation: derived from the on-going periodic radiological surveys done under the Environmental Surveillance program (Schmidt et al. 1992). Table 8-1 shows where surveys have indicated no detectable levels of surface radiation and so no additional survey is required before surface activities can be conducted.

- Expected maximum contaminant levels: these data can be used mainly on the results of subsurface soil sampling. Extensive sampling of this type has generally not been conducted at the Semi-Works Aggregate Area waste management units.

Table 8-1 also presents a first expression of the data needs for the individual waste management units in the Semi-Works Aggregate Area, which must be addressed for remediation approaches to be developed.

8.2.2 Data Needs

The data needs for the Semi-Works 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 Semi-Works 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 and radionuclide 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 Semi-Works Aggregate Area are discussed in Section 8.3 to provide focus to investigatory methods that may be employed. The data type requirements for the preliminary remedial action alternatives developed in Section 7.4 are summarized in Table 8-2.

8.2.2.2 Data Quality Needs. The various tasks and phases of a CERCLA investigation may require different levels of data quality. Important factors in defining data quality include selecting appropriate analytical levels and validation and identifying contaminant levels of concern as described below. The Westinghouse Hanford document, *A Proposed Data Quality Strategy for Hanford Site Characterization,* will be used to help define these levels (McCain and Johnson 1990). The DQOs will also be developed and defined on an operable unit basis in the work plans and, specifically, in the Quality Assurance Project Plans (QAPjPs) which will guide investigation activities.

Chemical and radionuclide laboratory analysis will be one of the most important data types, and is required at virtually all the waste management units in the Semi-Works Aggregate Area. In general, increasing accuracy, precision, and lower detection limits are obtained with increasing cost and time. Therefore, the analytical level used to obtain data should be commensurate with the intended use. Table 8-3 defines five analytical levels associated with different types of characterization efforts. While the bulk of the analysis during LFIs/RIs will be screening level (DQO Level I or II), these data will require confirmation sampling and analysis to allow final remedial decisions through quantitative risk assessment methods. Individual DQO analytical PARCC parameters for Level III or IV analytical data associated with each contaminant anticipated in the Semi-Works Aggregate Area (as developed in Section 5) are given in Table 8-4. These parameters will be used for the development of site-specific sampling and analysis plans and quality assurance plans for investigations and remediations in the aggregate area.

Before laboratory or even field data can be used in the selection of the final remedial action, they must first be validated. Exceptions are made for initial evaluations of the sites using existing data, which may not be appropriate for validation but will be used on a screening basis based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Other screening data (e.g., estimates of contaminant concentration inferred from field analyses) may also be excepted. Validation involves determining the usability and quality of the data. Once data are validated, they can be used to successfully complete the remedial action selection process. Activities involved in the data validation process include the following:

- Verification of chain-of-custody and sample holding times
- Confirmation that laboratory data meet Quality Assurance/Quality Control (QA/QC) criteria
- Confirmation of the usability and quality of field data, which includes geological logs, hydrologic data, and geophysical surveys
- Proper documentation and management of data so that they are usable.

Validation may be performed by qualified Westinghouse Hanford personnel from the Office of Sample Management (OSM), other Westinghouse Hanford organizations, or a qualified independent participant subcontractor. Data validation of laboratory analyses will be performed in accordance with *A Proposed Data Quality Strategy for Hanford Site Characterization* (McCain and Johnson 1990) and standards set forth by Westinghouse Hanford.

To accomplish the second point, all laboratory data must meet the requirements of the specific QA/QC parameters as set up in the QAPjP for the project before it can be considered usable. The QA/QC parameters address laboratory precision and accuracy, method blanks, instrument calibration, and holding times.

The usability of field data must be assessed by a trained and qualified person. The project geohydrologist/geophysicists will review the geologic logs, hydrologic data, geophysical surveys, and results of physical testing, on a daily basis, and senior technical reviews will be conducted periodically throughout the project.

Data management procedures are also necessary for the validation. Data management includes proper documentation of field activities, sample management and tracking, and document and inventory control. Specific consistent procedures are discussed in the Information Management Overview (Appendix D).

8.2.2.3 Data Quantity Needs. The number of samples that need to be collected during an investigation can be determined by using several approaches. In instances where data are lacking or are limited (such as for contamination in the vadose zone soils), a phased sampling approach will be appropriate. In the absence of any available data, an approach or rationale will need to be developed to justify the sampling locations and the numbers of samples selected. This will be accomplished and documented in the production of work plans and field sampling plans for each aggregate area, under the guidance and review of the Tri-Party Agreement participants. Specific locations and numbers of samples will be determined based on data collected during screening activities. For example, the number and location of beta/gamma spectrometer probe locations can be based on results of surface geophysical and radiation surveys. These may help locate some subsurface features, which may not be adequately documented. Details of any higher DQO level subsurface soil sampling scheme will depend on results of screening investigations such as geophysics surveys, surface radiation surveys, field chemical screening, and beta/gamma spectrometer probe surveys. In situations where and when available data are more complete, statistical techniques may be useful in determining the additional data required.

8.2.2.4 Sampling and Analysis Options. Data collection activities are structured to obtain the needed data in a cost-effective manner. Developing a sampling and analysis approach that ensures that appropriate data quality and quantity are obtained with the resources available may be accomplished by using field screening techniques and focusing the higher DQO level analyses on a limited set of samples at each site. The investigations on waste management units in the Semi-Works 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 1991c, EPA 1991d), *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 mg/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).

8.2.3 Data Gaps

Considering the data needs developed in Section 8.2.2, and the data available to meet these needs as presented in Section 8.1.2, it is apparent that a number of data gaps can be identified. These are summarized, on a waste management unit category basis, in Table 8-5, and should be the focus of LFIs on a waste management unit category basis, using the analogue sites approach. The contaminant concentration data are the highest priority because of the need to assess the need for remediation (through quantitative risk assessment and evaluation of compliance with ARARs) and appropriate remedial actions for each site.

In addition to these data needs specifically addressing contamination problems at sites included for consideration in this aggregate area, there are general data needs which will be required for characterization of the possible transport pathways, as presented in the conceptual model, at locations away from the individual units. These general, nonsite-specific needs include characterization of the following:

- Geologic stratigraphy, particularly for possible perched water zones
- Transport through the vadose zone (mobilization through natural or artificial recharge or drainage)
- Air transport of contamination
- Ecological impacts and transport mechanisms (bio-uptake, bio-concentration, secondary receptors through predation)
- Potential releases from process effluent lines between facilities and to waste disposal sites.

All of these needs will have to be addressed in the data collection program (Section 8.3). In addition, data gaps that impact groundwater are also addressed in the 200 East 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 is not possible, given the complexity and uncertainty of the parameters required to describe the site and the time to make decisions. Rather, the use of engineering judgement is considered sufficient to the decision process.

8.3.1 General Rationale

The general rationale for the investigation of sites in the Semi-Works Aggregate Area is to collect needed data that are not available. Because of 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.

The following work plan approach will be used for LFIs and RI/FS in the Semi-Works Aggregate Area. The results are described in Sections 8.3.2 and 8.3.3 in 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 fully validated, the data are still useful in developing a preliminary conceptual model (Section 4.2) and in helping to focus and guide the planning of investigations, expedited actions, and interim measures.

- Additional data at validated and screening levels should be collected to obtain the maximum amount of useful information for the amount of time and resources invested in the investigation.

- Data should be collected to support the intended data uses identified in Section 8.2.1.

- Nonintrusive sampling (e.g., geophysical surveys, surface radiation surveys, soil gas, and spectral gamma probe surveys), and surficial and source sampling should be conducted early in any investigation effort to identify necessary interim response actions (i.e., additional ERAs or IRMs).

- Data collected from initial investigation activities should be used to confirm and refine the conceptual model (Section 4.2), refine the analyte constituents of concern, and provide information to conduct interim response actions or risk assessment activities.

- Additional investigation activities are proposed to support (if needed) quantitative baseline risk assessments for final cleanup actions and further refine the conceptual model.

- Field investigation techniques should be used to minimize the amount of hazardous or mixed waste generated. Any waste generated will be in accordance with EII 4.3, "Control of CERCLA and Other Past-Practice Investigation Derived Waste" (WHC 1988d).

8.3.2 General Strategy

The overall objective of any field investigation (LFI, IRM, or RI) of the sites in the Semi-Works Aggregate Area will be to gather additional information to support risk assessment and remedial action selection according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) flow chart discussed in Section 8.1.5. The general approach or strategy for obtaining this additional information is presented below.

- Analytical parameter selection should be based on verifying overall conditions and then narrowed to specific constituents of concern, in consideration with regulatory requirements and site conditions. Periodic analyses of the long list of parameters should be conducted to verify that the list of constituents of concern has not changed, either because new constituents are identified or some of those considered as a potential concern do not appear to be significant.

- Similarly, investigations should work from a screening level (DQO Levels I or II, e.g., surface radiation surveys) to successively more specific sampling and analysis methodologies (e.g., beta/gamma spectral probes, then DQO Level III or IV soil sampling and analysis), without time consuming remobilizations.

- Dangerous and radioactive wastes may be generated during the field investigation. While efforts should be made to minimize these wastes, any waste generated will be handled in accordance with EII 4.3, "Control of CERCLA and Other Past-Practice Investigation Derived Waste" (WHC 1988d). 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 (Section 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 Semi-Works Aggregate Area is to characterize the known waste management units and unplanned releases that exist in the area and that may contribute to contamination of surface soil, vadose zone, surface water, sediment, air, and biota. The completeness of the characterization effort will be assessed according to the needs of risk assessment, ARARs compliance, and remedial action selection, which will also determine what levels of the various constituents of concern comprise "contamination."

Source sampling should be conducted at waste management units or unplanned release locations where the available data indicate that dangerous, mixed, or radioactive wastes may be present. Activities which are proposed to be performed during the source investigations include the following:

- Compile and evaluate additional existing data for the purpose of: verifying locations, specifications of engineered facilities, and pipelines, and waste stream characteristics; assessment of the construction and condition of boreholes/wells that exist in the operable unit and their suitability for use for investigation activities, QA/QC information, and raw data regarding radiological and hazardous substances monitoring; and integrating any additional environmental modeling data into the conceptual model. This has been done (on an aggregate area basis) in this report; the process will be extended to site-specific planning and on-going assessments of the investigation/remediation as it is carried out.

- Conduct surface radiological surveys 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 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 where volatile organic compounds 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 volatile organic compounds at lower concentrations may not be present. Data from the soil gas survey can be used to help locate surface and near-surface samples and vadose zone borings.

- Collect surface and near-surface samples of contaminated soils and/or waste materials at selected locations. Specific sampling sites will be chosen to assess particular facilities or releases. Additional sampling sites may be specified based on results from nonintrusive investigations.

8.3.3.2 Geologic Investigation. A geologic investigation should be performed to better characterize the vadose zone and the nature of unsaturated soils that make up this system. The geologic investigation will include the following tasks:

- Borings may be advanced into zones where an accurate interpolation of the subsurface stratigraphy is important to understanding migration pathways in the vadose zone.

- 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 AAMS) 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 and trenches 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 and trenches that still contain water. This will probably be limited to the Powerhouse Ditch. This sediment is likely to be windblown soil.

8.3.3.4 Soil Investigation. The purpose of soil investigations is to determine physical and chemical properties of the soil and to determine the nature, type, and extent of soil contamination associated with waste management units and unplanned releases to allow initiation of interim remedial actions and to assess the quantitative risk at other sites. Sampling will include:

- Samples of vadose zone soil will be collected and analyzed for constituents of concern when wells are drilled for other studies (i.e., groundwater investigations) in the vicinity of a waste management unit or unplanned release with reported liquid disposals or spills. Organic vapor (at sites with suspected volatiles) and radiation sampling should also be performed with samples selected by onsite screening.

- Data collected during this investigation will be evaluated to further understand the contribution of contaminants to the vadose zone from specific waste management units and/or unplanned releases and to better define the hydrology and water quality in the vadose zone system through moisture content profiles, tracking of specific contaminants, and soil hydraulic characteristics. However, the issue of contaminant transport through the vadose zone is more appropriate to studies conducted under the direction of the Groundwater AAMSRs.

8.3.3.5 Air Investigation. Air investigations (on an aggregate area scale) should consist of onsite particle sampling as part of the health and safety program. In addition, high-volume air samplers should be placed in appropriate locations on-site based on evaluation of existing meteorological data. The purpose of these samplers will be to determine if any migration of airborne contaminants occurs.

8.3.3.6 Ecological Investigation. Ecological investigation activities, on a site-wide scale, should include a literature search and data review, and a site walkthrough. Data collected during the soils characterization activities are expected to be sufficient to evaluate biota remediation technologies. These activities are intended to identify potential biota concerns which need to be addressed in the site investigation. Particular emphasis should be given to identifying potential exposure pathways to biota that migrate offsite or that introduce contaminants into the food web. Data obtained in this survey will be used to both refine the conceptual model as well as to conduct the ecological risk assessment.

8.3.3.7 Geophysical Stratigraphic Survey. A geophysical survey of subsurface stratigraphy should be conducted across the aggregate area to help characterize the geology and hydrogeology of the vadose zone.

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 used 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 investigating locations outside the 200 East Area to verify the locations of known archaeological sites by reviewing existing data. The focus of the investigation will be to confirm that no archaeological resources are present at proposed drilling sites.

8.3.4 Data Evaluation and Decision Making

Data will be evaluated as soon as results (e.g., soil gas, radiation screening, drilling results) become available for use in restructuring and focusing the investigation activities. Data reports will be developed that summarize and interpret new data. This includes groundwater sampling and RLS borehole logging as part of the AAMS. Data will be used to refine the conceptual model, further assess potential contaminant-specific ARARs, develop the quantitative risk assessment, and assess remedial action alternatives.

The objectives of data evaluation are the following:

- To reduce and integrate data to ensure that data gaps are identified and that the goals and objectives of the Semi-Works AAMS are met.

- To confirm that data are representative of the media sampled and that QA/QC criteria have been met.

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Table 8-1. Uses of Existing Data for Semi-Works Aggregate Area Waste Management Units. (sheet 1 of 2)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
Plants, Buildings, and Storage Areas					
201-C Process Building	●	●			
291-C Ventilation System	●	●			
Tanks and Vaults					
241-CX-70 Storage Tank	●	●		●	
241-CX-71 Storage Tank	●				
241-CX-72 Storage Tank	●	●		●	
Cribs and Drains					
216-C-1 Crib	●	●	●	●	
216-C-3 Crib	a	●		●	
216-C-4 Crib	●	●		●	
216-C-5 Crib	●	●	●	●	
216-C-6 Crib	a	●		●	
216-C-7 Crib	●	●		●	
216-C-10 Crib	●	●	●	●	
Reverse Wells					
216-C-2 Reverse Well	●			●	
Ponds, Ditches, and Trenches					
216-C-9 Pond	●	●	●		
200 East Powerhouse Ditch	●	●			

Table 8-1. Uses of Existing Data for Semi-Works Aggregate Area Waste Management Units. (sheet 2 of 2)

Waste Management Unit	Development of Sampling Plans			Health and Safety	
	Location	Possible Contamination	Depth of Contamination	Surface Radiation	Expected Max. Level
Septic Tanks and Associated Drain Fields					
2607-E-5 Septic Tank and Drain Field	●				
2607-E-7A Septic Tank and Drain Field	●				
Transfer Facilities, Diversion Boxes, and Pipelines					
Semi-Works Valve Pit	●				
Critical Mass Laboratory Valve Pit	●				
241-C-154 Diversion Box	●				
Burial Sites					
218-C-9 Burial Ground	●	●	●		
Unplanned Releases					
UN-200-E-36	a			●	
UN-200-E-37	a			●	
UN-200-E-98	●	●			
UN-200-E-141	●	●			

[a]Location of these units are known; however, exact boundaries of structure/site are not known.

Table 8-2. Data Needs for Preliminary Remedial Action Alternatives Semi-Works Aggregate Area.

Alternative	Physical Attribute	Chemical/Radiochemical Attribute
1. Multimedia Cover (plus possible vertical barriers)	• areal extent • depth of contamination • structural integrity (collapse potential) • runoff/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 transuranic • toxicity/radioactivity • levels of contaminants • concentrations in PM-10 fraction • reactivity • leachability/integrity of final waste form
6. In Situ Soil Vapor Extraction	• areal extent • depth • locations/depth of highest concentrations (vapors, adsorbed) • stratigraphy • soil permeability/porosity • voids	• volatility of constituents (Henry's Law Constant) • non-volatile organics • levels • volatile radionuclides (Radon) • treatability (catalytic oxidization)

[a]May be obtained during remediation using the observational approach recommended by the *Hanford Site Past-Practice Strategy* (DOE/RL 1992).

Table 8-3. Analytical Levels for the Semi-Works 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 on site, 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).

