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200 East Groundwater Aggregate Area Management Study Report

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200 EAST GROUNDWATER AAMS EXECUTIVE SUMMARY

This report presents the results of an aggregate area management study (AAMS) for the 200 East Groundwater 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). 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 management unit 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 the following:

- 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 the various contaminant plumes 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 evaluate existing groundwater contamination 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 recommendations for each of the groundwater plumes within the 200 East Groundwater Aggregate Area are provided in the report. Work plans will initially focus on limited intrusive investigations at the highest priority plumes as established in the AAMSR. The goal of this initial focus is to establish whether interim remedial measures are justified. Plumes identified as candidate ERAs 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 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 the

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

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

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

Background, environmental setting, and known contamination data are provided in Sections 2.0, 3.0, and Section 4.1. This information provides the basis for development of the preliminary conceptual model in Section 4.2 and 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 data quality objectives. 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 200 East Groundwater Aggregate Area includes the Hanford Site's 200 East Area plus other surrounding land where the contamination has spread.

Between 1944 and the present, the 200 Areas have housed various chemical processing plants for extracting plutonium, uranium, and fission products from irradiated fuels and secondary waste streams.

The 200 East Groundwater 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. Detailed descriptions of waste management units that may impact groundwater are provided in Section 2.3.

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There are several ongoing programs that affect activities in the 200 East Groundwater Aggregate Area (Section 2.7). These programs include RCRA, the Hanford Surplus Facilities Program, the Radiation Area Remedial Action Program, the Hanford Site Single-Shell Tank Program, and the Defense Waste Management Program. These programs do not affect groundwater remedial activities.

Discussions of surface hydrology and geology are provided on a regional, Hanford Site, and aggregate area basis in Section 3.0. The section also describes the flora and fauna, land use, water use and human resources of the 200 East Area and vicinity.

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 groundwater in the 200 East Groundwater Aggregate Area and organizes the results in terms of the various plumes.

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 plume evaluation and recommendation process.

Potential ARARs to be used in developing and assessing various remedial action alternatives at the 200 East Groundwater Aggregate Area are discussed in Section 6.0.

Preliminary remedial action technologies are presented in Section 7.0. The process includes identification of remedial action objectives, 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. The section provides a summary of data needs identified for the 200 East Groundwater Aggregate Area. The data needs provide the basis for development of detailed data quality objectives in subsequent work plans.

Section 9.0 provides management recommendations for the 200 East Groundwater Aggregate Area based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992a). Criteria for selecting appropriate *Hanford Site Past-Practice Strategy* paths (ERA, IRM, and final remedy selection) for individual plumes are developed in Section 9.1. As a result of this process, 1 plume (^{90}Sr) is recommended for an ERA. There are seven contaminants grouped

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into 3 operational plumes recommended for IRMs. Nineteen contaminants are proposed for LFIs, to determine if IRMs are justified. There are over 60 constituents for which the final remedy selection path is recommended. Finally, the tritium plume is proposed for a risk assessment. Two groundwater operable units are defined for the 200 East Area, GW-OU-3 and GW-OU-4. These are defined based on a groundwater hydrological divide, and encompass the contaminants listed for ERAs, IRMs, LFIs, final remedy, and risk assessment. Based on the relative priorities of the plumes in each groundwater operable unit, it is recommended that GW-OU-4 be given higher priority than GW-OU-3 for follow-up action.

The data evaluation process is discussed in Section 9.2. Recommendations for defining 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 and on-going CERCLA investigations. 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. Section 9.6 discusses characterization activities which will be done on an aggregate area scale.

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ACRONYMS AND ABBREVIATIONS

AAMS	aggregate area management study
AAMSR	aggregate area management study report
AFAN	ammonium fluoride-ammonium nitrate
AKART	all known, available, and reasonable treatment technologies
ARAR	applicable or relevant and appropriate requirement
ASD	ammonia scrubber distillate
ASIL	acceptable source impact level
BAT	est available technology
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
CPF	Cancer Potency Factor
CSL	chemical sewer
CWA	Clean Water Act
CWL	cooling water
DCG	Derived Concentration Guide
DNAPL	dense non-aqueous phase liquid
DOE/RL	U.S. Department of Energy, Richland Operations Office
DOE	U.S. Department of Energy
DQO	data quality objective
EC	evaporator-crystallizer
Ecology	Washington State Department of Ecology
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ERA	expedited response actions
FFS	focused feasibility study
FS	feasibility study
FWQC	Federal Water Quality Criteria
GIS	Geographic Information System
HBL	Health Based Level
HEAST	Health Effects and Assessment Summary Tables
HEHF	Hanford Environmental Health Foundation
HPPS	Hanford Past-Practice Strategy
HVAC	heating, ventilation, and air conditioning
IRM	interim remedial measure
ITS	in-tank solidification

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ACRONYMS AND ABBREVIATIONS (cont.)

LDR	land disposal restriction
LERF	Liquid Effluent Retention Facility
LFI	limited field investigation
LLBG	low-level burial grounds
LLRW	low-level radioactive waste
LLWMA	low-level waste management area
LLWMU	low-level waste management unit
MCL	maximum contaminant levels
MCLGs	maximum contaminant level goals
MEPAS	Multimedia Environmental Pollutant Assessment System
MIBK	methyl isobutyl ketone
MTCA	Model Toxics Control Act
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants Network
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRDWL	Nonradioactive Dangerous Waste Landfill
NSPS	New Source Performance Standards
NSTF	Near Surface Test Facility
NTU	nephelometric turbidity unit
OGWMN	Westinghouse Hanford Operational Groundwater Monitoring
OSM	Office of Sample Management
PARCC	precision, accuracy, representativeness, completeness
PCB	polychlorinated biphenyl
PDD	process condensate
PNL	Pacific Northwest Laboratory
PUREX	plutonium uranium extraction
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RA	risk assessment
RAO	remedial action objective
RAP	Remedial Action Policy
RARA	Radiation Area Remedial Action
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
REDOX	reduction and oxidation
RfD	Reference Doses

ACRONYMS AND ABBREVIATIONS (cont.)

RFI	RCRA Facility Investigations
RI	remedial investigation
RLS	Radionuclide Logging System
ROD	record of decision
RRI	relative risk index
SALDS	State-Approved Liquid Disposal Structure
SARA	Superfund Amendments and Reauthorization Act
SCD	steam condensate
SDWA	Safe Drinking Water Act
SMCLs	secondary maximum contaminant levels
T-BACT	toxic best available control technology
TBC	to-be-considered material
TCLP	toxic characteristic leaching procedure
TEDF	treated effluent disposal facility
TLV	Threshold Limit Value
TOC	total organic carbon
TOX	total organic halogens
TRAC	Tracks Radioactive Components
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TSD	treatment, storage, or disposal
USC	U.S. Code
USGS	U.S. Geological Survey
UV	ultra violet
WAC	Washington Administrative Code
WESF	Waste Encapsulation Storage Facility
WIDS	Waste Information Data System
WIPP	Waste Isolation Pilot Plant
WPCA	Washington State Water Pollution Control Act

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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 200 East Groundwater 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.

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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

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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

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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.

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1.2.2 Process Overview

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

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

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

Collectively this information is used to identify contaminants of concern, to determine the scope of future characterization efforts, and to develop a preliminary conceptual model of

the aggregate area. Although data collection objectives are similar, the types of information collected depend on whether the study is a source or groundwater AAMS. The data collection step serves to avoid duplication of previous efforts and facilitates a more focused investigation by the identification of data gaps.

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

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

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

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

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

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

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

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

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

needed, the intended data uses are identified, data quality objectives (DQOs) 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 that require rapid response. 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, rapid 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.

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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 limited and 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, as data allow, 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.

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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 quality assurance (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 *Contract Laboratory Program Statement of Work for Organic Analysis* (EPA 1988a) will also be followed.

1.5 ORGANIZATION OF REPORT

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

- Section 2.0, Facility, Process and Operational History Descriptions, describes the major facilities, waste management units and unplanned releases within the aggregate area. A chronology of waste disposal activities is established and waste generating processes are summarized.

- Section 3.0, Site Conditions, describes the physical, environmental, and sociological setting including geology, hydrology, ecology, meteorology, and demography.

- Section 4.0, Preliminary Conceptual Site Model, summarizes the conceptual understanding of the aggregate area with respect to types and extent of contamination, exposure pathways and receptors.

- Section 5.0, Health and Environmental Concerns, identifies chemicals used or disposed within the aggregate area that could be of concern regarding public health and/or the environment and describes and applies the screening process for determining the relative priority of follow-up action at each waste management unit.

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

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

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

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

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

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

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

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

Community relations requirements for the 200 East Groundwater Aggregate Area can be found in the *Community Relations Plan for the Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989).

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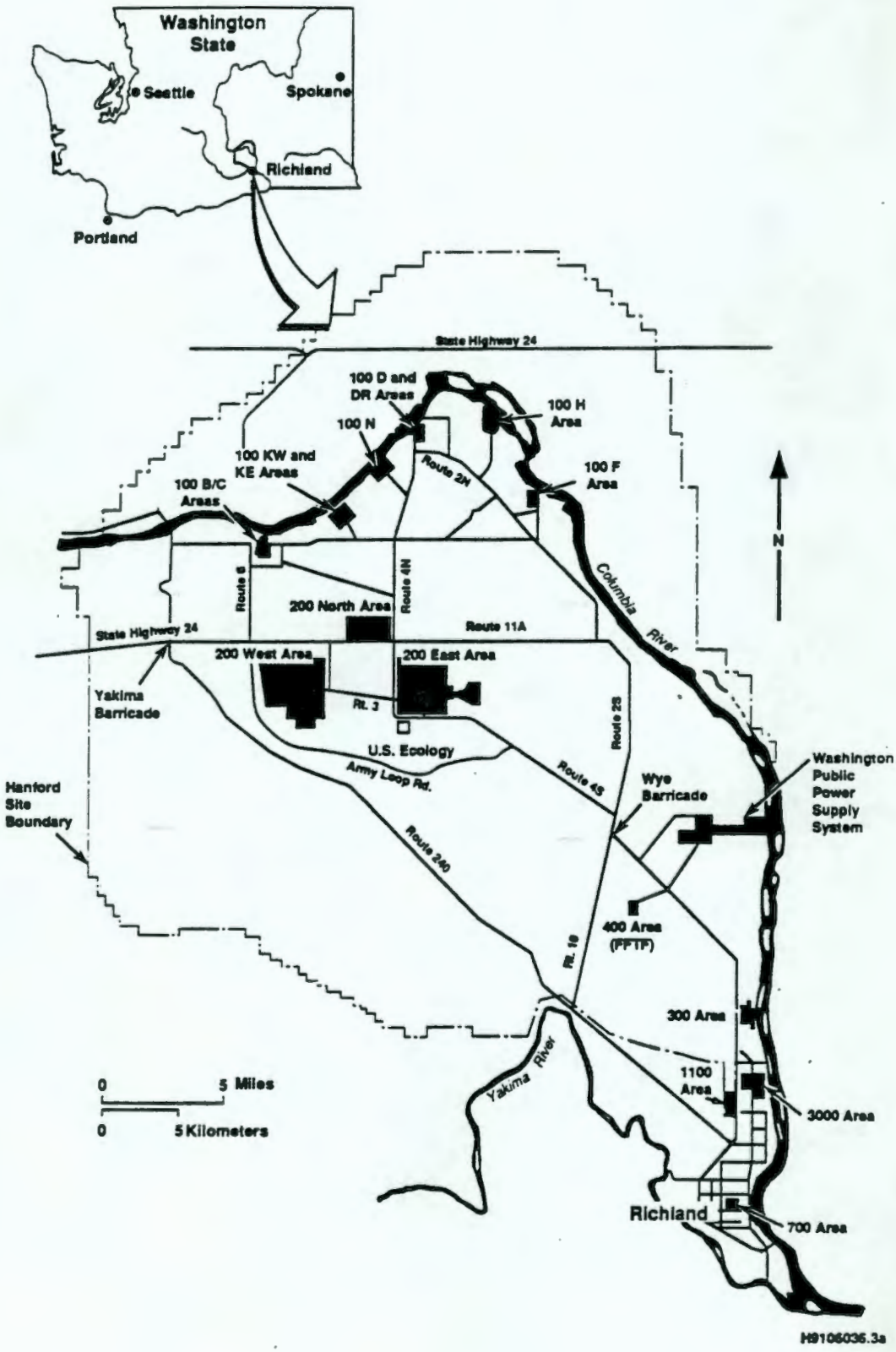

Figure 1-1. Hanford Site Map.

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

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

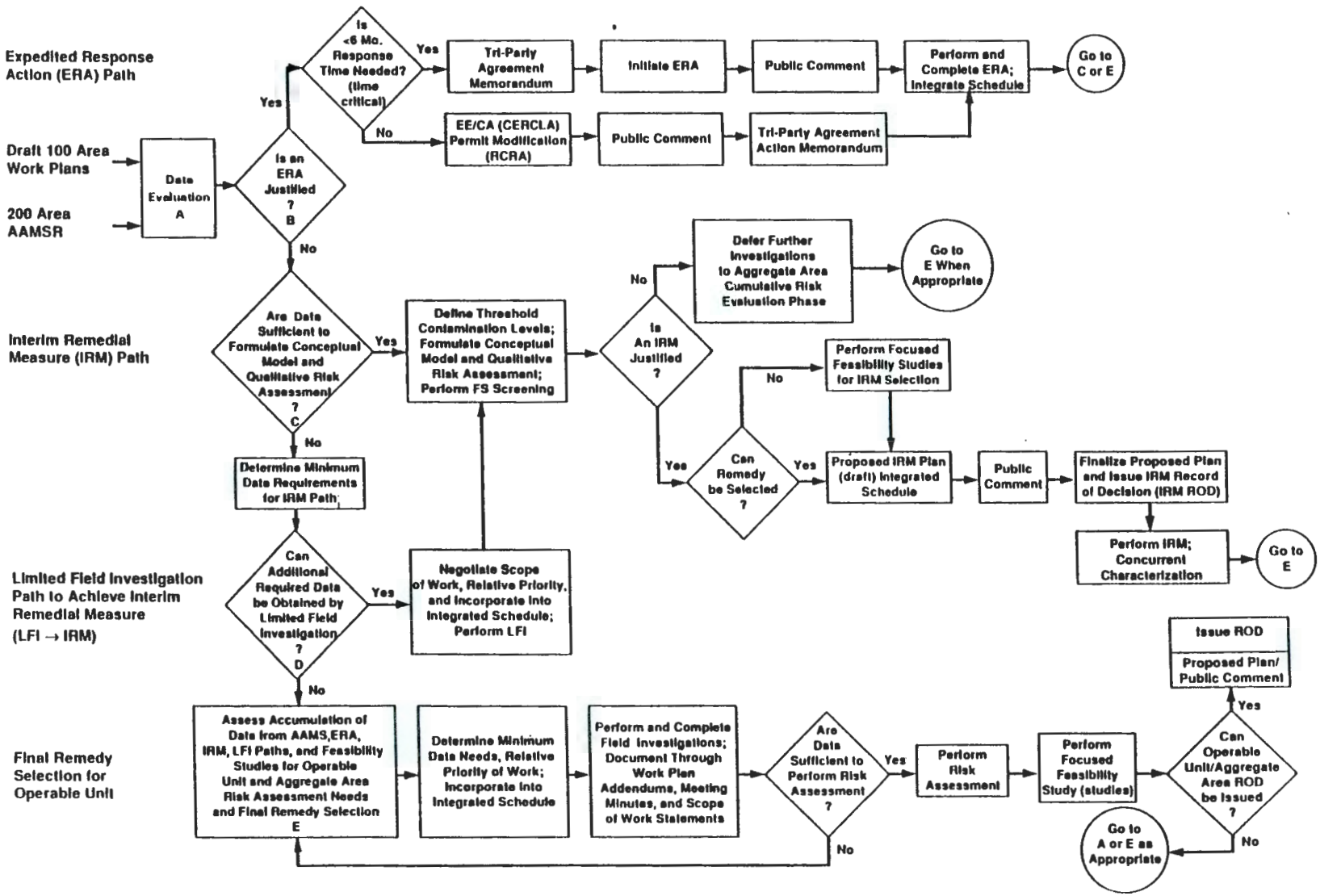

Figure 1-2. Hanford Site Past-Practice Strategy Flow Chart.

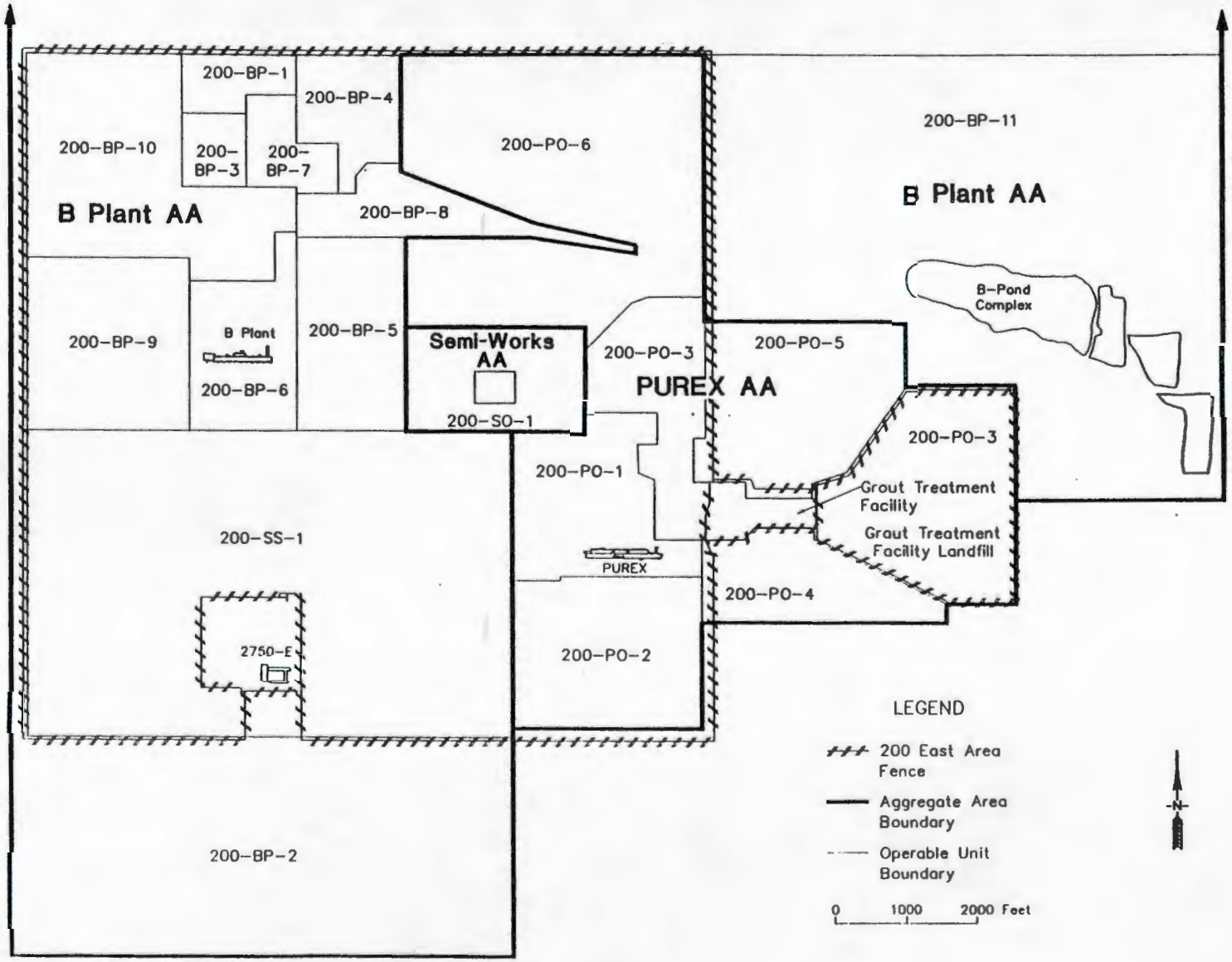

Figure 1-3. 200 East Aggregate Areas.

DOE/RL-92-19, Rev. 0

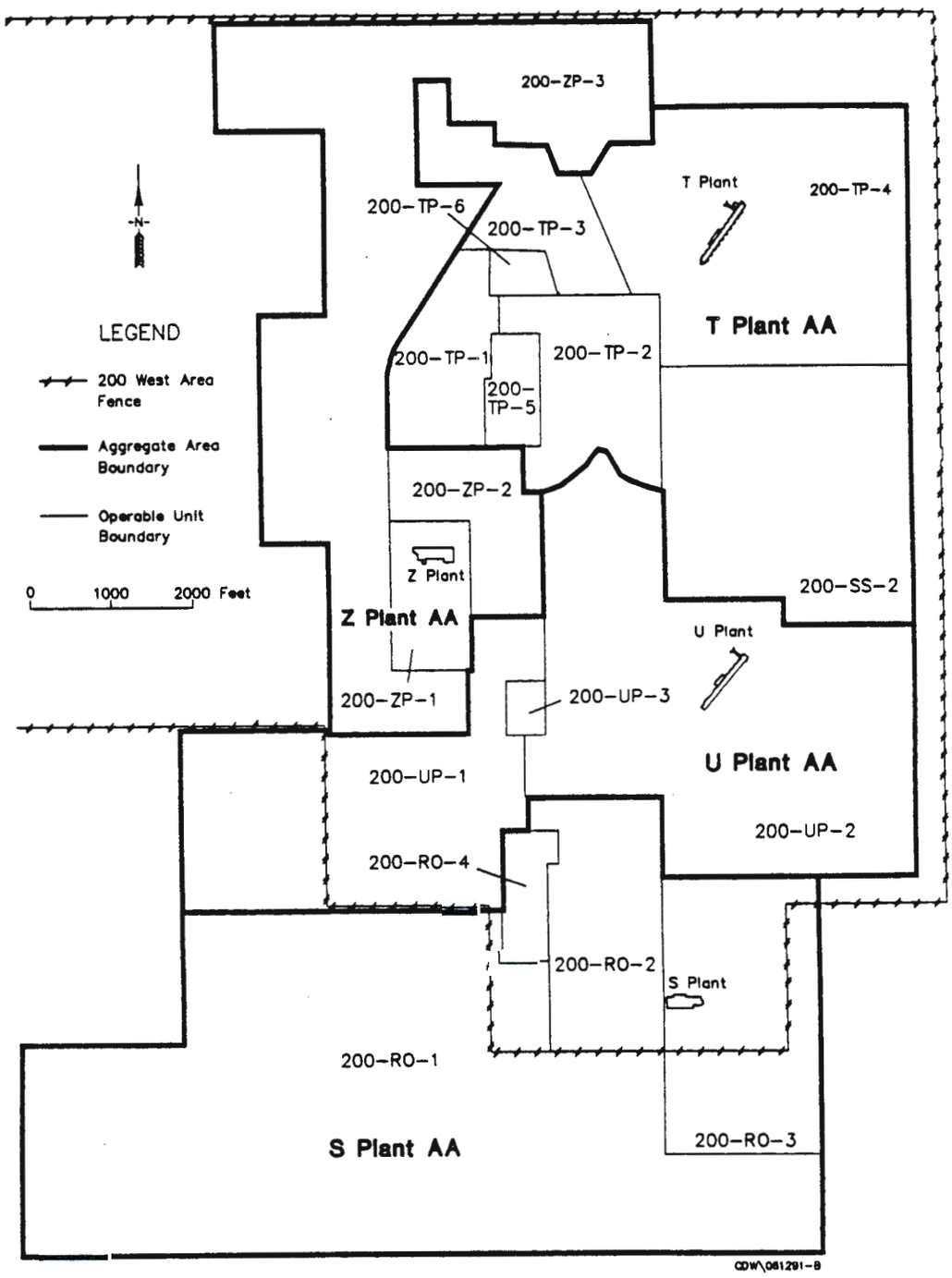

Figure 1-4. 200 West Aggregate Areas.

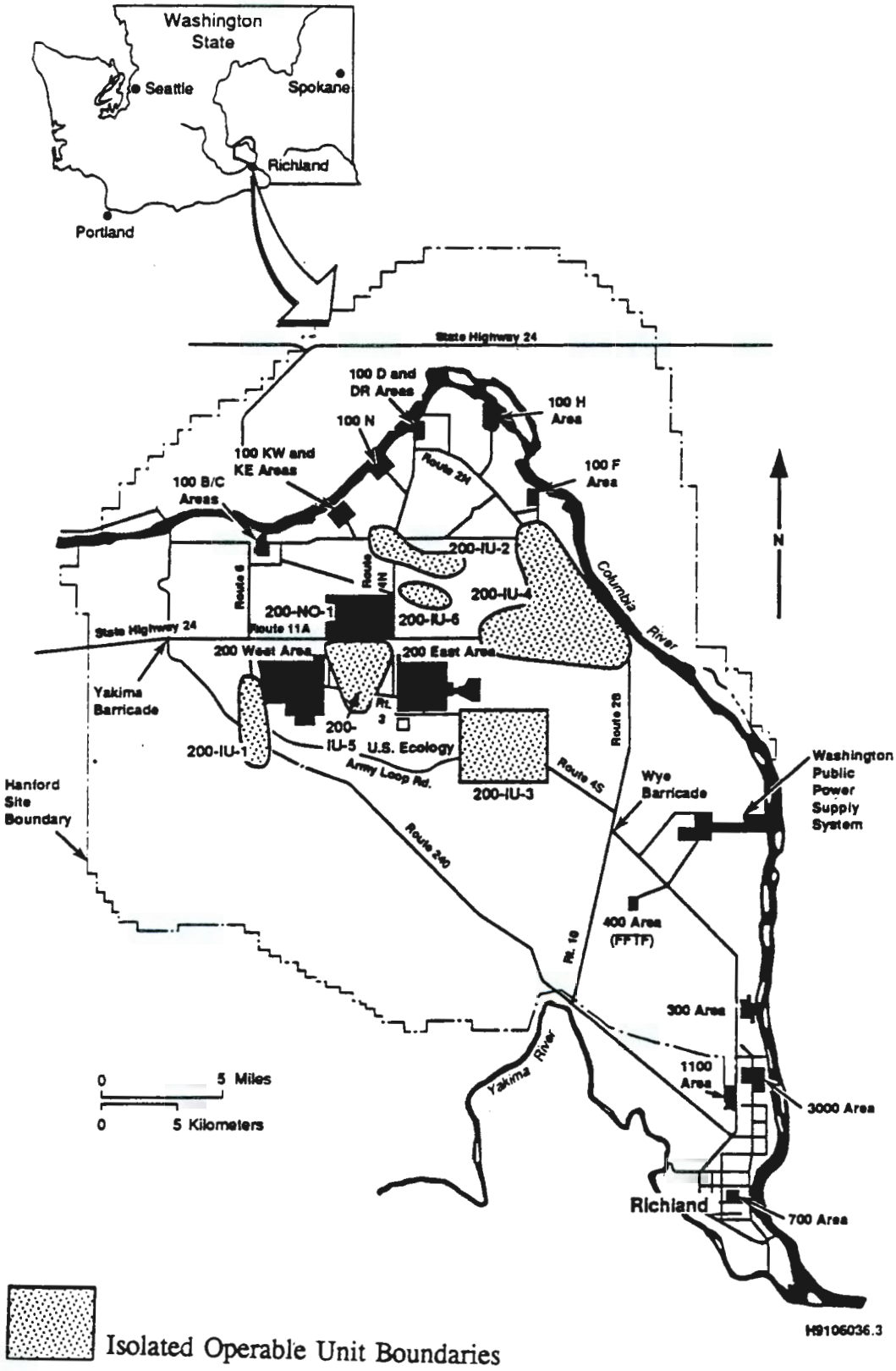

Figure 1-5. 200 NPL Site Isolated Operable Units.

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

AAMS Title	Operable Units	AAMS Type	Lead Regulatory Agency	M-27-00 Interim Milestones
U Plant	200-UP-1 200-UP-2 200-UP-3	Source	Ecology	M-27-02, January 1992
Z Plant	200-ZP-1 200-ZP-2 200-ZP-3	Source	EPA	M-27-03, February 1992
S Plant	200-RO-1 200-RO-2 200-RO-3 200-RO-4	Source	Ecology	M-27-04, March 1992
T Plant	200-TP-1 200-TP-2 200-TP-3 200-TP-4 200-TP-5 200-TP-6 S00-SS-2	Source	EPA	M-27-05, April 1992
PUREX	200-PO-1 200-PO-2 200-PO-3 200-PO-4 200-PO-5 200-PO-6	Source	Ecology	M-27-06, May 1992
B Plant	200-BP-1 200-BP-2 200-BP-3 200-BP-4 200-BP-5 200-BP-6 200-BP-7 200-BP-8 200-BP-9 200-BP-10 200-BP-11 200-IU-6 200-SS-1	Source	EPA	M-27-07, June 1992
Semi-Works	200-SO-1	Source	Ecology	M-27-08, July 1992
200 North	200-NO-1	Source	EPA	M-27-09, August 1992
200 West	NA	Groundwater	EPA/Ecology	M-27-10, September 1992
200 East	NA	Groundwater	EPA/Ecology	M-27-11, September 1992

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2.0 FACILITY, PROCESS, AND OPERATIONAL HISTORY DESCRIPTION

Section 2.0 of the 200 East Groundwater Aggregate Area Management Study Report (AAMSR) presents historical data and physical descriptions of waste management units and unplanned releases that potentially impact groundwater in the three 200 East source aggregate areas and the 200 North Aggregate Area. Detailed physical descriptions and historical data on waste sources and disposal practices are presented in the four AAMSRs for the PUREX Plant, B Plant, Semi-Works, and 200 North Aggregate Areas. This information is summarized in this section, generally organized by aggregate area in the order listed above. The focus of Section 2.0 is on those waste management units and unplanned releases that potentially could impact groundwater. Section 3.0 describes the environmental setting of those waste management units. Section 4.0 discusses the contaminants detected in the 200 East Area groundwater and qualitatively relates these contaminants to waste management units and unplanned releases.

Section 2.1 describes the location of the 200 East Groundwater Aggregate Area, Section 2.2 summarizes the history of operations for the four aggregate areas, Section 2.3 describes the waste management units and unplanned releases that could potentially impact groundwater, and Section 2.4 describes the waste generating processes in the four aggregate areas that could potentially affect groundwater quality. Section 2.5 discusses interactions with other aggregate areas or operable units. Sections 2.6 and 2.7 discuss interactions with Resource Conservation and Recovery Act (RCRA) and other Hanford programs. Section 2.8 describes the groundwater monitoring facilities that are currently active in the 200 East Area. Facilities, topography, and monitoring wells are shown in detail on Plates 1, 2, and 3, respectively.

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 Groundwater Aggregate Area is a controlled area of approximately 20 km^2 (7.7 mi^2) near the middle of the Hanford Site. The 200 East Groundwater Aggregate Area is about 8 km (5 mi) from the Columbia River and 11 km (6.8 mi) from the nearest Hanford boundary. There are 21 operable units grouped into four aggregate areas: PUREX Plant, B Plant, Semi-Works, and 200 North (Figures 1-1 and 1-3). The 200 East Groundwater Aggregate Area encompasses groundwater that underlies these four aggregate areas.

2.2 HISTORY OF OPERATIONS

The Hanford Site, established in 1943, was originally designed, built, and operated to produce plutonium for nuclear weapons using production reactors and chemical reprocessing plants. In March 1943, construction began on three reactor facilities (B,D, and F Reactors) and three chemical processing facilities (B,T, and U Plants). After World War II, six more reactors were built (H, DR, C, KW, KE and N Reactors). Beginning in the 1950's, energy research and development, isotope use, and other activities were added to the Hanford operation. In early 1964, a presidential decision was made to begin shut down of the reactors. Eight of the reactors were shut down by 1971. The N Reactor operated through 1987; and was placed on cold standby status in October 1989. Westinghouse Hanford was notified September 20, 1991, that they should cease preservation and proceed with activities leading to a decision on ultimate decommissioning of the reactor. These activities are scoped within a N Reactor shutdown program which is scheduled to be completed in 1999.

Operations in the 200 Areas (West and East) are mainly related to separation of special nuclear materials from spent nuclear fuel. Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The 200 East Groundwater Aggregate Area consists of four main processing areas (Figures 1-1 and 1-3).

- PUREX, where tributyl phosphate processes separate plutonium from spent uranium fuel rods
- B Plant, where bismuth phosphate processes separated plutonium from spent uranium fuel
- Semi-Works, where plutonium separation technology was developed before full-scale implementation
- 200 North, where irradiated nuclear fuel rods were stored before processing.

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

2.2.1 PUREX Plant Aggregate Area

The major processes conducted at PUREX Plant Aggregate Area have been involved with uranium and plutonium recovery.

The 202-A Building (PUREX Plant) is one of the primary PUREX Plant Aggregate Area facilities. The PUREX process is an advanced solvent extraction process that uses a tributyl phosphate in normal paraffin hydrocarbon solvent for recovering uranium and plutonium from nitric acid solutions of irradiated uranium. This process occurred between 1955 and 1972. After 11 years of nonoperation, the building resumed operations in November 1983 and is still considered an active site.

The PUREX Plant Aggregate Area contains eight tank farms. The 241-A, 241-AX, and 241-C Tank Farms are currently inactive and have undergone initial stabilization. The 241-AN, 241-AP, 241-AW, 241-AY, and 241-AZ Tank Farms are currently active.

2.2.2 B Plant Aggregate Area

The major processes at the B Plant Aggregate Area involved extraction of plutonium from nuclear fuels; purification, precipitation, and encapsulation of cesium and strontium from PUREX-derived waste streams; various waste handling processes such as evaporation; and transfer of single-shell tank waste.

The 221-B Building is one of the primary B Plant Aggregate Area facilities. It began operation in 1945, separating plutonium by bismuth phosphate chemical methods. It ceased operation in 1952, then began various waste treatment operations in 1965. Several additions to the 221-B Building, such as the 225-B Waste Encapsulation and Storage Facility (WESF) and the 221 Cask Transfer Facility were constructed during this period.

Waste evaporators and in-tank solidification (ITS) units have been used in the 241-B, 241-BX, and 241-BY Tank Farms to minimize the volume of the tanked waste. Also, some B Plant Aggregate Area tank wastes were transferred to the U Plant Aggregate Area for uranium recovery, then returned to the B Plant Aggregate Area and disposed to the ground.

2.2.3 Semi-Works Aggregate Area

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 the Reduction-Oxidation (REDOX) process. In 1954 the 201-C Process Building was converted to a pilot plant for the PUREX process and functioned in this capacity until 1956 when operations were terminated. In 1961 the 201-C Process Building was again converted, this time to recover strontium from fission product waste. This facility operated until 1967, during which time it was also used for recovery of cerium, technetium, and promethium. Decommissioning work began in 1983.

The Critical Mass Laboratory (209-E Building) operated from 1960 to 1983. Criticality experiments and research were conducted at this location. Currently, the laboratory is closed, although the administrative offices are occasionally used.

2.2.4 200 North Aggregate Area

The 200 North Aggregate Area's primary function was to store irradiated fuel from the plutonium reactors in the 100 Area. Three buildings, the 212-N, 212-P, and 212-R Buildings were constructed in 1944 for this purpose. After 1952, the buildings were no longer used to store irradiated fuel.

The 212-N Building currently is sealed and stores 2,332 m^3 (82,400 ft^3) of solid waste consisting of boxes containing hoods and equipment used for the fabrication of fuels for the Plutonium Recycle Test Reactor (PRTR). The 212-P Building has been used by Hanford electricians for transformer maintenance and as a temporary polychlorinated biphenyl (PCB) storage area. The 212-R Building is currently in laid-away status, meaning that it could be reactivated for its original purpose within six months. From 1982 to 1986, the 212-R Building was used for the maintenance, decontamination, and repair of contaminated railroad equipment.

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2.3 FACILITIES AND STRUCTURES POTENTIALLY IMPACTING GROUNDWATER

The 200 East Groundwater Aggregate Area contains a large variety of waste disposal and storage facilities that were associated with the operations in the three 200 East source aggregate areas (PUREX Plant, B Plant, and Semi-Works) and the 200 North Aggregate Area. High-level wastes were stored in underground tanks. Low-level wastes such as cooling and condensate water were allowed to infiltrate into the ground through ponds, cribs, and open ditches. However some high-level waste has been disposed of in cribs and trenches and unplanned releases have introduced high-level waste into units that normally received low-level waste. These waste types are defined in DOE Order 5820.2:

- 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.

- The TRU waste is defined as: without regard to source or form, radioactive waste that at the end of institutional control periods is contaminated with

alpha-emitting concentrations greater than 100 nCi/g. Heads of Field Elements (e.g., Richland Field Office Manager) can determine that other alpha contaminated wastes peculiar to a specific site must be managed as a TRU waste.

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

A discussion and detailed description of the waste management units and waste disposal practices are presented in the individual source AAMSRs for the four aggregate areas. Also included in those reports is a description of unplanned releases from waste disposal, transfer, or storage units in each of the four aggregate areas.

This section identifies and consolidates waste management units and unplanned releases that may potentially impact groundwater in the three 200 East source aggregate areas and the 200 North Aggregate Area. The waste management units within each aggregate area are divided into categories that are consistent with each source aggregate area management study (AAMS). Presented below is a description of waste management categories and the method for evaluating the potential impact on groundwater for each waste management unit and unplanned release. Table 2-1 lists the waste management units within the four source aggregate areas. Tables 2-2 and 2-3 present information used in the screening process to evaluate impact to groundwater, with a summary of waste management screening presented in Table 2-4. Tables 2-5 and 2-6 present the radionuclide and chemical waste discharge inventory for these waste management units and unplanned releases. Plate 1 shows facility locations.

The waste management unit categories are defined as follows:

- **Tanks and Vaults.** Tanks and vaults store radioactive liquid wastes generated by uranium and plutonium processing activities. Several types of tanks are present in the aggregate areas including catch tanks, settling tanks, and storage tanks. The catch tanks are generally associated with diversion boxes and other transfer units and were designed to accept overflow and spills; wastes collected in catch tanks were transferred to storage tanks. Settling tanks were used to settle particulates in liquid wastes prior to transfer to cribs. Storage tanks were used to collect and store large quantities of liquid wastes. Storage tanks include single-shell tanks and double-shell tanks, which are described in each source AAMSR.

Vaults typically are deep underground concrete structures that contain tanks as well as associated pumps, valves, and agitators. Vaults as such do not hold wastes themselves, rather they provide containment for other types of storage features and associated plumbing.

- **Cribs and Drains.** Cribs, drains, and drain fields were designed to percolate low-level radioactive process waste or noncontact liquid waste into the ground without exposing it to the open air. Cribs and drain fields are shallow excavations that are either backfilled with permeable material or held open by wood structures, both of which are covered with an impermeable layer. Water flows directly into the backfilled material or covered open space and percolates into the vadose zone. Drains, referred to as french drains, generally deliver wastewater at a greater depth [to depths of 12 m (40 ft)] and are constructed of steel or concrete pipes that are either open or filled with gravel. The drain diameters are less than their height and are therefore registered as Class V underground injection wells under the Safe Drinking Water Act.

- **Reverse Wells.** Most of the reverse wells were installed to dispose of waste liquid directly to the subsurface. The 216-B-5 Reverse Well discharged liquid waste directly to the groundwater. The reverse wells were generally designed for disposal of low-level liquid process or laboratory wastes. Often, their use was short-lived due to clogging of formation pores around the well screen. The diameter of these wells is less than the height, therefore they are registered as underground injection wells. By 1954 all reverse wells at the Hanford Site had been removed from service (Fecht et al. 1977).

- **Ponds, Ditches, and Trenches.** Ponds were designed to percolate high volumes of low-level liquid wastewater and noncontact wastewater into the vadose zone. Ditches are long, unlined excavations used to convey wastewaters to the ponds. Several ditches often supplied wastewater to one pond.

  Trenches are generally open, unlined, shallow excavations used for disposal of low-liquid discharges such as sludge often having a high salt content. Trenches were generally used for short periods (less than one year) and were deactivated when the discharge rate exceeded the soil infiltration rate or when the volume of the liquid waste discharge reached 10% of the soil column volume beneath the trench. Trenches were generally backfilled after use.

- **Septic Tanks and Associated Drain Fields.** These structures generally received sanitary wastewater and sewage. The drain fields are similar to tile fields consisting of lengths of perforated pipe laid in excavations and covered with gravel.

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- **Transfer Facilities, Diversion Boxes, and Pipelines.** Liquid wastes were transferred through a system of control structures, diversion boxes, pipelines, and valve pits. These structures are enclosures either containing jumpers or valved manifolds, which enable solution transfers via pipelines between various processes and storage facilities. Diversion boxes and receiving vaults are designed to contain leaks from the transfer operation. Pipelines are not waste management units according to the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). High-level waste transfer pipelines will be addressed in detail under the Hanford Surplus Facilities program. Lines associated with waste management units will be addressed along with its respective units.

- **Basins.** Retention basins are typically concrete structures (including a concrete bottom) which were used for intermittent storage of liquid wastes before transfer to ponds, ditches, and cribs.

- **Burial Sites.** Burial sites are locations for the disposal of solid wastes. These solid waste disposal facilities include caissons and various types of burial trenches. A burial ground generally consists of one or more of these solid waste disposal facilities. Caissons consist of concrete/steel chambers set below ground surface with an associated steel riser pipe through which waste packages were dropped into the caisson. Drop chutes consist of vertical steel casing or open-ended 55-gallon drums welded end to end and set vertically in an excavation. After filling with solid waste packages, the drop chutes were backfilled and capped with concrete. Burial trenches are open excavations. Most of the older trenches are unlined. Some of the more recently excavated trenches have either asphalt pads or polyethylene sheet linings. Solid wastes were generally placed in 55-gallon drums or boxes, which then were set into the trench. Generally an earthen cover was placed over the burial trenches.

- **Unplanned Releases.** Unplanned releases consist of releases to the atmosphere, soil, or groundwater from the waste management units listed above. The unplanned releases of interest to the 200 East Groundwater AAMS are those releases of wastewater with sufficient volume to reach the water table. These are generally confined to leakages from the single-shell tanks.

Evaluating Potential for Releases of Contaminants to Groundwater. The following sections discuss both waste management units designed to release liquid waste to the ground and unplanned releases that may have affected groundwater. The evaluation focuses on the potential for liquid waste to reach the groundwater. Waste management units were identified as potentially contributing contaminants to groundwater based on a combination of the following criteria:

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- Discharge of liquids from the waste management unit to the vadose zone
- Discharge of liquids containing radionuclide or hazardous materials from the waste management unit to the vadose zone
- Comparison between the reported volume of liquid discharged to a unit and the estimated vadose zone soil column pore volume underlying the waste management unit
- Evaluation of geophysical logs indicating movement of liquid or contaminants to the unconfined aquifer.

Another mechanism that potentially has aided downward contaminant migration is the flow of contaminated liquids down the casing of poorly sealed wells. This mechanism is suspected in some cases, but has not been quantified. While this mechanism has not been evaluated directly in this report, review of gross gamma logs should have revealed elevated levels for wells on which such flow has occurred.

The soil column pore volume calculations are analogous to the calculations in the *Expedited Response Action Proposal for the 200 West Area Carbon Tetrachloride Plume* (DOE/RL 1991a). The volume of liquid required for a wetting front to migrate downward to the water table was estimated based on the dimensions of the base of the waste unit, conservative estimates of soil porosity, and the depth to the water table. Two soil porosities were considered: a low value (0.1) and a high value (0.3). This range of porosities should also account for drainable volumes (field capacities) for these soils. The typical depth from the bottom of the waste management unit to the water table varies across the 200 East and North Areas from 50 to 87 m (164 to 230 ft). Lateral flow or potential perching of the wetting front on a less permeable layer was not considered in this calculation. If the reported volume discharged to the waste management unit exceeded the low pore space volume estimated beneath the waste management unit (assuming a 0.1 porosity), then the unit was listed as having a potential to migrate to the groundwater. This assumption is conservative because typical porosities in Hanford soils in the vadose zone are greater than 0.2. The hydraulic conductivity of unsaturated Hanford soils in the vadose zone is very low (Section 3.5.2.1.3), therefore the transit time for unsaturated flow is too long for contaminants to reach the groundwater via unsaturated flow. In addition, this approach assumes vertical flow only. It is highly probable that some lateral spreading of the wetting front would occur.

The results of this screening are presented in Table 2-2. When interpreting the results from the calculations, note that this is a simplified, one-dimensional model that neglects lateral spreading and assumes that discharged liquid is distributed evenly across the waste management unit area and that the discharge volumes in the Waste Inventory Data System

(WIDS, WHC 1991a) are accurate. Therefore, evaluations are to be viewed as conservative approximations that estimate the relative importance of each disposal site. Table 2-2 also identifies waste management units that may have had a significant impact on groundwater flow. Units that discharged greater than 100,000 m^3 (3,500,000 ft^3) of liquid were placed in this category. The choice of 100,000 m^3 (3,500,000 ft^3) was chosen because it is, except for the ponds, one or two orders of magnitude greater than typical soil column pore volume estimates. In addition, sources of noncontaminated water (plant irrigation, water supply leaks, construction practices including water compaction of bedding and backfill soils during pipeline placement, etc.) likely contributed water to the vadose zone that may have mixed with waste and contributed to downward migration. However, this potential contribution cannot be quantified. Thus, it has been neglected in this evaluation.

Geophysical log information presented in this report is a summary of the geophysical logs reviewed for each source aggregate area. A description of the review procedure and general log quality and availability is presented in Appendix A for each AAMSR. The logs reviewed were gross gamma logs; the primary sources for these logs were Fecht et al. (1977) and periodic reports (Hanlon 1991).

The gross gamma logs for each well were compared to the geologic log to identify variabilities in the gross gamma response which could be attributed to changes in lithology. Gross gamma responses that could not be attributed to lithology were called out as possible indications of contamination. The gross gamma log evaluations are semiquantitative due to the different log vintages, and lack of quantitative calibration of the various scintillation probes. It is possible that some of the elevated responses are due to radionuclides sorbed to the well casing as annular material rather than radionuclides in the soil, but this would still indicate that contamination has penetrated to that depth. Liquid discharges from waste management units were identified as potentially impacting the uppermost aquifer if an elevated gamma response was noted below or within 10 m (33 ft) of the water table. Elevated gross gamma response within 10 m (33 ft) of the water table should cover areas where the water table has changed elevation and areas where contaminants may have drained out of the lower vadose zone. The results of this screening are presented in Table 2-3. This screening method is limited because wells where logging can be performed are often some distance from the facility being monitored and a release to the soil, even if present, may not be detected due to shielding from intervening soil. It should be noted that failure to detect elevated gross gamma levels in monitoring wells does not disprove downward contaminant migration, as the wells may not intercept the zone through which migration may have occurred. The geophysical logs serve better as positive proof of contaminant migration.

Table 2-1 presents the waste management units that have the potential to impact the unconfined aquifer. The locations of these waste management units are shown on Plate 1. The following sections further screen the waste management units within each aggregate area using the process described in the introduction to Section 2.3. A complete description of

each waste management unit is presented in the source AAMSRs. Table 2-4 presents the results of the screening process to identify waste management units that potentially impact the unconfined aquifer. Tables 2-5 and 2-6 present information found regarding the estimated quantities of contaminants discharged to these waste management units.

2.3.1 PUREX Plant Aggregate Area

2.3.1.1 Tanks and Vaults. There are eight tank facilities within the PUREX Plant Aggregate Area: the 241-A, 241-AN, 241-AP, 241-AW, 241-AX, 241-AY, 241-AZ, and 241-C Tank Farms. In addition to the tank farms, there are six catch tanks and three vaults in the PUREX Plant Aggregate Area.

The following twelve tanks in the PUREX Plant Aggregate Area are either assumed leakers or have unplanned releases associated with them (Hanlon 1991):

- 241-A-103 Tank
- 241-A-104 Tank/UPR-200-E-125
- 241-A-105 Tank/UPR-200-E-126
- 241-AX-102 Tank
- 241-AX-104 Tank
- 241-C-101 Tank/UPR-200-E-136
- 241-C-110 Tank
- 241-C-111 Tank
- 241-C-201 Tank
- 241-C-202 Tank
- 241-C-203 Tank/UPR-200-E-137
- 241-C-204 Tank.

To evaluate the potential for these releases to impact groundwater using the comparison of the vadose zone pore volume to the release volume, the area is required over which the liquid wastes were released. This information is not available for unplanned releases from the tanks. Therefore, the potential for impact to groundwater could not be evaluated.

Gross gamma radiation logs for the 241-A, -AX and -C Tank Farms do not indicate release of contaminants to the groundwater from these tank farms. The 241-A Tank Farm has elevated gamma levels from the surface to 32 m (105 ft); the 241-AX Tank Farm has elevated gamma levels from the surface to 12 m (39 ft), and the 241-C Tank Farm has elevated gamma levels from the surface to 21 m (69 ft).

Two unplanned releases are associated with the 244-AR Vault. The volume of liquid released in UPR-200-E-70 is not known so the potential for impact to the groundwater could

not be evaluated. The other unplanned release, UPR-200-E-59, did not involve the release of liquid to the soil.

2.3.1.2 Cribs and Drains. Twenty-four cribs and 16 french drains were identified within the PUREX Plant Aggregate Area (WHC 1991a).

Based on a comparison of the waste volume at each waste management unit with the pore volume in the soil column below the unit, the following cribs and french drains potentially contributed contaminants to groundwater:

- 216-A-3 Crib
- 216-A-4 Crib
- 216-A-5 Crib
- 216-A-6 Crib
- 216-A-7 Crib
- 216-A-8 Crib
- 216-A-9 Crib
- 216-A-10 Crib
- 216-A-21 Crib
- 216-A-24 Crib
- 216-A-27 Crib
- 216-A-15 French Drain
- 216-A-30 Crib
- 216-A-36A Crib
- 216-A-36B Crib
- 216-A-37-1 Crib
- 216-A-37-2 Crib
- 216-A-45 Crib
- 216-A-11 French Drain
- 216-A-12 French Drain
- 216-A-13 French Drain
- 216-A-16 French Drain
- 216-A-17 French Drain.

The results of this screening are presented in Table 2-2.

In addition to potentially contributing contaminants to the groundwater, the following cribs may have had significant impact on the groundwater flow:

- 216-A-5 Crib
- 216-A-6 Crib
- 216-A-8 Crib
- 216-A-9 Crib
- 216-A-10 Crib
- 216-A-24 Crib
- 216-A-30 Crib
- 216-A-36B Crib
- 216-A-37-1 Crib
- 216-A-37-2 Crib
- 216-A-45 Crib.

Gross gamma log results were reviewed for the PUREX Plant Aggregate Area cribs and drains. The results of this review are presented in Table 2-3. The gross gamma logs support the potential for impact to the unconfined aquifer from the following cribs:

- 216-A-8 Crib
- 216-A-10 Crib
- 216-A-24 Crib

- 216-A-27 Crib
- 216-A-36A Crib.

Gamma results for several of the remaining cribs and drains indicate the presence of gamma-emitting radionuclides in the vadose zone but at depths above the water table.

A summary of the screening is presented in Table 2-4. An inventory of the radionuclides and chemicals discharged to the waste units that potentially impact groundwater is presented in Tables 2-5 and 2-6.

2.3.1.3 Reverse Well. One reverse well, 299-E24-111 Injection Well, is located in the PUREX Plant Aggregate Area. It was an experimental well that was in service from 1980 to 1982. This well did not receive waste. The 44,000 L of uncontaminated calcium and chloride solutions it received would not have significantly impacted the groundwater flow.

2.3.1.4 Ditches and Trenches. The two ditches and four trenches in the PUREX Plant Aggregate Area were designed to percolate low-level wastewater from various sources into the ground. Based on a comparison of the waste volume at each unit with the pore volume in the soil column below the unit, the following trenches and ditch potentially contributed contaminants to the groundwater:

- 216-A-19 Trench
- 216-A-20 Trench
- 216-A-29 Ditch.

The results of this screening are presented in Table 2-2.

In addition to potentially contributing contaminants to the groundwater, the 216-A-29 Ditch may have significantly impacted groundwater flow because of the large waste volume the ditch received.

Gross gamma log evaluations of the ditches and trenches are summarized in Table 2-3. These geophysical results do not provide evidence that gamma emitting contaminants have reached the groundwater from the ditches or trenches in the PUREX Plant Aggregate Area.

A summary of the screening is presented in Table 2-4. The inventory of wastes discharged to the three trenches and one ditch potentially contributing contaminants to groundwater is shown in Tables 2-5 and 2-6.

2.3.1.5 Septic Tanks and Associated Drain Fields. Seven septic tanks and associated drain fields were identified in the PUREX Plant Aggregate Area (WHC 1991a). No radionuclides or hazardous chemicals are associated with these waste management units.

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Therefore, these are not considered potential contributors of contaminants to groundwater. However, the 2607-E6 Septic Tank/Drain Field potentially may have affected the groundwater flow, as indicated in Table 2-2.

2.3.1.6 Transfer Facilities, Diversion Boxes, and Pipelines. Diversion boxes and sumps house the switching facilities where wastes can be routed from one process line to another. Twenty-seven diversion boxes were identified in the PUREX Plant Aggregate Area. The following three diversion boxes are associated with unplanned releases involving liquid waste being discharged to the soil:

- 241-A-151 Diversion Box/UN-200-E-25, UN-200-E-26, UN-200-E-31
- 241-C-152 Diversion Box/UN-200-E-82
- 241-CR-151 Diversion Box/UN-200-E-81.

The volume of liquid for the unplanned releases associated with the 241-A-151 Diversion Box is not known. The volume of liquid for the unplanned releases associated with the 241-C-152 and 241-CR-151 Diversion Boxes is known, but the area that was covered by the releases is not known. Therefore, the potential of liquid reaching the groundwater is not known. Details of the unplanned releases are in Table 2-1.

2.3.1.7 Basins. Two retention basins were identified within the PUREX Plant Aggregate Area: the 207-A Retention Basins and the 216-A-42 Retention Basin. These basins are open settling ponds where wastewater was held before overflowing into a ditch. The 207-A Retention Basins consist of six rubber-lined holding cells (WHC 1991a). The 216-A-42 Retention Basin consists of three covered concrete-lined sections. No liquid unplanned releases are associated with the retention basins in the PUREX Plant Aggregate Area. One geophysical log was examined near the 216-A-42 Retention Basin. No elevated gamma levels were detected in this log.

2.3.1.8 Burial Sites. There are five burial grounds (216-E-1, -8, -12A, -12B, and -13 Burial Grounds) and one burning pit (200-E Burning Pit) in the PUREX Plant Aggregate Area. The burial grounds reportedly received solid waste only, although some drummed liquids may have been disposed of without being reported. However, the quantity of such occasional disposal was probably not sufficient to allow liquids to migrate all the way to groundwater. Therefore, the driving force for the migration of contaminants from the burial grounds is natural recharge, which in the 200 East Area is low (see Section 3.5.2.2.1). Although contaminants may migrate from these burial grounds to the unconfined aquifer in the future, for the purposes of this study the current potential of contaminants reaching the unconfined aquifer from the burial grounds is low.

2.3.1.9 Unplanned Releases. The majority of the unplanned releases reported in the PUREX Plant Aggregate Area were confined to shallow surface spills. Many of these spills

were remediated by either removing the affected soil or covering the spill area with uncontaminated fill material. Based on the low natural recharge rates in the 200 East Area, the potential for these unplanned releases in the PUREX Plant Aggregate Area to contribute contaminants to the unconfined aquifer is low. Nine unplanned releases were previously discussed with the waste management unit they were associated with. Screening of unplanned releases could not be done because the surface area of the releases is not known.

2.3.2 B Plant Aggregate Area

2.3.2.1 Tanks and Vaults. Tanks and vaults were constructed to handle and store liquid wastes generated by plutonium processing. Three tank farms, 241-B, 241-BX, and 241-BY, are present at B Plant. The following twenty tanks in the B Plant Aggregate Area are either assumed leakers or have unplanned releases associated with them (Hanlon 1991):

- 241-B-101 Single-Shell Tank
- 241-B-103 Single-Shell Tank
- 241-B-107 Single-Shell Tank/UPR-200-E-116
- 241-B-110 Single-Shell Tank/UPR-200-E-127, UPR-200-E-128
- 241-B-111 Single-Shell Tank
- 241-B-112 Single-Shell Tank
- 241-B-201 Single-Shell Tank/UPR-200-E-129
- 241-B-203 Single-Shell Tank/UPR-200-E-130
- 241-B-204 Single-Shell Tank
- 241-BX-101 Single-Shell Tank
- 241-BX-102 Single-Shell Tank/UPR-200-E-131, UPR-200-E-132
- 241-BX-103 Single-Shell Tank/Unnumbered UPR
- 241-BX-108 Single-Shell Tank/UPR-200-E-133
- 241-BX-110 Single-Shell Tank
- 241-BX-111 Single-Shell Tank
- 241-BY-103 Single-Shell Tank
- 241-BY-105 Single-Shell Tank
- 241-BY-106 Single-Shell Tank
- 241-BY-107 Single-Shell Tank
- 241-BY-108 Single-Shell Tank/UPR-200-E-135.

Estimated volumes of tank releases are presented in Table 2-2. To evaluate the potential for these releases to impact groundwater using the comparison of the vadose zone pore volume to the release volume, the area is required over which the liquid wastes were released. This information is not available for the unplanned releases from the single-shell tanks. Therefore, the potential for impact to groundwater could not be evaluated using this criterion.

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Geophysical logs (gross gamma logs) were reviewed for the 241-B, 241-BX, and 241-BY Tank Farms to evaluate the potential of migration of gamma-emitting radionuclides to groundwater from the unplanned releases at this facility.

In the 241-B Tank Farm, elevated levels of gamma activity were detected within the backfill material around the tanks and near the surface, and within the Hanford sand beneath the bottom of the tanks. Elevated gamma activity at the base of the backfill and extending into the upper reach of the Hanford sand occurs near tanks 251-B-101, -105, -106, -107, and -110. Because of the limited depth of the wells, the possibility that gamma emitters may have reached the groundwater cannot be ruled out or confirmed.

In the 241-BX Tank Farm, elevated gamma activity is present within the backfill material around the tanks and near the surface. In addition, elevated gamma activity is indicated beneath the 241-BX-107 and 241-BX-111 Tanks within the Hanford sand. No definite migration is in evidence from the gamma logs available. Because of the limited depth of the wells, the possibility that gamma emitters may have reached the groundwater cannot be ruled out or confirmed.

In the 241-BY Tank Farm, elevated gamma activity is present within the backfill material around the tanks and near the surface, and within the Hanford sand beneath the tanks. Elevated gamma radiation is detected to the total depth of wells located near tanks 241-BY-102, -103, -104, -105, -107, and -108. The possibility that gamma emitters have reached the groundwater cannot be ruled out or confirmed.

2.3.2.2 Cribs, Drains, and Drain Fields. Twenty-four cribs and two french drains are present at the B Plant Aggregate Area. The cribs and drains typically received intermediate and low-level waste for disposal.

Based on a comparison of the waste volume in each unit with the pore volume in the soil column below the unit, the following cribs in the B Plant Aggregate Area may have contributed contaminants to the groundwater:

- 216-B-7A and B Cribs
- 216-B-8TF Crib and Tile Field
- 216-B-9TF Crib and Tile Field
- 216-B-10A Crib
- 216-B-12 Crib
- 216-B-14 Crib
- 216-B-15 Crib
- 216-B-16 Crib
- 216-B-18 Crib
- 216-B-19 Crib
- 216-B-44 Crib
- 216-B-45 Crib
- 216-B-46 Crib
- 216-B-47 Crib
- 216-B-48 Crib
- 216-B-49 Crib
- 216-B-50 Crib
- 216-B-55 Crib
- 216-B-57 Crib
- 216-B-62 Crib.

The results of the screening are presented in Table 2-2.

In addition, the screening presented in Table 2-2 indicates that the following cribs may have had a significant impact on the groundwater flow:

- 216-B-12 Crib
- 216-B-55 Crib
- 216-B-62 Crib.

Gross gamma logs were reviewed, as available, for the waste management units potentially contributing contaminants to groundwater (Table 2-3). Based on this screening, the following cribs in the B Plant Aggregate Area show evidence of contaminants reaching the groundwater:

- 216-B-14 Crib
- 216-B-16 Crib
- 216-B-43 Crib
- 216-B-44 Crib
- 216-B-45 Crib
- 216-B-46 Crib
- 216-B-50 Crib.

A summary of the screening is presented in Table 2-4. An inventory of the contaminants discharged to these waste management units is presented in Tables 2-5 and 2-6.

2.3.2.3 Reverse Wells. There are five reverse wells, 216-B-4, -5, -6, -11A, and-11B, located in the B Plant Aggregate Area. The reverse wells were used to inject wastewater into the ground at a greater depth than possible with cribs or french drains. The 216-B-5 Reverse Well discharged waste directly to the groundwater. Based on the screening process presented in Table 2-2, all four of the other reverse wells potentially contributed contaminants to the groundwater. Gross gamma logs indicate that the 216-B-5 Reverse Well contributed contaminants to the groundwater. No gross gamma logs were available to evaluate the 216-B-4 and -6 Reverse Wells. The gamma logs available for the 216-B-11A and -11B Reverse Wells do not indicate contribution of contaminants to the groundwater.

2.3.2.4 Ponds, Ditches, and Trenches. The ponds, ditches, and trenches in the B Plant Aggregate Area were designed to percolate wastewater into the ground. There are seven ponds, six ditches, and 29 trenches in the B Plant Aggregate Area.

The 216-B-3, 216-A-25, and 216-N-8 Ponds potentially contributed contaminants to the groundwater based on the screening presented in Table 2-2. The potential contribution of contaminants to the groundwater by the 2101-M Pond and the 216-B-3A, -3B, and -3C Ponds is unknown because the liquid volume received by these ponds is unknown. Because of the large liquid volume received by the 216-B-3 and 216-A-25 Ponds, they have had a significant impact on groundwater flow.

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There is no evidence of release of contaminants to the groundwater based on the gross gamma radiation logs available for these ponds.

The 216-B-2-1, 216-B-2-2, 216-B-3-1, and 216-B-3-2 Ditches may have potentially contributed contaminants to the groundwater based on the screening presented in Table 2-2. The 216-B-2-3 and 216-B-3-3 Ditches probably contributed contaminants to the groundwater even though the liquid volume received by these ditches is unknown. Because of the large liquid volume that passed through the 216-B-2-1, 216-B-3-1, and 216-B-3-2 Ditches they may have had a significant impact on groundwater flow.

There is no evidence of release of contaminants to the groundwater based on the available gross gamma radiation logs available for the ditches.

Based on the screening in Table 2-2, the following trenches in the B Plant Aggregate Area may have contributed contaminants to the groundwater:

- 216-B-20 Trench
- 216-B-21 Trench
- 216-B-22 Trench
- 216-B-23 Trench
- 216-B-24 Trench
- 216-B-26 Trench
- 216-B-28 Trench
- 216-B-29 Trench
- 216-B-30 Trench
- 216-B-31 Trench
- 216-B-32 Trench
- 216-B-33 Trench
- 216-B-34 Trench
- 216-B-36 Trench
- 216-B-37 Trench
- 216-B-40 Trench
- 216-B-52 Trench
- 216-B-53A Trench
- 216-B-63 Trench.

Because of the large liquid volume received by the 216-B-63 Trench, it may have had a significant impact on groundwater flow. There is no evidence of release of contaminants to the groundwater based on the available gross gamma radiation logs available for the trenches. A summary of the screening process is presented in Table 2-4. The inventory of wastes discharged to these waste management units is presented in Tables 2-5 and 2-6.

2.3.2.5 Septic Tanks and Associated Drain Fields. Nineteen septic tanks and their associated drain fields are identified for the B Plant Aggregate Area. The septic tanks accept sanitary wastewater and sewage for discharge.

Some of the septic tanks apparently have contributed a significant volume of water to the unconfined aquifer, based on the volumes indicated in Table 2-2. However, no contaminants are known to be associated with this effluent, so the potential for contributing contaminants to the groundwater likely does not exist. It is possible that these discharges can

be interacting in the vadose zone with discharges from other facilities. As indicated in Table 2-2, some septic tanks probably affect the water table and groundwater flow.

2.3.2.6 Transfer Facilities, Diversion Boxes, and Pipelines. Catch tanks were designed to collect releases from transfer facilities, diversion boxes, and pipelines. Any unplanned releases were small; therefore, no releases to the groundwater apparently occurred from these facilities.

2.3.2.7 Basins. There are three basins within the B Plant Aggregate Area. They are concrete-lined, open settling ponds designed to hold wastewater before it is released to ditches. No discharge of effluent to the soil is reported for the 207-B and 216-B-64 Retention Basins.

The 216-B-59B Retention Basin was initially the 216-B-59 Trench. This retention basin is referred to as 216-B-59/59B Trench/Retention Basin in Tables 2-1, 2-2, and 2-4. The screening in Table 2-2 does not indicate the possible migration of waste to the uppermost aquifer from this waste management unit.

2.3.2.8 Burial Sites. There are 13 identified solid waste burial sites in the B Plant Aggregate Area: the 200-E Powerhouse Ash Pit, the 216-E-2, -2A, -3, -4, -5, -5A, -6, -7, -9, and -10 Burial Grounds. No liquids are reported to have been disposed of at these sites. Therefore, the driving force for the migration of contaminants down from the burial grounds is natural recharge, which in the 200 East Area is low. Although contaminants may migrate from these burial grounds to the unconfined aquifer in the future, for the purposes of this study the potential is low for contribution of contaminants to the unconfined aquifer from these burial grounds.

2.3.2.9 Unplanned Releases. Sixty unplanned releases are included in the B Plant Aggregate Area. Unplanned releases associated with tanks are included above in Section 2.3.2.1. Other unplanned releases are of small scale and are unlikely to have a potential impact to groundwater. Known unplanned releases are summarized in Section 2.0 of the B Plant AAMSR.

2.3.3 Semi-Works Aggregate Area

2.3.3.1 Tanks and Vaults. Three storage tanks are located within the Semi-Works Aggregate Area. No unplanned releases or leaks are reportedly associated with these units.

2.3.3.2 Cribs and Drains. Seven cribs were identified within the Semi-Works Aggregate Area. Radionuclides and hazardous materials in the liquid reportedly discharged to these seven cribs.

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Based on a comparison of waste volume in each crib with the pore volume in the soil column below the crib, the following may have contributed contaminants to the unconfined aquifer:

- 216-C-1 Crib
- 216-C-3 Crib
- 216-C-4 Crib
- 216-C-6 Crib
- 216-C-10 Crib.

The results of the screening are presented in Table 2-2.

Available gross gamma logs were reviewed to further evaluate the potential of migration of liquid discharges in cribs 216-C-1, 216-C-5, and 216-C-10 to the unconfined aquifer. A summary of this evaluation is presented in Table 2-3. Based on this review, there is no evidence of release of contaminants from the cribs to the unconfined aquifer.

A summary of the screening is presented in Table 2-4. The waste inventory for these six cribs is presented in Tables 2-5 and 2-6.

2.3.3.3 Reverse Wells. One reverse well, 216-C-2, was identified in the Semi-Works Aggregate Area. The volume of waste received by the reverse well is unknown so the potential of contaminants having reached the unconfined aquifer is unknown.

2.3.3.4 Ponds, Ditches, and Trenches. One pond, 216-C-9, and one ditch, the 200 East Powerhouse Ditch, were identified in the Semi-Works Aggregate Area. Based on a comparison of waste volume at the units with the pore volume in the soil column below the units, both the 216-C-9 Pond and the Powerhouse Ditch have potentially contributed contaminants to the unconfined aquifer. In addition, both the pond and the ditch may have significantly impacted the groundwater flow based on the large volume of liquid waste they received.

One gross gamma radiation log was available for the 216-C-9 Pond. The results of this review are presented in Table 2-3. No evidence of release of contaminants to the groundwater is in evidence from this gamma log.

The waste inventory of the 216-C-9 Pond and the 200 East Powerhouse Ditch are presented in Table 2-5 and 2-6.

2.3.3.5 Septic Tanks and Associated Drain Fields. Two septic tanks and associated drain fields were identified within the Semi-Works Aggregate Area.

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The volume of waste received by these septic tanks is not known so the impact on groundwater cannot be determined. There are no radioactive or hazardous wastes reported for these sanitary waste septic tanks and drain fields.

2.3.3.6 Transfer Facilities, Diversion Boxes, and Pipelines. Control structures, diversion boxes, and valve pits are most often concrete structures that were designed to contain leaks from transfer and drainage operations. Therefore, contaminants from these structures may migrate to the unconfined aquifer through unplanned releases. No unplanned releases are associated with the two valve pits and two diversion boxes in the Semi-Works Aggregate Area. Therefore, the potential for impact of groundwater quality from these units is low.

2.3.3.7 Basins. There are no basins identified in the Semi-Works Aggregate Area.

2.3.3.8 Burial Sites. One burial ground, 218-C-9, is located in the Semi-Works Aggregate Area. Wastes disposed of in the burial ground was limited to solid waste. Therefore, the driving force for the migration of contaminants from the burial grounds is natural recharge, which is low in the 200 East Area. Although contaminants may migrate from the burial ground to the unconfined aquifer in the future, for the purposes of this study the potential is low for contribution of contaminants to the unconfined aquifer from the burial ground.

2.3.3.9 Unplanned Releases. Four unplanned releases have been identified in the Semi-Works Aggregate Area. These releases were of a small enough scale that it is unlikely that they could potentially impact groundwater.

2.3.3.10 Newly Identified Sites. There are seven newly identified sites in the Semi-Works Aggregate Area. The sites and the little information about them are presented in Table 2-1. Not enough information (volume, surface area) is available to evaluate the impact of these sites on groundwater.

2.3.4 200 North Aggregate Area

2.3.4.1 Tanks and Vaults. One tank, the 212-P Transformer Oil Tank, is located in the 200 North Aggregate Area. No unplanned releases or leaks have been reported for this tank.

2.3.4.2 Cribs, Drains, and Drain Fields. There are no cribs or drains located in the 200 North Aggregate Area.

2.3.4.3 Reverse Wells. There are no reverse wells located in the 200 North Aggregate Area.

2.3.4.4 Ponds, Ditches, and Trenches. The ponds and trenches in the 200 North Aggregate Area were designed to percolate liquid waste into the ground. The ponds in the 200 North Aggregate Area include the 216-N-1 Pond, the 216-N-4 Pond, and the 216-N-6 Pond. The trenches are the 216-N-2 Trench, the 216-N-3 Trench, the 216-N-5 Trench, and the 216-N-7 Trench.

Based on a comparison of the waste discharged at each unit with the pore volume in the soil column below the unit, all of the ponds and trenches in the 200 North Aggregate Area may have contributed contaminants to the unconfined aquifer. In addition, the three ponds may have had a significant impact on groundwater flow. The results of this screening are presented in Table 2-2.

A summary of the screening by soil pore capacity and gross gamma logs is presented in Table 2-4, with an inventory of waste discharged to these units presented in Tables 2-5 and 2-6.

2.3.4.5 Septic Tanks and Associated Drain Fields. Three septic tanks and their associated drain fields are identified for the 200 North Aggregate Area. The septic tanks received sanitary wastewater and sewage for disposal. The volume of this waste discharge is not known; therefore, the potential impact on the groundwater is not known. Contaminants are not known to have been associated with this effluent, so the potential for contributing contaminants to the groundwater is unlikely.

2.3.4.6 Transfer Facilities, Diversion Boxes, and Pipelines. In the 200 North Aggregate Area there are no diversion boxes; however, there are three main pipelines which carried waste to the ponds from each of the irradiated fuel storage basins. No unplanned releases are associated with these pipelines.

2.3.4.7 Basins. There are no retention basins within the 200 North Aggregate Area.

2.3.4.8 Unplanned Releases. There are two unnumbered unplanned release sites in the 200 North Aggregate Area. The history of these releases is not known.

2.4 WASTE GENERATING PROCESSES THAT POTENTIALLY AFFECT GROUNDWATER QUALITY

Operations in the 200 East Area and the 200 North Area have been related mainly to nuclear fuel separation. Each of these operations generated liquid waste. The following sections briefly describe the waste generating processes and associated waste streams for each of the four source areas in the 200 East Groundwater Aggregate Area. Greater details can be found in the appropriate source AAMSR. Solid waste disposal is not considered in this

section because the driving force for the migration of contaminants from solid waste disposal sites is natural recharge, which in the 200 East Area is low (Section 3.5.2.2.1). Although contaminants from solid waste disposal sites may migrate to the groundwater in the future, for the purposes of this study the potential for solid waste contaminants reaching the groundwater is considered to be low.

2.4.1 PUREX Plant Aggregate Area

The primary waste generating processes in the PUREX Plant Aggregate Area are associated with the operation of the 202-A Building and its ancillary support facilities. Operations in the 202-A Building complex have included the recovery of uranium and plutonium from spent reactor fuels, treatment and/or storage of liquid and solid wastes, and discharge of gaseous and liquid effluents that meet environmental release criteria. This section describes the primary waste generating processes and the associated building locations in the PUREX Plant Aggregate Area including:

- 202-A Building and 293-A Building (PUREX Process)
- 242-A Evaporator (Waste Volume Reduction Process)
- 241-A-431 Condenser Building in the 241-A Tank Farm (Tank Farm Condensate).

Table 2-7 summarizes the available information about the waste streams produced within the aggregate area. In addition, some waste management units within the aggregate area received wastes from outside facilities. Some of the B Plant waste was sent to the 241-A, 241-AX, and 241-C Tank Farms. The 201-C Building (Semi-Works) waste was also sent to the 241-C Tank Farm. Sections 2.4.1.1 through 2.4.1.3 describe the PUREX Plant Aggregate Area waste generating processes that were previously mentioned.

2.4.1.1 PUREX Process. The 202-A Building was the primary location of the PUREX process. The PUREX chemical separation processes are based on dissolving jacketed fuel rods in nitric acid and conducting multiple purification operations on the resulting aqueous nitrate solution. The goal is to extract, purify, and concentrate the uranium, plutonium and neptunium produced from the declad fuel elements. The driving forces for the separations consist of concentration changes, temperature changes, and chemical additions. The process steps include fuel-element decladding, uranium metal dissolution, solvent extraction, ion exchange, and product load-out.

The PUREX process begins with zirconium cladding on fuel elements being removed in an ammonium fluoride-ammonium nitrate (AFAN) solution. Ammonium nitrate is required

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to react with the ammonia and hydrogen that evolve during decladding due to the potential combustion hazard. Nitric acid is used to dissolve declad fuel elements for the solvent extraction process. The solvent extraction process used a light phase solvent, tributyl phosphate, in a normal paraffin hydrocarbon (kerosene) diluent to extract the uranium, plutonium, and neptunium from the fission products. The organic phase is sent to the partitioning cycle where the plutonium is partitioned from the uranium and neptunium. The plutonium stream is routed through two additional solvent-extraction cycles for further purification. After purification, the plutonium stream is concentrated. The other stream from the partition cycle, which bears the neptunium and uranium, is routed to the final uranium cycle where neptunium is separated. The aqueous neptunium stream is sent to the backcycle waste system for concentration and recycling to the solvent-extraction column. The uranium stream is routed to a column that strips the uranium from the organic stream with an aqueous nitric acid solution. The uranium product, uranyl nitrate hexahydrate, is then stored in tanks until it is shipped to the UO_3 Plant in the U Plant Aggregate Area.

The 202-A Building is the source of five liquid effluent streams. These liquid effluent streams are the process condensate (PDD), cooling water (CWL), steam condensate (SCD), chemical sewer (CSL), and ammonia scrubber distillate (ASD). The PDD stream comes from the concentration stages of the PUREX process. The concentration changes are provided by dilution with water and by removal of water by boiling. Most, but not all, of the water removed by boiling is recycled back into the dilution stages of the process. The fraction of water not recycled is disposed of through the PDD stream. Steam condensate and warm water constitute the liquid effluents from the PUREX process in the CWL, SCD, and most of the CSL streams. The steam condensate and warm water effluents are the condensed steam used for boiling process solutions and the warmed cooling water used for condensing the resulting process vapors. The rest of the CSL stream comes from ventilation, heating, water services, and room drainage (mostly shower rooms, water coolers, housekeeping water, and steam and water leaks, together with occasional chemical leaks). The ASD stream is the result of the first step in fuel dissolution, which produces large quantities of gaseous ammonia. The ammonia is scrubbed from the offgas with water to prevent releasing the ammonia to the air. Then the resulting ammonia solution is boiled to concentrate the ammonia and radionuclides for disposal to underground storage tanks. The condensed vapor becomes the ASD stream.

One of the secondary facilities within the PUREX process is the 293-A Building. This building houses the back-up facility, which removes nitrogen oxides from the dissolver offgas stream then converts them to nitric acid. Offgases are treated with hydrogen peroxide to remove the nitrogen oxides. The nitric acid is then recycled into the PUREX process via the 206-A Building.

Process wastes from the 202-A Building were discharged to various waste management units including the following:

- 216-A-1 and 216-A-2 Cribs
- 216-A-21 and 216-A-27 Cribs
- 216-A-11 and 216-A-12 French Drains
- 216-A-18 and 216-A-19 Trenches
- 216-A-29 Ditch/discharged to 216-B-3 Pond
- 241-A, 241-AX, and 241-C Tank Farms
- 216-A-42 Retention Basin/discharged to the 216-A-30 Crib, 216-A-37-2 Crib, and 216-B-3 Pond via the 216-A-29 Ditch.

2.4.1.2 Waste Volume Reduction Process. The 242-A Evaporator started operation in 1977. The purpose of this facility is to reduce the volume of radioactive liquid waste by evaporating water from the feed solution to produce a concentrated salt solution. The solution separates upon cooling to form salt cake and residual liquor. This process reduces the number of double-shell tanks required to store this type of waste by 35 to 60%.

The 242-A Building contains the evaporator vessel, supporting process equipment, and the principal process components of the evaporator-crystallizer (EC) system. The building comprises two adjoining, structurally independent structures, designated A and B. Structure A houses the processing and service areas while structure B houses operating and personnel support areas.

Process condensate from the 242-A Evaporator flows into one of the three cells at the 207-A Retention Basins until it reaches operational capacity. At this time the steam condensate flow is diverted to one of the two remaining cells. The cell that has reached capacity is then sampled and analyzed at the 222-S Laboratory for radionuclides as an indication of process control. The steam condensate from the full diversion basin is then discharged to the 216-B-3 Pond if the analytical results are within set radionuclide limits.

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

- 216-A37-1 Crib
- 207-A Retention Basins/discharged to double-shell tanks.

2.4.1.3 Tank Farm Condensate. Condensate waste from the 241-A Tank Farm was condensed in the 241-A-431 Building. The waste was then directed to eight waste

management units. The condensate was primarily water and included entrained radionuclides and chemicals from the waste in the tanks. The following waste management units received condensate waste:

- 216-A-9 Crib
- 216-A-16 and 216-A-17 French Drains
- 216-A-23A and 216-A-23B French Drains
- 216-A-19 and 216-A-20 Trenches
- 216-A-34 Trench.

2.4.2 B Plant Aggregate Area

Several processes have operated in the B Plant Aggregate Area since the construction of the original 221-B Building in 1945.

The 221-B Building (B Plant) was the second fuel reprocessing plant at the Hanford Site to separate plutonium from other fission products. The 221-B Building originally used the bismuth phosphate process to recover plutonium from irradiated uranium fuel pellets and operated from 1945 to 1952. In 1968, the plant was restarted with a new process to recover cesium and strontium from single-shell tank wastes. The plant continued this mission until 1984. The 221-B Building also has a low-level radioactive waste concentration process that reduces the volume of wastes by evaporating water from them. This process has not been used since 1986.