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Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 1 of 8)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Gross Alpha	900.0 M	TBD	±30	±25	900.0	10	±25	±25
Gross Beta	900.0 M	TBD	±30	±25	900.0	5	±25	±25
Gamma Scan	D3649 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	±20
Americium-241	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Americium-242	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-242m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Americium-243	Am-01	TBD	±30	±25	Am-03	TBD	±25	±25
Antimony-126	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Antimony-126m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Barium-137m	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-210	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-211	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-213	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Bismuth-214	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Carbon-14	C-01 M	TBD	±30	±25	TBD	TBD	±25	±25
Cesium-134	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 2 of 8)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Cesium-135	D3649 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	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Europium-154	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Europium-155	TBD	TBD	±30	±25	TBD	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	D3649 M	TBD	±30	±25	D3649 M	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 3 of 8)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Nickel-59	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Nickel-63	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Niobium-91	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-210	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-147	TBD	TBD	±30	±25	TBD	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

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 4 of 8)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Radium-226	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Radon-222	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Ruthenium-106	TBD	TBD	±30	±25	TBD	2.5	±25	±25
Samarium-106	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-209	TBD	TBD	±30	±25	TBD	300	±25	±25
Thorium-227	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-229	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-230	00-06	TBD	±30	±25	00-07	TBD	±25	±25
Thorium-231	TBD	TBD	±30	±25	TBD	TBD	±25	±25
Thorium-234	TBD	TBD	±30	±25	TBD	300	±25	±25
Tritium	906.0 M	TBD	±30	±25	906.0	TBD	±25	±25
Uranium	U-04	TBD	±30	±25	U-04	TBD	±25	±25
Uranium-233	U	TBD	±30	±25	908.0	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 5 of 8)

Radionuclides	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in pCi/g	Precision[2/] in RPD	Accuracy[2/] in %	Analysis[1/]	PQL[1/] in pCi/L	Precision[2/] in RPD	Accuracy[2/] in %
Uranium-234	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-235	U	TBD	±30	±25	908.0	TBD	±25	±25
Uranium-238	U	TBD	±30	±25	908.0	TBD	±25	±25
Yttrium-90	Sr-02	TBD	±30	±25	Sr-02	TBD	±25	±25
Zirconium-93	TBD	TBD	±30	±25	TBD	TBD	±25	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 6 of 8)

Inorganics	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in mg/kg	Precision[2/] (RPD)	Accuracy[2/] (%)	Analysis[1/]	PQL[1/] in µg/L	Precision[2/] (RPD)	Accuracy[2/] (%)
pH	9045	N/A	N/A	N/A	9040	N/A	N/A	N/A
Ammonia	350.2 M	500	±25	±30	350.2	500	±20	±25
Arsenic	7061	0.02	±25	±30	7061	10	±20	±25
Barium	6010	0.02	±25	±30	6010	20	±20	±25
Bismuth	TBD	TBD	±25	±30	TBD	TBD	±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
Hydrazine	TBD	TBD	±25	±30	TBD	TBD	±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
Molybdenum	6010	0.08	±25	±30	6010	80	±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. (sheet 7 of 8)

Inorganics	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in mg/kg	Precision[2/] (RPD)	Accuracy[2/] (%)	Analysis[1/]	PQL[1/] in μg/L	Precision[2/] (RPD)	Accuracy[2/] (%)
Nitrite	300 M	TBD	±25	±30	300	40	±20	±25
Palladium	TBD	TBD	±25	±30	TBD	TBD	±20	±25
Selenium	6010	0.75	±25	±30	272.2	10	±20	±25
Silver	6010	0.07	±25	±30	6010	70	±20	±25
Titanium	6010	TBD	±25	±30	6010	TBD	±20	±25
Vanadium	6010	0.08	±25	±30	2862	40	±20	±25
Zinc	6010	0.02	±25	±30	6010	20	±20	±25

Table 8-4. Data Quality Objective Parameters for Chemical/Radiochemical Analyses. (sheet 8 of 8)

Organics	Soil/Sediment				Water			
	Analysis[1/]	PQL[1/] in mg/kg	Precision[2/] (RPD)	Accuracy[2/] (%)	Analysis[1/]	PQL[1/] in μg/L	Precision[2/] (RPD)	Accuracy[2/] (%)
1-Butanol	TBD	TBD	±35	±30	TBD	TBD	±30	±25
Chloroform	8240	0.005	±25	±30	8240	5	±20	±25
MIBK	8240	0.5	±25	±30	8240	5	±20	±25
Tributyl phosphate	TBD	TBD	±35	±30	TBD	TBD	±30	±25

TBD = To Be Determined
M = EPA method modified to include extraction from the solid medium, extraction method is matrix- and laboratory-specific.

Prescribed Procedures for Measurements of Radioactivity in Drinking Water (EPA 1980)
Test Methods for Evaluation of 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 1986)
EML Procedures Manual (DOE/EML 1990)
Eastern Environmental Radiation Facility Radiochemistry Procedures Manual (EPA 1984)
High-Resolution Gamma-Ray Spectrometry of Water (ASTM 1985)

1/ Practical quantitation limits for organics and inorganics are reported in units of mg/kg for soil and mg/L for water.

2/ Precision and accuracy are goals. Since these parameters are highly matrix dependent they could vary greatly from the goals listed.

Table 8-5. Data Gaps by Site Category.

Site Category	Identified Data Gaps
Plants, Buildings and Storage Areas	• Surface radiation levels • Contents of tanks • Integrity of tanks
Tanks and Vaults	• Contaminant concentrations in waste management units other than single-shell tanks • Distribution of contaminants in subsurface soils, if leaks have occurred • Constituent concentrations in related surface contamination
Cribs and Drains	• Contaminant concentrations in soils in and beneath cribs • Specific constituents (especially organic chemicals) • Distribution and vertical/lateral extent of contamination
Reverse Wells	• Contaminant concentrations in subsurface soils impacted by discharges • Specific constituents (especially organics) • 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	• Contaminant 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

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Table 8-6. Applicable Characterization Methods at Semi-Works Aggregate Area Waste Management Units. (sheet 1 of 2)

Waste Management Unit	Surface Radiation Survey	Subsurface Geophysics*	Surface Geophysics (EM/GPR)	Soil Gas Survey	Surface Soil Sampling	Wipe Samples	Subsurface Soil Sampling	Surface Water Sediment Sampling	Remarks
Plants, Buildings, and Storage Areas									
201-C Process Building		•							
291-C Ventilation System		•							
Tanks and Vaults									
241-CX-70 Storage Tank	•	•					•		
241-CX-71 Storage Tank	•	•					•		
241-CX-72 Storage Tank	•	•					•		
Cribs and Drains									
216-C-1 Crib		A		A			A		
216-C-3 Crib			•						
216-C-4 Crib									
216-C-5 Crib									
216-C-6 Crib			•						
216-C-7 Crib									
216-C-10 Crib									
Reverse Wells									
216-C-2 Reverse Well		•					•		
Ponds, Ditches, and Trenches									
216-C-9 Pond		•					•		
200 East Powerhouse Ditch	•	•					•	•	

Table 8-6. Applicable Characterization Methods at Semi-Works Aggregate Area Waste Management Units. (sheet 2 of 2)

Waste Management Unit	Surface Radiation Survey	Subsurface Geophysics*	Surface Geophysics (EM/GPR)	Soil Gas Survey	Surface Soil Sampling	Wipe Samples	Subsurface Soil Sampling	Surface Water Sediment Sampling	Remarks
Septic Tanks and Associated Drain Fields									
2607-E-5 Septic Tank and Drain Field	•	•					•		
2607-E-7A Septic Tank and Drain Field	•	•					•		
Transfer Facilities, Diversion Boxes, and Pipelines									
Semi-Works Valve Pit	•	•				•	•		
Critical Mass Laboratory Valve Pit	•				•	•	•		
241-C-154 Diversion Box	•	•				•	•		
Burial Sites									
218-C-9 Burial Ground		•	•		•		•		
Unplanned Releases									
UN-200-E-36									
UN-200-E-37	•				•		•		
UN-200-E-98	•				•		•		
UN-200-E-141	•					•			

NOTES:
* Might require well installation due to lack of monitoring wells in Semi-Works Aggregate Area.
A - Representative analogue site for investigation of analogous units in this waste management unit category.

9.0 RECOMMENDATIONS

The purpose of the AAMS is to compile and evaluate the existing body of knowledge to support the *Hanford Site Past-Practice Strategy* (DOE/RL 1992) decision-making process. A primary task in achieving this purpose is to assess each waste management unit and unplanned release within the aggregate area to determine the most expeditious path for remediation within the statutory requirements of the CERCLA and RCRA. The existing body of pertinent knowledge regarding Semi-Works Aggregate Area waste management units and unplanned releases has been summarized and evaluated in the previous sections of this report. 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 or unplanned release. This data evaluation process is a refinement of the *Hanford Site Past-Practice Strategy* (Figure 1-2) and establishes criteria for selecting the appropriate *Hanford Site Past-Practice Strategy* path (ERA, IRM, 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 patterns each unit followed.

This section presents recommended assessment paths for the waste management units and unplanned releases at the Semi-Works 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 EPA, Ecology, or 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 on 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* (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* (DOE/RL 1992a). 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.

Seven IRM candidate waste management units and unplanned releases do not have sufficient information regarding the nature and extent of contamination for quantitative or qualitative risk assessment, especially with regard to hazardous constituents, and were recommended for additional investigation (e.g., LFI). No units were recommended for an ERA. Four waste management units may be decontaminated, decommissioned, and closed under other programs; however, these units were retained for evaluation under the Final Remedy Selection following final decommissioning and closure. Eighteen waste management units and unplanned releases were recommended solely for the Final Remedy Selection Path. Two of these are unplanned releases and are recommended for a RA, the other sixteen are recommended for a RI.

Waste management units and unplanned releases which are addressed entirely by other programs were not subjected to the data evaluation process. This includes units and unplanned releases that are within the scope of the Single-Shell Tank Closure Program, Hanford Decommissioning and RCRA Closure Program, and Waste Management Program. Table 9-3 provides a list of the units not included in the evaluation.

A discussion of the four decision-making paths shown on Figure 9-1 (ERA, IRM, LFI, and Final Remedy Selection) is provided in Section 9.1. Section 9.2 provides a discussion of the waste management units and unplanned releases grouped under each of these paths. A discussion of regrouping and prioritization of the waste management units and unplanned releases 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 (Ecology et al. 1990) and could include remedial investigations (RI)/feasibility study (FS), RCRA Facility investigations (RFI)/corrective measures study (CMS), or LFI work plans. Sections 9.4 and 9.5 provide recommendations for focused feasibility and treatability studies, respectively.

9.1 DECISION-MAKING CRITERIA

The criteria used to assess the most expeditious remediation process path are based primarily on urgency for action and whether site data are adequate to proceed along a given path (Figure 9-1). All waste management units and unplanned releases that are not completely addressed under other Hanford Site programs are assessed in the data evaluation process. All of the waste management units and unplanned releases that are addressed in the data evaluation process are initially evaluated as candidates for an ERA. Sites where a release has occurred or is imminent are considered candidates for ERAs. Conditions that might trigger an ERA are the determination of an unacceptable health or environmental risk or a short time-frame available to mitigate the problem (DOE/RL 1992a). As a result, candidate ERA units were evaluated against a set of criteria to determine whether potential for exposure to unacceptable health or environmental risks exists. Units and unplanned releases that are recommended for ERAs will undergo a formal evaluation following the selection process outlined in WHC (1991b).

Waste management units and unplanned releases that are not recommended for consideration as an ERA continue through the data evaluation process. Sites continuing through the process that potentially pose a high risk (refer to Section 5.0) become candidates for consideration as an IRM. The criteria used to determine a potential for high risk, thereby indicating a high priority site, were the HRS score used for nominating waste management units for CERCLA cleanup (40 CFR 300), the modified Hazard Ranking System (mHRS) scores, surface radiation survey data, and rankings by the Environmental Protection Program (Huckfeldt 1991b). Units and unplanned releases with HRS or mHRS scores greater than 28.5 (the CERCLA cleanup criterion) were designated as candidate sites for IRM consideration. Units and unplanned releases that did not have an HRS score were compared to similar sites to establish an estimated HRS score. Sites with surface contamination greater than 2 mrem/hr 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 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 and recommended for consideration as IRM sites may be altered.

For certain waste management 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 Hanford 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 program) were not considered in the 200 AAMS data evaluation process. In addition, potentially new waste management units or unplanned releases that were identified during the AAMS were also not considered. It is recommended that a formal determination be made regarding the regulatory status of all new sites following established procedures before they are considered further under the 200 AAMS data evaluation process. Potentially new sites identified in the Semi-Works Aggregate Area included four drains/dry wells and two unplanned releases, as described in Sections 2.3.3 and 2.3.10, respectively.

Specific criteria used to develop initial recommendations for ERAs, LFIs, and IRMs for waste management units and unplanned releases within the aggregate area are provided in Sections 9.1.1 and 9.1.2. Units and unplanned releases not initially addressed under an ERA, LFI, or IRM will be evaluated under the final remedy selection path discussed in Section 9.1.3.

9.1.1 Expedited Response Action Path

Candidate ERA sites are evaluated to determine if they pose an unacceptable health or environmental risk and a short time frame available to mitigate the problem exists. All units and unplanned releases other than those recommended for complete disposition under another Hanford program are assessed against the ERA criteria. The *Hanford Site Past-Practice Strategy* describes conditions that might trigger abatement of a candidate waste management unit or unplanned release under an ERA. Generally, these conditions would rely on a determination of, or suspected, existing or future unacceptable health or environmental risk, and a short time-frame available to mitigate the problem. Conditions include, but are not limited to the following:

- Actual or potential exposure to nearby human populations, biota, or the food chain from hazardous substances and radioactive or mixed waste contaminants

- Actual or potential contamination of drinking water supplies or sensitive ecosystems

- Threats of release of hazardous substances and radioactive or mixed waste contaminants

- High levels of hazardous substances and radioactive or mixed waste contaminants in soils that pose or may pose a threat to human health or the environment, or have the potential for migration

- Weather conditions that may increase the potential for release or migration of hazardous substances and radioactive or mixed waste contaminants

- The availability of other appropriate federal or state response mechanisms to respond to the release

- Time required to develop and implement a final remedy

- Further degradation of the medium which may occur if a response action is not expeditiously initiated
- Risks of fire or explosion or potential for exposure as a result of an accident or failure of a container or handling system
- Other situations or factors that may pose threats to human health or welfare or the environment.

These conditions were used as the initial screening criteria to identify candidate waste management units and unplanned releases for ERAs. Candidate waste management units and releases that did not meet these conditions were not assessed through the ERA evaluation path. Additional criteria for further, detailed screening of ERA candidates were developed based on the conditions outlined in the *Hanford Site Past-Practice Strategy*. Quantification of these criteria for further screening were developed. These screening criteria are depicted 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 waste management 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 waste management 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 best engineering judgment of what constitutes a high level of contamination warranting expedited action. In some cases, engineering judgment was used to estimate the quantity and concentration of a postulated release. Standards applied include Model Toxics Control Act (MTCA) standards for industrial sites and DOE and Westinghouse Hanford Company 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 the AAMS will be made collectively between DOE, EPA, and Ecology based only on the criteria established in the *Hanford Site Past-Practice Strategy*.

If a release is unacceptable with respect to health or environmental risk, a technology must be readily available to control the release for a unit or unplanned release to be considered for an ERA. An example that would require substantial technology development before implementation of cleanup would be a tritium release since no established treatment technology is available to separate low concentrations of tritium from water.

The next step in the ERA evaluation path involves determining whether implementation of the available technology would have adverse consequences that would offset the benefits of an ERA. Examples of adverse consequences include: (1) use of technologies that result in risks to cleanup personnel that are much greater than the risks of the release; (2) the ERA would foreclose future remedial actions; and (3) the ERA would prevent or greatly hinder future data collection activities. If adverse consequences are not expected, the site remains in consideration for an ERA.

The final criterion is to determine if the candidate ERA is within the scope of an operational program. Maintenance and operation of active waste management facilities are within the scope of activities administered by the Waste Management Program. Active facilities include certain transfer lines, diversion boxes, and the 200 East Powerhouse Ditch. Generally, active facilities will not be included in past practice investigations unless operation is discontinued prior to initiation of the investigation. The Hanford Decommissioning and RCRA Closure Program is responsible for safe and cost-effective surveillance, maintenance, and decommissioning of surplus facilities and RCRA closures at the Hanford Site. The Hanford 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 Semi-Works Aggregate Area will be made among DOE, EPA, and Ecology 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 exist in order that an IRM could be pursued. An IRM is desired for high priority waste management 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 or release 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 a LFI might provide enough data to perform an IRM. If a 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 Semi-Works Aggregate Area based, at least in part, on the recommendations provided in this AAMS, and the results of a supporting LFI.

9.1.3 Final Remedy Selection Path

Sites recommended for initial consideration in the final remedy selection path are those not recommended for IRMs, LFIs, or ERAs and those considered to be low priority sites. It is recognized that all units and unplanned releases within the operable unit or aggregate area will eventually be addressed collectively under the final remedy selection path to support a final aggregate area or operable unit Record of Decision (ROD).

The initial step in the Final Remedy Selection 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 DOE, EPA, and Ecology, these recommendations will be further developed and implemented in work plans.

9.2.1 Proposed Sites for Expedited Response Actions

None of the twenty-five waste management units and unplanned releases addressed in the Semi-Works Aggregate Area screening process met all the criteria for the ERA path. Twelve of the waste management units and unplanned releases met the criteria for the initial step in the ERA path, as indicated on Table 9-2 (i.e., the *Hanford Site Past-Practices Strategy* criteria).

The 216-C-2 Reverse Well and the Critical Mass Laboratory Valve Pit were not recommended for ERAs because of the lack of evidence of existing releases of contaminants. The 216-C-1, 216-C-3, 216-C-4, 216-C-5, 216-C-6, 216-C-7, and 216-C-10 Cribs, the 216-C-9 Pond, and Unplanned Releases UN-200-E-98 and UN-200-E-141 were not recommended for ERAs because of the lack of driving force to an exposure pathway.

9.2.2 Proposed Sites for Interim Remedial Measures

Two of the 25 waste management units and unplanned releases addressed in the Semi-Works Aggregate Area data evaluation process were identified as high priority units (refer to Section 5.0) and were assessed as candidates for IRMs. Both of the units were designated as high priority units because of high HRS and mHRS scores. Neither surface radiation measurements nor the Environmental Protection rankings added to the high priority sites. In addition, 5 low priority units were included as IRM candidates because of their similarities. Septic tanks and drain fields and the unplanned releases were two primary classes of units not considered in the IRM path.

All 7 of the candidate IRM waste management units met the criteria for IRM designation with the exception of having adequate data. No direct sampling information exists for any of these units. It was determined that an LFI could gather sufficient data for the 7 waste management units; therefore, all units remain IRM candidates. A discussion of the LFIs is provided in 9.2.3.

9.2.3 Proposed Sites for Limited Field Investigation Activities

Seven 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 seven 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 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. One analogous group has been identified in the Semi-Works Aggregate Area: cribs. Specific waste management units are then identified that are considered to be representative of the analogous groups. Considerations used to select an analogue site for an analogous group include, but are not limited to, the following:

- Disposal history (including type and quantity of waste received)
- Physical and chemical setting.

Generally the selection process favored as analogue sites those units or releases that received the most waste and were considered as conservative examples in terms of release mechanisms, media of concern, exposure routes, and receptors.

9.2.3.1 Cribs. Seven waste management units have been assigned to this analogous group based on their design and type of waste received. These units include:

- 216-C-1 Crib
- 216-C-3 Crib
- 216-C-4 Crib
- 216-C-5 Crib
- 216-C-6 Crib
- 216-C-10 Crib.

The 216-C-7 Crib, which is being evaluated as a high priority under the IRM path, is associated with and located south of the Critical Mass Laboratory.

The cribs have been grouped together because they have similar release points. 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 (37,900 to 23,400,000 liters) occurred at these waste management units likely affecting near-surface and deeper vadose zone soils.

- The waste management units were completed to roughly the same depths and thus are likely completed in the same stratigraphic horizon. Likewise, the depth to groundwater, approximately 85 m (280 ft), is similar for all of these waste management units.

- Semi-Works Aggregate Area stratigraphy, predominantly the Hanford formation sand unit and the gravels of the Ringold Formation, is generally uniform across the aggregate area and would tend to favor primarily downward fluid movement with limited lateral spreading. Perched water is possible, however, do to the presence of locally discontinuous paleosols in the Hanford formation.

- The waste management units likely received wastewater containing organic compounds such as TBP and also likely received some quantity of acidic wastewater which can enhance the mobility of radionuclides and metals in the subsurface. However, possibly due to microbial degradation, TBP does not appear to persist in the subsurface at the Hanford Site. Also, because Semi-Works was only a pilot-scale facility, the volume of acidic waste disposed of to these cribs appears to be substantially less than that disposed of to the subsurface at production facilities such as the RECUPLEX facility in the Z Plant Aggregate Area.

The 216-C-1 Crib is proposed as an analogue LFI site for the 216-C-3, 216-C-4, 216-C-5, and 216-C-6 Cribs. The 216-C-1 Crib received the largest volume of waste in the group (23,400,000 liters) and had the largest reported inventory of total plutonium and uranium (8 gm and 0.099 ci, respectively). In addition, the time of performance of the 216-C-1 Crib (1953 to 1957) overlaps the operating periods for the other four cribs. Thus, the 216-C-1 Crib would be a conservative representative, with a common operating history, for the other cribs in this analogous group.

The 216-C-1 Crib is also proposed as a partial analogue LFI site for the 216-C-7 and 216-C-10 Cribs. The inventory of waste volumes and radionuclides received by the 216-C-1 Crib compare to or exceed those received by the 216-C-7 and 216-C-10 Cribs. The physical and chemical setting for releases from the 216-C-7 and 216-C-10 Cribs would be basically similar to the physical and chemical setting described above for the other cribs (including 216-C-1). Thus, the 216-C-1 Crib should be able to serve as an analogue for the 216-C-7 and 216-C-10 Cribs in many areas, including contaminant migration, exposure pathways, and impacts on groundwater.

A significant difference, related to the waste streams received, must be considered. The 216-C-7 Crib received reflector tank water from the Critical Mass Laboratory. The waste stream routed to the 216-C-10 Crib was primarily acidic organic waste from the Strontium Recovery Process. Due to the potential presence of different contaminants, the 216-C-1 Crib can only function as a partial analogue and additional LFI activities are thus recommended for the 216-C-7 and 216-C-10 Cribs as well. However, the goal of these LFIs would only be to obtain supplemental data, specific to these cribs, that could not be obtained during the 216-C-1 Crib LFI. The LFIs for the 216-C-7 and 216-C-10 Cribs should focus on gathering information about the unique contaminants released to the cribs and their migration in the environment. The data could then be used to augment the information gathered from the 216-C-1 Crib LFI to determine if opportunities for IRMs exist at all the cribs.

9.2.4 Proposed Sites for Final Remedy Selection Path

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 all of the remaining 18 waste management units and unplanned releases due to the lack of information to perform RAs and select final remedies. These waste management units and unplanned releases are discussed in Section 9.2.4.1.

9.2.4.1 Proposed Sites for Remedial Investigation. A RI has been recommended for the Semi-Works Aggregate Area which includes several groups of waste management units and unplanned releases. The first group contains decommissioned process buildings. The second group contains ponds and burial grounds. The third group contains septic tanks and drain fields which require confirmatory sampling to show that the units do not contain hazardous or radioactive substances. The fourth group contains storage tanks. The fifth group contains unplanned releases with unique contamination histories. The sixth group contains a valve pit and the seventh group contains a ditch.

The RI recommended for the Semi-Works Aggregate Area includes several groups of waste management units and unplanned releases. These are discussed in Sections 9.2.4.2 through 9.2.4.8, and are grouped as follows:

- 201-C Process Building, 291-C Ventilation System, 241-C-154 Diversion Box, Semi-Works Valve Pit, and 216-C-2 Reverse Well
- 216-C-9 Pond and 218-C-9 Burial Ground
- Septic Tanks and Associated Drain Fields
- 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks
- Unplanned Releases UN-200-E-98 and UN-200-E-141
- Critical Mass Laboratory Valve Pit
- 200 East Powerhouse Ditch.

9.2.4.1.1 201-C Process Building, 291-C Ventilation System, 241-C-154 Diversion Box, Semi-Works Valve Pit, and 216-C-2 Reverse Well. These five waste management units are grouped together because they all underwent similar decommissioning techniques and are in relative proximity to each other. All five waste management units are presently located beneath a common, partially installed ash barrier.

The above-ground portions of the 201-C Process Building and the 291-C Ventilation System structures were decontaminated, dismantled, rubbled to the cell tops, and/or sealed with grout. The underground portions of the structures were stabilized in place by filling the voids with cement grout. The diversion box and valve pit were also filled with grout.

Due to past decommissioning activities and the stabilization of in-place contamination, the 201-C Process Building, 291-C Ventilation System, 241-C-154 Diversion Box, and Semi-Works Valve Pit were eliminated from the ERA path because they do not meet the *Hanford Site Past-Practice Strategy* criteria. Similarly, these waste management units were not ranked as high priority sites and consequently were not included in the IRM path. A RI is recommended for these waste management units to collect sufficient data to evaluate the limits under the overall RA for the operable unit/aggregate area.

The 216-C-2 Reverse Well has been stabilized, grouted, and is under the partially installed ash barrier. This unit was initially assessed in the ERA path, but was eliminated in the screening process due to lack of a driving force to an exposure pathway. It was not ranked as a high priority and thus was not assessed in the IRM path. Furthermore, the data were insufficient to perform a RA in the Final Remedy Selection Path. Consequently, a RI is recommended for the 216-C-2 Reverse Well to collect sufficient data for the overall operable unit/aggregate area RA.

9.2.4.1.2 216-C-9 Pond and 218-C-9 Burial Ground. These two units are grouped together due to their proximity. The 218-C-9 Burial Ground was situated in the eastern portion of the 216-C-9 Pond, after use of the pond had ceased and it had largely dried up.

The 216-C-9 Pond was initially assessed in the ERA path. However, given that the unit is inactive and has been stabilized with a gravel layer, it was eliminated from this path because there is no longer a driving force to an exposure pathway. Since it was not ranked a high priority site it was not assessed in the IRM path. Finally, there was insufficient data to perform a RA for the unit.

The 218-C-9 Burial Ground did not meet the initial criteria for the ERA path, nor was it considered a high priority site to be assessed in the IRM path. Again, due to a limited amount of available data, a RA could not be performed.

Data for a RI, the recommended path for this group, can be collected simultaneously for both waste management units. Subsequently, a RA can be performed and a final remedy selected.

9.2.4.1.3 Septic Tanks and Associated Drain Fields. The 2607-E-5 and 2607-E-7A Septic Tanks and Drain Fields have been grouped together not only because of their similarity, but also because they work in tandem and share a common drain field. These active waste management units are reported to receive only sanitary waste and, consequently, did not meet the criteria for the ERA path. The units were not ranked as high priorities, so they were not considered as candidates for IRMs. Insufficient site-specific sampling and waste inventory data preclude moving immediately into the RA branch of the Final Remedy Selection Path, so a RI is recommended. Investigation is recommended for these two units to provide enough data to confirm that no contamination exists. If no contamination were to be found, then no further action would be recommended.

9.2.4.1.4 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks. These three tanks are grouped together due to their proximity, similarity of wastes received, and general similarity of design and construction.

These tanks were, until recently, being addressed under the Hanford Decommissioning and RCRA Closure Program. In December 1992 a proposal was made to shift closure of these tanks as part of the CERCLA remediation of this operable unit. The 241-CX-70 tank has been cleaned of all residual waste and a monitoring system has been installed to detect leakage into the tank. The 241-CX-71 and 241-CX-72 tanks have been left in a safe configuration and all three tanks are inspected monthly by Decommissioning and RCRA Closure personnel. The 241-CX-70 Storage Tank Part A permit has been revised for the 241-CX-71 Tank and another revision is planned to incorporate the 241-CX-72 Storage Tank.

The 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks were not considered to be candidates for ERAs because they did not meet the criteria in the *Hanford Site Past-Practice Strategy* for ERAs. They did not rank as high priority sites, so were not considered candidates for IRMs. Thus, they were carried on for consideration under the Final Remedy Selection Path. Therefore, an RI is recommended for the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks to provide information for an RA and to recommend any further remediation needed for the tanks.

9.2.4.1.5 Unplanned Releases UN-200-E-98 and UN-200-E-141. These two unplanned releases are grouped together because they involve surface releases of radioactive contamination.

Unplanned Release UN-200-E-98 involved radioactive particulate matter and occurred near the base of the 291-C Stack and around the 216-C-2 Reverse Well. It was initially assessed in the ERA path. However, since the site had undergone cleanup and had subsequently been covered with the ash barrier, there is no driving force to an exposure pathway. Similarly, the unplanned release was not ranked as a high priority and thus not included in the IRM path. A RI is recommended for the Unplanned Release UN-200-E-98. A limited amount of additional data on this unplanned release is needed to conduct a RA.

Unplanned Release UN-200-E-141 involved an uranyl nitrate spill in the 2718 Storage Building near the Critical Mass Laboratory. All contaminated materials, including soil, were removed until background levels of contamination were encountered. The site was assessed in the ERA path, but was eliminated due to a lack of a driving force to an exposure pathway. The unplanned release was not included in the IRM path because it was not ranked a high priority. A RI is recommended for Unplanned Release UN-200-E-141 to confirm that the site was adequately remediated and provide data for a RA.

9.2.4.1.6 Critical Mass Laboratory Valve Pit. The Critical Mass Laboratory Valve Pit was, until recently, considered to be an active unit. The likely future status of the valve pit will be inactive, which will result in its decontamination and decommissioning under the Hanford Decommissioning and RCRA Closure Program. After the valve pit has been decommissioned, it will need to be finally considered under the Semi-Works AAMS process. Thus, even though decontamination of the valve pit will be performed under a separate program, it was evaluated under the ERA, IRM, and Final Remedy Selection Paths.

The Critical Mass Laboratory Valve Pit was assessed in the ERA path, but was eliminated due to a lack of a driving force to an exposure pathway. It did not rank as a high priority site, so was not considered a candidate for IRM. Thus, the valve pit was carried on for consideration under the Final Remedy Selection Path. The decontamination of the valve pit will be addressed by an existing operational program. Final evaluation of the need for further remediation within the overall context of the Semi-Works Aggregate Area activities will then be required.

It is recommended that the Critical Mass Laboratory Valve Pit be considered in the overall RA for the operable unit. Information obtained during decontamination and decommissioning as well as from other investigations at the Semi-Works Aggregate Area would be integrated in the operable unit RI to provide the needed information to perform a RA and recommend any further remediation needed for the valve pit.

9.2.4.1.7 200 East Powerhouse Ditch. The 200 East Powerhouse Ditch is currently an active waste management unit. However, discharges to the ditch will eventually be halted, at which time the ditch will need to be considered under the AAMS for potential investigation and remediation. Therefore, it was evaluated under the ERA, IRM, and Final Remedy Selection Paths.

The 200 East Powerhouse Ditch was not assessed in the ERA path because it did not meet the necessary criteria in the *Hanford Site Past-Practice Strategy* for ERAs. The ditch was not ranked a high priority and thus was not considered a candidate for IRM. The available data are insufficient to perform a RA, therefore a RI is recommended for the 200 East Powerhouse Ditch.

9.2.4.2 Unplanned Releases UN-200-E-36 and UN-200-E-37. Cleanup actions were taken in 1967 immediately after each of the Unplanned Releases UN-200-E-36 and UN-200-E-37 was discovered. The two are attributed to the initial release reported under UN-200-E-36. Because of the rapid cleanup actions and a lack of detection in current surface radiation data, Unplanned Releases UN-200-E-36 and UN-200-E-37 were eliminated from the ERA path because neither met the *Hanford Site Past-Practice Strategy* criteria. Neither Unplanned Release was ranked as high priority sites and consequently are not included in the IRM path. The releases are recommended for a RA. The available radiation data should result in a RA recommending no further action is needed.

9.3 SOURCE OPERABLE UNIT REDEFINITION AND PRIORITIZATION

The investigation process can be made more efficient if waste management 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 waste management units are studied together.

9.3.1 Units Addressed by Other Programs

During the course of the Semi-Works AAMS it was determined that as many as four of the original twenty-five waste management units could end up being addressed under other programs currently operating at the Hanford Site. These programs include the Hanford Decommissioning and RCRA Closure Program and RCRA Program. The following sections discuss the recommended programs for the four waste management units.

9.3.1.1 Hanford Decommissioning and RCRA Closure Program. Decontamination and decommissioning activities was originally planned to be carried out for four waste management units under the Hanford Decommissioning and RCRA Closure Program. These units include the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks, and the Critical Mass Laboratory Valve Pit. However, further activities will be needed for each of these units following final decommissioning.

The storage tanks will likely be closed under the CERCLA Program, as discussed further below. The Critical Mass Laboratory Valve Pit has been recommended for final assessment under the Final Remedy Selection Path for the operable unit once decommissioning has been completed. Under this recommended approach, it would be necessary to coordinate investigation and decontamination work performed for the valve pit under the Hanford Decommissioning and RCRA Closure Program with ongoing CERCLA activities at the Semi-Works Aggregate Area.

9.3.1.2 RCRA Program. The need for coordination between CERCLA activities and ongoing RCRA activities may diminish. Until recently, the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks were to be decontaminated and decommissioned under the Hanford Decommissioning and RCRA Closure Program. However, this program has recommended that closure be deferred to the CERCLA Operable Unit remediation activities.

9.3.2 Semi-Works Operable Unit Redefinition

The Semi-Works Aggregate Area contains only one operable unit, 200-SO-1, therefore there is no opportunity to consolidate operable units.

All of the waste management units and unplanned releases in the Semi-Works Aggregate Area, with the exception of the 200 East Powerhouse Ditch, are associated with past waste management practices at Semi-Works. The 200 East Powerhouse Ditch is an active liquid waste disposal unit that is connected to the 216-B-3 Pond Complex in the B Plant Aggregate Area. It is recommended that the 200 East Powerhouse Ditch be redefined to be in the 200-SS-1 operable unit. None of the other Semi-Works Aggregate Area waste management units and unplanned releases are recommended for investigation or remediation under other aggregate areas or operable units.

Investigation of groundwater should be removed from the scope and included in a 200 East Area Groundwater Operable Unit. Groundwater beneath the 200-SO-1 Operable Unit interacts with all surrounding operable units since it is not confined by the geographic boundaries. Contamination from nearby operable units has potentially migrated beneath the 200-SO-1 Operable Unit. Similarly, the contamination originating from the operable unit has potentially migrated outside the boundaries of the operable unit. These interactions with other operable units will necessitate the integration of groundwater response actions throughout the 200 East Area. This integration would likely be best handled in groundwater-specific operable units, rather than in combined groundwater and source operable units.

9.3.3 Investigation Prioritization

Very little if any data exist to rank the waste management units and unplanned releases within the Semi-Works Aggregate Area on a risk-related basis. The HRS, mHRS, 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 necessarily suitable to develop a risk-related priority ranking. The most useful data for indicating potential risk are probably a combination of the surface radiation data and the waste inventories.