Equipment conversions were made at 221-B Building beginning in 1986 to process NCAW and a test quantity of 80,000 L (20,000 gal) was processed. However, this mission for the 221-B Building has not been approved and the current processing mission of the 221-B Building has not been defined. The 225-B Building includes the WESF, which was designed to convert strontium and cesium solutions that were recovered at the 221-B Building, crystallize them, and store them in stainless steel cylinders that are immersed in a cooling water bath. Other waste generating processes in the B Plant Aggregate Area include the 242-B Evaporator used to reduce liquid volume in single-shell tanks and two ITS units (ITS-1 and ITS-2) that directly evaporated water from single-shell tanks.

Table 2-7 summarizes the available information about the waste streams produced within the aggregate area. Sections 2.4.2.1 through 2.4.2.11 describe the B Plant Aggregate Area waste generating processes in more detail.

2.4.2.1 221-B Building Bismuth Phosphate Plutonium Recovery Process. This was the original process for which the 221-B Building was designed and constructed in 1945. This process was designed to separate and concentrate the small amounts of plutonium contained

in the irradiated fuel pellets produced in the 100 Area reactors. In the bismuth phosphate process, all of the material contained within the irradiated fuel pellets was discarded as waste except for the recovered plutonium.

The first step in the bismuth phosphate process was to remove the aluminum cladding surrounding the fuel. This was done by dropping the pellets into a tank containing a solution of sodium hydroxide which preferentially dissolved the aluminum surrounding the pellet. Sodium nitrate was added to the solution to prevent the formation of excessive quantities of hydrogen gas during the dissolution of the aluminum metal. The waste solution from the cladding dissolution step contained sodium aluminate, sodium nitrate, and sodium nitrite as well as small amounts of fission products. This waste solution was combined with the first-cycle decontamination waste and transferred to single-shell tank storage (Waite 1991).

The next step in the process was to dissolve the uranium and extract the plutonium. The decladded uranium slugs were rinsed with water and dissolved in 50 to 60% nitric acid. Excess uranium metal remained in the dissolver as a heel to increase the rate of dissolution. The completion of the dissolving step was determined by specific gravity that was measured with a pair of bubbler tubes immersed in the solution (Ballinger and Hall 1991).

The plutonium was recovered from the dissolved uranium solution by adding sodium nitrate solution to convert the plutonium to the +4 valence state. Next, bismuth nitrate and phosphoric acid were added. Sulfuric acid was also used at this point in the process. The resulting precipitate of bismuth phosphate carried 99% of the plutonium with it. This precipitate was separated from the solution in a solid-bowl centrifuge, and the solution was transferred to single-shell tank storage as the metal waste stream (Ballinger and Hall 1991). The metal waste stream contained the bulk of the uranium and approximately 90% of the long-lived fission products (e.g., ^{137}Cs and ^{90}Sr) (Waite 1991).

Once the plutonium had been extracted in the precipitate, it went through two decontamination cycles to purify it further. In the first decontamination cycle, the precipitate was washed in the centrifuge and dissolved in strong nitric acid. The valence of the plutonium was then adjusted to +6 by the addition of a sodium dichromate solution and a precipitate of bismuth phosphate was again formed using bismuth nitrate, phosphoric acid, and sodium metabismuthate. However, this time the precipitate captured some of the fission products that were not extracted in the first liquid waste stream and the plutonium remained in solution. The precipitate was separated from the liquid product stream, dissolved in nitric acid, and transferred as a liquid to be mixed with other liquid wastes from the first decontamination cycle.

Following separation from the waste precipitate, a precipitate containing the plutonium was formed from the product solution using ammonium fluorosilicate, ferrous ammonium sulfate, bismuth oxynitrate, and phosphoric acid. The plutonium-containing precipitate was

separated from the solution and the solution was transferred to single-shell tank storage along with the other liquid wastes from the first contamination cycle. The plutonium product precipitate was dissolved in nitric acid prior to further processing (Ballinger and Hall 1991). The waste stream from the first decontamination cycle contained almost 10% of the long-lived fission products and was sent to single-shell tank storage (Waite 1991).

The second decontamination cycle was performed on the plutonium solution remaining from the first decontamination cycle to further purify it by removing additional fission products from the plutonium solution. The same process was used for the second decontamination cycle as was used for the first decontamination cycle. The waste stream from the second cycle contained less than 0.1% of the fission products. This was sent to single-shell tanks for storage until 1948. Because of limited tank space, the second-cycle waste supernatant was discharged directly to cribs and trenches from 1948 until the 221-B Building was shut down in 1952. This included second cycle material that had previously been stored in tanks (Waite 1991).

The product from the bismuth phosphate process was a dilute plutonium nitrate solution. This was transferred to the 224-B Concentration Facility to be purified and reduced in volume. The solution was first oxidized with sodium bismuthate. Next, phosphoric acid was added to precipitate byproduct followed by centrifugation. Product solution was treated with hydrogen fluoride and lanthanum salt to precipitate byproduct. Following separation by centrifuge, product solution was treated with oxalic acid, hydrofluoric acid, and lanthanum salt to precipitate plutonium and lanthanum fluoride. These solids were centrifuged from the solution and washed with water. The plutonium fluoride metathetically evolved to form plutonium hydroxide by digestion with hot potassium hydroxide. The solid hydroxides were centrifuged and dissolved in nitric acid to form plutonium nitrate, which was transferred in cans to the Isolation Building (the 231-Z Building in the Z Plant Aggregate Area).

The plutonium nitrate-lanthanum nitrate solution sent to the Isolation Building was treated with ammonium sulfite and sulfate. In addition, it was treated with hydrogen peroxide to form plutonium peroxide in two precipitations followed by dissolving in nitric acid. The final plutonium nitrate was concentrated in a still and then concentrated in a sample can by evaporation to a thick paste. The liquid waste stream from the 224-B Concentration Facility concentration processing was initially discharged to the 241-B-361 Settling Tank when processing began in 1945. The overflow from the settling was discharged to the 216-B-5 Reverse Well.

Beginning in 1947, the 224-B Concentration Facility waste was routed to the 241-B-201 through 241-B-204 (208,000 L, 55,000 gal capacity) Single-Shell Tanks for settling before being discharged to cribs. This discharge continued until the bismuth phosphate process was shut down in 1952. The primary concern about the waste streams from the 224-B Concentration Facility was plutonium. The majority of the plutonium remained in the tanks

after settling. However, the waste from this facility was the primary contributor of plutonium to the ground from all of the tank waste discharges (Ballinger and Hall 1991).

2.4.2.2 221-B Building Strontium and Cesium Recovery. In 1963, the 221-B Building began recovering strontium, cerium, and rare earths using an acid-side, oxalate-precipitation process as part of the Phase I processing for the 221-B Building Waste Fractionization Project. A centrifuge was used to separate the phases. The lead, cerium, and rare earth fractions were dissolved in nitric acid and stored. The strontium fraction was thermally concentrated and stored. Portions of the strontium and rare earths produced in Phase I were pumped by underground transfer line to the Semi-Works for purification of the ^{90}Sr fraction and separation of the rare earth fraction in ^{144}Ce and a rare earth fraction including ^{147}Pm. Phase I processing at the 221-B Building ended in June 1966 to accommodate Phase III construction.

The objective of the Phase I processing was to restore services to the 221-B Building after its extended shutdown and to accumulate an inventory of fission products. The Phase II portion of the project was the installation of facilities necessary to demonstrate a process system for packaging the long-lived fission products as a small volume concentrated waste. The purpose of Phase III was to provide waste fractionization facilities in the 221-B Building for processing high level wastes from PUREX Plant Aggregate Area and the B Plant Aggregate Area tank farms into fractions that could be immobilized and contained more safely.

The Phase III Waste Fractionization processing began at the 221-B Building in 1968. This process separated the long-lived radionuclides, ^{90}Sr and ^{137}Cs, from high-level PUREX and REDOX wastes and stored a concentrated solution of ^{90}Sr and ^{137}Cs at the 221-B Building. Individual tanks at the B Plant Aggregate Area contained up to 35 MCi of ^{90}Sr or ^{137}Cs at concentrations up to 10,000 Ci/gal. The combined storage capacity of the tanks was estimated to be 85 MCi of ^{90}Sr and 25 MCi of ^{137}Cs.

Three processes were used for the waste fractionization. The first process was the feed preparation and solvent extraction of current acid wastes generated by the 202-A Building and stored at PUREX Plant Aggregate Area and REDOX tank farms. The solids in these wastes contained about 55% of the strontium and 70% of the rare earths. The solids, consisting mostly of silicates, phosphates, and sulfates, were treated by a carbonate-hydroxide metathesis solution to convert the sulfates to carbonate-hydroxide solids. These solids were then separated from the solution by centrifuge and dissolved in nitric acid to recover the fission products. The dissolved fission products were combined with original acid waste supernate after it had been treated to form feed for the solvent extraction columns by adding a metal-ion complexing agent, a pH buffer, and a pH adjustment solution.

The feed went through a series of solvent extraction columns. The solvent used was a mixture of di(2-ethylhexyl) phosphoric acid extractant and tributyl phosphate modifier in a normal paraffin hydrocarbon diluent. The strontium, cerium, and other rare earths were extracted from the aqueous phase into the solvent. The aqueous fraction contained the cesium and was routed to the 241-A or 241-AX underground tank farms in the PUREX Plant Aggregate Area for temporary storage to allow the decay of short-lived activity.

The strontium fraction was stripped from the solvent with dilute nitric acid and thermally concentrated with the Cell 5 concentrator for storage in tanks in the 221-B Building Cells 6 to 8. The cerium and rare earth fraction was stripped from its solvent with nitric acid, combined with organic wash wastes, and sent to single-shell tank storage. The solvent was washed and recycled for reuse.

The second process used was a feed preparation and solvent extraction process for processing stored sludge wastes from the 241-A, 241-AX, and 241-SX Tank Farms. The sludge was sluiced with supernate and water and pumped out of the tanks to the 244-AR or 244-SR Vault. At these vaults, the sluicing water was decanted for storage to await treatment for cesium removal. The sludge, containing the bulk of the fission products, was dissolved in nitric acid and transferred to the 221-B Building for treatment.

At the 221-B Building, the rare earths and strontium were precipitated as sulfates using lead sulfate as a carrier to separate them from iron and aluminum. A sodium hydroxide-sodium carbonate metathesis was performed to convert the sulfates to hydroxides and carbonates and to eliminate the bulk of the lead. The product cake was centrifuged, dissolved with nitric acid, and accumulated for solvent extraction treatment. The solvent extraction was similar to the solvent extraction for the current acid waste, except that the waste aqueous fraction from the initial solvent extraction containing the rare earths and the solvent wash wastes were thermally concentrated at the 221-B Building using the Cell 20 concentrator and transferred to immobilization processing (in-tank solidification).

The third waste fractionation process was the ion exchange of stored cesium supernates and sluicing solutions. High-level tank farm supernates and sluicing water containing ^{137}Cs was passed through an ion-exchange column at the 221-B Building. The cesium and a small fraction of sodium were adsorbed on a synthetic alumino-silicate zeolite. About 97% of the adsorbed sodium and 0.5% of the loaded cesium were designed to be removed from the column with a dilute ammonium and carbonate-ammonium hydroxide scrub solution. Following this, the remaining cesium was removed with a concentrated mixture of ammonium carbonate and ammonium hydroxide. The cesium was thermally concentrated in the Cell 20 concentrator and stored in tanks in 221-B Building Cells 14 and 17. The waste from the adsorption step was routed directly to in-tank solidification. The column wash wastes and scrubs were thermally concentrated in the Cell 23 concentrator prior to transfer to in-tank solidification. In 1974, the 221-B Building began using Cell 38 to perform final

purification of the cesium prior to processing at the WESF. The WESF is described in Section 2.4.4. The strontium solvent extraction process operated until 1978. Cesium final purification ended in 1983 and strontium purification ended in 1984.

Wastewater continues to be generated from the 221-B Building from heating, ventilation, and air conditioning (HVAC) systems, floor drains, and steam condensate drains. This stream is known as the B Plant Chemical Sewer Stream and was disposed of to the 216-B-63 Trench. In February 1992, the effluent piping was revised to allow the chemical sewer stream to be discharged to the B Plant Cooling Water Stream which ultimately reaches the 216-B-3 Pond.

2.4.2.3 221-B Building Waste Concentration Process. The waste fractionization process described in Section 2.4.2 included a thermal evaporation concentrator in Cell 23 to concentrate process wastewaters prior to disposal. This system was used to concentrate low-level radioactive waste after the cesium and strontium waste fractionization process was shut down in 1984. Double-shell tank waste was received at the 221-B Building to be processed through the low-level waste concentrator until 1986. The 221-B Building received no double-shell tank wastes after April 1986 and processing of these wastes was complete by late 1986. Other sources of the low-level waste included miscellaneous sumps and drains in the WESF, which diverted decontamination waste solutions generated in the WESF process cells. Another contributor was a liquid collection system located beneath the 40 cells in the 221-B Building that collected cell drainage from decontamination work and water washdowns in the processing section of the 221-B Building. The concentrator also processed wastes produced by the cleanout of various process vessels at the 221-B Building and WESF through 1986 (Peterson 1990a).

The concentrator process consisted of a vertical, single-pass, shell-and-tube thermal-recirculated and steam-heated evaporator. The evaporator had two bundles of tubes that contained low-pressure steam to heat the process feed. The tube bundles heated the feed to the boiling point and vaporized it. The evaporated liquid passed through a high-efficiency de-entrainer to remove entrained liquid droplets and was condensed as process condensate (Peterson 1990a). The process condensate was disposed of in the 216-B-12 Crib beginning in May 1967 when disposal to the 216-B-12 Crib began again. In November 1973, the process condensate was diverted to the 216-B-62 Crib. Disposal continued to this crib until the concentrator was shut down (RHO 1986). The process condensate is known as the B Plant Process Condensate Stream.

The steam that was used to heat the feed was condensed by the heating process and was collected as steam condensate. The steam condensate was disposed of to 216-B-3 Pond until September 1967. In 1967, it was diverted to the 216-B-55 Crib (Peterson 1990b). The steam condensate is known as the B Plant Steam Condensate Stream.

9 3 1 2 9 3 7 1 0 8 7

The liquid remaining in the evaporator was reduced in volume by the removal of water through evaporation. The concentrated liquid waste was transferred to tank farm storage. The concentrator was shut down in January 1987 for repairs to its de-entrainment system (Peterson 1990b). The concentrator was restarted in April 1988 and over 2,000,000 L (500,000 gal) of flush water was processed through the concentrator to ensure that residuals from past processing were removed. The flush water was disposed of in double-shell tank underground storage (Peterson 1990a).

2.4.2.4 225-B Building Waste Encapsulation and Storage Facility. In 1974, four processes were undertaken at the WESF in the 225-B Building located west of, and attached to, the 221-B Building. Three processes were discontinued in 1984 and one process, capsule storage, is still in operation.

The first process converted purified cesium carbonate to cesium chloride. The cesium carbonate was converted to cesium chloride by the addition of 12 M hydrochloric acid. Carbon dioxide and heat were released during the reaction. The cesium chloride solution was cooled with a cooling coil and air sparging through mixing. The offgas from the acidification process was vented through a de-entrainer, condenser, and a scrubber which neutralized the hydrochloric acid. The cesium chloride solution was transferred to an electrically heated melter crucible which boiled the liquid away and then melted the cesium chloride salt. The molten cesium chloride was poured into capsules.

The second process converted strontium nitrate to strontium fluoride. The strontium nitrate was transferred to a precipitation tank and powdered sodium fluoride was added to precipitate the strontium as a slurry of strontium fluoride. The slurry was filtered to produce a cake that was allowed to dry and self-heat. The cake was loaded into a furnace boat which was placed into a furnace at a sintering temperature of 800 °C (1,472 °F) to remove water and nitrate volatiles. The sintered strontium fluoride was dumped or air chiseled out of the furnace boat and loaded into a capsule and compacted.

The third process was the encapsulation of the strontium and cesium. Two capsules were used to encapsulate the material; an inner capsule which contained the cesium or strontium, and an outer capsule which enclosed the inner capsule. The capsules arrived at the WESF with one end welded on. Ultrasonic inspection was performed by the manufacturer to verify weld penetration. At the WESF, the capsules were first degreased with acetone and weighed. After the inner capsule was filled it was purged with helium and sealed by welding a cap on the open end. Weld inspection was done visually and by a helium leak detection process in a vacuum chamber. A final check was done using a bubble test.

Following testing, the capsules were decontaminated by placing them in a capsule scrubber and an electropolisher. After decontamination, the capsule was placed into an outer

capsule and a cap was welded onto the open end of the outer capsule. The outer capsules were subjected to additional inspections using ultrasonic scanning followed by calorimetry to determine curie levels. The finished capsule was weighed and the known weights of the inner and outer capsules subtracted. The net weight of the capsule content was divided into the curie content to give the curie output per gram. Capsules that did not pass testing were disassembled and reworked. The contents were removed from the defective capsule and the process was repeated. The rejected capsule was discarded as solid waste.

The final process conducted at the WESF is capsule storage. This storage process continues to operate to maintain the inventory of capsules stored at the WESF. The finished capsules are smear sampled for loose residual contamination and decontamination if necessary. A surface contamination of less than 200 ct/min is required before the capsule can be stored in the capsule storage area. The completed capsule is transferred using pool cell tongs to one of eight capsule storage pools. The capsule is transferred through a transfer aisle filled to a depth of 3 m (9 ft) with demineralized water and placed in one of the storage pools that is filled to a depth of 3.3 to 4 m (11 to 13 ft) of water. The water provides both radiation shielding and a means of removing heat generated by the radioactive decay of the capsule contents. Each storage pool contains a vertical turbine pump that circulates the pool water continuously. The recirculated water passes through the tube side of a heat exchanger and is returned to the bottom of the pool cell. Raw water passes through the shell side of the heat exchanger to cool the pool water. If the pool water becomes contaminated, it is diverted to the 221-B Building low-level waste header (see Section 2.4.3). The raw water that is used for cooling passes through the heat exchanger and is discharged through the 216-B-2-3 Ditch to the 216-B-3 Pond. In an emergency, cooling water is diverted to the 216-B-63 Trench. The flowrate of cooling water used for WESF capsule storage cooling is about 5.7 m^3/min (1,500 gal/min) (Peterson 1990c). The cooling water is known as the B Plant Cooling Water Stream.

2.4.2.5 242-B Evaporator System. In December 1951, the 242-B Thermal Evaporation System was placed into operation at a location south of the 241-B Tank Farm. The evaporator was installed to evaporate cladding/first cycle waste and reduce the waste volume (Waite 1991). The evaporator was a steam-heated pot evaporator that operated at atmospheric pressure (Jungfleisch 1984). The liquors were partially boiled down to produce a more concentrated waste. The water that was evaporated from the waste was discharged as 242-B Evaporator process condensate to the 216-B-11A and 216-B-11B Reverse Wells. The evaporator bottoms were initially placed into single-shell tank storage (Anderson 1990). In 1954, evaporator bottoms from the 242-B Evaporator were discharged to the 216-B-37 Trench (Maxfield 1979). The 242-B Evaporator was shut down in December 1954 and was never restarted (Anderson 1990).

2.4.2.6 In-Tank Solidification Process. Two in-tank solidification units were installed in the 241-BY Tank Farm. The objective of the in-tank solidification units was to heat waste

liquors while they were inside of a single-shell tank and remove water leaving a solid salt cake behind in the tank. The first unit, ITS-1, began operation in March 1965. It used a hot air sparge into the tank. The air sparging was done on one individual tank. The hot air caused water in the tank to evaporate leaving the air and solids behind (Anderson 1990). The evaporated water was condensed and discharged to the 216-B-50 Crib. The cooling water was discharged to the 216-B-2-2 and 216-B-3-2 Ditches.

The second unit, ITS-2, began operation in February 1968. This unit used electrical immersion heaters to heat the tank contents. The heated liquor was then transferred to other tanks. In August 1971, ITS-1 was modified to become a cooler for ITS-2. Both units were shut down in June 1974.

2.4.2.7 Wastes Generated at the 221-U Building. In 1952, the previously unused 221-U Building began operation with a process using tributyl phosphate in a kerosene (paraffin hydrocarbon) diluent to recover uranium metal from metal waste that was in single-shell tank storage at the 221-B and 221-T Buildings. The aqueous phase waste stream from the solvent extraction process was neutralized with sodium hydroxide and transferred to the B Plant Aggregate Area for storage in single-shell tanks.

In addition to tributyl phosphate wastes, evaporator condensate from the 221-U Building was transferred to the 216-B-12 Crib for disposal between November 1952 and December 1957. Lanthanum fluoride wastes from the 221-U Building were also stored in single-shell tanks in the 241-B Tank Farm.

2.4.2.8 In-Tank Scavenging. A ferrocyanide scavenging process began in 1954 to attempt to reduce the volume of wastes that had to be stored in single-shell tanks. The objective of the scavenging process was to precipitate the soluble long-lived ^{137}Cs from the 221-U Building uranium recovery waste supernatant that had been stored in B Plant Aggregate Area single-shell tanks. The other principal long-lived fission product, ^{90}Sr, was already essentially insoluble in the neutralized uranium recovery waste and precipitated without adding scavenging chemicals. However, during the later operational years of the process, calcium nitrate or strontium nitrate were added to enhance the precipitation of the ^{90}Sr.

After precipitation, the waste was allowed to settle in single-shell tank storage and the solid precipitate particles settled to the bottom of the tanks as sludge. Following settling, the supernate was decanted from the sludge, tested for the applicable discharge requirements, and discharged to the ground.

Beginning in 1954, the newly-generated uranium recovery waste was scavenged in the 221-U Building and transferred to the B Plant Aggregate Area for settling in the single-shell tanks. Then it was discharged to the ground either through cribs or specific retention trenches. This scavenging process ended in June 1957.

Starting in May 1955, scavenging was also done on 221-U Building tributyl phosphate wastes that had previously been stored in single-shell tanks. The wastes were pumped to the 244-CR Vault in the PUREX Plant Aggregate Area where they were scavenged. The waste was then routed back to single-shell tanks for settling and the supernatant subsequently was pumped to the ground. This was referred to as "in-tank farm" scavenging. The scavenging in the 244-CR Vault ended in December 1957 and the last of these wastes was discharged to the ground in January 1958 (Waite 1991). Waste management units that received tributyl phosphate waste are the 216-B-14 through 216-B-19 Cribs, the 216-B-20 through 216-B-34 Trenches, the 216-B-42 Trench, the 216-B-43 through 216-B-49 Cribs, and the 216-B-52 Trench.

2.4.2.9 Wastes Generated at the 202-A Building. The 202-A Building produced coating wastes from the dissolution of the irradiated fuel pellet cladding that were disposed of to single-shell tanks in the 241-B and 241-BY Tank Farms.

2.4.2.10 Wastes Generated at S Plant. The S Plant located in 200 West operated between 1951 and 1967 and used a methyl isobutyl ketone (MIBK) solvent extraction process to accomplish the separation of uranium and plutonium from the irradiated fuel pellets. High level wastes were transferred to the 241-B-103 Single-Shell Tank. Waste from ion exchange processing was transferred to the 241-BX-101, 241-BX-103, and 241-BX-106 Single-Shell Tanks storage.

2.4.2.11 Analytical Laboratory Programs. The 222-B Laboratory supported operations at the 221-B Building complex and other 200 Area facilities with laboratory services. A liquid waste stream was generated from the laboratory facility that included sample disposal waste and hood and hot cell cleanup waste. Sampling and testing equipment, gloves, empty containers, and other materials were buried as solid waste. Laboratory liquid wastes were directed to the 216-B-6 Reverse Well from April 1945 to December 1949 and to the 216-B-10A Crib from December 1949 to January 1952.

2.4.3 Semi-Works Aggregate Area

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 facilities that generated wastes 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 sections 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 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 2-7.

2.4.3.1 201-C Process Building (Semi-Works Complex). A primary component of the Semi-Works Aggregate Area is a five-celled chemical processing facility, the 201-C Process Building, with ten support facilities surrounding it. The building complex was constructed in 1949 as a pilot plant for the reprocessing of reactor fuel using the REDOX process. In 1954, the facility was converted to a pilot plant for the PUREX process. It continued in this capacity until it was shut down in 1956. As a pilot fuel reprocessing plant, nuclear reactor fuel was brought into the facility and dissolved. The plutonium was separated, purified, loaded, and shipped out to other Hanford Site facilities.

After extensive cleaning and decontamination, the buildings were modified and put back into operation in 1961 for the recovery of strontium from fission product waste. Megacurie quantities of strontium were recovered, purified, and loaded into casks for offsite shipment. The facility was known as the Strontium Semi-Works during this period. The last processing operation, performed in 1967, was the recovery of cerium, technetium, and promethium.

The REDOX process was used to separate 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 into an organic solvent MIBK or hexone. This operation was conducted continuously in columns, packed with Raschig rings, through which the aqueous and organic phases were passed countercurrently. 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 as opposed to metallic nitrates used in the REDOX process (Cummings 1989).

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

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. Before commencing the actual pilot recovery activities, extensive "cold-run" trials were conducted routinely using nonradioactive materials to verify the operational status of the equipment. The following discussion summarizes the waste streams generated from these processes.

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, 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. The coating wastes from the aluminum and Zircaloy-clad fuels decladding were neutralized with caustic acid.

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 was 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, ferrous sulfate, ferrous phosphate, sodium, and aluminum.

Limited information from Cummings (1989) indicates that the strontium recovery process in the 201-C Process Building used a complex liquid organic ion exchanger, 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.

Radioactive condensates derived from processes associated with REDOX and PUREX between 1953 and 1957 contained ^{137}Cs, ^{106}Ru, ^{90}Sr, ^{239}Pu and uranium based on information from WIDS (WHC 1991a). Cummings (1989) reported the presence of

additional radionuclides including tritium, ^{60}Co, and ^{238}U in the waste stream. Nonradioactive constituents in PUREX process condensates included dilute nitric acid and other inorganic contaminants. Process condensates generated between 1964 and 1969 at the 201-C Process Building were acidic.

Limited information was obtained regarding the nature of cold-run wastes derived from start-up 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 hot shop sink.

Wastes from the 201-C Process Building were chemically and radiologically contaminated, and their disposition was accomplished in accordance with their radiological content. In general, high-level wastes were stored in underground tanks in the 200 East Area tank farms, and intermediate level wastes were routed in cribs in the Semi-Works Aggregate Area for disposal. Low-level wastes were discharged in the 216-C-9 Pond.

High-level process wastes from 201-C Process Building had been routed to the 241-CX-70 and 241-CX-71 Storage Tanks from 1952 to 1957. PUREX wastes were routed to the 241-CX-72 Storage Tank during 1955, and later, wastes with high levels of radioactivity from the strontium recovery process were routed to the tank. Unspecified material from the 201-C Process Building hot shop sink was routed to the 241-CX-71 Storage Tank. Neutralized acidic wastes from the PUREX process were also routed to the 241-C Tank Farm. Acidic wastes from the 201-C Process Building may have been neutralized with crushed lime in the 241-CX-71 Storage Tank, prior to discharge of the process wastes in the 216-C-1 Crib. Decontamination "flushes" of the 241-CX-71 Storage Tank following cessation of PUREX operations utilized potassium permanganate, caustic soda, hydrogen peroxide, tartaric acid, nitric acid, sodium fluoride, oxalic acid, and commercial cleaning agents.

Waste streams from processing activities in the 201-C Processing Building were routed to onsite cribs, based on the characteristics of the following streams:

- Acidic, radioactive wastes from REDOX operations in 1952 through 1954 were discharged to the 216-C-3 Crib. Acidic process condensates from PUREX and strontium recovery operations were discharged to the 216-C-6 Crib between 1955 and 1964, and to the 216-C-6 Crib from 1964 to 1969 (strontium recovery).

- High-salt, neutral-to-basic process condensates and cold-run wastes from REDOX and PUREX operations were discharged to the 216-C-1 Crib between 1953 and 1957, and to the 216-C-5 Crib in 1955 (PUREX).

Additionally, low-level process cooling water and other unspecified waste streams from the 201-C Process Building (and other site buildings as discussed below) were discharged to the 216-C-9 Pond between 1957 and 1985. The bulk of the waste is reported from 201-C Process Building since 1967.

2.4.3.2 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 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 containing mainly ^{137}Cs, ^{106}Ru, ^{90}Sr, plutonium, uranium, and some nitrates. These wastes are further characterized as neutron reflector tank water (Nielsen 1990).

The 216-C-7 Crib received about 60,000 L (16,000 gal) of liquid waste from the Critical Mass Laboratory transferred through the Critical Mass Laboratory Valve Pit. In the documents reviewed no other waste management units received process waste from the laboratory.

2.4.3.3 276-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. Radiologically contaminated, low-level, low-salt, neutral-to-basic organic wastes had been discharged to the 216-C-4 Crib between 1955 and 1965.

2.4.3.4 291-C Ventilation System Stack. The 291-C Ventilation System provided exhaust air ventilation for operation cells and process vessel vents from the 201-C Process Building. Exhaust air was discharged from the 291-C Ventilation System stack after passing various filters. Between 1953 and 1958 low-salt, neutral-to-basic stack drainage and ventilation filter seal water drainage were discharged at the 216-C-2 Reverse Well.

2.4.3.5 215-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 Building provided support services for the 201-C Process Building. Acid wastes from these facilities had been discharged to the 216-C-1 Crib (along with similar wastes from the 201-C Process Building) between 1953 and 1957.

2.4.4 200 North Aggregate Area

The facilities of the 200 North Aggregate Area were built to temporarily store irradiated fuel elements produced in the plutonium reactors in the 100 Area. Relatively little waste was generated from these storage facilities, hence there are few waste management units in the 200 North Aggregate Area.

The water used to store, shield, and cool the fuel was discharged into the ground via ponds. In addition, sediment that collected in the bottom of the storage basins was discharged to trenches following the shutdown of the storage facilities. Table 2-7 summarizes the available information about the waste streams produced within the aggregate area.

2.4.4.1 Irradiated Fuel Storage Operations. Three 200 North Aggregate Area buildings, the 212-N, 212-P, and 212-R Storage Facilities, contained storage basins and transfer facilities for moving buckets of irradiated fuel elements from the 100 Area into and out of the lead casks which were transported in railroad wellcars to the 200 North Aggregate Area. The fuel elements were irradiated in the reactors in the 100 Area and discharged from the reactors directly into water-filled basins adjacent to the reactors. The fuel elements were then placed into special "buckets" which were in turn hoisted into the lead casks. Approximately 105 fuel elements, weighing about 384 kg (845 lb), were placed into a bucket. The buckets were loaded into the lead-shielded casks, which weighed about 15,400 kg (17 tons), and three casks were loaded onto each railroad wellcar for transport to the 200 North Aggregate Area storage facilities. The casks were filled with water and cooled with pipes through which water flowed to prevent overheating and localized hot spots in the buckets.

At the 212 Buildings, the casks were lifted out of the wellcars by crane and lowered into a water-filled transfer pit. As a cask was lowered, its cover was removed by a ledge at the top of the pit. The cover was moved aside and a yoke was lowered from the overhead crane to pick up each bucket for transfer to the storage basin.

Irradiated fuel elements were stored in the basins for about 40 to 60 days in the early years. Water continuously flowed through the basins to prevent localized hot spots. Two wells located just east of the 212-R Storage Facility supplied the water to the storage basins. This water was unfiltered, meaning that dissolved and suspended solids in the water had the potential to be exposed to radiation from the fuel elements. Each storage facility had heating equipment to keep the water from freezing. Water overflow from the storage basin in each of the storage facilities basin was transported by an underground pipeline to its associated pond located about 275 m (900 ft) south of the storage facility.

Each of the three ponds, 216-N-1, 216-N-4, and 216-N-6, consisted of depressions existing in the natural terrain. Except for an occasional berm, no excavation or other effort was made to define or enhance the pond formation. The discharged water dispersed by evaporation and percolation into the soil.

Cooling time, or the time between the discharge of an irradiated fuel element and its processing, was used primarily to reduce the radioactivity of gaseous fission products (primarily iodine) by allowing the radioactive decay of the short-lived radionuclides before the dissolution of the fuel in the separation plants.

When the irradiated fuel was ready to be transferred to the separations processing areas, the transfer procedure was reversed to return the buckets to the casks and onto the wellcars. The wellcars were transferred to the separations plants by rail where they were again unloaded.

The storage of the irradiated fuel elements in the facilities in the 200 North Aggregate Area was found to be unnecessary because the storage basins at the reactors in the 100 Areas were large enough to store the fuel elements for the shorter periods that were eventually found to be adequate. However, in the processing configuration in use at Hanford from 1945 to 1952, the separations plants had processed fuel faster than the reactors had produced it. Therefore, when problems interrupted production at the separations facilities (B Plant or T Plant), the fuel elements had been stored in the 200 North storage facilities so that production at the reactors could continue. Later, the separations plants resumed production and worked off the extra quantity of fuel elements. In 1952, however, the B Plant separations facility was shut down and replaced by a more efficient process at the S Plant, and the T Plant operated at a reduced rate of production. The output from the reactor areas had increased by the construction of new reactors and the output from the existing reactors also had increased. By 1952, there was no longer a need for the excess fuel storage facilities in the 200 North Aggregate Area and the 212-N, 212-P, and 212-R facilities were shut down in June 1952.

The water that flowed through the storage basins in the 200 North Aggregate Area had the potential to become contaminated through exposure to radiation from the fuel elements, through particulate contamination from the surface of the fuel elements, or by leakage through the aluminum cladding that enclosed the irradiated fuel elements.

Leakage through the aluminum cladding surrounding the fuel element was less likely before 1952 when reactor power levels were stepped-up to increase production. The most likely means for a cladding-failed fuel element to reach the 200 North Aggregate Area may have been through mechanical shock caused by handling. The fact that low levels of radiation have been detected underground at several 200 North Aggregate Area waste

management units indicates that a small amount of radioactivity may have escaped the cladded fuel elements by some means.

All the 212 Storage Facilities were shut down in June 1952. As part of the shutdown procedure, the fuel storage basins were drained and cleaned. The water and sediment in the storage basins were disposed of by pumping to shallow [approximately 2 m (6 ft)] trenches located about 30 m (100 ft) northwest of each storage building. The trenches were immediately backfilled after disposal. The basin in the 212-N Building was first drained and cleaned in 1947 for a special test that is not documented. The water and basin sediments from this first cleanout were placed in the 216-N-2 Trench. The 212-N Storage Basin was drained and cleaned for the shutdown in 1952 and the cleanout wastes were placed in the 216-N-3 Trench. The storage basins in the 212-P and 212-R Buildings were cleaned only once in 1952, and the wastes were placed in the 216-N-5 and 216-N-7 Trenches, respectively.

Each of the three 200 North Aggregate Area storage facilities was surrounded with a high-security fence and guard towers. A gatehouse was located about 50 m (164 ft) south of the building. Each gatehouse had a septic tank and drain field south of its location. The fences, guard towers, and gatehouses have been partially removed so that only concrete foundations remain.

2.4.4.2 Electrical Maintenance Activities. Since 1982 the 212-P Storage Facility has been used as an electrical maintenance facility by Hanford electricians and as a temporary storage area for PCBs. Transformers and capacitors requiring servicing have been worked on at this facility. Drained items were occasionally stored on an asphalt pad at the site. The PCB-contaminated soils are temporarily stored in a small aboveground tank. Other PCB-contaminated wastes are stored in drums in a storage facility adjacent to the 212-P Building and inside the 212-P Building.

2.4.4.3 Railroad Car Maintenance Activities. From the spring of 1982 until the fall of 1986 the 212-R Storage Facility was used as a railroad car maintenance site. Railcars needing brake or wheel bearing maintenance were brought to the site, decontaminated, and repaired. The decontamination was done by wiping the surfaces of the equipment with swabs wetted with a liquid solvent. The decontamination wastes were placed in bags and transported to solid waste burial sites outside of the 200 North Aggregate Area. Although no longer used as a maintenance site, two locomotive engines and two wellcars (one without wheels) were spotted on the rail spur in front of the 212-R Building during a site visit in May 1992. They are surrounded by chain and marked as a surface contamination site.

2.5 INTERACTIONS WITH OTHER AGGREGATE AREAS OR OPERABLE UNITS

The 200 East Groundwater Aggregate Area interacts with several other organizational units involved in the remedial action process on the Hanford Site. These features include other groundwater aggregate areas, source aggregate areas, and operable units. These interactions can take place at various scales including within the 200 East Groundwater Area, between the 200 West and 200 East (and 200 North) Areas, and across the entire Hanford Site. The interactions can be hydrologic, operational (administrative), and regulatory. This section discusses these interactions.

This study, the 200 East Groundwater AAMS, recommends future investigative actions for groundwater beneath an area larger than the 200 East and 200 North Areas administratively delineated on the Hanford Site (see Section 2.1). The study addresses groundwater contamination originating from facilities in the 200 East and 200 North Areas, and so its areal extent (which is somewhat loosely defined) includes as much of the administrative "600 Area" as needed to encompass the spread of contamination (plumes) in the unconfined aquifer from the 200 East and 200 North Areas. Also, because of the same difference in focus, the areal coverage is also different from the combined area of the three 200 East source aggregate areas (PUREX Plant, B Plant, and Semi-Works) and the 200 North source aggregate area.

The 200 East Groundwater Aggregate Area must nevertheless be compatible with the three 200 East source aggregate areas and the 200 North Aggregate Area, since the contamination addressed in the study must have originated from waste management units in these source areas which discharged to the vadose zone in sufficient quantities to impact the groundwater system (see Section 2.3). It is also possible that some vadose zone (or perched water zones) still hold contamination from these facilities which can yet be mobilized, and may still impact groundwater quality. In this way, remedial actions in the source aggregate areas may affect remedial options for the groundwater aggregate area.

Implementation of remedial actions based on the 200 Areas groundwater AAMS (East and West) can also interact in a variety of ways. Most significantly, changes in the geohydrologic system in the 200 East Area can directly change flow pathways of groundwater migrating from the 200 West Area. Currently the effect of large discharges to the ground occurring in the 200 East Area causes a mounding of the groundwater beneath the site, and thereby affects groundwater to the west. This effect is partly to stagnate (reduce the gradient of) the groundwater in the region between the two 200 Areas (where stagnation primarily underlies the western portion of the 200 East Area) and partly to divert these flows toward the north or south around the mound. This hydrologic linkage would also extend to remedial actions that may be recommended for the 200 West Groundwater Aggregate Area. Pump and treat, or containment alternatives can cause similar effects (qualitatively although probably not quantitatively if at a smaller scale of discharge). The cause and effect

relationship can also occur in the opposite direction (200 East to 200 West), since alteration of groundwater flow in the 200 West Area may affect groundwater flow beneath the 200 East Area.

There is also potentially a similar interaction with the 100 Areas operable units in that contamination from the 200 East Groundwater Aggregate Area (particularly the northern portion) if unremediated could pass through Gable Gap and reach the Columbia River through one or more of the 100 Areas (under present groundwater conditions it could be any of these). This would complicate monitoring of concentration changes in those areas and could even interfere with remediation that might be proposed for these areas. Because of uncertainties in flow patterns and future modifications in groundwater recharge, this possibility is a very uncertain, long term, and limited inference.

Finally, the 200 East Groundwater AAMS also interacts with the operable units in the 200 East and 200 North source aggregate areas by defining new groundwater operable units. An operable unit is a portion or aspect of a remedial action site which can best be planned and remediated as a single entity. At the Hanford Site, an operable unit is usually a group of waste management units which are spatially close to each other and generally share a similar disposal history. Prior to the AAMS process, 12 of the 21 operable units in the 200 East and 200 North areas were also considered for groundwater contamination (i.e., were also groundwater operable units). These included:

- 200-BP-1
- 200-BP-2
- 200-BP-3
- 200-BP-4
- 200-BP-11
- 200-IU-6
- 200-NO-1
- 200-PO-1
- 200-PO-2
- 200-PO-4
- 200-PO-5
- 200-SO-1.

These earlier groundwater operable units are proposed to be replaced with groundwater operable units which are defined more on the basis of flow patterns and plume distribution (see Section 9.3).

2.6 INTERACTION WITH RESOURCE CONSERVATION AND RECOVERY ACT PROGRAMS

Groundwater monitoring is currently being performed at 14 RCRA TSD units and one nondangerous waste facility (i.e., the Solid Waste Landfill). Of the 19 RCRA TSD units, most will be closed under interim status, and a final status permit is being, or will be sought for the remainder. The RCRA-regulated facilities include the Nonradioactive Dangerous Waste Landfill (NRDWL), located approximately 5.5 km (3.5 mi) southeast of the 200 East

Area. The NRDWL is included with 200 East Area RCRA facilities in this section due to the presence of tritium and ^{129}I groundwater contaminant plumes that have been identified in this area during 200 East Area groundwater monitoring (Section 4.1.4). The NRDWL, along with the Solid Waste Landfill, are parts of the old Central Landfill Complex. Although not currently an RCRA-regulated facility, the Solid Waste Landfill has monitoring wells meeting RCRA compliance standards and is included here for completeness.

The RCRA groundwater monitoring projects are conducted at three levels, as described below:

- **A background monitoring program.** The purpose of this program is to gather data from upgradient monitoring wells to determine the levels of constituents and parameters in groundwater unaffected by the monitored RCRA facility.

- **An indicator evaluation program.** The purpose of this program is to compare background monitoring program data with indicator program data to determine if significant differences exist between upgradient and downgradient groundwater constituents or parameters. This program is frequently run simultaneously with the background monitoring program, if possible.

- **A groundwater quality assessment program.** The purpose of this program is to determine if the groundwater is being adversely affected by wastes managed at the monitored RCRA facility. It is initiated if the indicator program shows significant differences.

Several RCRA groundwater monitoring projects may be encompassed in the 200 East Groundwater Aggregate Area. As of December 31, 1991, the associated RCRA groundwater monitoring projects and their respective groundwater monitoring program status are as follows:

- **Grout Treatment Facility.** This project is currently in a groundwater quality assessment program.

- **216-B-3 Pond.** This project is currently in a groundwater quality assessment program.

- **216-A-29 Ditch.** This project is currently in a groundwater quality assessment program.

- **216-A-36B Crib.** This project is currently in an indicator evaluation program.

- **216-A-10 Crib.** This project is currently in an indicator evaluation program.
- **216-B-63 Trench.** This project is currently in a background monitoring program.
- **Liquid Effluent Retention Facility.** This project is currently in a background monitoring program.
- **2101-M Pond.** This project is currently in an indicator evaluation program.
- **Low-Level Waste Management Area 1 (LLWMA 1).** This project is currently in a groundwater quality assessment program.
- **Low-Level Waste Management Area 2 (LLWMA 2).** This project is currently in an indicator evaluation program.
- **Single-Shell Tanks Waste Management Area A/AX.** This project is currently in a background monitoring program.
- **Single-Shell Tanks Waste Management Area BX/BY.** This project is currently in a background monitoring program.
- **Single-Shell Tanks Waste Management Area C.** This project is currently in a background monitoring program.
- **Nonradioactive Dangerous Waste Landfill.** This project is currently in an indicator evaluation program.

As discussed above, the Solid Waste Landfill is included in this section for completeness, although the facility is not currently regulated under RCRA. Monitoring wells are currently sampled quarterly for chemical parameters required under the Washington Administrative Code (WAC) 173-304-490 (Minimum Functional Standards for Solid Waste Handling), volatile chlorinated hydrocarbons, tritium, and other constituents.

These projects are described in greater detail in Section 2.8.2.

Existing groundwater contamination detected from RCRA monitoring wells is expected to be largely mitigated under a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) remedial action program. During implementation of the CERCLA program, it is anticipated that RCRA site-specific groundwater cleanup levels and procedures will be identified, considered, and incorporated as potential applicable or relevant and appropriate requirements (ARARs). In the event that remediation is not completed in a

timely manner, the Tri-Party Agreement is revised, or that future releases from RCRA facilities are detected, remediation under RCRA authority could be initiated.

Hanford Site monitoring programs are discussed in Section 2.8. The integration of potential 200 East Groundwater Aggregate Area remedial actions with other programs is discussed in more detail in Section 9.3.3 of this AAMSR.

2.7 INTERACTIONS WITH OTHER HANFORD PROGRAMS

In addition to the RCRA groundwater monitoring program discussed in Section 2.6, and other groundwater programs discussed in Sections 2.8 and 2.9, several other ongoing Hanford programs have potential to interact with characterization and remedial activities related to the 200 East Groundwater AAMS. These programs include the following:

- Hanford Site Single-Shell Tank Programs
- Emergency Response Action Programs
- Effluent Treatment Programs
- Decommissioning and Decontamination Program
- Surplus Facilities Program
- Defense Waste Management Program
- Remedial Technology Development Programs.

Each of these programs and their interaction is discussed briefly below, based on information provided in the *Environmental Restoration and Waste Management Site-Specific Plan for the Richland Operations Office* (DOE/RL 1991b).

2.7.1 Hanford Site Single-Shell Tank Programs

The Hanford Site Single-Shell Tank Programs include the near-term waste management activities related to interim storage of waste in single-shell tanks, and long-term decommissioning. As part of the Hanford Site Single-Shell Tank Program, RCRA closure plans are developed for single-shell tanks and ancillary equipment. Currently, the single-shell RCRA closure plans incorporate groundwater assessment and mitigation activities being planned as part of the 200 East Groundwater AAMSR. Following remediation of single-shell tank facilities, related soil and groundwater contamination is anticipated to be remediated under either the CERCLA or RCRA Past Practices program.

2.7.2 Emergency Response Action Programs

Currently, no Emergency Response Action Programs relevant to the 200 East Groundwater Aggregate Area have been identified. In the event that future Emergency Response Action Programs are initiated, the feasibility of transferring remedial technologies to the 200 East Groundwater AAMS will be assessed. Potential remediation technologies associated with the 200 East Groundwater AAMS are discussed in Section 7.0.

2.7.3 Effluent Treatment Programs

The Effluent Treatment Program is implemented as part of the Hanford Defense Waste Management Program, as discussed in Section 2.7.6. The Effluent Treatment Program is responsible for developing best available technologies (BAT) for regulated effluents being produced throughout the Hanford Site. In addition, several classes of effluents are being evaluated for BAT treatment and subsequent disposal to soil as part of the W-049H project near the 200 East Area. As a result, the Effluent Treatment Program interacts with the 200 East Groundwater AAMS in several ways.

First, groundwater that may be extracted for treatment during remediation activities in the 200 East Groundwater Aggregate Area may be similar to liquids being evaluated under the Effluent Treatment Program, and may therefore be adaptable to the BAT developed. This interaction is further discussed in Section 7.0. Secondly, as part of the Effluent Treatment Program milestones discussed in the Tri-Party Agreement, process effluent discharges to existing cribs and ditches in the 200 East Area will be discontinued. Third, it is anticipated that some of the effluent temporarily stored in the Liquid Effluent Retention Basin (currently under construction east of the 200 East Area) will be discharged to soil at a proposed state-approved liquid disposal facility (SALDS). The proposed SALDS facility (Project W-049H) is a candidate site 3.5 km (2.1 mi) east of the 200 East Area and just east from the current 216-B-3 Pond System. Project W-049H will accept treated effluent from the 200 Areas that meets discharge limits without additional treatment. Modeling has been performed to assess the groundwater mounding effects and other potential changes to the groundwater flow pattern in this area. A second proposed SALDS facility (Project C-018H) is scheduled for construction just north of 200 West Area that will provide standby treatment and discharge for effluent that does not meet discharge limits for W-049H. Additional information obtained from this project and related support programs will be used during 200 East Groundwater AAMS assessment and remediation activities.

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2.7.4 Decommissioning and Decontamination Program

The Hanford Decommissioning and Decontamination Program is primarily concerned with decontamination and decommissioning of buildings and other structures with elevated levels of radioactivity. The Decommissioning and Decontamination Program does not typically involve mixed waste issues or groundwater studies.

2.7.5 Surplus Facilities Program

The Hanford Surplus Facilities Program is responsible for the surveillance and decommissioning of surplus facilities at the Hanford Site. As with the Hanford Site Single-Shell Tank closure projects, the Surplus Facilities Program is anticipated to incorporate data from 200 East Groundwater AAMS characterization and remedial activities to address RCRA groundwater mitigation requirements. Remediation of soil and groundwater contamination related to past waste disposal activities at surplus facilities is expected to be deferred to the AAMS program.

The Surplus Facilities Program also implements the Radiation Area Remedial Action (RARA) Program. The RARA program is primarily concerned with management and control of surface soil contamination and does not directly interact with groundwater activities.

2.7.6 Defense Waste Management Program

The Hanford Defense Waste Management Program is responsible for operation and maintenance of active waste management units and facilities. Several of these waste management units are currently RCRA interim status facilities. During the final permitting of active RCRA waste management units, data from remedial assessment and mitigation for the 200 East Groundwater AAMS will likely be incorporated into the RCRA permits. The Defense Waste Management Program includes activities implemented under the Effluent Treatment Program as discussed in Section 2.7.3.

2.7.7 Remedial Technology Development Programs

Innovative technologies for use in remedial action at Hanford are evaluated by several groups and organizations. These organizations include the DOE Office of Technology Development, Westinghouse Integrated Programs and Demonstrations (funded by the DOE Office of Technology Development), and the Pacific Northwest Laboratory (PNL). It is anticipated that technologies developed or evaluated by these groups will be applied to remedial actions implemented as part of the 200 East Groundwater AAMS, as practical.

2.8 GROUNDWATER MONITORING FACILITIES

Groundwater monitoring facilities within the 200 East Area include single piezometers, nested (multiple) piezometers, and groundwater monitoring wells. They have been constructed to monitor discrete horizons within the unconsolidated sediments, as well as the deeper confined basalt aquifers within the Saddle Mountains Basalt. In addition, other nearby wells monitor horizons within the Wanapum and Grande Ronde Basalts. Plate 3 shows the location of all groundwater monitoring wells within and adjacent to the 200 East Area.

Groundwater monitoring facilities at the Hanford Site are associated with five monitoring programs: the Westinghouse Hanford Operational Groundwater Monitoring Network (OGWMN), RCRA, CERCLA, the PNL Environmental Monitoring Program, and the Hanford Sanitary Water Quality Surveillance program administered by Hanford Environmental Health Foundation (HEHF). These programs all help determine the impact of Hanford past, present, and future waste disposal practices on human health and the environment across the Hanford Site. Each of these programs is discussed in the following sections. The Hanford Sanitary Water Quality Surveillance program is the only one that does not monitor groundwater within the 200 East Area.

Monitoring wells at the Hanford Site were first installed in 1944 and continue to the present. During this period, three general well designs were implemented, as shown in Figure 2-1 (Serkowski and Jordan 1989). Regardless of the design used, the vast majority of wells at the Hanford Site were drilled using the cable-tool method. The oldest and simplest design consists of a single 15- to 20-cm (6- to 8-in.) diameter carbon-steel casing, which is perforated at the top of the aquifer to allow groundwater to enter the well. This design has two major shortcomings: (1) the well lacks a seal that is necessary to block downward movement of contaminants along the outside of the casings; and (2) the size of the perforations are often too large to prevent the entry of sand into the well. In the early 1980s, a modified design was developed to address these design problems. In the modified design, an 20-cm (8-in.) carbon-steel casing was installed to a depth slightly above the aquifer and perforated along its entire length. A 15-cm (6 in.) carbon-steel casing was then inserted into the first casing and drilling continued to the desired depth. A telescoping stainless-steel screen assembly was lowered to the bottom of the well and the 15-cm (6-in.) casing was pulled back to expose the screen. A grout mixture was poured into the annulus between the two casings and allowed to flow out through the perforations to create a seal between the well and the formation. Finally, a cement surface seal was installed to inhibit erosion at the well head.

Beginning in 1986 and continuing to the present, the sealed, screened well design was further modified to more closely conform with RCRA well construction guidelines

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(Serkowski and Jordan 1989). The implemented changes include placing a sand pack around the screen, sealing the well with bentonite granules or other dry sealant, removing the outer casing as sealant is injected, and completing the well with 10-cm (4-in.) diameter stainless-steel casing. To lessen the back-pull friction and permit removal of the temporary outer casing, several progressively smaller casings are often used in deeper wells.

A program was initiated in 1986 to renovate the older wells to this new standard by perforating the casing, installing a liner, and grouting the annular spaces. Wells that were closest (less than 300 m, 1,000 ft) to liquid waste disposal facilities were assigned the highest priority under this program.

Groundwater monitoring wells that are currently being constructed at the Hanford Site are being completed in accordance with requirements set forth in the Washington State Administrative Code (WAC 173-160 through 162) as well as *RCRA Groundwater Monitoring Technical Enforcement Guidance Document* requirements (EPA 1986a).

Piezometers were installed on the Hanford Site to assist in evaluations of potentiometric surfaces and hydraulic gradients. Borings with nested piezometers originally were installed with separate screen depths but with sand filling the well casing the entire distance between screened intervals. Many of these have since been retrofitted with proper seals between screened materials. Others have been abandoned (Newcomer et al. 1992a).

To support the 200 East Groundwater AAMS, a sampling and analysis program is underway which includes a classification of Hanford Site wells based on their fitness for sampling. In a previous screening of wells at the Hanford Site (Golder Associates 1989), 70% of the wells evaluated require remediation of their installation or decommissioning. As part of the sampling and analysis program, maps of the groundwater contaminant plumes are anticipated to be periodically updated.

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2.8.1 Westinghouse Operational Groundwater Monitoring Network

The DOE maintains a groundwater monitoring program for the Hanford Site as part of its waste management responsibilities. This monitoring program is based on DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements." These requirements mandate the evaluation of impacts of Hanford Site operations on the aquifers from liquid waste discharges to the ground.

Westinghouse Hanford is the operations and engineering contractor for the DOE at the Hanford Site. As part of the requirements imposed by DOE Order 5484.1, Westinghouse Hanford manages the facilities within the Hanford Site. Westinghouse Hanford, therefore,

conducts an Operational Surveillance Program to control the impact of effluent releases and waste management practices at and near the waste management units.

One component of this surveillance program is the OGWMN. The OGWMN was originally established to observe the response of groundwater to storage and disposal of radioactive waste in soil at the 200 Areas. Groundwater monitoring in other operational areas of the Hanford Site was conducted by contractors responsible for these sites or was conducted by PNL as part of its groundwater monitoring program. In 1987, DOE consolidated all operational responsibilities into a single contract to be carried out by one contractor, and a five-year contract was awarded to Westinghouse Hanford.

The scope of this consolidation was to expand the OGWMN to incorporate all waste management units at the Hanford Site (including the 100, 200, 300, 400, 600, and 1100 Areas). Even after consolidation, the emphasis of the network remains on the 200 Areas, due in part to the significance of the 200 Areas as the major waste disposal areas on the Hanford Site.

Historically, the OGWMN program has emphasized the monitoring of radioactive constituents and nitrates. In 1985 the list of constituents monitored was expanded to include other hazardous chemicals. The OGWMN now routinely includes both radiological as well as nonradiological constituents in groundwater analyses. Table 2-8 lists the constituents analyzed for under the OGWMN program. The OGWMN program is intended to provide environmental data to Hanford Site waste management programs. Specific objectives of the OGWMN program include the following:

- Assess the quality of groundwater under waste management units to determine compliance with applicable water quality standards
- Monitor the performance of active and inactive waste management units
- Determine the impact to the groundwater from waste management unit activities.

The groundwater monitoring network (1990) for the 200 Areas consists of 166 wells. Of these, 86 wells were installed to monitor groundwater of the uppermost aquifer (for which this uppermost aquifer system primarily exhibits unconfined conditions but also contains localized areas of semiconfined to confined conditions), 9 wells were installed to monitor groundwater of the confined aquifer, and the remaining 71 wells monitor the vadose zone. The 9 confined aquifer wells monitor the Rattlesnake Ridge and Mabton interbeds. Within the 200 Areas, there were 50 wells sampled during the 1990 calendar year. Of these, 14 groundwater monitoring wells of the 200 East Area were selected to monitor 8 waste management units which include the 216-A-37-1, -37-2, -30, -45, and -8 Cribs around the

PUREX Plant and the 210-B-62, 216-B-5 and -55 Cribs around the B Plant. These wells are summarized on Table 2-9.

The sampling frequencies of wells within the OGWMN are based on a variety of different objectives. Wells monitoring active liquid waste management units are sampled monthly. Wells monitoring inactive waste management units containing radionuclides with a high potential for being mobilized are sampled monthly. Wells monitoring inactive waste management units containing radionuclides with a low potential for being mobilized are also sampled monthly or quarterly, depending upon the level and trend of concentration. Wells monitoring background concentrations are sampled semiannually. Samples from these wells are collected by PNL for Westinghouse Hanford and analyzed for the following radionuclides: ^{90}Sr, ^{129}I, tritium, total U, and ^{239}Pu. These parameters were chosen for analysis based upon effluent inventories and historical groundwater monitoring results.

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2.8.2 Resource Conservation and Recovery Act Monitoring Units

The RCRA groundwater monitoring program monitors active and recently inactive hazardous waste treatment, storage, or disposal units at the Hanford Site which are governed by RCRA regulations. There are currently 15 RCRA monitoring projects ongoing within the 200 East Area. These units are shown on Figure 2-2 and the wells are summarized in Table 2-10. The RCRA projects are monitored under three programs: (1) a background monitoring program; (2) an indicator evaluation program; and (3) a groundwater quality assessment program. The background and indicator evaluation programs provide two phases of detection level monitoring (DOE/RL 1992b).

Once a groundwater monitoring well has been installed, a background monitoring program is also commenced. Samples and water levels are obtained from upgradient well(s) and analyzed quarterly to obtain relevant background groundwater quality for the unit. These samples are analyzed for several general constituents. The specific site parameters are listed in the appropriate sections that follow. Due to the termination of the analytical support contract, sampling was temporarily halted on June 1, 1990 and restarted on June 6, 1991 under a new analytical laboratory. Therefore, current interpretations are based on a limited quantity of new data.

Once background groundwater quality has been determined an indicator evaluation program commences. During this program groundwater samples and water levels are obtained semiannually. Indicator data are then compared to background data. If significant differences are identified, then a groundwater quality assessment plan must be implemented. Groundwater monitoring wells installed under the RCRA program must meet the requirements set forth in WAC 173-160 through 162, and current RCRA regulations. The

following is a brief discussion of the RCRA units within the 200 East Area and their associated groundwater monitoring well networks (Figure 2-2).

2.8.2.1 Low-Level Burial Grounds. The 200 East Area Low-Level Burial Grounds (LLBG) consist of two low-level waste management areas. These are LLWMA 1 and LLWMA 2 (Figures 2-4 and 2-5). A permit application has been submitted to Ecology for these facilities (DOE/RL 1989a). The RCRA groundwater monitoring program for these LLBGs began in 1988 and is continuing under interim status (DOE/RL 1992b).

The LLWMA 1 is located within the northwest corner of the 200 East Area covering an area of 38.2 ha (94.4 acres) and is operating under an interim-status groundwater quality assessment plan. This waste management area contains all of the 218-E-10 Burial Ground. Only the southern portion of the burial ground is active while the northern portion is unused and set aside for future waste disposal. The 218-E-10 Burial Ground began receiving waste in 1960 consisting of primarily drag-off waste, failed equipment (tanks, pumps, ovens, agitators, heater, vehicles, hoods, and accessories), and mixed industrial waste from PUREX Plant, B Plant and N Reactor. The disposal of this waste continues at the present time.

There are currently 16 groundwater monitoring wells associated with LLWMA 1. Quarterly groundwater sampling at LLWMA 1 began in 1988. These wells are sampled for several constituents (Table 2-11). During the second phase of sampling (indicator evaluation program), the specific conductance in upgradient Well 299-E28-26 exceeded the established critical mean (492.78 μmhos/cm). In 1990, an interim-status groundwater quality monitoring program was started. The specific conductance in Well 299-E28-26 has decreased to an acceptable level, but downgradient Wells 299-E32-3 and 299-E32-5 have exceeded the critical mean for the specific conductance.

The LLWMA 2 area covers 70.1 ha (173.1 acres) and is located in the northeast corner of the 200 East Area (Figure 2-5). It is composed entirely of the 218-E12B Burial Ground. This burial ground began receiving waste in 1968 which includes miscellaneous dry waste, submarine reactor compartments, and transuranic waste.

Groundwater monitoring for LLWMA 2 is currently in Phase II detection monitoring. There are currently 14 groundwater monitoring wells associated with LLWMA 2. The well samples are analyzed for the same constituents as well samples from LLWMA 3. There were no detected chemical constituents in groundwater above regulatory standards in 1991, but in Wells 299-E27-9 and 299-E34-2 the turbidity exceeded the 1 nephelometric turbidity unit (NTU) limit.

2.8.2.2 Single-Shell Tanks. There are three RCRA single-shell tank waste management areas within the 200 East Area. These waste management areas group adjoining tank farms and include the 241-B, -BY, and -BX Tank Farms, the 241-A and -AX Tank Farms, and the

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241-C Tank Farm. Within these three waste management areas are six tank farm facilities with a total of 66 single-shell tanks that range in size from 208,000 to 3,800,000 L (55,000 to 1,000,000 gal). The single-shell tanks were decommissioned as disposal facilities in 1980 but because they are currently storing hazardous and radioactive wastes they have been designated as RCRA facilities.

The single-shell tanks are a RCRA past practice unit for which a draft closure plan was submitted to the Washington State Department of Ecology (Ecology) (DOE/RL 1989b). Locations of the facilities and their associated groundwater monitoring networks are shown in Figure 2-6. Table 2-10 contains a summary of single-shell tank facilities and their associated groundwater monitoring wells. Groundwater monitoring beneath the single-shell tanks is by an interim-status RCRA detection level groundwater monitoring network that was initiated in 1989. Sampling was initiated within the tank farm in February 1990 but was suspended until 1991 because of lack of analytical laboratory support. Sampling resumed in July 1991 at all three waste management areas. Quarterly background samples are currently being collected at the tank farms for those wells completed for calendar years 1989 and 1990. There are currently 18 groundwater monitoring wells included in the 200 East Area network for the tank farm facilities.

Installation of six new groundwater monitoring wells began in August 1991. These monitoring wells were completed in December 1991 and were designed to monitor the upper portion of the unconfined aquifer.

Groundwater samples from single-shell tank monitoring wells are analyzed for drinking water standards, indicator parameters, and water quality parameters as well as ammonium, tritium, total organics, ^{137}Cs, uranium, plutonium, ^{60}Co, ^{90}Sr, and gamma scans (Table 2-12).

2.8.2.3 216-B-3 Pond. The 216-B-3 Pond System consists of a main pond and three pond lobes (Figure 2-7). These ponds are located east of the 200 East Area and are used for wastewater disposal. Wastewater primarily comes from the PUREX and B Plants, and additional waste effluent comes from the 242-A Evaporator, 244-AR Vaults, 241-A-702 Vessel Ventilation System, 283-E Water Treatment Facility, and the 284-E Powerhouse. This waste consists of cooling water, PUREX Plant chemical sewer, steam condensates, liquid effluent, and filter backwash. The 216-B-3 Pond System began receiving waste in 1945 and continues to the present. In the early 1980's the three lobes, 216-B-3A, 216-B-3B, and 216-B-3C, were constructed to handle greater waste volumes. The four ponds cover an area of 40 ha (98 acres) and are a maximum of 6 m (20 ft) deep. Currently, the 216-B-3B Pond is not in use. A closure/post closure plan for this RCRA unit has been submitted (DOE/RL 1989c). The 216-B-3 Pond System is part of the 200-BP-11 Operable Unit, which is regulated under the CERCLA program.

The groundwater monitoring network consists of 2 upgradient wells (299-E18-1 and 299-E32-4) and 18 downgradient wells. Wells are sampled for the general groundwater constituents listed in Table 2-13 and these site specific parameters: hydrazine, tritium, ammonium, total organics, herbicides, pesticides, enhanced volatiles, PCBs and acid/bases/neutrals. Sampling is on two schedules; wells older than 1988 are sampled semiannually, and those younger are sampled quarterly. The 216-B-3 Pond System is currently in assessment monitoring status. Wells 699-43-41E and 699-43-41 both have a history of high total organic halogen (TOX) concentrations, however, the TOX levels are declining with time. Wells 699-42-40A, 699-43-42J, and 699-43-43 were detected to be above the background levels for Total Organic Carbon (TOC) in 1991. Tritium was also detected in the downgradient wells in concentrations up to 180,000 pCi/L.

2.8.2.4 Grout Treatment Facility. The Grout Treatment Facility is located in the eastern-central portion of the 200 East Area (Figure 2-8). At the Grout Treatment Facility, selected radioactive and hazardous waste is mixed with grout. The slurry is then poured into underground vaults for curing. This produces stabilized cement-like blocks which are suitable for long-term, in-place storage. Currently these vaults are under construction. From August 1988 to July 1989, one vault was filled during a demonstration campaign. The first pouring with dangerous waste is scheduled for the end of 1992.

The Grout Treatment Facility is a treatment and disposal facility regulated under RCRA (EPA 1989a) and Washington State Dangerous Waste regulations (Ecology 1991a). There are 8 monitoring wells in the detection network. Wells continue to be sampled quarterly. This will allow data collected for the background study to be comparable for all monitoring wells. The groundwater is analyzed for several site-specific parameters: arsenic, chromium, selenium, and ^{99}Tc (Table 2-14). Currently, there are no readings that are above the acceptable limits. Evidence suggests that some contamination is coming from the Grout Treatment Facility. The downgradient wells' constituent levels are higher than the upgradient wells. Due to the proximity to the several active cribs, trenches, and ponds, this is only speculation.

2.8.2.5 216-A-29 Ditch. The 216-A-29 Ditch was located east of the 200 East Area extending from the PUREX Plant to the 216-B-3 Pond System (Figure 2-9). This facility was an excavated unlined trench used to carry effluent from the PUREX chemical sewer to the 216-B-3 Pond System. There have been substantial discharges of sodium hydroxide and sulfuric acid during the usage of this ditch. The 216-A-29 Ditch had been in service from 1955 until termination in July 1991. The facility has been backfilled and interim stabilized with vegetation. It is a RCRA unit in which the preliminary closure/postclosure plans have been prepared by DOE (1987). It is currently in groundwater assessment.

The groundwater monitoring network consists 20 wells of which 3 are upgradient wells. These wells were analyzed for drinking water and water quality parameters (Table 2-

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15). The sampling program was scheduled to begin in 1990 but due to the absence of a laboratory this program did not get under way until July 1991. Consequently, there is insufficient information to make conclusions on the groundwater beneath the 216-A-29 Ditch.

2.8.2.6 216-A-36B and 216-A-10 Cribs. The 216-A-36B and 216-A-10 Cribs are located in the PUREX Plant Aggregate Area, approximately 250 m (800 ft) and 121 m (400 ft), respectively, south of the PUREX Plant (Figures 2-10 and 2-11). Both cribs received waste from this facility and were permanently retired in 1987. The RCRA closure/postclosure plans for the 216-A-36B and 216-A-10 Cribs are to be submitted in March 1996 in accordance with the Hanford Federal Facility Agreement and Consent Order milestone M-20-34 (Ecology et al. 1990).

The 216-A-36B Crib received solutions containing ammonium, fluoride, nitrate, tritium, ^{90}Sr, ^{137}Cs, ^{106}Ru and U starting in 1965. These solutions were derived from nuclear fuel decladding operations. In 1966 the crib, then called the 216-A-36 Crib, was divided into two sections. One section was removed from service at this time. The remaining section, referred to as the 216-A-36B Crib, remained in service until 1987 with a temporary closure from 1972 to 1982.

The groundwater monitoring network consists of seven wells of which one is upgradient (299-E17-17). The wells are sampled semiannually for the general parameters plus the site-specific constituents: tritium, ammonium, uranium, and gamma (Table 2-16). In 1990 there were elevated levels of nitrates in Wells 299-E17-5, 299-E17-9, 299-E17-14, 299-E17-15, 299-E17-16, and 299-E17-17, tritium in all wells, and total beta in Wells 299-E17-6, 299-E17-14, and 299-E17-15. The 1991 sample data have not been interpreted so the current analyte levels are unconfirmed.

The 216-A-10 Crib is 84 m (275 ft) long and 14 m (45 ft) deep. Starting in 1956, the process distillate discharge waste streams were disposed of in this crib. The waste consisted of aliphatic hydrocarbon compounds, organic complexes, and radionuclides including plutonium, uranium, ^{90}Sr, ^{60}Co, ^{134}Ce, ^{137}Cs, ^{103}Ru, ^{106}Ru, and tritium. As mentioned previously, this crib was retired in 1987 and replaced by the 216-A-45 Crib.

In 1988 the 216-A-10 Crib was placed on an interim-status RCRA groundwater monitoring network. This network consists of eight monitoring wells, of which two are upgradient (Wells 299-E24-18 and 299-E25-36) (DOE/RL 1992c). These wells are sampled semiannually. The site-specific analytical parameters are uranium, tritium, and gamma (Table 2-17). In 1990 (the most current date available) the network indicated elevated chemical levels. Nitrates above 45,000 ppb, although showing a decrease from 1989 to 1990; tritium, was variable but increasing during this same period. Gross beta was elevated only in Well 299-E24-16 in early 1989 but diminished to acceptable levels by the end of the year.

2.8.2.7 216-B-63 Trench. This trench is located in the central portion of the 200 East Area east of B Plant (Figure 2-12). This facility started service in 1970 and is still actively receiving nondangerous waste, a combination of steam condensate and raw water, from B Plant. Between 1970 and 1985 there had been releases of sulfuric acid and sodium hydroxide. No radioactive waste reportedly has been disposed of, but in 1970 radioactive soil was dredged from the trench. In 1985 controls were added to avoid further unplanned releases of hazardous and radioactive waste. Because the 216-B-63 Trench is not expected to receive additional hazardous substances, DOE/RL has proposed that the trench be closed under RCRA interim status, although it will continue to receive wastewater not regulated under RCRA.

There are currently ten monitoring wells in the groundwater network. Six of these wells are upgradient (Wells 299-E27-8, 299-E27-9, 299-E34-8, 299-E34-10, 299-E27-11, and 299-E27-17). The site-specific parameters are tritium, uranium, volatile organics, and a gamma scan (Table 2-18). Sampling was scheduled to start in 1990 but was postponed due to lack of laboratory facilities. Currently, there are no data available from this network.

2.8.2.8 Liquid Effluent Retention Facility. The Liquid Effluent Retention Facility (LERF) is currently under construction east of LLWMA 1 outside the fenced 200 East Area (Figure 2-13). This site is 16 ha (39 acres) and will consist of four 25,000,000 L (6.5 million gallons) double-lined surface impoundments with leachate collection systems and floating covers. These impoundments will be used to store effluent suspected of containing listed waste constituents (DOE/RL 1992c). The 242-A Evaporator process condensate effluent is regulated as a dangerous waste under WAC 173-303 (Ecology 1991a).

There are four groundwater monitoring wells in the current network. Sampling of these wells is on a quarterly basis and started in June 1991. These samples are analyzed for the general parameters as well as ammonia, tritium, and 1-butanol (Table 2-19). To date, there has been no evidence of elevated levels that exceed regulatory standards.

2.8.2.9 2101-M Pond. The 2101-M Pond is an unlined, U-shaped trench located west of the 2101-M Building (Figure 2-14). It was put in service in 1953 to receive wastewater from the 2101-M Building heating and air conditioning system. The Basalt Waste Isolation Project laboratories also discharged into the pond between 1981 and 1985. A closure plan for this facility was submitted to Ecology for review (DOE/RL 1989d).

The groundwater monitoring network consists of four groundwater monitoring wells of which Well 299-E18-1 is upgradient. These wells are sampled semiannually for the general parameters plus volatile organics, tritium, turbidity, radium, uranium, technetium, barium, copper, inductively coupled plasma metals as well as alpha, beta and gamma radiation (Table 2-20). To date, there have been no constituent concentrations in the groundwater above acceptable levels.

2.8.2.10 Nonradioactive Dangerous Waste Landfill. Located approximately 5.5 km (3.5 mi) southeast of the 200 East Area, the NRDWL is a 4 ha (10 acre) part of the Central Landfill Complex (Figure 2-15). This facility had received dangerous waste from 1975 to 1985 and continued to receive asbestos waste until 1988. A closure plan (DOE/RL 1990a) for the NRDWL was submitted to Ecology in 1990, and as part of the Tri-Party Agreement, the NRDWL will be retired.

A groundwater monitoring network of seven wells was established in 1986 and is currently on a semiannual sampling schedule. Three of the seven wells are located upgradient of the facility (Wells 699-26-35A, 699-26-35C, and 699-26-34). All water samples are analyzed for tritium, volatile chlorinated hydrocarbons, and the general water quality constituents listed in Table 2-21. Well 299-25-34B had an elevated TOC reading of 1,025 ppb in April 1990. The allowable limit is 940.8 ppb. In 1991 the well was resampled and found to be below 500 ppb and acceptable. There was also an elevated reading for tritium due to a migrating tritium plume originating in the 200 East Area that moved to the southeast. A pulse of the plume had passed beneath the NRDWL in 1988 to 1989 and tritium values are declining.

2.8.2.11 Solid Waste Landfill. The solid waste landfill is adjacent to the NRDWL, 5.5 km (3.5 mi) southeast of the 200 East Area (Figure 2-15). This facility is active and under the jurisdiction of the Benton-Franklin County Health Department. This is not an RCRA site but is included here for clarity. This 27 ha (66 acre) facility has been accepting waste since 1972. This waste includes paper wastes, construction debris, asbestos wastes and lunchroom wastes. In addition to the solid waste, liquid waste was disposed of in trenches from 1975 to 1987. This liquid consisted of 3,000,000 L to 5,700,000 L (1 to 1.5 million gallons) of sewage waste and 380,000 L (100,000 gal) of wash water from the Hanford bus garage.

The eight well groundwater monitoring network was set up in 1987. These wells are sampled quarterly and analyzed for a selected group of constituents (Table 2-22).

2.8.3 Comprehensive Environmental Response, Compensation and Liability Act

The Hanford Site is organized into numerically designated operational areas including the 100, 200, 300, 400, 600, and 1100 Areas. The 100, 200, 300, and 1100 Areas are listed on the EPA's National Priorities List (NPL). The *Hanford Site Past-Practice Strategy* (DOE/RL 1992a) outlines procedures for approaching the various sites within the framework of the CERCLA guidelines. Under the Tri-Party Agreement, the 200 NPL Site was divided into ten aggregate areas. Currently, the 200 East Area is divided into three source aggregate areas containing 20 operable units and the 200 North Aggregate Area is a separate source area and operable unit (Figures 1-3 and 1-5). There are also five other 200 Area isolated operable units (in addition to 200-IU-6 in the B Plant Aggregate Area).

Of these 26 operable units, the 200-BP-1 Operable Unit is currently the only operating CERCLA operable unit under investigation in the 200 East Area. In accordance with milestones M-15-02A, M-15-02B, and M-15-02C, draft reports to Ecology and EPA are due in May 1993 for 200-BP-1 Feasibility Study Phase 1 and Phase 2; April 1994 for 200-BP-1 Remedial Investigation Phase 2; and March 1995 for 200-BP-1 Feasibility Study Phase 3 (Ecology et al. 1991).

The 200-BP-1 Operable Unit is located in the center, along the north boundary of the 200 East Area. This operable unit consists of ten inactive cribs and contains three unplanned releases. Two of the cribs received ITS condensate waste. Seven of the cribs received waste from the 221-U Building, mainly tributyl phosphate supernate process waste, in the late 1950's. The last crib was never used. There is a concentration of man-made radionuclides, ^{137}Cs and ^{90}Sr, as well as cyanide and nitrate compounds in the soil beneath the cribs. This contamination is believed to extend to the unconfined aquifer.

Nine groundwater monitoring wells have been installed during 1992. Six of these wells monitored the unconfined aquifer and the remaining three sampled the uppermost confined aquifer. Samples will be analyzed for the parameters listed in Table 2-23. This project is still in the investigative stage and has just begun to collect data. These wells are summarized in Table 2-24.

2.8.4 Pacific Northwest Laboratory Environmental Monitoring Network

The PNL, operated for the DOE by Battelle Memorial Institute (Contract No. DE-AC06-76-RLO 1830), assesses the impact of Hanford Site operations on the groundwater. This program is performed independently of the other monitoring programs discussed above.

This groundwater monitoring network is designed to comply with the environmental surveillance portions of DOE Order 5400.1. As such, it evaluates existing and potential pathways of exposure to radioactivity and hazardous chemicals from site operations. The objectives of this program are as follows:

- Verify compliance with environmental laws and regulations
- Verify compliance with environmental commitments
- Characterize impacts of Hanford Site operations to the environment.

Although PNL's groundwater monitoring program is performed independently of the other programs, data collected from all monitoring programs at the Hanford Site are used to

assess the groundwater quality across the site. Sampling schedules from each of the site groundwater monitoring programs are reviewed by project staff in context with the requirements for the environmental surveillance needs. A supplemental monitoring program is developed each year to meet the objectives of the groundwater surveillance program.

For calendar year 1990 there were 110 wells sampled in and around the 200 East Area (Evans et al. 1990). These included wells from the RCRA, OGWMN, and other monitoring programs. These wells are summarized on Table 2-25.

2.8.5 Hanford Sanitary Water Quality Surveillance

Sanitary water quality surveillance on the Hanford Site is conducted as a joint effort by the HEHF Environmental Health Services, and PNL Environmental Health Sciences Department. The HEHF oversees surveillance in the areas of chemical and microbial quality, while PNL efforts focus on radiological quality.

The primary purpose of the surveillance program is to protect the health of persons consuming water on the Hanford Site by regulating sanitary water with applicable drinking water standards. There are no groundwater wells within the 200 East Area that are used as a supply of drinking water. The nearest drinking water wells to the 200 East Groundwater Aggregate Area are Well 699-41-900-C at the Yakima Barricade, Well S28-EO at the Patrol Training Academy, and 3 wells including 499-SJ, 499-SO8, and 499-SO7 within the 400 Area (Fast Flux Test Facility).

Drinking water constituents that are monitored for under this program include selected inorganics, volatile organics, microbiological constituents, and radiological constituents including total alpha and beta, tritium, and ^{90}Sr. These constituents are sampled quarterly.