Given the volume of liquids received and the potential that some of this may have reached the groundwater table (Table 4-14), the cribs and 216-C-9 Pond/218-C-9 Burial Ground should be considered as higher priority sites. The cribs are recommended as having a higher priority than the 216-C-9 Pond/218-C-9 Burial Ground. Although the 216-C-9 Pond received relatively large volumes of liquids, most of these were process cooling waters that would not have contained the levels of contaminants present in the crib discharges. The 218-C-9 Burial Ground received only dry demolition and decommissioning wastes, thus is not likely to present as significant a threat of contaminant migration as would the cribs. Of the cribs, the 216-C-1 Crib should be investigated first as the analogue site for the other cribs, followed by investigation of the 216-C-7 and 216-C-10 Cribs.

In general, priorities for the remaining waste management units and unplanned releases are not critical, and should be developed in subsequent work plans. However, it should be noted that investigations of several units (the 241-CX-70, 241-CX-71, and 241-CX-72 Storage Tanks, and the Critical Mass Laboratory Valve Pit), originally to be performed as part of decontamination, decommissioning, and closure activities under the Hanford Decommissioning and RCRA Closure Programs may now be handled under the CERCLA closure. If they remain under the RCRA path, these activities should be given sufficient priority within their respective programs to enable effective integration with final evaluation of these units under the RA of the Final Remedy Selection Path for the Semi-Works AAMS. Otherwise they will be addressed as a part of the RI under Final Remedy Selection Path for the AAMS process.

9.3.4 RCRA Facility Interface

One RCRA TSD facility is currently identified in the Semi-Works Aggregate Area; the 241-CX-70 Storage Tank. A revision to the Part A Permit has been submitted to Ecology for the 241-CX-71 Storage Tank and another revision to the Part A will be prepared and submitted to Ecology for the 241-CX-72 Storage Tank. All three tanks are currently considered to be subject to RCRA. If the storage tanks will not be closed under RCRA, it is recommended that the need for remediation be addressed under the CERCLA process as part of the RI under Final Remedy Selection Path for the operable unit.

If the storage tanks cannot be clean-closed, it is recommended that post-closure or remediation be addressed under the CERCLA process as part of the Final Remedy Selection Path for this operable unit. The rationale for this recommendation is based on the intent expressed in the *Hanford Site Past-Practice Strategy* to integrate the CERCLA RI/FS and RCRA TSD Closure processes wherever possible to avoid duplication of efforts. Since the processes are intended to support each other, and all other work at the Semi-Works Aggregate Area would be performed under the CERCLA process, the storage tanks would most efficiently be addressed by incorporating them under the ongoing CERCLA investigation and remediation work. RCRA considerations would be addressed as ARARs under the CERCLA activities.

Implementing the above recommendations would require interfacing the Semi-Works AAMS process with the RCRA Program as the tanks are investigated and evaluated for permanent closure options. The RCRA closure and AAMS processes would identify opportunities to integrate their activities, including efforts to: select mutually supportive data quality objectives; coordinate data collection; and use compatible closure/remediation methods.

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. Focused feasibility studies (FFSs) are studies in which a limited number of units or remedial alternatives are considered. A final FS will be prepared to provide the data necessary to support the preparation of final ROD. Insufficient data exist to prepare either a focused or final FS for any waste management units or group of units within the Semi-Works 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 Semi-Works Aggregate Area for individual waste management units or waste management unit groups. The IRMs will be implemented as they are approved, and the FFSs will be prepared to support their implementation. The

FFSs applied in this manner are intended to examine a limited number of alternatives for a specific waste management unit or group of waste management units. The FFSs supporting IRMs will be based on the technology screening process applied in Section 7.0, engineering judgement, and/or new characterization data such as that generated by an LFI.

Recommendations for the FFS in support of IRMs are not provided in this report because of the limited data availability. In all cases, LFIs will be conducted at sites initially identified for IRMs. The information gathered is considered necessary prior to a final determination on whether an IRM is actually necessary or whether a remedy can be selected.

Rather than being driven by an IRM, the FFSs will also be prepared to evaluate select remedial alternatives. In this case the FFSs focus on technologies or alternatives that are considered to be viable based on their implementability, cost, and effectiveness and have broad application to a variety of sites. The following recommendations are made for FFSs that focus on a particular technology or alternative:

- Capping
- Ex situ treatment of contaminated soils
- In situ stabilization.

These recommendations reflect select technologies developed in Section 7.0 of this report.

The FFS is intended to provide a detailed analysis of select remedial alternatives. The results of the detailed analysis provide the basis for identifying preferred alternatives. The detailed analysis for alternatives consists of the following components:

- Further definition of each alternative, if appropriate, with respect to the volumes or areas of contaminated environmental media to be addressed, the technologies to be used, and any performance requirements associated with those technologies. Remedial investigations and treatability studies, if conducted, will also be used to further define applicable alternatives.
- An assessment and summary of each alternative against evaluation criteria specified in EPA's *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988b).
- A comparative analysis of the alternatives that will facilitate the selection of a remedial action.

9.4.2 Final Feasibility Study

To complete the remediation process for an aggregate area, a final or summary FS will be prepared. This study will address those sites not previously evaluated and will summarize the results of preceding evaluations. The overall study and evaluation process for an aggregate area will consist of a number of FFSs, field investigations, and interim RODs. All of this study information will be summarized in one final FS to provide the data necessary for the final ROD. The summary FS will likely be conducted on an aggregate area basis; however, future considerations may indicate that a larger scope is appropriate.

9.5 TREATABILITY STUDIES

A range of technologies which are likely to be considered for remediation of sites within the Semi-Works 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 radionuclides
- In situ soil vapor extraction of volatile organic compounds.

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 treatability testing needs outlined in Section 7.3 is as follows:

- Engineered multimedia cover--A number of cover design efforts have taken place in support of Hanford Site waste management, permitting, RARA, and RCRA closure activities. Although performance testing is lacking, a number of conceptual cover designs have been developed for various types of waste management units. The feasibility/treatability process can be accelerated by utilizing existing cover design information. Long-term performance and maintenance objectives, and design criteria should be established for various categories of waste management units based on the degree of protection required. The adequacy of existing conceptual designs should be evaluated against these design criteria and modified appropriately. Hydrologic performance and constructibility data needs can then be assessed by pilot-scale testing of preliminary cover designs.

- In situ grouting—Field pilot tests would be required to assess the required injection well spacing and the optimum grout injection methods; bench-scale and pilot-scale tests would be required to demonstrate the effectiveness for stabilizing the contaminants.

- Excavation and soil treatment—Testing will likely be required for several components of an excavation and treatment system. It is anticipated that the waste management units would be excavated with conventional mining and construction equipment. However, some equipment modifications may be required to ensure worker protection. If available, remote excavation equipment could be utilized to protect workers at waste management units containing high exposure potential. Testing of measures to control fugitive dust during retrieval activities will be required.

  The testing required for the treatment process will depend on the type of treatment considered and the site-specific conditions. It is anticipated that most of the treatability information required could be obtained by a combination of literature research, laboratory screening, and bench-scale studies. However, pilot-scale testing may be required for certain treatment processes.

  Physical separation (i.e., soil washing) pilot-scale treatability testing within the 300-FF-I Operable Unit is being planned which will be applicable for the 200 Areas. The soils of the Hanford Site are well suited for treatment with a physical separations process. The soils are predominantly coarse sand and gravel, with less than 10% silts and clay. It is expected that contaminants will be found largely adsorbed on the smaller soil particles and as coatings on larger particles. The physical soil washing process should provide removal of the precipitate coatings from the large particles and separation of large from small particles. This would result in a large volume reduction by separating and concentrating the contaminants.

  The physical separations test in the 300-FF-1 Operable Unit will be conducted in three phases. In Phase I, soils will be characterized to assess physical, chemical, and radioactive properties. Phase II testing will establish baseline operations and capabilities of a system utilizing water as the washing solution. In Phase III, performance of the system will be optimized. Phase III may consist of two parts, processing with water only, and processing using selected nonhazardous and environmentally acceptable chemical extractants, if necessary to optimize the system. Laboratory bench tests may be performed to determine the primary and secondary chemical extractants to be considered for use in Phase III testing. However, it is anticipated that in the 300 Area, physical separation resulting in a large volume reduction of contaminated soil may be achieved with water only. Chemical extracts maybe required for soil washing to be successful in other areas of the Hanford Site (i.e., 200 and 100 Areas). This will depend to a large extent on the type of contaminant at the adsorption coefficient.

If the pilot-scale test is successful in the 300 Area, then the application of this process to the 200 Areas should be tested.

- In situ vitrification—In situ vitrification has been tested and field demonstrated on soil sites contaminated with radionuclides, heavy metals, and organic wastes. As a result of this testing and demonstration program, established capabilities and limitations of the in situ vitrification technology have been identified, along with technical issues that need to be resolved for successful implementation. The In Situ Vitrification Integrated Program was created by DOE's office of Technology Development to help resolve these issues and promote deployment of the technology in the field. The In Situ Vitrification Integrated Program is currently working to resolve the following key issues for implementation at contaminated soil sites:

  - Develop methods that accurately predict, measure, and achieve significantly greater melt depth and control of the melt shape. Presently, the in situ vitrification process has been demonstrated to a depth of 5 m (16 ft).

  - Improve the understanding of and verify VOC contaminant transport behavior.

  - Determine the potential for transient gas release events while vitrifying contaminated soils under varying conditions. Better define operating parameters and limits to ensure containment and treatment of offgases during processing.

  - Resolve secondary waste generation and handling concerns as they relate to the volatilization of ^{137}Cs from highly concentrated soils.

Other DOE in situ vitrification related activities include evaluating the cost of in situ vitrification against other technologies (report to be released before fiscal year end) and a field demonstration at the Idaho National Engineering Laboratory (INEL) during fiscal year 1993. Additional field demonstrations will be required before all issues surrounding implementation of in situ vitrification to contaminated soil sites can be resolved.

There is a large uncertainty whether the In Situ Vitrification Integrated Program will obtain the funding required to resolve these issues. Without resolution of these issues in situ vitrification will have very limited application to remediation at the Hanford Site.

- Excavation, treatment and disposal of transuranic radionuclides--Development and testing of methods to characterize, retrieve, treat, and package waste from TRU contaminated waste management units will be required. The DOE Office of Technology Development has established the Buried Waste Integrated Demonstration (BWID) at INEL to resolve these issues. The BWID is focused on sites containing buried waste; however, it is expected that many of the original containers at INEL degraded significantly, resulting in contamination of the immediately surrounding soil. As a result, the BWID will also be resolving some of the issues surrounding retrieval and treatment of TRU contaminated soil.

  A major concern for retrieval of TRU contaminated materials will be control of fugitive dust. Testing of various types of foams and fixants, that will not interfere with treatment and disposal, will be required. In addition, development of foams and fixants for dust control will be important for non-TRU contaminated waste management units. The use of containment structures (e.g. buildings) to contain fugitive dust during remediation is very expensive and cumbersome (creating problems for both equipment and workers). A significant cost savings could be realized if foams and fixants are used in place of containment structures.

- In situ soil vapor extraction of volatile organic compounds--Development and testing of methods to characterize, retrieve, and treat waste from VOC contaminated soil will be required. The DOE has established the VOC-Arid Integration Demonstration to resolve these issues. The Z Plant Aggregate Area is currently the initial host site for the demonstration and is associated with an active ERA to remove carbon tetrachloride from the vadose zone using vapor extraction. These activities are expected to resolve numerous design and treatability issues associated with in situ soil vapor extraction. However, additional treatability testing may be required to resolve site specific data needs.

As treatability testing of the various alternatives progresses, other parameters are likely to be identified which require further development.

Figure 9-1. 200 Aggregate Area Management Study Data Evaluation Process.

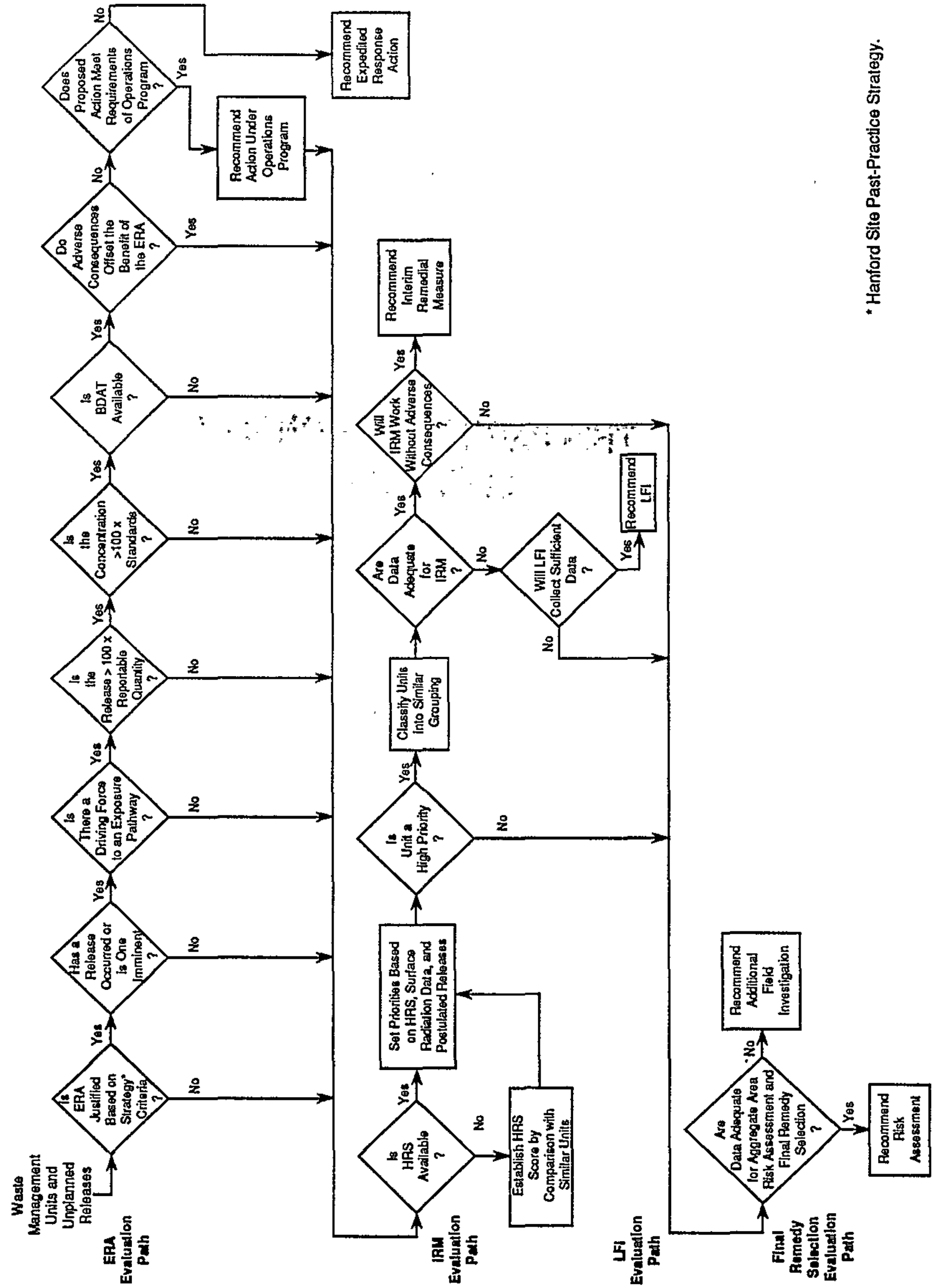

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Table 9-1. Summary of the Results of Remediation Process Path Assessment. (sheet 1 of 2)

Waste Management Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Plants, Buildings, and Storage Areas							
201-C Process Building					X		Structures have been stabilized under Hanford Surplus Facilities Program.
291-C Ventilation System					X		
Tanks and Vaults							
241-CX-70 Storage Tank					X		Tanks likely to be decontaminated and decommissioned under CERCLA. Evaluations for post-closure care or remediation to be performed under Final Remedy Selection Path.
241-CX-71 Storage Tank					X		
241-CX-72 Storage Tank					X		
Cribs and Drains							
216-C-1 Crib		X	X				All cribs included under one analogous group. 216-C-1 Crib to be investigated as analogue site, with supplemental LFIs at 216-C-7 and 216-C-10 Cribs.
216-C-3 Crib		X	X				
216-C-4 Crib		X	X				
216-C-5 Crib		X	X				
216-C-6 Crib		X	X				
216-C-7 Crib		X	X				
216-C-10 Crib		X	X				
Reverse Wells							
216-C-2 Reverse Well					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
Ponds, Ditches, and Trenches							
216-C-9 Pond					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
200 East Powerhouse Ditch					X		Recommended to be removed from the Semi-Works operable unit and included as a waste management unit under B Plant AAMS.

Table 9-1. Summary of the Results of Remediation Process Path Assessment. (sheet 2 of 2)

Waste Management Unit	ERA	IRM	LFI	RA	RI	OPS	Remarks
Septic Tanks and Associated Drain Fields							
2607-E-5 Septic Tank and Drain Field					X		
2607-E-7A Septic Tank and Drain Field					X		
Transfer Facilities, Diversion Boxes, and Pipelines							
Semi-Works Valve Pit					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
Critical Mass Laboratory Valve Pit					X		To be decommissioned under Hanford Decommissioning and RCRA Closure Program, then evaluated under Final Remedy Selection Path.
241-C-154 Diversion Box					X		Unit has been decontaminated and decommissioned under Hanford Surplus Facilities Program.
Burial Sites							
218-C-9 Burial Ground					X		
Unplanned Releases							
UN-200-E-36				X			
UN-200-E-37				X			
UN-200-E-98					X		
UN-200-E-141					X		

ERA = Expedited Response Action.
IRM = Interim Remedial Measure.
LFI = Limited Field Investigation.
RA = Risk Assessment.
RI = Remedial Investigation.
OPS = Operational Programs.