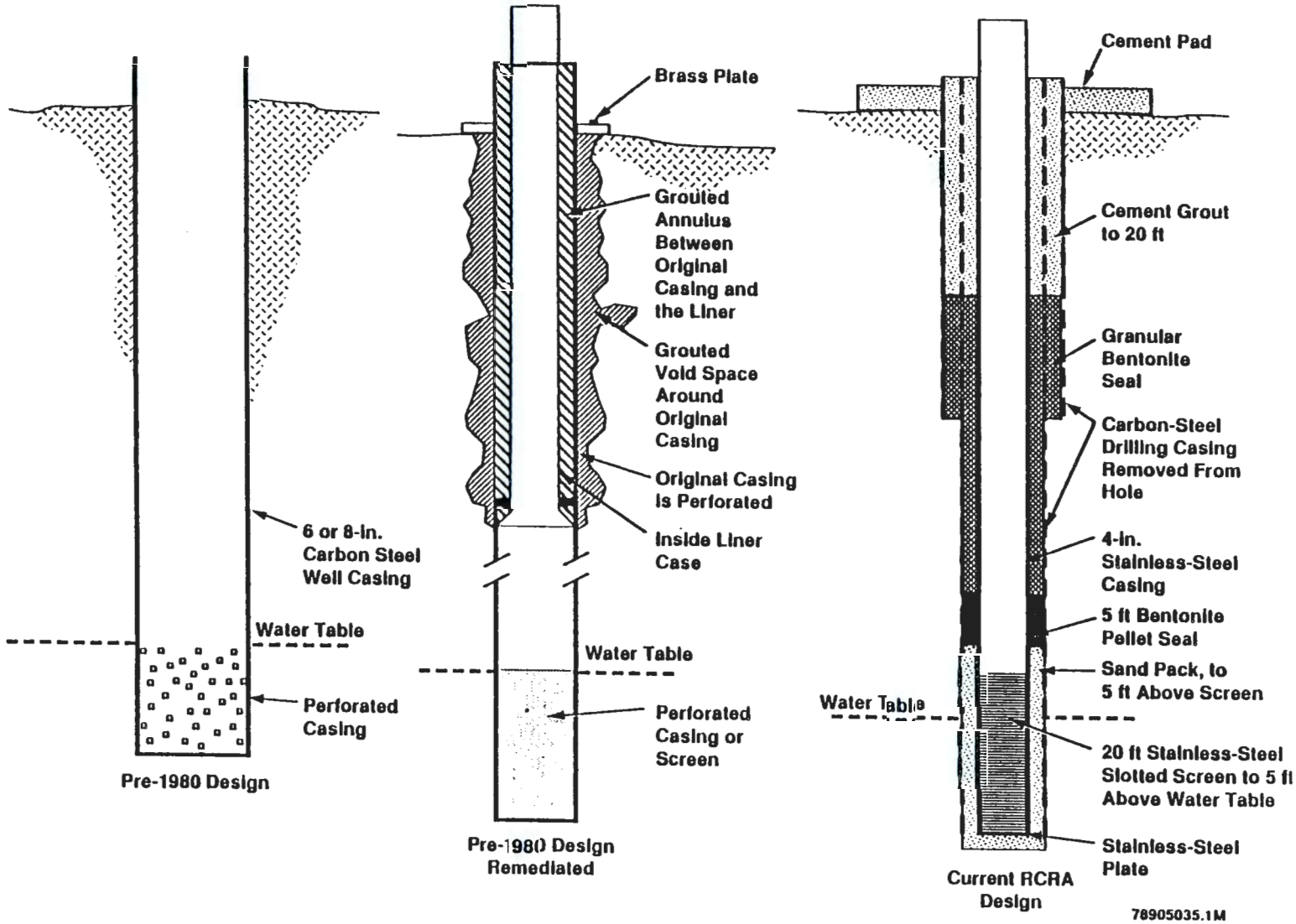


Figure 2-1. Schematic Design of Typical Hanford Site Monitoring Wells (Serkowski and Jordan 1989).

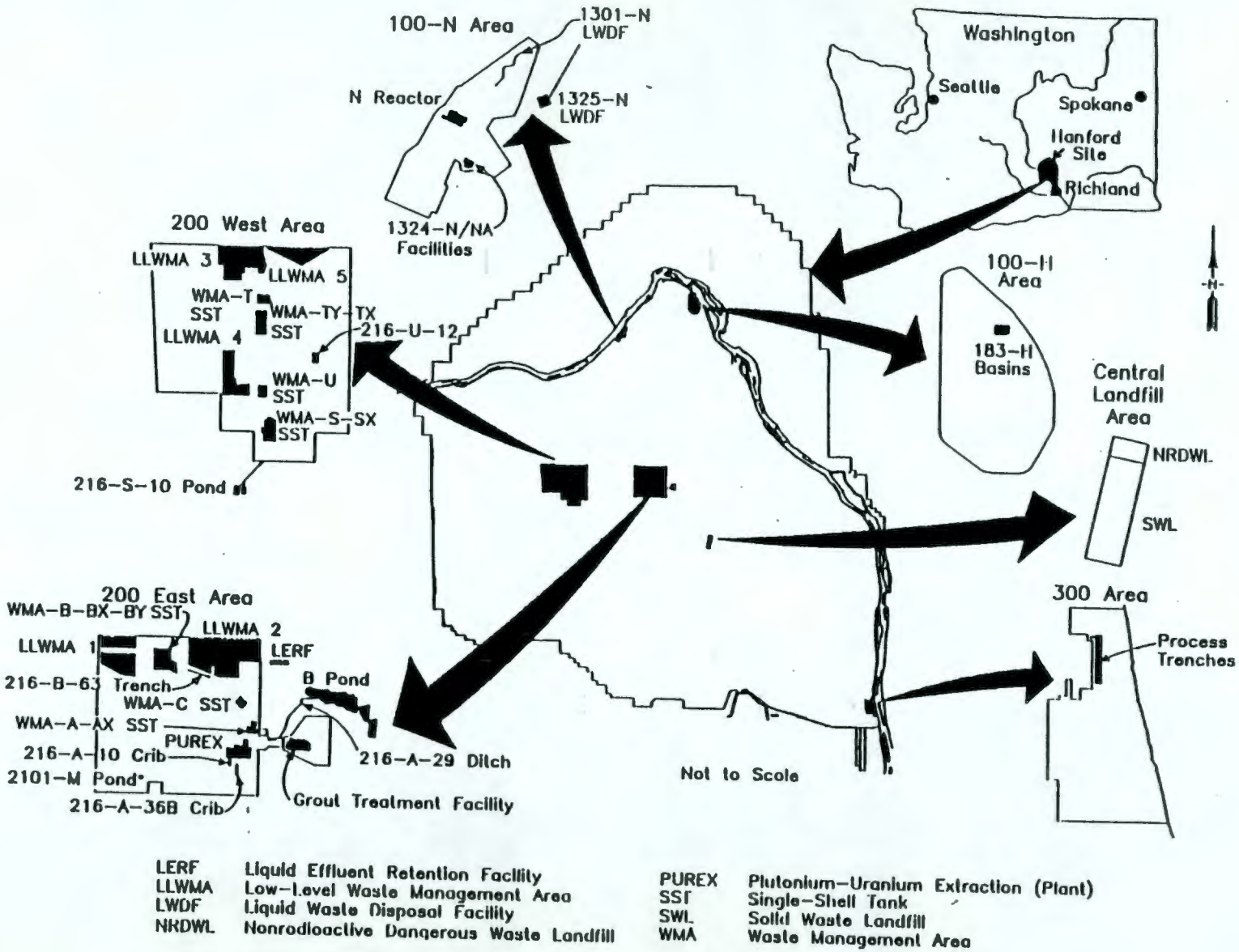
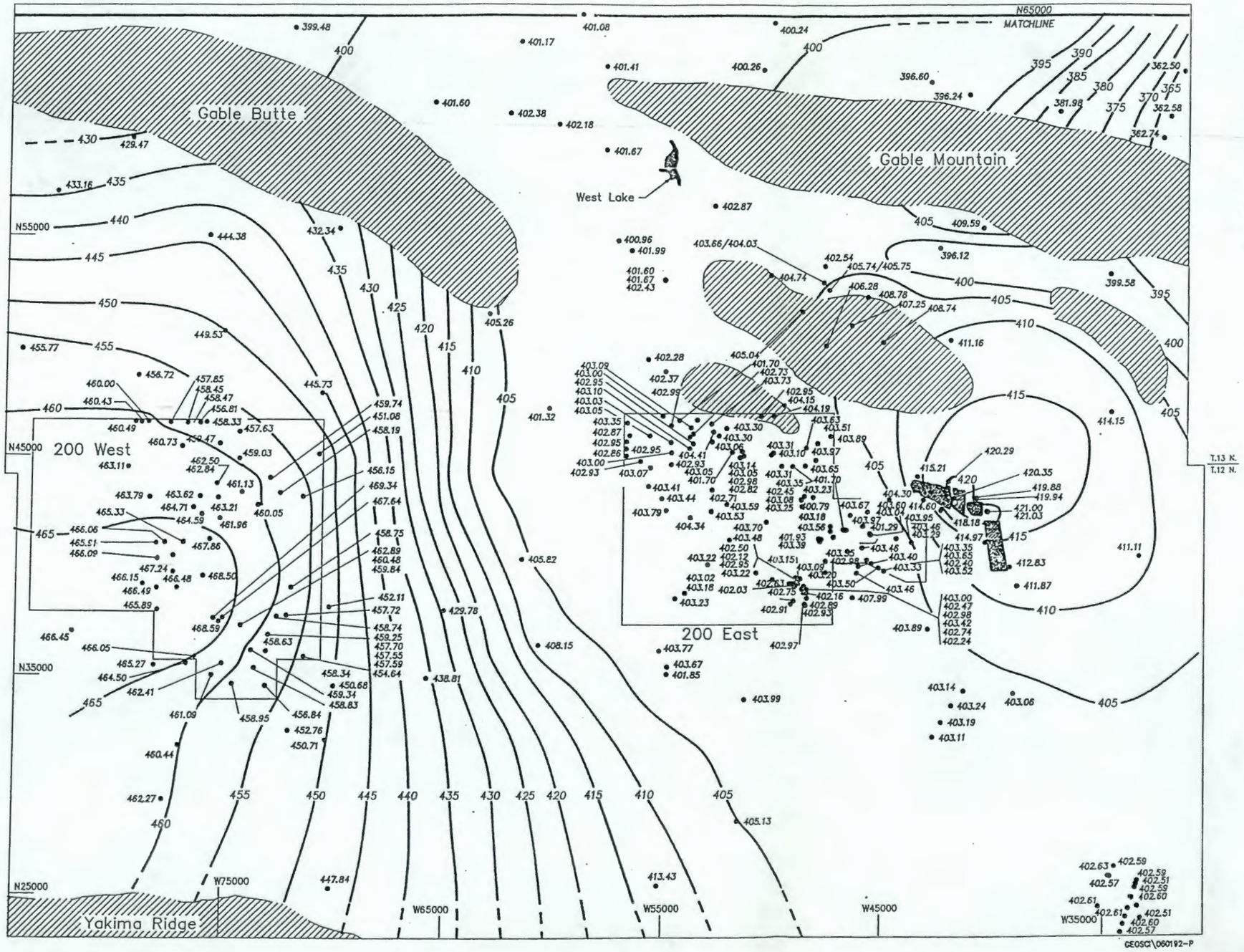


Figure 2-2. Location of RCRA Facilities at the Hanford Site (DOE/RL 1991b).



200 Areas Water Table Elevation December 1991

411.49 Water table elevation (feet above mean sea level)

395 Groundwater table elevation contour interval = 5ft

Ponds

Areas where the basalt surface is generally above the water table

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

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

0 1 Mile

0 1 Kilometer

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Figure 2-3. 200 Areas Water Table Elevation for December 1991 (Kasza et al. 1992).

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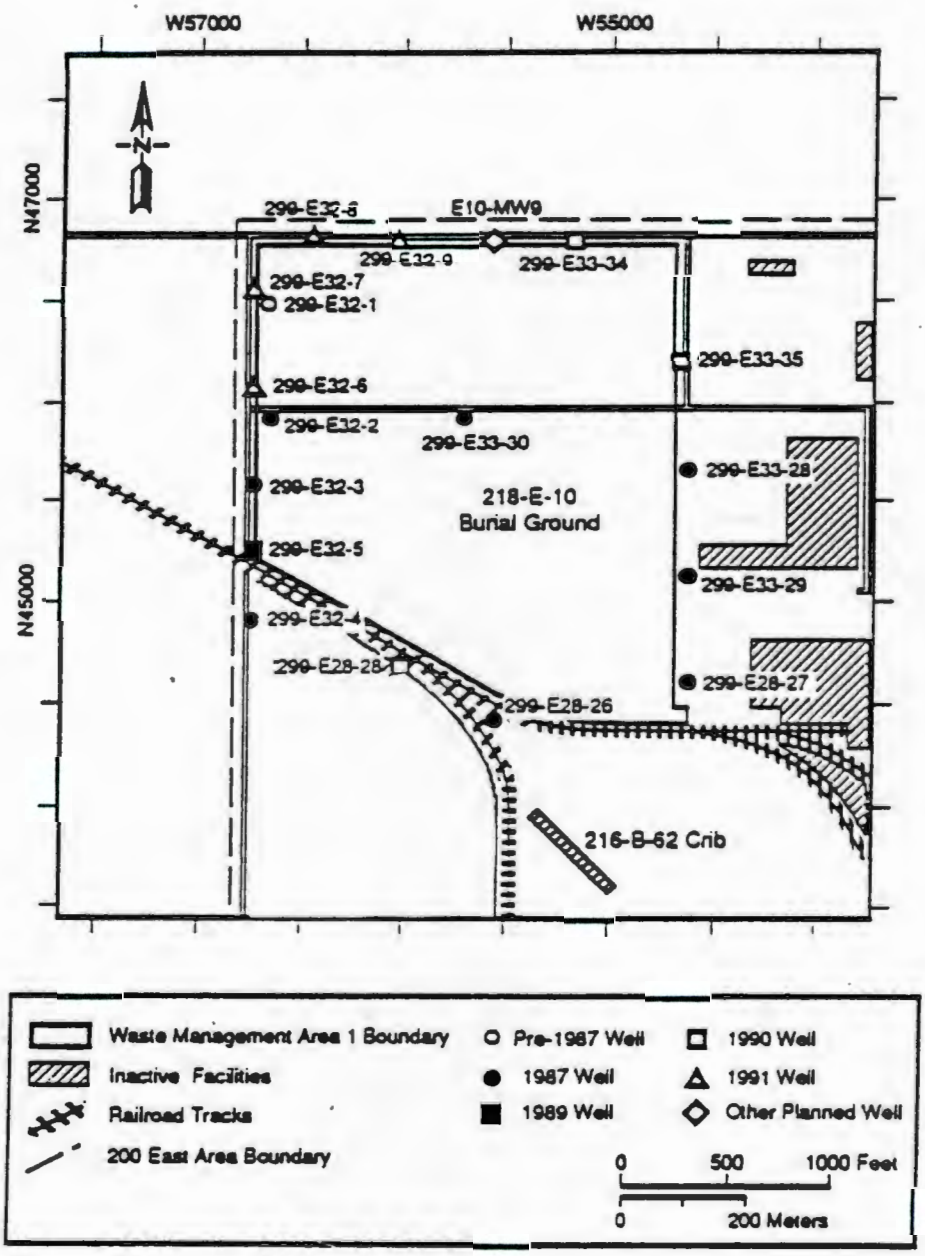

Figure 2-4. Monitoring Well Locations for the Low-Level Waste Management Area 1.

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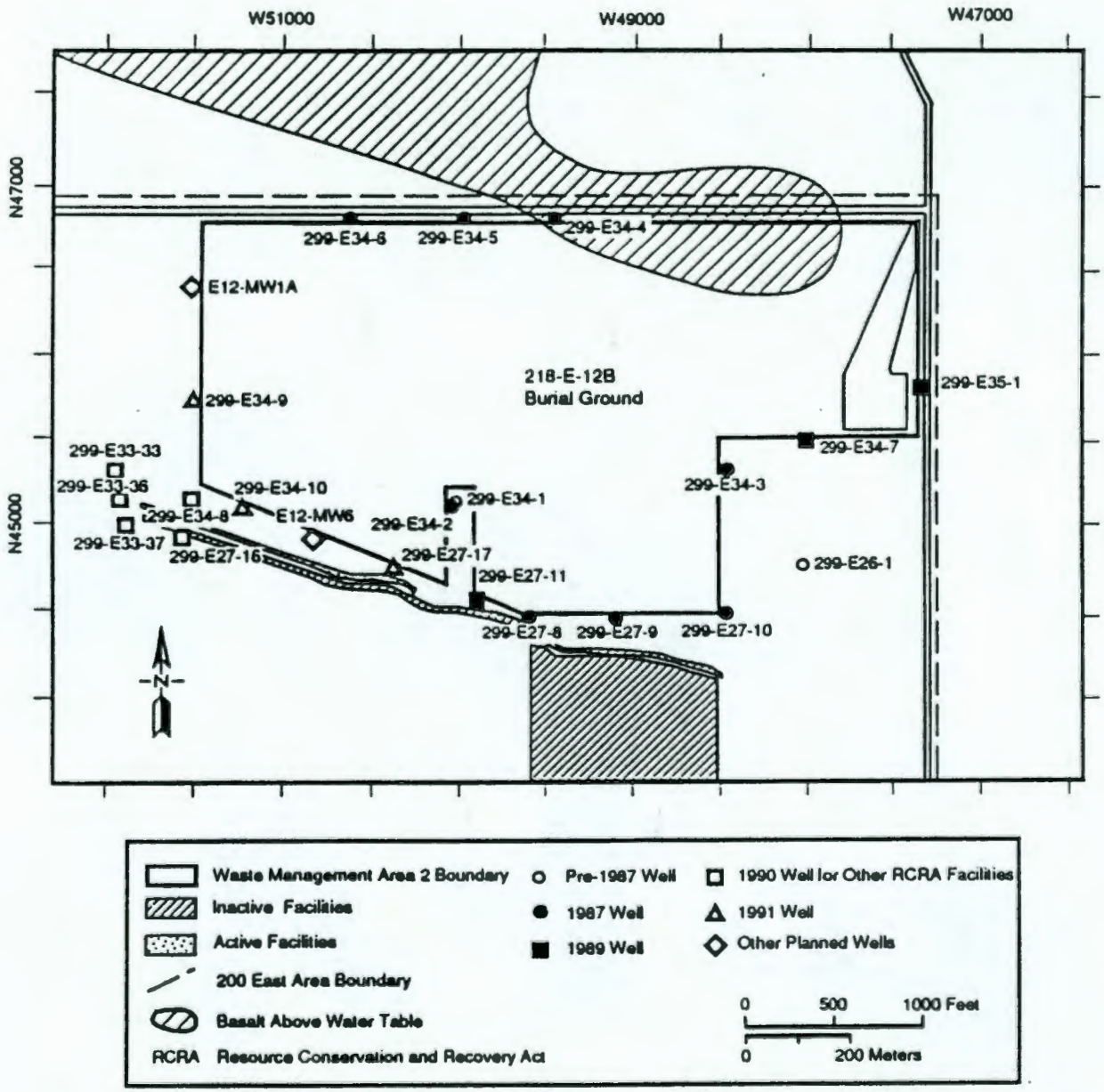
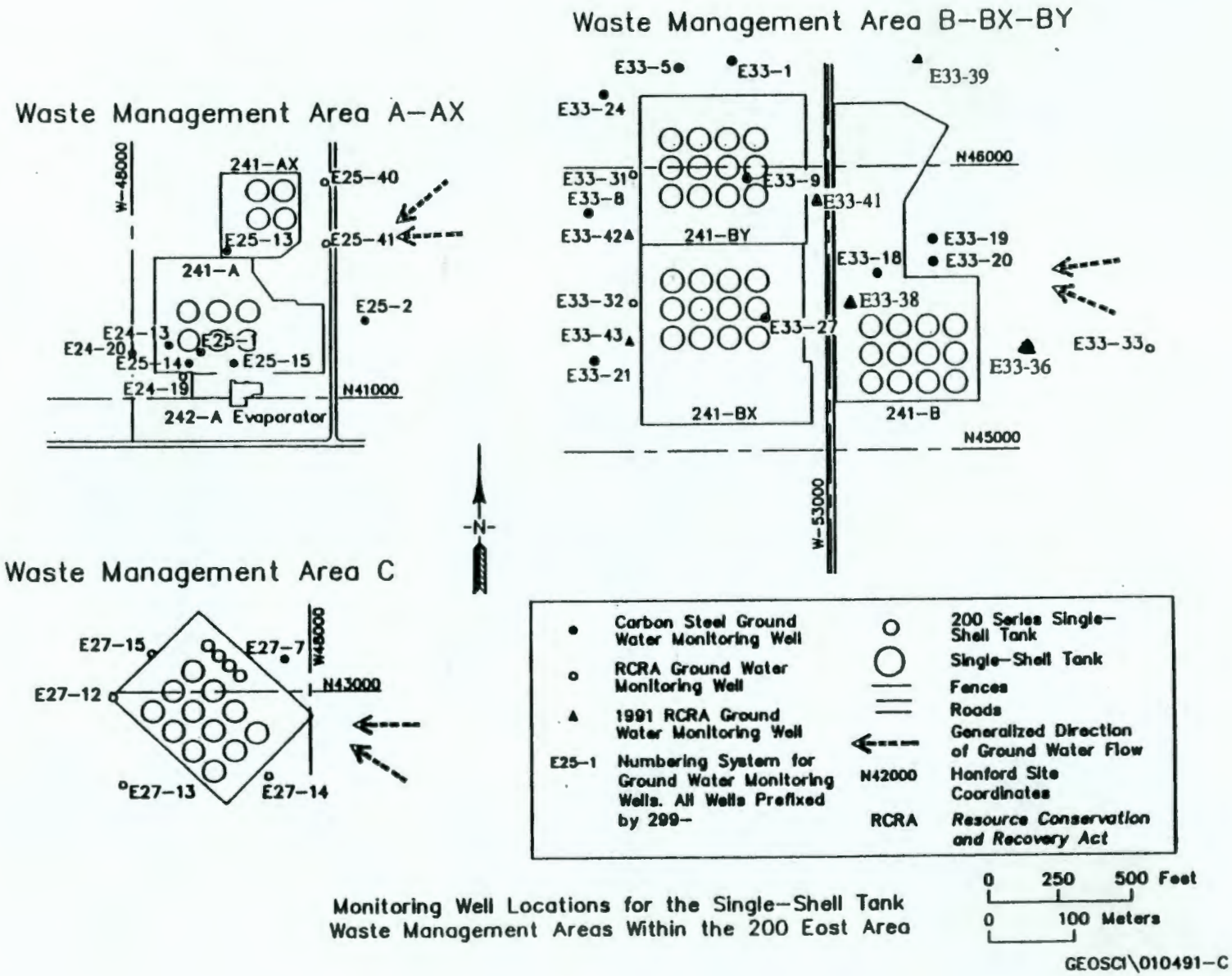


Figure 2-5. Monitoring Well Locations for the Low-Level Waste Management Area 2.



Monitoring Well Locations for the Single–Shell Tank Waste Management Areas Within the 200 East Area

Figure 2-6. Monitoring Well Locations for the Single-Shell Tank Waste Management Areas in the 200 East Area.

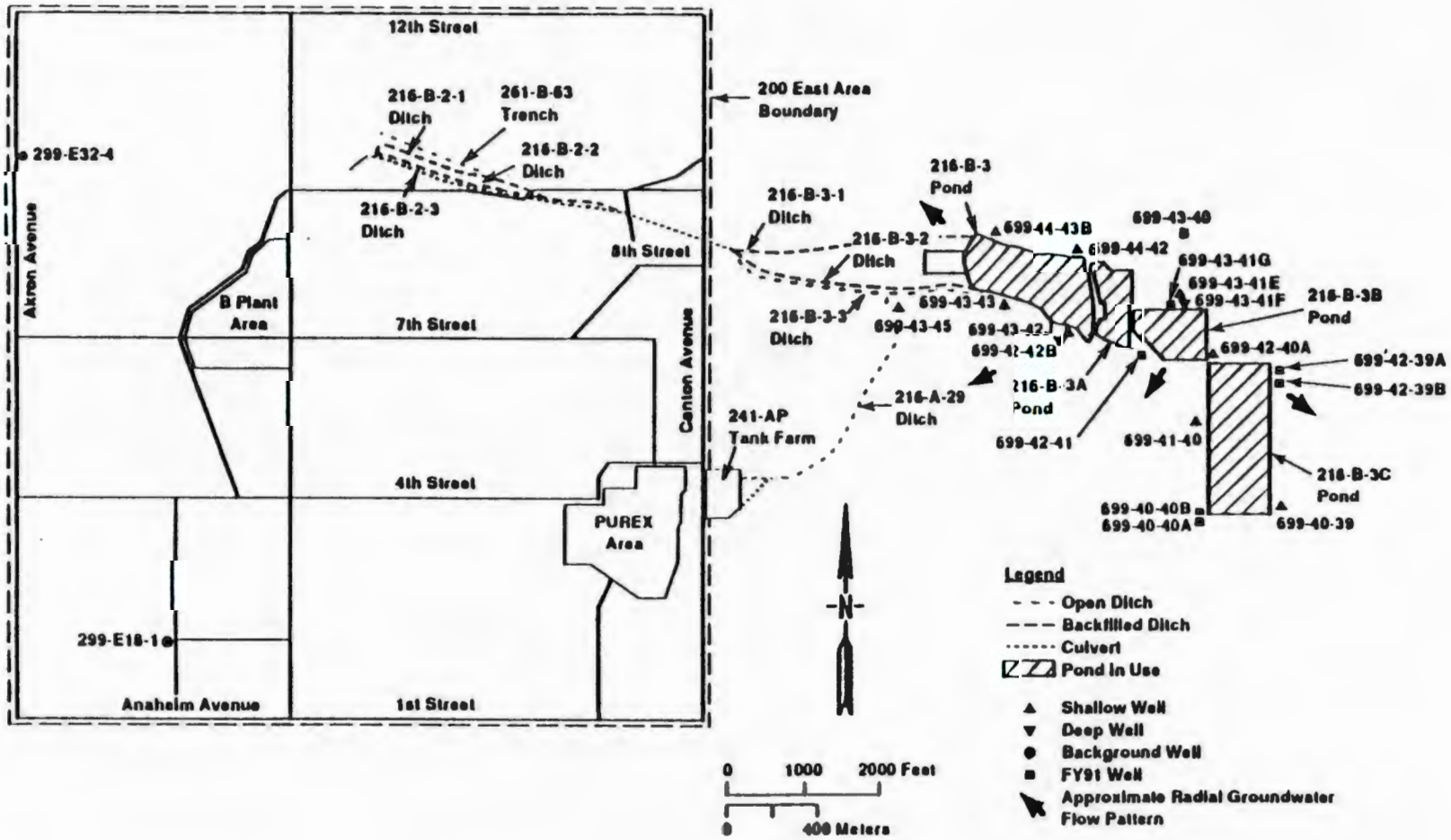


Figure 2-7. Monitoring Well Locations for the 216-B-3 Pond System.

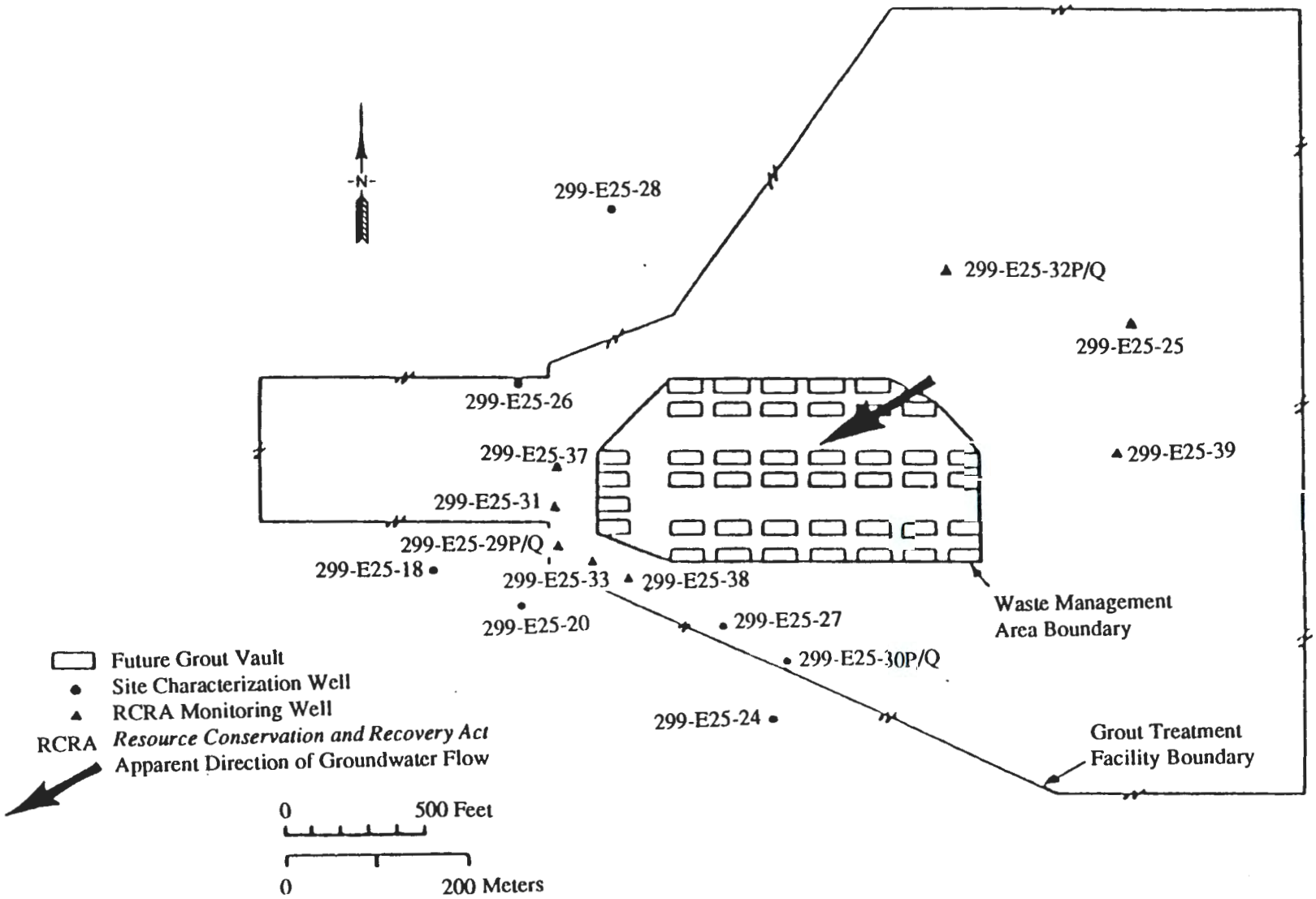


Figure 2-8. RCRA Monitoring Well Locations for the Grout Treatment Facility.

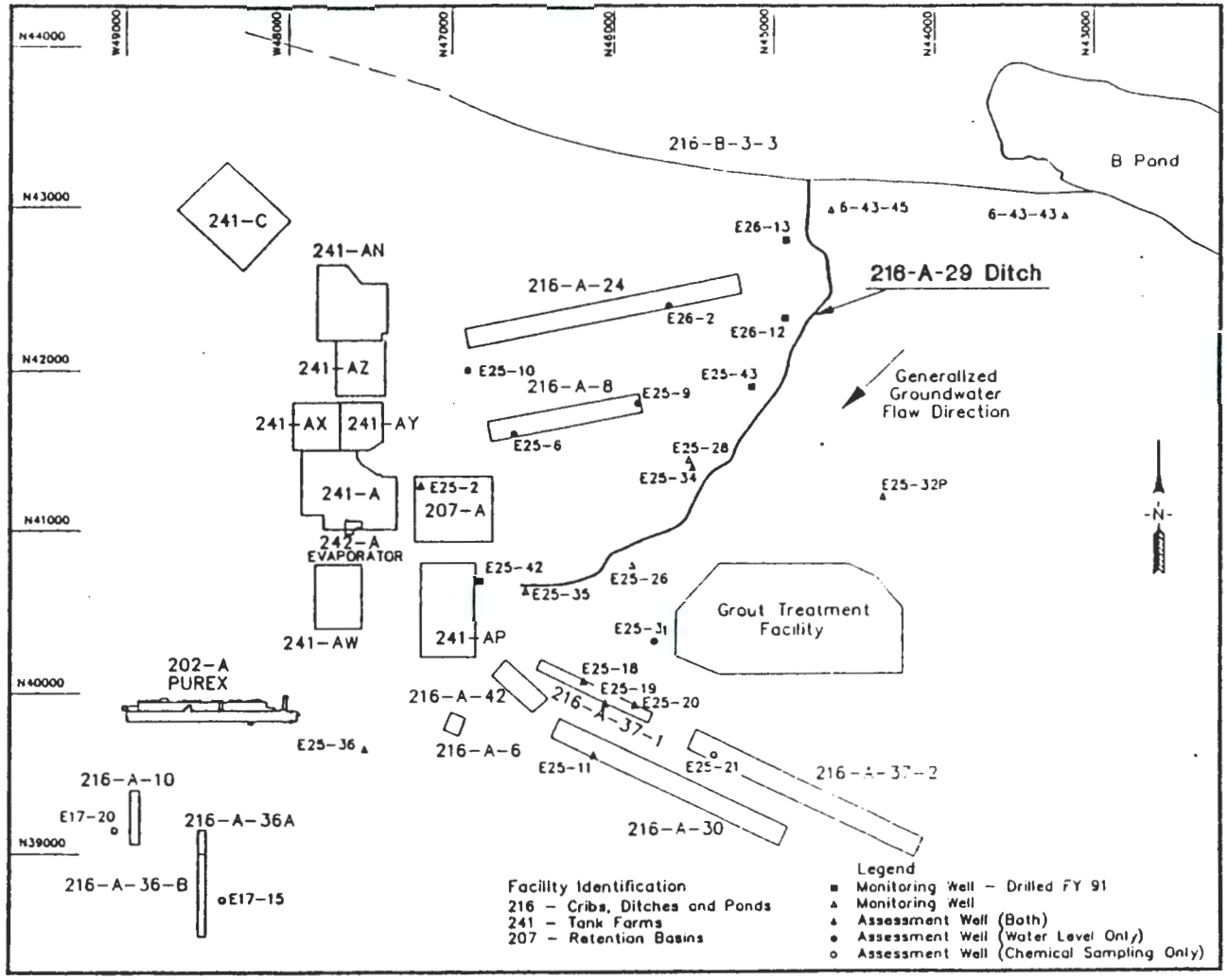


Figure 2-9. Monitoring Well Locations for the 216-A-29 Ditch.

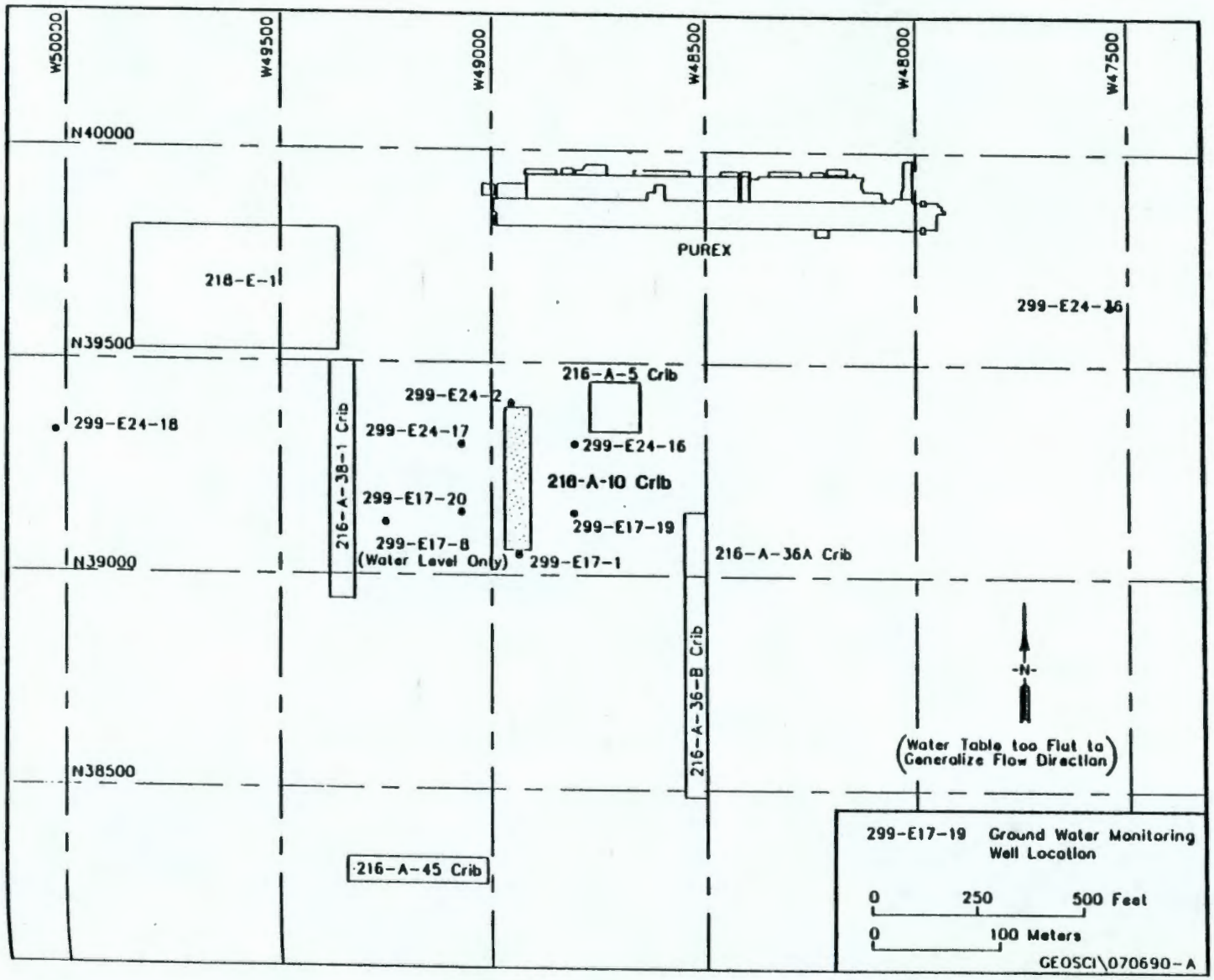


Figure 2-10. Monitoring Well Locations for the 216-A-10 Crib.

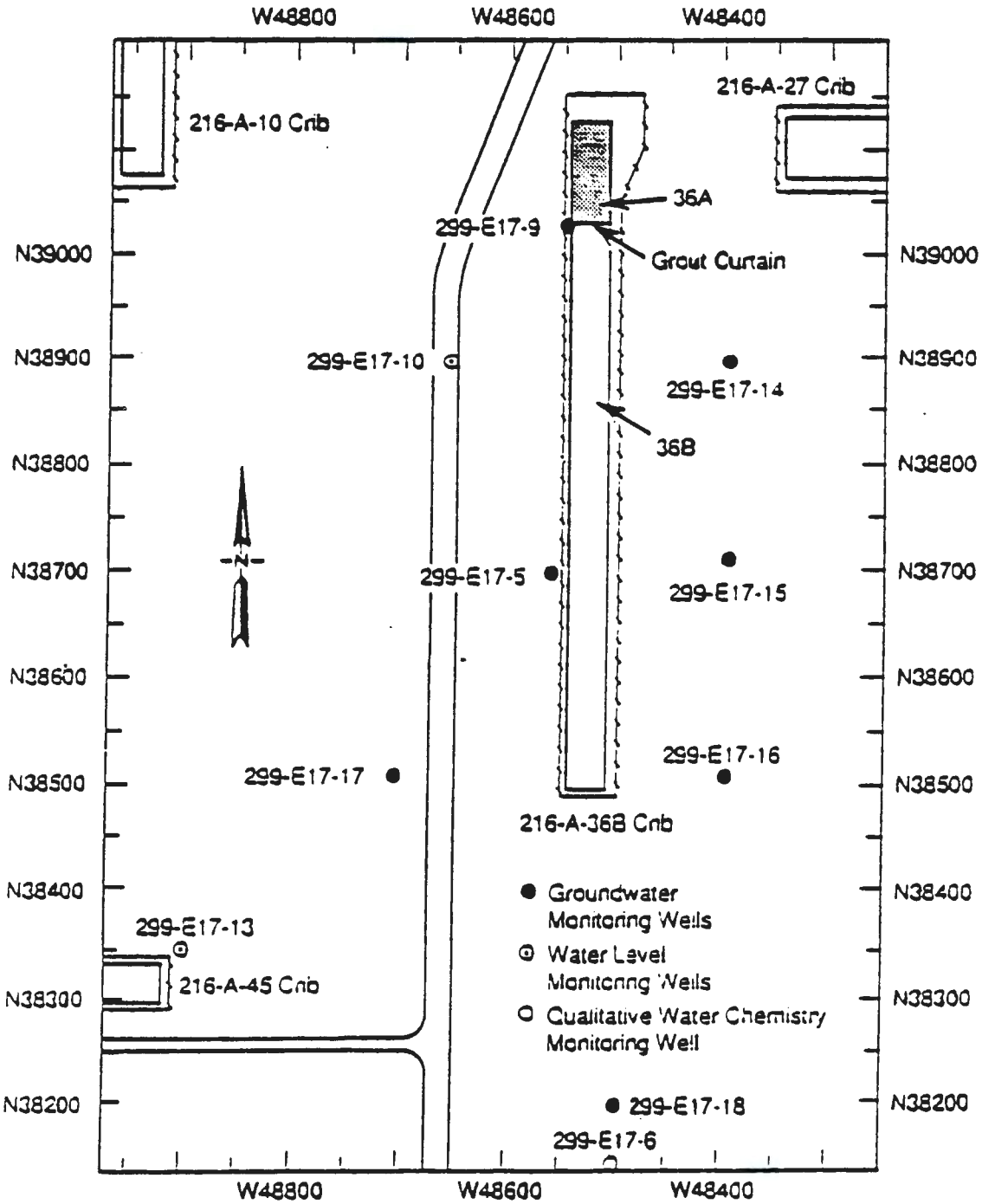


Figure 2-11. Monitoring Well Locations for the 216-A-36B Crib.

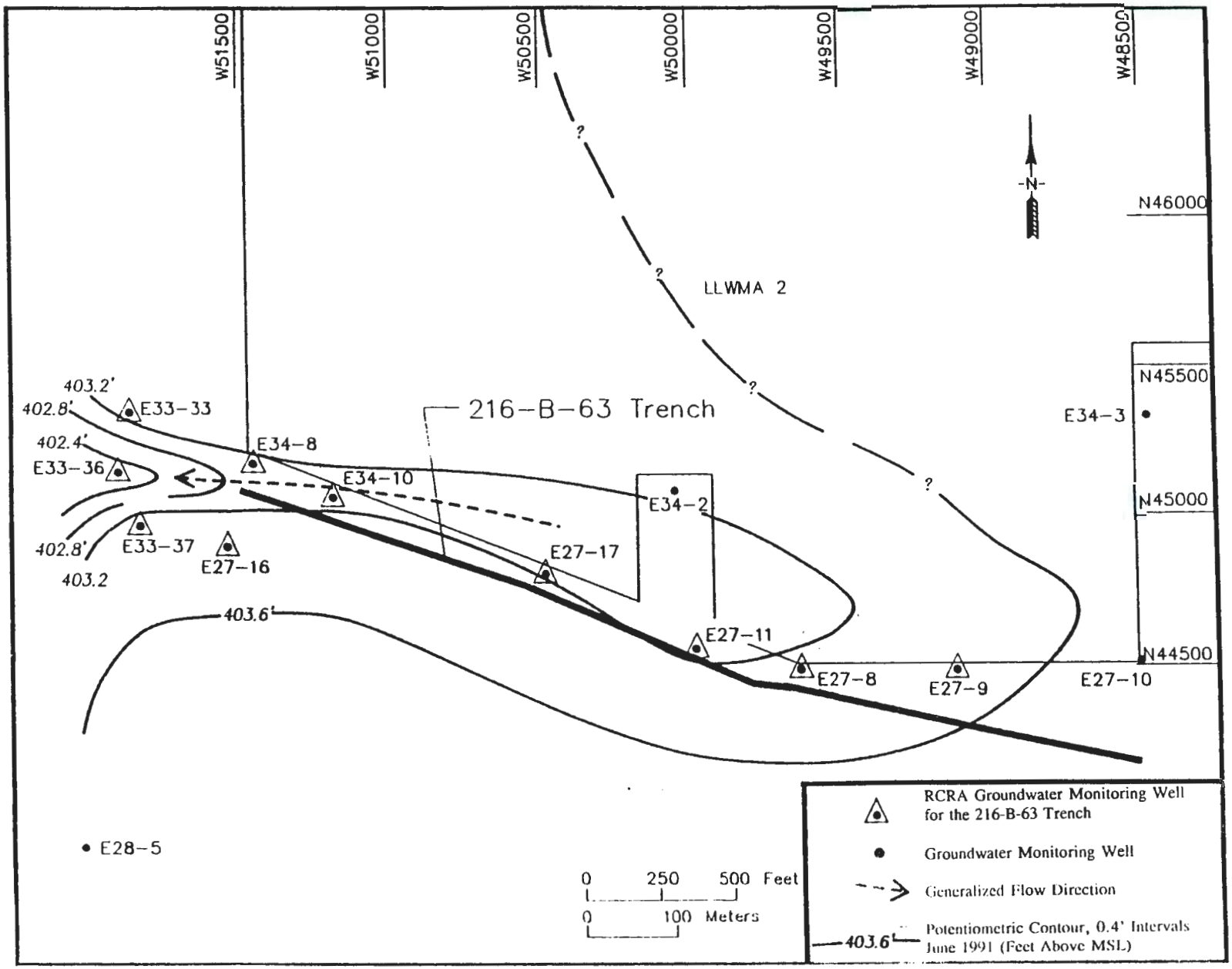


Figure 2-12. Monitoring Well Locations for the 216-B-63 Trench.

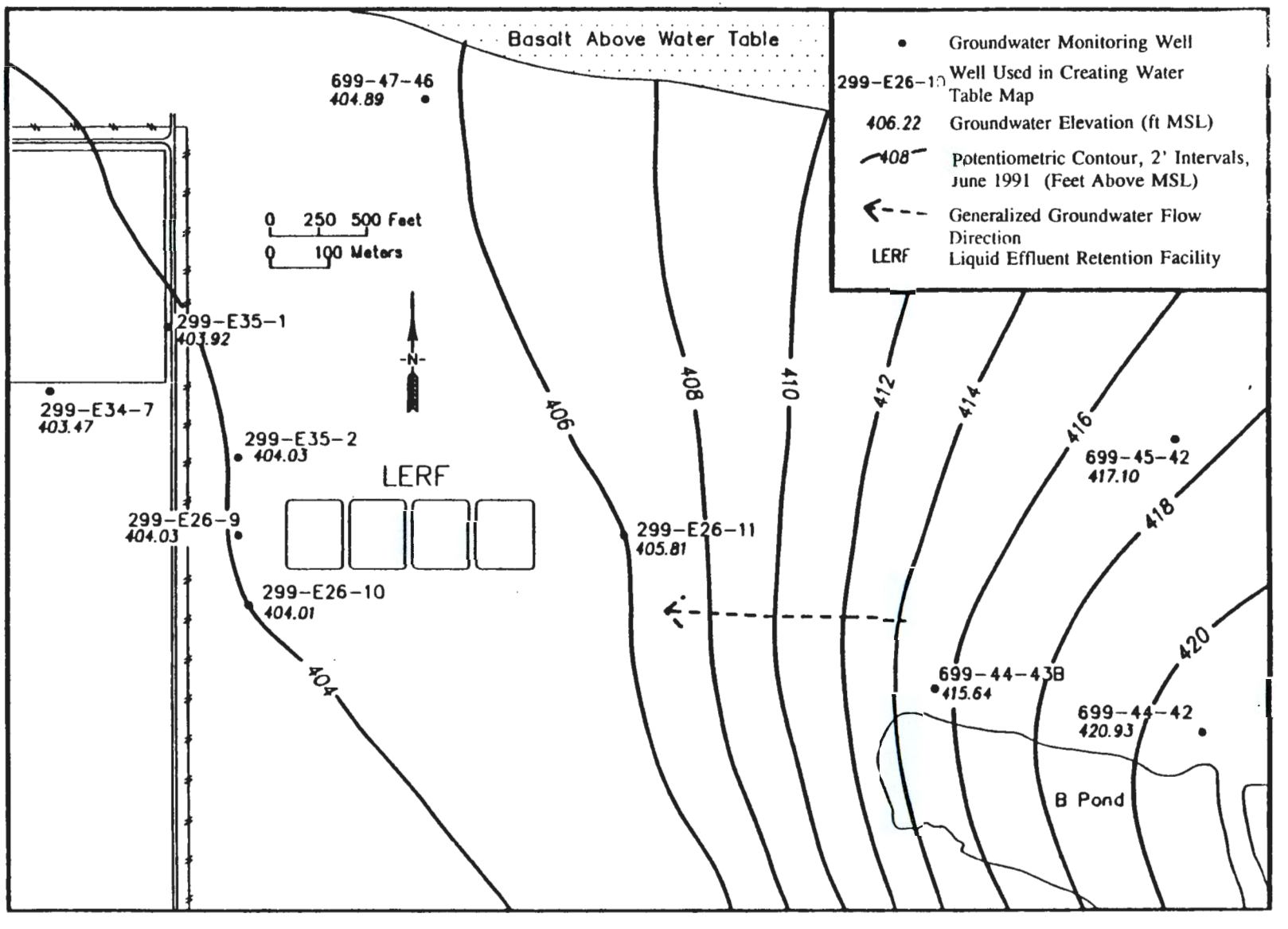


Figure 2-13. Monitoring Well Locations for the Liquid Effluent Retention Facility, June 1991.

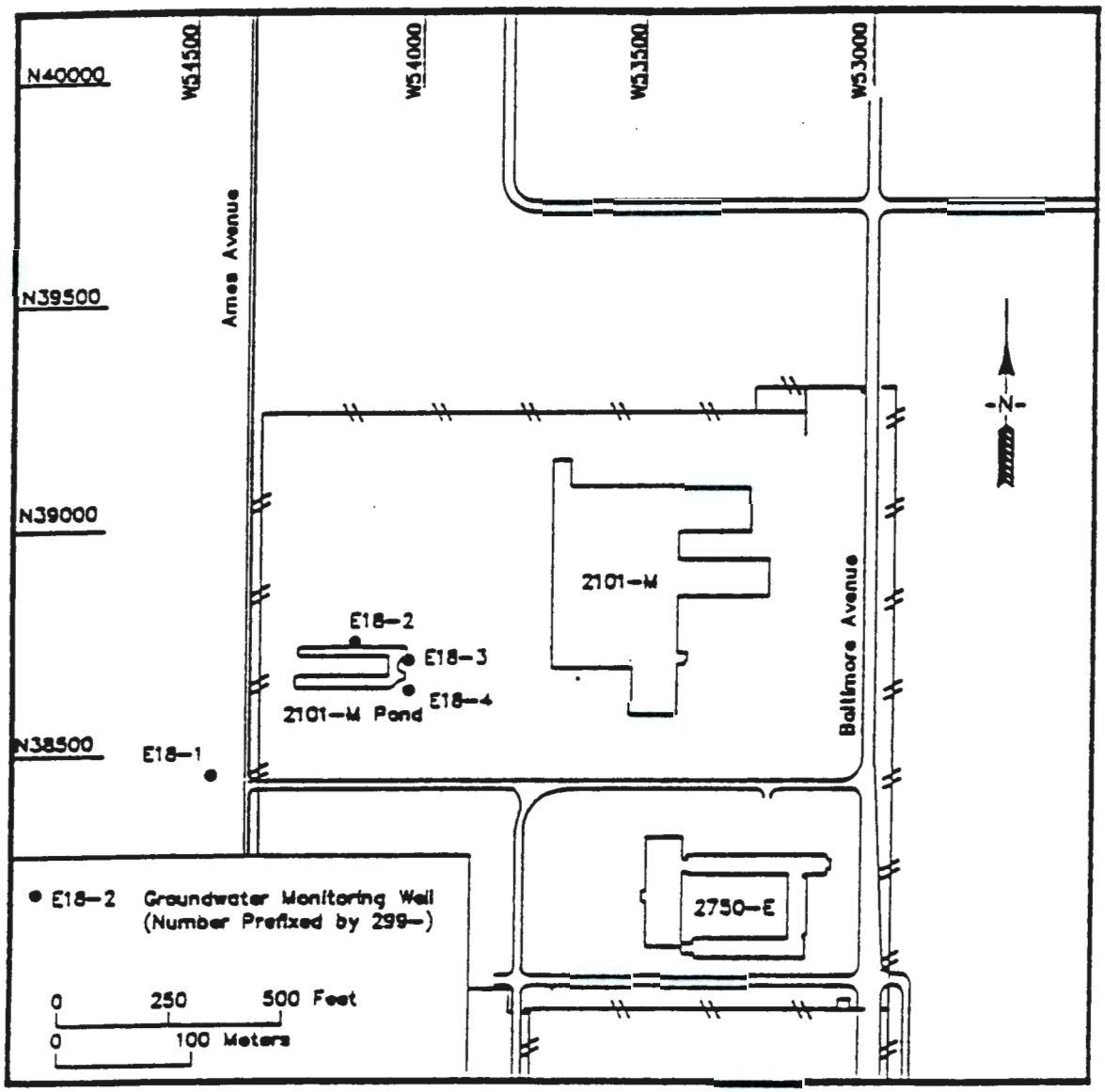
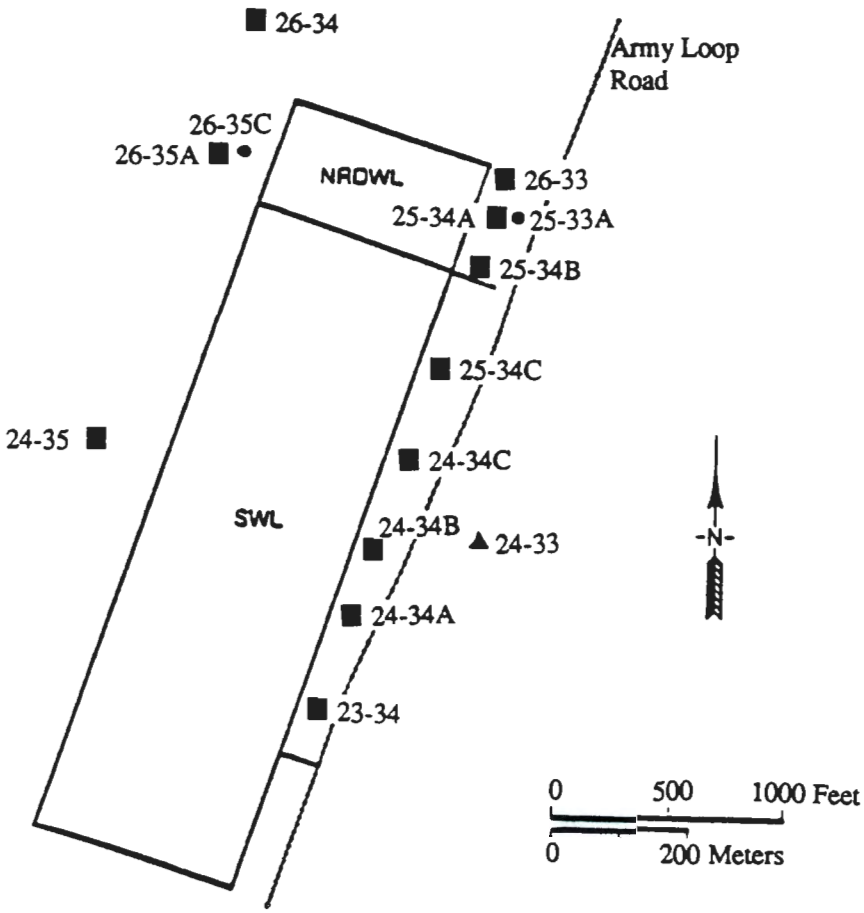


Figure 2-14. Monitoring Well Locations for the 2101-M Pond.



■ Well completed at the top of the unconfined aquifer
● Well completed in the upper Ringold Formation
▲ Well not constructed to RCRA specifications
NRDWL Nonradioactive Dangerous Waste Landfill
SWL Solid Waste Landfill

All wells prefixed by 699-

Figure 2-15. Monitoring Well Locations for the Nonradioactive Dangerous Waste Landfill and Solid Waste Landfill.

9 3 1 2 9 7 1 1 3 2

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
PUREX Plant Aggregate Area				
Plants, Buildings, and Storage Areas				
204-AR Waste Unloading Station	1982-Present *Active*	Receives wastes generated from decontamination and regeneration operations in 100 Area; from recovery, fuels fabrication, and laboratory operations in 300 Area; from decontamination operations in 400 Area; Waste is chemically adjusted prior to pumpout to double-shell tanks	No	Contains 1,966 (catch tank only)
241-A-431 Ventilation Building	1955-1969 *Inactive*	Contains radioactively contaminated equipment and concrete	No	Unknown
241-C-801 Support Facility	1962-1976 *Inactive*	This unit is a radioactively contaminated structure	No	Unknown
242-A Evaporator	1977-Present *Active*	Dilute noncomplexed radioactive waste; PUREX Dilute misc. waste; PUREX cladding removal waste; complexed radioactive waste; NaNO3 is used to regenerate ion exchange column, Turco 4518 or NaOH is used for decontamination applications, a Dow-Corning antifoam agent is used in the evaporator vessel	No	Unknown
244-AR Lift Station	1975-Present *Active*	Transports waste from processing and decontamination operations	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
		Tanks and Vaults		
241-A-101 Single-Shell Tank	1956-1980 *Inactive*	PUREX carbonate wash waste, organic wash waste, high-level waste; B Plant high-level waste (Waste Fractionization); supernatant with B Plant high-level waste, PUREX high-level waste, double-shell slurry feed, and complexed and noncomplexed wastes from 241-A, -AX, -BX, -SX Tanks	No	Contains 3,602,340
241-A-102 Single-Shell Tank	1956-1980 *Inactive*	PUREX carbonate wash waste; PUREX high-level waste; B Plant high-level waste (Waste Fractionization); supernatant with PUREX high-level waste, B Plant high-level waste, PUREX sludge supernatant, evaporator waste, noncomplexed and complexed waste, and double-shell slurry feed from 241-A, -AX, -AY, -AZ, -BX, -C, and -SX Tank Farms and 244-AR Vault	No	Contains 154,980
241-A-103 Single-Shell Tank	1956-1980 *Inactive*	PUREX carbonate wash waste, organic wash waste, high-level waste; B Plant high-level waste (Waste Fractionization); Waste Fractionization ion exchange waste; and supernatant with B Plant high-level waste, Waste Fractionization ion exchange waste, PUREX high-level waste, PUREX sludge supernatant, and double-shell slurry feed from 241-A, -AX, -BY, and -C Tank Farms and 244-AR, -CR Vaults	Yes	Contains 1,398,600

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-A-104 Single-Shell Tank	1958-1975 *Inactive*	PUREX carbonate wash waste, organic wash waste, high-level waste; Waste Fractionization (B Plant) ion exchange waste; and supernatant with PUREX sludge supernatant from the 241-A Tank Farm and 244-AR Vault	Yes	Contains 105,840
241-A-105 Single-Shell Tank	1962-1971 *Inactive*	PUREX inorganic wash waste and supernatant with PUREX high-level waste from the 241-A Tank Farm	Yes	Contains 71,820
241-A-106 Single-Shell Tank	1957-1980 *Inactive*	PUREX organic and inorganic wash waste; PUREX carbonate wash waste; PUREX high-level waste; B Plant high-level waste; supernatant with PUREX high-level waste, B Plant high-level waste, and complexed concentrate from the 241-A Tank Farm, 244-AR Vault, and the B-302 Tanks	No	Contains 472,500
241-AN-101 Double-Shell Tank	1981-Present *Active*	100/300 Area customer waste; salt well liquor; dilute noncomplexed waste	No	Contains 2,074,406
241-AN-102 Double-Shell Tank	1981-Present *Active*	Dilute and concentrated complexant waste	No	Contains 4,145,026
241-AN-103 Double-Shell Tank	1981-Present *Active*	Salt well liquor and dilute noncomplexed waste	No	Contains 3,599,927
241-AN-104 Double-Shell Tank	1981-Present *Active*	Dilute noncomplexed waste and double-shell slurry feed	No	Contains 4,023,893
241-AN-105 Double-Shell Tank	1981-Present *Active*	Dilute noncomplexed waste and double-shell slurry feed	No	Contains 4,288,872
241-AN-106 Double-Shell Tank	1981-Present *Active*	Dilute and concentrated phosphate waste from 100-N Area	No	Contains 3,853,549

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-AN-107 Double-Shell Tank	1981-Present *Active*	Dilute and concentrated complexant wastes	No	Contains 4,076,888
241-AP-101 Double-Shell Tank	1986-Present *Active*	PUREX ammonia scrubber feed waste	No	Contains 4,023,893
241-AP-102 Double-Shell Tank	1986-Present *Active*	Dilute noncomplexed customer waste; unit is the Grout Treatment Facility feed tank	No	Contains 503,460
241-AP-103 Double-Shell Tank	1986-Present *Active*	PUREX ammonia scrubber feed	No	Contains 4,296,442
241-AP-104 Double-Shell Tank	1986-Present *Active*	Dilute noncomplexed waste; unit is designated as a receiver tank	No	Contains 75,708
241-AP-105 Double-Shell Tank	1986-Present *Active*	Double-shell slurry feed	No	Contains 3,126,750
241-AP-106 Double-Shell Tank	1986-Present *Active*	Neutralized cladding removal waste	No	Contains 4,288,872
241-AP-107 Double-Shell Tank	1986-Present *Active*	Unknown	No	Contains 4,266,159
241-AP-108 Double-Shell Tank	1986-Present *Active*	Unknown	No	Contains 700,301
241-AW-101 Double-Shell Tank	1980-Present *Active*	Double-shell slurry feed and dilute noncomplexed waste	No	Contains 4,258,588
241-AW-102 Double-Shell Tank	1980-Present *Active*	Unit is designated as the 241-A Evaporator feed tank	No	Contains 3,910,330
241-AW-103 Double-Shell Tank	1980-Present *Active*	PUREX decladding supernate and TRU sludge	No	Contains 2,449,161

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-AW-104 Double-Shell Tank	1980-Present *Active*	Double-shell slurry feed and dilute noncomplexed waste	No	Contains 4,262,374
241-AW-105 Double-Shell Tank	1980-Present *Active*	Supernate and TRU PUREX decladding sludge	No	Contains 3,418,227
241-AW-106 Double-Shell Tank	1980-Present *Active*	Unit is designated as the 241-A Evaporator receiver tank; waste may be complexed or noncomplexed waste	No	Contains 2,002,483
241-AX-101 Single-Shell Tank	1965-1980 *Inactive*	Fission product waste; PUREX organic wash waste; PUREX high & low-level waste; B Plant high-level waste (waste fractionization); and supernatant with fission product waste, PUREX sludge supernatant, organic wash waste, and double-shell slurry feed from 241-A and 241-AX Single-Shell Tanks	No	Contains 2,827,440
241-AX-102 Single-Shell Tank	1966-1980 *Inactive*	PUREX high & low-level wastes; PUREX organic wash waste; B Plant high-level waste (waste fractionization); and supernatant with PUREX high-level waste, complexant concentrate, B Plant high-level waste, and complexed waste from 241-A, -AX, and -C Tanks, 244-AR Vault, and TK-417	Yes	Contains 147,420
241-AX-103 Single-Shell Tank	1965-1980 *Inactive*	PUREX high & low-level wastes; PUREX organic and inorganic wash waste; B Plant low-level & high-level waste (waste fractionization); supernatant with PUREX high-level and sludge supernatant from 241-A, -AX, -AZ, and -C Tanks, 244-AR Vault, and AX-152 Tank	No	Contains 423,360

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-AX-104 Single-Shell Tank	1966-1976 *Inactive*	PUREX high & low-level wastes; PUREX organic and inorganic wash waste; B Plant high-level waste (waste fractionization); and supernatant with PUREX high-level and sludge supernatant waste from 241-A and -AX Tanks and 244-AR-002 Tank	Yes	Contains 26,460
241-AY-101 Double-Shell Tank	1971-Present *Active*	Sr and Cs depleted, neutralized, high-level waste from B Plant; dilute noncomplexed waste from single-shell tanks; dilute complexed waste; PUREX and b Plant high-level waste and supernatant with complexed waste from -A and -AX Tank Farms	No	Contains 3,384,158
241-AY-102 Double-Shell Tank	1972-Present *Active*	Neutralized high-level waste and double-shell slurry feed; dilute noncomplexed waste; supernatant with double-shell slurry feed and noncomplexed waste from -A and -BX Tank Farms	No	Contains 3,724,845
241-AZ-101 Double-Shell Tank	1976-Present *Active*	Dilute B Plant high-Sr waste; complexed waste; double-shell slurry feed, and noncomplexed waste; aging waste (NCAW) from PUREX; supernatant with complexed waste, double-shell slurry feed, and noncomplexed waste from the -A, -AX, -BX, and -C Tank Farms	No	Contains 3,675,635
241-AZ-102 Double-Shell Tank	1976-Present *Active*	Dilute B Plant high-Sr waste and complexed waste; aging waste (NCAW) from PUREX; supernatant with complexed waste from -AX Tank Farm	No	Contains 3,599,927
241-C-101 Single-Shell Tank	1946-1970 *Inactive*	Bismuth phosphate metal waste; tributyl phosphate waste and PUREX coating waste	Yes	Contains 332,640

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-C-102 Single-Shell Tank	1946-1976 *Inactive*	Bismuth phosphate metal waste; tributyl phosphate waste; PUREX coating waste; thorium high-level waste; PUREX organic wash waste; and supernatant with organic wash wastes and coating wastes from 241-A, -AX, and -C Single-Shell Tanks	No	Contains 1,614,060
241-C-103 Single-Shell Tank	1946-1979 *Inactive*	PUREX coating waste; tributyl phosphate; supernatant with tributyl phosphate waste, coating waste, PUREX high-level waste, B Plant high-level waste, B Plant waste fractionization low-level waste, PUREX sludge supernatant, PUREX low-level waste, waste fractionization, PUREX, sludge, PUREX organic wash waste, laboratory waste, decontamination waste, REDOX ion exchange waste, REDOX high-level waste, noncomplexed waste, waste fractionization ion exchange waste, N Reactor waste, PNL waste, and evaporator bottoms from 241-A, -B, -BX, and -C Tank Farms. This unit was used as the receiver for operating P-10 saltwater systems within the 241-C Farm	No	Contains 737,100

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-C-104 Single-Shell Tank	1946-1980 *Inactive*	PUREX coating waste; bismuth phosphate metal waste; PUREX low-level & high-level waste; thorium low-level & high-level waste; PUREX organic wash waste; supernatant containing metal waste, PUREX organic wash waste, PUREX low-level & high-level waste, coating waste, complexed waste, PNL waste, N Reactor complexed waste, waste fractionization exchange waste, decontamination waste, B Plant low-level & high-level waste, evaporator bottoms; REDOX high-level waste, and tributyl phosphate waste from 241-A, -AX, -C, -BY, -TY, and -U Tanks	No	Contains 1,115,100
241-C-105 Single-Shell Tank	1947-1979 *Inactive*	PUREX coating waste; tributyl phosphate waste; PUREX sludge supernatant; REDOX supernatant; and supernatant with tributyl phosphate waste, coating waste, PUREX sludge supernatant, REDOX supernatant, PUREX high-level waste, REDOX high-level waste, noncomplexed waste, B Plant waste fractionization low-level and metal wastes from 241-A, -AX, -AY, -B, -C, and -TX Tanks; and solids with PUREX sludge supernatant, coating waste, and cesium feet from 241-AX and -A Single-Shell Tanks	No	Contains 567,000
241-C-106 Single-Shell Tank	1947-1979 *Inactive*	PUREX coating waste; B Plant low-level waste (waste fractionization); supernatant with PUREX high-level waste, and tributyl phosphate waste from 241-A and -C Tank Farms; solids with PUREX sludge supernatant from 241-A Single-Shell Tank Farm	No	Contains 865,620

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-C-107 Single-Shell Tank	1946-1978 *Inactive*	Bismuth phosphate first-cycle waste; Hot Semiworks waste; tributyl phosphate; PUREX coating waste; Hanford Laboratory Operations waste; supernatant with PUREX coating waste, PNL waste, PNL waste, N Reactor waste, laboratory waste, decontamination waste, waste fractionization ion exchange waste, and evaporator bottoms waste from 241-C and -BX Tanks	No	Contains 1,273,860
241-C-108 Single-Shell Tank	1947-1976 *Inactive*	Bismuth phosphate first-cycle waste; Hot Semiworks waste; tributyl phosphate; PUREX coating waste; supernatant with tributyl phosphate waste, coating waste, PUREX organic wash waste, fractionization ion exchange waste, PNL waste; N Reactor waste, laboratory waste, decontamination waste, and REDOX high-level waste from 241-C Single-Shell Tank Farm	No	Contains 249,480
241-C-109 Single-Shell Tank	???-1976 *Inactive*	Bismuth phosphate first-cycle waste; Hot Semiworks waste; tributyl phosphate; PUREX coating waste; supernatant with PUREX coating waste, Hot Semiworks waste, evaporator bottoms, and ion exchange waste from 241-C Single-Shell Tank Farm	No	Contains 249,480
241-C-110 Single-Shell Tank	1946-1976 *Inactive*	Bismuth phosphate first-cycle waste; tributyl phosphate; supernatant with PUREX organic wash waste, ion exchange waste, coating waste, evaporator bottoms, and REDOX ion exchange waste	Yes	Contains 759,780

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-C-111 Single-Shell Tank	1946-1976 *Inactive*	Bismuth phosphate first-cycle waste; PUREX organic wash waste, tributyl phosphate waste, PUREX coating waste; evaporator bottoms; Hot Semiworks waste; and supernatant with evaporator bottoms, coating waste, and tributyl phosphate waste from 241-B and -C tanks	Yes	Contains 215,460
241-C-112 Single-Shell Tank	???-1976 *Inactive*	Tributyl phosphate waste; PUREX coating waste; Hot Semiworks waste; supernatant with coating waste, tributyl phosphate waste, and ion exchange waste from 241-C Single-Shell Tank Farm	No	Contains 393,120
241-C-201 Single-Shell Tank	1953-1977 *Inactive*	Bismuth phosphate metal waste and strontium Semiworks waste	Yes	Contains 7,560
241-C-202 Single-Shell Tank	1953-1977 *Inactive*	Bismuth phosphate metal waste; strontium Semiworks waste; supernatant with bismuth phosphate metal waste from 241-C-201 Single-Shell Tank	Yes	Contains 3,780
241-C-203 Single-Shell Tank	1953-1976 *Inactive*	PUREX high-level waste	Yes	Contains 18,900
241-C-204 Single-Shell Tank	1953-1977 *Inactive*	PUREX high-level waste	Yes	Contains 11,340
241-C-302A Catch Tank	1956-Present *Active*	Transports wastes from processing and decontamination operations	No	Contains 13,627
241-A-302B Catch Tank	1956-1980 *Inactive*	Transports wastes from processing and decontamination operations	No	Contains 12,247
241-A-350 Catch Tank	1956-Present *Active*	Transports wastes from processing and decontamination operations	No	Variable

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-A-417 Catch Tank	1956-Present *Active*	Collects condensate from the 241-A-401 Condenser House	No	Contains 120,431
241-A-152CT Catch Tank	???-Present *Active*	Transports wastes from processing and decontamination operations	No	Contains 10,040
241-C-301C Catch Tank	1946-1985 *Active*	Transports wastes from processing and decontamination operations	No	Contains 120,600
244-A Receiving Vault	1975-Present *Active*	This unit receives waste from several tank farms	No	Contains 13,956
244-AR Vault	1977-Present *Active*	Transports wastes from processing and decontamination operations	Yes	Variable
244-CR Vault	1988-Present *Active*	Transports wastes from processing and decontamination operations	No	Variable
Cribs and Drains				
216-A-1 Crib	1955-1966 *Inactive*	Depleted uranium waste from cold startup run in the 202-A Building	Yes	98,400
216-A-2 Crib	1956-1964 *Inactive*	Organic wastes from 202-A Building	Yes	230,000
216-A-3 Crib	1956-1982 *Inactive*	Received waste from 203-A Building, uranyl nitrate hexahydrate storage pit drainage liquid from 203-A Pump House	Yes	3,050,000
216-A-4 Crib	1955-1958 *Inactive*	Laboratory cell drainage from 201-A Building and 291-A-1 Stack drainage	Yes	6,210,000
216-A-5 Crib	1955-1966 *Inactive*	Process condensate from 202-A Building	Yes	1,630,000,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-6 Crib	1955-1970 *Inactive*	Steam condensate, equipment disposal tunnel floor drainage, water-filled door drainage, and waste from 202-A Building	Yes	3,400,000,000
216-A-7 Crib	1955-1966 *Inactive*	Catch tank overflow, sump waste, pump pit drainage from the 241-A-152 Diversion Box, TBP-Soltrol organic inventory from 202-A Building	Yes	326,000
216-A-8 Crib	1955-1991 *Inactive*	Condensate from 241-A, -AX, -AY, -AZ Tank Farms, cooling water from the contact condenser in the 241-A-431 Building	Yes	1,150,000,000
216-A-9 Crib	1956-1969 *Inactive*	Acid fractionator condensate and cooling water from 202-A Building; N Reactor decontamination waste, acid fractionator condensate from 202-A Building	Yes	981,000,000
216-A-10 Crib	1956-1987 *Inactive*	Nonradioactive water, process condensate from 201-A Building	Yes	3,210,000,000
216-A-21 Crib	1957-1965 *Inactive*	Sump waste from 293-A Building, laboratory cell drainage from the 202-A Building, 291-A-1 Stack drainage	Yes	77,900,000
216-A-24 Crib	1958-1966 *Inactive*	Condensate from 241-A and -AX Single-Shell Tank Farms	Yes	820,000,000
216-A-27 Crib	1965-1970 *Inactive*	Sump waste from 293-A Building, lab cell drainage from 202-A Building, 291-A-1 Stack drainage	Yes	23,200,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-30 Crib	1961-1991 *Inactive*	Steam condensate, equipment disposal tunnel floor and water-filled door drainage, and slug storage basin overflow waste from the 202-A Building	Yes	7,110,000,000
216-A-31 Crib	1964-1966 *Inactive*	Organic waste from 202-A Building	Yes	10,000
216-A-32 Crib	1959-1966 *Inactive*	202-A crane maintenance facility floor, sink and shower drainage	Yes	4,000
216-A-36A Crib	1965-1966 *Inactive*	Ammonia scrubber waste from 202-A Building	Yes	1,070,000
216-A-36B Crib	1966-1987 *Inactive*	Ammonia scrubber waste from 202-A Building	Yes	317,000,000
216-A-37-1 Crib	1977-1991 *Inactive*	Process condensate from 241-A Evaporator	Yes	377,000,000
216-A-37-2 Crib	1983-Present *Active*	Steam condensate from PUREX Plant	Yes	1,090,000,000
216-A-38-1 Crib	Not used	The site was never used	No	0
216-A-39 Crib	1966 *Inactive*	Floor drainage from 241-AX-801-B Building	Yes	20
216-A-41 Crib	1968-1974 *Inactive*	296-A-13 Stack drainage	Yes	10,000
216-A-45 Crib	1987-1989 *Inactive*	Process condensate from 202-A Building	Yes	103,000,000
216-A-11 French Drain	1956-1972 *Inactive*	Trap Pit No. 1 drainage from 202-A Building	Yes	100,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-12 French Drain	1955-1972 *Inactive*	Steam trap Pit No. 3 drainage from 202-A Building	Yes	100,000
216-A-13 French Drain	1956-1962 *Inactive*	Seal water from air sampler vacuum pumps in 202-A Building	Yes	100,000
216-A-14 French Drain	1956-1972 *Inactive*	Vacuum cleaner filter and blower pit drainage from 202-A Building	Yes	1,000
216-A-15 French Drain	1955-1972 *Inactive*	Drainage from 216-A-10 Process Condenser Sampler Pit	Yes	10,000,000
216-A-16 French Drain	1956-1968 *Inactive*	Floor drainage and 296-A-11 Stack drainage from 241-A-431 Building	Yes	122,000
216-A-17 French Drain	1956-1969 *Inactive*	Floor drainage and 296-A-11 Stack drainage from 241-A-431 Building drainage from 241-A-431 Building	Yes	60,000
216-A-22 French Drain	1956-1957 *Inactive*	Drainage from 203-A Building truck layout apron, sump waste from 203-A Building enclosure	Yes	10,000
216-A-23A French Drain	1957-1969 *Inactive*	Deentrainer tank condensate, backflush waste from 241-A-431 Building	Yes	6,000
216-A-23B French Drain	1957-1969 *Inactive*	Deentrainer tank condensate, backflush waste from 241-A-431 Building	Yes	6,000
216-A-26 French Drain	1965-1991 *Inactive*	Floor drainage from the 291-A Fan Control House	Yes	Unknown
216-A-26A French Drain	1959-1965 *Inactive*	Floor drainage from the 291-A Fan Control House	Yes	1,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-28 French Drain	1958-1966 *Inactive*	203-A Building enclosure sumps, heating coil condensate from uranyl nitrate hexahydrate tanks	Yes	30,000
216-A-33 French Drain	1955-1964 *Inactive*	Did not receive any waste	No	0
216-A-35 French Drain	1963-1966 *Inactive*	Seal cooling water from air sampler vacuum pumps in 202-A Building	Yes	10,000
216-C-8 French Drain	1962-1965 *Inactive*	Ion exchange waste from 271-CR Building	Yes	10,000
Reverse Wells				
299-E24-111 Injection Well	1980-1982 *Inactive*	Experimental well, 11 injections of calcium, chloride, solutions	Yes	0[c/]
Ponds, Ditches, and Trenches				
216-A-18 Trench	1955-1956 *Inactive*	Depleted uranium from the cold startup run at 202-A Building	Yes	488,000
216-A-19 Trench	1955-1956 *Inactive*	241-A-431 Building contact condenser cooling water, depleted uranium waste from cold startup run at 202-A Building	Yes	1,100,000
216-A-20 Trench	1955-1956 *Inactive*	241-A-431 Building contact condenser cooling water, depleted uranium waste from cold startup run at 202-A Building	Yes	961,000
216-A-40 Trench	1968-1979 *Inactive*	Diverted cooling water and steam condensate from 244-AR Vault	Yes	946,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-29 Ditch	1955-1991 *Inactive*	202-A chemical sewer, acid fractionator condensate, condenser cooling water, process cooling water, seal cooling water from air sampler vacuum pumps in 202-A Building	Yes	10,400,312
216-A-34 Ditch	1955-1957 *Inactive*	Cooling water from contact condenser in 241-A-431 Building	Yes	Unknown
Septic Tanks and Associated Drain Fields				
2607-EA Septic Tank & Field	1976-Present *Active*	Sanitary wastewater and sewer	Yes	60/day
2607-EC Septic Tank & Field	1955-Present *Active*	Sanitary wastewater and sewer	Yes	450/day
2607-ED Septic Tank & Field	1980-Present *Active*	Sanitary wastewater and sewer	Yes	280/day
2607-EG Septic Tank & Field	1953-Present *Active*	Sanitary wastewater and sewer	Yes	170/day
2607-EJ Septic Tank & Field	1980-Present *Active*	Sanitary wastewater and sewer	Yes	320/day
2607-EL Septic Tank & Field	1983-Present *Active*	Sanitary wastewater and sewer	Yes	7,900/day
2607-E6 Septic Tank & Field	1954-Present *Active*	Sanitary wastewater and sewer	Yes	43,500/day
Transfer Facilities, Diversion Boxes, and Pipelines				
241-A-A Diversion Box	1956-Present *Active*	Transports waste from processing and decontamination operations	No	Variable

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-A-B Diversion Box	1956-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-A-151 Diversion Box	1956-Present *Active*	Transports waste from processing and decontamination operations	Yes	Variable
241-A-152 Diversion Box	1956-1980 *Inactive*	Transports waste from processing and decontamination operations	No	Variable
241-A-153 Diversion Box	1956-1985 *Inactive*	Transports waste from processing and decontamination operations	No	Variable
241-AN-A Diversion Box	1981-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AN-B Diversion Box	1981-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AR-151 Diversion Box	1983-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AW-A Diversion Box	1980-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AW-B Diversion Box	1980-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AX-A Diversion Box	1965-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AX-B Diversion Box	1965-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AX-151 Diversion Box	???-Present *Active*	Receives wastes from 202-A PUREX plant	No	Variable