Table 9-2. Semi-Works Aggregate Area Data Evaluation Decision Matrix. (sheet 1 of 2)

	ERA Evaluation Pathway								IRM Evaluation Pathway			LFI Path	Final Remedy
Waste Management Unit	Hanford Site Past-Practice Strategy Criteria?	Release?	Pathway?	Quantity?	Concentration?	Treat-ment Available?	Adverse Consequences?	Operational Programs?	High Priority?	Data Adequate?	Adverse Consequences?	Collect Data?	Data Adequate?
Plants, Buildings, and Storage Areas													
201-C Process Building	N	—	—	—	—	—	—	—	N	—	—	—	N
291-C Ventilation System	N	—	—	—	—	—	—	—	N	—	—	—	N
Tanks and Vaults													
241-CX-70 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
241-CX-71 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
241-CX-72 Storage Tank	N	—	—	—	—	—	—	—	N	—	—	—	N
Cribs and Drains													
216-C-1 Crib	Y	Y	N	—	—	—	—	—	Y	N	—	Y	—
216-C-3 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-4 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-5 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-6 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-7 Crib	Y	Y	N	—	—	—	—	—	N[a]	N	—	Y	—
216-C-10 Crib	Y	Y	N	—	—	—	—	—	Y	N	—	Y	—
Reverse Wells													
216-C-2 Reverse Well	Y	N	—	—	—	—	—	—	N	—	—	—	N
Ponds, Ditches, and Trenches													
216-C-9 Pond	Y	Y	N	—	—	—	—	—	N	—	—	—	N
200 East Powerhouse Ditch	N	—	—	—	—	—	—	—	N	—	—	—	N

Table 9-2. Semi-Works Aggregate Area Data Evaluation Decision Matrix. (sheet 2 of 2)

	ERA Evaluation Pathway								IRM Evaluation Pathway			LFI Path	Final Remedy
Waste Management Unit	Hanford Site Past-Practice Strategy Criteria?	Release?	Path-way?	Quan-tity?	Concen-tration?	Treat-ment Available?	Adverse Conse-quences?	Opera-tional Pro-grams?	High Priority?	Data Ade-quate?	Adverse Conse-quences?	Collect Data?	Data Ade-quate?
Septic Tanks and Associated Drain Fields													
2607-E-5 Septic Tank and Drain Field	N	—	—	—	—	—	—	—	N	—	—	—	N
2607-E-7A Septic Tank and Drain Field	N	—	—	—	—	—	—	—	N	—	—	—	N
Transfer Facilities, Diversion Boxes, and Pipelines													
Semi-Works Valve Pit	N	—	—	—	—	—	—	—	N	—	—	—	N
Critical Mass Laboratory Valve Pit	Y	N	—	—	—	—	—	—	N	—	—	—	N
241-C-154 Diversion Box	N	—	—	—	—	—	—	—	N	—	—	—	N
Burial Sites													
218-C-9 Burial Ground	N	—	—	—	—	—	—	—	N	—	—	—	N
Unplanned Releases													
UN-200-E-36	N	—	—	—	—	—	—	—	N	—	—	—	Y
UN-200-E-37	N	—	—	—	—	—	—	—	N	—	—	—	Y
UN-200-E-98	Y	Y	N	—	—	—	—	—	N	—	—	—	N
UN-200-E-141	Y	Y	N	—	—	—	—	—	N	—	—	—	N

*Evaluated as high priority site because of proximity and/or similarity to other high priority sites.
N = No.
Y = Yes.
ERA = Expedited Response Action.
IRM = Interim Remedial Measure.
LFI = Limited Field Investigation.

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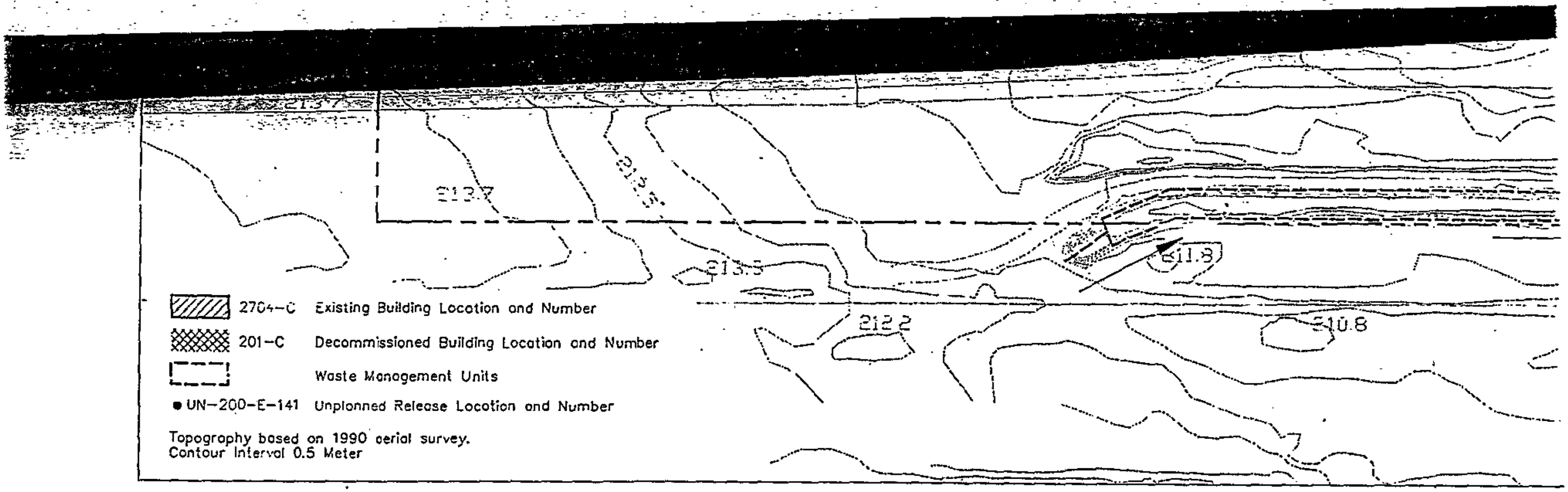
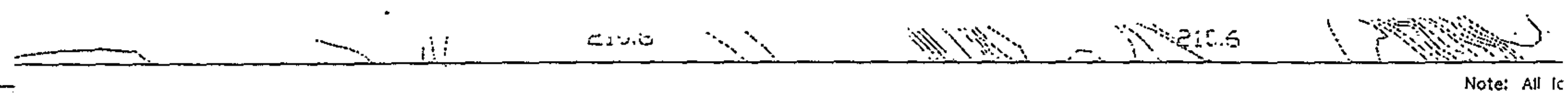


Plate 1. Facilities, Sites, Unplanned Releases and T



and Topographic Map of Semi-Works Aggregate Area

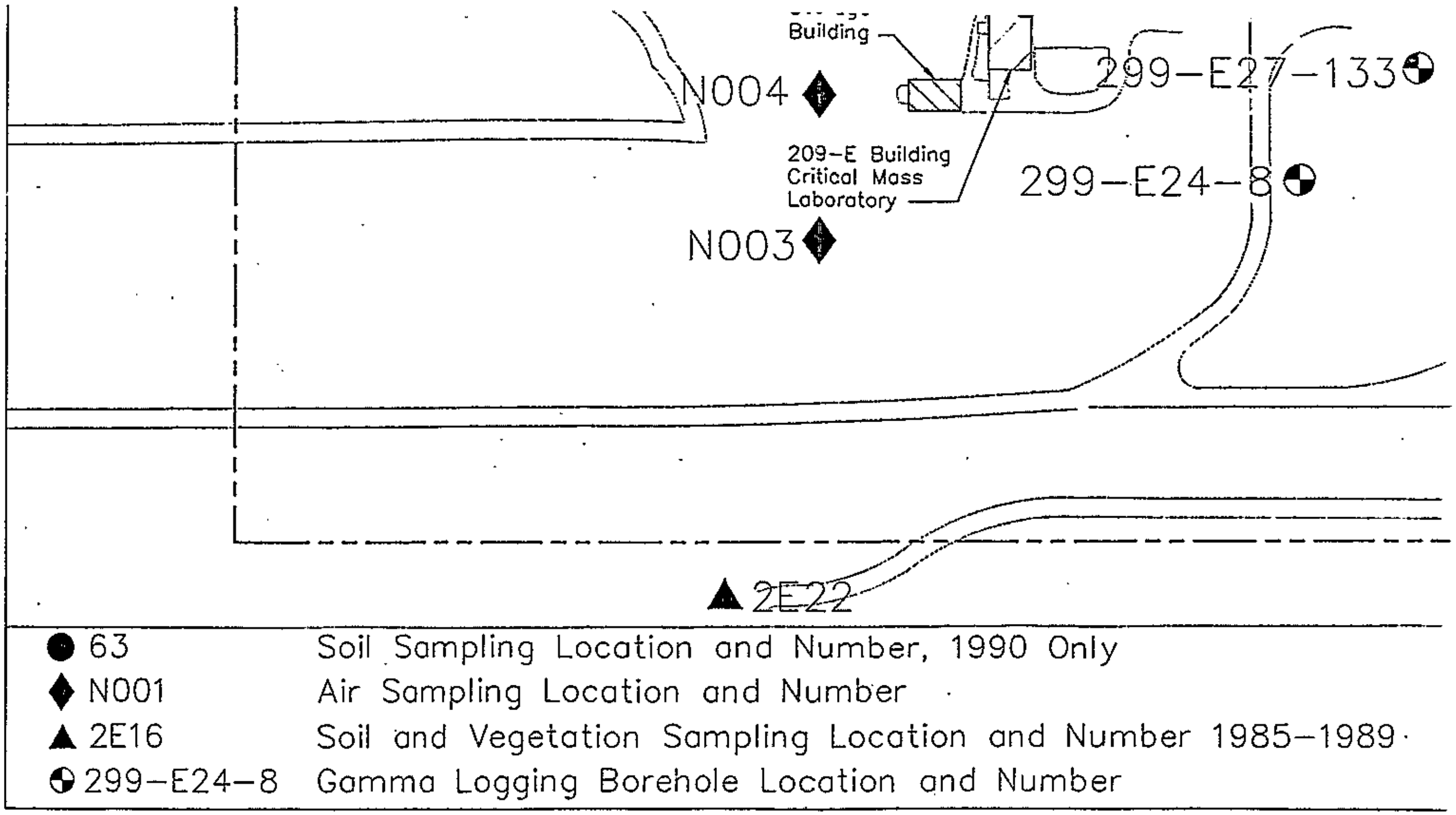


Plate 2. Semi-Works Aggregate Area Surfac

face Media and Air Sampling Location Map

APPENDIX A

SUPPLEMENTAL DATA

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TABLES

A.1.0 GEOPHYSICAL DATA

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 Semi-Works Aggregate Area since at least as early as 1959. Such logging can be used to map lithologic boundaries (Additon et al. 1978; Last et al. 1989; Brodeur and Koizumi 1989), soil moisture content and to evaluate the location and extent of radionuclides in the subsurface due to waste disposal activities (Fecht et al. 1977; Additon et al. 1978). 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..

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. Additon 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 Additon 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. Additon 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 Additon 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.

Four inactive waste management units in the Semi-Works Aggregate Area which are monitored by wells in which gross gamma logs have been collected were evaluated in this study. These waste management units have been 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 Section A.1.4.

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.

The gamma logs available for the Semi-works 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; Additon et al. 1978; Brodeur and Koizumi 1989; Arthur 1990).

The accuracy and precision of gamma activity measurements in the subsurface is determined by details of the logging system instrumentation, the field data acquisition methodology, the surrounding media and the radionuclides present. The relationship between the gamma activity detected by a scintillation probe and the actual activity, the distance gamma radiation may travel through geologic materials before being completely attenuated and the vertical resolution of changes in activity by the logging systems used is discussed below.

The time required for the logging system to process a detected gamma photon, or "dead time," is an important limitation in the measurement gamma activity (Brodeur and Koizumi 1989; Arthur 1990). During this short span of time, no other photons will be processed by the instrument. The "dead time" computed for the PNL system currently in use is 17.8 microseconds (Arthur 1990). Based on 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 No. 4 (Strong 1980). This suggests that the "dead time" of their logging system is about 10 microseconds. There is no evidence that the TFSA&S system will become paralyzed if this activity level is exceeded.

The actual gamma activity on an interval may be computed by multiplying the "dead time" corrected activity by a factor consistent with the amount of attenuation due to well construction. The amount of attenuation the gamma radiation experiences in penetrating well casing is significant. A single string of casing reduces the count rate measured by the scintillation probe by about 25%, groundwater in an uncased hole reduces the observed count rate by 11%, and groundwater in a cased hole reduces the observed count rate by about 33% (Brodeur and Koizumi 1989; Arthur 1990).

The relationship between the gamma activity observed with a scintillation probe and the actual activity is linear over much of the system's range. However, above some threshold activity level, the relationship between the observed and actual activity becomes non-linear. At this point the tool is said to be saturated. The gross gamma logging system currently in use by PNL becomes saturated around 14,500 ct/sec (Brodeur and Koizumi 1989; Arthur 1990), and that currently in use by TFSA&S with Probe No. 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 (Schlumberger 1972). The radius of investigation is larger on intervals where there are high concentrations of radionuclides since higher intensities of gamma radiation will penetrate a greater thickness of a given material. The radius of investigation is decreased by well casing, grout, and groundwater since they increase the effective density of sediments. Another factor in determining the radius of investigation is the tool response to low energy (frequency) gamma photons. The scintillation probe currently used by PNL has a low energy cutoff of between 46.5 and 59.5 keV (Arthur 1990). Gamma radiation with energies below this value will not be detected by that probe. The low energy cutoff for the probes used by TFSA&S is unknown.

The vertical resolution and apparent location of a change in the gamma activity measured by a scintillation probe depends upon details of how the probe signal is processed by the rate meter and the logging speed. The rate meter used in PNL's logging system differs from that used by TFSA&S. The rate meter used by PNL smooths its output using an electronic circuit (an RC circuit). The amount of smoothing is determined by the time constant of the circuit used. This removes statistical variations in the signal detected by the scintillation probe and improves the reproducibility and sensitivity of the data. However, a "lag" is introduced between the depth at which a change in the gamma activity is first encountered by the scintillation probe and the depth at which it is plotted. The size of this "depth lag" is the distance traveled before half of the amplitude of the change in activity is recorded. One time constant is required to reach 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 (Schlumberger 1972). 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 1 inch (2.54 centimeters).

A.1.3 TECHNICAL APPROACH

Scintillation probe profiles collected periodically from monitoring wells within the Semi-works 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.

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. Depth discrepancies of up to 1.52 m (5 ft) have been noted between logs. Differences in the responses of the PNL logging systems may account for some of this discrepancy.

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. Boundaries of zones of elevated gamma radiation were also marked. The evaluation of the scintillation probe profiles referenced these graphical representations to describe the location and extent of any zones of elevated gamma radiation, and the behavior of this zone over time, particularly in regards to vertical or lateral migration. Any evidence of gamma emitters reaching the groundwater was also noted.

To represent the logs used in the cross sections in a clear, yet compact format and to facilitate comparisons between different vintages of data, it was necessary to digitize the original logs and to redisplay them on a semi-logarithmic scale. Depth in feet from the top of casing was represented on the linear scale, and activity in ct/sec on the logarithmic scale. The 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 inset plan on the figure illustrates the spatial relationship of the wells used in the cross section.

In the Semi-Works Aggregate Area, the upper 80 m (262 ft) is the Hanford formation which consists of interbedded coarse sands, gravelly sands, and sandy gravel. This unit has a fairly low and uniform gamma response. Underlying the Hanford formation are the sands and gravel of the Ringold Formation. In the Semi-Works Aggregate Area the Ringold Formation is approximately 20 to 30 m (65 to 98 ft) thick and rests on top of the Elephant Mountain member of the Columbia River Basalt Group. The gamma response of the Ringold Formation in this area is also fairly low and uniform.

In all logs that penetrate to groundwater there is a striking increase in the gamma response typically from 10 to 20 ct/sec to around 100 to 300 ct/sec. This increase is present in logs from 1959 and later to varying degrees and probably represents groundwater contamination.

A.1.4 EVALUATION OF DATA IDENTIFIED FOR WASTE MANAGEMENT UNITS

Based on availability of both gross gamma-ray logs and geologic logs for a particular waste management unit, an analysis of the potential nature and extent of radionuclide contamination was performed. Sections A.1.4.1 through A.1.4.4 discuss data identified for the following waste management units:

- 216-C-1 Crib
- 216-C-5 Crib
- 216-C-10 Crib
- 216-C-9 Pond/218-C-9 Burial Ground.

A.1.4.1 216-C-1 Crib

A.1.4.1.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3.3.1 and 4.1 concerning this 216-C-1 Crib.