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-AX-152DS Diversion Box	1965-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AX-155 Diversion Box	1983-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AY-151 Diversion Box	???-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AY-152 Diversion Box	1985-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AZ-151DS Diversion Box	1976-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AZ-152 Diversion Box	1977-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-C-151 Diversion Box	1946-1985 *Active*	Transports waste from processing and decontamination operations	No	Variable
241-C-152 Diversion Box	1946-1985 *Active*	Transports waste from processing and decontamination operations	Yes	Variable
241-C-153 Diversion Box	1946-1985 *Inactive*	Transports waste from processing and decontamination operations	No	Variable
241-C-252 Diversion Box	1946-1985 *Inactive*	Transports waste from processing and decontamination operations	No	Variable
241-CR-151 Diversion Box	1946-1985 *Inactive*	Transports waste from processing and decontamination operations	Yes	Variable
241-CR-152 Diversion Box	1946-1985 *Inactive*	Transports waste from processing and decontamination operations	No	Variable

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-CR-153 Diversion Box	1946-1985 *Inactive*	Transports waste from processing and decontamination operations	No	Variable
241-ER-153 Diversion Box	1945-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
216-A-524 Control Structure	1957-1966 *Inactive*	Unit contains radioactive piping and cement	No	Variable
241-AP Valve Pit	1986-Present *Active*	Transports waste from processing and decontamination operations	No	Variable
241-AX-501 Valve Pit	???-Present *Active*	Receives and routes tank farm condensate	No	Variable
Basins				
207-A Retention Basins	1976-Present *Active*	Waste streams from the 242-A Evaporator	No	Variable
216-A-42 Retention Basin	1978-Present *Active*	Chemically or radioactively contaminated diversions from the PUREX chemical sewer line, cooling water line, and steam condensate discharge	No	Variable
Burial Sites and Burning Pits				
218-E-1 Burial Ground	1945-1954 *Inactive*	Mixed fission products and transuranic dry waste	No	3,030 m^3
218-E-8 Burial Ground	1958-1959 *Inactive*	Mixed fission products and transuranic waste, repair and construction wastes from 293-A and PUREX new crane addition	No	2,265 m^3
218-E-12A Burial Ground	1953-1968 *Inactive*	Dry waste and acid-soaked material	No	15,249 m^3

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
218-E-12B Burial Ground	1966-Present *Active*	Navy reactor subcomponents	No	Unknown
218-E-13 Burial Ground	1966 *Inactive*	Pieces of concrete from pipe trench	No	184 m^3
200-E-Burning Pit	1950-1970 *Inactive*	Radioactive waste	No	1,500 m^3
Unplanned Releases				
UN-200-E-10	1957	PUREX tube bundles	No	Unknown
UN-200-E-11	1957	Spots along railroad tracks of unknown origin	No	Unknown
UN-200-E-12	1957	Contaminated liquid from a burial box	Yes	Unknown
UN-200-E-13	1958	216-A-4 Crib became plugged and flooded ground	Yes	Unknown
UN-200-E-15	1959	216-A-4 Crib became plugged causing ground contamination	Yes	Unknown
UN-200-E-16	1959	241-C-105 to 241-C-108 overground transfer line broke	Yes	Unknown
UN-200-E-18	1959	Moisture from vent pipe bonnet at the A-8 Proportional Sample Pit	Yes	Unknown
UN-200-E-19	1959	Moisture from vent pipe bonnet at the A-6 Proportional Sample Pit	Yes	Unknown
UN-200-E-20	1959	PUREX tube bundles	No	Unknown
UN-200-E-22	1959	General contamination around 291-A Stack	No	Unknown
UN-200-E-25	1960	Leakage from 241-A-151 Diversion Box	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UN-200-E-26	1960	Leakage from 241-A-151 Diversion Box	Yes	Unknown
UN-200-E-27	1960	Near the 244-CR Vault	No	Unknown
UN-200-E-28	1961	Fission products from a process vessel steam coil	Yes	Unknown
UN-200-E-31	1961	Leakage from 241-A-151 Diversion Box	Yes	Unknown
UN-200-E-33	1964	Leaking tube bundle burial box	Yes	Unknown
UN-200-E-35	1966	Contaminated concrete	No	Unknown
UN-200-E-39	1968	Pressurized ammonia scrubber waste containing fission products	No	Unknown
UN-200-E-40	1968	Vent line valve at the 216-A-36B Crib	No	Unknown
UN-200-E-42	1972	Thought to be from 244-AR Diverter Tank	No	Unknown
UN-200-E-47	1974	Contaminated soil of unknown origin in 241-A Tank Farm	No	Unknown
UN-200-E-48	1974	241-A-106 pump pit contaminated parking lot	No	Unknown
UN-200-E-49	1975	Thermocouple well contaminated road	No	Unknown
UN-200-E-56	1979	Unknown	No	Unknown
UN-200-E-58	1980	Contaminated tumbleweeds near 218-E-1 Burial Ground	No	Unknown
UN-200-E-60	1981	Contaminated dirt from an overfilled dump truck	No	Unknown
UN-200-E-62	1982	Liquid from pressure test assembly	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UN-200-E-65	1982	Wind spread contamination from 241-A-151 Diversion Box	No	Unknown
UN-200-E-67	1984	An old, contaminated pipe encasement	No	Unknown
UN-200-E-68	1985	Wind spread contamination from 241-C-151 Diversion Box	No	Unknown
UN-200-E-72	1985	Previously buried contaminated waste of unspecified origin	No	Unknown
UN-200-E-81	1969	PUREX coating waste via the transfer line from the 202-A Building to the 102-C waste storage tank via 241-CR-151 Diversion Box	Yes	136,274
UN-200-E-82	1969	Feed line from 241-C-105 Tank to the 221-B Building	Yes	9,842
UN-200-E-86	1971	Line no. 812, used to transfer process waste from AR Vault to C Farm	Yes	Unknown
UN-200-E-88	1980	Unknown, associated with TC-4 railroad spur	No	Unknown
UN-200-E-91	1980	Migration of low-level radioactivity from 241-C Tank Farm	No	Unknown
UN-200-E-94	1979	Possible moisture from 216-A-24 Crib	No	Unknown
UN-200-E-96	1980	Residue contamination from PUREX 291-A Stack and Diversion Box	No	Unknown
UN-200-E-97	1980	Unknown source south of PUREX near railroad tunnel	No	Unknown
UN-200-E-99	1980	Near the 244-CR Vault	Yes	Unknown
UN-200-E-100	1986	Spill to ground	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UN-200-E-107	1952	Tributyl phosphate from 221-U Building	Yes	Unknown
UN-200-E-114	1974	Value Pit outside the 202-A Building	No	Unknown
UN-200-E-117	1972	Liquid spurting out of ground near PUREX area	Yes	Unknown
UN-200-E-118	1957	107-C effluent tank released airborne contamination	No	Unknown
UN-200-E-142	1986	Diesel fuel	Yes	76
UPR-200-E-17	1959	Uranium from 216-A-22 Crib	Yes	Unknown
UPR-200-E-21	1959	216-A-6 Crib overflowed contaminating ground	Yes	Unknown
UPR-200-E-24	1960	Collapse of burial box of 218-E-12A	No	Unknown
UPR-200-E-29	1961	216-A-6 Crib overflowed	Yes	Unknown
UPR-200-E-30	1961	Collapse of burial box at 218-E-12A	No	Unknown
UPR-200-E-50	1974	Wind spread contamination from 241-C Tank Farm	No	Unknown
UPR-200-E-53	1978	Contamination spread by uncovering previously buried waste at the 218-E-1 Burial Ground	No	Unknown
UPR-200-E-59	1979	Contaminated mud and tumbleweeds from 216-A-40 Trench used by swallows to build nests at 244-AR Vault	No	Unknown
UPR-200-E-66	1984	Wind spread contamination from 216-A-42 Retention Basin	No	Unknown
UPR-200-E-70	1984	Contamination during a jumper removal at 244-A Lift Station	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UPR-200-E-106	1946	Contaminated paper towels	No	Unknown
UPR-200-E-115	1974	Liquid from AX-103 Pump Pit	Yes	Unknown
UPR-200-E-119	1969	High-level waste	No	Unknown
UPR-200-E-125	1975	Waste from the 241-A-104 Single-Shell Tank	Yes	9,450
UPR-200-E-126	1963	241-A-105 Single-Shell Tank	Yes	18,900
UPR-200-E-136	1946-1970	241-C-101 Single-Shell Tank	Yes	64,260 to 90,720
UPR-200-E-137	1947-1978	241-C-203 Single-Shell Tank	Yes	1,512
B Plant Aggregate Area Tanks and Vaults				
241-B-101 Single-Shell Tank	May 1945-1974	$Bi(PO)_4$ metal waste; PUREX coating waste: B Plant high-level waste (Cell 23); evaporator bottoms from 241-B tanks	Yes	Contains 428,000
241-B-102 Single-Shell Tank	Oct 1945-1978	$Bi(PO)_4$ metal waste; PUREX coating waste; supernatant containing B Plant low-level, ion exchange, evaporator bottoms	No	Contains 110,000
241-B-103 Single-Shell Tank	Dec 1953-1977	$Bi(PO)_4$ metal waste; PUREX coating waste; B Plant low level waste, ion exchange, evaporator bottoms, N Reactor, organic wash, PNL, REDOX high-level waste, coating waste, decon, tributyl phosphate and lab waste	Yes	Contains 223,000
241-B-104 Single-Shell Tank	Aug 1946-1972	$Bi(PO)_4$ 2-C and 1-C; evaporator bottoms from 241-B Tanks	No	Contains 1,404,000
241-B-105 Single-Shell Tank	Jan 1947-1972	$Bi(PO)_4$ 2-C and 1-C; flush water containing evaporator bottoms from 241-B Tanks	No	Contains 1,580,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-B-106 Single-Shell Tank	Sept 1947-1977	$Bi(PO)_4$ 2-C and 1-C; Hanford Lab operations, evaporator bottoms, tributyl phosphate waste, 224-U waste, PNL, B Plant low-level, ion exchange	No	Contains 443,000
241-B-107 Single-Shell Tank	May 1945-1969	PUREX coating waste, $Bi(PO)_4$ 1-C and 2-C, evaporator bottoms	Yes	Contains 625,000
241-B-108 Single-Shell Tank	1945-1977	$Bi(PO)_4$ 1-C and 2-C, PUREX coating waste, evaporator bottoms, ion exchange from 241-B and -BY Tank Farms	No	Contains 356,000
241-B-109 Single-Shell Tank	Jan 1946-1977	$Bi(PO)_4$ 1-C, PUREX coating waste, evaporator bottoms, ion exchange 224-U waste, coating waste from 241-B, -BY, -S Tank Farms	No	Contains 481,000
241-B-110 Single-Shell Tank	May 1945-1971	$Bi(PO)_4$ 2-C and 1-C, fission product waste, B Plant high-level waste fractionization, B Plant Cells 5 and 6; B Plant flushes, ion exchange	Yes	Contains 931,000
241-B-111 Single-Shell Tank	Nov 1945-1976	$Bi(PO)_4$ 2-C, fission product waste, ion exchange (waste fractionization), B Plant Cells 5 and 6	Yes	Contains 897,000
241-B-112 Single-Shell Tank	April 1946-1977	$Bi(PO)_4$ 2-C, fission product waste, evaporator bottoms from 241-B and -BX B Plant Cells 5 and 6, ion exchange	Yes	Contains 125,000
241-B-201 Single-Shell Tank	1952-1971	224-U wastes (lanthanum fluoride)	Yes	Contains 110,000
241-B-202 Single-Shell Tank	1951-1977	224-U wastes (lanthanum fluoride), B Plant high-level waste	No	Contains 102,000
241-B-203 Single-Shell Tank	1951-1977	224-U wastes (lanthanum fluoride)	Yes	Contains 193,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-B-204 Single-Shell Tank	1951-1977	224-U wastes (lanthanum fluoride), B Plant flushes	Yes	Contains 189,000
241-B-301B Catch Tank	1945-June 1984	Processing and decon wastes	No	Variable
241-B-302B Catch Tank	1945-July 1985	Processing and decon wastes	No	Variable
241-B-361 Settling Tank	April 1945-Sep 1947	Low salt, alkaline radioactive from cell washings collected in 5-6W Cell in 221-B and from 224-B. Solids primarily $Bi(PO)_4$	No	Contains 121,000
241-BX-101 Single-Shell Tank	Jan 1948-1972	$Bi(PO)_4$ metal waste; B Plant low-level waste, ion exchange (waste fractionization), evaporator bottoms, N Reactor, organic wash, REDOX ion exchange waste, tributyl phosphate and coating waste	Yes	Contains 163,000
241-BX-102 Single-Shell Tank	June 1948-1971	$Bi(PO)_4$ metal waste, diatomaceous earth, tributyl phosphate, metal, and coating waste, B Plant low level, evaporator bottoms	Yes	Contains 363,000
241-BX-103 Single-Shell Tank	Sept 1948-1977	$Bi(PO)_4$ metal waste; PUREX high- and low-level waste and sludge supernatant; exchange, evaporator bottoms, N Reactor, organic wash, PNL, REDOX ion exchange waste, coating waste, decon, tributyl phosphate and lab waste, B Plant low-level	Yes	Contains 250,000
241-BX-104 Single-Shell Tank	1949-1980	$Bi(PO)_4$ metal waste; PUREX coating waste, ion exchange (waste fractionization) evaporator bottoms, REDOX high-level, complexed and noncomplexed waste, double-shell slurry feed, tributyl phosphate and lab waste, B Plant low-level, ion exchange	No	Contains 374,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-BX-105 Single-Shell Tank	1949-1980	$Bi(PO)_4$ metal waste, tributyl phosphate waste, coating, ion exchange waste; evaporator bottoms, complexed and noncomplexed waste, double-shell slurry feed	No	Contains 193,000
241-BX-106 Single-Shell Tank	1949-1977	$Bi(PO)_4$ metal waste, tributyl phosphate waste, coating, ion exchange waste; evaporator bottoms, B Plant low-level, organic wash, REDOX ion exchange waste from 241-B, -BX, and -BY tanks	No	Contains 174,000
241-BX-107 Single-Shell Tank	Sept 1948-1977	$Bi(PO)_4$ 1-C, tributyl phosphate waste, ion exchange waste from the 241-BX Tank Farm	No	Contains 133,000
241-BX-108 Single-Shell Tank	1949-1974	$Bi(PO)_4$ 1-C, tributyl phosphate waste, coating, ion exchange waste from the 241-BX and -C Tanks	Yes	Contains 98,000
241-BX-109 Single-Shell Tank	1950-1974	$Bi(PO)_4$ 1-C; ion exchange (waste fractionization), tributyl phosphate waste, tributyl phosphate waste from the 241-BY and -C Tanks	No	Contains 731,000
241-BX-110 Single-Shell Tank	1949-1977	$Bi(PO)_4$ 1-C, ion exchange (waste fractionization), tributyl phosphate waste, evaporator bottoms, coating waste, B Plant 1-C from the 241-B and -C Tank Farms. It is an ITS-2 Unit	Yes	Contains 753,000
241-BX-111 Single-Shell Tank	1950-1977	$Bi(PO)_4$ 1-C, ITS-2 bottoms and recycle systems, evaporator bottoms, coating waste, ion exchange waste, 1-C from the 241-BY Tanks	Yes	Contains 870,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-BX-112 Single-Shell Tank	1950-1977	Ion exchange (waste fractionization), evaporator bottoms, coating waste, 1-C from the 241-C Tanks	No	Contains 625,000
241-BX-302A Catch Tank	1948-July 1985	Processing and decon wastes	No	Variable
241-BX-302B Catch Tank	1948-July 1985	Processing and decon wastes	No	Variable
241-BX-302C Catch Tank	1948-July 1985	Processing and decon wastes	No	Variable
241-BY-101 Single-Shell Tank	Jan 1950-1971	$Bi(PO)_4$ metal waste, tributyl phosphate waste, evaporator bottoms from the 241-BY and -C Tank Farms. This is an ITS-2 Unit	No	Contains 1,465,000
241-BY-102 Single-Shell Tank	1950-1977	$Bi(PO)_4$ metal waste, tributyl phosphate and coating waste, evaporator bottoms from the 241-BX, -BY and -C farms. This is an ITS-2 Unit	No	Contains 1,291,000
241-BY-103 Single-Shell Tank	Nov 1950-May 1973	$Bi(PO)_4$ metal waste, PUREX coating waste, evaporator bottoms, coating and tributyl phosphate waste, PUREX high-level and organic wash wastes from 241-BX, -BY, -C, and -B Tanks. This is an ITS-2 Unit	Yes	Contains 1,514,000
241-BY-104 Single-Shell Tank	1950-1977	$Bi(PO)_4$ metal waste, tributyl phosphate and coating waste, evaporator bottoms from the 241-BX, -BY and -C Tank Farms, and ion exchange waste. This is an ITS-2 Unit	No	Contains 1,536,000
241-BY-105 Single-Shell Tank	June 1951-1974	tributyl phosphate waste, $Bi(PO)_4$ metal waste and coating waste, evaporator bottoms from the 241-BY and -C Tank Farms, concrete. This is an ITS-2 Unit	Yes	Contains 1,904,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-BY-106 Single-Shell Tank	1953-1977	I-C and $Bi(PO)_4$ 1-C waste, tributyl phosphate waste, coating waste, evaporator bottoms from 241-BY and -C Tank Farms. It is an ITS-2 Unit	Yes	Contains 2,430,000
241-BY-107 Single-Shell Tank	December 1950-1974	tributyl phosphate waste, $Bi(PO)_4$ 1-C waste and coating waste, evaporator bottoms from the 241-BY and -C Tank Farms. This is an ITS-2 Unit	Yes	Contains 1,007,000
241-BY-108 Single-Shell Tank	April 1951-1972	$Bi(PO)_4$ 1-C waste, evaporator bottoms from the 241-BY and -C Tank Farms. This is an ITS-2 Unit	Yes	Contains 863,000
241-BY-109 Single-Shell Tank	1953-1979	Supernatant containing tributyl phosphate waste, PUREX coating waste, $Bi(PO)_4$ metal waste, evaporator bottoms, PUREX organic wash waste from the 241-B, -BX, -BY, and -C Tank Farms. This is an ITS-2 Unit	No	Contains 1,601,000
241-BY-110 Single-Shell Tank	1952-1979	$Bi(PO)_4$ 1-C waste, tributyl phosphate waste, evaporator bottoms, coating waste from the 241-BY and -C Tank Farms, and the WR-241 Tank	No	Contains 1,507,000
241-BY-111 Single-Shell Tank	1952-1977	$Bi(PO)_4$ metal waste, tributyl phosphate waste, PUREX coating waste, organic wash waste, evaporator bottoms, coating waste, and organic was waste from the 241-BY and -C Tank Farms. This is an ITS-2 Unit.	No	Contains 1,737,000
241-BY-112 Single-Shell Tank	1951-1976	$Bi(PO)_4$ metal waste, tributyl phosphate waste, coating waste, evaporator bottoms from the 241-B, -BX, -BY, and -C Tank Farms. This is an ITS-2 Unit	No	Contains 1,102,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
244-BXR Receiving Vault	1948-July 1985	Process and decon wastes	No	Variable
241-ER-311 Catch Tank	1945-present/*active*	Process and decon wastes	Yes	Variable
270-E Cond. Neutralization Tank	1952-1976	Sludge	No	Contains 14,000
Cribs and Drains				
216-B-7A & B Crib	Oct 1946-May 1967	224-B via overflow from 201-B Tank, cell drainage from Tank 5-6 in 221-B, equipment cleanout waste from 224-B, decon and construction waste from 221-B	Yes	43,600,000
216-B-8TF Crib and Tile Field	April 1948-July 1953	2-C supernatant from 221-B, cell drainage and other waste from Tank 5-6, decon and cleanup waste generated i shutdown of 224-B	Yes	27,200,000
216-B-9TF Crib and Tile Field	Aug 1948-July 1951	Cell drainage and other liquid waste via Tank 5-6 in 221-B	Yes	36,000,000
216-B-10A Crib	Dec 1949-Jan 1952	Decon sink and sample slurper waste from 222-B and floor drainage from 292-B	Yes	9,990,000
216-B-10B Crib	June 1969-Oct 1973	Decon sink and shower waste from 221-B, overflow from 216-10A	Yes	28,000
216-B-12 Crib	Nov 1952-Nov 1973	Process condensate from 221-U and 224-U waste evaporators, construction waste from 221-B and process condensate from 221-B	Yes	520,000,000
216-B-14 Crib	Jan 1956-Feb 1956	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	8,710,000
216-B-15 Crib	April 1956-Dec 1956	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	6,320,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-B-16 Crib	April 1956-Aug 1956	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	5,600,000
216-B-17 Crib	Jan 1956-Jan 1956	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	3,410,000
216-B-18 Crib	March 1956-April 1956	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	8,520,000
216-B-19 Crib	Feb 1957-Oct 1957	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	6,400,000
216-B-43 Crib	Nov 1954	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	2,120,000
216-B-44 Crib	Nov 1954-March 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	5,600,000
216-B-45 Crib	April 1955-June 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	4,920,000
216-B-46 Crib	Sept 1955-Dec 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	6,700,000
216-B-47 Crib	Sept 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	3,710,000
216-B-48 Crib	Nov 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	4,090,000
216-B-49 Crib	Nov 1955-Dec 1955	Scavenged tributyl phosphate supernatant from 221-U during uranium recovery operations	Yes	6,700,000
216-B-50 Crib	Jan 1965-Jan 1974	Waste storage tank condensate from the ITS-1 unit in the 241-BY Tank Farms	Yes	54,800,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-B-55 Crib	Sept 1967-present *Active*	Steam condensate from 221-B	Yes	1,230,000,000
216-B-56 Crib	Not Used	Waste storage tank condensate from the ITS-2 unit in the 241-BY Tank Farm	No	0
216-B-57 Crib	Feb 1968-June 1973	Waste storage tank condensate from the ITS-2 unit in the 241-BY Tank Farm	Yes	84,400,000
216-B-60 Crib	Nov 1967	Cell cleanout solid and liquid waste from the 24 in. sewer in 221-B	Yes	18.9 m^3
216-B-61 Crib	Not Used	Not used	No	0
216-B-62 Crib	Nov 1973-present *Active*	Process condensate from the 221-B Separations Facilities	Yes	282,000,000
Chem TF North of 2703-E	Unknown	Mixed Waste	Yes	Unknown
216-B-13 French Drain	Aug 1947-June 1976	291-B stack drainage	Yes	28,000
216-B-51 French Drain	Jan 1956-Jan 1958	Flush drainage from the BC Crib pipeline	Yes	1,000
Reverse Wells				
216-B-4 Reverse Well	April 1945-Dec 1949	291-B stack drainage and floor drainage from 292-B	Yes	10,000
216-B-5 Reverse Well	April 1945-Oct 1947	Supernatant overflow from the 216-B-361 settling tank waste via Tank 5-6 in 221-B and liquid waste from 224-B. Cell drainage and other liquid waste via Tank 5-6 in 221-B	Yes	30,600,000
216-B-6 Reverse Well	April 1945-Dec 1949	Decontamination sink and sample slurper waste from 222-B	Yes	6,000,000
216-B-11A & -11B Rev. Well	Dec 1951-Dec 1954	Process condensate from the 242-B Evaporator	Yes	29,600,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
Ponds, Ditches, and Trenches				
216-B-3 Pond	April 1945-Present *Active*	221-B steam condensate and process cooling water, 284-E Powerhouse water, 244-CR, -AR, and 242-A cooling water, 202-A process, condenser, and air sampler vacuum pump cooling water, 202-A chem sewer, fractionator condensate, WESF cooling water	Yes	240,000,000,000
216-B-3A Pond	Oct 1983-Present *Active*	221-B steam condensate and process cooling water, 284-E Powerhouse water, 244-CR, -AR, and 242-A cooling water, 202-A process, condenser, and air sampler vacuum pump cooling water, 202-A chem sewer, fractionator condensate, WESF cooling water	Yes	Not reported
216-B-3B Pond	June 1984-present *Active*	221-B steam condensate and process cooling water, 284-E Powerhouse water, 244-CR, -AR, and 242-A cooling water, 202-A process, condenser, and air sampler vacuum pump cooling water, 202-A chem sewer, fractionator condensate, WESF cooling water	Yes	Not reported
216-B-3C Pond	1985-present *Active*	221-B steam condensate and process cooling water, 284-E Powerhouse water, 244-CR, -AR, and 242-A cooling water, 202-A process, condenser, and air sampler vacuum pump cooling water, 202-A chem sewer, fractionator condensate, WESF cooling water	Yes	Not reported
216-E-28 Contingency Pond	Constructed in 1986; never used	Emergency diversion pond for the 216-B-3 Pond system	No	0

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-A-25 Pond	Dec 1957-1987	Process cooling water from 202-A, contact condenser cooling water from 241-A-431, surface condenser cooling water from 241-A-401, 284-E Powerhouse wastewater, cooling water and steam condensate from 244-AR Vault, 242-A steam condensate cooling water and B Plant cooling water	Yes	307,000,000,000
216-N-8 Pond	1958-1987	Sewage sludge from Hanford construction camp	Yes	Unknown
2101-M Pond	1983-present *Active*	Swamp-cooler condensate and overflow drain wastewater from the 2101-M air conditioning system. Barium chloride lab waste solution, nitric and hydrochloric acid. Waste from the BWIP laboratory.	Yes	Not reported
216-B-2-1 Ditch	April 1945-Nov 1963	Steam condensate, process cooling water, chem sewer from 221-B waste, 241-CR vault cooling water	Yes	149,000,000,000
216-B-2-2 Ditch	Nov 1963-May 1970	Steam condensate, process cooling water, chem sewer from 221-B waste, 241-CR vault cooling water, ITS-1 and -2 cooling water, cleanup waste from 207-B Retention Basin	Yes	49,700,000
216-B-2-3 Ditch	1970-1987	221-B cooling water, 241-CR vault cooling water, condenser cooling water from ITS-1 and -2 cooling water	Yes	Not reported
216-B-3-1 Ditch	April 1945-July 1964	Steam condensate, process cooling water, chem sewer from 221-B waste, 284-E Powerhouse waste, 241-CR vault cooling water, 202-A acid fractionator condensate, 202-A air sampler vacuum pumps seal cooling water, 283-E water treatment	Yes	149,000,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-B-3-2 Ditch	July 1964-Sept 1970	Steam condensate, process cooling water, chem sewer from 221-B waste, 284-E Powerhouse waste, 241-CR vault cooling water, 202-A acid fractionator condensate, 202-A air sampler vacuum pumps seal cooling water, ITS-1 condenser cooling water, 283-E water treatment	Yes	149,000,000
216-B-3-3 Ditch	Sept 30, 1970-present *Active*	221-B cooling water, 202-A chem sewer, ITS-1 and -2 cooling water, 244-CR cooling water, 244-AR vault water, 242-A cooling water and steam condensate	Yes	Not reported
216-B-20 Trench	Aug 1956-Sept 1956	Scavenged tributyl phosphate waste from 221-U	Yes	4,680,000
216-B-21 Trench	Sept 1956-Oct 1956	Scavenged tributyl phosphate waste from 221-U	Yes	4,670,000
216-B-22 Trench	Oct 1956	Scavenged tributyl phosphate waste from 221-U	Yes	4,740,000
216-B-23 Trench	Oct 1956	Scavenged tributyl phosphate waste from 221-U	Yes	4,520,000
216-B-24 Trench	Oct 1956-Nov 1956	Scavenged tributyl phosphate waste from 221-U	Yes	4,700,000
216-B-25 Trench	Nov 1956-Dec 1956	Scavenged tributyl phosphate waste from 221-U	Yes	3,760,000
216-B-26 Trench	Dec 1956-Feb 1957	Scavenged tributyl phosphate waste from 221-U	Yes	5,880,000
216-B-27 Trench	Feb 1957-April 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,420,000
216-B-28 Trench	April 1957-June 1957	Scavenged tributyl phosphate waste from 221-U	Yes	5,050,000
216-B-29 Trench	June 1957-July 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,840,000
216-B-30 Trench	July 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,780,000
216-B-31 Trench	July 1957-Aug 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,740,000
216-B-32 Trench	Aug 1957-Sept 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,770,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-B-33 Trench	Sept 1957-Oct 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,740,000
216-B-34 Trench	Oct 1957	Scavenged tributyl phosphate waste from 221-U	Yes	4,870,000
216-B-35 Trench	Feb 1954-March 1954	1-C supernatant from 221-B	Yes	1,060,000
216-B-36 Trench	March 1954-April 1954	1-C supernatant from 221-B	Yes	1,940,000
216-B-37 Trench	Aug 1954	1-C bottom supernatant waste from the 242-B waste evaporator	Yes	4,320,000
216-B-38 Trench	July 1954	1-C supernatant from 221-B	Yes	1,430,000
216-B-39 Trench	Dec 1953-Nov 1954	1-C supernatant from 221-B	Yes	1,540,000
216-B-40 Trench	April 1954-July 1954	1-C supernatant from 221-B	Yes	1,640,000
216-B-41 Trench	Nov 1954	1-C supernatant from 221-B	Yes	1,440,000
216-B-42 Trench	Jan 1955-Feb 1955	Scavenged tributyl phosphate waste from 221-U	Yes	1,500,000
216-B-52 Trench	Dec 1957-Jan 1958	Scavenged tributyl phosphate waste from 221-U	Yes	8,530,000
216-B-53A Trench	Oct 1965-Nov 1965	Waste from the 300 Area Hanford lab operations	Yes	549,000
216-B-53B Trench	Nov 1962-March 1963	Waste from the 300 Area Hanford lab Operations (321 Building)	Yes	15,100
216-B-54 Trench	March 1963-Oct 1965	Waste from the 300 Area Hanford Laboratories operations	Yes	999,000
216-B-58 Trench	Nov 1965-June 1967	PNL waste from the 300 Area	Yes	413,000
216-B-63 Trench	March 1970-present *Active*	Effluent from 221-B, 225-B, and 271-B floor drains and chem sewer wastes	Yes	7,220,000,000
Septic Tanks and Associated Drain Fields				

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
2607-EB Septic Tank and DF	1951-present *Active*	Sanitary wastewater and sewage	Yes	20/day
2607-EH Septic Tank and DF	1983-unknown	Sanitary wastewater and sewage	Yes	1,360/day
2607-EK Septic Tank and DF	1980-present *Active*	Sanitary wastewater and sewage	Yes	24,200/day
2607-EM Septic Tank and DF	1984-present *Active*	Sanitary wastewater and sewage	Yes	6,380/day
2607-EN Septic Tank and DF	Pre 1980-present *Active*	Sanitary wastewater and sewage	Yes	2,060/day
2607-EO Septic Tank and DF	Circa 1985-present *Active*	Sanitary wastewater and sewage	Yes	2,120/day
2607-EP Septic Tank and DF	1984-present *Active*	Sanitary wastewater and sewage	Yes	1,875/day
2607-EQ Septic Tank and DF	1985-present *Active*	Sanitary wastewater and sewage	Yes	10,500/day
2607-ER Septic Tank	Unknown-present *Active*	Sanitary wastewater and sewage	Yes	Unknown
2607-GF Septic Tank	Unknown	Sanitary wastewater and sewage	Yes	Unknown
2607-E1 Septic Tank and DF	1970-present *Active*	Sanitary wastewater and sewage	Yes	21,555/day
2607-E2 Septic Tank and DF	Pre 1980-present *Active*	Sanitary wastewater and sewage	Yes	2,380/day
2607-E3 Septic Tank and DF	1944-present *Active*	Sanitary wastewater and sewage	Yes	14,400/day

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
2607-E4 Septic Tank and DF	1944-present *Active*	Sanitary wastewater and sewage	Yes	240/day
2607-E7B Septic Tank	Unknown	Sanitary wastewater and sewage	Yes	Unknown
2607-E8 Septic Tank and DF	1978-present *Active*	Sanitary wastewater and sewage	Yes	7,400/day
2607-E9 Septic Tank and DF	1951-present *Active*	Sanitary wastewater and sewage	Yes	Unknown
2607-E11 Septic Tank and DF	Circa 1985-present *Active*	Sanitary wastewater and sewage	Yes	3,160/day
Transfer Facilities and Diversion Boxes				
241-B-151 Diversion Box	1945-June 1984	Processing and decon wastes	Yes	Unknown
241-B-152 Diversion Box	1945-June 1984	Processing and decon wastes	Yes	Unknown
241-B-153 Diversion Box	1945-June 1984	Processing and decon wastes	Yes	Unknown
241-B-154 Diversion Box	1945-June 1984	Processing and decon wastes	No	Unknown
241-B-252 Diversion Box	1945-June 1984	Processing and decon wastes	No	Unknown
241-BR-152 Diversion Box	1948-June 1984	Processing and decon wastes	No	Unknown
241-BX-153 Diversion Box	1948-June 1983	Processing and decon wastes	No	Unknown
241-BX-154 Diversion Box	1948-July 1985	Processing and decon wastes	No	Unknown
241-BX-155 Diversion Box	1948-June 1984	Processing and decon wastes	No	Unknown
241-BXR-151 Diversion Box	1948-June 1984	Processing and decon wastes	No	Unknown
241-BXR-152 Diversion Box	1948-June 1984	Processing and decon wastes	No	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-BXR-153 Diversion Box	1948-June 1984	Processing and decon wastes	No	Unknown
241-BYR-152 Diversion Box	1950-June 1984	Processing and decon wastes	No	Unknown
241-BYR-153 Diversion Box	1950-June 1984	Processing and decon wastes	No	Unknown
41-BYR-154 Diversion Box	1950-June 1984	Processing and decon wastes	No	Unknown
241-ER-151 Diversion Box	1945-present *Active*	Processing and decon wastes	No	Unknown
241-ER-152 Diversion Box	1945-present *Active*	Processing and decon wastes	No	Unknown
Basins				
207-B Retention Basin	April 1945-present *Active*	Process cooling water from equipment jackets in 221-B	No	Not reported
216 B-59/59B Trench/Retention Basin	Dec 1967-present *Active*	Diverted cooling water from 221-B	Yes	477,000
216-B-64 Retention Basin	Never used	Never used	No	0
Burial Sites				
200-E Powerhouse Ash Pit	1943-present *Active*	Ash from the 200 East Powerhouse	No	63,000 m^3
218-E-2 Burial Ground	1945-1953	Source unknown; contains MFP/TRU dry wastes	No	9,033 $m^{3a/}$ 9,056 $m^{3b/}$
218-E-2A Burial Ground	1945-1955	Source unknown; also used as a storage site	No	Unknown
218-E-3 Burial Ground	1954	Source unknown; site exhumed	No	NA
218-E-4 Burial Ground	Feb 1955-1956	No trenches suspected; contaminated equipment was stored above ground	No	1,586 $m^{3a/}$ 1,585 $m^{3b/}$

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
218-E-5 Burial Ground	1954-1956	Industrial mixed waste and small boxes. North end contains railroad boxcars contaminated with UNH	No	3,172 $m^{3a/}$ 3,113 $m^{3b/}$
218-E-5A Burial Ground	1956-1959	Waste from L Cell (202-A burial package); four large boxes containing failed equipment and industrial wastes. D-2 Column from PUREX buried	No	6,173 $m^{3a/}$ 6,226 $m^{3b/}$
218-E-6 Burial Ground	Fall 1955	Wooden shack and other items from 291-B stack area were placed in a trench and burned	No	0
218-E-7 Burial Ground	1947-1952	Lab and sample waste; mixed MFP/TRU wastes	No	170 $m^{3a/}$ 170 $m^{3b/}$
218-E-9 Burial Ground	1953-1958	Storage site for fission product equipment contaminated in U recovery program at the tank farm	No	Unknown
218-E-10 Burial Ground	1960-present *Active*	Failed equipment and mixed industrial waste, PUREX cover and centrifuge blocks	No	21,764 $m^{3a/}$ 153,000 $m^{3b/}$
UN-200-E-1	Oct 14, 1966	Failure of 221-B to 241-BX-154 waste line	Yes	Unknown
UN-200-E-2	Nov 18, 1947	Radioactive particulate matter	No	Unknown
UN-200-E-3	Nov 21, 1951	Failure of 221-B to 241-BX waste line	Yes	Unknown
UN-200-E-7	Nov 30, 1954	Cell wash water from 5-9 Tank	Yes	19,000
UN-200-E-9	Sept 15, 1955	Tributyl phosphate scavenged supernatant	Yes	42,000
UN-200-E-14	1958	216-B-3 pond water	Yes	Unknown
UN-200-E-41	July 19, 1972	Line leak including C_s-137	Yes	Unknown
UN-200-E-43	Jan 10, 1972	Liquid from 102-BY Pump	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UN-200-E-44	Aug 16, 1972	BCS cribline leak	Yes	Unknown
UN-200-E-45	Aug 26, 1974	Mixed waste from 241-B-154 Diversion Box	Yes	Unknown
UN-200-E-52	Aug 1, 1975	Steam from E-5-2 strontium concentrator	Yes	Unknown
UN-200-E-54	July 20, 1977	Contaminated wash water	Yes	2
UN-200-E-55	April 27, 1979	Presumably wind-blown materials	No	Unknown
UN-200-E-61	Oct 31, 1981	Contamination resulting from burial operations	No	Unknown
UN-200-E-63	June 4, 1981	Vegetation absorbed radionuclides	No	Unknown
UN-200-E-64	Oct 12, 1984	Ants transported radionuclides from 216-B-64 Retention Basin	No	Unknown
UN-200-E-69	June 19, 1984	Flush water spilled beneath a burial box	Yes	Unknown
UN-200-E-76	Jan 4, 1968	9-2 Tank line to 241-B-110 Tank	Yes	Unknown
UN-200-E-79	June 1953	Leaks in line between 242-B Evaporator and 207-B Retention Basin	Yes	Unknown
UN-200-E-80	June 17, 1946	Underground waste line south of 221-B Building	Yes	Unknown
UN-200-E-83	1958 to 1989	Contaminants spread from BC Controlled Area by wildlife	No	Unknown
UN-200-E-85	July 20, 1972	Suspected leak in 18-1 waste line	Yes	Unknown
UN-200-E-87	1945-1953	Seepage from underground pipe joints south of 221-B Building	Yes	Unknown
UN-200-E-89	1978	Airborne release from 241-BX Tank Farm	No	Unknown
UN-200-E-90	Sept 1980	Material from 291-B Stack sand filter	No	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UN-200-E-92	1981	Russian thistles accumulated along East perimeter fence	No	Unknown
UN-200-E-95	Sept 1980	Series of small releases on railroad spur between 218-E-2A and 218-E-5	No	Unknown
UN-200-E-101	1986	Contaminated weeds between 242-B Evaporator and 241-B Tank Farm fence	No	Unknown
UN-200-E-103	Mar 8, 1972	BCS crib line leak	Yes	Unknown
UN-200-E-105	Dec 15, 1952	First cycle liquid waste from 107-BY Tank Farm	Yes	87,000
UN-200-E-109	Nov 11, 1953	Concentrated tributyl phosphate waste	Yes	570
UN-200-E-110	Aug 7, 1955	241-BY-112 Tank at the 112-BY Pit	Yes	Unknown
UN-200-E-112	Feb 12, 1979	Ion-exchange liquid	Yes	Unknown
UN-200-E-140	April 23, 1986	PCB contaminated oil	Yes	7.6
UPR-200-E-4	Fall 1951	Leakage from 241-B-151 Diversion Box	Yes	Unknown
UPR-200-E-5	Mar 20, 1951	Depleted uranium from BX-102 Tank	Yes	Unknown
UPR-200-E-6	1954	Leakage from 241-B-153 Diversion Box	Yes	Unknown
UPR-200-E-32	Nov 7, 1963	A coil leak in 221-B Building contaminated primary low-level cooling water discharged through the 207-B Retention Basin and 216-B-2-1 Ditch	Yes	4,900,000
UPR-200-E-34	June 1964	Coil leak at the F-15 PUREX Tank	Yes	Unknown
UPR-200-E-38	Jan 4, 1968	Leak from 241-B-152 Diversion Box	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UPR-200-E-51	May 1977	15 Kg of cadmium nitrate was released from PUREX Tank TK-324 to the 216-B-3 Pond and 216-B-3-3 Ditch	Yes	Unknown
UPR-200-E-73	1951-1952	Leakages and spills from 241-B-151 Diversion Box	Yes	Unknown
UPR-200-E-74	Spring 1954	Leakages and spills from 241-B-152 Diversion Box	Yes	Unknown
UPR-200-E-75	1954-1955	Leakages from 241-B-153 Diversion Box	Yes	Unknown
UPR-200-E-77	1946	Metal waste solution with fission products spilled from 241-B-154 Diversion Box	Yes	Unknown
UPR-200-E-78	Oct 1955	Mixed fission product salt waste	Yes	Unknown
UPR-200-E-84	March 1953	241-ER-311 Catch Tank leak of acid	Yes	6,500
UPR-200-E-108	Unknown	Supernatant leak between 241-B-102 and 101 Tanks	Yes	Unknown
UPR-200-E-116	Nov 20, 1972	Caustic flush water containing Cs-137, Y-90, Sr-90 from 241-B-107 Tank	Yes	Unknown
UPR-200-E-127	1968	Liquid with 2,000 Ci of Cs-137 from 241-B-110 Tank	Yes	30,000
UPR-200-E-128	169	Liquid with 4,300 Ci of Cs-137 from 241-B-110 Tank	Yes	31,000
UPR-200-E-129	1968	Liquid with 420 Ci of CS-137 from 241-B-201 Tank	Yes	4,500
UPR-200-E-130	1951-1977	Lathium fluoride from 241-B-203 Tank	Yes	11,000
UPR-200-E-131	1948-1971	51,000 Ci of Cs-137 from 241-BX-102	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
UPR-200-E-132	1974	500 Ci liquid from 241-BX-102	Yes	9,500
UPR-200-E-133	1949-1974	Tank leak from 241-BX-108 containing 500 Ci Cs-137	Yes	9,500
UPR-200-E-134	1973	PUREX coating waste leaked from 241-BX-103 Tank	Yes	19,000
UPR-200-E-135	1955-1972	Tributyl phosphate waste from 241-BX-108 Tank	Yes	19,000
UPR-200-E-138	Mar 22, 1970	1,000 Ci Sr-90 released to 216-B-2-2 Ditch	Yes	Unknown
No number	1951	Overflow of 241-BX-103 Tank	Yes	100,000-300,000
Semi-Works Aggregate Area				
Plants, Buildings, and Storage Areas				
Tank Storage Area	Unknown	5 Steel tanks from 201-C Process Building	No	Unknown
Tanks and Vaults				
241-CX-70 Storage Tank	1952-1957	High-level process waste	No	Contains 40,000
241-CX-71 Storage Tank	1952-1957	201-C Building, Hot Shop	No	Contains 14,400
241-CX-72 Storage Tank	1957-1976	PUREX Pilot Plant	No	7,500
Cribs and Drains				
216-C-1 Crib	1953-1957	201-C Building REDOX, PUREX Pilot Plant, 215 Gas Preparation and 271-C Aqueous Makeup and Control Building	Yes	23,400,000
216-C-3 Crib	1953-1954	201-C Building, 215-C Building, 271-C Building	Yes	5,000,000

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
216-C-4 Crib	1955-1965	276-C Building	Yes	170,000
216-C-5 Crib	1955	201-C Building REDOX, PUREX Pilot Plant	Yes	37,900
216-C-6 Crib	1955-1964	201-C Building REDOX, PUREX Pilot Plant, 241-CX vault floor drains	Yes	530,000
216-C-7 Crib	1961-Present	Critical Mass Laboratory	Yes	60,000
216-C-10 Crib	1964-1969	201-C Process Building	Yes	897,000
Reverse Well				
216-C-2 Reverse Well	1953-1988	291-C Stack	Yes	Unknown
Ponds, Ditches, and Trenches				
216-C-9 Pond	1953-1985	209-E Building, 226-C, 201-C, 215-C, 209-C	Yes	1,030,000,000
200 East Powerhouse Ditch	1943-Present	284-E Power Plant	Yes	13,800/mo
Septic Tanks				
2607-E-5 Septic Tank & Field	1949-Present	Critical Mass Laboratory, mobile offices	Yes	Unknown
2607-E-7A Septic Tank & Field	1983-Present	Critical Mass Laboratory	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
Transfer Facilities, Diversion Boxes, and Pipelines				
Semi-Works Valve Pit	???-late 1980s	201-C Process Building	No	Variable
Critical Mass Laboratory Valve Pit	???-Present	Critical Mass Laboratory	No	Variable
241-C-154 Diversion Box	???-1985	Promethium transfer line from B Plant	No	Variable
Burial Sites				
218-C-9 Burial Ground	1985-1989	Decommissioning rubble from 201-C Process Building	No	2,265 m^3
Unplanned Releases				
UN-200-E-36	July 1967	Beta/gamma sources	Yes	Unknown
UN-200-E-37	July 1967	Beta/gamma sources	Yes	Unknown
UN-200-E-98	Sept 1980	Strontium 90 source	No	Unknown
UN-200-E-141	Sept 1984	Uranyl nitrate spill	Yes	208.2
Newly Identified Sites				
216-C-9 Pond Diversion Box	???	209-E Building, 226-C, 201-C, 209-C	No	Variable
Critical Mass Laboratory Valve Box	???	Unknown	No	Unknown
Soils Holding Tank	???	Soil	No	Unknown
Critical Mass Laboratory Dry Well North	???	Unknown	Unknown	Unknown
Critical Mass Laboratory Dry Well East	???	Unknown	Unknown	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
241-C Waste Line Unplanned Release No. 1	1957	241-C Process Building/Tank Farm Line	Yes	Unknown
241-C Waste Line Unplanned Release No. 2	1957	241-C Process Building/Tank Farm Line	Yes	Unknown
200 North Aggregate Area Tanks and Vaults				
212-P Transformer Oil Tank	1982-present/active	Transformer Oil containing PCBs	No	Unknown
Ponds, Ditches, and Trenches				
216-N-1 Pond	1944-1952/inactive	Cooling water from 212-N Building	Yes	946,000,000
216-N-4 Pond	1944-1952/inactive	Cooling water from 212-P Building	Yes	946,000,000
216-N-6 Pond	1944-1952/inactive	Cooling water from 212-R Building	Yes	946,000,000
216-N-2 Trench	1947/inactive	Low activity water and sludge from 212-N basin	Yes	7,500,000
216-N-3 Trench	1952/inactive	Low activity water and sludge from 212-N basin	Yes	7,600,000
216-N-5 Trench	1952/inactive	Low activity water and sludge from 212-P basin	Yes	7,600,000
216-N-7 Trench	1952/inactive	Low activity water and sludge from 212-R basin	Yes	7,600,000
Septic Tanks and Associated Drain Fields				
2607-N Septic Tank/Drain Field	1944-1952/inactive	Sanitary wastewater and sewage from 2734-N guard house	Yes	Unknown
2607-P Septic Tank/Drain Field	1944-1952/inactive	Sanitary wastewater and sewage from 2734-P guard house	Yes	Unknown

Table 2-1. Summary of 200 East Area Waste Management Units.

Waste Management Unit	Years in Service/*Status*	Source Description	Liquid Discharge to Soil	Waste Volume Received (L)
2607-R Septic Tank/Drain Field	1944-1952/inactive	Sanitary wastewater and sewage from 2734-R guard house	Yes	Unknown
Transfer Facilities, Diversion Boxes, and Pipelines				
212-N to 216-N-1 Pipeline	1944-1952/inactive	Cooling water overflow	No	Unknown
212-P to 216-N-4 Pipeline	1944-1952/inactive	Cooling water overflow	No	Unknown
212-R to 216-N-6 Pipeline	1944-1952/inactive	Cooling water overflow	No	Unknown
Burial Sites				
Ballast Pits	Unknown	Unknown	Unknown	Unknown
Unplanned Releases				
Unnumbered	Unknown	Unknown	Unknown	Unknown
Unnumbered	Unknown	Unknown	Unknown	Unknown

Source description and waste volumes from WIDS (WHC 1991a).

a/ Source: WHC/1991a.
b/ Source: Maxfield 1979.
c/ 299-E24-111 Injection Well never received waste. It did receive eleven 4,000 L injections of liquid for radionuclide migration data.

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 1 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
PUREX Plant Aggregate Area				
241-A-103 Tank	Unknown	--	No	No
241-A-104 Tank	Unknown	--	No	No
241-A-105 Tank	776	--	No	No
241-AX-102 Tank	Unknown	--	No	No
241-AX-104 Tank	Unknown	--	No	No
241-C-101 Tank	64 to 91	--	No	No
241-C-110 Tank	Unknown	--	No	No
241-C-111 Tank	Unknown	--	No	No
241-C-201 Tank	Unknown	--	No	No
241-C-202 Tank	Unknown	--	No	No
241-C-203 Tank	1.5	--	No	No
241-C-204 Tank	Unknown	--	No	No
244-AR Vault	Unknown	--	No	No
216-A-1 Crib	98	660 to 1,980	No	No
216-A-2 Crib	230	307 to 921	No	No
216-A-3 Crib	3,050	317 to 952	Yes	No
216-A-4 Crib	6,210	316 to 948	Yes	No
216-A-5 Crib	1,630,000	975 to 2,925	Yes	Yes
216-A-6 Crib	3,400,000	7,675 to 23,024	Yes	Yes
216-A-7 Crib	326	73 to 220	Yes	No
216-A-8 Crib	1,150,000	11,747 to 35,241	Yes	Yes
216-A-9 Crib	981,000	6,685 to 20,054	Yes	Yes
216-A-10 Crib	3,210,000	9,357 to 28,072	Yes	Yes
216-A-21 Crib	77,900	791 to 2,373	Yes	No
216-A-24 Crib	820,000	18,000 to 54,000	Yes	Yes
216-A-27 Crib	23,200	1,665 to 4,996	Yes	No

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 2 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-A-30 Crib	7,110,000	10,586 to 31,758	Yes	Yes
216-A-31 Crib	10	567-1,701	No	No
216-A-32 Crib	4	446 to 1,337	No	No
216-A-36A Crib	1,070	910 to 2,729	Yes	No
216-A-36B Crib	317,000	4,533 to 13,598	Yes	Yes
216-A-37-1 Crib	377,000	5,293 to 15,879	Yes	Yes
216-A-37-2 Crib	1,090,000	10,190 to 30,569	Yes	Yes
216-A-39 Crib	.02	315 to 945	No	No
216-A-41 Crib	10	79 to 237	No	No
216-A-45 Crib	103,000	19,358 to 58,074	Yes	Yes
216-A-11 French Drain	100	4 to 11	Yes	No
216-A-12 French Drain	100	4 to 11	Yes	No
216-A-13 French Drain	100	6 to 17	Yes	No
216-A-14 French Drain	1	4 to 12	No	No
216-A-15 French Drain	10,000	10 to 29	Yes	No
216-A-16 French Drain	122	7 to 22	Yes	No
216-A-17 French Drain	60	7 to 22	Yes	No
216-A-22 French Drain	10	23 to 68	No	No
216-A-23A French Drain	6	7 to 22	No	No
216-A-23B French Drain	6	7 to 22	No	No
216-A-26 French Drain	Unknown	10 to 31	No	No
216-A-26A French Drain	1	6 to 17	No	No
216-A-28 French Drain	30	64 to 191	No	No
216-A-35 French Drain	10	23 to 70	No	No
216-C-8 French Drain	10	20 to 61	No	No
216-A-18 Trench	488	4,350 to 13,050	No	No
216-A-19 Trench	1,100	411 to 1,232	Yes	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a]	Indicates Possible Migration to Uppermost Aquifer[b]	Significant Impact on Groundwater Flow[c]
216-A-20 Trench	961	425 to 1,274	Yes	No
216-A-40 Trench	946	6,072 to 18,215	No	No
216-A-29 Ditch	10,400,312	14,341 to 43,024	Yes	Yes
216-A-34 Ditch	Unknown	3,997 to 11,990	No	No
2607-EA Septic Tank/Drain Field	350[d]	Unknown	No	No
2607-EC Septic Tank/Drain Field	6,077[d]	Unknown	No	No
2607-ED Septic Tank/Drain Field	1,226[d]	Unknown	No	No
2607-EG Septic Tank/Drain Field	2,420[d]	Unknown	No	No
2607-EJ Septic Tank/Drain Field	1,400[d]	Unknown	No	No
2607-EL Septic Tank/Drain Field	25,942[d]	Unknown	No	No
2607-E6 Septic Tank/Drain Field	603,345[d]	Unknown	Yes	Yes
241-A-151 Diversion Box	Unknown	--	No	No
241-C-152 Diversion Box	9.8	--	No	No
241-CR-151 Diversion Box	136.3	--	No	No
B Plant Aggregate Area				
241-B-101 Tank	Unknown	--	No	No
241-B-103 Tank	Unknown	--	No	No
241-B-107 Tank	Unknown	--	No	No
241-B-110 Tank	61	--	No	No
241-B-111 Tank	Unknown	--	No	No
241-B-112 Tank	Unknown	--	No	No
241-B-201 Tank	4.5	--	No	No
241-B-203 Tank	1	--	No	No

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 4 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
241-B-204 Tank	Unknown	--	No	No
241-BX-101 Tank	Unknown	--	No	No
241-BX-102 Tank	9.5	--	No	No
241-BX-103 Tank	100 to 300	--	No	No
241-BX-108 Tank	9.5	--	No	No
241-BX-110 Tank	Unknown	--	No	No
241-BX-111 Tank	Unknown	--	No	No
241-BY-103 Tank	Unknown	--	No	No
241-BY-105 Tank	Unknown	--	No	No
241-BY-106 Tank	Unknown	--	No	No
241-BY-107 Tank	Unknown	--	No	No
241-BY-108 Tank	19	--	No	No
241-ER-311 Catch Tank	6.5	--	No	No
216-B-7A&B Cribs	43,600	186 to 558	Yes	No
216-B-8TF Crib and Tile Field	27,200	17,580 to 52,730	Yes	No
216-B-9TF Crib and Tile Field	36,000	8,660 to 25,990	Yes	No
216-B-10A Crib	9990	155 to 465	Yes	No
216-B-10B Crib	28	6,100 to 18,300	No	No
216-B-12 Crib	520,000	6,100 to 18,300	Yes	Yes
216-B-14 Crib	8,710	5,890 to 17,670	Yes	No
216-B-15 Crib	6,320	5,890 to 17,670	Yes	No
216-B-16 Crib	5,600	5,890 to 17,670	Yes	No
216-B-17 Crib	3,410	5,890 to 17,670	No	No
216-B-18 Crib	8,520	5,890 to 17,670	Yes	No
216-B-19 Crib	6,400	5,890 to 17,670	Yes	No
216-B-43 Crib	2,100	3,400 to 10,200	No	No
216-B-44 Crib	5,600	3,295 to 9,885	Yes	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-B-45 Crib	4,920	3,295 to 9,885	Yes	No
216-B-46 Crib	6,700	3,243 to 9,730	Yes	No
216-B-47 Crib	3,710	3,452 to 10,355	Yes	No
216-B-48 Crib	4,090	3,347 to 10,042	Yes	No
216-B-49 Crib	6,700	3,295 to 9,885	Yes	No
216-B-50 Crib	54,800	3,295 to 9,885	Yes	No
216-B-55 Crib	1,230,000	6,073 to 18,220	Yes	Yes
216-B-57 Crib	84,400	1,925 to 5,775	Yes	No
216-B-60 Crib	18.9	146 to 438	No	No
216-B-62 Crib	282,000	3,860 to 11,580	Yes	Yes
Chem TF North of 2703-F	Unknown	Unknown	No	No
216-B-13 French Drain	28	29 to 118	No	No
216-B-51 French Drain	1	45 to 135	No	No
216-B-4 Reverse Well	10	.8 to 2.3	Yes	No
216-B-5 Reverse Well	30,600	0	Yes	No
216-B-6 Reverse Well	6,000	.5 to 1.4	Yes	No
216-B-11 A&B Reverse Wells	29,600	56.4 to 169.12	Yes	No
216-B-3 Pond	240,000,000	760,840 to 2,282,510	Yes	Yes
216-A-25 Pond	307,000,0000	229,870 to 689,620	Yes	Yes
216-N-8 Pond[e/]	Unknown	0	Yes	No
216-M Pond	Unknown	--	No	No
216-B-3A Pond	Unknown	--	No	No
216-B-3B Pond	Unknown	--	No	No
216-B-3C Pond	Unknown	--	No	No
216-B-2-1 Ditch	149,000,000	37,120 to 111,360	Yes	Yes
216-B-2-2 Ditch	49,700	24,600 to 73,800	Yes	No

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer.

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-B-2-3 Ditch	Unknown	--	Yes[f/]	Yes[f/]
216-B-3-1 Ditch	149,000,000	8,037 to 24,111	Yes	Yes
216-B-3-2 Ditch	149,000,000	23,230 to 69,700	Yes	Yes
216-B-3-3 Ditch	Unknown	--	Yes[f/]	Yes[f/]
216-B-20 Trench	4,680	4,560 to 13,670	Yes	No
216-B-21 Trench	4,670	4,650 to 13,950	Yes	No
216-B-22 Trench	4,740	4,600 to 13,800	Yes	No
216-B-23 Trench	4,520	4,465 to 13,390	Yes	No
216-B-24 Trench	4,700	4,560 to 13,670	Yes	No
216-B-25 Trench	3,760	4,420 to 13,260	No	No
216-B-26 Trench	5,880	4,465 to 13,390	Yes	No
216-B-27 Trench	4,420	4,465 to 13,390	No	No
216-B-28 Trench	5,050	4,510 to 13,530	Yes	No
216-B-29 Trench	4,840	4,510 to 13,530	Yes	No
216-B-30 Trench	4,780	4,510 to 13,530	Yes	No
216-B-31 Trench	4,740	4,510 to 13,530	Yes	No
216-B-32 Trench	4,770	4,510 to 13,530	Yes	No
216-B-33 Trench	4,740	4,510 to 13,530	Yes	No
216-B-34 Trench	4,870	4,510 to 13,530	Yes	No
216-B-35 Trench	1,060	1,730 to 5,190	No	No
216-B-36 Trench	1,940	1,730 to 5,190	Yes	No
216-B-37 Trench	4,320	1,710 to 5,130	Yes	No
216-B-38 Trench	1,430	1,685 to 5,055	No	No
216-B-39 Trench	1,540	1,685 to 5,055	No	No
216-B-40 Trench	1,640	1,640 to 4,920	Yes	No
216-B-41 Trench	1,440	1,640 to 4,920	No	No
216-B-42 Trench	1,500	1,755 to 5,265	No	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 7 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-B-52 Trench	8,530	5,240 to 15,710	Yes	No
216-B-53A Trench	549	543 to 1,630	Yes	No
216-B-53B Trench	15.1	1,370 to 4,120	No	No
216-B-54 Trench	999	1,823 to 5,470	No	No
216-B-58 Trench	413	1,880 to 5,640	No	No
216-B-63 Trench	7,220,000	3,650 to 10,940	Yes	Yes
2607-EB Septic Tank/Tile Field	300[d/]	--	No	No
2607-EH Septic Tank/Drain Field	4,468[d/]	--	No	No
2607-EK Septic Tank/Drain Field	106,000[d/]	1,706 to 5,118	Yes	Yes
2607-EM Septic Tank/Drain Field	18,600[d/]	1,168 to 3,505	Yes	No
2607-EN Septic Tank/Drain Field	9,022[d/]	288 to 864	Yes	No
2607-EO Septic Tank/Drain Field	5,400[d/]	688 to 2,064	Yes	No
2607-EP Septic Tank/Drain Field	56,475[d/]	--	No	No
2607-EQ Septic Tank	26,800[d/]	440 to 1,320	Yes	No
2607-ER Septic Tank	Unknown	--	No	No
2607-GF Septic Tank	Unknown	--	No	No
2607-E1 Septic Tank/Drain Field	173,000[d/]	7,386 to 22,158	Yes	Yes
2607-E2 Septic Tank/Drain Field	10,400[d/]	27,000 to 84,000	No	No
2607-E3 Septic Tank/Tile Field	252,000[d/]	--	Yes	Yes
2607-E4 Septic Tank/Tile Field	4,200[d/]	--	No	No
2607-E7B Septic Tank	Unknown	--	No	No

Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 8 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
2607-E8 Septic Tank/Drain Field	37,800[d/]	6,900 to 20,880	Yes	No
2607-E9 Septic Tank/Drain Field	Unknown	--	No	No
2607-E11 Septic Tank/Drain Field	8,070[d/]	1,035 to 3,105	Yes	No
216-B-59/59B Trench/Retention	477	1,800 to 5,400	No	No
Semi-Works Aggregate Area				
216-C-1 Crib	23,400	91 to 274	Yes	No
216-C-3 Crib	5,000	392 to 1,175	Yes	No
216-C-4 Crib	170	161 to 484	Yes	No
216-C-5 Crib	37.9	161 to 484	No	No
216-C-6 Crib	530	161 to 484	Yes	No
216-C-7 Crib	60	323 to 967	No	No
216-C-10 Crib	897	161 to 484	Yes	No
216-C-2 Reverse Well	Unknown	78 to 235	No	No
216-C-9 Pond	1,030,000	64,500 to 193,700	Yes	Yes
200 East Powerhouse Ditch	246,813[d/]	40,000 to 120,000	Yes	Yes
2607-E-5 Septic Tank/Drain Field	Unknown	Unknown	No	No
2607-E-7A Septic Tank/Drain Field	Unknown	Unknown	No	No
200 North Aggregate Area				
216-N-1 Pond	946,000	22,980 to 68,930	Yes	Yes
216-N-4 Pond	946,000	43,450 to 130,340	Yes	Yes
216-N-6 Pond	946,000	32,370 to 97,120	Yes	Yes
216-N-2 Trench	7,500	246 to 737	Yes	No
216-N-3 Trench	7,600	491 to 1,473	Yes	No

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Table 2-2. Soil Column Calculation of Potential for Migration of Liquid Discharges to the Unconfined Aquifer. Page 9 of 9

Liquid Discharge Source	Liquid Effluent Volume Received By Soil (m^3)	Soil Column Pore Volume Range (m^3)[a/]	Indicates Possible Migration to Uppermost Aquifer[b/]	Significant Impact on Groundwater Flow[c/]
216-N-5 Trench	7,600	580 to 1,738	Yes	No
216-N-7 Trench	7,600	518 to 1,554	Yes	No
2607-N Septic Tank/Drain	Unknown	--	No	No
2607-P Septic Tank/Drain	Unknown	--	No	No
2607-R Septic Tank/Drain	Unknown	--	No	No

a/ Pore volume calculation: (waste unit section area) x (depth to groundwater) x (porosity). Low pore volume value reflects 0.1 porosity; higher pore volume value reflects 0.3 porosity. Pore volume calculation does not account for the ability of the soil to retain the liquid discharged.

b/ Yes, when liquid effluent volume received by soil exceeds the lower range of soil column pore volume.

c/ Yes, when discharge exceeded 100,000 m^3.

d/ Based on reported daily rates from first year through 1991.

e/ 216-N-8 Pond formed as a result of the rising water table. Before the pond was formed, the area received sewage sludge from the Hanford construction camp.

f/ Although the volumes received by the 216-B-2-3 and 216-B-3-3 is not known, it was probably great enough to have had an impact on groundwater.

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Table 2-3. Summary of Well Geophysical Log Results For Units Potentially Contributing Contaminants to Groundwater. Page 1 of 5

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response (m)	Approximate Depth to Groundwater	Confirms Release to Groundwater
PUREX Plant Aggregate Area				
241-A-101 to 106 Tank Farm	54	0-32	90	No
241-AX-101 to 104 Tank Farm	32	0-12	85	No
241-C-101 to 112 Tank Farm	70	0-21	78	No
216-A-1 Crib	1	--	92	No
216-A-2 Crib	1	8-??	90	No*
216-A-4 Crib	1	8-??	95	No*
216-A-5 Crib	5	8-16	95	No
216-A-6 Crib	2	6-12	90	No
216-A-7 Crib	1	0-5	85	No
216-A-8 Crib	7	0-37 and 44-55	80	Yes
216-A-9 Crib	4	--	90	No
216-A-10 Crib	6	15-61	97	Yes
216-A-21 Crib	1	43-45	95	No
216-A-24 Crib	7	1-61	65	Yes
216-A-27 Crib	2	24-44 and 88-98	95	Yes
216-A-30 Crib	6	2-13	85	No
216-A-31 Crib	1	--	85	No
216-A-36A Crib	2	6-49 and 88-98	95	Yes
216-A-36B Crib	6	6-41 +	95	No
216-A-31-1 Crib	3	--	90	No
216-A-37-2 Crib	2	--	87	No
216-A-38 Crib	2	--	85	No
216-A-45 Crib	4	--	85	No
216-A-15 French Drain	1	--	95	No

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Table 2-3. Summary of Well Geophysical Log Results For Units Potentially Contributing Contaminants to Groundwater. Page 2 of 5

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response (m)	Approximate Depth to Groundwater	Confirms Release to Groundwater
216-A-26 French Drain	1	7-??	95	No*
216-A-26A French Drain	1	7-??	95	No*
216-A-18 Trench	1	--	80	No
216-A-19 Trench	1	--	73	No
216-A-20 Trench	1	--	74	No
216-A-40 Trench	1	--	75	No
216-A-29 Ditch	1	5-9	75	No
216-A-34 Ditch	1	--	80	No
216-A-42 Retention Basin	1	--	80	No
B Plant Aggregate Area				
241-B-1-1 to 112 Tank Farm	16	0-??	80	No*
241-BX-101 to 112 Tank Farm	16	0-??	75	No*
241-BY-101 to 112 Tank Farm	15	0-??	70	No*
216-B-7 A & B Cribs	5	4-23	70	No
216-B-8 Crib & Tile Field	14	4-37	70	No
216-B-9 Crib & Tile Field	9	2-13	83	No
216-B-10 A Crib	1	Unknown	93	No
216-B-10-B Crib	1	Unknown	93	No
216-B-12 Crib	6	0-??	90	No*
216-B-14 Crib	1	0-82	100	Yes
216-B-15 Crib	1	3-32	100	No
216-B-16 Crib	2	0-93	100	Yes
216-B-17 Crib	1	4-21	100	No
216-B-18 Crib	2	4-27	100	No
216-B-19 Crib	1	3-32	100	No
216-B-43 Crib	3	7-70	68	Yes
216-B-44 Crib	2	12-70	68	Yes

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Table 2-3. Summary of Well Geophysical Log Results For Units Potentially Contributing Contaminants to Groundwater. Page 3 of 5

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response (m)	Approximate Depth to Groundwater	Confirms Release to Groundwater
216-B-45 Crib	2	9-70	68	Yes
216-B-46 Crib	2	2-70	68	Yes
216-B-47 Crib	1	12-38	68	No
216-B-48 Crib	1	3-47	68	No
216-B-49 Crib	1	3-47	68	No
216-B-50 Crib	1	3-70	68	Yes
216-B-55 Crib	2	Unknown	90	No
216-B-56 Crib	1	0		No
216-B-57 Crib	1	8-21	70	No
216-B-61 Crib	2	0	68	No
216-B-62 Crib	4	10-35	85	No
216-B-51 French Drain	4	0	70	No
216-B-5 Reverse Well	2	82-101	90	Yes
216-B-6 Reverse Well	1	Unknown	93	No
216-B-11 A & B Reverse Wells	3	23-30	78	No
216-B-3 Pond	16	--	47	No
216-B-3A Pond	3	--	45	No
216-B-3B Pond	3	--	40	No
216-B-3C Pond	3	--	40	No
216-E-25 Pond	1	--	55	No
216-A-25 Pond	8	--	25	No
216-N-8 Pond	3	--	0	No
216-B-2-1 Ditch	8	--	75	No
216-B-2-2 Ditch	8	--	75	No
216-B-2-3 Ditch	8	--	75	No
216-B-3-1 Ditch	4	--	55	No
216-B-3-2 Ditch	4	--	55	No

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Table 2-3. Summary of Well Geophysical Log Results For Units Potentially Contributing Contaminants to Groundwater. Page 4 of 5

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response (m)	Approximate Depth to Groundwater	Confirms Release to Groundwater
216-B-3-3 Ditch	4	--	55	No
216-B-20 Trench	2	5-12	100	No
216-B-21 Trench	1	--	100	No
216-B-22 Trench	1	--	100	No
216-B-23 Trench	1	5-12	100	No
216-B-24 Trench	2	--	100	No
216-B-25 Trench	1	1-??	100	No*
216-B-26 Trench	2	--	100	No
216-B-27 Trench	1	1-7	100	No
216-B-28 Trench	2	--	100	No
216-B-29 Trench	1	--	100	No
216-B-30 Trench	0	Unknown	100	No
216-B-31 Trench	4	1-??	100	No*
216-B-32 Trench	2	10-11	100	No
216-B-33 Trench	2	7-9	100	No
216-B-34 Trench	4	--	100	No
216-B-35 Trench	1	6-??	80	No*
216-B-36 Trench	2	0-21	80	No
216-B-37 Trench	2	0-??	80	No*
216-B-38 Trench	2	0-??	80	No*
216-B-39 Trench	--	--	80	No
216-B-40 Trench	--	--	80	No
216-B-41 Trench	1	8-19	80	No
216-B-42 Trench	2	5-11	80	No
216-B-52 Trench	1	9-??	100	No*
216-B-53A Trench	1	--	100	No
216-B-53B Trench	--	--	100	No

Table 2-3. Summary of Well Geophysical Log Results For Units Potentially Contributing Contaminants to Groundwater. Page 5 of 5

Waste Management Unit	Number of Wells Reviewed	Elevated Gamma Log Response (m)	Approximate Depth to Groundwater	Confirms Release to Groundwater
216-B-54 Trench	1	--	90	No
216-B-58 Trench	1	--	90	No
216-B-63 Trench	3	--	90	No
216-B-154 Diversion Box	2	--	90	No
216-BX-155 Diversion Box	3	Unknown	90	No
216-B-361 Settling Tank	2	--	80	No
216-BX-302B Catch Tank	2	--	80	No
216-BX-302C Catch Tank	2	--	80	No
216-B-64 Retention Basin	2	--	90	No
218-E-2 Burial Ground	2	--	75	No
218-E-3 Burial Ground	1	--	100	No
218-E-4 Burial Ground	1	--	75	No
218-E-5 Burial Ground	2	--	75	No
218-E-5A Burial Ground	2	--	75	No
218-E-9 Burial Ground	2	--	75	No
218-E-10 Burial Ground	12	--	75	No
Semi-Works Aggregate Area				
216-C-1 Crib	1	2-12	85	No
216-C-5 Crib	1	0-3	85	No
216-C-10 Crib	1	--	85	No
216-C-9 Pond	1	--	85	No
218-C-9 Burial Ground	1	--	85	No

Source = PUREX, B, Semi-Works AAMSRs.

??: The depth interval of elevated gamma-ray activity extends deeper than the well.

* The wells do not extend to the depth of the groundwater and have elevated gamma to the bottom of well. These wells could not be used to confirm the release of radionuclides to the groundwater.

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Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
PUREX Plant Aggregate Area				
241-A-103 Tank	1956-1980	No	No	No
241-A-104 Tank	1958-1975	No	No	No
241-A-105 Tank	1962-1972	No	No	No
241-AX-102 Tank	1966-1980	No	No	No
241-C-101 Tank	1946-1970	No	No	No
241-C-110 Tank	1946-1976	No	No	No
241-C-111 Tank	1946-1976	No	No	No
241-C-201 Tank	1953-1977	No	No	No
241-C-202 Tank	1953-1977	No	No	No
241-C-203 Tank	1953-1976	No	No	No
241-C-204 Tank	1953-1977	No	No	No
244-AR Vault	1977-Present	No	No logs	No
216-A-1 Crib	1955-1966	No	No	No
216-A-2 Crib	1956-1964	No	No*	No*
216-A-3 Crib	1956-1982	Yes	No	Yes
216-A-4 Crib	1955-1958	Yes	No*	Yes
216-A-5 Crib	1955-1966	Yes	No	Yes
216-A-6 Crib	1955-1970	Yes	No	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-A-7 Crib	1955-1966	Yes	No	Yes
216-A-8 Crib	1955-1991	Yes	Yes	Yes
216-A-9 Crib	1956-1969	Yes	No	Yes
216-A-10 Crib	1956-1987	Yes	Yes	Yes
216-A-21 Crib	1957-1965	Yes	No	Yes
216-A-24 Crib	1958-1966	Yes	Yes	Yes
216-A-27 Crib	1965-1970	Yes	Yes	Yes
216-A-30 Crib	1961-1991	Yes	No	Yes
216-A-31 Crib	1964-1966	No	No	No
216-A-32 Crib	1959-1966	No	No logs	No
216-A-36A Crib	1965-1966	Yes	Yes	Yes
216-A-36B Crib	1966-1987	Yes	No	Yes
216-A-37-1 Crib	1977-1991	Yes	No	Yes
216-A-37-2 Crib	1983-Present	Yes	No	Yes
216-A-39 Crib	1966	No	No logs	No
216-A-41 Crib	1968-1974	No	No logs	No
216-A-45 Crib	1987-1989	Yes	No	Yes
216-A-11 French Drain	1956-1972	Yes	No logs	Yes
216-A-12 French Drain	1955-1972	Yes	No logs	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-A-13 French Drain	1956-1962	Yes	No logs	Yes
216-A-14 French Drain	1956-1972	No	No logs	No
216-A-15 French Drain	1955-1972	Yes	No	Yes
216-A-16 French Drain	1956-1968	Yes	No logs	Yes
216-A-17 French Drain	1956-1968	Yes	No logs	Yes
216-A-22 French Drain	1956-1957	No	No logs	No
216-A-23A French Drain	1957-1969	No	No logs	No
216-A-23B French Drain	1957-1969	No	No logs	No
216-A-26 French Drain	1965-1991	No	No*	No*
216-A-26A French Drain	1959-1965	No	No*	No*
216-A-28 French Drain	1958-1966	No	No logs	No
216-A-35 French Drain	1963-1966	No	No logs	No
216-C-8 French Drain	1962-1965	No	No	No
216-A-18 Trench	1955-1956	No	No	No
216-A-19 Trench	1955-1956	Yes	No	Yes
216-A-20 Trench	1955-1956	Yes	No	Yes
216-A-40 Trench	1968-1979	No	No	No
216-A-29 Ditch	1955-1991	Yes	No	Yes
216-A-34 Ditch	1955-1957	No	No	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
2607-EA Septic Tank/Drain Field	1976-Present	No	No logs	No
2607-EC Septic Tank/Drain Field	1955-Present	No	No logs	No
2607-ED Septic Tank/Drain Field	1980-Present	No	No logs	No
2607-EG Septic Tank/Drain Field	1953-Present	No	No logs	No
2607-EJ Septic Tank/Drain Field	1980-Present	No	No logs	No
2607-EL Septic Tank/Drain Field	1983-Present	No	No logs	No
2607-E6 Septic Tank/Drain Field	1954-Present	Yes	No logs	Yes
241-A-151 Diversion Box	1956-Present	No	No logs	No
241-C-152 Diversion Box	1946-1985	No	No logs	No
241-CR-151 Diversion Box	1946-1985	No	No logs	No
B Plant Aggregate Area				
241-B-101 Tank	1945-1974	No	No*	No*
241-B-103 Tank	1953-1977	No	No*	No*
241-B-107 Tank	1945-1969	No	No*	No*
241-B-110 Tank	1945-1971	No	No*	No*
241-B-111 Tank	1945-1976	No	No*	No*
241-B-112 Tank	1946-1977	No	No*	No*
241-B-201 Tank	1952-1971	No	No*	No*
241-B-203 Tank	1951-1977	No	No*	No*

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
241-B-204 Tank	1951-1977	No	No*	No*
241-BX-101 Tank	1948-1972	No	No*	No*
241-BX-102 Tank	1948-1971	No	No*	No*
241-BX-103 Tank	1948-1977	No	No*	No*
241-BX-108 Tank	1949-1974	No	No*	No*
241-BX-110 Tank	1949-1977	No	No*	No*
241-BX-111 Tank	1950-1977	No	No*	No*
241-BY-103 Tank	1950-1977	No	No*	No*
241-BY-105 Tank	1951-1974	No	No*	No*
241-BY-106 Tank	1953-1977	No	No*	No*
241-BY-107 Tank	1950-1974	No	No*	No*
241-BY-108 Tank	1951-1972	No	No*	No*
241-ER-311 Catch Tank	1945-Present	No	No	No
216-B-7A&B Cribs	1946-1967	Yes	No	Yes
216-B-8TF Crib	1948-1953	Yes	No	Yes
216-B-9TF Crib	1948-1951	Yes	No	Yes
216-B-10A Crib	1949-1952	Yes	No	Yes
216-B-10B Crib	1952-1973	Yes	No	Yes
216-B-12 Crib	1952-1973	Yes	No*	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-B-14 Crib	1956	Yes	Yes	Yes
216-B-15 Crib	1956	Yes	No	Yes
216-B-16 Crib	1956	Yes	Yes	Yes
216-B-17 Crib	1956	No	No	No
216-B-18 Crib	1956	Yes	No	Yes
216-B-19 Crib	1957	Yes	No	Yes
216-B-43 Crib	1954	No	Yes	Yes
216-B-44 Crib	1954-1955	Yes	Yes	Yes
216-B-45 Crib	1955	Yes	Yes	Yes
216-B-46 Crib	1955	Yes	Yes	Yes
216-B-47 Crib	1955	Yes	No	Yes
216-B-48 Crib	1955	Yes	No	Yes
216-B-49 Crib	1955	Yes	No	Yes
216-B-50 Crib	1965-1974	Yes	Yes	Yes
216-B-55 Crib	1967-Present	Yes	No	Yes
216-B-57 Crib	1968-1973	Yes	No	Yes
216-B-60 Crib	1967	No	No	No
216-B-62 Crib	1973-Present	Yes	No	Yes
Chem TF North of 2703-F	Unknown	No	No logs	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-B-13 French Drain	1947-1976	No	No logs	No
216-B-51 French Drain	1956-1958	No	No	No
216-B-4 Reverse Well	1945-1949	Yes	No logs	Yes
216-B-5 Reverse Well	9145-1947	Yes	Yes	Yes
216-B-6 Reverse Well	1945-1949	Yes	No	Yes
216-B-11 A&B Reverse Wells	1951-1954	Yes	No	Yes
216-B-3 Pond	1945-Present	Yes	No	Yes
216-A-25 Pond	1957-1987	Yes	No	Yes
216-N-8 Pond[e/]	1958-1987	Yes	No	Yes
216-M Pond	1983-Present	No	No	No
216-B-3A Pond	1983-Present	No	No	No
216-B-3B Pond	1984-Present	No	No	No
216-B-3C Pond	1985-Present	No	No	No
216-B-2-1 Ditch	1945-1963	Yes	No	Yes
216-B-2-2 Ditch	1963-1970	Yes	No	Yes
216-B-2-3 Ditch	1970-1987	Yes	No	Yes
216-B-3-1 Ditch	1945-1964	Yes	No	Yes
216-B-3-2 Ditch	1964-1970	Yes	No	Yes
216-B-3-3 Ditch	1970-Present	Yes	No	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-B-20 Trench	1956	Yes	No	Yes
216-B-21 Trench	1956	Yes	No	Yes
216-B-22 Trench	1956	Yes	No	Yes
216-B-23 Trench	1956	Yes	No	Yes
216-B-24 Trench	1956	Yes	No	Yes
216-B-25 Trench	1956	No	No*	No*
216-B-26 Trench	1956-1957	Yes	No	Yes
216-B-27 Trench	1957	No	No	No
216-B-28 Trench	1957	Yes	No	Yes
216-B-29 Trench	1957	Yes	No	Yes
216-B-30 Trench	1957	Yes	No	Yes
216-B-31 Trench	1957	Yes	No*	Yes
216-B-32 Trench	1957	Yes	No	Yes
216-B-33 Trench	1957	Yes	No	Yes
216-B-34 Trench	1957	Yes	No	Yes
216-B-35 Trench	1954	No	No*	No*
216-B-36 Trench	1954	Yes	No	Yes
216-B-37 Trench	1954	Yes	No*	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-B-38 Trench	1954	No	No*	No*
216-B-39 Trench	1953-1954	No	No	No
216-B-40 Trench	1954	Yes	No	Yes
216-B-41 Trench	1954	No	No	No
216-B-42 Trench	1955	No	No	No
216-B-52 Trench	1957-1958	Yes	No*	Yes
216-B-53A Trench	1965	Yes	No	Yes
216-B-53B Trench	1962-1963	No	No	No
216-B-54 Trench	1963-1965	No	No	No
216-B-58 Trench	1965-1967	No	No	No
216-B-63 Trench	1970-Present	Yes	No	Yes
2607-EB Septic Tank/Tile Field	1951-Present	No	No logs	No
2607-EH Septic Tank/Drain Field	1983-Present	No	No logs	No
2607-EK Septic Tank/Drain Field	1980-Present	Yes	No logs	Yes
2607-EM Septic Tank/Drain Field	1984-Present	Yes	No logs	Yes
2607-EN Septic Tank/Drain Field	1980-Present	Yes	No logs	Yes
2607-EN Septic Tank/Drain Field	1980-Present	Yes	No logs	Yes
2607-EO Septic Tank/Drain Field	1985-Present	Yes	No logs	Yes
2607-EP Septic Tank/Drain Field	1984-Present	No	No logs	No

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
2607-EQ Septic Tank	1985-Present	Yes	No logs	Yes
2607-ER Septic Tank	Unknown-Present	--	No logs	No
2607-GF Septic Tank	Unknown	--	No logs	No
2607-E1 Septic Tank/Drain Field	1070-Present	Yes	No logs	Yes
2607-E2 Septic Tank/Drain Field	1980-Present	No	No logs	No
2607-E3 Septic Tank/Tile Field	1944-Present	Yes	No logs	Yes
2607-E4 Septic Tank/Tile Field	1944-Present	--	No logs	No
2607-E7B Septic Tank	Unknown	--	No logs	No
2607-E8 Septic Tank/Drain Field	1978-Present	Yes	No logs	Yes
2607-E9 Septic Tank/Drain Field	1951-Present	--	No logs	No
2607-E11 Septic Tank/Drain Field	1985-Present	Yes	No logs	Yes
216-B-59/59B Trench/Retention Basin	1967-Present	No	No logs	No
Semi-Works Aggregate Area				
216-C-1 Crib	1953-1957	Yes	No	Yes
216-C-3 Crib	1953-1954	Yes	No logs	Yes
216-C-4 Crib	1955-1965	Yes	No logs	Yes
216-C-5 Crib	1955	No	No	No
216-C-6 Crib	1955-1964	Yes	No logs	Yes

Table 2-4. Summary of Screening for Potential to Contribute Contaminants to the Unconfined Aquifer.