Source - High salt waste, cold run waste, and process condensate from the 201-C Process Building

Service Dates - 1953 to 1957

Fluid Volume Received in Liters - 23,400,000

Quantity of Radionuclides Disposed of in 216-C-1 Crib in Curies

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{239}Pu	^{240}Pu
216-C-1 Crib	8.0	0.0988	0.0455 0.0496	1.89E-08	85.5 93.8	0.002	70.0	0.4579	0.1230

A.1.4.1.2 Scintillation Probe Profile Evaluation. As shown on Figure A-1, soil boring 299-E27-133 which is located 5 m (16 ft) east of the crib, shows an elevated gamma response to the total depth of 15.4 m (50.5 ft). Peak counts occur 2 to 3 m (6.5 to 9.8 ft) below ground surface in the range of 2,000 to 3,000 ct/sec. This suggests that there is subsurface radionuclide contamination in the vicinity of the 216-C-1 Crib.

A.1.4.2 216-C-5 Crib

A.1.4.2.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3.3.4 and 4.1 concerning the 216-C-5 Crib.

Source - High salt waste and cold run waste from the 201-C Process Building

Service Dates - 1955

Fluid Volume Received in Liters - 37,900

Quantity of Radionuclides Disposed of in 216-C-5 Crib in Curies

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{239}Pu	^{240}Pu
216-C-5	1.0	0.0182	0.0444 0.484	1.38E-10	4.2 4.610	0.0018			

A.1.4.2.2 Scintillation Probe Profile Evaluation. As shown on the logs for Well 299-E-24-8 on Figure A-1 there is an elevated gamma response between 0 and 2 m (0 to 6.5 ft) below ground surface. Peak values are approximately 30,000 ct/sect. This response is not present prior to the 1968 log and gains in intensity between 1968 and 1976. Fecht et al. (1977) attribute this to a waste transfer line located 3.2 m (10.5 ft) from the well and not to the 216-C-5 Crib located 20 m (65 ft) to the north. It cannot be determined at this time whether there is contamination migration beneath the 216-C-5 Crib.

A.1.4.3 216-C-10 Crib

A.1.4.3.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3.3.7 and 4.1 concerning the 216-C-10 Crib.

Source - Acidic process condensate from the 201-C Process Building

Service Dates - 1964 to 1969

Fluid Volume Received in Liters - 897,000

Quantity of Radionuclides Disposed of in 216-C-10 Crib in Curies

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{239}Pu	^{240}Pu
216-C-10 Crib	0.15	0.00001	0.0855 0.0932	8.95E-08	3.45 37.8	0.0113			

A.1.4.3.2 Scintillation Probe Profile Evaluation. Well 299-E27-5, located 3 m (10 ft) north of the crib, shows no elevated gamma response other than in the groundwater.

A.1.4.4 216-C-9 Pond/218-C-9 Burial Ground

A.1.4.4.1 Waste Description. This section briefly summarizes information presented in Tables 2-1 and 2-2, and Sections 2.3.5.1, 2.3.9.1, and 4.1 concerning the 216-C-9 Pond/218-C-9 Burial Ground.

Source - The 216-C-9 Pond received process cooling water from the 201-C Process Building and the Hot Semi-Works facilities, and wastewater from the 209-E Building. The 218-C-9 Burial Ground received 2.265 m^3 (80 ft^3) of rubble (rags, paper, cardboard, plastic, equipment and other dry waste) from decommissioning of the 201-C Process Building.

Service Dates - 1953 to 1985/1985

Fluid Volume Received in Liters - 1,030,000,000/NA

Quantity of Radionuclides Disposed of in 216-C-9 Pond in Curies

Waste Management Unit	Total Pu in gm	^{238}U	^{137}Cs	^{106}Ru	^{90}Sr	^{60}Co	^{3}H	^{239}Pu	^{240}Pu
216-C-9 Pond	0.338		0.703	8.66E-08	2.43				

A.1.4.4.2 Scintillation Probe Profile Evaluation. Well-299-E27-1, as shown on Figure A-1, shows a natural gamma response. It is, however, located approximately 50 m (164 ft) north of the Pond area and may not be representative of conditions closer to the actual site.

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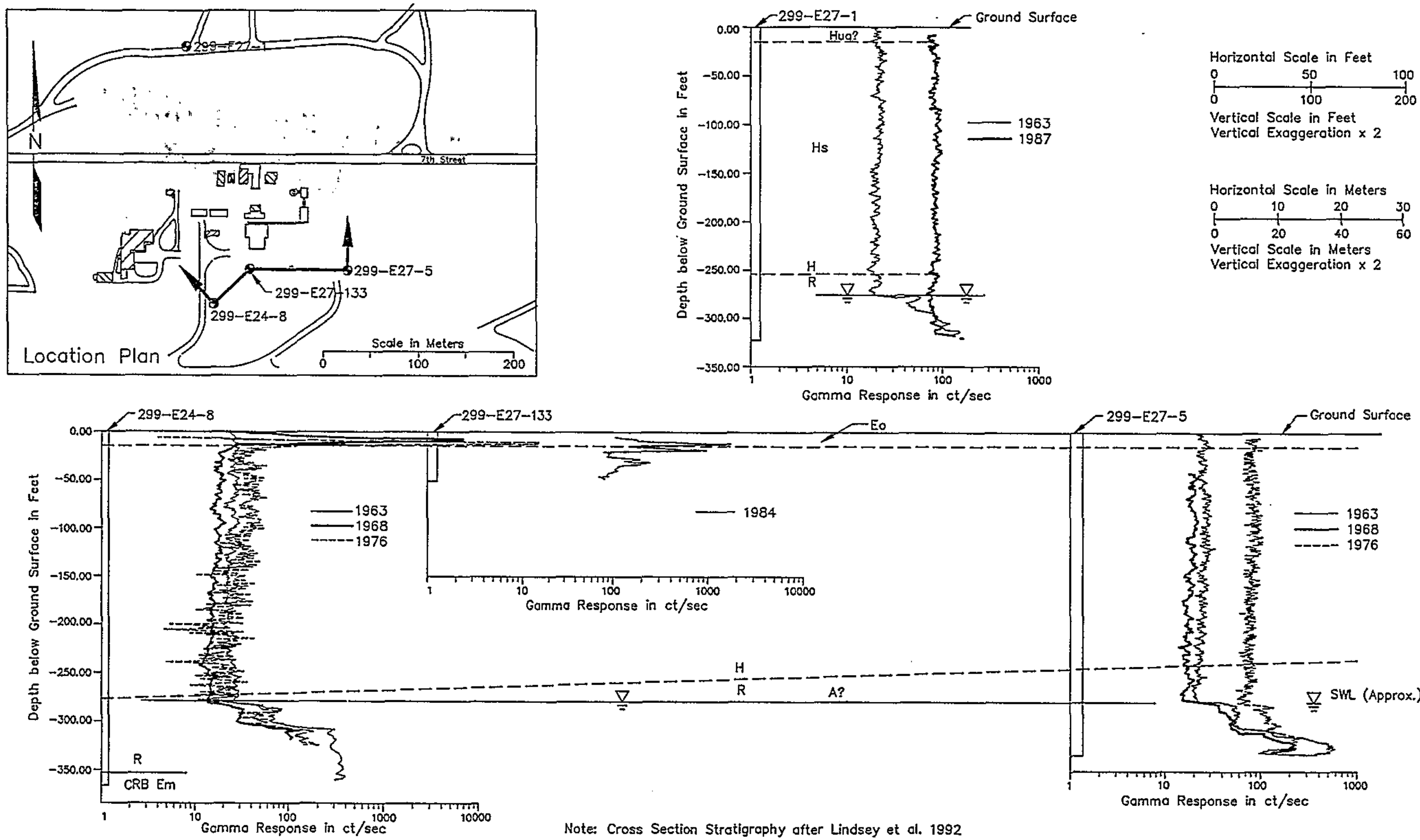

Figure AF-1. Semi-Works Aggregate Area Borehole Gamma Response Data

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Table A-1. Air Sampling Results. (Sheet 1 of 4)

Radionuclide in pCi/m³		1985 Result	1985 Error	1986 Result	1986 Error	1987 Result	1987 Error	1988 Result	1988 Error	1989 Result	1989 Error	Average Result
Sample Location: N001												
Strontium-90	max	not sampled		not sampled		not sampled		8.0E-04	2.9E-04	not sampled		6.0E-04
	min							4.0E-04	1.8E-04			
	avg							6.0E-04	4.1E-04			
Cesium-137	max							5.6E-04	5.6E-04			-9.0E-06
	min							<-5.8E-04	1.1E-03			
	avg							-9.0E-06	1.2E-03			
Plutonium-239	max							6.6E-06	5.8E-06			6.5E-06
	min							6.5E-06	5.8E-06			
	avg							6.5E-06	1.0E-07			
Uranium (total)	max							2.8E-05	3.7E-05			1.2E-05
	min							<-4.1E-06	2.3E-05			
	avg							1.2E-05	3.5E-05			

Table A-1. Air Sampling Results. (Sheet 2 of 4)

Radionuclide in pCi/m³		1985		1986		1987		1988		1989		Average Result
		Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	
Sample Location: N002												
Strontium-90	max	not sampled		not sampled		not sampled		4.3E-04	1.7E-04	not sampled		3.7E-04
	min							3.1E-04	1.9E-04			
	avg							3.7E-04	1.2E-04			
Cesium-137	max							<-1.1E-04	9.2E-04			-9.0E-06
	min							<9.3E-05	7.3E-04			
	avg							-9.0E-06	2.8E-04			
Plutonium-239	max							3.2E-05	1.1E-05			2.4E-05
	min							1.7E-05	9.6E-06			
	avg							2.4E-05	1.5E-05			
Uranium (total)	max							5.3E-06	2.4E-05			-4.7E-07
	min							<-6.2E-06	3.6E-05			
	avg							-4.7E-07	1.7E-05			

APPENDIX B

HEALTH AND SAFETY PLAN

CONTENTS

B.1.0 GENERAL CONSIDERATIONS AND REQUIREMENTS

B.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 Semi-Works 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 Semi-Works AAMS shall read the site-specific safety document and attend a pre-job safety or tailgate meeting to review and discuss the task.

B.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 personal and fellow employee health and safety. 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.

B.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.

B.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).

B.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 1991).

All visitors shall be informed of potential hazards and emergency procedures by their escorts and shall conform to EII 1.1 (WHC 1991).

B.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.

B.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.

B.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 <u>at all times</u>.

B.2.1 GENERAL WORK SAFETY PRACTICES

B.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.

B.2.1.2 Personal Protective Equipment

- Personal protective equipment will be selected specifically for the hazards identified in the HWOP. The site safety officer in conjunction with Westinghouse Hanford Health Physics and Industrial Hygiene and Safety is responsible for choosing the appropriate type and level of protection required for different activities at the job site.

- Levels of protection shall be appropriate to the hazard to avoid either excessive exposure or additional hazards imposed by excessive levels of protection. The HWOP will contain provisions for adjusting the level of protection as necessary. These personal protective equipment specifications must be followed at all times, as directed by the field team leader, health physics technician, and site safety officer.

- Each employee must have a hard hat, safety glasses, and substantial protective footwear available to wear as specified in the HWOP or JSA.
- The exclusion zone around drilling or other noisy operations will be posted "Hearing Protection Required" and team members will have had noise control training.
- Personnel should maintain a high level of awareness of the limitations in mobility, dexterity, and visual impairment inherent in the use of level B and level C personal protective equipment.
- Personnel should be alert to the symptoms of fatigue, heat stress, and cold stress and their effects on the normal caution and judgment of personnel.
- Rescue equipment as required by Occupational Safety and Health Administration (OSHA), Washington Industrial Safety and Health Act (WISHA), or standards for working over water will be available and used.

B.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.

B.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.

B.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 Semi-Works AAMS should not require confined space entry. Nevertheless, the hazards associated with confined spaces are of such severity that all employees should be familiar with the safe work discussed in the following paragraphs.

No employee shall enter any test pit or trench deeper than 1 m (4 ft) unless the sides are shored or laid back to a stable slope as specified in OSHA 29 CFR 1926.652 or equivalent state occupational health and safety regulations.

When an employee is required to enter a pit or trench 1 m (4 ft) deep or more, an adequate means of access and egress, such as a slope of at least 2:1 to the bottom of the pit or a secure ladder or steps shall be provided.

Before entering any confined space, including any test pit, the atmosphere will be tested for flammable gases, oxygen deficiency, and organic vapors. If other specific contamination, such as radioactive materials or other gases and vapors may be present, additional testing for those substances shall be conducted. Depending on the situation, the space may require ventilation and retesting before entry.

An employee entering a confined or partially confined space must be equipped with an appropriate level of respiratory protection in keeping with the monitoring procedures discussed previously and the action levels for airborne contaminants (see "Warnings and Action Levels" in HWOP).

No employee shall enter any test pit requiring the use of level B protection, unless a backup person also equipped with a pressure-demand self-contained breathing apparatus (SCBA) is present. No backup person shall attempt any emergency rescue unless a second backup person equipped with an SCBA is present, or the appropriate emergency response authorities have been notified and additional help is on the way.

B.3.0 SITE BACKGROUND

Specific details on the Semi-Works AAMS background and known and suspected contamination are described in Chapters 2.0 through 10.0 of the plan. The Semi-Works 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 (3 mi) to the west.

The Semi-Works Aggregate 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.

B.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 Semi-Works AAMS will be to characterize the nature and extent of contamination in the vadose (unsaturated subsurface soil) zone.

B.4.1 WORK TASKS

Work tasks are described in Chapter 5.0 of the plan.

B.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; and
- Biological hazards; snakes, spiders, etc.

B.4.3 ASSESSMENT AND MITIGATION OF POTENTIAL HAZARDS

The likelihood of significant exposure (100 mrem/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.

B.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 not be initiated or continued until such equipment is in place. These instruments are to be used only by persons who are trained in their use and who understand their limitations. No work shall be performed 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.

B.5.1 AIRBORNE RADIOACTIVE AND RADIATION MONITORING

An onsite health physics technician will monitor airborne radioactive contamination levels and external radiation levels. Action levels will be consistent with derived air concentrations and applicable guidelines as specified in the radiation protection manual WHC-CM-4-10 (WHC 1988).

Appropriate respiratory protection shall be required when conditions are such that the airborne contamination levels may exceed an 8-hour derived air concentration (e.g., the presence of high levels of uncontained, loose contamination on exposed surfaces or operations that may raise excessive levels of dust contaminated with airborne radioactive materials, such as excavation or drilling under extremely dry conditions).

Specific conditions requiring the use of respiratory protection because of radioactive materials in air will be incorporated into the RWP. If, in the judgement of the health physics technician, any of these conditions arise, work shall cease until appropriate respiratory protection is provided.

B.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.

B.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.

B.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, "Decontamination of Equipment for RCRA/CERCLA Sampling" (WHC 1991), or other approved decontamination procedures.

B.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.

B.10.0 REFERENCES

DOE, 1986, *Environment, Safety & Health Program for DOE Operations*, DOE Order 5480.1B, U.S. Department of Energy, Washington, D.C.

NIOSH, 1991, *Pocket Guide to Chemical Hazards, National Institute for Occupational Safety and Health*, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Washington, D.C.

WHC, 1988, *Radiation Protection*, WHC-CM-4-10, Westinghouse Hanford Company, Richland, Washington.

WHC, 1991, *Environmental Investigations and Site Characterization Manual*, WHC-CM-7-7, Westinghouse Hanford Company, Richland, Washington.

WHC, 1992, *Health and Safety for Hazardous Waste Field Operations*, WHC-CM-4-3 Vol. 4, Westinghouse Hanford Company, Richland, Washington.

APPENDIX C

PROJECT MANAGEMENT PLAN

CONTENTS

FIGURES

TABLE

C.1.0 INTRODUCTION

This Project Management Plan (PMP) defines the administrative and institutional tasks necessary to support the Semi-Works 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.

C.2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

C.2.1 INTERFACE OF REGULATORY AUTHORITIES AND THE U.S. DEPARTMENT OF ENERGY

The Semi-Works 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 (CERCLA). The U.S. 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.

C.2.2 PROJECT ORGANIZATION AND RESPONSIBILITIES

The project organization for implementing remedial activities at the Semi-Works Aggregate Area is shown on Figure C-1. The following sections describe the responsibilities of the individuals shown on Figure C-1.

C.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.

C.2.2.2 Unit Managers

As shown on Figure C-1, EPA, DOE, and Ecology will each designate an individual as a unit manager for the Semi-Works 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 Semi-Works 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 Semi-Works Aggregate Area, particularly the status of agreements and commitments.

C.2.2.3 Quality Assurance Officer

The quality assurance officer is responsible for monitoring overall environmental restoration program activities through establishment of Hanford Site quality assurance auditing program controls that may be appropriately applied to the remedial activities. The quality assurance officer is specifically vested with the organizational independence and authority to identify conditions adverse to quality, and to systematically seek effective corrective action.

C.2.2.4 Quality Coordinator

The quality coordinator is responsible for coordinating and monitoring performance of the Quality Assurance Project Plan (QAPP) requirements by means of internal surveillance techniques and by auditing, as directed by the quality assurance officer. The quality coordinator retains the necessary organizational independence and authority to identify conditions adverse to quality, and to inform the technical lead of needed corrective action.

C.2.2.5 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.

C.2.2.6 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.

C.2.2.7 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.

C.2.2.8 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 Semi-Works 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.

C.2.2.9 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.

C.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.

C.4.0 FINANCIAL AND PROJECT TRACKING REQUIREMENTS

C.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 Semi-Works 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.