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening (Table 2-2)	Confirmed by Geophysical Logs (Table 2-3)	Criteria Indicate Possible Contribution to the Uppermost Aquifer
216-C-7 Crib	1961-Present	No	No logs	No
216-C-10 Crib	1964-1969	Yes	No	Yes
216-C-2 Reverse Well	1953-1988	No	No logs	No
216-C-9 Pond	1953-1985	Yes	No	Yes
200 East Powerhouse Ditch	1943-Present	Yes	No logs	Yes
2607-E-5 Septic Tank/Drain Field	1949-Present	No	No logs	No
2607-E-7A Septic Tank/Drain Field	1983-Present	No	No logs	No
200 North Aggregate Area				
216-N-1 Pond	1944-1952	Yes	No logs	Yes
216-N-4 Pond	1944-1952	Yes	No logs	Yes
216-N-6 Pond	1944-1952	Yes	No logs	Yes
216-N-2 Trench	1947	Yes	No logs	Yes
216-N-3 Trench	1952	Yes	No logs	Yes
216-N-5 Trench	1952	Yes	No logs	Yes
216-N-7 Trench	1952	Yes	No logs	Yes
2607-N Septic Tank/Drain	1944-1952	No	No logs	No
2607-P Septic Tank/Drain	1944-1952	No	No logs	No
2607-R Septic Tank/Drain	1944-1952	No	No logs	No

*Wells in which geophysics was performed do not extend to groundwater.

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Table 2-5. Radionuclide Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Radionuclides (Ci)																		Reported Waste Volume Received (L)
	Am-241	Co-60	Cs-137	H-3	I-129	Pm-147	Pu-238	Pu-239	Pu-240	Pu-241	Total Pu in grams	Ru-106	Sn-113	Sr-90	U-238	Total U	Alpha	Beta	
PUREX Plant Aggregate Area																			
216-A-3 Crib			0.0455								0.2	1.52E-07		0.0431		0.559	0.0123	0.182	3,050,000
216-A-4 Crib		0.0226	6.93					7.99	2.16		140	4.38E-08		4.39	0.134	0.133	8.6	2.21	6,210,000
216-A-5 Crib		3.32	12.1					3.71	1		65	1.08E-07		41.6	0.0881	0.0877	3.99	109	1,630,000,000
216-A-6 Crib		0.18	10.5					2.09	0.548		35.6	5.5E-06		44.1	0.0553	0.055	2.19	291	3,400,000,000
216-A-7 Crib		0.00204	2.31					0.0571	0.0154		1	1.1E-07		0.431	0.00228	0.00227	0.0614	5.29	326,000
216-A-8 Crib			522	0.346							50	4.69E-05		51.5		0.123	3.07	1110	1,150,000,000
216-A-9 Crib		0.00583	4.65	4000				0.0285	0.0077		0.5	3.63E-08		11	0.00008	7.57E-05	0.0307	31	981,000,000
216-A-10 Crib	0.773		80.5	18500	0.107		0.329	3.39		42.3	350	0.309		8.25		0.081	28.1	360	3,210,000,000
216-A-21 Crib		0.471	78.5					8.56	2.31		150	1.45E-06		7.51	0.0653	0.065	9.21	166	77,900,000
216-A-24 Crib		0.0219	268					0.289	0.0779		5.06	1.32E-06		18.3	0.0168	0.0167	9.21	166	77,900,000
216-A-27 Crib		0.3	32.4					5.51	1.49		96.5	1.38E-05		24.5	0.0228	0.0227	5.92	112	23,200,000
216-A-30 Crib			117	16.4		0.429		0.0751			73.1	0.0814	0.00315	102		0.1	4.64	432	7,110,000,000
216-A-36A Crib		0.71	847					4.57	1.23		80	0.000116		978	0.0486	0.0484	4.91	3630	1,070,000
216-A-36B Crib	0.217		350	507	0.00842	1.99		0.0569		0.558	178	3.17	0.000579	331		0.0398	1.1	1360	317,000,000
216-A-37-1 Crib	0.000369		0.0947	1600	0.00426	0.0919		0.000201			0.0283	0.0415	0.00252	0.0542		0.0109	0.00845	0.508	377,000,000
216-A-37-2 Crib	0.0982		0.204	6.13		0.196		373				0.0407	0.00157	0.307		0.0172	0.105	1.85	1,090,000,000
216-A-45 Crib	0.11		0.0097	3850	0.0111	0.0421	0.00613	0.0556		0.658		0.0133	6.56E-05	0.00834		0.00225	0.0551	0.112	103,000,000
216-A-11 French Drain																			100,000
216-A-12 French Drain																			100,000
216-A-13 French Drain																			100,000
216-A-15 French Drain																			10,000,000
216-A-16 French Drain																			122,000
216-A-17 French Drain																			60,000
216-A-18 Trench		0.00179	0.0444					0.00571	0.00154		0.1	2.75E-12			0.472	0.469	0.00614	0.172	488,000
216-A-19 Trench		0.00179	0.0444					0.00571	0.00154		0.1	2.75E-12			13.1	13	0.00614	0.17	1,100,000
216-A-20 Trench		0.00179	0.0444					0.00571	0.00154		0.1	2.75E-12			0.135	0.135	0.00614	0.17	96,000
B Plant Aggregate Area																			
216-B-7A&B Cribs	0	0.012	43.2	0			0	246	66.2	0	4300	0		2200	0.061	0.0606	264	4490	43,600,000
216-B-8 Crib and Tile Field	0	0.009	19.8	0			0	1.7	0.462	0	30	0		5.58	0	0.0151	1.84	49.3	27,200,000
216-B-9 Crib and Tile Field	0	0.0009	3.92	0			0	9.94	2.68	0	174	0		5.52	0.0152	0.0151	10.7	2	36,000,000
216-B-10A Crib	0	0.00099	0.401	0			0	0.56	0.151	0	9.8	0		0	1.89	0.00302	0.602	4.55	9,990,000
216-B-10B Crib	0	0	0.0001	0			0	0	0	0	0	0		0	0.0002	2.49E-07	2.91E-06	5.31E-07	28,000
216-B-12 Crib	0	0.232	716	0			0	21.4	5.76	0	374	0.0001		0	79.3	6.96	23	1540	520,000,000
216-B-14 Crib	0	0.103	114	0			0	1.43	0.385	0	25	0		172	0.073	0.0726	1.53	567	8,710,000
216-B-15 Crib	0	0.109	92.4	0			0	0.285	0.077	0	5	0		87.3	0.0348	0.0348	0.307	357	6,320,000

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Table 2-5. Radionuclide Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Radionuclides (Ci)																		Reported Waste Volume Received (L)
	Am-241	Co-60	Cs-137	H-3	I-129	Pm-147	Pu-238	Pu-239	Pu-240	Pu-241	Total Pu in grams	Ru-106	Sn-113	Sr-90	U-238	Total U	Alpha	Beta	
216-B-40 Trench	0	0.00031	153	0			0	0.0571	0.0154	0	1	0		115	0.00117	0.017	0.0614	523	1,640,000
216-B-52 Trench	0	0.113	160	0			0	1.08	0.293	0	19	0		4.92	0.01	0.00998	1.17	317	8,530,000
216-B-53A Trench	0	0.0335	0.0559	0			0	5.71	1.54	0	100	0		0.0538	0.076	0.00756	6.14	0.246	549,000
216-B-63 Trench	0.0348		0.625	2.12				0.0108			0.573	2.39E-07		2.41		0.15	0.0742	6.32	7,220,000,000
Semi-Works Aggregate Area																			
216-C-1 Crib		0.002	0.0455	70				0.4579	0.123		8	1.89E-08		85.5	0.0988				23,400,000
216-C-3 Crib		0.0014	0.0424								1	8.3E-11		8.04	0.0153				5,000,000
216-C-4 Crib		0.0018	0.0433								1	5.35E-10		11.8	0.0011				170,000
216-C-5 Crib		0.0018	0.0444								1	1.38E-10		4.2	0.0182				37,900
216-C-6 Crib		0.0025	0.0465								0.1	2.73E-08		28.8	0.0001				530,000
216-C-10 Crib		0.0113	0.0855								0.15	8.95E-08		3.45	0.00001				897,000
216-C-9 Pond			0.703								0.338	8.66E-08		2.43					1,030,000,000
200 East Powerhouse Ditch																			13,800/mo
200 North Aggregate Area																			
216-N-1 Pond			0.0813					0.0571	0.0154		1	3.32E-13		0.0713	0.00152	0.00151	0.0614	0.3	946,000,000
216-N-4 Pond			0.0813					0.0571	0.0154		1	3.32E-13		0.0713	0.00152	0.00151	0.0614	0.3	946,000,000
216-N-6 Pond			0.0813					0.0571	0.0154		1	3.23E-13		0.0713	0.00152	0.00151	0.0614	0.3	946,000,000
216-N-2 Trench			0.0785									4.73E-14		0.0687				0.29	7,500,000
216-N-3 Trench			0.0881									1.49E-12		0.0777				0.326	7,600,000
216-N-5 Trench			0.0881									1.49E-12		0.0777				0.326	7,600,000
216-N-7 Trench			0.0881									1.49E-12		0.0777				0.326	7,600,000

Source: WIDS (WHC 1991a).

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)											Waste Volume Received (L)
	Aluminum Nitrate	Ammonium Carbonate	Ammonium Nitrate	BP	Fluoride	Ferrocyanide	Nitrate	Nitrite	Nitric Acid	Normal Paraffin Hydrocarbons	Oxalate	
PUREX Plant Aggregate Area												
216-A-3 Crib												3,050,000
216-A-4 Crib							300					6,210,000
216-A-5 Crib							1,000,000					1,630,000,000
216-A-6 Crib							10,000					3,400,000,000
216-A-7 Crib										180,000		326,000
216-A-8 Crib			320,000	130,000						46,000		1,150,000,000
216-A-9 Crib							300,000					981,000,000
216-A-10 Crib												3,210,000,000
216-A-21 Crib		400,000					9,000					77,900,000
216-A-24 Crib			200,000	90,000						30,000		77,900,000
216-A-27 Crib		300,000					5,000					23,200,000
216-A-30 Crib							16,000					7,110,000,000
216-A-36A Crib												1,070,000
216-A-36B Crib												317,000,000
216-A-37-1 Crib							600					377,000,000
216-A-37-2 Crib												1,090,000,000
216-A-45 Crib												103,000,000
216-A-11 French Drain							100					100,000
216-A-12 French Drain							100					100,000
216-A-13 French Drain							1					100,000
216-A-15 French Drain									1			10,000,000
216-A-16 French Drain							1					122,000
216-A-17 French Drain							1					60,000
216-A-18 Trench							730					488,000
216-A-19 Trench							20,000					1,100,000
216-A-20 Trench							210					96,000
B Plant Aggregate Area												
216-B-7A&B Cribs			22,000		240,000		1,800,000				60,000	43,600,000
216-B-8 Crib and Tile Field			160,000		25,000		1,400,000				6,000	27,200,000
216-B-9 Crib and Tile Field							1,000					36,000,000
216-B-10A Crib							1,000		1,000			9,990,000
216-B-10B Crib									2			28,000
216-B-12 Crib			1,800,000									520,000,000
216-B-14 Crib						5,000	1,500,000					8,710,000
216-B-15 Crib						3,300	90,000					6,320,000

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)											Waste Volume Received (L)
	Aluminum Nitrate	Ammonium Carbonate	Ammonium Nitrate	BP	Fluoride	Ferrocyanide	Nitrate	Nitrite	Nitric Acid	Normal Paraffin Hydrocarbons	Oxalate	
216-B-16 Crib						3,000	1,100,000					5,600,000
216-B-17 Crib						1,800	1,100,000					3,410,000
216-B-18 Crib						5,000	1,000,000					8,520,000
216-B-19 Crib						3,400	1,500,000					6,400,000
216-B-43 Crib						1,100	400,000					2,120,000
216-B-44 Crib						3,000	800,000					5,600,000
216-B-45 Crib						2,600	90,000					4,920,000
216-B-46 Crib						4,000	1,200,000					6,700,000
216-B-47 Crib						2,000	700,000					3,710,000
216-B-48 Crib						2,200	1,000,000					4,090,000
216-B-49 Crib						4,000	1,500,000					6,700,000
216-B-50 Crib		9,100	10,000				1,500					54,800,000
216-B-55 Crib			90,000									1,230,000,000
216-B-57 Crib		12,000										84,400,000
216-B-62 Crib												282,000,000
216-B-4 Reverse Well									1,000			10,000
216-11A&B Reverse Wells												29,600,000
216-B-5 Reverse Well	5,000				50,000		400,000				12,000	30,600,000
216-B-6 Reverse Well									10,000			6,000,000
216-A-25 Pond												307,000,000,000
216-B-3 Pond												240,000,000,000
216-N-8 Pond												unknown
216-B-2-1 Ditch												149,000,000,000
216-B-2-2 Ditch												49,700,000
216-B-3-1 Ditch												149,000,000,000
216-B-3-2 Ditch												149,000,000,000
216-B-20 Trench						2,500	1,100,000					2,680,000
216-B-21 Trench												4,670,000
216-B-22 Trench						2,500	900,000					4,740,000
216-B-23 Trench						2,400	1,000,000					4,520,000
216-B-24 Trench						2,500	600,000					4,700,000
216-B-26 Trench						3,100	800,000					3,760,000
216-B-28 Trench						2,700	1,000,000					5,880,000
216-B-29 Trench						2,600	700,000					4,420,000
216-B-30 Trench						2,500	1,100,000					4,780,000
216-B-32 Trench						2,500	1,000,000					4,770,000
216-B-33 Trench						2,500	1,700,000					4,740,000
216-B-34 Trench						2,600	1,900,000					4,800,000
216-B-36 Trench					5,000		160,000	18,000				1,940,000
216-B-37 Trench					50,000		1,700,000	200,000				4,320,000

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)											Waste Volume Received (L)
	Aluminum Nitrate	Ammonium Carbonate	Ammonium Nitrate	BP	Fluoride	Ferrocyanide	Nitrate	Nitrite	Nitric Acid	Normal Paraffin Hydrocarbons	Oxalate	
216-B-40 Trench				153	4,000		130,000	15,000				1,640,000
216-B-52 Trench				160		5,000	2,100,000					8,530,000
216-B-53A Trench							1					549,000
216-B-63 Trench												7,220,000,000
Semi-Works Aggregate Area												
216-C-1 Crib									15,000			23,400,000
216-C-3 Crib							20					5,000,000
216-C-4 Crib										24,000		170,000
216-C-5 Crib							8,000					37,900
216-C-6 Crib							330					530,000
216-C-10 Crib												897,000
216-C-9 Pond												1,030,000,000
200 East Powerhouse Ditch												13,800/mo
200 North Aggregate Area												
216-N-1 Pond												946,000,000
216-N-4 Pond												946,000,000
216-N-6 Pond												946,000,000
216-N-2 Trench												7,500,000
216-N-3 Trench												7,600,000
216-N-5 Trench												7,600,000
216-N-7 Trench												7,600,000

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)									Waste Volume Received (L)
	Phosphate	Potassium	Sodium Aluminate	Sodium Dichromate	Sodium	Sulfate	Sulfuric Acid	TBP	Tributyl Phosphonate	
PUREX Plant Aggregate Area										
216-A-3 Crib										3,050,000
216-A-4 Crib				110	4,000					6,210,000
216-A-5 Crib										1,630,000,000
216-A-6 Crib										3,400,000,000
216-A-7 Crib								100,000		326,000
216-A-8 Crib										1,150,000,000
216-A-9 Crib										981,000,000
216-A-10 Crib										3,210,000,000
216-A-21 Crib				300	11,000					77,900,000
216-A-24 Crib										77,900,000
216-A-27 Crib				200	6,000					23,200,000
216-A-30 Crib										7,110,000,000
216-A-36A Crib										1,070,000
216-A-36B Crib										317,000,000
216-A-37-1 Crib										377,000,000
216-A-37-2 Crib										1,090,000,000
216-A-45 Crib										103,000,000
216-A-11 French Drain										100,000
216-A-12 French Drain										100,000
216-A-13 French Drain										100,000
216-A-15 French Drain										10,000,000
216-A-16 French Drain										122,000
216-A-17 French Drain										60,000
216-A-18 Trench										488,000
216-A-19 Trench										1,100,000
216-A-20 Trench										96,000
B Plant Aggregate Area										
216-B-7A&B Cribs	130,000	400,000				15,000				43,600,000
216-B-8 Crib and Tile Field	500,000	40,000				70,000	1,400,000			27,200,000
216-B-9 Crib and Tile Field										36,000,000
216-B-10A Crib				100		1,000				9,990,000
216-B-10B Crib										28,000
216-B-12 Crib										520,000,000
216-B-14 Crib	40,000					50,000				8,710,000
216-B-15 Crib	50,000					60,000				6,320,000

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)									Waste Volume Received (L)
	Phosphate	Potassium	Sodium Aluminate	Sodium Dichromate	Sodium	Sulfate	Sulfuric Acid	TBP	Tributyl Phosphonate	
216-B-16 Crib	70,000					110,000				5,600,000
216-B-17 Crib	60,000					90,000				3,410,000
216-B-18 Crib	50,000					70,000				8,520,000
216-B-19 Crib	100,000					90,000				6,400,000
216-B-43 Crib	21,000					29,000				2,120,000
216-B-44 Crib	40,000					60,000				5,600,000
216-B-45 Crib	41,000					60,000				4,920,000
216-B-46 Crib	70,000					100,000				6,700,000
216-B-47 Crib	40,000					60,000				3,710,000
216-B-48 Crib	60,000					80,000				4,090,000
216-B-49 Crib	60,000					80,000				6,700,000
216-B-50 Crib										54,800,000
216-B-55 Crib										1,230,000,000
216-B-57 Crib										84,400,000
216-B-62 Crib										282,000,000
216-B-4 Reverse Well						11				10,000
216-11A&B Reverse Wells										29,600,000
216-B-5 Reverse Well	29,000	80,000				3,300				30,600,000
216-B-6 Reverse Well				100			10,000			6,000,000
216-A-25 Pond										307,000,000,000
216-B-3 Pond										240,000,000,000
216-N-8 Pond										unknown
216-B-2-1 Ditch										149,000,000,000
216-B-2-2 Ditch										49,700,000
216-B-3-1 Ditch										149,000,000,000
216-B-3-2 Ditch										149,000,000,000
216-B-20 Trench	80,000					100,000				2,680,000
216-B-21 Trench										4,670,000
216-B-22 Trench	40,000					80,000				4,740,000
216-B-23 Trench	60,000					60,000				4,520,000
216-B-24 Trench	34,000					50,000				4,700,000
216-B-26 Trench	40,000					60,000				3,760,000
216-B-28 Trench	50,000					80,000				5,880,000
216-B-29 Trench	35,000					50,000				4,420,000
216-B-30 Trench	70,000					110,000				4,780,000
216-B-32 Trench	60,000					90,000				4,770,000
216-B-33 Trench	100,000					110,000				4,740,000
216-B-34 Trench	80,000					90,000				4,800,000
216-B-36 Trench	40,000		24,000			8,000				1,940,000
216-B-37 Trench	400,000					90,000				4,320,000

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Table 2-6. Chemical Waste Inventory Summary for Units Potentially Contributing Contaminants to Groundwater.

Waste Management Unit	Quantity of Reported Chemical Waste (kg)									Waste Volume Received (L)
	Phosphate	Potassium	Sodium Aluminate	Sodium Dichromate	Sodium	Sulfate	Sulfuric Acid	TBP	Tributyl Phosphonate	
216-B-40 Trench	31,000		20,000			7,000				1,640,000
216-B-52 Trench	80,000					80,000				8,530,000
216-B-53A Trench										549,000
216-B-63 Trench										7,220,000,000
Semi-Works Aggregate Area										
216-C-1 Crib										23,400,000
216-C-3 Crib										5,000,000
216-C-4 Crib									14,000	170,000
216-C-5 Crib										37,900
216-C-6 Crib										530,000
216-C-10 Crib										897,000
216-C-9 Pond										1,030,000,000
200 East Powerhouse Ditch										13,800/mo
200 North Aggregate Area										
216-N-1 Pond										946,000,000
216-N-4 Pond										946,000,000
216-N-6 Pond										946,000,000
216-N-2 Trench										7,500,000
216-N-3 Trench										7,600,000
216-N-5 Trench										7,600,000
216-N-7 Trench										7,600,000

Source: WIDS (WHC 1991a).

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Table 2-7. Summary of Waste-Producing Processes in the 200 East Groundwater Aggregate Area. Page 1 of 5

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
PUREX Plant Aggregate Area						
Plutonium Uranium Extraction (PUREX 202-A Building)	Process waste	Nitric acid Tributyl phosphate Bismuth phosphate Paraffin hydrocarbon	High	Acidic (neutralized before disposal)	Low	High
	Wastewater	Nitrates	Low	Acidic to neutral/ basic	Low	Low
Waste Reduction (242 Evaporator)	Cooling water	Beta activity Cadmium Copper Potassium Sodium Nitrate	Unknown	Basic	Low	Low
Tank Farm Condensate (241-A-431 Building)	Wastewater	Unknown	Low	Neutral/basic	Low	Low
B Plant Aggregate Area						
Bismuth Phosphate	Process waste	Nitric acid				
	Aqueous process waste	Phosphoric acid Nitrate solution Uranium Plutonium	High	Acidic (neutralized)	Low	High
Lanthanum Fluoride	Process waste	Plutonium Sodium bismuthate Phosphoric acid	NA	NA	NA	High

Table 2-7. Summary of Waste-Producing Processes in the 200 East Groundwater Aggregate Area. Page 2 of 5

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
	Aqueous process waste	Nitric acid Hydrogen fluoride Lanthanum salts				
Cesium and Strontium Recovery	Process waste	Hydrochloric acid Nitric acid Phosphoric acid	High	Acidic (neutralized)	Low	High
	Aqueous process waste	Normal paraffin hydrocarbon Ammonium carbonate Ammonium hydroxide				
PUREX Wastes	Cladding waste	Sodium hydroxide Nitric acid	High	Acidic (neutralized)	Low	High
	Process waste	Tributyl phosphate Paraffin hydrocarbon Nitrates	Low			Low
S Plant Wastes	Process waste	Nitric acid Sodium aluminate	High	Neutral/basic	Low	High
	Ion exchange waste	Hexone Uranium Plutonium				

Table 2-7. Summary of Waste-Producing Processes in the 200 East Groundwater Aggregate Area. Page 3 of 5

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
		Semi-Works Aggregate Area				
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
	REDOX spent solvent	MIBK	Low	Neutral/basic	High	Intermediate
	Other REDOX wastes	Sodium aluminate Sodium hydroxide Sodium nitrate Chromate Sodium sulfate Ferric hydroxide Plutonium Uranium	Low		Low	Low-High

Table 2-7. Summary of Waste-Producing Processes in the 200 East Groundwater Aggregate Area. Page 4 of 5

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
REDOX and PUREX Pilot Plants (cont.)	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
	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	Intermediate
	Hot Shop sink wastes					
	Cold-run wastes		High	Neutral/basic	Low	
Strontium Recovery Pilot Plant (201-C Process Building)	Process waste	Hydrochloric acid Nitric acid Di-2-ethylhexyl-phosphoric acid		Acidic (neutralized)	High	High

Table 2-7. Summary of Waste-Producing Processes in the 200 East Groundwater Aggregate Area. Page 5 of 5

Process	Waste Generated	Major Chemical Constituents	Ionic Strength	pH	Organic Concentration	Radioactivity
Critical Mass Laboratory (209-E Building)	Neutron reflector tank water	Cesium-137 Ruthenium-106 Strontium-90 Plutonium Uranium Nitrates		Acidic		Intermediate
276-Solvent Handling Facility			Low	Neutral/basic	High	Intermediate
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		
200 North Aggregate Area						
Irradiated Fuel Storage	Basin water overflow	None	Low	Neutral	None	Low
Basin Cleanout	Sediment/sludge	None	Low	Neutral	None	Low
Contaminated Equip. Storage	Boxed solid waste	None	NA	NA	NA	Low
Electrical Maintenance	PCB contaminated oil	PCBs	NA	NA	High	Low
Railroad Maintenance	Radioactive solid waste	None	NA	NA	NA	Low

NA = No information available

Table 2-8. Chemical Parameters for OGWMN Well Samples.

PUREX Plant Cribs Sample Parameters	
Gross Beta	Anions
Gross Alpha	TOC
Tritium	VOA
TOX	I-129
lab pH	Uranium (total)
Conductivity	Sr-90
Filtered metals	Gamma scan
B Plant Cribs Sampling Parameters	
Gross Beta	Anions
Gross Alpha	TOC
Tritium	Sr-90
TOX	Pu-239
lab pH	Uranium (total)
Filtered metals	Gamma scan

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Table 2-9. OGWMN Wells Within the 200 East Area.

Facility	Well Number	Year of Installation	Depth of Screened Interval (feet)[c]	Formation Screened Within[b]	Current Depth to Water (feet)[a]
B Tank Farm	299-E33-1	54	215-235	Hlg	224
	299-E33-3	54	219-231	Hlg	224
	299-E33-7	55	215-230	Hlg	224
	299-E33-6	55	214-219	Hlg	223
	299-E33-12	53	305-385	Hlg	219
	299-E33-9	49	252-262	Hlg	DNF
	299-E33-24	67	219-241	Hlg	235
	299-E33-8	53	230-257	Hlg	249
	299-E33-21	57	235-275	Hlg	265
	299-E33-10	55	259-285	Hlg	270
	299-E33-18	50	240-260	Hlg	241
	299-E33-28	87	256-276	Hlg	261
216-B-62	299-E28-21	69	257-325	Unit E	285
	299-E28-19	69	260-325	DNF	DNF
	299-E28-18	69	260-235	Unit E	289
216-B-12	299-E28-8	57	250-294	DNF	DNF
	299-E28-16	68	270-323	Unit E	300
216-B-55	299-E28-13	66	DNF	DNF	301
	299-E28-12	DNF	DNF	DNF	305
B Plant	299-E28-17	69	289-335	Unit E	304
	299-E28-23	69	278-328	Unit E	DNF
	299-E28-24	80	277-327	Unit E	280
	299-E28-7	57	270-335	Unit E	283
	299-E28-25	80	279-328	Unit E	280
B/C Cribs	299-E13-14	56	317-362	Hlg	288
and Trenches	299-E13-8	56	341-362	DNF	DNF
	299-E13-6	55	280-372	DNF	DNF
Semi-Works	299-E24-8	57	262-333	Unit E	285
	299-E27-5	62	317-338	DNF	DNF
216-A-45	299-E17-12	86	317-337	Unit E	319
	299-E17-13	86	303-333	Unit E	316

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Table 2-9. OGWMN Wells Within the 200 East Area. Page 2 of 3

Facility	Well Number	Year of Installation	Depth of Screened Interval (feet)[c]	Formation Screened Within[b]	Current Depth to Water (feet)[a]
216-A-10	299-E17-1	55	300-341	Unit E	316
	299-E24-1	55	295-348	Unit E	313
	299-E24-2	56	308-362	Unit E	314
216-A-38	299-E24-11	67	308-362	Unit A	315
	299-E17-6	65	303-362	Hlg	317
216-A-36B	299-E17-8	67	298-335	Unit E	316
	299-E17-5	65	298-335	Unit E	316
	299-E17-2	60	310-320	Unit E/A	316
	299-E24-12	68	272-298	Unit E	300
216-A-9	299-E24-4	56	256-315	Unit A	293
A Tank Farm	299-E25-13	63	270-338	DNF	279
	299-E24-13	69	270-338	Unit E	288
	299-E26-6	60	250-290	Unit E	241
C Tank Farm	299-E27-7	82	241-281	Unit E	231
	299-E26-8	82	326-396	Unit E	198
216-A-24	299-E26-2	58	220-265	Unit E	232
	299-E26-4	58	225-281	Unit E	244
216-A-8	299-E25-6	58	234-288	Unit E	258
	299-E25-8	56	244-284	DNF	DNF
207-A	299-E25-2	55	276-316	Unit A	272
	299-E25-3	54	270-312	Unit A	274
216-A-6	299-E25-17	76	273-295	Unit E	273
	299-E25-18	76	269-296	Undifferentiated	276
216-A-37-1	299-E25-19	76	270-295	Undifferentiated	274
	299-E25-20	76	268-293	Undifferentiated	273
216-A-30	299-E25-11	60	265-335	Undifferentiated	278
	299-E16-2	60	265-336	Unit A/Hlg	275
216-A-37-2	299-E25-22	83	265-295	Unit E	271
	299-E25-21	83	270-293	Unit E	273
	299-E25-24	83	270-290	Unit E	276
	299-E25-23	83	273-304	Unit E	273
Gable Mountain	699-63-58	DNF	DNF	DNF	90

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Table 2-9. OGWMN Wells Within the 200 East Area.

Facility	Well Number	Year of Installation	Depth of Screened Interval (feet)[c/]	Formation Screened Within[b/]	Current Depth to Water (feet)[a/]
Pond (216-A-25)	699-54-57	55	85-100	DNF	96
	699-54-57	55	236-331	Basalt	174
	699-55-55A	90	148-169	Hlg	157
	699-53-50	80	145-195	Unit A	39
	699-50-48B	80	210-250	Basalt	144
	699-47-50	80	260-295	Basalt	180
	699-42-40A	81	139-171	Unit A	123
	699-42-40B	81	130-150	Unit a	125
	699-42-40C	82	306-390	Basalt	132
	699-45-42	48	158-180	DNF	DNF
	699-50-45	80	133-178	DNF	43
	699-50-42	55	50-64	Hlg	56
	699-51-46	80	120-163	DNF	38
	699-53-47A	66	0-41	Undifferentiated	33
	699-52-47B	84	26-46	Undifferentiated	33
	699-52-46A	80	170-225	DNF	47
	699-52-48	80	145-195	Unit A	DNF
	699-53-48A	84	0-53	Hlg	61
	699-53-48B	84	24-44	Hlg	DNF
	699-54-48	84	42-62	Hlg	54
	699-54-49	84	32-52	Hlg	DNF
	699-55-50C	56	35-56	Hlg	50
	699-55-50D	56	33-92	Hlg	DNF
	699-56-53	53	190-270	Basalt	32

Well network for calendar year 1991.
a/ Information obtained in Lindsay et. al. (1992).
b/ Water level data obtained in Kasza et. al. (1991).
c/ Information obtained in McGhan (1989), Legerwood

DNF: Data not found.
Unit E: Ringold Formation Unit E
Unit A: Ringold Formation Unit A
Hlg: Hanford formation lower gravel unit

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Table 2-10. RCRA Groundwater Monitoring Network Within the 200 East Area.

Facility	Type of Facility	Monitoring Well	Year of Installation	Depth of Screened Interval[c]	Formation Screened Within[b]	Current Depth to Water[a]
LLWMA 1	Burial	299-E28-26	87	278-325	Hlg	284
	Ground	299-E28-27	87	270-290	Hlg	277
		299-E28-28	90	275-295	Hlg	284
		299-E32-2	87	258-278	Unit E	267
		299-E32-3	87	266-286	Hlg	274
		299-E32-4	87	278-298	Hlg	283
		299-E32-5	89	270-290	Hlg	279
		299-E32-6	91	255-276	Hlg	261
		299-E32-7	91	247-267	Hlg	252
		299-E32-8	91	235-255	Hlg	238
		299-E32-9	91	231-251	Hlg	236
		299-E33-28	87	256-276	Hlg	261
		299-E33-29	87	263-283	Hlg	271
		299-E33-30	87	255-275	Unit E	261
		299-E33-34	90	219-239	Unit E	230
		299-E33-35	90	228-249	Hlg	240
LLWMA 2	Burial	299-E27-8	87	226-246	Hlg	235
	Ground	299-E27-9	87	219-239	Hlg	226
		299-E27-10	87	213-233	Hlg	221
		299-E27-11	89	251-231	Hlg	240
		299-E27-17	91	223-244	Hlg	213
		299-E34-2	87	220-240	Hs/Hlg	227
		299-E34-3	87	193-213	Hlg	208
		299-E34-4	87	DNF	Hlg	DNF
		299-E34-5	87	171-191	Hlg	187
		299-E34-6	87	175-195	Hlg	195
		299-E34-7	89	194-205	Hlg	201
		299-E34-9	91	213-234	Hlg	222
		299-E34-10	91	225-246	Hlg	233
		299-E35-1	89	231-251	Hlg	194
WMA A-AX	Single	299-E24-19	89	280-300	Unit E	290
	Shell	299-E24-20	90	279-300	Unit E	286
	Tank	299-E25-40	89	252-273	Unit E	262

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Table 2-10. RCRA Groundwater Monitoring Network Within the 200 East Area.

Facility	Type of Facility	Monitoring Well	Year of Installation	Depth of Screened Interval[c]	Formation Screened Within[b]	Current Depth to Water[a]
		299-E25-41	89	255-276	Unit E	267
WMA B-BY-BX	Single	299-E33-31	89	235-256	Hlg	244
	Shell	299-E33-32	89	246-267	Hlg	257
	Tanks	299-E33-33	89	227-248	Hlg	237
		299-E33-36	90	234-255	Hlg	245
		299-E33-41	90	270-245	Hlg	252
		299-E33-38	90	219-240	Hlg	229
		299-E33-39	90	208-229	Hlg	220
		299-E33-42	91	239-259	Hlg	251
		299-E33-43	91	250-271	Hlg	260
WMA C	Single	299-E27-12	89	247-267	Unit E	258
	Shell	299-E27-13	89	245-275	Unit E	266
	Tank	299-E27-14	89	246-267	Unit E	255
		299-E27-15	89	238-259	Unit E	250
		299-E27-7	82	241-281	Unit E	231
Liquid Effluent		299-E35-2	90	DNF	Hlg	198
Retention Facility		299-E26-9	90	DNF	Hlg	199
		299-E26-10	90	DNF	Hlg	198
		299-E26-11	90	DNF	Hlg	194
2101-M	Waste	299-E18-1	88	308-329	Unit E	317
	Pond	299-E18-2	88	308-329	Unit E	319
		299-E18-3	88	309-330	Hlg/Unit E	319
		299-E18-4	88	308-328	Unit E	319
216-B-63	Trench	299-E27-11	89	231-251	Hlg	240
		299-E27-16	90	239-260	Unit E	249
		299-E27-8	87	226-246	Unit E	235
		299-E27-9	87	219-239	Unit E	226
		299-E33-33	90	227-248	Unit E	237
		299-E33-36	90	234-255	Unit E	245
		299-E33-37	90	240-261	Unit E	250
		299-E34-8	90	228-248	Unit E	238
		299-E34-10	91	225-246	Unit E	233
		299-E27-17	91	223-244	Hlg	213

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Table 2-10. RCRA Groundwater Monitoring Network Within the 200 East Area.

Facility	Type of Facility	Monitoring Well	Year of Installation	Depth of Screened Interval[c]	Formation Screened Within[b]	Current Depth to Water[a]
216-A-10	Crib	299-E24-18	88	308-329	Unit E	316
		299-E25-36	88	296-317	Unit E	304
		299-E17-19	88	304-324	Unit E	317
		299-E17-20	88	303-324	Hlg	316
		299-E24-16	88	304-324	Unit E	318
		299-E24-17	88	308-328	Unit E	317
		299-E17-1	55	300-341	Unit E	316
		299-E24-2	56	295-348	Unit E	314
216-A-36B	Crib	299-E17-16	88	309-329	Unit E	318
		299-E17-17	88	310-330	Unit E	317
		299-E17-18	88	309-329	Unit E	318
		299-E17-15	88	307-327	Hlg	319
		299-E17-14	88	310-330	Unit E	319
		299-E17-9	68	310-320	Unit E	315
		299-E17-5	65	298-335	Unit E	316
216-A-29	Ditch	299-E25-32P	88	259-279	Hlg	266
		299-E25-26	85	270-290	Unit E	265
		299-E25-28	86	320-340	Unit A	252
		299-E25-34	88	252-272	Unit E	259
		299-E25-35	88	260-281	Unit E	271
		299-E17-15	88	307-327	Hlg	319
		299-E17-20	88	303-324	Hlg	316
		299-E25-11	60	265-335	Undifferentiated	278
		299-E25-18	76	269-294	Undifferentiated	276
		299-E25-19	76	270-295	Undifferentiated	274
		299-E25-20	76	268-293	Undifferentiated	273
		299-E25-21	83	270-293	Unit E	273
		299-E25-31	87	259-279	Unit E	269
		299-E25-36	88	296-317	Unit E	304
		699-43-43	88	157-177	Hlg	164
		699-43-45	89	183-203	Hlg	193
		299-E25-42	91	268-289	Hlg	280
		299-E25-43	91	238-259	Hlg	246

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Table 2-10. RCRA Groundwater Monitoring Network Within the 200 East Area.

Facility	Type of Facility	Monitoring Well	Year of Installation	Depth of Screened Interval[c]	Formation Screened Within[b]	Current Depth to Water[a]
		299-E26-12	91	218-239	Hlg	227
		299-E26-13	91	DNF	Unit E	201
216-B-3	Pond	299-E18-1	88	308-329	Hlg	317
		299-E32-4	87	278-298	Hlg	283
		699-40-39	89	201-212	Unit A	128
		699-40-40A	91	215-226	Unit A	134
		699-40-40B	91	188-200	Unit A	128
		699-41-40	89	164-174	Unit A	130
		699-42-39A	91	169-180	Unit A	139
		699-42-39B	91	203-214	Unit A	141
		699-42-40A	81	139-171	Unit A	123
		699-42-41	91	134-155	Unit E	142
		699-42-42B	88	193-203	Unit A	166
		699-43-40	91	113-134	Unit A	123
		699-43-41E	89	136-146	Unit A	129
		699-43-41F	89	165-175	Unit A	129
		699-43-41G	91	188-199	Unit A	133
		699-43-42J	88	157-177	Unit A	162
		699-43-43	88	157-177	Unit A	165
		699-43-45	89	183-203	Unit A	193
		699-44-42	88	151-172	Unit A	158
		699-44-43B	89	156-176	Unit A	165
Grout Treatment		299-E25-25	85	269-289	Unit E	265
Facility		299-E25-31	87	259-279	Hlg	269
		299-E25-32P	88	260-280	Unit A	266
		299-E25-33	88	262-282	Unit A	247
		299-E25-37	89	260-280	Unit E	270
		299-E25-38	89	260-280	Unit E	270
		299-E25-39	90	DNF	Hlg	267
		299-E25-29P	87	256-330	Unit E	271
Nonradioactive		699-26-34	86	117-137	Hlg	125
Dangerous Waste		699-26-35A	86	120-140	Hlg	130
Landfill		699-26-35C	87	DNF	Hlg	129

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Table 2-10. RCRA Groundwater Monitoring Network Within the 200 East Area.

Facility	Type of Facility	Monitoring Well	Year of Installation	Depth of Screened Interval[c]	Formation Screened Within[b]	Current Depth to Water[a]
		699-26-33	86	123-143	Unit E	133
		688-25-34A	86	118-138	Hlg	127
		699-25-34B	86	118-138	Hlg	126
		699-25-33A	87	191-200	Hlg	126
Solid Waste		699-24-35	87	130-145	Hlg	133
Landfill		699-25-34C	87	124-139	Hlg	133
		699-24-34C	87	121-136	Hlg	130
		699-24-34B	87	122-137	Hlg	131
		699-24-34A	87	122-137	Hlg	130
		699-23-34	87	121-136	Hlg	130
		699-25-35A	86	DNF	DNF	DNF
		699-24-33	48	116-164	Hlg	122

Shading indicates upgradient wells.
DNF - Data not found.
[a] Water level data obtained for December 1991, from Kasza et al. (1991).
[b] Information obtained in DOE/RL 1992c.
[c] Information obtained in McGhan (1989), Ledgerwood (1992), and DOE/RL (1992b).
Hlg - Hanford formation lower gravel
Unit E - Ringold Formation unit E gravel
Unit A - Ringold Formation unit A gravel

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Table 2-11. Constitiuents Analyzed for at the Low Level Burial Grounds.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross Alpha	Toxaphene
Gross Beta	2,4-D
Lead	2,4,5-Silvex
Site-Specific Parameters	
1,1,2,2-Tetrachloroethane	Cyanide
1,2-Dichloroethane	Ethylbenzene
1,2-Dichloropropane	Gamma Scan Plutonium
Acetone	Naphthalene
Benzene	Strontium-90
Beryllium	Toluene
Bromoform	Tetrachloroethylene
Carbon tetrachloride	trans-1,1-Dichloroethylene
Cesium-137	Trichloroethylene
Chlorobenzene	Uranium
cis-1,1-Dichloroethylene	Vinyl Chloride
Copper	Xylenes

Source: DOE/RL 1991c

Table 2-12. Constituents Analyzed for at the Single-Shell Tanks.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-Silvex
Site-Specific Parameters	
1,1,2,2-Tetrachloroethane	Cyanide
1,2-Dichloroethane	Ethylbenzene
1,2-Dichloropropane	Gamma Scan Plutonium
Acetone	Naphthalene
Benzene	Stratitium-90
Beryllium	Toluene
Bromoform	Tetrachloroethylene
Carbon tetrachloride	trans-1,1-Dichloroethylene
Cesium-137	Trichloroethylene
Chlorobenzene	Uranium
cis-1,1-Dichloroethylene	Vinyl Chloride
Copper	Xylenes

Source: DOE/RL 1991c

Table 2-13. Constituents Analyzed for at the 216-B-3 Pond.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Hydrazine	Tritium
Ammonium	Total organics
Assessment Monitoring Parameters	
Herbicides	Enhanced volaites
Pesticides	Acid/Base/Neutrals
PCBs	

Source: DOE/RL 1992b

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Table 2-14. Constituents Analyzed for at the Grout Treatment Facility.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Arsenic	Selenium
Chromiun	Technetium-99
Long List	
Equivalent to 40 CFR 264, Appendix IX, "Groundwater Quality Monitoring List" (EPA 1989c)	

Source: DOE/RL 1992b

Table 2-15. Constituents Analyzed for at the 216-A-29 Ditch.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Hydrazine	Ammonium
Tritium	Total organics
Assessment Monitoring Parameters for the 216-A-29 Ditch	
Herbicides	Enhanced volaites
Pesticides	Acid/Base/Neutrals
PCBs	Anions
	ICP metals

Source: DOE/RL 1992b

Table 2-16. Constituents Analyzed for at the 216-A-36B Crib.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Uranium	Ammonium
Tritium	Gamma

Source: DOE/RL 1992b

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Table 2-17. Constituents Analyzed for at the 216-A-10 Crib.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Uranium	Gamma
Tritium	

Source: DOE/RL 1992b

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Table 2-18. Constituents Analyzed for at the 216-B-63 Trench.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Uranium	Gamma
Tritium	Volatile organics analysis

Source: DOE/RL 1992b

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Table 2-19. Constituents Analyzed for at the Liquid Effluent Retention Facility.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Fluoride	Selenium
Gross alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters for the Low-Level Buriel Grounds	
Ammonia	1-Butanol
Tritium	

Source: DOE/RL 1992b

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Table 2-20. Constituents Analyzed for at the 2101-M Pond.

Contamination Indicator Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Site Specific Parameters for the Low-Level Burial Grounds	
Volatile organics	Tritium*
Turbidity	Gamma Scan*
Radium	Technetium-99*
Alpha	ICP metals
Beta	Barium
Uranium*	Copper

* These constituents will be analyzed to help establish contamination and groundwater flow.
Source: DOE/RL 1992b

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Table 2-21. Constituents Analyzed for at the Nonradioactive Dangerous Waste Landfill.

Contaimination Indicator Parameters	
pH	Total organic carbon (TOC
specific conductance	Total organix halogen (TOX)
Groundwater Quality Parameters	
Chloride	Phenols
Iron	Sodium
Manganese	Sulfate
Drinking Water Parameters	
Arsenic	Lindane
Barium	Methoxychlor
Cadmium	Mercury
Chromium	Nitrate
Coliform bacteria	Radium
Endrin	Silver
Flurode	Selenium
Gross Alpha	Toxaphene
Gross beta	2,4-D
Lead	2,4,5-TP Silvex
Site Specific Parameters	
Tritium	Volatile chlorinated hydrocarbons

Source: DOE/RL 1992b

Table 2-22. Constituents Analyzed for at the Solid Waste Landfill.

Parameters and Constituents Required by WAS 173-304-490	
pH	Sulfate
Temperature	Dissolved iron
Conductivity	Dissolved zinc
Chloride	Chemical oxygen demand
Nitrate	Total organic carbon (TOC)
Ammonia as nitrogen	Total coliform
Site Specific Parameters	
Total organic halogen	
1,1,1-Trichloroethane	
Trichloroethylene	
Others	
Tritium	

Source: DOE/RL 1992b

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Table 2-23. Constituents Analyzed for Under the CERCLA Groundwater Monitoring Program.

Groundwater Quality Parameters	
pH	Total organic carbon (TOC)
Specific conductance	Total organic halogen (TOX)
Anions	Total dissolved solids
Drinking Water Parameters	
Hydrazine	Cyanide
Pesticides	Semivolatile organic compounds
Volatile organic compounds	Lindane
Coliform bacteria	Mercury
Gross alpha	Selenium
Gross beta	Lead
Other Parameters	Gamma Scan
Technetium-99	Cesium-137
Tritium	Uranium
U-Chem	Ruthenium-106
	Plutonium
	Strontium
	Cobalt-60

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Table 2-24. CERCLA Groundwater Monitoring Network. Page 1 of 2

Well Number	Year of Installation	Depth of Screened Interval (feet)[c]	Formation Screened Within[b]	Current Depth to Water (feet)[a]
299-E28-26	87	278-325	Hlg	284
299-E28-27	87	270-290	Hlg	277
299-E28-28	90	275-295	Hlg	284
299-E32-02	57	258-278	Unit E	267
299-E32-05	87	270-290	Hlg	279
299-E33-01	54	215-235	Hlg	224
299-E33-03	54	219-231	Hlg	224
299-E33-04	54	215-231	Hlg	227
299-E33-05	55	218-235	Hlg	227
299-E33-07	55	215-230	Hlg	224
299-E33-12	53	305-385	Hlg	219
299-E33-13	53	210-235	Hlg	224
299-E33-14	53	212-227	Hlg	219
299-E33-15	53	222-237	Hlg	223
299-E33-18	50	240-260	Hlg	241
299-E33-24	67	219-241	Hlg	235
299-E33-26	69	DNF	Hlg	228
299-E33-28	87	256-276	Hlg	261
299-E33-29	87	263-283	Hlg	271
299-E33-30	87	255-275	Unit E	261
299-E33-31	89	235-256	Hlg	245
299-E33-32	89	246-267	Hlg	256
299-E33-33	89	227-248	Hlg	237
299-E33-34	91	219-239	Unit E	231
299-E33-35	DNF	228-249	Hlg	240
299-E33-38	90	219-240	Hlg	229
299-E33-40	91	DNF	Unit E	DNF
699-47-50	80	260-295	Basalt	180

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Table 2-24. CERCLA Groundwater Monitoring Network. Page 2 of 2

Well Number	Year of Installation	Depth of Screened Interval (feet)[c]	Formation Screened Within[b]	Current Depth to Water (feet)[a]
699-47-60	48	235-277	Hlg/Unit E	249
699-48-50	DNF	DNF	DNF	170
699-49-55A	61	125-135	Hlg	128
699-49-55B	55	175-226	Basalt	127
699-49-57A	56	144-161	Hlg	150
699-49-57B	56	220-230	Basalt	153
699-50-53A	55	142-159	Hlg	154
699-50-53B	90	215-225	Hs	155
699-52-54	90	157-167	Hlg	162
699-52-57	90	139-159	Hlg	155
699-53-55A	61	165-280	Hlg	175
699-53-55B	75	232-252	Hs	175
699-53-55C	75	187-220	Hs	174
699-54-57	55	236-331	Basalt	174
699-55-55	90	148-169	Hug	157
699-57-59	92	166-186	Hun	171
699-55-57	75	139-169	Hun	166

DNF - Data not found.
[a] Water level data obtained from Kasza et al. (1991).
[b] Information obtained in Lindsey et al. (1992).
[c] Information obtained in McGhan (1989), Ledgerwood (1992), and DOE/RL (1992b).
Hlg - Hanford formation lower gravel
Unit E - Ringold Formation unit E
Hs - Hanford formation sand
Hug - Hanford formation upper gravel
Hun - Hanford formation undifferentiated
The CERCLA Network is discussed in Section 2.8.3.

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Table 2-25. PNL Groundwater Monitoring Well Network. Page 1 of 5

Well Number	Year of Installation	Depth of Screened Interval (ft)[a]	Formation Screened Within[b]	Current Depth to Water (ft)[a]
299-E13-14	56	317-362	Hlg	288
299-E13-19	57	310-360	Hlg/Unit E	324
299-E13-5	55	330-365	Hlg/Unit E	341
299-E16-2	60	265-336	Unit A/Hlg	275
299-E17-1	55	300-341	Unit E	316
299-E17-12	86	317-337	Unit E	319
299-E17-13	86	303-333	Unit E	316
299-E17-14	88	310-330	Unit E	319
299-E17-15	88	307-327	Unit E	319
299-E17-16	88	309-329	Unit E	318
299-E17-17	88	310-330	Unit E	317
299-E17-18	88	309-329	Unit E	318
299-E17-19	88	304-324	Unit E	317
299-E17-2	60	310-320	Unit A/Unit E	316
299-E17-20	88	303-324	Hlg	316
299-E17-5	65	298-335	Unit E	316
299-E17-6	65	303-362	Hlg	317
299-E17-8	67	298-335	Unit E	316
299-E17-9	68	310-320	Unit E	315
299-E18-1	88	308-329	Unit E	317
299-E18-2	88	308-329	Unit E	319
299-E18-3	88	309-330	Hlg/Unit E	319
299-E18-4	88	308-328	Unit E	319
299-E24-1	55	295-348	Unit E	313
299-E24-11	67	308-362	Unit A	315
299-E24-12	68	272-298	Unit E	300
299-E24-13	69	270-338	Unit E	288
299-E24-16	88	304-324	Unit E	318

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Table 2-25. PNL Groundwater Monitoring Well Network. Page 2 of 5

Well Number	Year of Installation	Depth of Screened Interval (ft)[a]	Formation Screened Within[b]	Current Depth to Water (ft)[a]
299-E24-17	88	308-328	Unit E	317
299-E24-18	88	308-329	Unit E	316
299-E24-2	56	308-362	Unit E	314
299-E24-4	56	256-315	Unit A	293
299-E24-7	56	305-350	Hs	313
299-E24-8	57	262-333	Unit E	285
299-E25-11	60	265-335	Undifferentiated	278
299-E25-13	63	256-315	Unit A	280
299-E25-17	76	273-295	Unit E	273
299-E25-18	76	269-294	Undifferentiated	276
299-E25-19	76	270-295	Undifferentiated	274
299-E25-2	55	276-316	Unit A	272
299-E25-20	76	268-293	Undifferentiated	273
299-E25-21	83	270-293	Hlg	273
299-E25-22	83	265-295	Unit E	271
299-E25-23	83	273-304	Unit E	273
299-E25-24	83	270-290	Unit E	276
299-E25-25	85	269-289	Unit E	265
299-E25-26	85	270-290	Unit E	265
299-E25-27	85	274-294	Unit E	272
299-E25-28	86	320-340	Unit A	252
299-E25-29P	87	256-330	Unit E (bottom)	271
299-E25-3	54	270-312	Unit A	274
299-E25-30P	87	264-284	Unit E	274
299-E25-31	87	259-279	Unit E	269
299-E25-32P	88	259-279	Hlg	266
299-E25-33	88	262-282	Unit A	247
299-E25-34	88	252-272	Unit E	259

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Table 2-25. PNL Groundwater Monitoring Well Network.

Well Number	Year of Installation	Depth of Screened Interval (ft)[c]	Formation Screened Within[b]	Current Depth to Water (ft)[a]
299-E25-35	88	260-281	Unit E	271
299-E25-36	88	296-317	Unit E	304
299-E25-37	89	260-280	Unit E	270
299-E25-38	89	260-280	Unit E	270
299-E25-6	58	234-288	Unit E	258
299-E25-9	56	233-288	Unit E	254
299-E26-1	48	217-227	Unit E	213
299-E26-2	58	220-265	Unit E	232
299-E26-4	58	225-281	Unit E	244
299-E26-6	60	250-290	Unit E	241
299-E26-8	82	326-396	Unit E	198
299-E27-10	87	213-233	Hlg	221
299-E27-5	62	317-338	DNF	DNF
299-E27-7	82	241-281	Unit E	231
299-E27-8	87	226-246	Hlg	235
299-E27-9	87	219-239	Hlg	226
299-E28-12	DNF	DNF	DNF	305
299-E28-13	66	DNF	DNF	301
299-E28-16	68	270-323	Unit E	300
299-E28-17	69	289-335	Unit E	304
299-E28-18	69	260-325	Unit E	289
299-E28-21	69	257-325	Unit E	285
299-E28-23	69	278-328	Unit E	DNF
299-E28-24	80	277-327	Unit E	280
299-E28-25	80	279-328	Unit E	280
299-E28-26	87	278-325	Hlg	284
299-E28-27	87	270-290	Hlg	277
299-E28-7	57	270-335	Unit E	283

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Table 2-25. PNL Groundwater Monitoring Well Network. Page 4 of 5

Well Number	Year of Installation	Depth of Screened Interval (ft)[a]	Formation Screened Within[b]	Current Depth to Water (ft)[a]
299-E28-9	57	290-340	Unit E	397
299-E32-1	57	241-271	Unit E	253
299-E32-2	87	258-278	Unit E	267
299-E32-3	87	266-286	Hlg	274
299-E32-4	87	278-298	Hlg	283
299-E33-1	54	215-235	Hlg	224
299-E33-10	55	259-285	Hlg	270
299-E33-12	53	305-385	Hlg	219
299-E33-18	50	240-260	Hlg	241
299-E33-20	56	225-251	Hlg	234
299-E33-21	57	235-275	Hlg	265
299-E33-24	67	219-241	Hlg	235
299-E33-25	69	199-233	Hlg	262
299-E33-28	87	256-276	Hlg	261
299-E33-29	87	263-283	Hlg	271
299-E33-3	54	219-231	Hlg	224
299-E33-30	87	255-275	Unit E	261
299-E33-5	55	218-235	Hlg	230
299-E33-7	55	215-230	Hlg	224
299-E33-8	53	230-257	Hlg	249
299-E33-9	49	252-262	Hlg	DNF
299-E34-1	61	215-230	Hlg	226
299-E34-2	87	220-240	Hs/Hlg	228
299-E34-3	87	193-213	Hlg	208

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Table 2-25. PNL Groundwater Monitoring Well Network. Page 5 of 5

Well Number	Year of Installation	Depth of Screened Interval (ft)[c]	Formation Screened Within[b]	Current Depth to Water (ft)[a]
299-E34-6	87	171-191	Hlg	187
299-E34-6	87	175-195	Hlg	195

DNF - Data not found.
[a] Water levels obtained in Kasza et al. (1991).
[b] Information obtained in Lindsey et al. (1992).
[c] Information obtained in McGhan (1989), Ledgerwood (1992), and DOE/RL (1992b).
Unit E - Ringold Formation unit E
Lm - Ringold Formation lower mud unit
Unit A - Ringold Formation unit A
Hlg - Hanford formation lower gravel
Hs - Hanford formation sand
The PNL Network is discussed in Section 2.8.4.

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3.0 SITE CONDITIONS

The following sections describe the physical nature and setting of the Hanford Site and the 200 East 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).

These sections incorporate information from other documents which are referenced as applicable. At some locations in the vicinity of the 200 East Area additional geologic, geophysical, hydrogeologic, and water quality data are needed for a more detailed interpretation of site conditions and to support future site investigations. These data gaps and generalized future site investigation strategies are discussed in Section 8.0.

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3.1 PHYSIOGRAPHY AND TOPOGRAPHY

The Hanford Site (Figure 3-1) is situated within the Pasco Basin of south-central 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 Paulouse 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 1988). 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 3-1). The elevation ranges from approximately 225 m (740 ft) above msl in the southern part of the B Plant Aggregate Area to about 133 m (435 ft) above msl in the northern part of the B Plant Aggregate Area. A detailed topographic map is provided as Plate 2.

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 semi-arid 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 hr storm event is approximately 5 cm (2 in.). Average winter snowfall ranges from 13 cm (5.3 in.) in January to 0.8 cm (0.31 in.) in March. The record snowfall of 62 cm (24.4 in.) occurred in February 1916 (Stone et al. 1983). During December through February, snowfall accounts for about 38% of all precipitation in those months.

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

3.2.2 Winds

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

Figure 3-6 shows wind roses for the Hanford Telemetry Network (Stone et al. 1983). The gravity drainage from the Cascades produces a prevailing west-northwest wind in the 200 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 °C (-27 °F) to -6 °C (+22 °F), and maximum summer temperatures vary from 38 °C (100 °F) to 46 °C (115 °F). Between 1914 and 1980, a total of 16 days with temperatures -29 °C (-20 °F) or below had been recorded. There are 10 days of record when the maximum temperature failed to go above -18 °C (0 °F). Prior to 1980, there were three summers on record when the temperatures were 38 °C (100 °F) or above for 11 consecutive days (Stone et al. 1983).

3.3 SURFACE HYDROLOGY

3.3.1 Pasco Basin Surface Hydrology

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

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

3.3.2 Hanford Site Surface Hydrology

Primary surface water features associated with the Hanford Site, located near the center of the Pasco Basin, are the Columbia and its major tributaries, the Yakima, Snake, and Walla Walla Rivers. West Lake, about 4 hectares (10 acres) in area and less than 0.9 m (3 ft) deep, is the only natural lake within the Hanford Site (DOE 1988). 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 Nuclear Project 2, and Hanford Site intakes for onsite water use. Much of the northern and eastern parts of the Hanford Site is 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. The Washington State

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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 1988).

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.

3.3.3 200 East Area Surface Hydrology

The 200 East 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 (Skaggs and Walters 1981).

The following sections describe surface water bodies within each of the 200 East source aggregate areas, and the potential for flooding related to these structures. Locations of facilities described are identified on Plate 1.

3.3.3.1 PUREX Plant Aggregate Area. No natural surface water bodies exist in the PUREX Plant Aggregate Area. The only existing man-made surface water bodies are the 207-A Retention Basins and the open stretches of the 216-A-29 Ditch. The 216-A-29 Ditch is located outside the perimeter fence, southeast of the southeast corner of the 241-A Tank Farm. The ditch empties into the 216-B-3-3 Ditch and terminates at the 216-B-3 Pond. During the fall of 1991, the physical configuration of the 216-A-29 Ditch was modified. The southern portion of the ditch located within the Grout Treatment Facility was stabilized and filled to grade. The section of the ditch north of the Grout Treatment Facility has been cleared of vegetation and regraded to produce gentle sidewall slopes. These discontinuous open portions of the ditch represent minor, if any, flooding potential due to the lack of drainage area and the nature of the ditch soils that allow infiltration surface water into the ground. The 207-A Retention Basins present no threat of flooding because the north basins discharge into the other waste management units.

3.3.3.2 B Plant Aggregate Area. The 216-N-8 Pond (West Pond), located 1.2 km (0.75 mi) northeast of the 216-A-25 Pond (Gable Mountain Pond) is the only naturally occurring body of water on the Hanford Site. Prior to the creation of Gable Mountain Pond, West Pond was an intermittent seasonal pond located in a natural basin at the base of Gable Mountain. After the introduction of large quantities of water to Gable Mountain Pond in 1957, the water table in the area was raised sufficiently to provide year-round water to West Pond.

The existing manmade surface water bodies in the B Plant Aggregate Area include the 2101-M Pond, 216-B-3 Pond, 216-B-3A Pond, 216-B-3B Pond, 216-B-3C Pond, 216-B-3-3 Ditch, 216-B-63 Ditch, and the 207-B Retention Basin.

The 2101-M Pond, located near the 200 East Powerhouse, receives small quantities of wastewater and generally contains less than 15 cm (6 in.) of standing water. The pond lost water through evaporation and infiltration to soil.

The 216-B-3 Pond is part of a pond system that receives water from the 216-B-3-3 Ditch, and includes "lobes" designated as the 216-B-3A Pond, the 216-B-3B Pond (currently inactive), and the 216-B-3C Pond. The 216-B-3 Pond System is located 1,100 m (3,500 ft) east of the 200 East Area perimeter fence. The potential for flooding from the 216-B-3 Pond System is minimized by the lack of any catchment area and the presence of a dike system surrounding the ponds. Also, the water level in the 216-B-3A Pond can be controlled by discharge to either the 216-B-3B or the 216-B-3C Ponds. Water from the 216-B-3C Pond infiltrates rapidly into the gravelly bottom soils. If necessary, water can also be diverted to the 216-E-25 Contingency Pond located north of the 216-B-3 Pond System.

The 216-B-3-3 Ditch is an open structure that originates just south of the 200 East Area perimeter fence and is fed by the 216-B-2 Pipeline. The ditch discharges to the 216-B-3 Pond System. The open portions of the ditch represent minor, if any, flooding potential due to the lack of a contributing catchment area, the high bermed sides of the ditch, and rapid infiltration of surface water to soil.

The 216-B-3 Emergency Ditch, located east of the 207-B Retention Basin, is a closed-end percolation ditch that receives chemical sewer water from the 221-B Building which is then discharged to soil. Flooding potential for this ditch is low again due to the lack of catchment and rapid infiltration of surface water to soil beneath the ditch.

The 207-B Retention Basin, located 610 m (2,000 ft) northeast of the 221-B Building, is a concrete-lined basin that receives cooling water from the 221-B Building and discharges it to the 216-B-2 Pipeline. The 207-B Retention Basin has no catchment area and therefore presents no flooding threat.

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3.3.3.3 Semi-Works Aggregate Area. The Semi-Works Aggregate Area has no natural surface water bodies. The only existing man-made surface water body is the 200 East Powerhouse Ditch located along the southern boundary of the aggregate area. The ditch receives cooling brines from batch processes and boiler blowdown rinsate from the 200 East Powerplant. The flow rate from the powerhouse facility to the ditch is estimated at 12,300,000 L/month (3,250,000 gal/month). Ditch effluent is also dispersed by evaporation and infiltration to the soil column along the ditch. Ditch effluent flows eastward and is discharged to an approximately 76 cm-diameter (30 in.) corrugated metal pipe connected to the 216-B-3 Pond System. There is, again, no flooding threat from this feature.

3.4 GEOLOGY

The following sections provide information pertaining to geologic characteristics of south-central Washington, the Hanford Site, and the 200 East Area. Topics included are the regional tectonic framework (Section 3.4.1), Pasco Basin and Hanford Site stratigraphy (Section 3.4.2), known or suspected faulting and other subsurface structures in the Gable Mountain-200 East Areas (Section 3.4.3), and 200 East Area geology (Section 3.4.4).

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

3.4.1 Regional Tectonic Framework

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

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

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

The principal characteristics of the Yakima Fold Belt (Figure 3-10) are a series of segmented, narrow, asymmetric anticlines that have wave lengths 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 Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills anticlines, and on the south by the Rattlesnake Mountain anticline (Figure 3-11). The Pasco Basin is divided by the Gable Mountain anticline, the easternmost extension of the Umtanum Ridge anticline, into the Wahluke syncline in the north, and the Cold Creek syncline in the south. Both the Cold Creek and Wahluke synclines are asymmetric and relatively flat-bottomed structures. The north limbs of both synclines dip gently (approximately 5°) to the south and the south limbs dip steeply to the north. The deepest parts of the Cold Creek syncline, the Wye Barricade depression, and the Cold Creek depression, are approximately 12 km (7.5 mi) southeast of the Hanford Site 200 Areas, and just to the west-southwest of the 200 West Area, respectively. The deepest part of the Wahluke syncline lies just north of Gable Gap.

The 200 East Area is situated on the generally southward dipping north limb of the Cold Creek syncline about 4 to 7 km (2.5 to 4.5 mi) north of the syncline axis. The Gable Mountain-Gable Butte segment of the Umtanum Ridge anticline lies approximately 3.2 km (2 mi) north of the 200 East 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

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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 1988). The historical seismic record for eastern Washington began in approximately 1850, and no earthquakes large enough to be felt during this period had epicenters on the Hanford Site. The closest regions of historical 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. In 1991 two small earthquakes occurred in the same area; a magnitude 4.2 earthquake on November 27, 1991 and a magnitude 3.3 on December 15, 1991. Both epicenters were located approximately 10 km (6 mi) southeast of Walla Walla.

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 Pasco Basin and Hanford Site Stratigraphy

This section summarizes regional stratigraphic characteristics of the Columbia River Basalt Group and the overlying sediments. Specific references to the Hanford Site and the 200 East Area are made where applicable to describe the general occurrence of these units within the Pasco Basin. Much of the text is modified from Lindsey et al. (1992), with additional information in Section 3.4.2.1 (Regional Columbia River Basalt Group) included from DOE (1988). Information in Section 3.4.2.2 (Ellensburg Formation) was included from Delaney et al. (1991) and DOE (1988). Additional information regarding distinguishing features of the sediments overlying the basalt was taken from Bjornstad (1990) and cited where applicable.

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 unconsolidated sediments (Figure 3-12). Sedimentary interbeds within the Columbia River Basalts collectively comprise the Ellensburg Formation. 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 is dominated by laterally extensive deposits assigned to the late Miocene- to Pliocene-age Ringold Formation and the Pleistocene-age Hanford formation (Figure 3-13). Locally occurring strata informally referred to as pre-Missoula gravels, Plio-Pleistocene unit, and early "Palouse" soil comprise the remainder of the sedimentary sequence. The pre-Missoula gravels are encountered between the Ringold Formation and Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline. The pre-Missoula gravels have not been identified in the 200 East Area. As discussed in Sections 3.4.2.4 and 3.4.2.6, the Plio-Pleistocene unit and the early "Palouse" soil are encountered in the western Cold Creek syncline in the vicinity of the 200 West Area. Most of these sediments, particularly the Ringold Formation, are at least partially consolidated. Relatively thin surficial deposits of eolian sand, loess, alluvium, and colluvium discontinuously overlie the Hanford formation.

The following sections describe the stratigraphic characteristics of the Columbia River Basalt Group (Section 3.4.2.1), Ellensburg Formation (Section 3.4.2.2), Ringold Formation (Section 3.4.2.3), Plio-Pleistocene unit (Section 3.4.2.4), pre-Missoula gravels (Section 3.4.2.5), early "Palouse" soils (Section 3.4.2.6), Hanford formation (Section 3.4.2.7), and surficial deposits (Section 3.4.2.8).

Stratigraphic features of the Saddle Mountains Basalt and the Ellensburg Formation are described for the following reasons:

- Groundwater elevation data presented by DOE (1988), Kasza and Schatz (1989), Kasza et al. (1990), Kasza et al. (1991), and Jackson (1992) indicate that a downward hydraulic gradient exists between the uppermost aquifer in the suprabasalt sediments and the confined aquifers of the Saddle Mountains Basalt-Ellensburg Formation interbeds. As discussed in Section 3.5, the uppermost aquifer is dominated by unconfined conditions, but is locally semiconfined to confined where the Ringold lower mud sequence is present. The data indicate that the downward gradient continues with depth through the Saddle Mountains Basalt and Ellensburg Formation interbeds (Section 3.4.2.2). The area over which the downward gradient is present occurs mainly in areas of artificial recharge at the Hanford Site, including liquid waste disposal sites associated with the 200 East Area. Because of the apparent vertical downward gradient, potential exists for migration of contaminated groundwater from the uppermost aquifer to deeper groundwater-bearing zones. Hydrostratigraphic units, groundwater flow,

hydraulic parameters, and groundwater elevation contour maps are discussed in detail in Sections 3.5.1 (Pasco Basin and Hanford Site Hydrogeology) and 3.5.2 (200 East Area Hydrogeology). Because of the poorly understood nature of vertical intercommunication between aquifers this is identified as a data gap in Section 8.2.3 and is recommended for further investigation in Section 8.3.3.1 of this report.

- Groundwater chemical data presented by Jensen (1987) and Graham et al. (1984) indicate that nitrate and tritium may have migrated vertically downward from the uppermost aquifer to the confined Rattlesnake Ridge aquifer. As discussed in Section 4.1.1, beta radiation has also been detected in groundwater samples from the Rattlesnake Ridge aquifer. However, the vertical extent of these compounds and other chemical constituents in deeper confined aquifers is not well understood.

- Basalt intraflow structures (Section 3.4.2.1.2), erosional windows, and faults (none currently identified) (Section 3.4.3) could potentially represent conduits for downward groundwater migration in the 200 East Area. In general, previous Hanford Site investigations did not determine "how leaky" basalt intraflow structures and faults may be. Also, Graham et al. (1984) reported that some of the nitrate and tritium detections in the Rattlesnake Ridge aquifer can be attributed to downward groundwater migration through a poorly sealed well (299-E33-12). A similar conclusion applies to beta radiation detected in the Rattlesnake Ridge aquifer.

- The confined aquifers represent a potential source of future potable water supply on the Hanford Site, and are currently an important source of agricultural and domestic water adjacent to the Hanford Site.

3.4.2.1 Columbia River Basalt Group. The Columbia River Basalt Group (Figure 3-12) comprises an assemblage of tholeiitic, continental flood basalts of Miocene age. These flows cover an area of more 163,700 km^2 (63,000 mi^2) in Washington, Oregon, and Idaho and have an estimated volume of about 174,356 km^3 (40,800 mi^3) (Tolan et al. 1989). Isotopic age determinations indicate that basalt flows were erupted approximately 17 to 6 Ma (million years before present), with more than 98% by volume being erupted in a 2.5 million-year period (17 to 14.5 Ma) (Reidel et al. 1989b; Reidel and Fecht 1981).

Columbia River Basalt Group 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.

3.4.2.1.1 Saddle Mountains Basalt. The Saddle Mountains Basalt, divided into the Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, Elephant Mountain, and Ice Harbor Members from bottom to top (Figure 3-12), forms the uppermost basalt unit throughout most of the Pasco Basin. Members of this formation were erupted intermittently over a period from about 14.5 to 6 Ma, during a waning phase of Columbia River Basalt Group volcanism. Distribution of the Saddle Mountains Basalt is limited compared with older Columbia River Basalt Group units, with many of its members confined to structural lows or paleoriver canyons (Reidel and Fecht 1981; DOE 1988). The Wilbur Creek Member occurs north of Gable Mountain-Umtanum Ridge. The Asotin Member occurs in the north-central portion of the Cold Creek syncline, north and east of the 200 East Area. The Esquatzel Member is present in the central and east-central portions of the Cold Creek syncline. The Ice Harbor Member is confined primarily to the southern and eastern Pasco Basin and surrounding area. On anticlinal ridges bounding the Pasco Basin, the Saddle Mountains Basalt is locally absent, exposing the Wanapum and Grande Ronde Basalts.

On the Hanford Site, the Saddle Mountains Basalt reaches a maximum thickness of about 314 m (1,030 ft) near the 300 Area, and commonly reaches thicknesses of 280 m (918 ft) or more along the axis of the Cold Creek syncline southwest of the 200 West Area. Throughout most of the Hanford Site south of the Gable Mountain-Gable Butte structures, the Saddle Mountains Basalt is comprised primarily of the Umatilla, Esquatzel, Pomona, and Elephant Mountain Members. Maximum thicknesses of individual flows within the Saddle Mountains Basalt on the Hanford Site range from about 39 m (128 ft) for the Esquatzel Member, to about 87 m (285 ft) for the Umatilla Member. The Umatilla and the Esquatzel Members reach maximum thicknesses along the axis of the Cold Creek syncline southwest of the 200 West Area. The Pomona and Elephant Mountain Members are thickest along the eastern side of the Hanford Site and generally thin to the west.

Over part of the eastern portion of the Hanford Site, the Elephant Mountain Member consists of upper and lower flow units. The lower flow unit (Elephant Mountain flow) is separated from the upper flow unit (Ward Gap flow) by a sand and clay layer (Lindsey et al. 1992; Jensen 1987). A zone of fracturing has also been identified within the upper flow (Graham et al. 1984). Additional description of the distribution of the two flow units in the vicinity of the 200 East Area is provided in Section 3.4.4.1.

With a few localized exceptions, the Elephant Mountain Member is the uppermost unit beneath most of the Hanford Site. Near the 300 Area, the Ice Harbor Member is found stratigraphically above the Elephant Mountain Member. In the Gable Gap area, erosion has locally occurred down to the Umatilla Member (Myers and Price 1981; Graham et al. 1984; Figure 3-14). Additional areas of erosion of the Elephant Mountain Member to the southeast

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of Gable Gap, in the vicinity of the 200 East Area are discussed in Section 3.4.4.1. The areas of basalt erosion near Gable Gap and to the southeast are significant because they represent locations of potential groundwater intercommunication between the upper sedimentary interbeds of the Ellensburg Formation, and the unconfined groundwater system. The potential for groundwater intercommunication between aquifers is further discussed in Sections 3.5.1.6.3 and 3.5.2.3.3.

Near the northwest corner of the Hanford Site, the Saddle Mountains Basalt thins to only 64 m (211 ft) or less, probably due to nondeposition and erosion. Farther to the north and northwest (near the southeast end of Umtanum Ridge and west of Gable Butte) the Pomona or Umatilla Members are the uppermost units of the Saddle Mountains Basalt. In this area, flows higher in the basalt sequence (Asotin, Esquatzel, Pomona, and Elephant Mountain Members), and the associated Ellensburg Formation sedimentary interbeds were not deposited, or have been completely removed by erosion. Drilling and geophysical information in DOE (1986 and 1988) is insufficient to determine whether the Ellensburg Formation sedimentary interbeds were truncated by erosion, or were pinched out between basalt flows. If the flows and interbeds were truncated by erosion, a zone of potential groundwater intercommunication between the interbed aquifers and the overlying unconfined groundwater system may be present.

3.4.2.1.2 Basalt Intraflow Structures and Cooling Joints. This section describes intraflow structures and cooling joints typical for Columbia River Basalt Group flows. Intraflow structures are primary, internal features or stratified portions of basalt flows exhibiting grossly uniform macroscopic characteristics. These features originate during the emplacement and solidification of each flow. Intraflow structures therefore differ from tectonically-induced fractures and joints formed after consolidation of the flow (DOE 1988). As applied to the Saddle Mountains Basalt, the intraflow structures are significant because they represent potential conduits for groundwater flow within the basalts and between intervening sedimentary interbeds.

Intraflow structures for typical Columbia River Basalt Group flows, including the Saddle Mountains Basalt, can be described according to their position in the flow top, flow interior, or flow bottom, and are shown diagrammatically on Figure 3-15. Flow top structures consist of vesicular to rubbly or brecciated basalt in the glassy, chilled upper crust of the flow. The predominant intraflow structures within flow interiors are zones characterized by patterns of cooling joints, commonly referred to as colonnade and entablature (Figure 3-15). Contacts between colonnade tiers and entablature may be distinct, or they may be gradational. Other intraflow features observed within flow interiors include pipes, cylinders, sheets of vesicles and vesiculated zones; and platy horizontal fracturing. The basal part of a typical Columbia River Basalt Group flow is predominantly a thin, glassy, chilled zone a few centimeters thick, which may be vesicular, rubbly, or brecciated. Additional detailed description of intraflow structures is presented by DOE (1988). Intraflow

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features may be continuous in flows over long distances but in some cases change abruptly. Lateral variation in thickness of intraflow structures can occur gradually in some flows and suddenly in others at a given location. Clays and other alteration minerals are common along cooling joints and tend to retard the movement of fluids as well as increase sorptive properties.

Cooling joints in basalt flows are ubiquitous fractures that resulted from tensional stress in response to contraction of solidified portions of the flow as it cooled. Cooling joints form columns, subdivisions of columns, and zones of irregular basalt blocks. Cooling joints are primary features that are distinct from secondary tectonic fractures such as faults, shears, and joint sets.

At the Hanford Site in general, and in the 200 East Area in particular, little compiled intraflow or fracture information was available for the Saddle Mountains Basalt in the documents reviewed for this report. Moak and Wintczak (1980) compiled and reported cooling joint data from the Pomona flow entablature during mapping of the underground Near Surface Test Facility (NSTF) completed within Gable Mountain. However, the applicability of these data to subsurface occurrences of the Pomona Member and other flows of the Saddle Mountains Basalt near the 200 East Area is not discussed in the documents reviewed.

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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 age of the Ellensburg Formation is principally Miocene, although locally it may be equivalent to early Pliocene. The Ellensburg Formation generally displays two main lithologies: volcaniclastics (Reidel and Fecht 1981; Smith et al. 1989), and siliciclastics (DOE 1988). The volcaniclastics consist mainly of primary pyroclastic air fall deposits and reworked epiclastics derived from volcanic terrains west of the Columbia Plateau. Siliciclastic strata in the Ellensburg Formation consists of clastic, plutonic, and metamorphic detritus derived from the Rocky Mountain terrain. These two lithologies occur both individually and together 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) provide a discussion of age equivalent units adjacent to the Columbia Plateau.

As discussed in Section 3.4.2, discussion of Ellensburg Formation is included in this report due to potential for downward migration of groundwater from the uppermost aquifer to the confined aquifers associated with the sedimentary interbeds. The stratigraphic names for individual units of the Ellensburg Formation are given in Figure 3-12. The Ellensburg Formation nomenclature was derived by considering the lateral extent of the upper and lower basalt flows bounding each of the interbeds. Each interbed name is valid only where the bounding flows occur within Pasco Basin and Hanford Site. The interbed names on Figure 3-12 are therefore applicable to the Pasco Basin and Hanford Site, except where the

bounding flows are not present. From bottom to top, the sedimentary interbeds of the Ellensburg Formation associated with the Saddle Mountains Basalt include the Mabton interbed (dividing the Saddle Mountains Basalt from the underlying Wanapum Basalt), the Cold Creek interbed, the Selah interbed, the Rattlesnake Ridge interbed, and the Levey interbed. For the Cold Creek interbed, Ellensburg Formation nomenclature applies to three separate stratigraphic intervals within the interbed, based on the areal extent of the Umatilla, Esquatzel, and Asotin flows as discussed in Section 3.4.2.2.2, below.

The following descriptions include Ellensburg Formation sedimentary interbeds from bottom to top for the Saddle Mountains Basalt.

3.4.2.2.1 Mabton Interbed. The Mabton interbed lies stratigraphically below the Umatilla Member of the Saddle Mountains Basalt and above the Priest Rapids Member of the Wanapum Basalt in the Pasco Basin. The Mabton interbed is thickest in the central Pasco Basin area (including the 200 East Area) and thins out in all directions. Vertical lithologic and textural changes in the Mabton interbed are relatively uniform. From bottom to top, the interbed generally consists of: (1) a thin, basal silty clay; (2) a quartzitic to arkosic sandstone with interlayered, tuffaceous sandstones and siltstones; (3) a fine-grained, tuffaceous, clayey quartzitic sandstone; and (4) a well-indurated, lapilli tuffstone, locally baked.

3.4.2.2.2 Cold Creek Interbed. The Cold Creek interbed refers to the sequence of Ellensburg sediments that occur stratigraphically between the Esquatzel and Umatilla Members of the Saddle Mountains Basalt. The Asotin Member of the Saddle Mountains Basalt partly controlled the distribution of the Cold Creek interbed. Three separate units of the interbed are identified on the basis of the bounding basalt flows. These intervals are the Umatilla-Esquatzel, Umatilla-Asotin, and Asotin-Esquatzel intervals. The Umatilla-Esquatzel interval is present over the much of the central part of the Hanford Site, including the 200 East Area. The Umatilla-Asotin and Asotin-Esquatzel intervals are present to the northeast of the 200 East Area where the Asotin Member of the Saddle Mountains Basalt occurs.

The Umatilla-Esquatzel interval is the thickest interval and has the largest areal extent. This interval is divided into two textural facies: (1) a finer-grained, tuffaceous sandstone facies; and (2) a coarser-grained sandstone and conglomerate facies with tuffaceous siltstone and clays. The coarser-grained facies follows an arcuate trend to the northwest across the central part of the Hanford Site. The coarser-grained facies represents the high-energy, main channel of a fluvial system which is interpreted to have flowed parallel to the flow front of the Asotin flow (to the northeast). The finer-grained facies is present along the southwest bounding-edge of the coarser-grained facies and in the southeastern part of the Hanford Site.

3.4.2.2.3 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.

3.4.2.2.4 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.

3.4.2.2.5 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 100B Area. The Ringold Formation pinches out against the Gable Mountain, Yakima Ridge, Saddle Mountains, and Rattlesnake Mountain anticlines. It is largely absent in the northern and northeastern parts of the 200 East Area and adjacent areas to the north in the vicinity of West Lake. The Ringold Formation is assigned a late Miocene to Pliocene age (Fecht et al. 1987; DOE 1988) and was deposited in alluvial and lacustrine environments (Bjornstad 1985; Fecht et al. 1987; Lindsey et al. 1991).

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

- Fluvial gravel--Clast-supported granule to cobble gravel with a sandy matrix dominates the association. Intercalated sands and muds also are found. Clast composition is very variable, with common types being basalt, quartzite, porphyritic volcanics, and greenstones. Silicic plutonic rocks, gneisses, and volcanic breccias also are found. Sands in this association are generally quartzo-feldspathic, with basalt contents generally in the range of 5 to 25%. Low angle to planar stratification, massive channels, wide-shallow channels, and large-scale

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cross-bedding are found in outcrops. The association was deposited in a gravelly fluvial system characterized by wide, shallow shifting channels.

- Fluvial sand--Quartzo-feldspathic sands displaying cross-bedding and cross-lamination in outcrop dominate this association. These sands usually contain less than 15% basalt lithic fragments, although basalt contents as high as 50% may be encountered. Intercalated strata consist of lenticular silty sands and clays up to 3 m (10 ft) thick and thin (<0.5 m) gravels. Fining upwards sequences less than 1 m (3 ft) to several meters thick are common in the association. Strata comprising the association were deposited in wide, shallow channels.

- Overbank deposits--This association predominantly consists of laminated to massive silt, silty fine-grained sand, and paleosols containing variable amounts of calcium carbonate. Overbank deposits occur as thin lenticular interbeds [<0.5 m to 2 m (<1.6 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 sequences less than 1 m (3 ft) to 10 m (30 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 are generally 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 (Figure 3-13), are separated by intervals containing deposits typical of the overbank and lacustrine facies associations. The lowermost of the fine-grained sequences, overlying unit A, is designated the lower mud sequence. The uppermost gravel unit, unit E, grades upwards into interbedded fluvial sand and overbank deposits. These sands and overbank deposits are overlain by lacustrine-dominated strata.

Fluvial gravel units A and E correspond to the lower basal and middle Ringold units, respectively, as defined by DOE (1988). Gravel units B, C, and D do not correlate to any previously defined units. The lower mud sequence corresponds to the upper basal and lower units as defined by DOE (1988). The upper basal and lower units are not differentiated.

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The sequence of fluvial sands, overbank deposits, and lacustrine sediments overlying unit E corresponds to the upper unit as seen along the White Bluffs in the eastern Pasco Basin. This essentially is the same usage as originally proposed by Newcomb (1958) and Myers et al. (1979).

3.4.2.4 Plio-Pleistocene Unit. Unconformably overlying the Ringold Formation in the western Cold Creek syncline in the vicinity of 200 West Area (Figures 3-11, 3-12 and 3-13) is the laterally discontinuous Plio-Pleistocene unit (DOE 1988; Baker et al. 1991). The unit is up to 25 m (80 ft) thick and divided into two facies: (1) sidestream alluvium and (2) calcic paleosol (Stage III and Stage IV) (DOE 1988; Baker et al. 1991). The calcic paleosol facies consists of massive calcium carbonate-cemented silt, sand, gravel (caliche) to interbedded caliche-rich and caliche-poor silts and sands. The basaltic detritus facies consists of weathered and unweathered basaltic gravels deposited as locally derived slope wash, colluvium, and sidestream alluvium. The Plio-Pleistocene unit appears to be correlative to other sidestream alluvial and pedogenic deposits found near the base of the ridges bounding the Pasco Basin on the north, west, and south. These sidestream alluvial and pedogenic deposits are inferred to have a late Pliocene to early Pleistocene age on the basis of stratigraphic position and magnetic polarity of interfingering loess units. The white color of the unit, high degree of cementation, and the presence of animal burrows and root traces in cores also support the pedogenic nature of the Plio-Pleistocene unit (Bjornstad 1990). Bjornstad (1990) also indicates that natural gamma activity within the Plio-Pleistocene unit is erratic; high in places and moderate to low elsewhere.

3.4.2.5 Pre-Missoula Gravels. Quartzose to gneissic clast-supported pebble to cobble gravel with a quartzo-feldspathic sand matrix underlies the Hanford formation in the east-central Cold Creek syncline and at the east end of Gable Mountain anticline east and south of the 200 East Area (Figures 3-11, 3-12 and 3-13). These gravels, called the pre-Missoula gravels (PSPL 1982), are up to 25 m (80 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 indicate 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 (65 ft) of massive, brown-yellow, and compact loess-like silt and minor fine-grained sand (Tallman et al. 1979; 1981; Bjornstad 1984; DOE 1988). These deposits overlie the Plio-Pleistocene unit in the western Cold Creek syncline around the 200 West Area (Figures 3-11, 3-12 and 3-13). The unit is differentiated from overlying graded rhythmites (Hanford formation) by greater calcium carbonate content, massive structure in core, and high natural gamma response in geophysical logs (Bjornstad 1984; DOE 1988). This natural gamma response is due to the

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inherent stratigraphic properties of the unit, rather than from effects of radionuclide contamination. Other distinguishing features include uniform fine-grained texture, unconsolidated nature, and high mica content (Bjornstad 1990). Bjornstad also indicates that it may be difficult to differentiate the early "Palouse" soil from the underlying Plio-Pleistocene unit without careful analysis of calcium carbonate data and gross gamma logs. The upper contact of the unit is poorly defined, and it may grade up-section into the lower part of the Hanford formation. Based on a predominantly reversed polarity the unit is inferred to be early Pleistocene in age (Baker et al. 1991).

3.4.2.7 Hanford Formation. The Hanford formation consists of pebble to boulder gravel, fine- to coarse-grained sand, and silt (Baker et al. 1991). These deposits are divided into three facies: (1) gravel-dominated; (2) sand-dominated; and (3) silt dominated facies. These facies are referred to as coarse-grained deposits, plane-laminated facies, and rhythmite facies, respectively by Baker et al. (1991). The silt dominated deposits also are referred to as the "Touchet Beds," while the gravelly facies are generally referred to as the Pasco Gravels. The Hanford formation is thickest in the Cold Creek bar in the vicinity of 200 West and 200 East Areas where it is up to 65 m (210 ft) thick (Figures 3-11, 3-12 and 3-13). The Hanford formation was deposited by cataclysmic flood waters that drained out of glacial Lake Missoula (Fecht et al. 1987; DOE 1988; and Baker et al. 1991). Hanford deposits are absent on ridges above approximately 385 m (1,260 ft) above sea level. The following sections describe the three Hanford formation facies.

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

3.4.2.7.2 Sand-Dominated Facies. The sand-dominated facies consists of fine-grained to coarse-grained sand and 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 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 referred to as black or gray or salt and pepper sands. This facies is most common in the central Cold Creek syncline, in the central to southern parts of the 200 East and 200 West Areas, and in the vicinity of the WPPSS facilities. The sand-dominated facies was deposited in and adjacent to the main flood channelways as flow velocity decreased. Coarser-grained materials were deposited as channel competency was lost. The facies is transitional between gravel-dominated facies and silt-dominated facies.

3.4.2.7.3 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 displays normally graded rhythmites similar to Bouma sequences, a few centimeters to several tens of centimeters thick in outcrop (Myers et al. 1979; DOE 1988). This facies dominates the Hanford formation throughout the central, southern, and western Cold Creek syncline within and south of 200 East and West Areas. These sediments were deposited under slackwater conditions and in backflooded areas (DOE 1988).

3.4.2.7.4 Clastic Dikes. The following description of clastic dikes was taken from Hoffmann et al. (1992), Connelly et al. (1992a), and Lindsey et al. (1992). In addition to the three Hanford formation facies outlined above, clastic dikes also are commonly found at the Hanford Site, including the 200 East Area. These dikes, while common in the Hanford formation, also are found locally in other sedimentary units in the Pasco Basin. The dikes do not occur in Holocene deposits, but are sometimes truncated by Hanford formation sediments and therefore their age is probably Pleistocene. Clastic dikes are found in all facies of the Hanford formation but they are more common in the finer-grained facies and rare in open-work gravel. Whether in the Hanford formation or other sedimentary units, clastic dikes generally cross-cut bedding, although they do locally parallel bedding. Clastic dikes have been omitted from Figure 3-13 because the stratigraphic distribution of the clastic dikes and cross cutting relationships with the suprabasalt sediments cannot be readily depicted.

The dikes may be simple and composed of one layer or filling, or composite and composed of multiple layers (typically vertical to subvertical) of alternating silt, sand, and granules, with silt and sand being most common. Individual layers may be millimeters to centimeters in thickness, with overall dike widths commonly one centimeter to over a meter. In some cases, filling materials can be traced to underlying, overlying or interbedded sediments. A geomorphic feature known as patterned ground may be present at locations where clastic dikes intersect the ground surface.

Origin of clastic dikes in the Columbia Plateau has been attributed to earthquakes, melting of buried ice and frozen sediments, upward injections of groundwater, thermal contraction of permafrost, desiccation cracks or deep frost cracks, and extension fracturing

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from sediment loading on unstable deposits. None of the suggested origins can explain all the physical characteristics of the clastic dikes, suggested that the dikes may have more than one origin. As a possible mechanism, Black (1980) proposed that the dikes were formed during Pleistocene cataclysmic flooding and are the result of hydraulic injection of water and sediment into cracks formed by the sudden loading of water on the ground surface.

3.4.2.8 Surficial Deposits. Surficial deposits consist of silt, sand, and gravel that form a thin (< 10 m [30 ft]) veneer across much of the Hanford Site. These sediments were deposited by a mix of eolian and alluvial processes.

3.4.3 Known or Suspected Faulting and other Subsurface Structures in the Gable Mountain-200 East Areas

At the Hanford Site, faults have been identified on the Umtanum Ridge-Gable Mountain structure and on the Yakima Ridge from geologic mapping, trenching and drilling (Figure 3-10 and 3-14). There is no direct evidence of faulting in the 200 East Area (Lindsey et al. 1992), but good exposures of faults are present in the Gable Mountain area north of the 200 East Area. Subsurface structures have also been identified between Gable Mountain and the 200 East Area during previous studies using borehole drill core and geophysical data. Like the intraflow structures of the Saddle Mountains Basalt (as discussed in Section 3.4.2.1.2), faults and tectonic fractures could potentially provide conduits for groundwater intercommunication between confined aquifers, and between the uppermost and confined systems. Vertical and horizontal offsets along faults can also potentially juxtapose highly permeable units and promote migration of contaminated groundwater.

The structural geology of the Hanford Site including the area between the 200 East Area and Gable Mountain is summarized by Lindsey et al. (1992), DOE (1988), and Myers and Price (1981). These discussions describe folding and faulting, results of geophysical studies, and tectonic brecciation and shearing of basalt. The following sections summarize information from these sources for structures near Gable Mountain (Section 3.4.3.1), and the area between Gable Mountain and the 200 East Area (Section 3.4.3.2). Section 3.4.3.3 discusses results of geophysical studies in the vicinity of the 200 East Area, and Section 3.4.3.4 discusses occurrences of tectonic brecciation and shearing. In general, very limited structural and geophysical data are available for the 200 East Area itself.

3.4.3.1 Gable Mountain Area Structures. Gable Mountain forms the eastern-most topographic expression of the Umtanum Ridge/Gable Mountain anticline, as discussed in Section 3.4.1.2 (Figures 3-10 and 3-14). The Gable Mountain anticline consists of a series of en echelon, southeast to northwest trending folds (Fecht 1978). Faults investigated on Gable Mountain during geologic mapping, trenching, and drilling include the west, central, and south faults. These faults are identified on Figure 3-10 as numbers 7M, 7N, and 7O

respectively. The west and central faults are oriented roughly perpendicular to the axis of Gable Mountain. The fault nomenclature is presented by DOE (1988), and the faults are named based on their general geographic occurrence on Gable Mountain. The central fault is notable because the top of the Esquatzel Member of the Saddle Mountains Basalt has been offset by about 50 m (164 ft) of reverse, dip-slip movement along the fault. The south fault is oriented east/west (nearly parallel the trend of Gable Mountain) and has 12 m (39 ft) of reverse displacement. Several other faults in the Gable Mountain area were identified from borehole data or via trenching, including a northwest/southeast-striking fault with a shallow northward dip and 98 m (321 ft) of stratigraphic throw. DOE (1988) indicates that "topographic and structural relief" possibly suggests that a fault known as the Umtanum fault, and present along the Umtanum Ridge to the west of Gable Mountain Gable Butte may extend to the east end of Gable Mountain. Faults on Gable Mountain truncate Hanford formation sediments in addition to basalt (Lindsey et al. 1992).

3.4.3.2 Structures in the Area Between Gable Mountain and the 200 East Area. South of Gable Mountain, and about 5 km (3 mi) northeast of the 200 East Area, two faults were identified in borehole DB-10 (Figure 3-14). Repetition of the stratigraphic section of the Pomona, Esquatzel, and Asotin Members of the Saddle Mountains Basalt across the DB-10 faults indicates that they are reverse faults with about 55 m (180 ft) of combined, dip-slip offset. Additional boreholes drilled near DB-10 indicate that the upper fault in DB-10 is a north/south-striking structure that dips moderately to the west.

Other subsurface structures located in the area between Gable Mountain and the 200 East Area include the Pearl and Willa anticlines (Figure 3-14). These anticlines are small en echelon folds similar to those on Gable Mountain, and generally conform to bedrock areas lying above the water table (Lindsey et al. 1992; Figure 3-14). The folds have relatively small amplitudes that are generally less than about 6 m (20 ft). As further discussed by Lindsey et al. (1992) and in Section 3.4.4, the thin remnants of Ringold unit A gravels and the lower mud sequence found in the area between Gable Mountain and the 200 East Area are most common in the troughs separating the low amplitude anticlines.

A fracture zone was identified within the upper Elephant Mountain flow unit east of the 200 East Area, but is not believed to be regionally extensive (Graham et al. 1984). No additional details regarding the origin of the fracture zone were discussed.

Information regarding vertical and horizontal extent of known or suspected fracture zones is limited. However, as these zones represent possible pathways for aquifer intercommunication (Section 3.5.2.3.3) they will need to be assessed as part of future site characterization work. This assessment will likely involve obtaining vertical hydraulic conductivity data across the confining layer, or data regarding the contrast in hydraulic conductivities between the overlying and underlying water bearing zones.

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3.4.3.3 Geophysical Investigations. The characteristics of potential faults and other subsurface structures between Gable Mountain and the 200 East Area, and the area east of the 200 East Area have been investigated via geophysical surveys. Previous investigations have utilized a variety of geophysical methods including gravity, magnetic, seismic refraction, and seismic reflection surveys. These investigations have provided relatively limited resolution of potential subsurface structures, however. Many of the investigations were completed in support of BWIP characterization activities (DOE 1988). Results of these investigations are summarized below, and describe subsurface structures that could affect groundwater flow.

During BWIP characterization activities a subsurface gravity and magnetic anomaly known as the May Junction linear was identified about 4.8 km (3.0 mi) east of the 200 East Area (Figure 3-14). The May Junction linear is roughly 3.5 km (2.2 mi) long and trends north-northeast. Subsequent seismic refraction and seismic reflection lines were also used to examine the structure. The seismic refraction data could not determine whether the structure was fault-controlled, but results of seismic reflection surveys suggested a possible fault feature. The trend of the possible fault and other characteristics could not be determined from the seismic reflection data (DOE 1988). A sudden change in the top-of-basalt elevation contours occurs across the anomaly and the feature is currently interpreted to be a fault on the basis of the geologic and geophysical information. As discussed by Lindsey et al. (1992) and Delaney et al. (1991), the inferred fault is believed to affect Ringold Formation sediments but it is unclear whether younger sediments are truncated.

Seismic refraction surveys were used to investigate the faults identified in borehole DB-10, south of Gable Mountain (Section 3.4.3.1), but were not able to confirm the presence of these structures (DOE 1988). The refraction data did confirm the presence of a buried anticline in the borehole DB-10 area with a west-northwest to east-southeast orientation similar to the west anticline of Gable Mountain (DOE 1988). This structure would be approximately parallel to and northeast of the Willa anticline (Figure 3-14).

Other seismic refraction surveys in the central part of the Hanford Site and 200 East Area have been completed to determine depths to top of basalt and to delineate the structure and stratigraphy of the overlying unconsolidated sediments. The surveys generally have not been successful in characterizing potential faults and other structures within the basalts. Similarly, seismic reflection surveys in the vicinity of the 200 East Area have not been able to delineate bedrock structural features, and are complicated by difficulties in data processing and interpretation. Limited borehole geophysical logging (sonic, density, and gravity logs; and vertical seismic profiling) have mainly focused on the unconsolidated sediments or have not provided specific data about potential deeper faulting. As discussed in Section 3.4.1.3 low-magnitude earthquakes (up to about a magnitude of 2.0 to 3.0) in basalt have been recorded in the vicinity of the 200 East Area.

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Conclusions regarding the structural integrity of the 200 East Area are probably similar to conclusions presented by DOE (1988) for the 200 West Area and vicinity (encompassing the BWIP reference repository location). For the 200 West Area, gravity and aeromagnetic data from previous studies indicated that the rock is not an evenly layered, homogenous mass. DOE (1988) concluded, however, that there is less geophysical variability in the 200 West Area than in adjacent structures such as the buried extension of Yakima Ridge to the west-southwest. DOE (1988) indicated that the 200 West Area and vicinity although probably not free of structures, contains smaller structures than the surrounding areas. Alternatively, the thickness of the unconsolidated sediments could conceivably mask potential structures.

3.4.3.4 Tectonic Brecciation and Shearing. As discussed by DOE (1988), field studies have identified tectonic brecciation and shear zones in basalt related to geologic structures in the Columbia River Basalt Group in the Pasco Basin and elsewhere. Tectonic breccias are attributed to localized fracturing of in-place rock in response to regional tectonic forces. Although undocumented, potential zones of the tectonic brecciation in the Saddle Mountains Basalt beneath the 200 East Area could, if present, represent significant structures for channeling groundwater flow. This is particularly so if potential brecciated zones are associated with larger fault structures such as those seen in borehole DB-10 (Figure 3-14), as discussed below. As discussed in Section 3.4.1.3 tectonic breccias may be associated with low-magnitude earthquakes (up to about a magnitude of 2.0 to 3.0) recorded at Coyote Rapids and Wooded Island.

In the thousands of feet of core drilled in the Columbia River Basalt Group flows of the Cold Creek syncline, zones of tectonic brecciation are relatively infrequent (DOE 1988). Where observed in core, brecciated zones are typically bounded by fracturing, resulting in a distinct demarcation between the zone and the surrounding intact rock. Breccia zones that do occur are most common in the Grande Ronde Basalt, followed by the Wanapum Basalt, and then the Saddle Mountains Basalt. The nearest occurrences to the 200 East Area of tectonic brecciation in the Saddle Mountains Basalt were observed in borehole DB-10 (Figure 3-14) (Pomona, Esquatzel, and Asotin Members), and are associated with the reverse faults discussed in Section 3.4.3.1. Tectonic brecciation was also noted in the Umatilla Member of the Saddle Mountains Basalt in borehole DB-11 [about 2 km (1.2 mi) west-northwest of the 200 West Area], and in borehole DC-12 [8 km (5.0 mi) south of the 200 East Area]. No breccia zones have been observed in the suprabasalt sediments, although a thin zone of slickensides, thought to be of tectonic origin, is present in the Ringold Formation in borehole DH-27 near the 200 West Area (DOE 1988).

Where they occur in boreholes in the Cold Creek syncline, tectonic breccias are similar in appearance to those observed in the gentle-dipping south limb of the Frenchman Hills anticline. This suggests that the breccias are not necessarily associated with areas of greatest deformation in a fold, and could possibly be related to other fault structures (DOE 1988).

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The repeated stratigraphic interval in borehole DB-10 is a candidate for such a fault, although similar repeats in section are not observed in adjacent boreholes. The magnitude of the feature in borehole DB-10 is therefore uncertain, but can indicate a potential conduit for intercommunication of the confined aquifers in the Ellensburg Formation sediments.

3.4.4 200 East Area Geology

The following sections describe the occurrence of the Saddle Mountains Basalt, Ellensburg Formation and suprabasalt sediments in the 200 East Area. The sections discuss notable stratigraphic characteristics, thickness variations, dip trends, and geometric relationships of the sediments. Stratigraphic variations pertinent to the 200 East Area are presented in the overall context of regional stratigraphic trends. Descriptions of the suprabasalt units in Sections 3.4.4.4 through 3.4.4.7 are modified from Lindsey et al. (1992).

Geologic cross sections depicting the distribution of basalt and sedimentary units within or near the 200 East Area are presented on Figures 3-18 through 3-25. Figure 3-16 illustrates cross section locations, with a legend for symbols used provided on Figure 3-17. 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 wells and boreholes in the 200 East Area were reviewed and the most relevant logs were selected. Chamness et al. (1992a, 1992b, 1992c; Teel et al. 1992) provide a compilation of these geologic logs, a listing of other logs that are available, and additional geological, geochemical, and geophysical data available from these and other boreholes. This information was compiled as topical reports in support of the aggregate area management study reports for the PUREX Plant, B Plant, Semi-Works and 200 North Aggregate Areas. The cross sections depict subsurface geology in the 200 East Area. For each cross section, locations of pertinent source aggregate areas are identified for reference. Figures 3-26 through 3-40 present isopach maps depicting the thickness of the sedimentary units, and structure contour maps showing the elevation of the tops of each sedimentary unit and basalt. The structure contour and isopach maps are included from Lindsey et al. (1992).

Structure contours and isopach data on Figures 3-27 through 3-40 were extrapolated beyond actual known data points by incorporating the projected dip and change in unit thickness into the computer plotting routine. These dip and thickness data were based primarily on the projected orientation of the top of basalt, and assumed similar configuration of the suprabasalt sediments. On Figures 3-29 and 3-33, for example, Ringold Unit A and Unit E Gravels are shown as continuing to dip southward, beyond the south boundary of the 200 East Area (into the Cold Creek syncline) based on the continuous southward dip of the underlying basalt.

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3.4.4.1 Saddle Mountains Basalt. During the 1970's and early- to mid-1980's, numerous boreholes were completed at the Hanford Site to characterize physical and chemical properties of the basalt bedrock and intervening sedimentary interbeds. The boreholes were completed in support of the BWIP and other Hanford Site programs. During review of the documents for the 200 East Groundwater Aggregate Area Management Study Report (AAMSR), specific data describing the thickness and stratigraphic characteristics of Saddle Mountains Basalt flows in the vicinity of the 200 East Area were found for boreholes DC-1/2, DDH-1, DB-5, DB-15, and DB-8. These boreholes are located up to about 1.6 km (1 mi) north, northeast, and east of the 200 East Area (Figure 3-14). The following discussion of Saddle Mountains Basalt stratigraphic and thickness characteristics near the 200 East Area is based primarily on borehole intercept data reported by Lindsey et al. (1992) and DOE (1988). For the 200 East Area itself, top-of-basalt elevation data were obtained from Connelly et al. (1992a) and thickness information for the Elephant Mountain flow was obtained from Reidel and Fecht (1981). No other information was found for the Saddle Mountains Basalt in the 200 East Area.

Near the 200 East Area, the Saddle Mountains Basalt consists of (from bottom to top) the Umatilla, Esquatzel, Pomona, and Elephant Mountain Members. With the exception of the Elephant Mountain Member, there is currently no indication of erosion or nondeposition of these flows between the 200 East Area and Gable Gap/Gable Butte. Near the 200 East Area, the entire Saddle Mountains Basalt/Ellensburg Formation interbeds package maintains a fairly uniform thickness of about 222 to 238 m (728 to 781 ft). Individual flows range in thickness from about 24 to 44 m (79 to 144 ft) for the Umatilla Member, 28 to 34 m (92 to 112 ft) for the Esquatzel Member, and 56 to 60 m (184 to 197 ft) for the Pomona Member. The Elephant Mountain Member thickens (where present) from about 21 m (69 ft) northwest of the 200 East Area to more than 36 m (118 ft) south of the area.

Figures 3-26 (Graham et al. 1984) and 3-27 (Connelly et al. 1992a) are isopach and top-of-basalt contour maps of the Elephant Mountain Member near the 200 East Area. The isopach map on Figure 3-26 shows the distribution of the upper and lower Elephant Mountain flow units (Section 3.4.2.1.1) and erosional areas. As shown on the map, the upper unit (Elephant Mountain flow) is present only in the extreme southeastern corner of the 200 East Area, and in the area to the east. The lower flow (Ward Gap flow) has been partially eroded over a northwest-southeast trending area extending from Gable Gap, to the area just east of the 200 East Area. Two areas are also identified on Figure 3-26 where the Elephant Mountain Member was identified or inferred by Graham et al. (1984) to be completely eroded. Much of the erosion occurred during deposition of the Ringold sediments and subsequent Pleistocene catastrophic flooding (Lindsey et al. 1992; Graham et al. 1984) (see Sections 3.1, 3.4.2.3, and 3.4.2.7). More recent interpretation of borehole information near the inferred erosional window at the northeastern corner of the 200 East Area has questioned the extent/existence of this feature, as illustrated by its absence on Figure 3-27. Also, Hoffmann et al. (1992) indicate that the northerly erosional window of the Elephant

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Mountain Member may be contiguous with the eroded area near Gable Gap to the north. Because of the relatively small number of deep boreholes north of the 200 East Area, the extent of the erosional windows are not clearly defined (Lindsey et al. 1992).

The areas of basalt erosion near Gable Gap and to the southeast are significant because they represent locations of potential aquifer intercommunication between the upper sedimentary interbeds of the Ellensburg Formation, and the uppermost aquifer system. Graham et al. (1984) present evidence for intercommunication between the unconfined groundwater system and groundwater from the Rattlesnake Ridge interbed of the Ellensburg Formation in this area (see Section 3.5.2). The Rattlesnake Ridge interbed lies directly below the Elephant Mountain Member (Section 3.4.2.2). In the Gable Gap area (Figure 3-14) erosion has cut down to the Umatilla Member, exposing the Rattlesnake Ridge, Selah, and Cold Creek interbeds of the Ellensburg Formation (Section 3.4.2.2). The interbeds in this area are in hydraulic communication with the unconfined system in this area.

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3.4.4.2 Ellensburg Formation. Near the 200 East Area, thickness data for the sedimentary interbeds of the Ellensburg Formation were reported by Myers and Price (1981) for boreholes DC-1/2, DDH-1, DB-5, DB-15, and DB-8 (Figure 3-14). Additional thickness information was available for the Rattlesnake Ridge interbed from Lindsey et al. (1992) for the 200 East Area and adjacent areas. Reported thicknesses of the interbeds ranged from 30 to 36 m (98 to 118 ft) for the Mabton interbed, 28 to 29 m (93 to 95 ft) for the Umatilla-Esquatzel interval of the Cold Creek interbed (where present), 5.5 to 6.7 m (18 to 22 ft) for the Selah interbed, and about 6.1 in the north to about 24 m in the south (20 to 79 ft) for the Rattlesnake Ridge interbed. The Umatilla-Esquatzel interval becomes the Umatilla-Asotin interval where the Asotin Member of the Saddle Mountains Basalt is present northeast of the 200 East Area (boreholes DB-5, DDH-1, DB-15 and beyond).

3.4.4.3 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 localized occurrences of fluvial gravels of unit C and sand and minor muds of the upper unit. Ringold strata are found throughout the southern two-thirds of the 200 East Area and overlie the basalt bedrock of the Elephant Mountain Member. Ringold units B and D are not found in the immediate vicinity of the 200 East Area.

The deepest Ringold unit in the 200 East Area, the fluvial gravels of unit A, thicken and dip to the south and southwest toward the axis of the Cold Creek syncline (Figures 3-28 and 3-29) although the southward dip indicated in the southern portion of Figure 3-29 is not controlled by well data. The top of the unit is a relatively flat surface that dips to the south into 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). Intercalated lenticular sand and silt of the fluvial sand and overbank facies associations are found locally in the middle part of the unit A gravels in the southeastern part of the area. The Ringold unit A ranges in thickness from zero in the northern half of the 200 East Area, to 35 m (115 ft) or more east of the PUREX Plant 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 (Figures 3-30 and 3-31). Within the central part of the 200 East Area the lower mud sequence is largely absent. Unlike the Ringold unit A gravels, the line along which the lower mud sequence pinches out is very irregular, and the nature of the pinchout varies from location to location. At some locations the lower mud sequence pinches out laterally against uplifted basalt, while at other locations the sequence is truncated by overlying Ringold unit E gravels or Hanford formation sediments (Figures 3-21, 3-22, and 3-25). In the area between Gable Mountain and the 200 East Area, and in the vicinity of the 216-B-3 Pond System, the lower mud sequence forms the uppermost part of the Ringold Formation and is overlain by the Hanford formation (e.g., Figures 3-18 and 3-19). Throughout the rest of the 200 East Area the lower mud sequence is overlain by the gravels of Ringold unit E. The lower mud sequence ranges in thickness from zero m along the pinchout line to more than 29 m (95 ft) south of the 200 East Area and south of the Gable Mountain Pond.

Fluvial gravels of Ringold unit E thicken to the south and southwest in the 200 East Area (Figure 3-32). The unit E gravels are largely restricted to the southern part of the 200 East Area, and are absent in the 216-B-3 Pond area and between the 200 East Area and Gable Mountain. The structure contour map for the top of unit E (Figure 3-33) shows a rise in the upper surface of the unit south of the 200 East Area, but this is an artifact of the computer contouring routine due to lack of data in that area (Connelly et al. 1992a). The top of the unit probably does not exceed an elevation of 140 m msl. Based on the stratigraphic relationships shown on the geologic cross sections on Figures 3-18 through 3-25, 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. In addition to gravelly sediments, strata typical of the Ringold fluvial sand and overbank facies associations may be encountered locally. However, predicting where these intercalated lithologies will occur is difficult. Maximum measured thickness of the unit E gravels in the vicinity of 200 East Area reaches about 35 m (115 ft) south of the 200 East Aggregate Area.

The fluvial gravels of Ringold unit C, and the overbank-dominated deposits of the upper unit have been identified near the southeast corner of the 200 East Area in borehole 699-37-43 (Figure 3-18). These units pinch out immediately north and west of the borehole, but thicken to the south-southwest into the Cold Creek syncline.

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A contour map of the top of the Ringold Formation (pre-Hanford formation paleogeographic surface) is presented in Figure 3-34. The figure illustrates the complex nature of the pinchout of the Ringold unit A gravels, unit E gravels, and the lower mud sequence as discussed above. In the southwestern corner of the 200 East Area, and west and south of the 200 East Area, the unit E gravels form the top of the Ringold Formation. Within the central part of the 200 East Area, the unit E gravels pinch out and unit A gravels form the top of the Ringold Formation. The unit A gravels subsequently pinch out south of the northern boundary of the 200 East Area. The lower mud unit forms the top of the Ringold Formation east and northeast of the 200 East Area before pinching out irregularly.

3.4.4.4 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. They are encountered only in the vicinity of the 200 West Area approximately 5 km (3 mi) west of the 200 East Area.

3.4.4.5 Hanford Formation. In the 200 East Area, cataclysmic flood deposits of the Hanford formation overlie the Ringold Formation in the southern two-thirds of the area, but overly basalt bedrock directly in the northern third of the area where the Ringold Formation is absent. As discussed in Section 3.4.2, the Hanford formation is 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. Because of the variability of Hanford deposits, definition of stratigraphic sequences is arbitrary and lithologic contacts can be gradational.

The Hanford formation includes three stratigraphic sequences composed mostly of the gravel-dominated and sand-dominated facies. The stratigraphic sequences are essentially the same units as defined by Last et al. (1989). None of the three sequences are continuous across the 200 East Area, and the sequences display marked changes in thickness and continuity. The sequences are also lithologically heterogeneous. Two of the stratigraphic sequences are dominated by the gravel-dominated facies, and are designated the upper and lower gravel units. The third sequence consists of deposits of the sand-dominated facies with lesser intercalated sediments from the gravel-dominated and silt-dominated facies. This sequence is designated the sandy sequence, and is situated between the upper and lower gravel sequences where present.

The lower gravel sequence is dominated by deposits typical of the gravel-dominated facies, with locally-intercalated intervals of the sand-dominated facies. The lower gravel sequence ranges in thickness from zero to 44 m (135 ft) and is found throughout much of the 200 East Area (Figures 3-35 and 3-36). However, the unit is notably absent in the east-central part of the 200 East Area and to the west. The sequence may be present northeast

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and northwest of the 200 East Area, but because of the absence of the sandy sequence that separates the lower from the upper coarse sequences it is impossible to determine the true extent of the lower coarse sequence. The upper contact of the lower coarse sequence is placed at the top of the first gravel interval exceeding a thickness of 6 m (20 ft) below the sand-dominated strata of the overlying sandy sequence.

The sandy sequence consists of a heterogenous mix of sands typical of the sand-dominated facies. The sandy sequence is differentiated from the upper and lower gravel sequences on the basis of greater sand content. Silts typical of the slackwater facies are present, but are less abundant. The sandy sequence pinches out north of the 200 East Area, but dips and thickens to 90 m (295 ft) or more west of the 200 East Area (Figures 3-37 and 3-38). The sandy sequence is dominated by the sand-dominated facies to the north, and the silt-dominated facies to the south. Gravels commonly occur as individual fragments and as interbeds (typical of the gravel facies), especially in the north. Thin, lenticular silty paleosols (1 to 2 m [3 to 6 ft] thick) with high carbonate concentrations have been found in the northern part of the 200 East Area (Hoffmann et al. 1992). The sandy sequence probably contains the greatest concentration of clastic dikes, and is laterally equivalent with the lower fine sequence of the Hanford formation in the 200 West Area (Lindsey et al. 1991). Where the sandy sequence pinches out north of the 200 East Area 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 arbitrary. The lower contact of the sandy sequence is placed at the top of the highest gravelly interval in the lower gravel sequence, and the upper contact is placed at the top of the highest thick, sand-dominated interval.

The upper gravel sequence of the Hanford formation consists of deposits typical of the gravel-dominated facies, with local occurrences of the sand-dominated facies. The sequence ranges in thickness up to 55 m (180 ft) or more north and possibly west of the 200 East Area. In the northern part of 200 East Area the upper gravel sequence forms an elongate, northwest- to southeast-oriented body. North of the 200 East Area the unit becomes indistinguishable with the lower gravel sequence of the Hanford formation (Figure 3-39). The upper gravel sequence thins markedly to about 4 m (13 ft) just north of the B Plant Aggregate Area, and is not present in the east-central portion of the 200 East Area.

An isopach map for the entire Hanford formation is presented on Figure 3-40. The map depicts the general thickening of the formation towards the axis of the Cold Creek syncline.

3.4.4.6 Surficial Deposits. Holocene-age surficial deposits in the 200 East Area are dominated by fine- to medium-grained to occasionally silty eolian sands. These deposits have been removed from much of the area by construction activities. Where the eolian sands are found they tend to consist of thin (<3 m) sheets that cover the ground. Dunes are not generally well developed within the 200 East Area.

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3.5 HYDROGEOLOGY

The following sections discuss Pasco Basin and Hanford Site hydrogeology (Section 3.5.1) and 200 East Area hydrogeology (Section 3.5.2). Each section discusses hydrostratigraphic units of interest, hydraulic properties, groundwater recharge, groundwater flow, and vadose zone characteristics.

3.5.1 Pasco Basin and Hanford Site Hydrogeology

The hydrogeology of the Pasco Basin and Hanford Site is characterized by a multi-aquifer 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 sediments overlying the Columbia River Basalt Group (Figure 3-41). The basalt aquifers are usually confined and occur in the sedimentary interbeds of the Ellensburg Formation and the basalt flow top and flow bottom zones adjacent to the sedimentary interbeds. The uppermost aquifer in most places consists of the sediments comprised of fluvial, lacustrine, and glaciofluvial sediments. The uppermost aquifer is generally unconfined but is also semiconfined and confined in parts of the 200 Areas. The uppermost aquifer is contained largely within the Ringold Formation and Hanford formation. Within the sediments, a vadose zone of variable thickness overlies the uppermost aquifer. Perched water zones were also identified in the vadose zone and are associated with carbonate-rich strata in the 200 West Area and lenticular silty paleosols in the 200 East Area.

The following sections describe hydrogeologic characteristics of the basalt aquifers, unconfined aquifer, vadose zone, and potential perching horizons (Sections 3.5.1.1 through 3.5.1.4). Discussions incorporate general geologic and hydrologic material from Lindsey et al. (1992), Connelly et al. (1992a), Delaney et al. (1991), and specific information from other documents referenced where appropriate. Hydraulic properties are summarized for these lithologies based on published aquifer testing data for the Hanford Site. Groundwater recharge and flow for the Pasco Basin and the Hanford Site are discussed in Sections 3.5.1.5 and 3.5.1.6, respectively.

3.5.1.1 Basalt Aquifers. A number of regionally extensive, confined water-bearing zones are associated with Saddle Mountains Basalt-Ellensburg Formation hydrogeologic unit. As discussed in Section 3.4.2, confined aquifers associated with these interbeds are included in this report because of the potential for downward contaminant migration from the unconfined aquifer.

From bottom to top, the Saddle Mountains Basalt hydrogeologic unit is comprised of seven basalt flows (Umatilla, Wilbur Creek, Asotin, Esquatzel, Pomona, Elephant Mountain,

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and Ice Harbor Members). The hydrogeologic unit also includes the intervening sedimentary interbeds of the Ellensburg Formation (Mabton, Cold Creek, Selah, Rattlesnake Ridge, and Levey interbeds). As discussed in Sections 3.4.2.1 and 3.4.2.2, the Wilbur Creek and Ice Harbor flows and the Levey interbed are not present over much of the Hanford Site, including the 200 East and 200 West Areas. The Asotin flow is not present in the western and south-central portions of the Hanford Site. Within the confined aquifers, groundwater flow primarily occurs within the permeable sedimentary interbeds of the Ellensburg Formation and to a lesser extent within the adjacent flow top and flow bottom zones of the basalt flow members.

Beneath most of the Hanford Site, the Rattlesnake Ridge interbed is the uppermost confined aquifer and is separated from the overlying unconfined aquifer system by the Elephant Mountain Member of the Saddle Mountains Basalt. The Elephant Mountain Member thins and has been removed locally by erosion between the 200 East Area and Gable Mountain (Section 3.4.2.1.1). In these areas, the Rattlesnake Ridge interbed is in contact with, and is thus a part of, the uppermost aquifer. At Gable Gap, erosional downcutting has also exposed the Elephant Mountain, Selah, and Cold Creek interbeds (as discussed in Section 3.4.4.1), placing these interbeds in hydraulic communication with the unconfined aquifer.

With the exception of the Rattlesnake Ridge interbed, most of the reported hydraulic property data for the Ellensburg Formation were obtained in the vicinity of the 200 West Area in support of the BWIP. Reported hydraulic conductivities for the interbeds range from 2×10^{-8} to 2×10^{-4} m/s (6.0×10^{-3} to 30 ft/day) (Ledgerwood and Deju 1976; Strait and Mercer 1987). Many of the Rattlesnake Ridge conductivity values included in this range were obtained from testing north of the 200 East Area. Reported transmissivities for the Rattlesnake Ridge aquifer range from 3×10^{-13} to 5×10^{-8} m^2/s (3×10^{-3} to 1.2×10^{3} ft^2/day) (Graham et al. 1981; Graham et al. 1984; DOE 1988) and are summarized by Newcomer et al. (1992a).

Within individual basalt flows, zones of increased permeability may be associated with vesicles, rubble zones, and other intraflow structures (Graham et al. 1984; Gephart et al. 1979). A description of basalt intraflow structures is presented in Section 3.4.2.1.2. The vesicle and rubble zones are usually found at the top and bottom flow boundaries and generally contribute to the interbed permeability (Graham et al. 1984). Hydraulic properties related to fracture and interflow zones associated with the Elephant Mountain Member in the vicinity of the 200 East Area are discussed in Section 3.5.2.1.

In addition to intraflow structures, tectonic fractures and faults, if present, can also potentially contribute to increased permeability if these structures are not closed or filled with clay gouge-like materials. As discussed in Sections 3.4.2.1.2 and 3.4.3, a limited amount of

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fault and fracture information was available from geological and geophysical investigations reviewed for this report.

3.5.1.2 Uppermost Aquifer System. The uppermost regional aquifer in the Pasco Basin and the Hanford Site generally occurs within fluvial/lacustrine sediments of the Ringold Formation and glaciofluvial sands and gravels of the Hanford formation. The uppermost aquifer system primarily displays unconfined conditions but also exhibits locally confined or semiconfined conditions, although for ease of discussion it is referred to simply as the unconfined aquifer. Groundwater ranges from less than 0.3 m (1 ft) below ground surface near West Lake and the Columbia and Yakima Rivers to greater than 110 m (350 ft) in the central portion of the Cold Creek syncline. The saturated thickness of the unconfined aquifer ranges from approximately 67 m (220 ft) in the 200 West Area to zero north of the 200 East Area. This is where the aquifer thins and laps onto basalt that extends upward to an elevation above the water table.

Semiconfined to confined conditions occur locally in the otherwise unconfined aquifer at the Hanford Site. Within the lower part of the aquifer, semiconfined to confined groundwater exists in the Ringold unit A gravels where the unit is overlain by fine-grained sediments of the Ringold lower mud sequence. In the 200 West Area, the thickness of the Ringold unit A semiconfined to confined zone ranges from 38 m (125 ft) or more in the southeastern portion of the area to zero where the unit A gravels and the lower mud sequence pinch out near the northern and northeastern portions of the area, respectively. The confining zone overlying unit A gravels is up to 30 m (100 ft) thick below the south-central part of the 200 West Area. Semiconfining and confining conditions in the 200 East Area are discussed in Section 3.5.2.1.

A second type of confining condition has been identified near the water table in the north-central part of the 200 West Area and at a location about 600 m (2,000 ft) north of the 200 West Area. At these areas, drilling has indicated that the water table is locally confined beneath carbonate-rich sediments in the Ringold unit E gravels. The condition is apparently associated with carbonate buildup on gravel fragments and in the sediment pore spaces. During drilling, boreholes penetrating this layer (possibly 0.5 m [1.5 ft]) thick or more) have subsequently encountered water that immediately rises about 2 to 3 m (6.5 to 10 ft) or more above the gravel layer. The water level typically falls below the elevation of the carbonate-rich layer as drilling progresses deeper. Borehole data describing the confining condition are preliminary and hydrologic testing of these zones has not been completed. The lateral persistence of the confining condition near the 200 West Area is currently uncertain. Additionally, local zones of the Ringold lower mud sequence in the 216-B-3 Pond area east of the 200 East Area form semiconfining layers above the uppermost aquifer, and a distinct unconfined aquifer is not present (Connelly et al. 1992a) (see Section 3.5.2.2).

Because the uppermost aquifer transports potential chemical and radionuclide contaminants, it is generally the most characterized hydrologic unit beneath the Hanford Site. Numerous wells have been installed in the unconfined aquifer to obtain groundwater elevation data, samples for chemical analyses, and aquifer properties data.

3.5.1.2.1 Hydraulic Properties/Unconfined Portion of Uppermost Aquifer. The following discussion summarizes hydraulic properties data for the unconfined portion of the uppermost aquifer at the Hanford Site. It is organized to first reference the sources of the data followed by the testing methods used to acquire the data. Methods of analysis are presented along with several factors, or assumptions, which affect the final value and this is followed by a discussion of differences between testing methods applied. Finally the ranges of estimated aquifer hydraulic conductivity, storativity, specific yield, and porosity are presented.

Table 3-1 presents a summary of Hanford Site hydraulic conductivities and transmissivities based on data reported by Newcomer et al. (1992a), Connelly et al. (1992a), Delaney et al. (1991), Bjornstad (1990), and Last et al. (1989). The Hanford Site data for the unconfined portion of the uppermost aquifer are broken out separately for the Ringold Formation and for the Hanford formation on Table 3-1. Most of the unconfined aquifer data for the Ringold Formation (unit E gravels) represents testing results for the 200 West Area. Delaney et al. (1991) and Last et al. (1989) report data that also includes testing results from other Hanford Site areas. For comparison, Table 3-1 presents a summary of hydraulic conductivities and transmissivities for the 200 East Area (and adjacent locations), using data primarily from Newcomer et al. (1992a), Swanson et al. (1992), Connelly et al. (1992a), and supplemented with data from Delaney et al. (1991) and Last et al. (1989). Because of the geologic variability associated with the uppermost aquifer in the 200 East Area, hydraulic data were not broken out separately for the Ringold Formation and Hanford formation by Newcomer et al. (1992a) and Connelly et al. (1992a), and these data are not summarized separately on Table 3-1. This approach is consistent with that used by Connelly et al. (1992a) during evaluation of the Newcomer et al. (1992a) and Swanson et al. (1992) data for the 200 East Area hydrogeologic model. The original data tables from Newcomer et al. (1992a) and Connelly et al. (1992a) for the 200 East Area are provided as Appendix A Tables A-8 and A-9.

Hydraulic conductivity and transmissivity data presented on Table 3-1 represent information obtained from a variety of aquifer testing methods. Data reported by Newcomer et al. (1992b) includes field testing results from Last et al. (1989), Graham et al. (1981), PNL file data, and older pumping/recovery data for the 200 West Area. During preparation of the 200 West Area hydrogeologic model, Connelly et al. (1992b) incorporated the Newcomer et al. (1992b) data for the unconfined portion of the uppermost aquifer, supplemented by previously unpublished slug test data for the Ringold E gravels collected over the last several years. Hydraulic data reported by Bjornstad (1990) includes results

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from aquifer pump tests, laboratory permeameter testing (vertical hydraulic conductivities), and some re-analysis of the Last et al. (1989) data. Data reported by Newcomer et al. (1992a) for the 200 East Area includes results of pumping, recovery tests, and slug tests from Last et al. (1989), Graham et al. (1984), Graham et al. (1981), PNL and Westinghouse Hanford Company (WHC) file data, and a variety of other sources.

Results of aquifer testing at the Hanford Site and the interpretation of the Table 3-1 summary data depend on several factors. These factors include the location and depth of wells tested, type of geologic material tested, well screen interval and construction features, well bore storage effects, type of geologic material tested, and analytical/data reduction methods. Major factors affecting field testing results are the heterogeneity of the sediments within the screened interval and whether the well screen is only partially penetrating the aquifer. Most of the aquifer analysis methods assume a fully penetrating well screen and a homogenous, isotropic aquifer (e.g., Theis or modified Theis analysis). Differing estimates of saturated aquifer thickness produce different estimates of hydraulic conductivity reported in the references cited in the previous paragraph. Additionally, aquifer tests conducted using clustered piezometers in the same borehole may not represent true aquifer responses because of potential hydraulic intercommunication of the tested zones. Intercommunication can occur if the sandpack material used to isolate each open interval provides a conduit for groundwater migration between the tested zones through the well annulus. Newcomer et al. (1992b) report intercommunication for some nested wells in the 200 West Area.

Differences in field testing methods produce variations in the data. In general, hydraulic properties obtained from aquifer recovery tests may be the most representative of the actual aquifer conditions because the well response is not affected by fluctuations in pumping rates. Slug testing may provide a conservatively low estimate of hydraulic conductivity because of the limited volume of the aquifer stressed during testing. The size of sand particles used for the well screen filter pack may also affect interpretation of slug tests. In recent evaluations of slug interference testing at the Hanford Site, Spane (1992) suggests, however, that slug tests with large head displacements monitored in observation wells 3 to 30 m (10 to 100 ft) away from the test well may provide representative estimates of hydraulic conductivity and specific yield.

Evaluation of the hydraulic properties for the unconfined portion of the uppermost aquifer at the Hanford Site indicates that higher hydraulic conductivities and transmissivities are generally associated with the Hanford formation. As presented on Table 3-1, site-wide Hanford formation conductivity values vary widely from about 2×10^{-3} to 7×10^{-2} m/s (500 to 20,300 ft/day) and transmissivities vary from about 2×10^{-2} to 0.6 m^2/s (14,000 to 594,000 ft^2/day). In comparison, conductivities for the Ringold unit E gravels vary from about 2×10^{-7} to 2×10^{-3} m/s (0.06 to 600 ft/day). Transmissivities in the Ringold gravels vary from about 1.7 to 4,320 m^2/day (20 to 51,000 ft^2/day). Because hydraulic conductivities and transmissitivities were determined from field aquifer testing, these field

scale values differ from those derived from laboratory testing of Hanford formation and Ringold Formation vadose zone samples (Sections 3.5.1.3 and 3.5.2.1.3).

Graham et al. (1981) evaluate other hydraulic properties for the uppermost aquifer for the Hanford Site and conclude that the ratio of horizontal to vertical hydraulic conductivity ranges between 13 and 16, primarily because of anisotropy in the sedimentary structure of the deposits. For wells completed just below the water table in the Hanford formation, Graham et al. (1981) report specific yield values ranging from 0.15 to 0.18, and a storativity value of 0.07. Graham et al. (1981) estimate that the effective porosity of the uppermost aquifer ranges from 10 to 30%. The lower value is reportedly more representative of the Ringold Formation, and the higher value is representative of the Hanford formation sediments.

3.5.1.3 Vadose Zone. The vadose zone at the Hanford Site is composed of several units, including: (1) Holocene surficial deposits such as loess, sand dunes, alluvium, and talus; (2) Hanford formation; (3) early "Palouse" soils; (4) Plio-Pleistocene unit; and (5) Ringold Formation. The vadose zone beneath the Hanford Site ranges in thickness from approximately 0.3 m (1 ft) thick near West Lake to approximately 110 m (350 ft) thick west of the 200 East Area (Last et al. 1989). Variable surface topography and the variable elevation of the water table in the underlying unconfined aquifer causes this observed variation in vadose zone thickness.

At the Hanford Site, much of the existing moisture content and hydraulic properties data for the unsaturated zone have been obtained from borehole soil samples collected in the 200 East and 200 West Areas. Determining unsaturated hydraulic conductivities and other vadose zone hydraulic properties via direct measurement is generally expensive and impractical because of the inherent complexity of factors affecting groundwater flow through unsaturated soils. For this reason, much of the unsaturated hydraulic conductivity data have been derived using theoretical, computer-based modeling methods (Van Genuchten et al. 1991) in conjunction with measured soil moisture retention contents and saturated hydraulic conductivity data.

The following discussions summarize moisture content and unsaturated hydraulic conductivity data for the 200 West Area vadose zone sediments reported by Connelly et al. (1992b) and Bjornstad (1990). Much of this information was obtained as part of ongoing performance assessment activities for the 200 West Area low-level burial grounds. As discussed above, these data were generated via computer modeling techniques using measured soil moisture and saturated hydraulic conductivity data. Unsaturated hydraulic conductivities may vary by orders of magnitude with varying moisture contents and among differing lithologies with significantly different soil textures. Results for the 200 West Area samples are further discussed in the 200 West Groundwater AAMSR. Unsaturated moisture contents and hydraulic conductivity data for the 200 East Area are discussed in Section

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3.5.2.1.3. Section 3.5.2.1.3 also includes a background discussion of vadose zone soil transport and the Van Genuchten et al. (1991) modeling approach for deriving unsaturated conductivities.

For the 200 West Area, reported unsaturated hydraulic conductivities for two samples collected from the Ringold unit E gravels ranged from about 10^{-13} to 10^{-10} m/s (3×10^{-8} to 3×10^{-5} ft/day) at a moisture content of 10% to 2×10^{-5} to 1×10^{-4} m/s (6 to 30 ft/day) at saturation (26 to 46%), respectively. Bjornstad (1990) indicates, however, that the sample with a moisture content of 26% at saturation may have been significantly compacted or cemented. Therefore, the sample with the higher saturated hydraulic conductivity may be more representative of the Ringold unit E gravels, but too few samples were available for comparison. For the upper Ringold unit, the predicted unsaturated conductivities generally ranged from about 10^{-12} to 10^{-6} m/s (3×10^{-7} to 3×10^{-1} ft/day) at a moisture content of 10% to about 10^{-6} to 10^{-5} m/s (0.3 to 3 ft/day) at moisture contents of 32 to 42% (saturation). One of the upper Ringold unit samples had a relatively high saturated hydraulic conductivity of 3.7×10^{-4} m/s (1.0×10^{2} ft/day; drying conditions), and may therefore represent sediments transitional into the Ringold unit E gravels in the borehole where the sample was collected.

A high degree of variability is present for unsaturated hydraulic conductivities associated with samples of Plio-Pleistocene unit soils from the 200 West Area. This unit is hydrologically important because of the calcareous paleosols that could cause lateral spreading and perched water table development from downward percolating water (Section 3.5.1.4). At saturated water contents of 33 to 52%, hydraulic conductivities ranged from about 10^{-8} to 10^{-3} m/s (3×10^{-3} to 3×10^{2} ft/day; drying conditions). These variations are mainly attributable differences in grain size and the degree of cementation and compaction.

Connelly et al. (1992b) report unsaturated conductivity data for the early "Palouse" soils in the 200 West Area were limited to two samples consisting of fine sand and silt. Measured laboratory saturated hydraulic conductivities were in the range of 1×10^{-6} m/s (0.3 ft/day). Additional data points would be required to assess variability in the unit.

For the Hanford formation, reported hydraulic conductivity testing results for all but one of 13 samples collected were obtained from the coarse-grained gravel facies with the remaining sample collected from the fine-grained facies. The derived unsaturated conductivity values, and measured saturated hydraulic conductivity values varied widely. At saturation moisture contents ranging from 34 to 52%, measured saturated conductivities ranged from about 10^{-7} to 10^{-3} m/s (3×10^{-2} to 3×10^{2} ft/day). Particle size analyses of the samples tested by Bjornstad (1990) indicated that some of the samples were sand and silt rather than gravels. If these samples are eliminated, the range of saturated hydraulic conductivities (moisture contents of 40 to 50%) for the gravel facies is much smaller, 10^{-4} to 10^{-3} m/s (3×10 to 3×10^{2} ft/day). It should be noted that calculated unsaturated

conductivities range over several orders of magnitude at lower moisture contents and that finer-grained facies may have higher conductivities than a coarse-grained facies, for the same moisture content. Hydraulic conductivity values reported by Bjornstad (1990) corresponding to volumetric water contents ranging from 2 to 10% typically range from 2×10^{-13} to 7×10^{-9} m/s (6×10^{-8} to 2×10^{-3} ft/day). In addition, Connelly et al. (1992) report conductivity values for the Hanford formation in the 200 West Area ranging from 7×10^{-8} to 5.5×10^{-4} m/s (0.02 to 160 ft/day).

Additional data regarding vadose zone conductivities and other hydraulic properties were obtained during infiltration and recharge studies (including lysimeter studies) at the Hanford Site. These hydraulic properties are discussed in Section 3.5.1.5.

3.5.1.4 Perched Water Zones. Perched water zones form when moisture moving downward through the vadose zone accumulates on top of low permeability soil lenses, highly cemented horizons, or 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, and a perched water table condition may develop. Additional input of downward percolating moisture to this horizon may cause 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 Plio-Pleistocene unit and early "Palouse" soil form potential perching horizons within the vadose zone in the vicinity of the 200 West Area. The Plio-Pleistocene unit, consisting of calcium-carbonate cemented silt, sand, and gravel, occurs at 12 to 61 m (40 to 200 ft) deep and is up to 9 m (30 ft) thick. The early "Palouse" soil horizon, consisting of loess-like silt and minor fine-grained sand, ranges from 12 to 46 m (40 to 150 ft) deep and is up to 12 m (40 ft) thick in the vicinity of the 200 West Area. Neither the Plio-Pleistocene unit nor the early "Palouse" soil is found in the 200 East Area, however, silty paleosols have been identified that may serve as perching horizons (Hoffmann et al. 1992).

3.5.1.5 Groundwater Recharge. Natural and artificial sources recharge the unconfined aquifer within the sedimentary rocks of the Pasco Basin. Rainfall and runoff within area of basalt outcrop along the margins of the Pasco Basin recharge the basalt aquifers as does downward groundwater movement from the overlying sediments, but a lesser extent. Downward groundwater movement is discussed in Section 3.5.1.6. The following sections discuss natural and artificial groundwater recharge.

3.5.1.5.1 Natural Groundwater Recharge. 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 naturally recharge the uppermost aquifer

system within the Pasco Basin. The principal source of recharge occurs along the periphery of the basin where precipitation runoff infiltrates to the water table (Graham et al. 1981). Small ephemeral streams draining the western slopes, such as Cold Creek and Dry Creek, lose water to the ground as they spread out on the valley plain. Water conducted in these streams is lost through both infiltration to the ground and evapotranspiration to the air. Most of the infiltrating water eventually percolates to the water table. Larger rivers either gain or lose water to the aquifer depending on the river stage, location, and groundwater flow direction. The Yakima River, for example, recharges the unconfined aquifer along its reach from Horn Rapids to Richland, Washington. Along the Columbia River, some river water is transferred during high stages to bank storage as groundwater. Some of this bank storage may recharge the aquifer, but the rest will flow back into the river when the stage drops.

The Cold Creek and Dry Creek valleys to the west of the 200 West Area naturally recharge the unconfined aquifer. Gee (1987) reported that natural recharge to the 200 West Area is approximately 130,000 L/yr (34,000 gal/yr). Further discussion is presented in Section 3.5.2.2.1.

Natural precipitation infiltration at or near waste management units or unplanned releases may provide a driving force for mobilizing contaminants previously introduced to surface or subsurface soils. For this reason, many previous investigations focus on determining precipitation recharge rates at the Hanford Site. Previous field programs were 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 zero to 10 cm/yr (4 in./yr) are estimated from various studies.

The primary factors affecting precipitation recharge appear to be surface soil type, vegetation type, topography, and spatial and temporal variations in seasonal precipitation. In general, infiltration to soils is higher in the winter when precipitation is more frequent and evapotranspiration is low. Examples of precipitation recharge studies at the Hanford Site, and some of the conclusions reached, are given below:

- Gee and Heller (1985) describe various models used to estimate natural recharge rates. Many of the models use a water retention relationship for the soil. This is the relation between soil moisture content and the suction required to remove (or move) the moisture. Gee and Heller (1985) developed two of these models 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 on Figure 3-42. 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 were obtained from a number of core-barrel samples in the 200 Areas (East and West) and varied from 1 to 18% (by weight), with most samples in the range of 2 to 6% (Last et al. 1989). The data appear to indicate zones of increased moisture content that can be interpreted as signs of moisture transport. Also, during monitoring well drilling near 200 West Area single-shell tanks, measured moisture contents in silty sediments have been as high 26 to 28% (by weight). The high moisture contents indicate local saturation or near-saturation in vadose zone sediments; however, this condition may reflect some contribution from suspected tank leaks in addition to infiltration from precipitation.

- Gee (1987) describes results of lysimeter studies and indicates greater soil moisture infiltration is associated with winter and early spring precipitation and runoff.

- Routson and Johnson (1990) describe a lysimeter study conducted at a location 1.6 km (1 mi) south of the 200 East Area. During much of the lysimeter's 13-year study period between 1972 and 1985, the ground surface above the lysimeter was kept unvegetated by using herbicides. No information regarding the soil types in which the lysimeter was installed is provided. To a precision of $\pm$ 0.2 cm (0.08 in.), 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.

- Rockhold et al. (1990) also report on a weighing lysimeter study conducted at a grassy plot approximately 5 km (3 mi) northwest of the 300 Areas. The grassy 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 (i.e., cheatgrass and bluegrass). The upper 3.5 m (11.5 ft) of the soil profile consist of slightly silty to silty sand (sandy loam) with an estimated saturated hydraulic conductivity of 9×10^{-5} m/s. Rockhold et al. (1990) estimate 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 period.

- Fayer and Jones (1990) developed the computer model UNSAT-H to simulate the infiltration of recharge through typical Hanford vadose zone soils. To date, however, the model has been used only for very location-specific studies rather than the Hanford Site or the 200 Areas as a whole.

- Rockhold et al. (1990) discuss a gravel-covered lysimeter study conducted at the 622 Area Lysimeter Site, approximately 0.5 km (0.3 mi) east of the 200 West

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Area. Approximately 4 cm (1.6 in.) of downward moisture movement was observed in two gravel-covered lysimeters during 1988 and 1989. This represented approximately 25% of the total precipitation recorded in the area during the study period. The authors conclude that gravel placed on the soil surface reduces evaporation and facilitates precipitation infiltration.

- Smoot et al. (1989) conducted a modeling analysis and indicate that 68 to 86% of the precipitation falling on a gravel-covered site might infiltrate to a depth greater than 2 m (6 ft).

Smoot et al. (1989) present an example of the potential use of this vadose zone hydraulic parameter information 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 computer code to predict the precipitation infiltration for several different soil horizon combinations and characteristics. The researchers used statistically generated precipitation values 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.

3.5.1.5.2 Artificial Groundwater Recharge. Artificial recharge to the groundwater in the Pasco Basin comes from two sources: agricultural irrigation and liquid waste disposal operations on the Hanford Site. Agricultural land on the eastern and northern sides of the Columbia River and in the Cold Creek valley to the west of the Hanford Site is currently irrigated; however, the volume of irrigation water used has not been quantified. Possibly as much as 40% of this irrigation water reaches the water table (U.S. Bureau of Reclamation 1971).

Hanford liquid waste disposal practices artificially recharge mainly the 200 East and West Areas. Graham et al. (1981) estimate that historical artificial recharge from liquid waste disposal in the separations areas exceeded all natural recharge on the Hanford Site by a factor of ten. Zimmerman et al. (1986) report that between 1943 and 1980, 6.33×10^{11} L (1.7×10^{11} gal) of liquid wastes were discharged to the soil column in the 200 Areas. Artificial recharge is further discussed in Section 3.5.2.2.2. Potential recharge to the Rattlesnake Ridge confined aquifer is presented in Section 3.5.1.6.2.

3.5.1.6 Regional Groundwater Flow. Groundwater flow beneath the 200 East Area is affected by regional groundwater flow conditions. This section describes regional and Hanford Site groundwater flow patterns for the uppermost aquifer and basalt aquifers.

3.5.1.6.1 Unconfined Aquifer. The areal pattern of groundwater flow for the past and present in the uppermost aquifer can be determined from potentiometric surface maps presented on Figures 3-43 and 3-44. Areas of varying hydraulic conductivity in the sedimentary strata may cause localized deflection of groundwater flow from the general pattern shown on the figures.

Natural groundwater inflow to the unconfined aquifer primarily occurs along the western boundary of the Hanford Site. In the past, groundwater flow across the Hanford Site in the unconfined aquifer generally moved toward the east-northeast, although flow north of Gable Mountain was more to the north. Figure 3-43 is a hindcast map of the 1944 groundwater table, i.e., estimated from relatively few data points and estimates of flow. The uppermost 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.

Groundwater flow north of Gable Mountain now trends in a more northeasterly direction as a result of mounding in the 100 Areas and flow through Gable Gap. Figure 3-44 is a June 1991 groundwater table map for the Hanford Site. South of Gable Mountain, flow is interrupted locally by the groundwater mounds in the 200 Areas. Groundwater flow directions are affected to a large degree by wastewater discharge and groundwater mounding in the 200 East Area (Delaney et al. 1991). During periods of increased recharge from the 200 East Area, more of the recharge from the 200 West Area is diverted north through Gable Gap toward the 100 Areas. There is also a component of groundwater flow to the north between Yakima Ridge and Gable Butte from the 200 Areas. Because disposal of liquid waste to the soil column operations will continue to be reduced in the 1990's, this reduction in artificial recharge at the Hanford Site will continue a gradual reversion back toward natural conditions in the regional groundwater flow pattern. Because of increased irrigation in the Pasco Basin, the flow pattern will probably never match the 1944 flow pattern (Figure 3-43), but the flow direction may roughly approach previous flow directions.

Graham et al. (1981) calculate horizontal hydraulic gradients for the 200 West Area of 0.004 to 0.015 for data collected in December 1979. Before operations at the Hanford Site began in 1944, the hydraulic gradient in all but the southwestern-most portion of the Hanford Site was approximately 0.001 (5 ft/mi). These data indicate an overall increase in gradients across the site. The largest increase is in the vicinity of the groundwater mounds below the 200 Areas. Graham et al. (1981) estimate that vertical hydraulic gradients in the unconfined aquifer exceed 10% in some areas; however, these authors did not specify specific areas. Information on gradients and flow velocities is presented in Section 3.5.2.3.1.

3.5.1.6.2 Basalt Aquifers. Lateral groundwater movement within the Saddle Mountains Basalt hydrogeologic unit occurs from upland recharge areas along the periphery

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of the Pasco Basin and along anticlinal ridges to discharge areas along the Columbia River. A potentiometric surface map of the basalt aquifers is discussed in Section 3.5.2.3.3.

3.5.1.6.3 Unconfined/Basalt Aquifer Interconnection. Erosional windows through Saddle Mountains Basalt flows, areas of basalt nondeposition, or poor groundwater well seals may allow communication between the uppermost aquifer system and underlying confined aquifers (Ledgerwood and Deju 1976; Graham et al. 1984). Also, basalt intraflow structures or fractures could potentially serve as interconnections (Section 3.4.2.1.2).

In zones of potential intercommunication, contaminants could be transported from the shallow unconfined aquifer to deeper water bearing zones via advective transport or density-driven plumes. Downward gradients in erosional window areas, for example, could promote recharge to the deeper formations. Deju and Fecht (1979) and DOE (1988) present data indicating that overall potentiometric head decreases with depth in the Saddle Mountains Basalt causing downward gradients. Gradients in the Saddle Mountains Basalt, which are in contact with the overlying sediments, are believed to have been upward before the start of wastewater disposal (DOE 1988), but subsequently may have been reversed to a downward gradient (Graham et al. 1984; DOE 1988).

The interconnection of the unconfined aquifer and the Rattlesnake Ridge aquifer between the 200 East Area and Gable Gap/Gable Mountain is discussed in Section 3.5.2.3.2.

3.5.2 200 East Area Hydrogeology

Sections 3.5.2.1.1 through 3.5.2.1.4 describe the hydrogeologic characteristics of the basalt aquifers, unconfined aquifer, and vadose zone sediments in the 200 East Area. Sections 3.5.2.2 and 3.5.2.3 describe 200 East Area groundwater recharge and flow, respectively.

3.5.2.1 200 East Area Hydrostratigraphy. The primary hydrostratigraphic units in the 200 East Area are (1) the Rattlesnake Ridge interbed and deeper interbeds of the Ellensburg Formation (confined water-bearing zones); (2) the Elephant Mountain Member and deeper flows of the Saddle Mountains Basalt (confining horizons with local interflow zones); (3) the Ringold Formation (locally semiconfined to confined water-bearing zones in unit A gravels beneath the lower mud sequence, and unconfined aquifer in unit A and unit E gravels); and (4) the Hanford formation (unconfined aquifer and vadose zone sediments). The hydrogeologic designations for the 200 East Area were determined by reviewing borehole and well data summaries from Chamness et al. (1992a through 1992c) and Teel et al. (1992) and integrating these data with hydrostratigraphic data from Connelly et al. (1992a), Lindsey et al. (1992), and Hoffmann et al. (1992). Figure 3-45 summarizes hydrogeologic units identified in the 200 East Area.

3.5.2.1.1 Basalt Aquifers. Regionally confined aquifers exist within the Saddle Mountains Basalt-Ellensburg Formation hydrostratigraphic unit in the 200 East Area. From bottom to top, the confined water-bearing zones occur within the Mabton, Cold Creek, Selah, and Rattlesnake Ridge interbeds of the Ellensburg Formation, and associated Saddle Mountains Basalt flow tops/bottoms. The Wilbur Creek, Asotin, and Ice Harbor flows and the Levey interbed are not present in the 200 East Area (Section 3.4.2).

The uppermost regionally confined aquifer in the vicinity of the 200 East Area is generally contained in the Rattlesnake Ridge interbed of the Ellensburg Formation. The Rattlesnake Ridge interbed is confined on the top and bottom by the Elephant Mountain and Pomona Members of the Saddle Mountains Basalt, respectively. Where the Elephant Mountain Basalt is locally eroded north of the 200 East Area (Figures 3-27 and 3-28), the Rattlesnake Ridge interbed is in contact with the unconfined aquifer, and the uppermost confined aquifer is located in the Selah interbed. Transmissivity data for the Rattlesnake Ridge aquifer have been obtained from wells tested in the vicinity of the 200 East Area and are summarized by Newcomer et al. (1992c). The reported data were obtained from Graham et al. (1984), Strait and Moore (1982), Westinghouse Hanford files, and other sources since about 1981. Reported transmissivities range from 2.5×10^{-1} to 173 m^2/day (3 to 1,540 ft^2/day). Many of the values are in the 8.6 to 86 m^2/day (100 to 1,000 ft^2/day) range.

An additional confined aquifer is associated with Elephant Mountain Basalt in the vicinity of the 200 East Area (Jensen 1987; Graham et al. 1984; Gephart et al. 1979). As discussed in Section 3.4.3.1, the Elephant Mountain Member is composed of separate upper and lower flows over part of this area (Figure 3-26). The figure shows that the lower flow (Ward Gap flow) is present only in the south eastern corner of the 200 East Area and the areas to the south and east. Where both flow units are present, a groundwater interflow zone consisting of sands and clays occurs between the upper and lower flows (Jensen 1987). Graham et al. (1984) describe the interflow zone as containing interconnecting vesicles and rubble. The interflow zone is referred to as the Elephant Mountain aquifer (Jensen 1987) but is not regionally extensive. As further discussed by Jensen (1987) and Graham et al. (1984), the Elephant Mountain aquifer is in contact with the unconfined aquifer in the northeastern corner of the 200 East Area where the lower Elephant Mountain flow is absent. The Elephant Mountain aquifer probably discharges to the unconfined aquifer, but it may be locally influenced by the groundwater mound under 216-B-3 Pond (Graham et al. 1984).

For the Elephant Mountain aquifer, Graham et al. (1981) reported a hydraulic conductivity of 622 m/day (190 ft/day). The aquifer reportedly exhibits higher transmissivities (6.9×10^{-1} to 605 m^2/day [7.5 to 6,120 ft^2/day]) than the bounding flows (Graham et al. 1984). Graham et al. (1984) also report a range of hydraulic conductivities of 10^{-7} to 10^{-3} m/day (3×10^{-3} to 3×10^{3} ft/day) for the flow top of the upper Elephant Mountain flow (Elephant Mountain II unit). In contrast, Deju and Fecht (1979) reported a

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hydraulic conductivity value for fractured zones within Saddle Mountains Basalt flow interiors of 1 x 10^{-7} m/s (3 x 10^{-2} ft/day).

3.5.2.1.2 Uppermost Aquifer System. The following discussion addresses the uppermost aquifer system that primarily is comprised of the unconfined aquifer but also includes localized semiconfined and confined areas. In contrast to the 200 West Area, hydrostratigraphic relationships associated with the unconfined aquifer in the vicinity of the 200 East Area are relatively complex because of the depositional and erosional history of the geologic units. The following discussions of 200 East Area hydrostratigraphy and hydraulic properties are modified from Connelly et al. (1992a). As discussed by Connelly et al. (1992a), the unconfined aquifer in the vicinity of the 200 East Area occurs primarily within sediments of the Ringold Formation and Hanford formation. In areas north of the 200 East Area where the Elephant Mountain flow has been eroded, the Rattlesnake Ridge interbed is also included in the unconfined aquifer system. The base of the unconfined aquifer is the Ringold lower mud unit where the latter unit is present in the southern and eastern portions of the 200 East Area (Figure 3-31). North of the 200 East Area, the unconfined system extends down to the top of the Elephant Mountain flow, or to the top of the Pomona flow where the Elephant Mountain flow has been eroded. As discussed in Sections 3.4.4.1 and 3.5.1.1, the unconfined system extends to the Umatilla flow near Gable Gap due to erosion of the overlying flows. In this area the unconfined aquifer is in hydraulic communication with the confined aquifers of the Ellensburg Formation interbeds. The thickness of the uppermost aquifer system varies considerably from near zero in the northern and northeastern portions of the area where basalt bedrock extends above the water table to more than 80 m to the south (Figure 3-46). A distinct unconfined system does not exist where the fine-grained sediments of the Ringold lower mud unit forms a semiconfining to confining layer above the uppermost aquifer near the 216-B-3 Pond.

Within the central part of the 200 East Area, the water table is located within the Ringold unit A gravels. This area coincides with locations where the fine-grained sediments of the Ringold lower mud sequence are not present to act as confining layer. In the southern part of the 200 East Area, the water table intersects gravelly sediments of Ringold unit E and the Hanford formation. The water table is near the contact of the Ringold Formation and Hanford formation beneath the central and southern portions of the 200 East Area. South and west of the 200 East Area the water table is present in the Ringold unit E gravels. In the northern part of the 200 East Area and in the area between the 200 East Area and Gable Gap/Gable Mountain, the water table generally lies within gravelly and sandy sediments of the Hanford formation, except in areas where basalt bedrock extends above the water table.

Figure 3-48 (Connelly et al. 1992a) represents the uppermost aquifer system. Connelly et al. report that information obtained from drilling and well installation near 216-B-3 Pond indicates that the unconfined aquifer is absent in this area. This condition can be described by comparing December 1991 water table elevations in the 200 East Area, shown on

Figure 3-49, with top-of-unit elevations for the Ringold lower mud sequence shown on Figure 3-31. This comparison indicates that the water table and the top of the lower mud sequence nearly coincide in this area, and each have elevations varying between about 125 and 128 m (410 and 420 ft) above msl. In the 216-B-3 Pond area, the Ringold lower mud sequence appears to have little moisture, and water generally is not encountered during drilling until the underlying saturated gravels are encountered. The potentiometric surface for the gravels is approximately even with the top of the lower mud sequence because of locally confining conditions. The water table elevations therefore represent, in part, the potentiometric surface associated with semiconfined to confined groundwater in the Ringold lower mud sequence/unit A gravels. It is also possible that during periods of increased groundwater recharge from the 216-B-3 Pond System, mounded groundwater could extend above the upper surface of lower mud sequence and create a perched condition above the lower mud sequence. A similar condition may exist in the west-central part of the 200 East Area where Figure 3-31 shows the top of the lower mud sequence possibly extending above the 123 m (405 ft) groundwater table elevation. The lower mud unit elevation contours are based on limited borehole intercept data in this area however, and were extrapolated from known elevations below the water table.

Hydraulic conductivity and transmissivity data for the unconfined aquifer in the 200 East Area are presented on Table 3-1. As discussed in Section 3.5.1.2, the transmissivity data are summarized primarily from Newcomer et al. (1992a), Swanson et al. (1992), and Connelly et al. (1992a). Additional transmissivity and hydraulic conductivity were reported for the 200 East Area by Delaney et al. (1991) and Last et al. (1989). The data are not summarized for individual geologic units due to the stratigraphic complexity of the unconfined system. Wide ranges of hydraulic conductivities [5×10^{-5} to 8×10^{-2} m/s (15 to 25,000 ft/day)] and transmissivities [7×10^{-2} to 64,000 m^2/day (0.9 to 694,000 ft^2/day)] were reported. For aquifer tests where transmissivity was the determined property reported by Newcomer et al. (1992a) and Swanson et al. (1992), equivalent hydraulic conductivities were derived by Connelly et al. (1992a) by dividing the reported transmissivity value by the thickness of the tested interval. Other factors affecting results of aquifer tests and interpretation of the data derived are discussed in Section 3.5.1.2. The original data tables from Newcomer et al. (1992a) and Connelly et al. (1992a) for the 200 East Area are provided as Appendix A Tables A-8 and A-9 of this report.