C.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 units and/or treatment, storage, and disposal groups/units. The meetings shall be technical in nature, with emphasis on technical issues and work progress. The assigned DOE unit manager for the Semi-Works 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 Semi-Works 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.

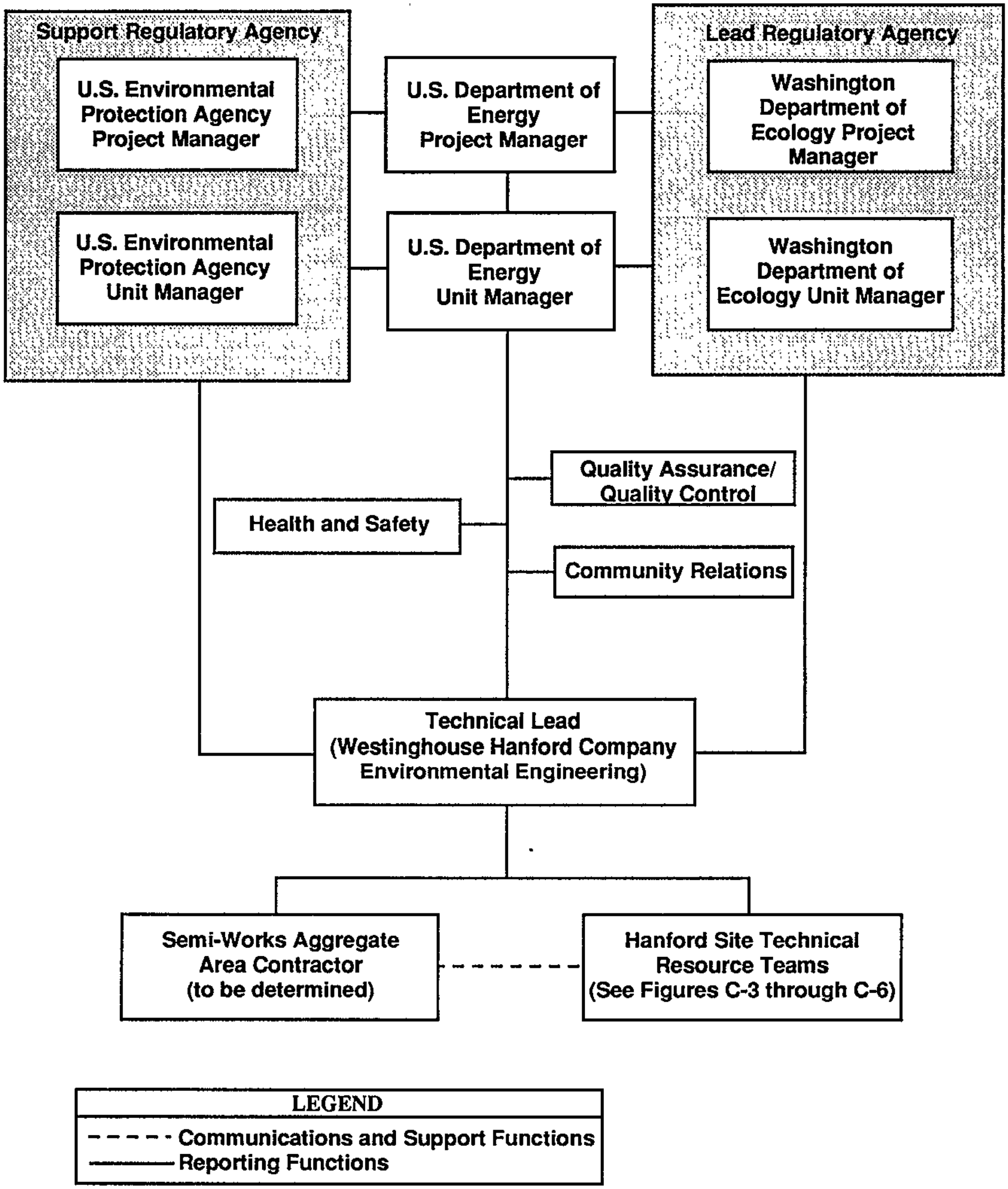
Project coordinators for each operable unit also will meet on a monthly basis to share information and to discuss progress and problems.

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 Semi-Works Aggregate Area Project.



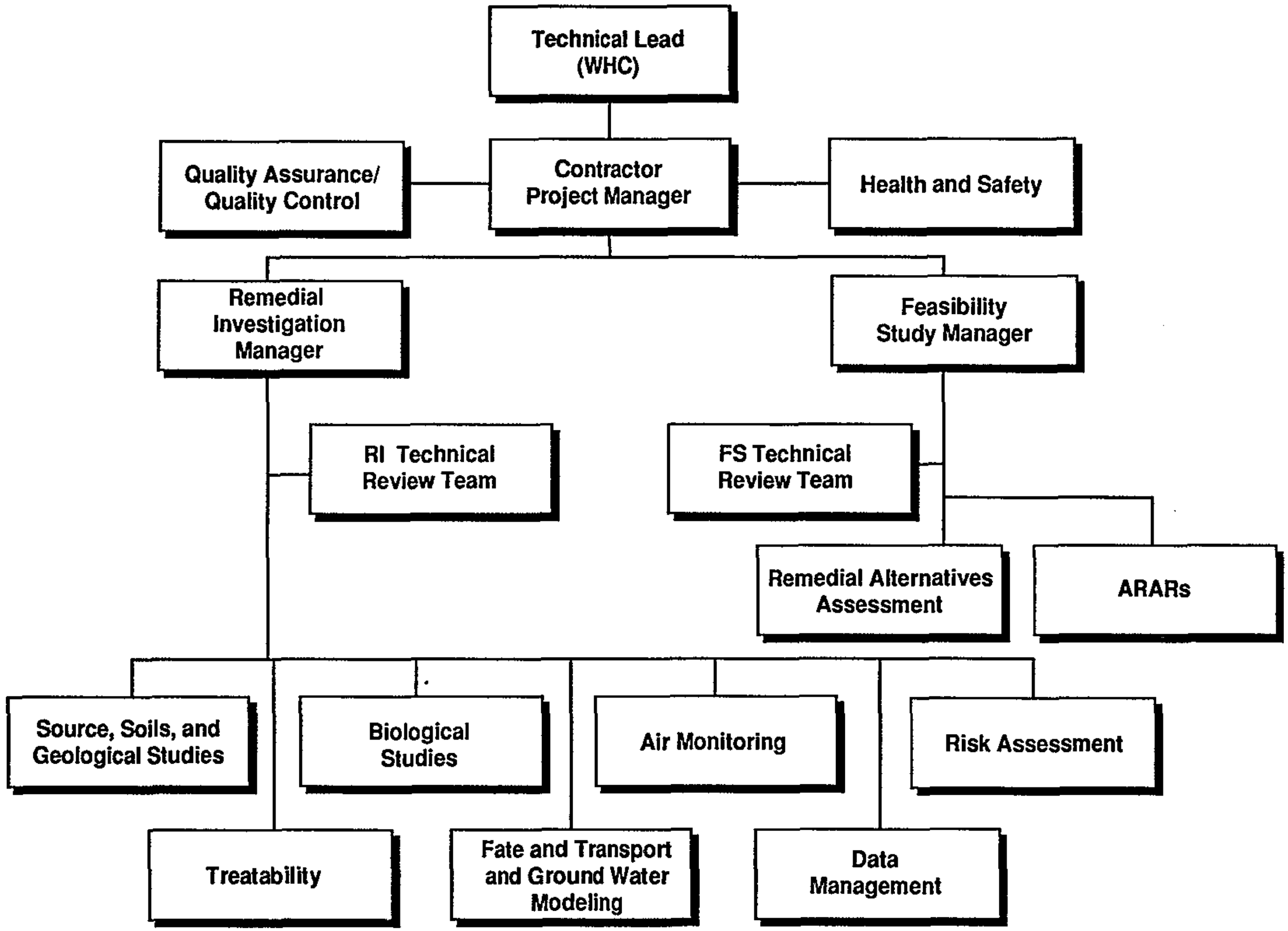


Figure C-2. Example Project Organization for the Semi-Works Aggregate Area Contractor Team.

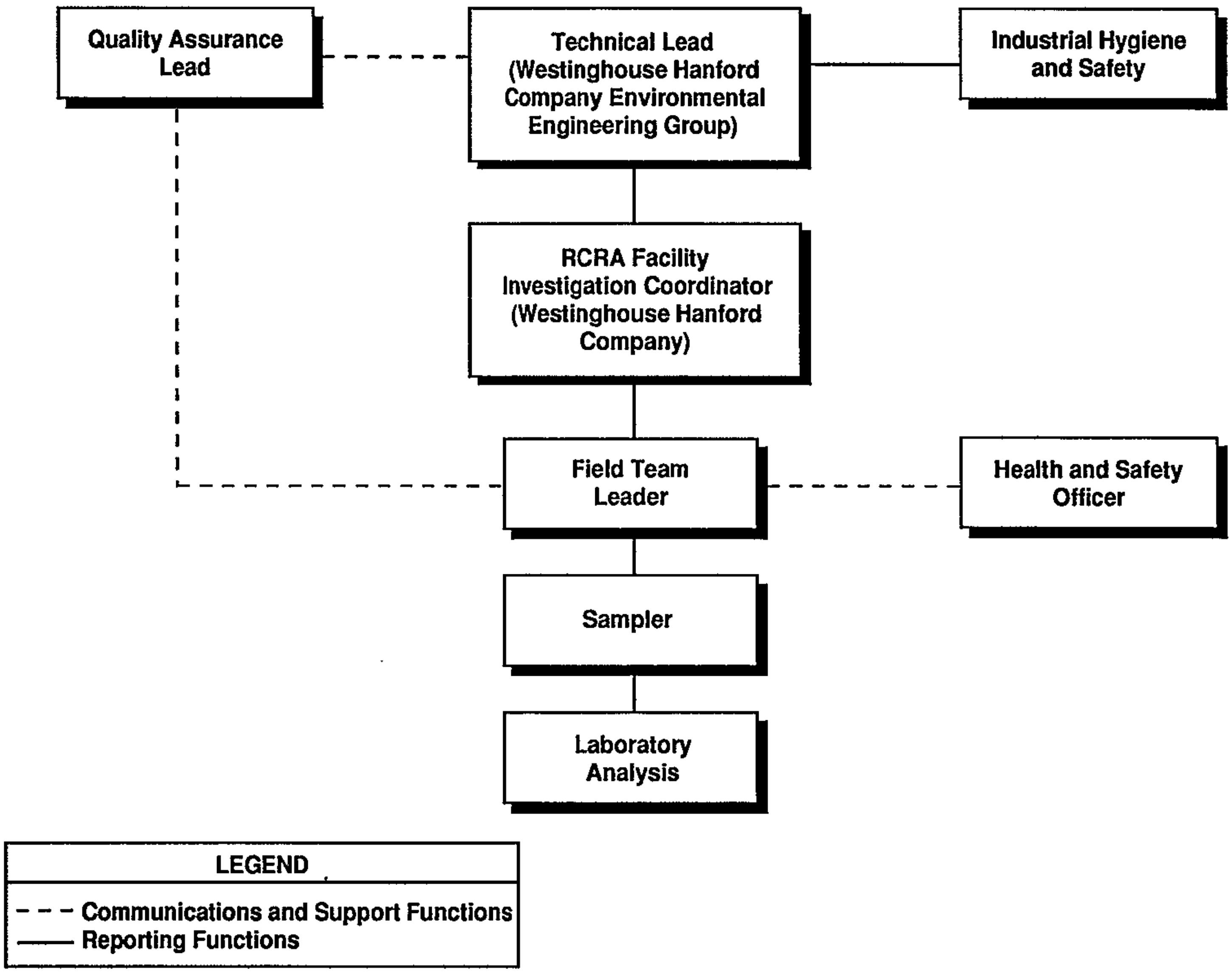


Figure C-3. The Hanford Site Soil Sampling Team.

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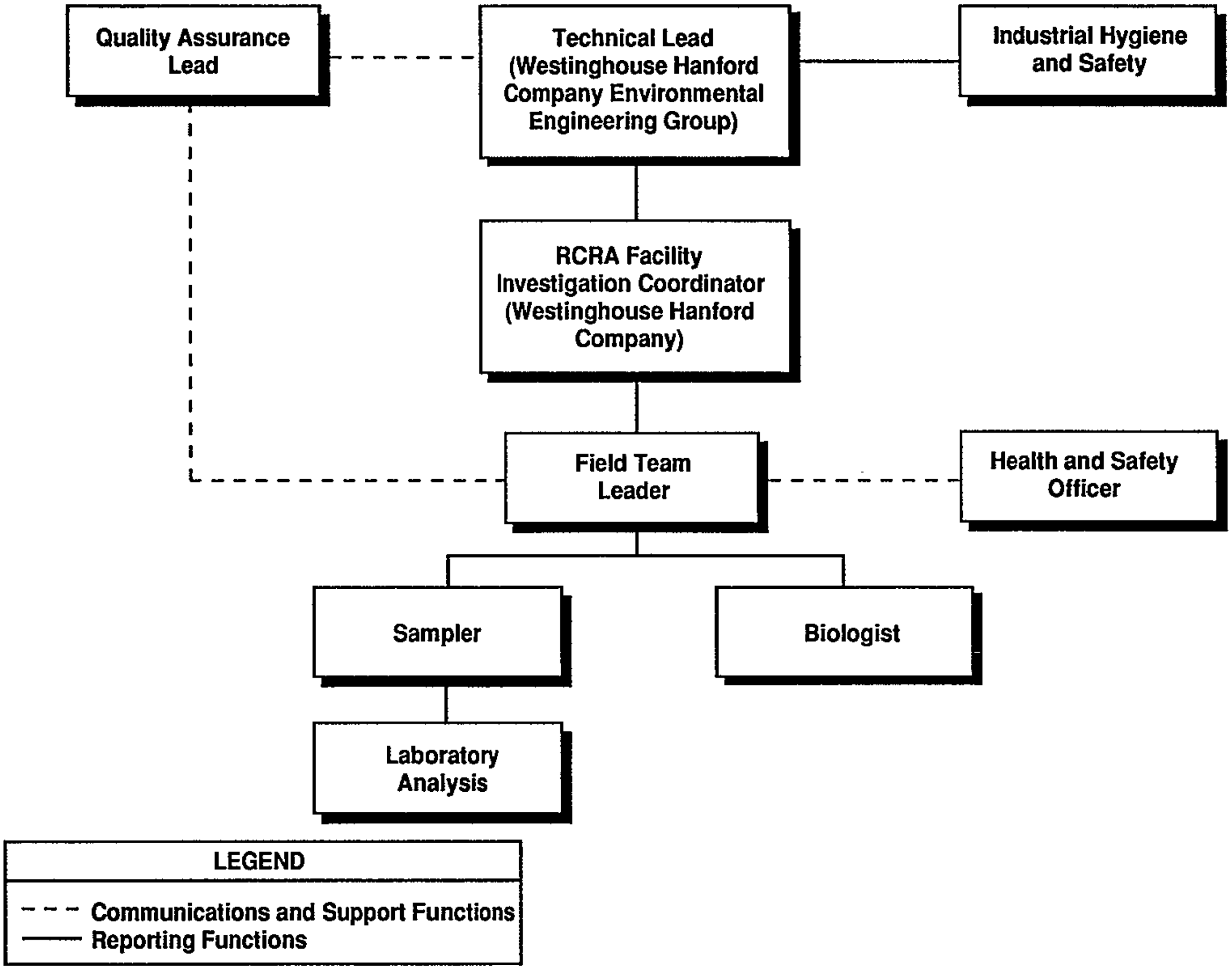

Figure C-4. The Hanford Site Biological Sampling Team.