Using aquifer testing results from Newcomer et al. (1992a) and Swanson et al. (1992), Connelly et al. (1992a) prepared a hydraulic conductivity contour map for the 200 East Area (Figure 3-50). The map represents aquifer pump testing results (constant discharge tests) from wells installed in the shallow portion of the uppermost aquifer. As reported by Connelly et al. (1992a), the aquifer test results were predominantly analyzed by using the Cooper-Jacob straight line method. Connelly et al. (1992a) examined hydraulic conductivities derived from instantaneous injection/withdrawal tests for the study area but discarded them because values appeared to be "much lower" when compared to the pumping

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test data. Connelly et al. (1992a) lists several shortcomings of the injection/withdrawal test method as reasons for the lower values of the data. They include: (1) the limited areal extent of the test; (2) potential sandpack influences; (3) limited stress applied to the aquifer; (4) difficulty of obtaining a complete data set in quick response formations; and (5) the relatively low values of transmissivity for which the tests are interpretable. The majority of the constant discharge/recovery pumping tests were single well tests using partially penetrating wells, and, therefore, little information on the storage properties of the uppermost aquifer were obtained. Limitations of single well pumping tests (and pumping tests in general) include pump influence, well losses, partial penetration, and borehole storage. Connelly et al. (1992a) state that an attempt to incorporate slug test data into the hydraulic conductivity contour map produced a map that did not conform to the general hydrostratigraphic knowledge of the area. Therefore the data were excluded. Additional criteria for the exclusion of the injection withdrawal test results (based on magnitude) were not provided.

In general, the distribution of hydraulic conductivities on Figure 3-50 compares reasonably well with area geology depicted on Figure 3-47. Two high conductivity zones of about 0.03 m/s (10,000 ft/day) or greater are apparent on Figure 3-50. One of the zones extends from the north-central portion of the 200 East Area to the southeast. The second area is located between Gable Mountain and the prominent basalt subcrop area above the water table north of the 200 East Area. These higher conductivity areas are generally associated with the relatively permeable deposits of the Ringold unit A gravels and the Hanford formation. Conversely, lower conductivity values [about 30 m/day (100 ft/day) or less] are present west and southwest of the 200 East Area in generally less-permeable Ringold E gravels. Near the southwestern corner of the 200 East Area, however, the low hydraulic conductivity values coincide with an area of Hanford gravels. Connelly et al. (1992a) indicate that Hanford deposits are thin in the latter area, and that tested interval is actually more representative of the less permeable Ringold unit E gravels.

3.5.2.1.3 Vadose Zone. In the vicinity of the 200 East Area, the vadose zone units primarily include the Ringold gravel unit A through the central and southern portions of the area and the Ringold lower mud unit to the east near 216-B-3 Pond. Because of the discontinuous nature of the Ringold Formation north of the central part of the 200 East Area, the vadose zone is dominantly comprised of Hanford formation sediments between the 200 East Area and Gable Mountain/Gable Gap. Areas of basalt outcrop above the water table north of the 200 East Area are also included in the vadose zone, as are sediments of the Ringold lower mud sequence in the 216-B-3 Pond area where the latter unit forms a semiconfining to confining layer above the uppermost aquifer.

The vadose zone beneath the 200 East Area ranges from about 104 m (317 ft) thick along the southern part of the eastern PUREX Plant Aggregate Area boundary to 37 m (123 ft) thick in the vicinity of the 216-B-3C Pond, based on December 1991 groundwater

elevation levels (Figure 3-51). The observed variation in vadose zone thickness is the result of variations in both surface topography and elevation of the water table. As discussed in Section 3.5.2.1.2, the depth to groundwater in the 216-B-3 Pond area is influenced by the presence of the semiconfining to confining Ringold lower mud sequence. Water table elevations shown on Figure 3-49 in this area in part represent the potentiometric surface of deeper confined systems and may therefore underestimate the depth of the vadose zone.

Vadose zone hydraulic characteristics are an important factor affecting the transport of aqueous phase contaminants. These hydraulic characteristics also affect infiltration and potential recharge from precipitation (Section 3.5.1.5.1). The following sections summarize the theoretical approaches used to describe the vadose zone flow, as applied to the 200 West Area (and the Hanford Site in general). Results of laboratory hydraulic properties testing are then discussed for vadose zone sediment soil samples.

The flow of water through unsaturated soils in the vadose zone depends on several factors, including most significantly the moisture content of the soil and its hydraulic properties. Although a variety of methods have been developed to measure a soil's hydraulic properties directly (in particular, unsaturated hydraulic conductivity) most of them are expensive and difficult to implement. An alternative to direct measurement of unsaturated hydraulic conductivity is to use theoretical methods that predict the conductivity based on measured soil moisture retention data and saturated hydraulic conductivity (Van Genuchten et al. 1991).

Van Genuchten's computer program RETC is commonly used to develop wetting and drying curves for soils, based on laboratory data. The program uses a nonlinear least squares fit to generate a θ-φ (θ being moisture content and φ being matric potential or suction head) curve from lab data. An example of the wetting and drying curves, and corresponding unsaturated hydraulic conductivity functions, is provided on Figure 4-52 for Hanford formation sediments in the vadose zone. A relative hydraulic conductivity function $K_r(\theta)$ is required to relate saturated hydraulic conductivity K_s, generally measured in the laboratory, to the unsaturated conductivity $K(\theta)$ function.

$$K(\theta) = K_s \, K_r(\theta)$$

Van Genuchten developed a closed form predictive function to generate relative hydraulic conductivities from the θ-φ data. With the saturated hydraulic conductivity (K_s) and the relative hydraulic conductivity function ($K_r(\theta)$), unsaturated hydraulic conductivity values ($K(\theta)$) can be generated for a specific moisture content. Examples of the $K(\theta)$ curves generated by this method for vadose zone soil samples from the 200 East Area are presented on Figures 3-53 through 3-56, as discussed below.

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Rockhold et al. (1988) compare direct measurement of unsaturated hydraulic conductivities to those predicted from measured water retention data for three locations on the Hanford Site. Rockhold et al. (1988) find that each method produces results different from other methods and recommends that several methods should be used to determine unsaturated hydraulic conductivities. Only water retention data were reported in the sources reviewed for this report.

Knowledge of hydraulic conductivity values for a soil and a gradient allows the calculation of flow through that soil. 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, $K(\theta)$, and the driving force is predominantly differences in moisture level. The moisture flux, θ, in centimeters per second in one direction is then described by a modified form of Darcy's law commonly referred to as Richards' Equation (Hillel 1971) as follows:

$$q = K(\theta)\left(\frac{\partial\varphi}{\partial\theta}\right)\left(\frac{\partial\theta}{\partial x}\right) \text{ (Richard's Equation)}$$

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 as shown in Figure 3-42 [Gee and Heller 1985]
- $\partial\theta/\partial x$ 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.

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 (hysteresis). 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 and hydraulic conductivity directly using lysimeters and permeameters, respectively (e.g., Rockhold et al. 1990; Routson and Johnson

1990). These direct measurements are discussed in the natural groundwater recharge section (Section 3.5.1.5.1).

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 smooth out after sufficient time. Travel time for each lithologic unit of a set thickness and calculated for any given recharge rate, and the total travel time is equivalent to the sum of the travel times for each individual lithologic unit. To calculate the travel time for any particular site, the detailed layering of the lithologic units should be considered. For sites with artificial recharge (e.g., cribs and trenches), more complicated analyses are required to account for the effects of variable saturation.

Moisture content and vertical hydraulic conductivity data for the unsaturated zone have been obtained from 60 vadose zone soil samples collected in the 200 East Area and vicinity, and are reported by Connelly et al. (1992a). Hydraulic properties data were obtained for these samples as part of ongoing performance assessment work in the 200 East Area. The samples were collected from boreholes at the Grout Treatment Facility and AP Tank Farm in the eastern and central parts of PUREX Plant Aggregate Area, respectively; the 200-BP-1 Operable Unit in the B Plant Aggregate Area; the B Pond Area; and near the Ecology facility south of the southwest corner of the 200 East Area. The following samples were collected from the units listed:

- 2 samples - Ringold unit A gravels
- 2 samples - Ringold lower mud sequence
- 41 samples - Hanford sandy sequence
- 15 samples - Hanford gravel sequence (lower and upper gravels undifferentiated).

For each of these samples, soil moisture retention data were measured, and soil moisture curves were generated from the data. Saturated hydraulic conductivity (K_s) values were also measured in the laboratory for these samples. As discussed in Section 3.5.1.3 for soil samples collected in the 200 West Area, unsaturated hydraulic conductivities may vary by orders of magnitude with varying moisture contents and among differing lithologies with significantly different soil textures. Figures 3-53 through 3-56 illustrate the variations in unsaturated hydraulic conductivity with moisture content for the Ringold Formation and Hanford formation samples tested. The following discussion summarizes results of the hydraulic properties testing for the unsaturated zone in the 200 East Area.

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For the two Ringold lower mud samples tested, unsaturated hydraulic conductivities ranged from less than about 10^{-18} cm/s at a 10% moisture content, to about 10^{-9} cm/s at saturation moisture contents near 57% (Figure 3-53). Unsaturated conductivities for the two Ringold unit A gravel samples had wider variability, ranging from less than 10^{-18} to 10^{-10} cm/s at moisture contents near 10%, to 10^{-7} to 10^{-5} cm/s at saturation moisture contents of 38% and 57%, respectively for each of the samples. These differences are likely due to lithologic variations such as changes in the percentages of fine sand and silt with depth.

Samples of the Hanford formation sandy sequence and gravel sequence generally had higher saturated hydraulic conductivities than the Ringold Formation samples. Figure 3-54 and 3-55 are two sets of unsaturated conductivity curves for the Hanford sandy sequence. At a 10% moisture content, unsaturated conductivities ranged from about 10^{-16} to 10^{-5} cm/s, with many of the values falling in the 10^{-10} to 10^{-5} m/s range. At saturation, hydraulic conductivities ranged from about 10^{-6} to 10 cm/s, with many of the values falling in the 10^{-5} to 10^{-3} cm/s range. Lower range values of saturated hydraulic conductivity were measured in sandy-clay soils collected in the Hanford formation. Measured moisture contents for the Hanford formation sandy sequence samples at saturation had a wide range (24 to 52%).

Marked variability in unsaturated hydraulic conductivities and saturation moisture contents is also apparent for the Hanford formation gravelly sequence samples (Figure 3-56). At a 10% moisture content, unsaturated conductivities ranged from about 10^{-12} to 10^{-6} cm/s, with the sample from Well 3A-1 (Well 699-43-41H) (16.6 m depth) in the 216-3-B Pond area never reaching a volumetric moisture content this low. At saturation, hydraulic conductivities ranged from about 10^{-7} to 10^{-3} cm/s, and were generally lower than saturated hydraulic conductivities for the sandy sequence. Measured moisture contents for the Hanford formation gravelly sequence samples at saturation had a wide range (26 to 53%).

3.5.2.1.4 Perched Water Zones. As discussed in Section 3.5.1.4, the primary potential for perched water at the Hanford Site is associated with the calcareous paleosols of the Plio-Pleistocene unit and the early "Palouse" soil. These units are only present in the vicinity of the 200 West Area and therefore do not form potential perching horizons near the 200 East Area. In the 200 East Area, potential silt lens paleosol perching horizons have been identified in the Hanford formation sands and gravels (Hoffmann et al. 1992). These layers are found locally and appear to be discontinuous. The Ringold lower mud sequence also represents a potential perching layer. Perching potential is greatest near the 200 East Powerhouse Ditch along the southern border of the Semi-Works Aggregate Area because of the large quantity of water being discharged. Perched water zones in the Hanford formation may also be possible near the 216-B-3 Pond System, and near former liquid waste disposal sites where considerable amounts of liquid were discharged to the soils. Up to 2.1 m (7 ft) of perched water have been found above the lower mud sequence in the vicinity of the 216-

B-3C Pond lobe. Perched water was encountered during drilling of wells 299-E33-27 and 299-E33-41, near liquid discharge releases from the 102-BX Tank.

3.5.2.2 200 East Area Groundwater Recharge. Recharge to the unconfined aquifer within the 200 East Area is from artificial and possibly natural sources. If natural recharge occurs, it is only from precipitation. The only naturally occurring body of water (West Lake) in the 200 East Area is created by the outflow of the unconfined aquifer in the area. Artificial recharge occurs from several active and recently active cribs, trenches, ditches, ponds, and drains located throughout the 200 East Area, as well as from leaks in pipelines, transfer lines, and spills.

3.5.2.2.1 Natural Recharge. Within the 200 East Area, natural recharge originates from precipitation. As discussed in Section 3.2.1, annual precipitation for the Hanford Site is approximately 16 cm (6.3 in.). Evapotranspiration of precipitation is considered to reduce the amount of precipitation that reaches the groundwater significantly (Gee 1987). Estimates for the percentage of evapotranspiration range from 38 to 99%. The primary factors affecting precipitation recharge are surface soil type, vegetation type, topography, and spatial and temporal 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). However, a study using a gravel-covered lysimeter at the 200 East Area indicated no recharge had occurred in soil 4.9 m (16 ft) below surface over a 16-year period (Rockhold et al. 1990). Gee (1987) conducted recharge analyses for two different soil types, and concluded that recharge rates vary from 0.1 cm/yr (0.04 in./yr) for a fine-textured soil with deep-rooted vegetation, to 10 cm/yr (4 in./yr) for a coarse-grained soil (gravel) devoid of vegetation. If recharge from precipitation does occur in the 200 East Area, by using the 0.1 cm/yr recharge rate, since most of the 200 East Area is covered by sparse vegetation and eolian sand, the total annual natural recharge volume for the 200 East Area can be estimated approximately at 19 million L/yr (5 million gal/yr). These values are significantly lower than the volumes of artificial discharges recorded throughout the 200 East Groundwater Aggregate Area (see also Section 3.5.2.2.2). As discussed in Section 3.5.1.5.1, Routson and Johnson (1990) conducted a lysimeter study 1.6 km (1mi) south of the 200 East Area and concluded that no downward moisture movement was observed over a 13 year period.

3.5.2.2.2 Artificial Recharge. Artificial recharge to the groundwater system began in 1944 and continues through the present. Sources of artificial recharge include cribs, ditches, trenches, ponds, basins, and drains. The following sections discuss sources of artificial recharge within the PUREX Plant, B Plant, Semi-Works, and 200 North Aggregate Areas, respectively. The location of these facilities are shown in Plate 1. Quantities of discharge to these facilities are shown in Table 2-2.

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Artificial Recharge in the PUREX Plant Aggregate Area. The principal sources of artificial recharge within the PUREX Plant Aggregate Area include the 216-A-30 Crib and 216-A-29 Ditch, which both ceased operating in 1991. Other sources that have contributed significant volumes of wastewater discharge to the soil include the 216-A-5, -6, -8, -9, -10, -24, -37-1, and -37-2 Cribs. The 216-A-37-2 Crib is the only currently active waste management unit within the PUREX Plant Aggregate Area.

There are also seven septic tank and drain fields reported to be active within the PUREX Plant Aggregate Area. These are the 2607-EA, -EC, -ED, -EG, -EJ, -EL, -E6 Septic Tanks and Drain Fields. The combined amount of wastewater discharged from these facilities between 1946 and 1992 is estimated to be 640 million liters (170 million gallons).

Artificial Recharge in the B Plant Aggregate Area. The principal source of artificial recharge within the B Plant Aggregate Area during the Hanford Site operational period has been the 216-A-25 Pond, which operated between 1957 and 1987. Other sources that have been active and have discharged significant volumes of wastewater to soils within the B Plant Aggregate Area include the 216-B-3 Pond; 216-B-12, 216-B-62, and 216-B-55 Cribs; the 216-B-2-1, 216-B-2-2, 216-B-2-3, 216-B-3-1, and 216-B-3-2 Ditches; and 216-B-63 Trench. Currently there are nine active waste management units: 216-B-55 and 216-B-62 Cribs; 216-B-3, 2101-M, 216-B-3A, 216-B-3B, and 216-B-3C Ponds; 216-B-3-3 Ditch; and 216-B-63 Trench. The 216-B-3 Pond, which is the second largest source of artificial recharge, has been in operation since 1945. It is a Resource Conservation and Recovery Act (RCRA) facility and a closure/postclosure plan (DOE/RL 1989b) has been prepared pending Ecology approval. The 216-B-3C Pond will become the main disposal pond for the 216-B-3 Pond System in the future. The 2101-M is also a RCRA facility, and a closure/postclosure plan has been submitted. Although it is still an active facility, the 216-B-55 Crib has not received any effluent in the last three to four years.

There are also 18 septic tanks and drain fields/tile fields that are actively discharging water to the soil. These are the 2607-EB, -EH, -EK, -EM, -EN, -EO, -EP, -EQ, -ER, -GF, -E1, -E2, -E3, -E4, -E7B, -E8, -E9, and -E11 Drain/Tile Fields. The combined discharge volumes are estimated at 97,650 L/day (25,800 gal/day), according to the Waste Information Data System (WIDS) database (WHC 1991a). The combined amount of wastewater discharged from these facilities between 1951 and 1991 is estimated to be 1.35 billion L (190 million gal) based on WIDS data presented on Table 2-1.

Artificial Recharge in the Semi-Works Aggregate Area. The principal source of artificial recharge within the Semi-Works Aggregate Area is the 216-C-9 Pond, which operated between 1953 and 1985 and contributed 97% of the total volume of the wastewater discharged into the soil. The only active waste management unit within the Semi-Works Aggregate Area is the 216-C-7 Crib. There are also two septic tanks and drain fields reported to be active: the 2607-E-5 and 2607-E-7A Septic Tanks and Drain Fields. The

combined amount of wastewater discharged to these facilities is estimated to be approximately 1.1 billion liters (280 million gallons).

The 200 East Powerhouse Ditch is currently active, which drains nonradioactive wastewater from the Semi-Works Aggregate Area into the 216-B-3 Pond System in the B Plant Aggregate Area. Its monthly flow rate is estimated to be 13.8 million L/month (3.6 million gal/month).

Artificial Recharge in the 200 North Aggregate Area. The principal historical sources of artificial recharge within the 200 North Aggregate Area include the 216-N-1, -4, and -6 Ponds, all which had operated between 1944 and 1952. Other significant sources of wastewater discharge include 216-N-2, -3, -5, and -7 Trenches. There are no waste management units presently active within the 200 North Aggregate Area. The combined amount of wastewater discharged from these facilities between 1944 and 1952 is estimated to be 2.9 billion liters (758 million gallons).

3.5.2.3 200 East Area Groundwater Flow. Groundwater has been actively monitored at the Hanford Site since 1944. This monitoring has been in response to artificial wastewater discharges to the soil which have impacted the natural flow system of the groundwater beneath the Hanford Site. Several monitoring programs, discussed in Section 2.8 have been implemented in the past to monitor the response of the unconfined aquifer to discharges from various sources throughout the Hanford Site.

3.5.2.3.1 Uppermost Aquifer

Historical Groundwater Flow Conditions. Data are not available on groundwater conditions before the construction and operation of the Hanford Site. However, the pre-Hanford groundwater flow conditions have been presented by Kipp and Mudd (1974). This "hindcast" map was developed from well data accumulated between 1948 and 1951.

Before the initiation of waste disposal activities at the Hanford Site in the mid-1940's, groundwater elevations across the 200 East Area varied from approximately 119 m (390 ft) above sea level at the western boundary to approximately 117 m (385 ft) at the eastern boundary (Figure 3-57). The general groundwater flow direction appears to have been from west to east across the Hanford Site with an average hydraulic gradient of 0.001 (Graham et al. 1981). These flow lines are shown on Figure 3-57. Vertical gradients within the upper unconfined aquifer were probably negligible although a slight upward gradient was present between the basalt aquifers and the unconfined aquifer due to recharge to the basalt aquifers at higher elevations at the edge of the Pasco Basin.

A persistent drop in hydraulic gradient has been observed over time between the 200 West and 200 East Areas where data provide sufficient resolution. This may be due in part

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to two hydrostratigraphic factors: (1) the Ringold Formation, which exhibits lower hydraulic conductivities than the Hanford formation, thins to the east, so the flow moves into the more permeable Hanford formation; and (2) the basalt dips in a southeasterly direction, which increases the saturated thickness of the unconfined aquifer.

Waste disposal activities at the Hanford Site have greatly affected groundwater flow in the unconfined aquifer. Within the 200 East Area, discharges to the various waste management units have created a groundwater mound in the vicinity of now closed 216-A-25 Pond and the active 216-B-3 Pond System. Conditions of the unconfined aquifer have varied with the amount of wastewater discharged from the various waste management units. These changes are shown on Figures 3-57 through 3-62, which depict groundwater contour elevations and flow directions for the years 1944, 1955, 1965, 1970, 1987, and 1991. The following discussion focuses on the historical effects that waste disposal practices have had on the dynamics of the unconfined aquifer.

Groundwater Flow from 1944 to 1955. In 1944, groundwater flow in the unconfined aquifer is thought to have occurred essentially from west to east across the site. Groundwater levels increased dramatically between 1944 and 1955 (Figures 3-57 and 3-58). Artificial recharge from wastewater discharges created a mound under the active 216-B-3 Pond. The elevation of groundwater in the vicinity of the mound increased by approximately 6 m (20 ft) during this time. Groundwater elevations within the upper Cold Creek valley rose 15 m (50 ft) in response to artificial recharge from agricultural irrigation. By 1955 groundwater mounding under the 216-B-3 Pond had altered the general west to east groundwater flow direction to more of a radial configuration east of the 200 East Area (Figure 3-58). Flow gradients increased to the east of the mound, and west of the mound the flow direction temporarily reversed to the west and redirected flows to the north and south. Groundwater flowing to the west due to this gradient reversal appears to have headed in part toward Gable Gap. The 1955 groundwater contour map also shows the mound was located directly under 216-B-3 Pond and elongated to the northwest due to the discharge of the 216-A-25 Pond. Groundwater flow from the 200 East Area in 1955 was directed to the southeast and east.

Groundwater Flow from 1955 to 1965. A comparison of the 1955 and 1965 groundwater contour maps (Figures 3-58 and 3-59) shows that the center of the mound remained stationary over this period while groundwater rose 3 m (10 ft) in elevation under the ponds. This rise may have been due to increased wastewater discharges from facilities in the PUREX Plant and B Plant Aggregate Areas from 1955 to 1965. The hydraulic gradient east of the mound increased slightly while flow west of the mound decreased in response to elevated groundwater levels from irrigation in the upper Cold Creek valley and waste disposal in the 200 West Area. Groundwater flow in 1965 from the 200 East Area was directed to the southeast and east, with the exception of a small component of flow from 216-A-25 Pond that was directed to the northwest and Gable Gap.

Groundwater Flow from 1970 to 1985. Groundwater contour maps for 1970 and 1987 (Figures 3-60 and 3-61) show that the mound has changed shape due to the closure of the 216-A-25 Pond. The mound is rounded instead of elongated, and flow to the west from the mound bifurcates into components directed to the northwest and to the southeast. Flow from the west into the 200 East Area (i.e., from 200 West Area) underwent a similar bifurcation to the northwest and southeast. The increased use of the 216-B-3 Pond and the construction of the 216-B-3A, -3B, -3C Pond lobes had elevated the groundwater under the 216-B-3 Pond System another 2 m (5 ft by 1987). At the same time, the water table elevation under the Gable Pond area had decreased 2 m (5 ft).

Groundwater Flow from 1987 to 1991. The configuration of the water table contours from 1987 to 1991 (Figure 3-61 and 3-62) remained relatively constant. The mound under the 216-B-3 Pond System appears to have maintained a peak water level of over 128 m (420 ft) in the center, although the gradient on the west bank of the mound appears less steep in 1991. This may be a result of change in the usage of the 216-B-3 Pond lobes.

Well Hydrographs. Well hydrographs prepared for four areas within and around the 200 East Area (Figures 3-63 through 3-66) show the response over time of the unconfined aquifer to wastewater discharges from the 200 East facilities. Also shown on these hydrographs are the historical operational periods of the waste management units located within each aggregate area. Greater detail on future groundwater flow trends is provided in **Current Groundwater Flow Conditions**.

Hydrographs from six wells within the PUREX Plant Aggregate Area were plotted in Figure 3-63. These wells all appear to be significantly impacted by historical discharges from the PUREX Plant. After the shutdown of the 216-A-5 and -6 Cribs in 1967, the water levels had dropped several feet until 1972 then gradually had leveled out until 1977. In 1977 water levels had increased corresponding to the start up of the 216-A-37-1 Crib. Water levels continued to rise until they leveled off in 1985. Water levels for all wells have decreased from 1986 to present because the 216-A-29 Ditch, the 216-A-8, -6, -5, and -37-1 Cribs were retired. The general consistency (parallel nature) of the hydrographs in Figure 3-63 indicates that generally the direction and approximate gradient have been maintained during the period of observation.

Hydrographs were prepared for four wells within the central portion of the B Plant Aggregate Area (Figure 3-64). The general trend of water levels within the B Plant Aggregate Area are very similar to those of the PUREX Plant Aggregate Area. Evident in this hydrograph is that water levels in wells decrease with increased distance from the mound center.

Hydrographs are included for four wells around the 216-B-3 Pond area (Figure 3-65). The effect of the expansion ponds can be seen in Wells 699-39-39 and 699-43-43. In

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general, all water levels around the 216-B-3 Pond System had risen from 1983 until 1989 due to the increased use of the ponds caused by the shutdown of the 216-A-25 Pond. As with B Plant, the farther the distance of the well from the mound center, the lower the water level. Since 1989, water levels in wells near the 216-B-3 Pond have decreased 0.3 to 1 m (1 to 3 ft) due to reduced effluent discharge rates.

Six wells were used to prepare hydrographs for the northern B Plant Aggregate Area (Figure 3-66). Water levels had risen in 1955 and continued to increase until 1990, except in Well 699-49-55A. This well is the farthest away from the ponds and close to B Plant. The well's trends seem to be the same as those in the B Plant hydrographs. The continued increase in water levels after the retirement of Gable Pond is probably due to the 216-B-3 Pond mound backing up the water under this area. The water levels are returning to an equilibrium at approximately the same rates in both of these areas.

Groundwater Flow Velocities. Groundwater flow in the unconfined aquifer within the 200 East Area occurs within the Hanford sandy and lower gravel units in the central and northern parts of the 200 East Area, as well as in the locally semiconfined area within the Ringold unit A beneath the 216-B-3 Pond System, and occurs within the Ringold fluvial gravel unit E at the south and southwest corner of the 200 East Area. The direction of the groundwater flow within the 200 East Area historically has been difficult to determine because of the lack of a pronounced horizontal hydraulic gradient, except in areas surrounding the 216-B-3 Pond. Before activity at the Hanford Site (1944), the average horizontal hydraulic gradient across the 200 Areas is estimated to be 0.001 [approximated from the 1944 contour map presented in Kipp and Mudd (1974)]. Using this along with hydraulic conductivity (k) of 6×10^{-3} m/s (1,600 ft/day; Table 3-1) and a porosity (n) of 0.3, the calculated average natural flow velocity (K and n obtained from Table 3-1) is 0.6 m/day (1.9 ft/day) to the east.

Artificial recharge from the waste management units within the 200 East Area, especially the 216-A-25 and 216-B-3 Ponds, has created groundwater mounds beneath the liquid waste disposal units, and significantly increased the overall groundwater elevation within and to the east of the 200 East Area. The hydraulic gradients have also been increased markedly due to mounding underneath 216-B-3 Pond, up to a maximum of 0.005 directed both to the east and west. However, the hydraulic gradients are significantly reduced away from the mound, and a broad area of very low gradients extends across the western portion of the 200 East Groundwater Aggregate Area in a northwest-southeast trend. The central part of the 200 East Area has a gradient of roughly 0.0003, oriented both towards the northwest and southeast.

Hydraulic conductivity values from 30 existing wells within the 200 East Groundwater Aggregate Area range from 6×10^{-5} to 9×10^{-2} m/s (17 to 2.5×10^{4} ft/day) (Connelly et al. 1992a). A region of high hydraulic conductivity is oriented along a northwest-southeast

trend in the northern and eastern parts of the study area (Figure 3-50). The hydraulic conductivity is generally lower [less than 3.5×10^{-3} (1,000 ft/day)] in the southwestern part of the 200 East Area (Figure 3-48). The high conductivity values are generally associated with the lower gravel unit of the Hanford formation, while the low conductivity values commonly correspond to unit E of the Ringold Formation. Vertical differences in hydraulic conductivity due to lithologic differences can be great, as shown by low values determined by slug and constant discharge tests for the Ringold unit A in the vicinity of the 216-B-3 Pond that are in the order of 3.5×10^{-6} to 3.5×10^{-4} m/s (1 to 100 ft/day).

Groundwater flow velocities of the unconfined aquifer within and near the 200 East Area have been difficult to determine because of the variability of hydraulic conductivity in a local scale, spatial and temporal occurrence of artificial recharges, and limited coverage of subsurface data. Based on groundwater level data of December 1991 (Kasza et al. 1991) and hydrologic properties of the 200 East Area discussed in Connelly et al. (1992a), the groundwater mound underneath the 216-B-3 Pond System has generated relatively fast groundwater flows radiating away from the mound. Hydraulic gradients around the mound range from 0.001 on the east to 0.005 on the west. The velocity of the groundwater flow (assuming a hydraulic conductivity of 3×10^{-3} to 1×10^{-2} m/s [1,000 to 4,000 ft/day] and an average porosity of 0.2) is approximately 2×10^{-5} to 7×10^{-5} m/s (5 to 20 ft/day) in the easterly direction, and approximately 7.5 to 30 m/day (25 to 100 ft/day) in the westerly direction from the mound into the 200 East Area.

Groundwater flow velocity decreases drastically away from the 216-B-3 Pond System. The velocities within the central and south-central 200 East Area are estimated to be between 3×10^{-6} to 9×10^{-6} m/s (1.0 to 2.6 ft/day), based on hydraulic gradients of 0.0001 and 0.0004 and an estimated hydraulic conductivity of 5×10^{-3} m/s (1,300 ft/day), and have either northwest or southeast flow direction. The northwestern flow, which passes through the Gable Mountain Gap and eventually reaches the Columbia River at the 100 Areas, has an estimated flow velocities of 2×10^{-6} m/s (0.7 ft/day) from 200 East Area to the Gable Mountain Gap.

Flow to the east-southeast from the southern part of the 200 East Area trends toward the Columbia River to the north of 300 Area (Figure 3-62). The estimated generalized velocity of this flow path is 3×10^{-5} m/s (7.2 ft/day), assuming the aquifer is situated within the Hanford formation and the average hydraulic conductivity throughout the flow path is similar to the values associated with the Hanford formation (7×10^{-3} m/s [2,000 ft/day]). With this flow rate, the estimated time for groundwater from the 200 East Area to reach the Columbia River is 28 years. In comparison, Freshley and Graham (1988) estimate the travel time from the PUREX cribs southeast to the Columbia River to be 21 to 23 years, based on elapsed time between the release of tritium and its arrival at the river. Similarly, USGS (1987) estimate an average arrival time of 13 years for tritium to travel from the PUREX

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cribs to the river by assuming that most of the tritium was discharged to the ground after 1963.

Vertical Hydraulic Gradients. Groundwater monitoring wells that are screened within the upper portion of the unconfined aquifer exhibit a greater head than the few wells that are screened in the lower portion of the unconfined aquifer. This difference in groundwater levels indicates a downward vertical gradient. Downward vertical hydraulic gradients within the 200 East Area ranged from indistinguishable (zero) to 0.7 at groundwater mound underneath the 216-B-3 Pond System. Wells 6-43-42J and 6-42-42B are located near 216-B-3 Pond, and are screened in the upper and lower portions of the unconfined aquifer, respectively, within the Ringold unit A (Connelly et al. 1992a). Plots of hydrographs from these wells are shown on Figure 3-67. These wells have an approximate head difference of 0.6 m (2 ft) over a vertical distance of 9 m (30 ft), and thus the approximate value of the vertical gradient is calculated to be 0.07. As the amount of discharge from the 216-B-3 Pond and other waste management units decreases, the vertical gradients between these wells are also expected to decrease. In addition, these wells may represent conditions that are uncommon to most of the site as the presence of the Ringold lower mud sequence appears to create semiconfined to confined conditions in this area, and significant mounding of the water table is present at this location.

Wells 6-53-55B and 6-53-55C monitor the upper-middle and lower-middle of the unconfined aquifer within the erosional window at the northwestern part of the 200 East Area, and Well 6-53-55A previously monitored the top to the lower-middle of the unconfined aquifer before December 1990. These wells are all screened into the Hanford formation. Well 6-53-55A is presently screened about 9 m (30 ft) in the top of the aquifer. The vertical hydraulic gradient between Wells 6-53-55B and 6-53-55C is calculated to be 0.01, according to 1991 hydrologic data.

Other nested wells, 299-E25-29P and -29Q, 299-E-25-30P and -30Q, 299-E25-32P and -32Q, and 299-E25-34 and 299-E25-28, are located near the Grout Treatment Facility and 216-A-29 Ditch. From limited available data, values reported in Kasza et al. (1992) indicate that these wells all have indistinguishable vertical head differences.

The lower mud sequence of the Ringold Formation occurs only in the southernmost areas of the 200 East Area (Figure 3-30). This unit has a low hydraulic conductivity [1.9×10^{-10} m/s (5.3×10^{-5} ft/day)], and where this unit is present it acts as an aquitard separating the basal Ringold gravel (unit A) from the upper unconfined aquifer. However, its limited occurrence within the 200 East Area apparently does not affect the vertical hydraulic gradient at the lower unconfined aquifer significantly.

Generally, the vertical hydraulic gradient between the uppermost aquifer and the Rattlesnake Ridge aquifer is insignificant in most areas within the 200 East Area, except two

zones where downward and upward gradients is notable. Downward hydraulic gradient exists in areas surrounding the 216-B-3 Pond System, at the eastern part of the 200 East Area (Kasza et al. 1991). An extensive area with observed upward hydraulic gradient is present around the West Lake, at the northwestern end of the 200 East Area. Connelly et al. (1992a) evaluate the vertical gradient between the uppermost aquifer and Rattlesnake Ridge aquifer through comparison of hydrographs for well clusters.

In general, the hydrographs evaluated by Connelly et al. (1992a) indicate that the head differential between the uppermost aquifer and the Rattlesnake Ridge aquifer is minimal in the northern portion of the 200 East Area and farther north. Table 3-2 summarizes vertical hydraulic gradient values and direction of the vertical component of groundwater flow for all well clusters. The greatest head differential occurs at the 299-E33-40/299-E33-07 well cluster. At this well cluster location, the vertical hydraulic gradient is estimated at 0.005 ft/ft (maximum) with an upward-directed vertical flow component. Connelly et al. (1992a) conclude that other well clusters do not exhibit major head differentials. Heads at cluster sites 699-49-55A/B and 699-49-47A/B indicate that there is virtually no vertical hydraulic gradient most of the year. During the fall and winter months, heads in the Rattlesnake Ridge aquifer are slightly greater than those in the uppermost aquifer, probably reflecting different recharge rates and/or different recharge areas for the two aquifers. The head differential at well cluster 699-50-53A/B indicates a slight upward gradient during all months of the year, with the greatest head differential during the early fall. The maximum vertical hydraulic gradient is 0.0037 ft/ft. For the well clusters north of the 200 East area evaluated by Connelly et al. (1992a), well cluster 699-54-57/699-55-57 shows the greatest head differential with a maximum vertical hydraulic gradient of 0.0038 ft/ft. Although these two wells are separated by horizontal distance of approximately 700 feet, Connelly et al. feel that the minimal horizontal hydraulic gradients in both the uppermost and the Rattlesnake Ridge aquifers in the vicinity of these monitoring wells do not preclude the comparison of hydraulic heads to assess the vertical hydraulic gradient and direction of the vertical flow component at this locality.

An interesting aspect of the hydrographs for the well clusters is the fact that head trends seen in the uppermost aquifer are typically mirrored in the Rattlesnake Ridge aquifer. This mirroring in the Rattlesnake Ridge aquifer is probably related to the hydraulic interconnectivity of these two aquifers.

Current Groundwater Flow Conditions. Kasza et al. (1991) have compiled water table measurements for the Hanford Site and have contoured the potentiometric surface of the unconfined aquifer for June 1991. Representative horizontal flow paths for the 200 East Groundwater Aggregate Area are shown on Figure 3-62 based on these data. In general, these flow paths show an overall trend of flow from west to east across the site, but this is largely modified by artificial recharge, especially to the 216-B-3 Pond System.

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The mounding underlying 216-B-3 Pond System results on radial flow from that area and divides the east directed regional flow into two components of flow; one to the southeast and one to the northwest. The elevated water levels created by the mounding also result in a broad flattening of hydraulic gradients along a northwest-southeast trend that extends through the center at 200 East Area. Because of the mounding, horizontal flowpaths through the 200 East Area originate both to the west from eastward directed regional flow and to the east from reverse gradients created by mounding, with flow patterns converging at about the center of the area and dividing into components directed to the east-southeast and to the northwest. Flow to the east-southeast travels to the Columbia River where it discharges to the river from east of Gable Mountain to just north of 300 Area. Flow to the northwest passes through Gable Gap and reaches the Columbia River on the 100 Area.

The mound underlying 216-B-3 Pond is slowly receding at a rate of 0.2 m/yr (0.6 ft/yr), as shown by hydrographs (Figure 3-65), following the peaks discharge of wastewater to the area in the mid-1980's. If wells closer to the center of the mounding are also considered, then the dissipation rate has been approximately 0.4 m/yr (1 ft/yr) which reflects greater reduction at the mound's apex. The location of the mound also appears to be undergoing a slight shift to the northwest, perhaps due to a shifting of discharge to lobes A and C in 216-B-3 Pond. Discharge to the 216-B-3 Pond System and other current waste management units are scheduled to be shifted to the Project W-049H State-Approved Liquid Disposal Structure (SALDS) facility just to the east of the pond (along with a SALDS north of 200 West Area), as described in Section 2.7.4. The W-049H SALDS likely will maintain mounding at the water table to the west of 200 East Area, although the location shift may cause a slight reduction in flow directed toward Gable Gap.

Eventually, all artificial discharge in the 200 East Groundwater Aggregate Area is expected to cease, and mounding will dissipate completely over a 20- to 30- year period. Overall, water levels likely will remain elevated, largely due to recharge resulting from irrigation in upper Cold Creek valley to the east, but general trends will generally revert to natural conditions. Flows to the north and to Gable Gap from the 200 East Area will be eliminated, and most groundwater flow in the unconfined aquifer will occur to the east or southeast with a hydraulic gradient in the range of 0.002.

3.5.2.3.2 Basalt Aquifers. The main occurrence of groundwater in the basalt sequence beneath the 200 East Area is in the interbeds of the Ellensburg Formation. These interbed units generally offer the least resistance and greatest permeability for flow. The principal basalt aquifers within the 200 East Area include the three interbeds of the Ellensburg Formation within the Saddle Mountains Basalt Formation (Rattlesnake Ridge, Selah, Cold Creek) and the Mabton interbed that separates the Saddle Mountains and Wanapum Basalt Formations. Hydraulic properties of these interbeds are presented in Section 3.5.2.1.4.

The uppermost aquifer within the basalt is the Rattlesnake Ridge interbed. The Rattlesnake Ridge interbed is confined between the upper Elephant Mountain Member above and the Pomona Member below. The interbed is 15 to 25 m (50 to 82 ft) thick beneath the 200 East Area and generally thickens towards the west (Graham et al. 1981; 1984). Graham et al. (1984) identified two extensive areas of complete erosion: the area around West Lake and the area north of Gable Mountain. The authors infer an erosional window within the 200 East Area (see also Section 3.5.2.3.3). Intercommunication (recharge/discharge) between the overlying unconfined aquifer and the Rattlesnake Ridge interbed is possible through these erosional windows. Figure 3-68 shows the most complete groundwater levels for the Rattlesnake Ridge interbed. Also superimposed on this map are the water table elevations for the uppermost unconfined aquifer. In general there is a greater head within the unconfined aquifer at the western part of the 200 East Area, while the potentiometric head of the Rattlesnake Ridge confined aquifer becomes greater compared to the overlying unconfined aquifer towards the northwest of the 200 East Area.

Recharge from the overlying unconfined aquifers to the Rattlesnake Ridge aquifer occurs when the vertical hydraulic gradient is downward, and where the two aquifers are interconnected. Currently, a downward hydraulic gradient occurs around the 216-B-3 Pond area. It also apparently occurred near the Gable Mountain Pond in the late 1960's and early 1970's, when the pond was active and the unconfined groundwater level was higher. The possible existence of an erosional window around the vicinity of the Gable Mountain Pond was hypothesized by Graham et al. (1984), but no hard evidence supports this condition. Connelly et al. (1992a) suggest as an alternative that a well-developed fracture system in the Elephant Mountain Basalt could similarly provide intercommunication. Such intercommunication, if present, could provide for potential recharge to the Rattlesnake Ridge interbed from the unconfined aquifer, and the potential for contamination of the confined aquifer.

In other parts of the 200 East Area, upward vertical hydraulic gradient conditions exist and the Rattlesnake Ridge interbed discharges into the overlying unconfined aquifer where erosional windows are present. The major area of discharge is West Lake, northwest of the 200 East Area.

Within the 200 East Area, confined groundwater flow of the Rattlesnake Ridge interbed is generally in from the east and north and out toward the west and northwest where it discharges to the overlying unconfined aquifer in the West Lake area. Another flow component originates from the 200 West Area eastward through the southernmost part of the 200 East Area towards the Columbia River. This flow pattern is similar to the flow of the unconfined aquifer, which suggests that flow within the Rattlesnake Ridge aquifer is influenced by seepage from the overlying unconfined aquifer, especially in the area of the 216-B-3 Pond.

Considerably less data are available for the deeper Selah, Cold Creek, and Mabton interbeds. Generally flow through these interbeds is predominantly west to east (Gephart et al. 1979). A slight upward gradient has been reported in some areas between these interbeds (Ledgerwood and Deju 1976).

3.5.2.3.3 Unconfined/Basalt Aquifer Intercommunication. The groundwater potentiometric map averaged across the Rattlesnake Ridge, Selah, and Cold Creek aquifers is presented in Figure 3-69 (DOE/RL 1988). A comparison of the potentiometric surfaces of the Rattlesnake Ridge interbeds and the unconfined aquifer is presented in Figure 3-68. Figure 3-26 shows the possible erosional windows within the Elephant Mountain Basalt Member (upper-most basalt unit within the 200 East Area), where the tilted capping basalt flows were removed by severe erosional processes (e.g., glacial floods), and the Rattlesnake Ridge interbed becomes directly overlain by the glaciofluvial sediments. Therefore, intercommunication may occur between the overlying unconfined aquifer and the Rattlesnake Ridge confined aquifer.

In the Elephant Mountain Basalt north of the 200 East Aggregate Area, Graham et al. (1984) identified two areas of complete erosion: the area around Gable Gap, and the area just north of the 200 East Area. These authors infer an erosional window within the northeast portion of the 200 East Aggregate Area from barometric efficiency analysis. Kasza et al. (1991) also identified an area around the 216-B-3 Pond of downward hydraulic gradient between the overlying unconfined aquifer (Ringold Formation) and the underlying Rattlesnake Ridge interbeds (Figure 3-70). If secondary fractures or unidentified erosional windows exist in the area of downward hydraulic gradient, flow from the uppermost aquifer system to the confined aquifer may occur.

In the area west of Gable Mountain, the potential exists for upward flow from the Rattlesnake Ridge aquifer to the uppermost aquifer due to apparent intercommunication between the aquifers (Figure 3-70), (Kasza et al. 1991). Discharges from basalt interbeds are likely to take place at the horn of Yakima River (Ledgerwood and Deju 1976).

Water table elevations have risen in response to artificial recharge from both wastewater discharges in the 200 East Area and from agricultural irrigation in areas to the west. The elimination of wastewater discharges from waste management units on the Hanford Site will eventually dissipate the mounds that have existed under the 216-B-3 Pond System in the 200 East Area and reduce the downward vertical gradient between the upper unconfined aquifer and the underlying confined basalt aquifers. However, continued sanitary wastewater discharge within the 200 Areas and agricultural activities to the west will prevent the groundwater level from dropping down to the pre-1944 level.

3.6 ENVIRONMENTAL RESOURCES

The following sections discuss Hanford Site and 200 East Area environmental resources including flora and fauna (Section 3.6.1), land use (Section 3.6.2), and water use (Section 3.6.3).

3.6.1 Flora and Fauna

The Hanford Site is characterized as a cool desert or a shrub-steppe and supports a biological community typical of this environment. The 200 Areas Plateau in particular 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 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 tridentate/Poa sandbergii - Bromus tectorum* community (Rogers and Rickard 1977) meaning that the dominant shrub is big sagebrush (*Artemisia tridentate*) and the understory is dominated by the native Sandberg's bluegrass (*Poa sandbergii*) and the introduced annual cheatgrass (*Bromus tectorum*). Other shrubs that are typically present include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), spiny hopsage (*Grayia spinosa*), and occasionally antelope bitterbrush (*Purshia tridentate*). Other native bunchgrasses that are typically present include bottlebrush squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread (*Stipa commode*), and prairie junegrass (*Koeleria cristata*). Common and important herbaceous species include turpentine cymopteris (*Cymopteris terebinthinus*), globemallow (*Sphaeraica munroana*), balsamroot (*Balsamorhiza careyana*), several milk vetch species (*Astragalus caricinus*, *A. sclerocarpus*, *A. succumbens*), long-leaf phlox (*Phlox longifolia*), the common yarrow (*Achillea millifolium*), pale evening-primrose (*Oenothera pallida*), thread-leaf phacelia (*Phacelia linearis*), and several daisy/fleabane species (*Erigeron poliospermus*, *E. Filifolius*, and *E. pumilus*). In all, well over 100 plant species have been documented to occur in native stands on the 200 Areas Plateau.

Disturbed communities on the 200 Areas Plateau are primarily the result of either mechanical disturbance or range fires. Mechanical disturbance, including construction activities, soil borrow areas, road clearings, and fire breaks, results in drastic changes to the plant community. This type of disturbance usually entails a complete loss of soil structure and total disruption of nutrient cycling. The 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 are also present including several sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), cattails (*Typha latifolia* and *T. angustifolia*), and pond-weeds (*Potamogeton* spp.).

3.6.1.2 Plant Species of Concern. The Washington State Department of Natural Resources, Natural Heritage Program classifies rare plants in the state of Washington in three different categories, depending on the overall distribution of the taxon and the state of its natural habitat. These categories are: *Endangered*, which is a "vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. Populations of these taxa are at critically low levels or their habitats have been degraded or depleted to a significant degree"; *Threatened*, which is a "vascular plant taxon likely to become endangered within the near future in Washington if factors contributing to its population decline or habitat degradation or loss continue"; and *Sensitive*, which is a taxon that is "vulnerable or declining, and could become endangered or threatened in the state without active management or removal of threats" (definitions taken from 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, and is unlikely to occur in the 200 Areas. The northern wormwood (*Artemisia campestris* spp. *borealis*) is known in the state of Washington by only two populations, one across from The Dalles, Oregon, and the other near Beverly, Washington, just north of the Hanford Site. This taxon has not been found on the Hanford Site, but would probably occur only on rocky areas immediately adjacent to the Columbia River if it were present. Neither of the Threatened taxa listed in Table 3-3 have been observed on the Hanford Site. The Columbia milk vetch (*Astragalus columbianus*) is

known to be relatively common on the Yakima Firing Range, and has been documented to occur within 1.6 to 3.2 km (1 to 2 mi) to the west of the Hanford Site on both sides of Umtanum Ridge. This species could occur on the 200 Areas Plateau. Hoover's desert parsley (*Lomatium tuberosum*) inhabits the steep talus slopes near Priest Rapids Dam. Potentially, it could be found on similar slopes on Gable Mountain and Gable Butte, but has yet to be documented in these areas.

Of the eleven 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 rivuloris*), southern mudwort (*Limosella acoulis*), and false-pimpernel (*Lindernia anagallidea*) are all known to occur in the 100 Areas, especially near the 100 B-C Area, in or near the Columbia River. Some of these species could be present in or near ponds and ditches in the 200 Areas. The few-flowered collinsia (*Collinsia sparsiflora* var. *bruciae*) may also occur in these habitats. The gray cryptantha (*Cryptantha leucophaea*) occurs on open dunes throughout the Hanford Site. Piper's daisy (*Erigeron piperianus*) is fairly common on Umtanum Ridge and Rattlesnake Ridge, but has also been documented in the vicinity of B Pond, the A-24 Crib, and 100-H Area. Bristly cryptantha (*Cryptantha interrupta*) 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 arrectus*) and coyote tobacco (*Nicotiana attenuata*) are not as well documented but are known to inhabit dry sandy areas such as the 200 Areas Plateau.

In addition to the three classifications for species of concern listed above, the Natural Heritage Program also maintains a "Monitor" list, which is divided into three groups. Group 1 consists of taxa in need of further field work before a formal status can be assigned. The tooth-sepal dodder (*Cuscuta denticulata*), which has been found in the state of Washington only on the Hanford Site, is the only taxon in this group that is of concern to Hanford operations. This parasitic species has been found in the area west of McGee Ranch. Group 2 of the Monitor list includes species with unresolved taxonomic questions. Thompson's sandwort (*Arenaria franklinii* var. *thompsonii*) is of concern to Hanford operations. However, the representatives of this species in the state of Washington are now believed to all be variety *franklinii* which is not considered particularly rare. Group 3 of the Monitor list includes taxa that are either more abundant or less threatened than previously believed. There are approximately 15 taxa on the Hanford Site that are included on this list.

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

3.6.1.3.1 Mammals. The largest mammal occurring on the 200 Areas Plateau is the mule deer (*Odocoileus hemionus*). Although mule deer are much more common to riparian sites along the Columbia River, they are frequently observed foraging throughout the 200 Areas. Elk (*Cervus elaphus*) also occur at the Hanford Site 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 the Hanford Site. 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 verticalis*), rock doves (*Columba livia*), barn swallows (*Hirundo rustica*), cliff swallows (*Hirundo pyrrhonota*), black-billed magpies (*Pica pica*), and ravens (*Corvus corax*). Common raptors include the northern harrier (*Circus cyaneus*), American kestrel (*Falco sparvarius*), and red-tailed hawk (*Buteo jamaicensis*). Swainson's hawks (*Buteo swainsoni*) sometimes nest in the trees located at some of the army bunker sites that were used in the 1940's. Golden eagles (*Aquila chrysaetos*) are observed infrequently. Burrowing owls (*Athene cunicularia*) nest at several locations throughout the 200 Areas. The most common upland game birds found in the 200 Areas are California quail (*Callipepla californica*) and Chukar partridge (*Alectoris chukar*); however, ring-necked pheasants (*Phasianus colchicus*) and gray partridge (*Perdix perdix*) may be found in limited numbers. The only native game bird common to the 200 Areas Plateau is the mourning dove (*Zenaida macroura*), which migrates south each fall. Other species of note which nest in undisturbed sagebrush habitats in the 200 Areas include sage sparrows (*Amphispiza belli*) and loggerhead shrikes (*Lanius ludovicianus*). Long-billed curlews (*Numenius americanus*) also use the sagebrush areas and revegetated burial grounds for nesting and foraging.

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

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

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

3.6.1.4 Wildlife Species of Concern. Some animals which inhabit the Hanford Site have been given special status designations by the state and federal government. Some of these designations include state and federal threatened and endangered species, federal candidate, state monitor, state sensitive, and state candidate species. Species listed in Table 3-4 as state and\or federal threatened and endangered such as the bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrinus*), American white pelican (*Pelecanus erythroryhnchos*), ferruginous hawk (*Buteo regalis*), and sandhill crane (*Grus canadensis*) do not inhabit the 200 Areas. The bald eagle and American white pelican utilize the Columbia River and associated habitats for roosting and feeding. Peregrine falcons and sandhill cranes fly over the Hanford Site during migration. Ferruginous hawks nest on the Hanford Site but nesting has not been documented for this species on the 200 Areas Plateau. Other species listed in Table 3-4 as state and/or federal candidates and state monitor species such as burrowing owls, great blue herons, prairie falcons (*Falco mexicanus*), sage sparrows, and loggerhead shrikes are not uncommon to the 200 Areas Plateau.

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3.6.2 Land Use

Operations in the 200 East Area have been related to nuclear fuels processing, separation, and recovery. Activities at the B Plant and PUREX Plant included processing of irradiated fuel rods for uranium and plutonium separation. In the Semi-Works Aggregate Area, pilot processes for plutonium and uranium extraction, strontium and other fission product recovery, and critical mass experiments were conducted. In the 200 North Aggregate Area fuel rods were stored temporarily before processing. Aggregate area facilities and process activities are described in detail in Sections 2.2 and 2.3. Waste management units that remain active are noted in Table 2-1. A summary of the land use within each of these facilities is presented below.

The B Plant Aggregate Area is the location of the main B Plant facility (221-B Building), and related structures including the 222-B Laboratory, 224-B Concentrator, and 2101-M offices. Past activities at B Plant were primarily associated with plutonium extraction from spent fuel uranium fuel rods, and strontium and cesium recovery. Other buildings within the unit served mainly as powerplants and office and storage space. The B Plant is currently inactive.

The PUREX Plant Aggregate Area is the location of the PUREX Plant (202-A Building) and related structures including the 242-A Evaporator, 293-A Building, Grout Treatment Facility, and the 204-AR waste unloading station. Past activities include plutonium and uranium extraction from uranium fuel rods. Current activities at the PUREX Plant include waste treatment and storage at the Grout Treatment Facility, waste unloading at 204-AR facility, and liquid waste evaporation. The PUREX Plant is currently in standby mode.

The Semi-Works Aggregate Area is the site of the former Semi-Works complex (201-C Building) and related structures including the 291-C and 271-C Buildings, and the Critical Mass Laboratory. Past activities include plutonium separation technology development; pilot extraction of strontium, cesium, and promethium from process waste; and criticality experiments. Semi-Works is currently decommissioned and the Critical Mass Laboratory has been converted to office space. Other structures have been demolished or currently serve as storage space.

3.6.3 Water Use

There is no consumptive use of groundwater within the 200 East Area. Water for drinking, emergency use, and facilities process 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 699-49-100-C) about 13 km (8 mi) west of the 200

East Area; at the Hanford Safety Patrol Training Academy (Well 699-S28-E0) about 25 km (16 mi) to the southeast; at the PNL Observatory (developed spring); and near the Fast Flux Test Facility in the 400 Area (Well 699-S1-8J) about 16 km (10 mi) to the southeast. The nearest water supply wells located offsite are about 21 km (13 mi) to the northwest (upgradient). The latter wells obtain their water from the basalt and the basalt interbeds (the Berkshire Well and Chateau Ste. Michelle No. 1 and No. 2), and are reportedly used for irrigation although they may also be used to supply drinking water. Three wells for emergency cooling water supply are located in the 200 East Area, two near B Plant and one for the 241-A Tank Farm Vent System.

3.7 HUMAN RESOURCES

The following sections provide an overview of the demography (Section 3.7.1), archaeology (Section 3.7.2), historical resources (Section 3.7.3), and community involvement (Section 3.7.4) relating to the Hanford Site and 200 East Area.

The environmental conditions at the 200 East 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 10 km (6 mi) west of the 200 West Area at the orchard across from the Ste. Michelle vineyard, and on the farm next to the vineyard on Cold Creek and Highway 29. 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 West Area but not within the 200 East 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.

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3.7.3 Historical Resources

The only historic site near 200 East Area is the old White Bluffs road which is 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 which includes any potentially affected community with respect to the 200 East Groundwater AAMSR. The Community Relations Plan includes a discussion on analysis of key community concerns and perceptions regarding the project, along with a list of all interested parties.

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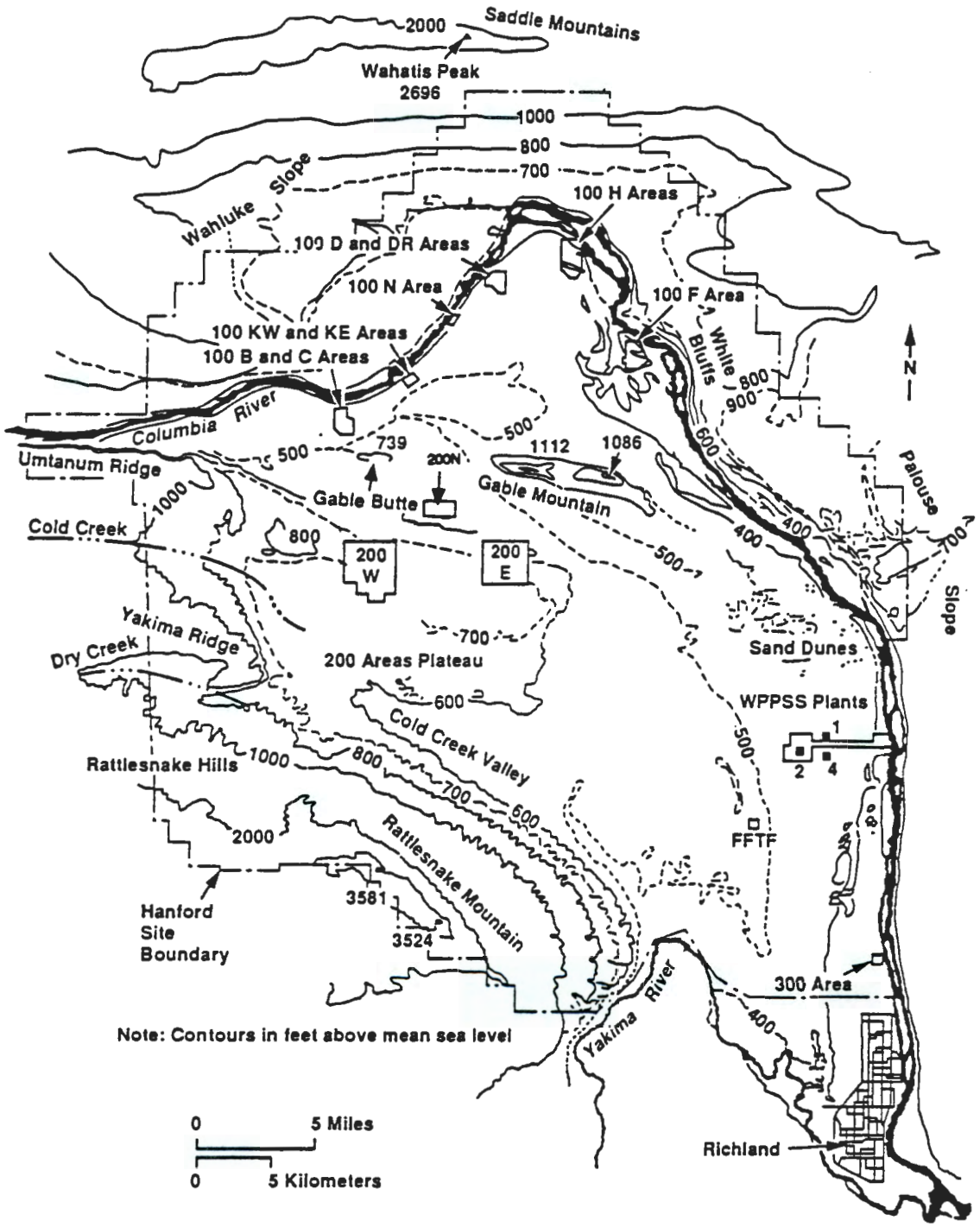

Figure 3-1. Topography and Location Map for the Hanford Site.

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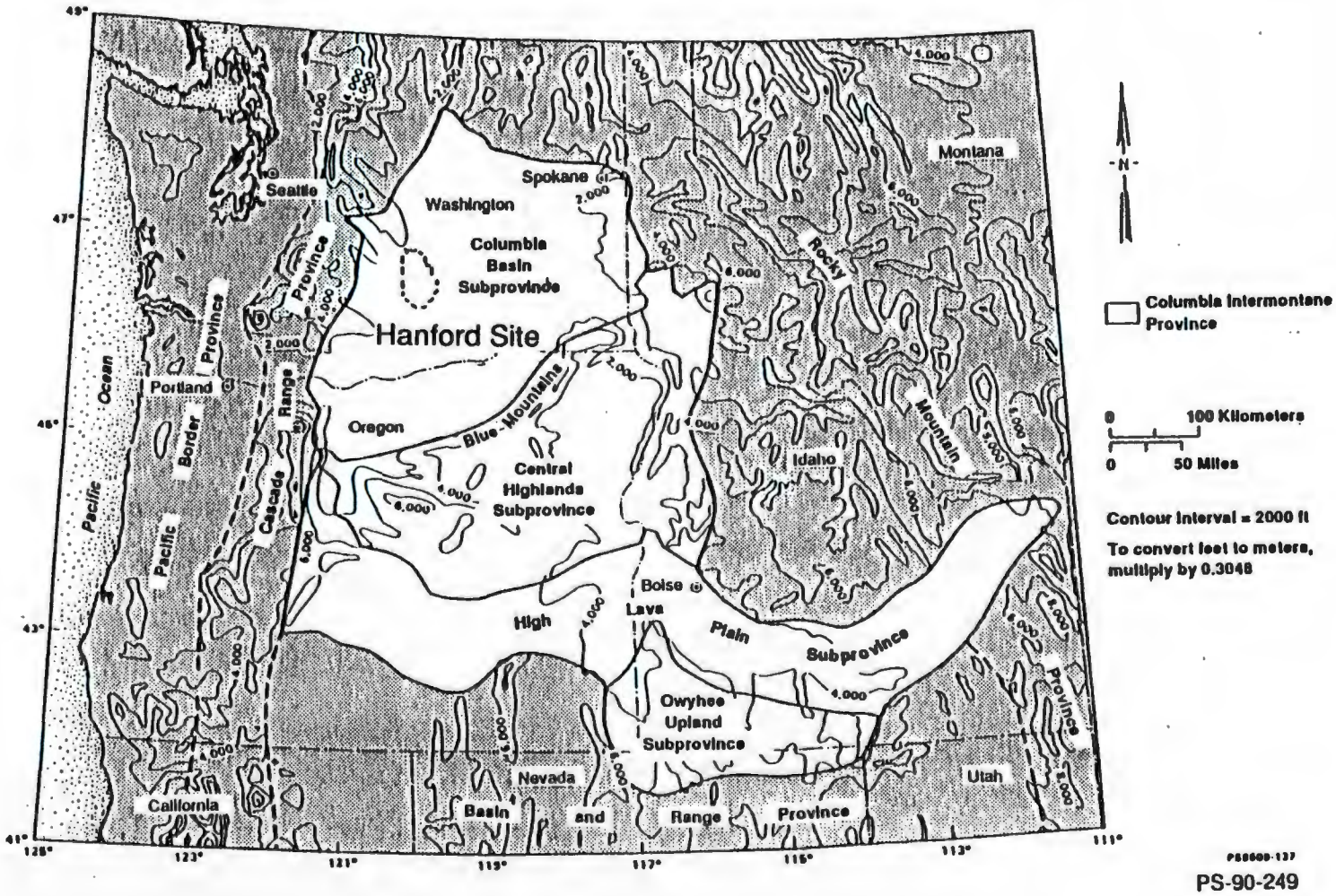

Figure 3-2. Divisions of the Columbia Intermontane Province and Adjacent Snake River Plains Province (DOE 1988).

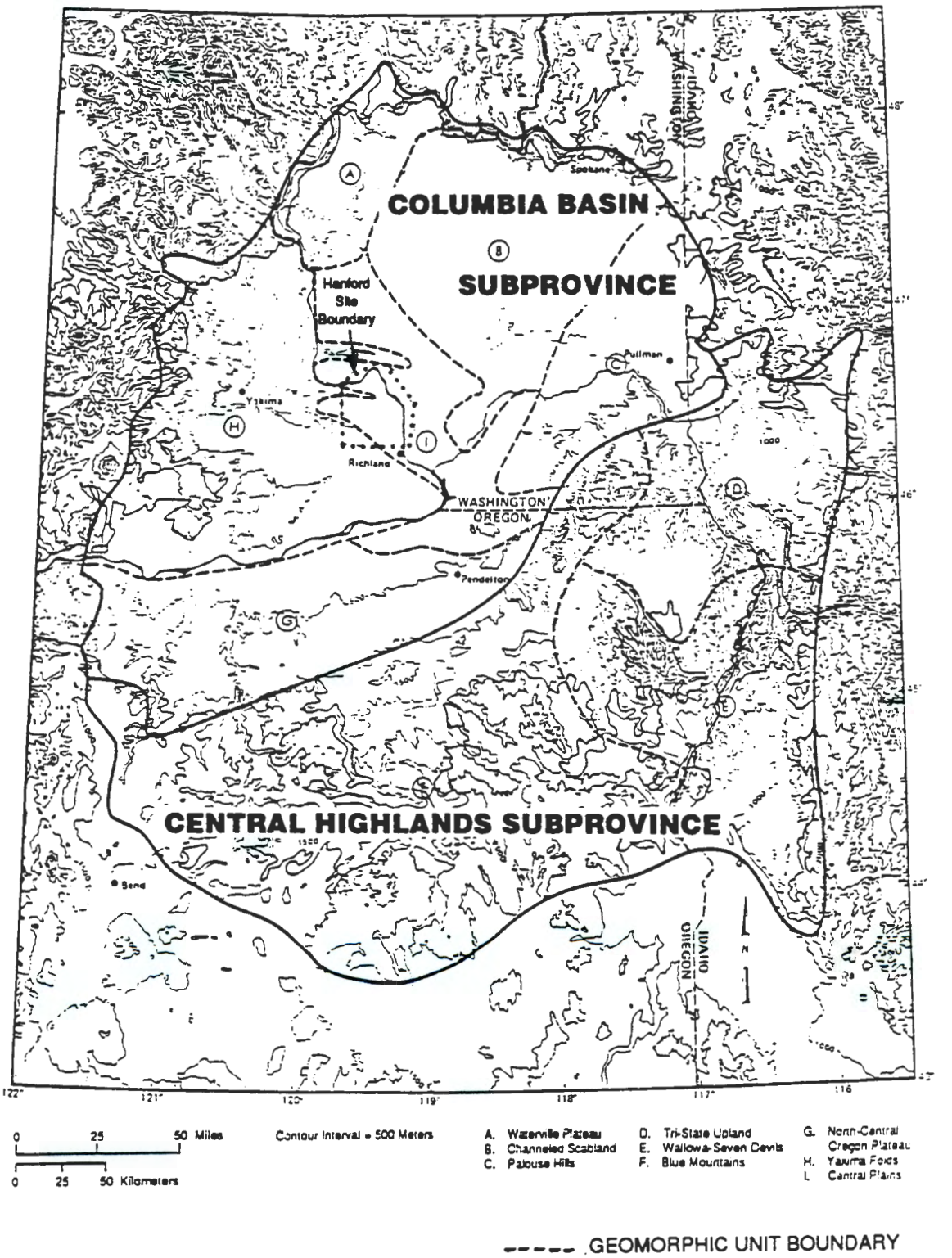

Figure 3-3. Geomorphic Units Within the Central Highlands and Columbia Basin Subprovinces that Contain the Columbia River Basalt Group (DOE 1988).

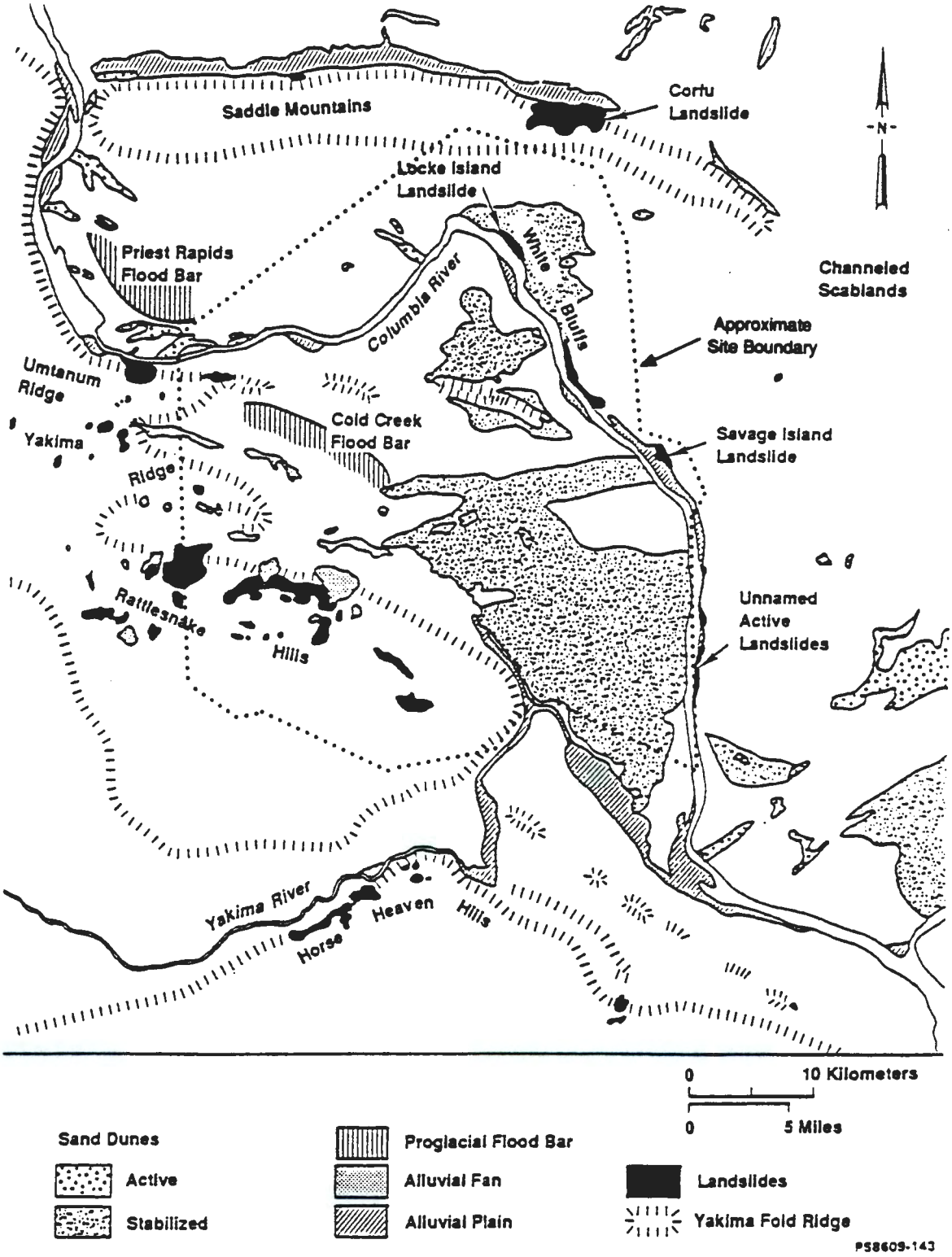

Figure 3-4. Landforms of the Pasco Basin and the Hanford Site (DOE 1988).

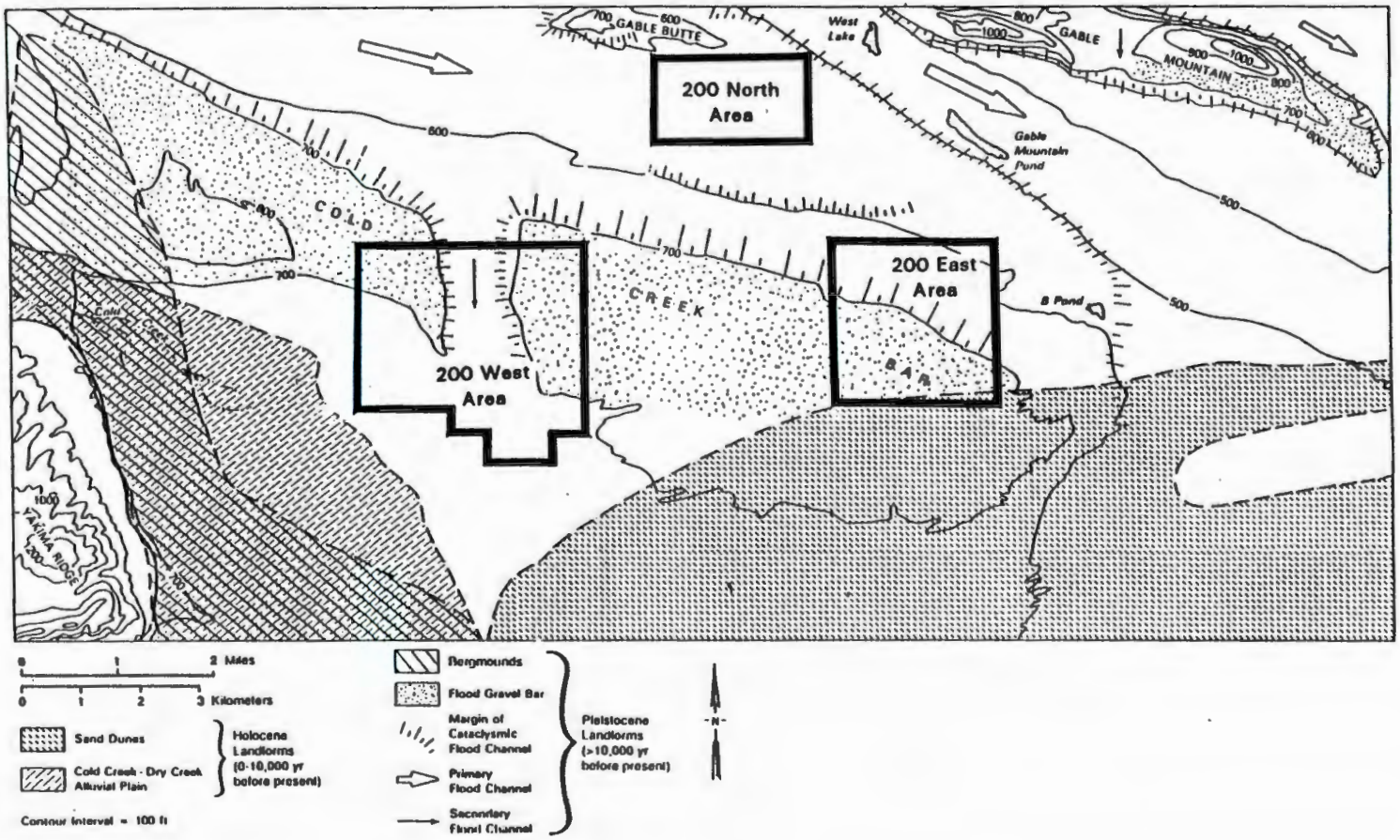

Figure 3-5. Geomorphic Features Surrounding the 200 Areas (Last et al. 1989).

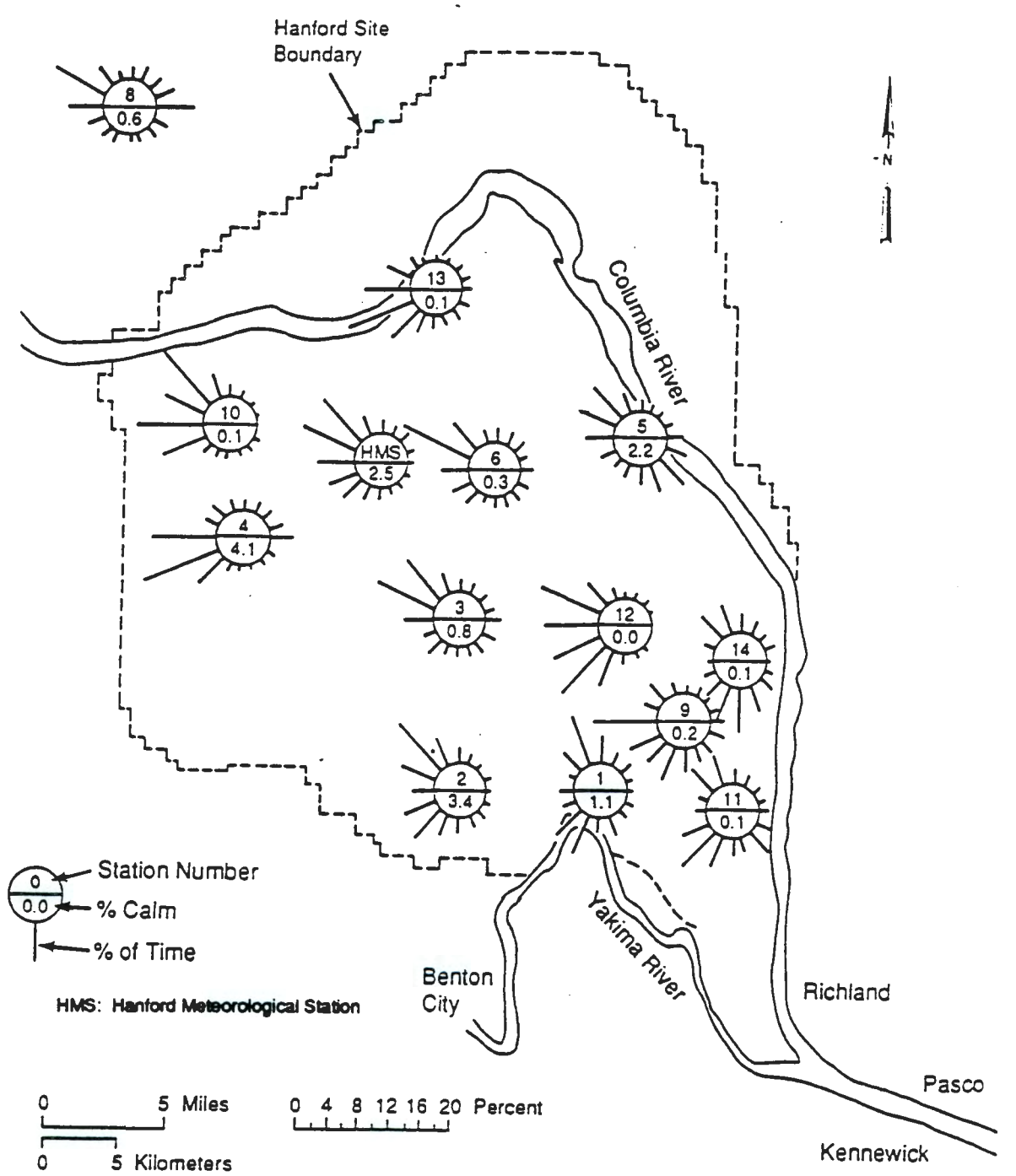

Figure 3-6. Hanford Site Wind Roses, 1979 through 1982 (Stone et al. 1983).