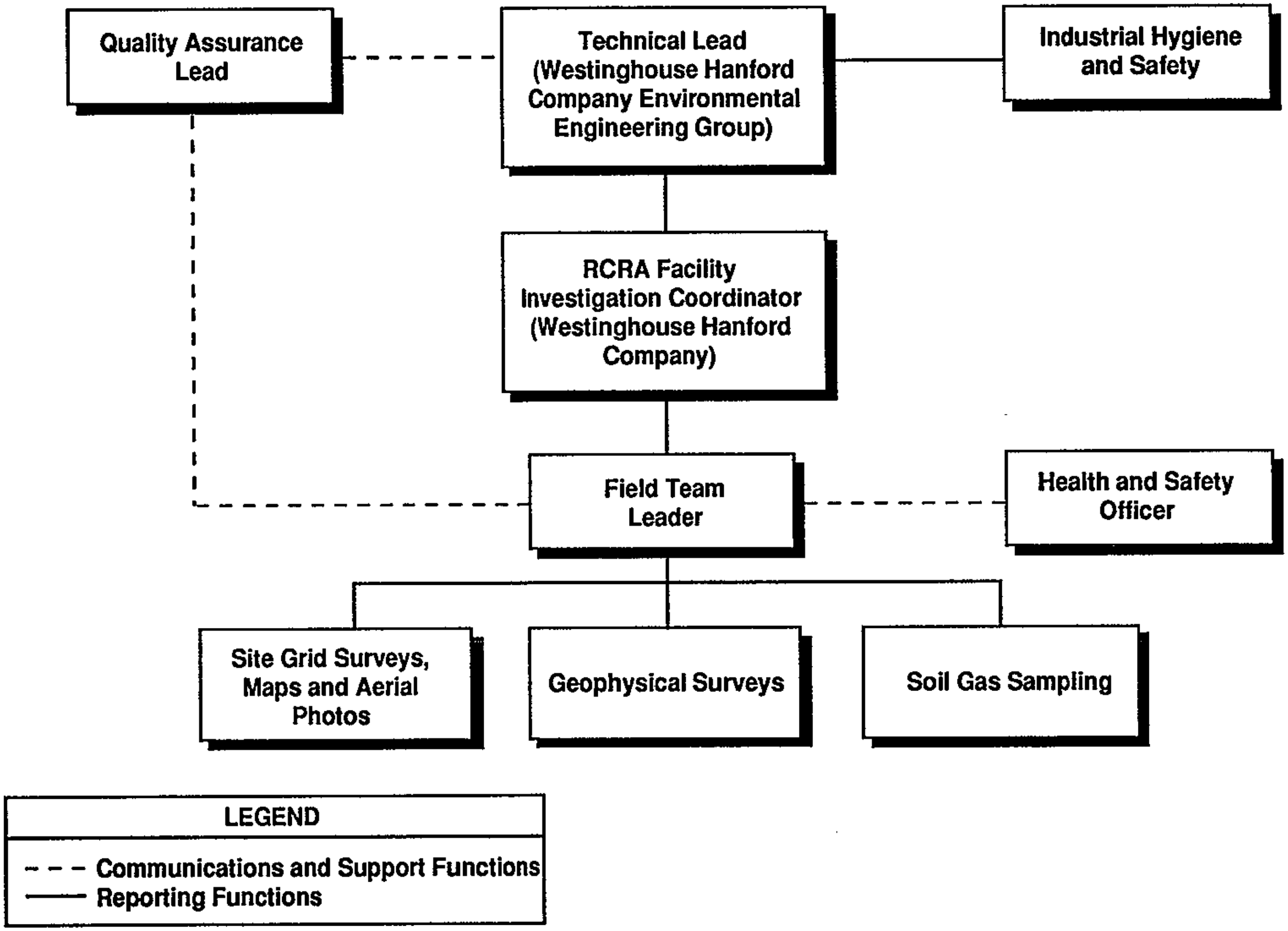

Figure C-5. The Hanford Site Physical and Geophysical Survey Team.

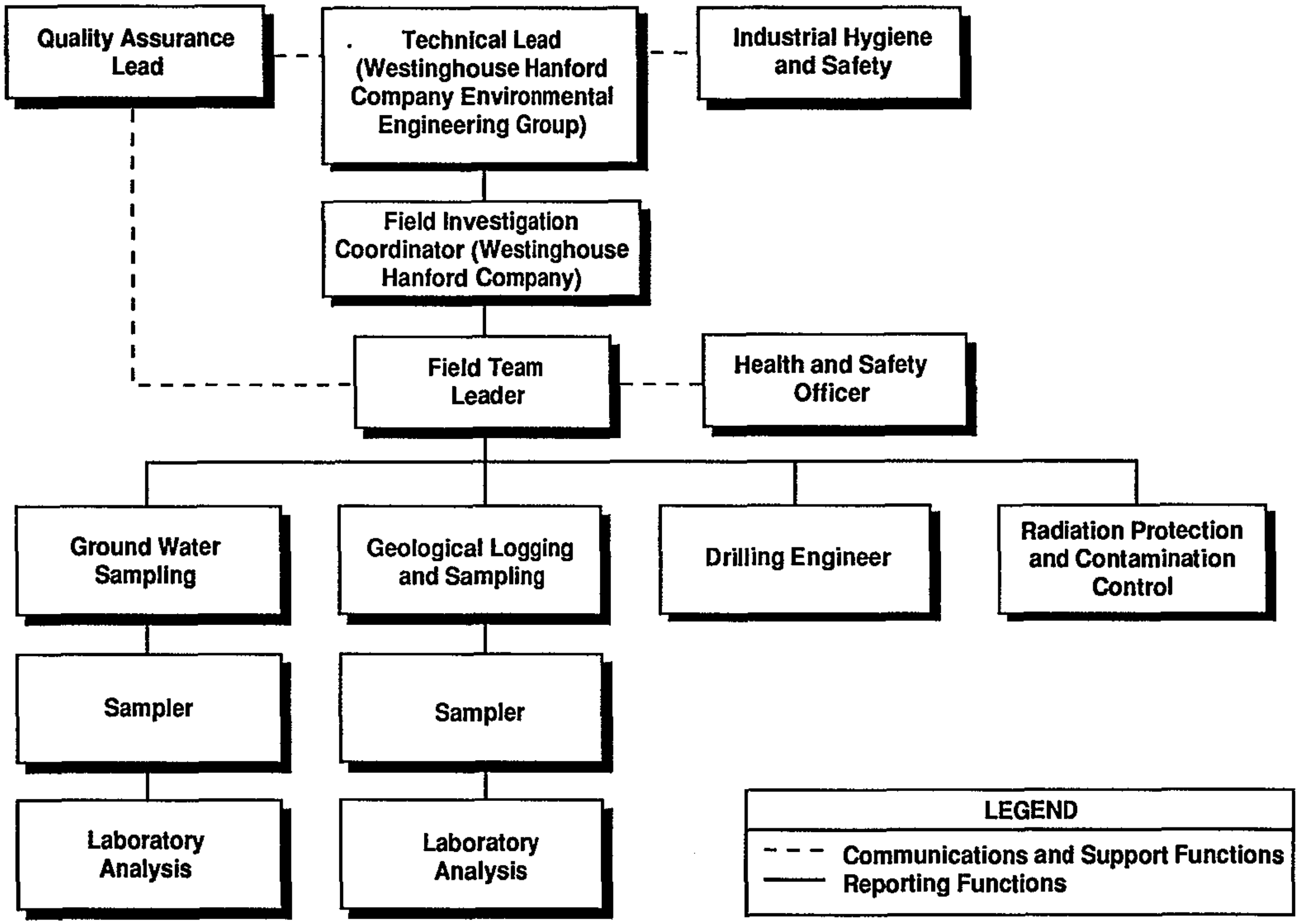

Figure C-6. Drilling, Sampling, and Well-Development Team.

Table C-1. Hanford Site RI/FS Technical Resources. (Page 1 of 2)

Subject/Activity	Technical Resources: RI	Technical Resources: FS
Hydrology and geology	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Toxicology and risk/endangerment assessment	Westinghouse Hanford/Environmental Technology PNL/Earth and Environmental Sciences Center PNL/Life Sciences Center	Westinghouse Hanford/ Environmental Technology
Environmental chemistry	Westinghouse Hanford/Geosciences PNL/Earth and Environmental Sciences Center	Westinghouse Hanford/Geosciences
Geotechnical and civil engineering	Westinghouse Hanford/Geosciences (Planning) Environmental Field Services	NA
Geotechnical and civil engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Groundwater treatment engineering	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Waste stabilization and treatment	NA	Westinghouse Hanford/ Environmental Engineering PNL/Waste Technology Center
Surveying	Kaiser Engineers Hanford	NA

Table C-1. Hanford Site RI/FS Technical Resources. (Page 2 of 2)

Subject/Activity	Technical Resources: RI	Technical Resources: FS
Soil and water sampling and analysis	Westinghouse Hanford/Environmental Engineering Westinghouse Office of Sampling Management PNL/Earth and Environmental Sciences Center PNL/Materials and Chemical Sciences Center	NA
Drilling and well installation	Westinghouse Hanford/Geosciences Environmental Field Services Kaiser Engineers	NA
Radiation monitoring	Westinghouse Hanford/Operational Health Physics	NA

NA = Not applicable.

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APPENDIX D

INFORMATION MANAGEMENT OVERVIEW

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DEFINITIONS OF TERMS

Action Plan. Action plan for implementation of the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990). A negotiation between the U.S. Environmental Protection (EPA), the U.S. Department of Energy (DOE), and the State of Washington Department of Ecology (Ecology). The Action Plan defines the methods and processes by which hazardous waste permits will be obtained, and by which closure and post-closure actions under the Resource Conservation and Recovery Act of 1976 (RCRA) and by which remedial actions under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) will be conducted on the Hanford Site.

Administrative Record (AR). In CERCLA, the official file that contains all information that was considered or relied on by the regulatory agency in arriving at a final remedial action decision, as well as all documentation of public participation throughout the process. In RCRA, the official file that contains all documents to support a final RCRA permit determination.

Administrative Record File. The assemblage of documents compiled and maintained by an agency pertaining to a proposed project of administrative action and designated as AR or that are candidates for inclusion in the AR once a record of decision (ROD) is attained.

Data Management. The planning and control of activities affecting data.

Data Quality. The totality of features and characteristics of data that bears on its ability to satisfy a given purpose. The characteristics of major importance are accuracy, precision, completeness, representativeness, and comparability.

Data Validation. The process whereby data are accepted or rejected based on a set of criteria. This aspect of quality assurance involves establishing specified criteria for data validation. The quality assurance project plan (QAPP) must indicate the specified criteria that will be used for data validation.

ENCORE. The name given to the combination of hardware, software, and administrative subsystems that serve to integrate the management of the Hanford Site environmental data.

Environmental Data Management Center (EDMC). The central facility and services that provide a files management system for processing environmental information.

Environmental Information. Data related to the protection or improvement of the Hanford Site environment, including data required to satisfy environmental statutes, applicable DOE orders, or the Tri-Party Agreement.

Field File Custodian. An individual who is responsible for receipt, validation, storage, maintenance, control, and disposition of information or other records generated in support of Environmental Division activities.

Hanford Environmental Information System (HEIS). A computer-based information system under development as a resource for the storage, analysis, and display of investigative data collected for use in site characterization and remediation activities. Subject areas currently being developed include geophysics/soil gas, vadose zone soil (geologic), atmospherics, and biota.

Information System. Collection of components relate to the management of data and reporting of information. Information systems typically include computer hardware, computer software, operating systems, utilities, procedures, and data.

Lead Agency. The regulatory agency (EPA or Ecology) that is assigned the primary administrative and technical responsibility with respect to actions at a particular operable unit.

Nonrecord Material. Copies of material that are maintained for information, reference, and operating convenience and for which another office has primary responsibility.

Operable Unit. An operable unit at the Hanford Site is a group of land disposal and groundwater sites placed together for the purposes of doing a remedial investigation/ feasibility study. The primary criteria for placement of a site into an operable unit are geographic proximity, similarity of waste characteristics and site types, and the possibility for economies of scale.

Primary Document. A document that contains information on which key decisions are made with respect to the remedial action or permitting process. Primary documents are subject to dispute resolution and are part of the administrative record file.

Project Manager. The individual responsible for implementing the terms and conditions of the Action Plan on behalf of his respective party. The EPA, DOE, and Ecology will each designate one project manager.

Quality Affecting Record. Information contained on any media, including but not limited to, hard copy, sample material, photo copy, and electronic systems, that is complete in terms of appropriate content and that furnishes evidence of the quality of items and/or activities affecting quality.

Quality Assurance. The systematic actions necessary to provide adequate confidence that a material, component, system, process, or facility performs satisfactorily or as planned in service.

Quality Assured Data. Data developed under an integrated program for assurance of the reliability of data.

Raw Data. Unprocessed or unanalyzed information.

Record Validation. A review to determine that records are complete, legible, and meet records requirements. Documents are considered valid records only after the validation process has been completed.

Retention Period. The length of time records must be held before they can be disposed of. The time is usually expressed in years from the date of the record, but may also be expressed as contingent on the occurrence of an event.

Secondary Document. A document providing information that does not, in itself, reflect or support key decisions. A secondary document is subject to review by the regulatory agencies and may be part of the administrative record field. It is not subject to dispute resolution.

Validated Data. Data that meet criteria contained in an approved company procedure.

Verified Data. Data that have been checked for accuracy and consistency following a transfer action (e.g., from manual log to computer, or from distributed database to centralized data repository).

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CONTENTS

CONTENTS (Continued)

D.1.0 INTRODUCTION AND OBJECTIVES

D.1.1 INTRODUCTION

An extensive amount of data will be generated over the next several years in connection with the activities planned for the Semi-Works Aggregate Area. The quality of these data is 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 Data Management Plan (DMP) 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 DMP 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.

D.1.2 OBJECTIVES

This DMP describes the process for the collection and control procedures for validated data, records, documents, correspondence, and other information associated with this aggregate area. This DMP 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).

D.2.0 TYPES OF DATA

D.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 are 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.

D.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).

D.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.

D.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.

D.3.0 DATA MANAGEMENT PLAN

D.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 DMP outline for data generated through work plan activities.

D.3.2 ORGANIZATIONS CONTROLLING DATA

This section addresses the organizations that will receive data generated from aggregate area activities.

D.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.

D.3.2.2 Office of Sample Management

The Westinghouse Hanford OSM and their subcontractors 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. Non-validated 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.

D.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).

D.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.

D.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.

D.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.

D.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).

D.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).

D.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.

D.3.3.1 Meteorological Data

The HMS collects and maintains meteorological data. Its database contains meteorological data from 1943 to the present, and Andrews (1988) is the document containing meteorological data management information.

D.3.3.2 Nonradiological Exposure and Medical Records

The HEHF collects and maintains data for all nonradiological exposure records and medical records.

D.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.

D.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-hr hazardous waste worker training
- Annual 8-hr 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.

D.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.

D.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.

D.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).

D.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 is 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 flow 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.

D.4.2 ENVIRONMENTAL RESTORATION REMEDIAL ACTION PROGRAM RECORDS MANAGEMENT PLAN

The ERRA Program records management plan was developed to fulfill the requirements of the 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.

D.5.0 HANFORD ENVIRONMENTAL INFORMATION SYSTEM

D.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.

D.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 are currently accessible via the Hanford Local Area Network (HLAN) to local users and to off-site 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.

D.6.0 REFERENCES

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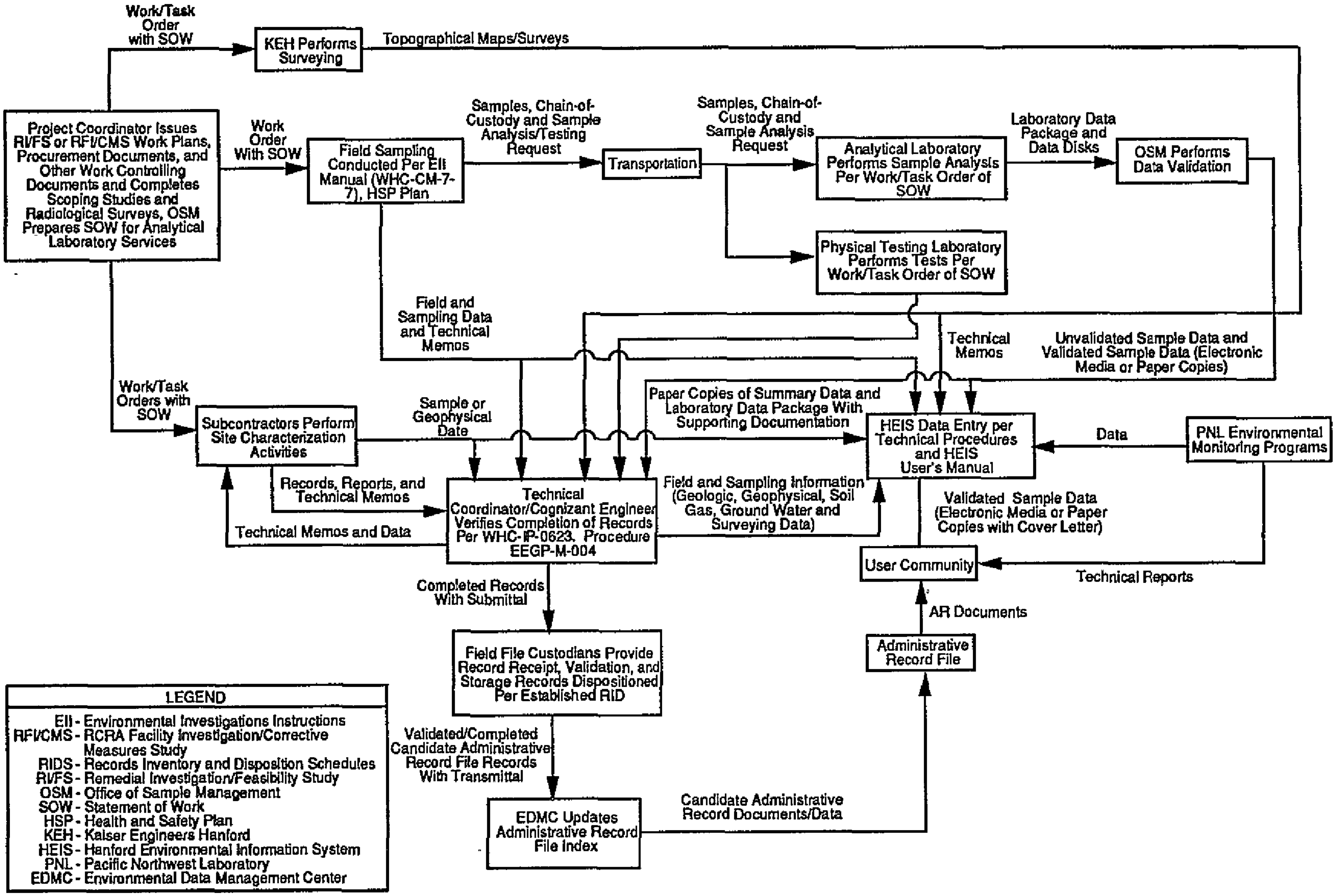

Figure D-1. Environmental Engineering, Technology, and Permitting Data Management Model.

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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