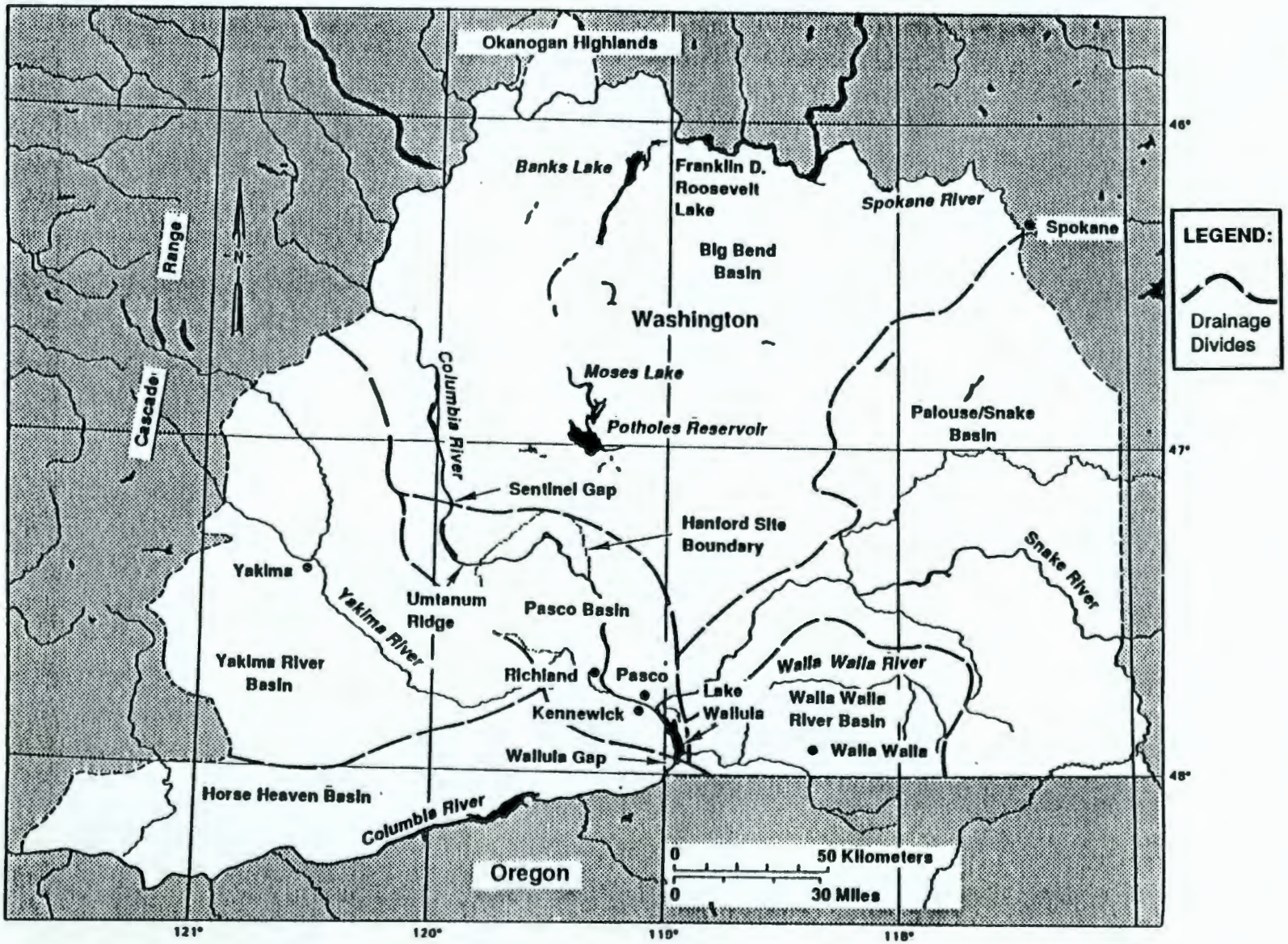

Figure 3-7. Hydrologic Basins Designated for the Washington State Portion of the Columbia Plateau (DOE 1988).

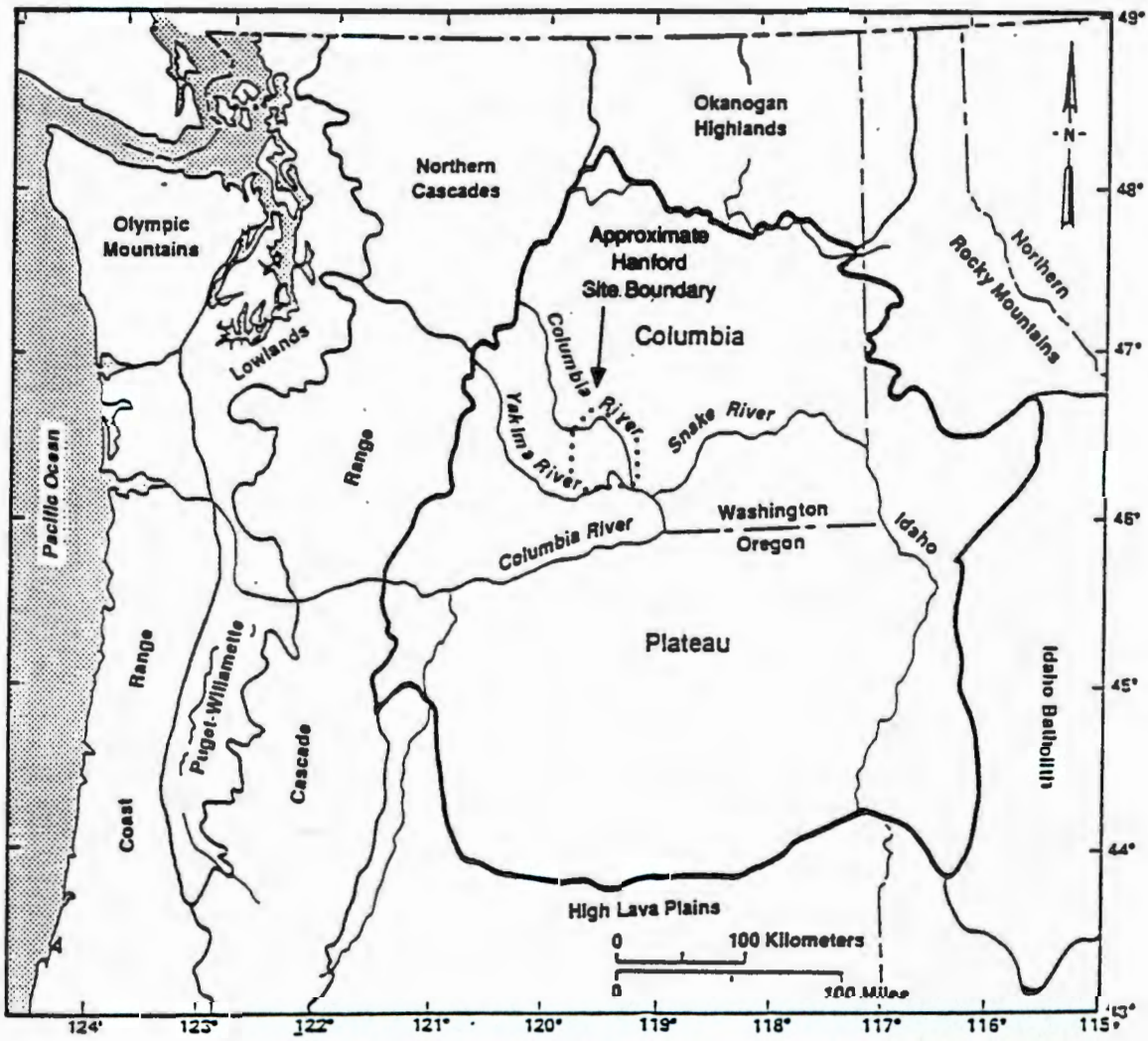

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Figure 3-8. Columbia Plateau and Surrounding Structural Provinces (DOE 1988).

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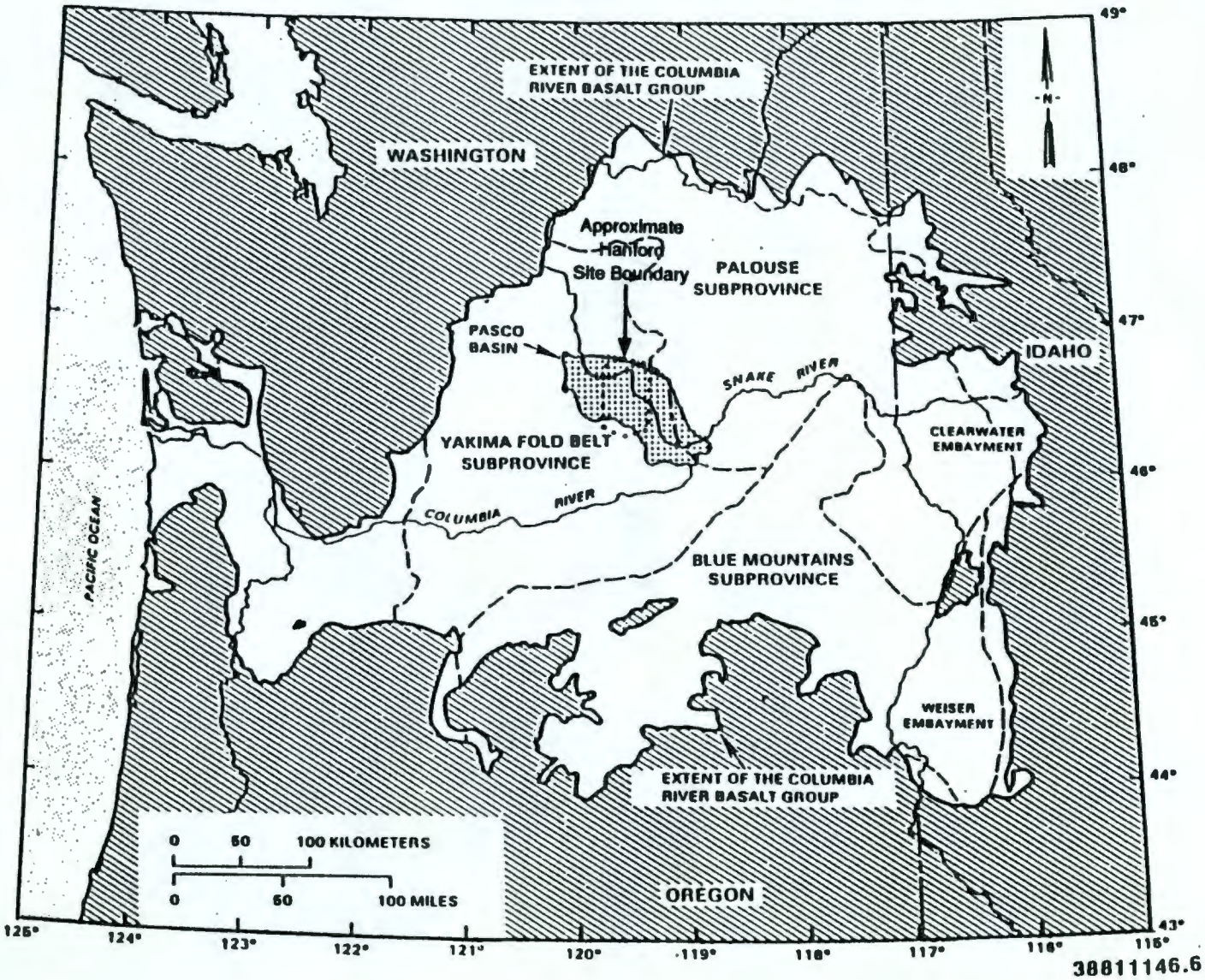

Figure 3-9. Structural Subprovinces of the Columbia Plateau (DOE 1988).

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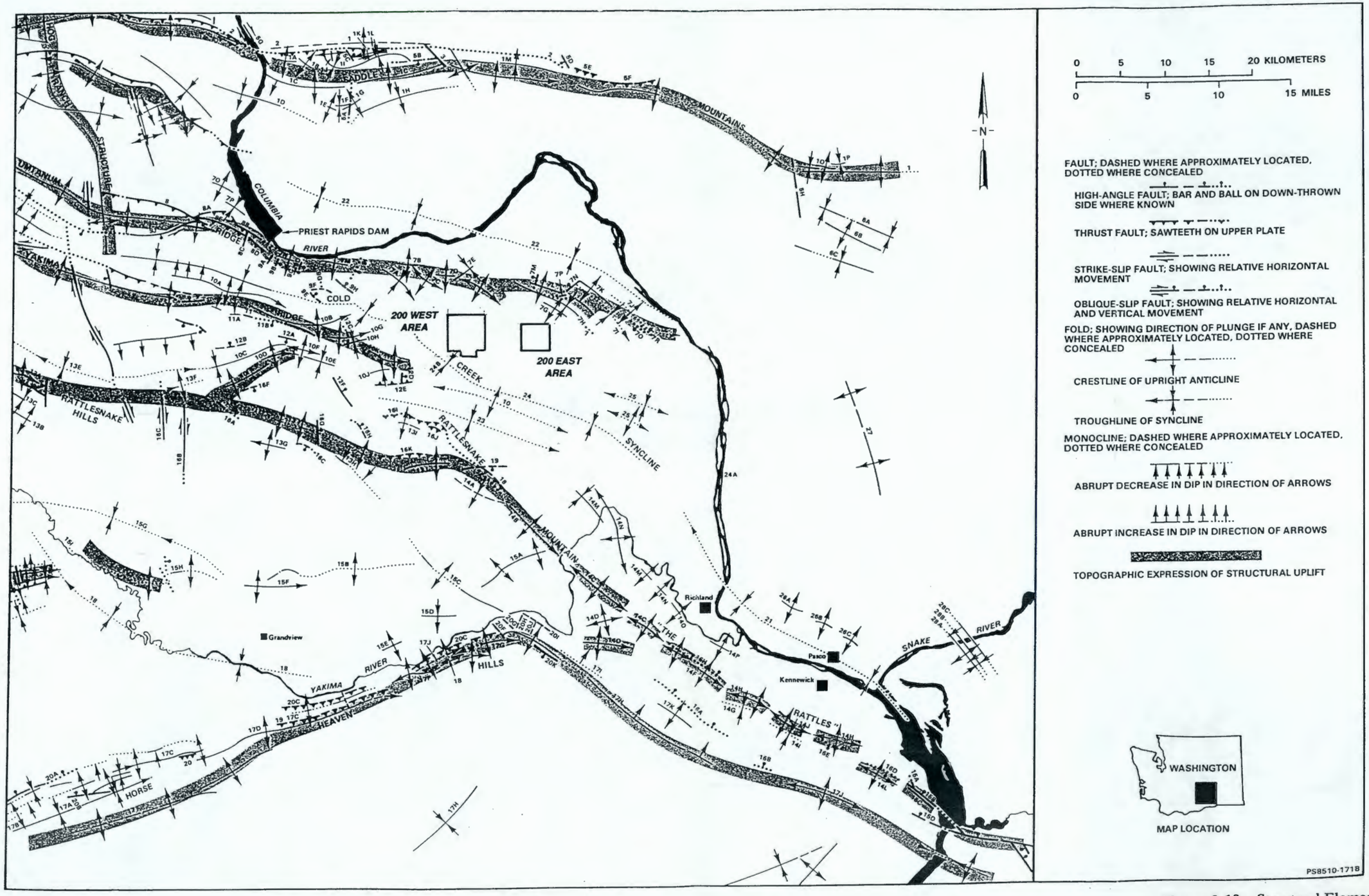

Figure 3-10. Structural Elements of the Yakima Fold Belt Subprovince (DOE 1988).

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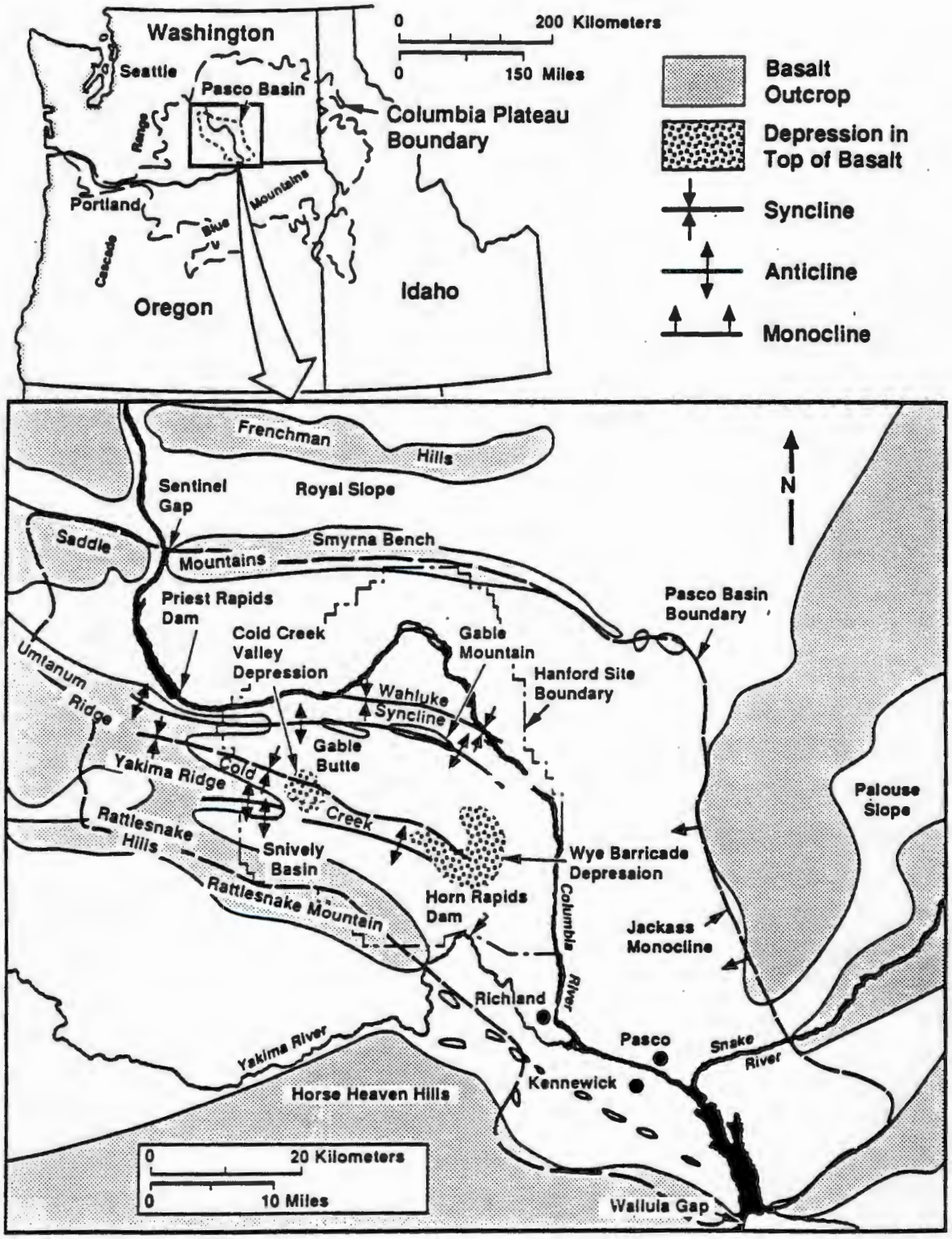


Figure 3-11. Geologic Structures of the Pasco Basin and the Hanford Site (Reidel et al. 1989a)

9 3 1 2 9 7 1 3 2 9

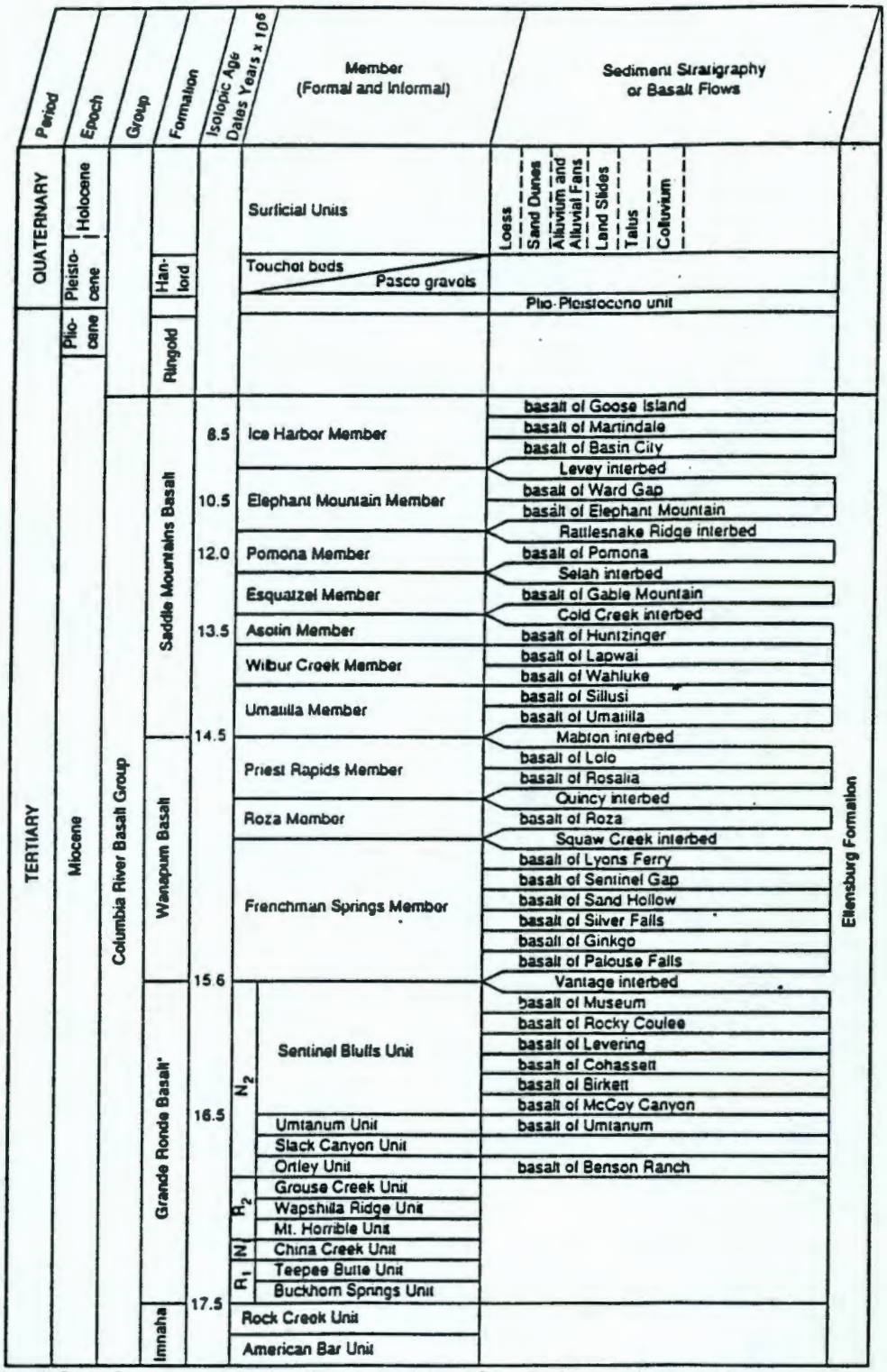


Figure 3-12. Generalized Stratigraphy of the Hanford Site (DOE 1988).

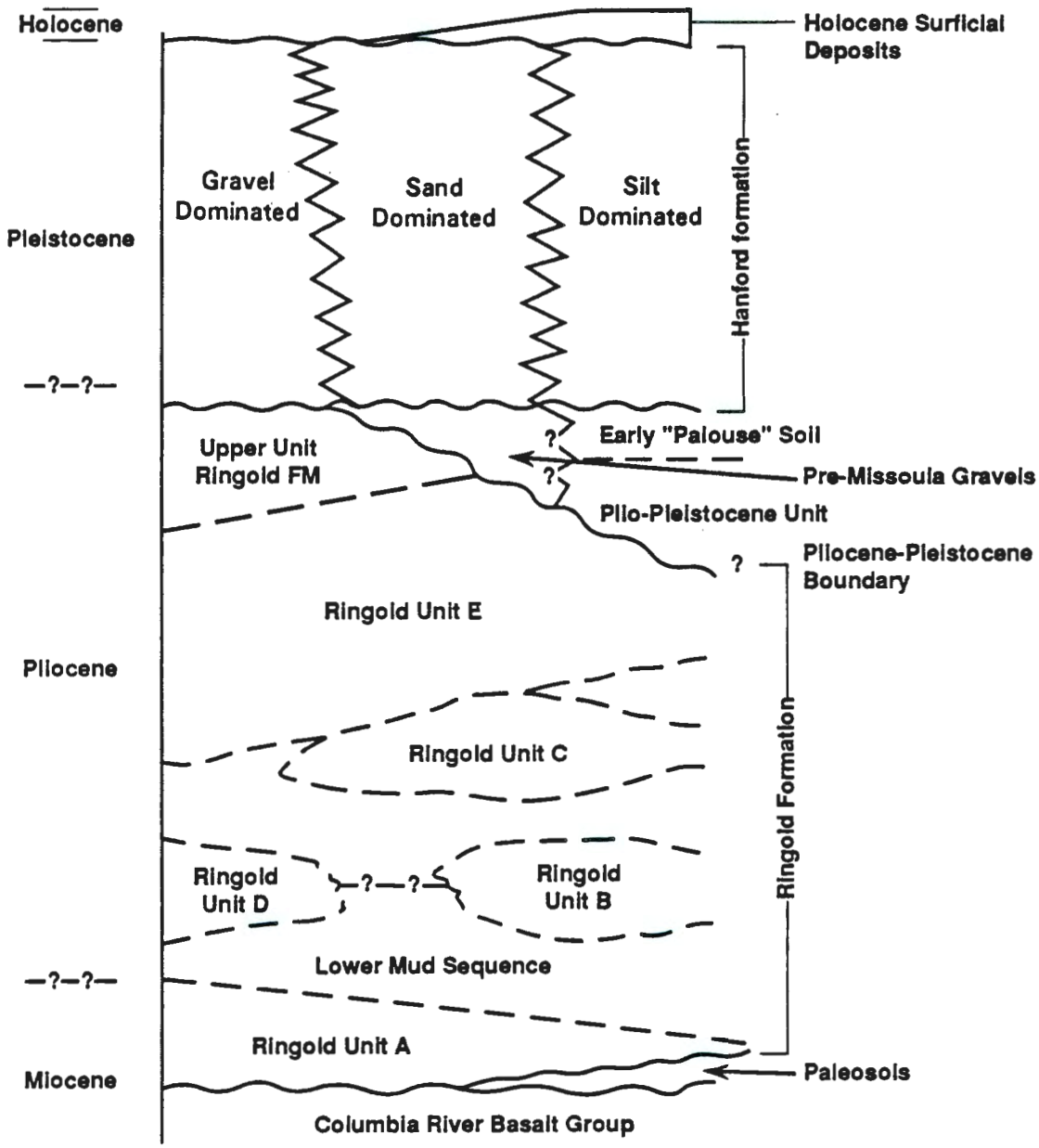
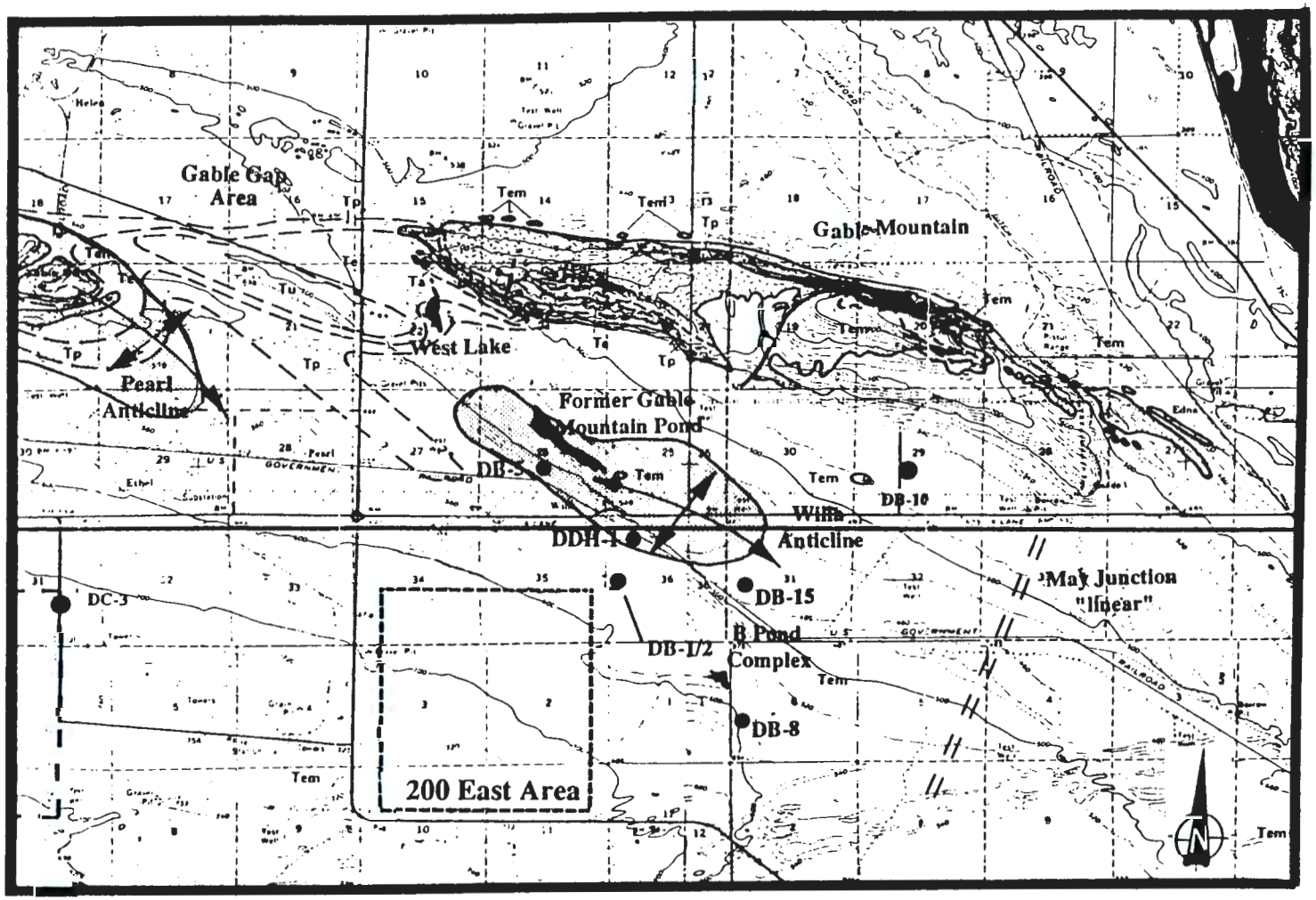


Figure 3-13. Generalized Stratigraphy of the Suprabasalt Sediments Beneath the Hanford Site (Lindsey et al. 1989).



Saddle Mountains Basalt Units:

Tem Elephant Mountain Member
Tp Pomona Member
Te Esquatzel Member
Tu Umatilla Member

0 1 2 MILES

0 1 2 KILOMETERS

DC-20 Borehole number and location referenced in text

Anticline axis and plunge direction

Approximate area of basalt above the water table

Geologic Unit contact

Fault (ball and bar on down-thrown side)

Figure 3-14. Bedrock Geology Map (modified from Meyers and Price 1981).

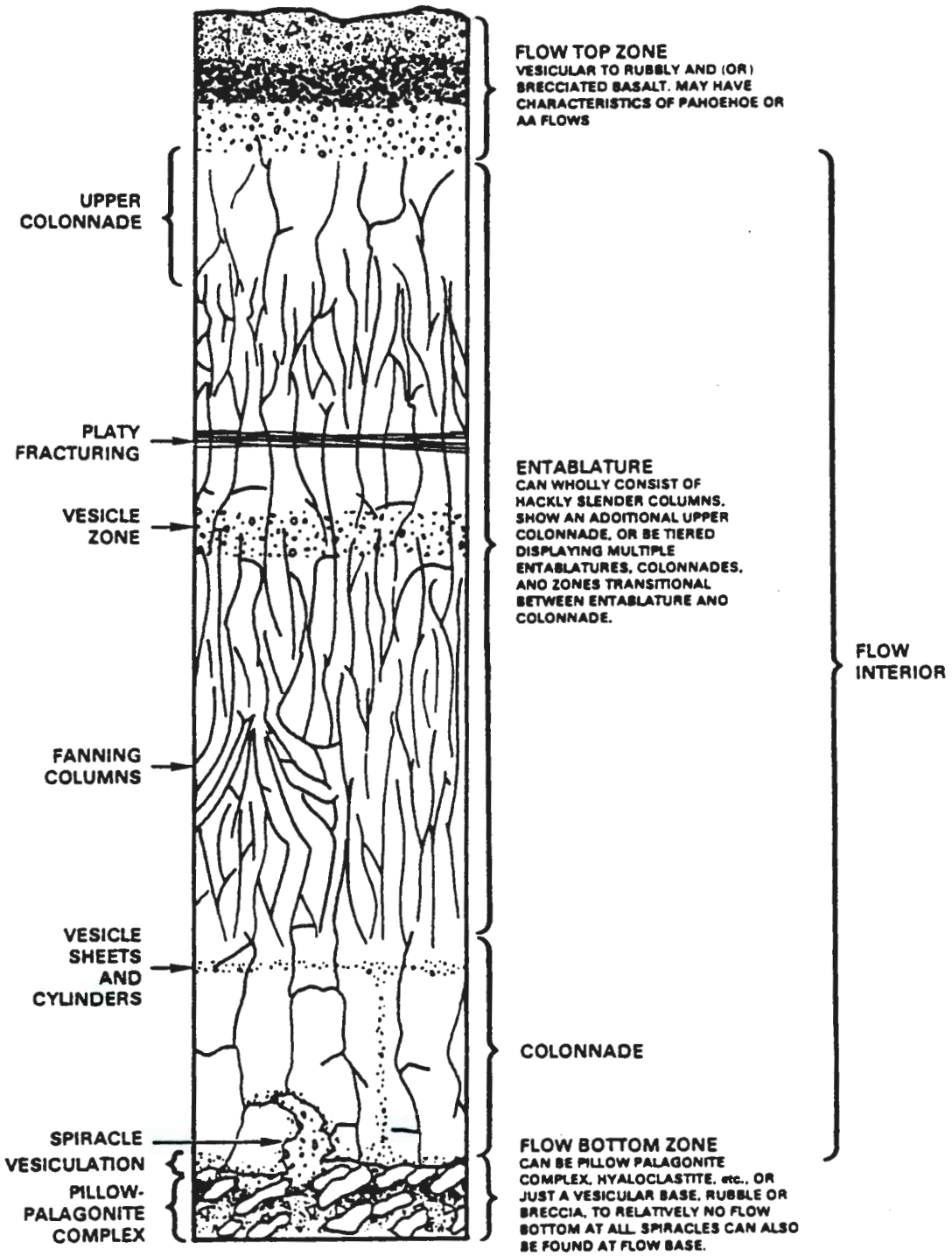


Figure 3-15. Idealized Columnar Section Showing the Variety of Intraflow Structures Possible in Columbia River Basalt Group Flows (Swanson et al. 1979).

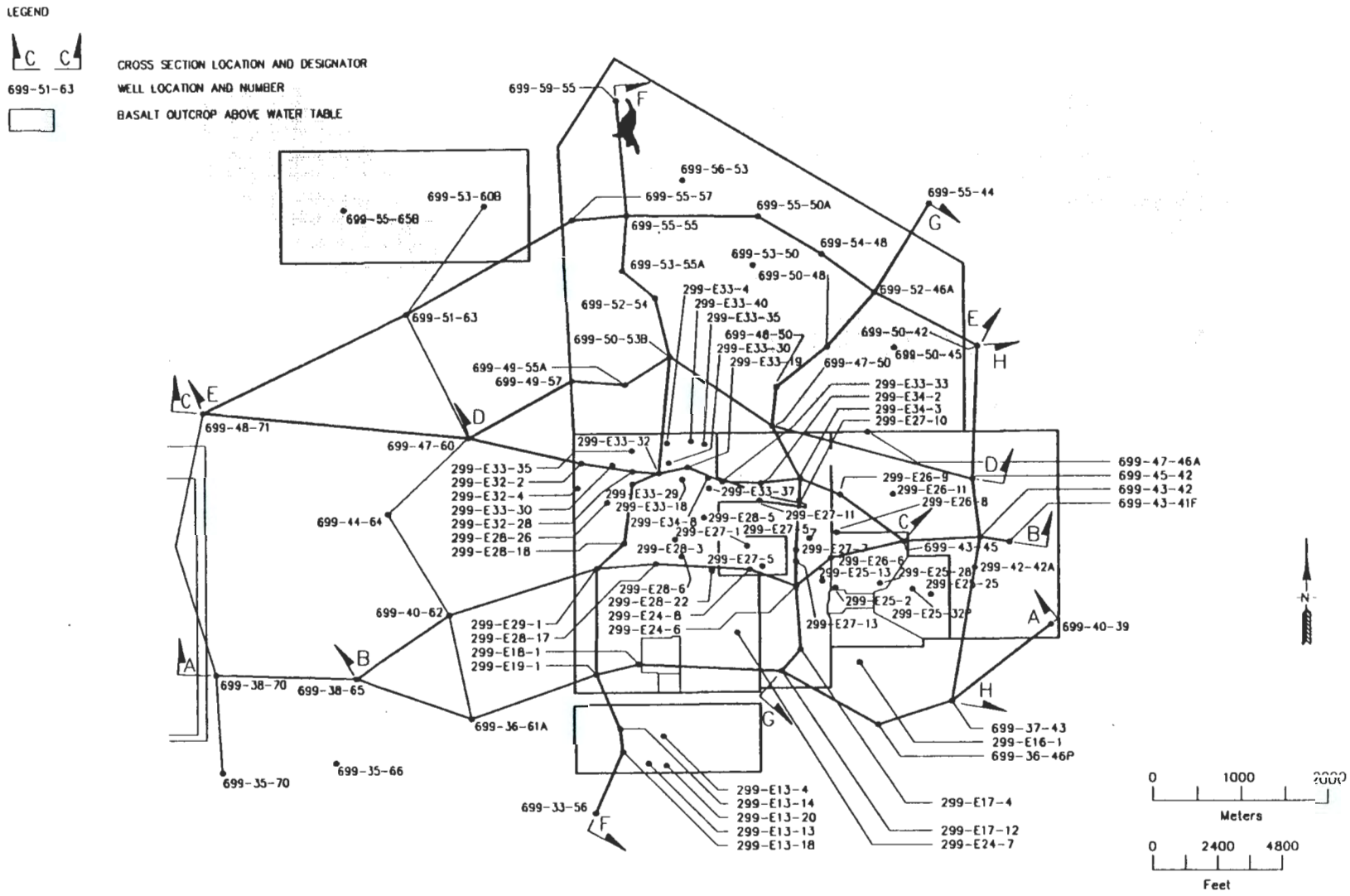
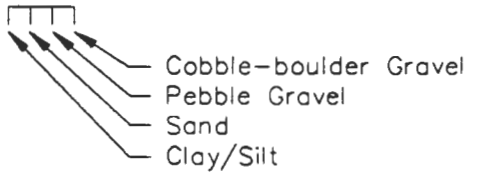


Figure 3-16. Location of 200 East Area Geologic Cross Sections (Modified from Lindsey et al. 1992).

Explanation

Grain Size Scale, Indicates Dominant Grain Size in an Interval



Additional Lithologic Symbols
Includes Subordinate Lithologies

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

Other Symbols

- Formational contact, ? where inferred
- Unit or sequence contact, ? where inferred
- Water Table Elevation (December 1991)

Unit Abbreviations

Eo – Eolian (Holocene) deposits
Hug – Upper Gravel Unit, Hanford formation
Hun – Undifferentiated Hanford formation
Hs – Sandy sequence, Hanford formation
Hlg – Lower Fine Gravel Unit, Hanford formation
H/R – Hanford/Ringold contact
PP – Plio–Pleistocene unit
UP – Upper unit, Ringold Formation
E – Gravel unit E, Ringold Formation
C – Gravel unit C, Ringold Formation
LM – Lower mud sequence, Ringold Formation
A – Gravel unit A, Ringold Formation
EM – Elephant Mountain Member, Saddle Mountains Basalt
RRI – Rattlesnake Ridge Interbed, Ellensburg Formation
P – Pomona Member, Saddle Mountains Basalt

NOTE:

1. Refer to Figure 3–16 for cross section locations and designation. Cross sections presented on Figures 3–18 through 3–25.
2. Figures based on Lindsey et al. 1992.

200east/2east002

Figure 3-17. Legend for Cross Sections.

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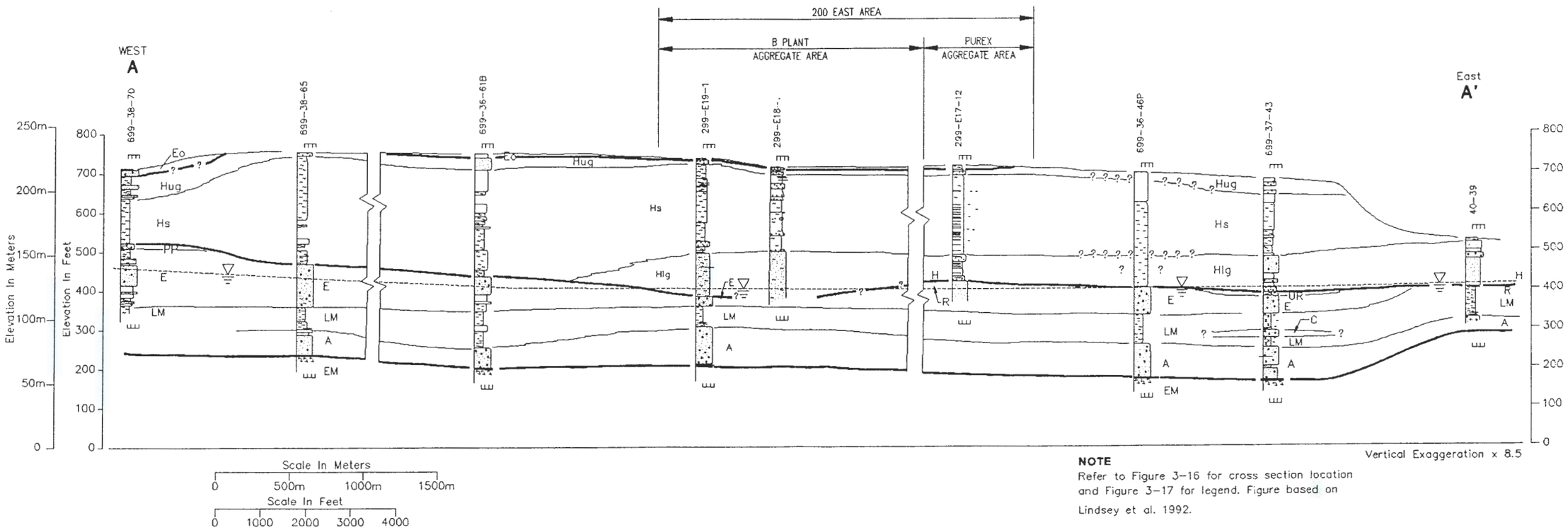
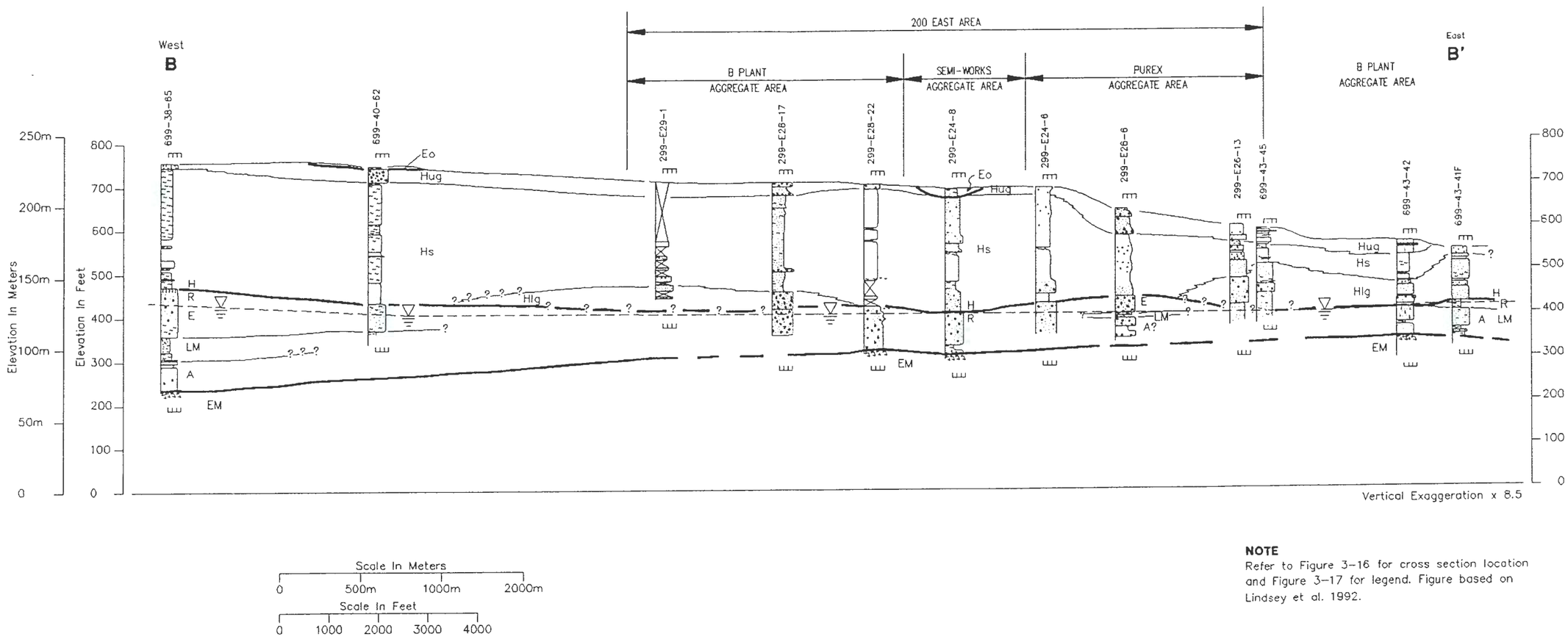


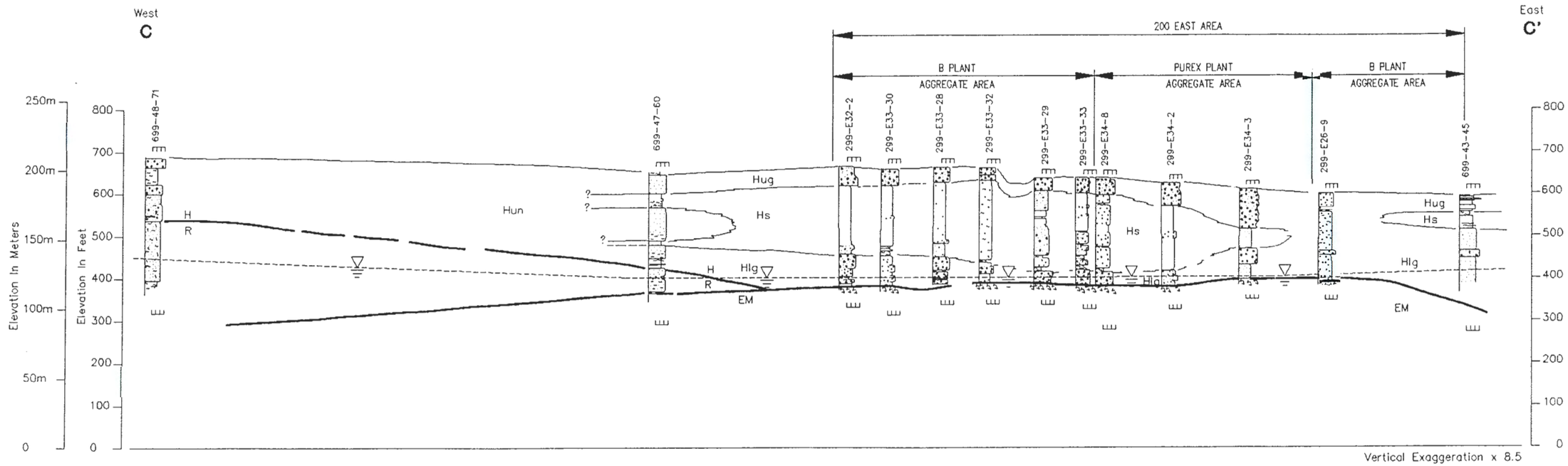
NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

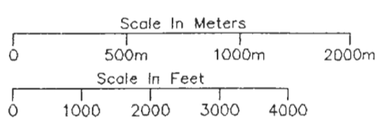
Figure 3-18. 200 East Area Geologic Cross Section A-A'.



NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

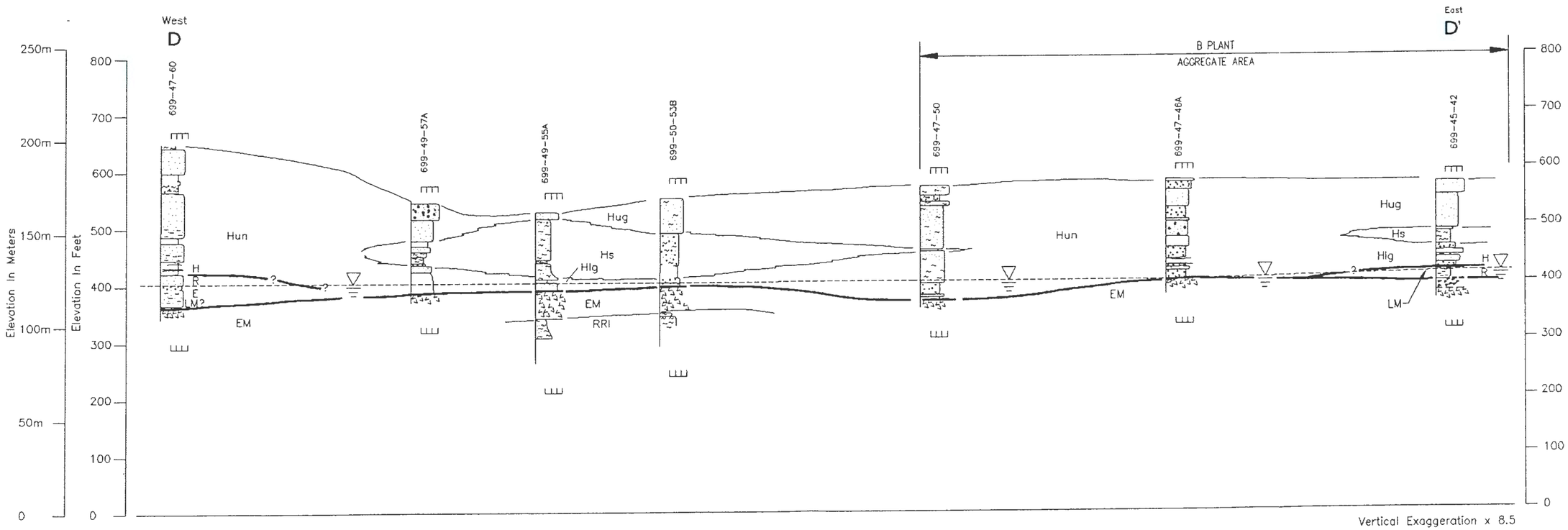
Figure 3-19. 200 East Area Geologic Cross Section B-B'.

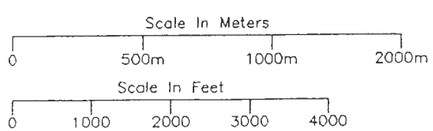




NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

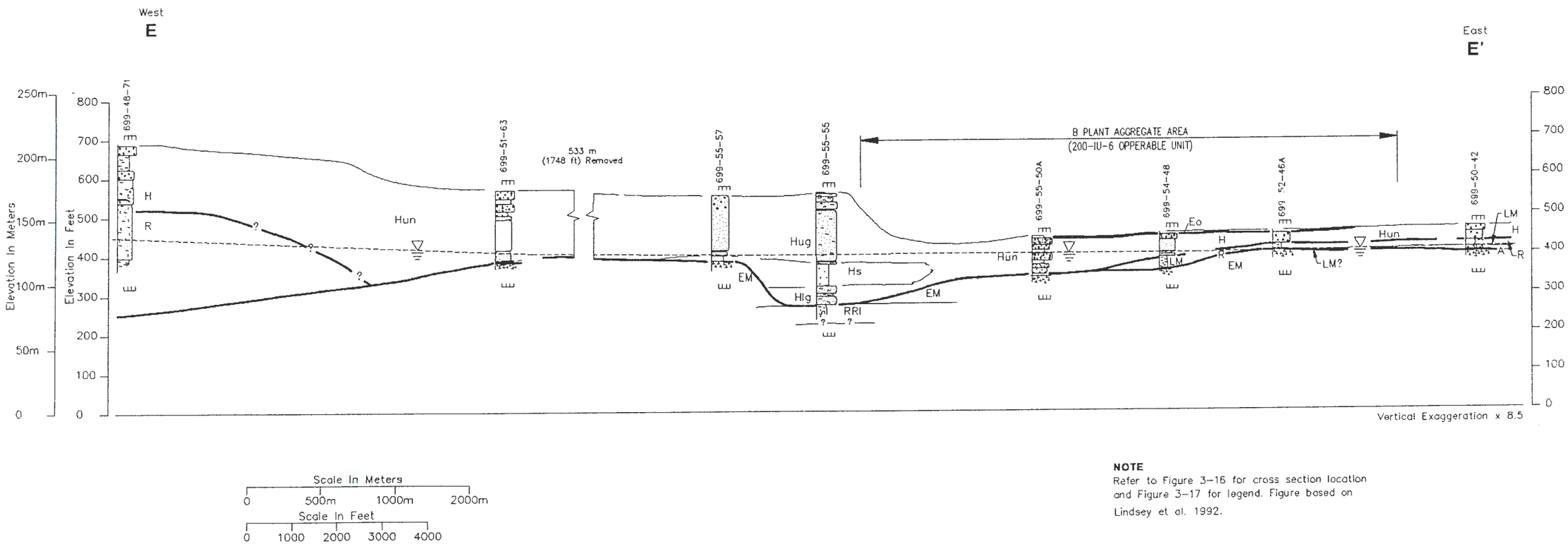
Figure 3-20. 200 East Area Geologic Cross Section C-C'.





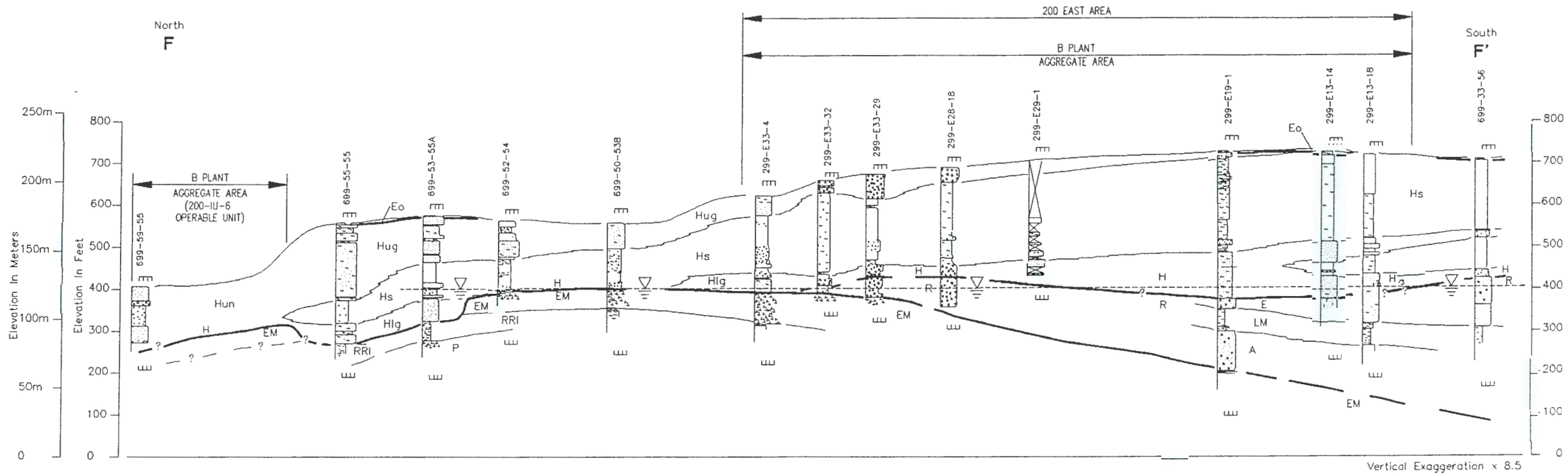
NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

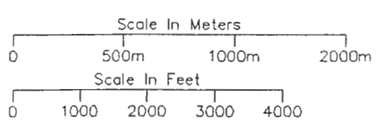
Figure 3-21. 200 East Area Geologic Cross Section D-D'.



NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

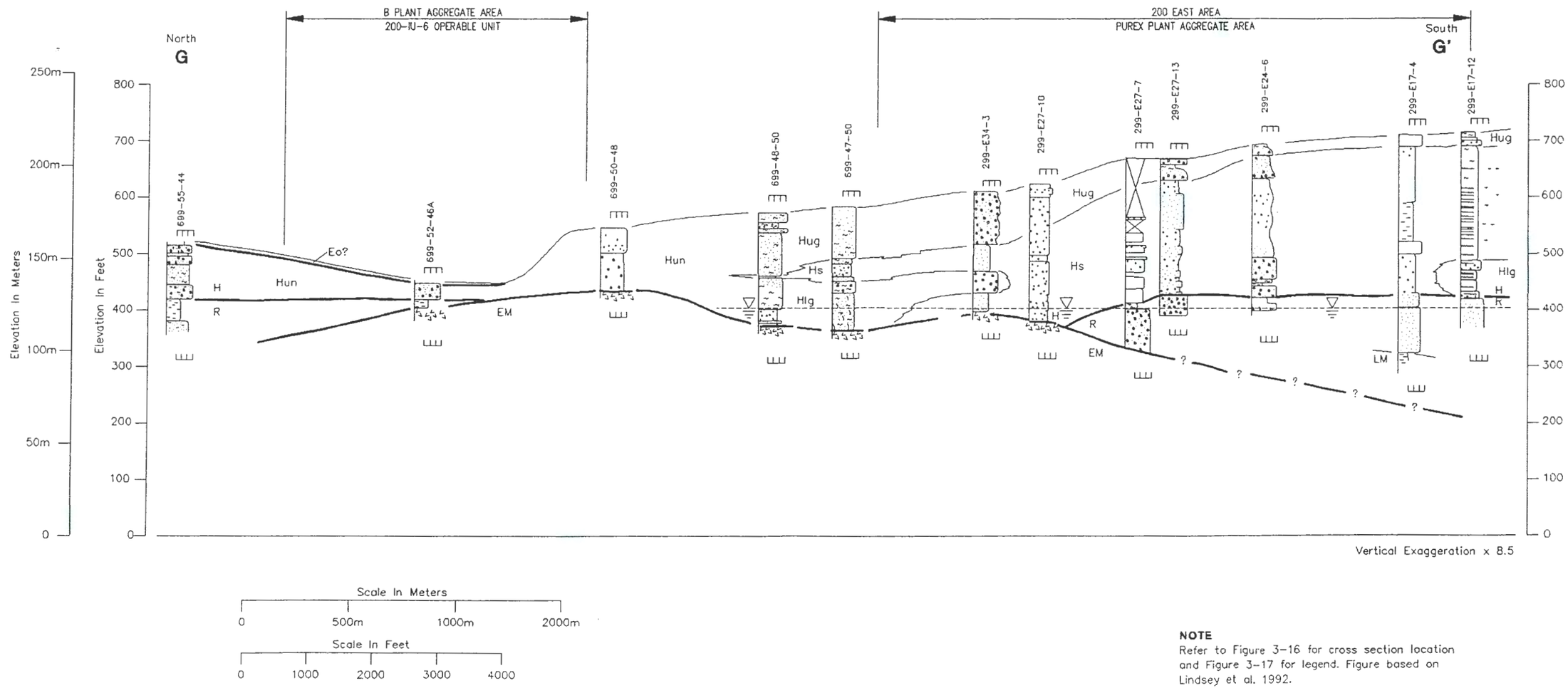
Figure 3-22. 200 East Area Geologic Cross Section E-E'.





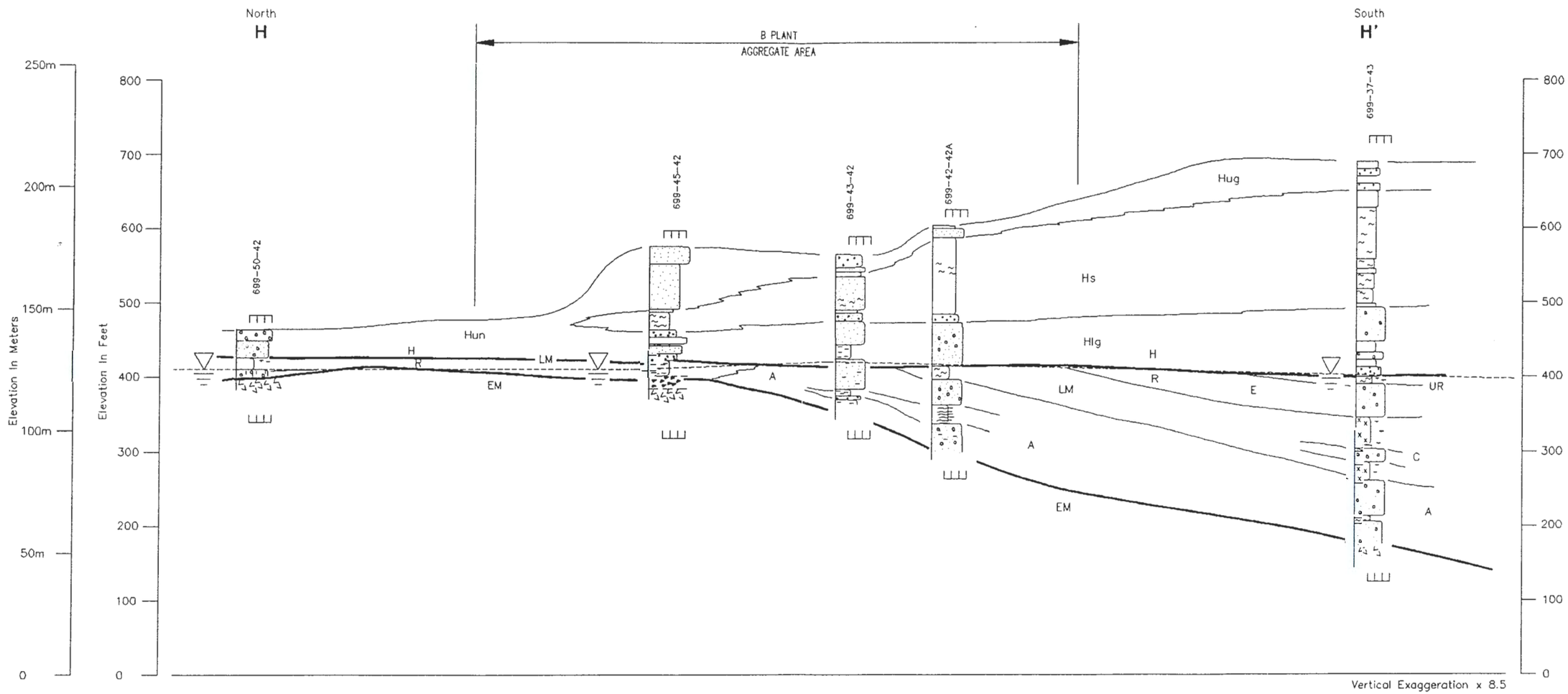
NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

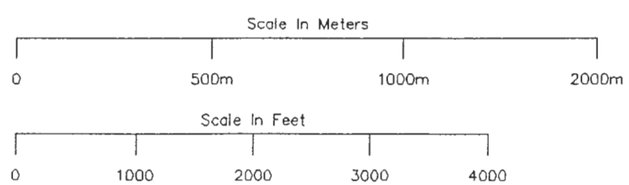
Figure 3-23. 200 East Area Geologic Cross Section F-F'.



NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

Figure 3-24. 200 East Area Geologic Cross Section G-G'.





NOTE
Refer to Figure 3-16 for cross section location and Figure 3-17 for legend. Figure based on Lindsey et al. 1992.

Figure 3-25. 200 East Area Geologic Cross Section H-H'.

9 3 1 2 9 7 1 3 4 3

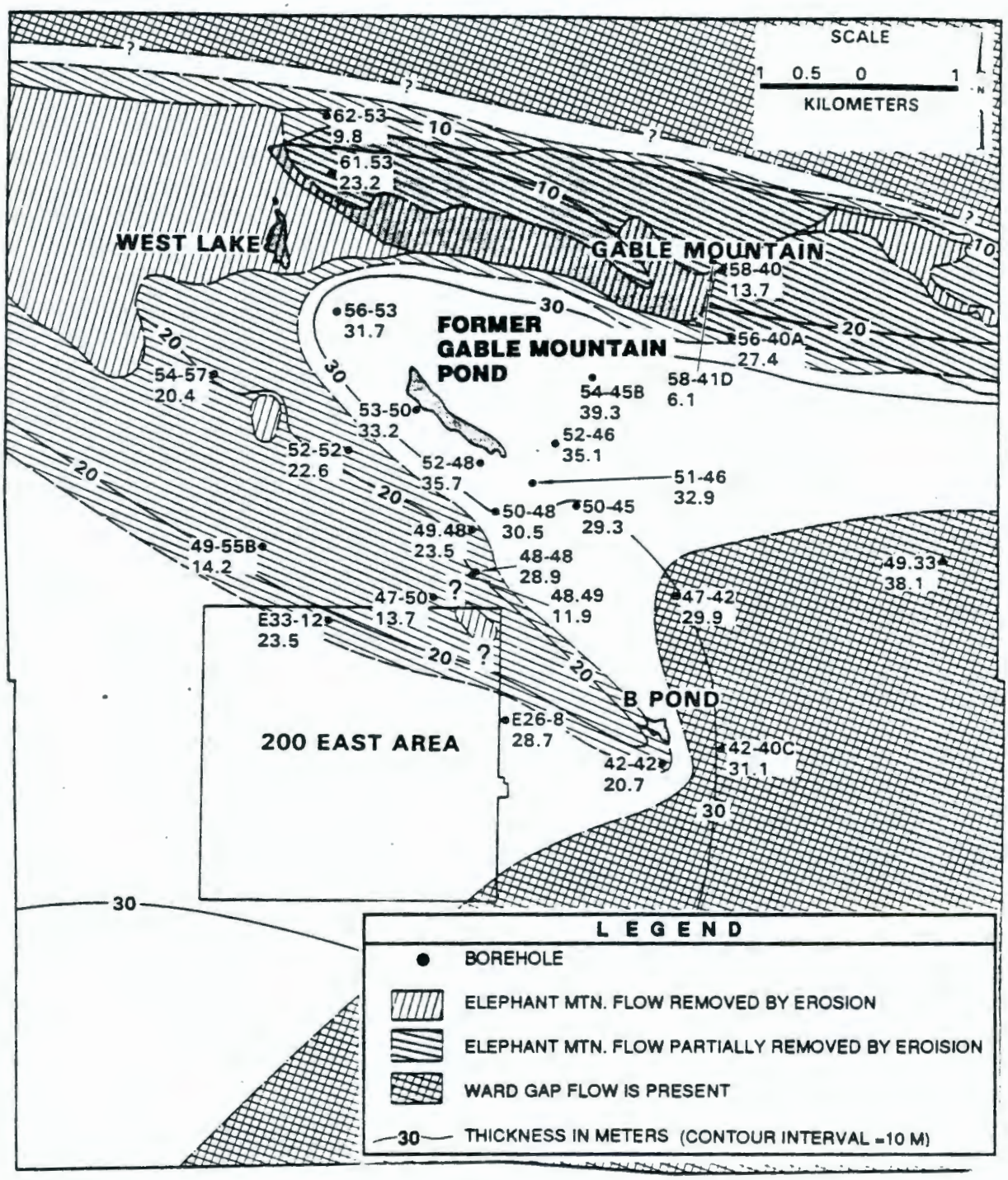


Figure 3-26. Isopach Map of the Elephant Mountain Member (Graham et al. 1984).

9 3 1 2 9 7 1 3 4 4

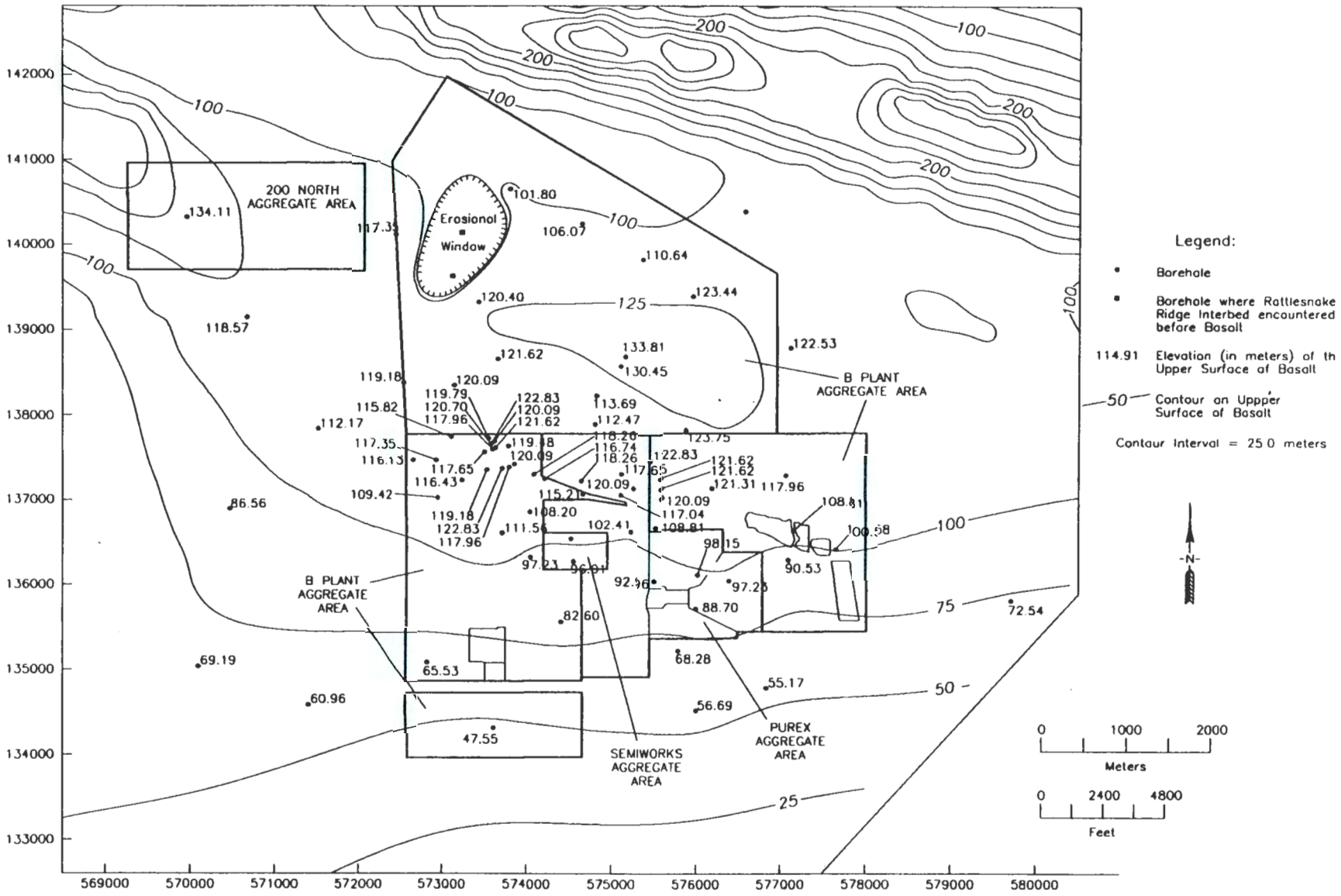


Figure 3-27. Structure Contour Map of the Top of Basalt (Connelly et al. 1992a).

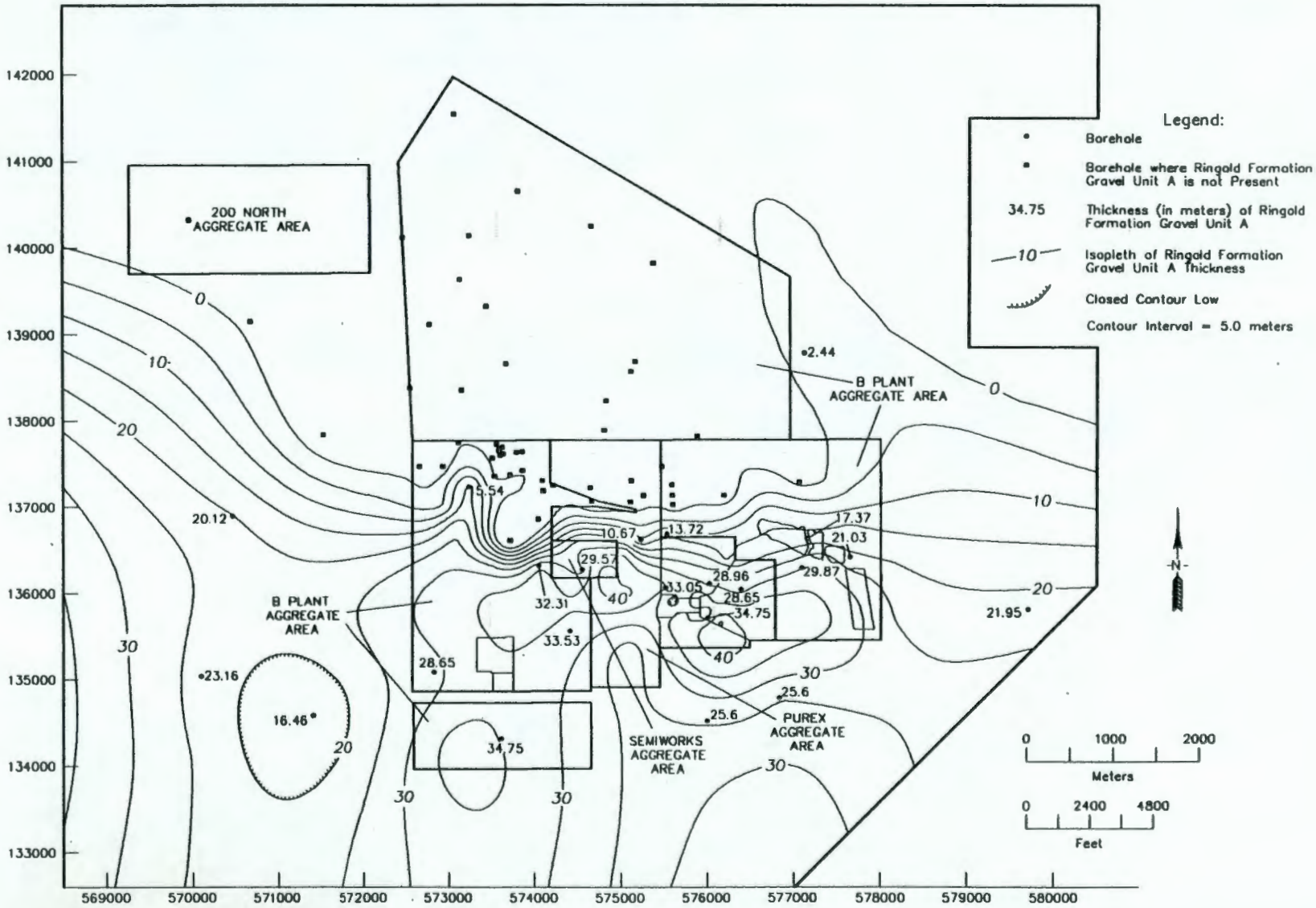


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Figure 3-28. Isopach Map of the Ringold Formation Gravel Unit A (Connelly et al. 1992a).

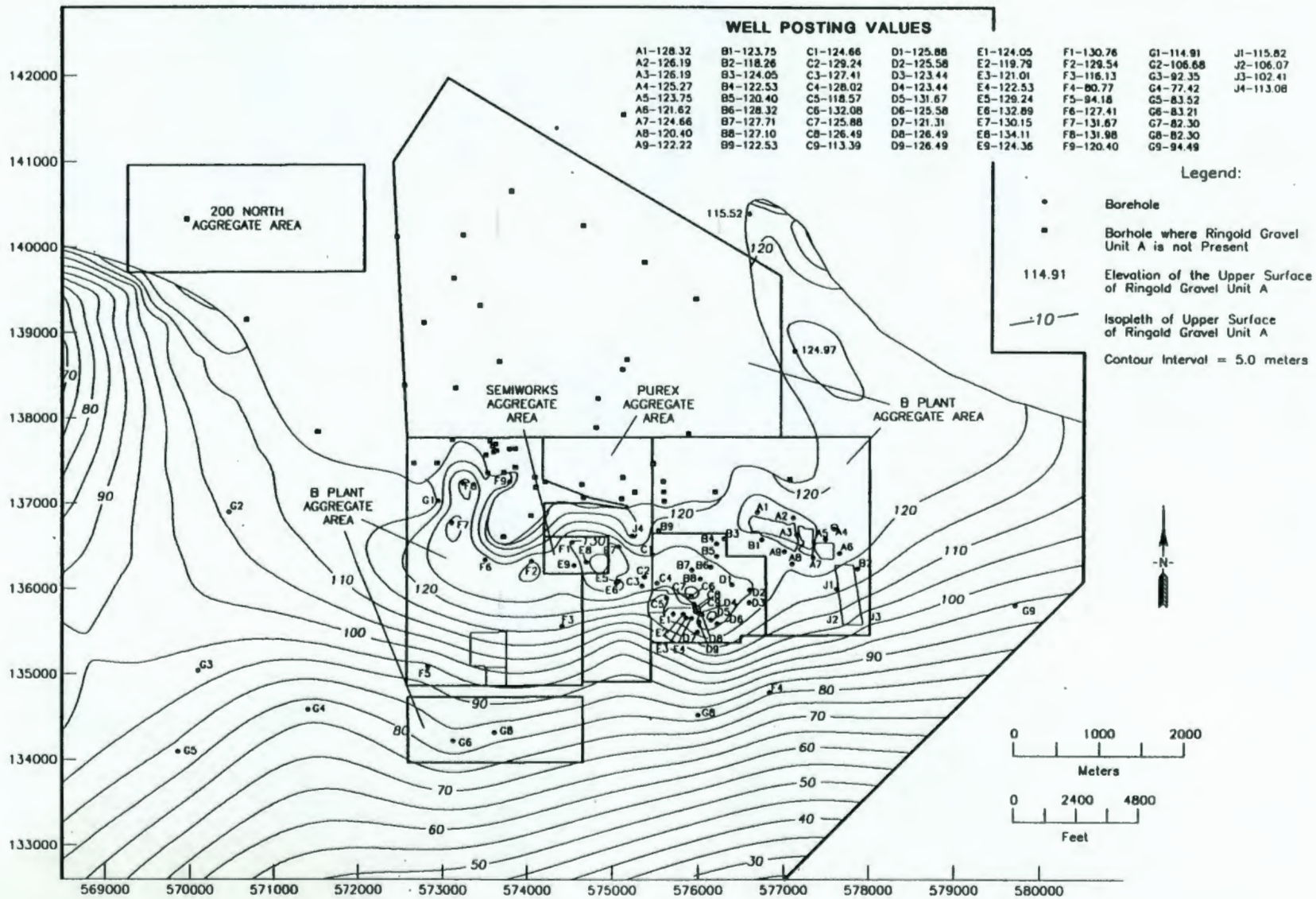

Figure 3-29. Structure Contour Map of the Top of the Ringold Formation Gravel Unit A (Connelly et al. 1992a).

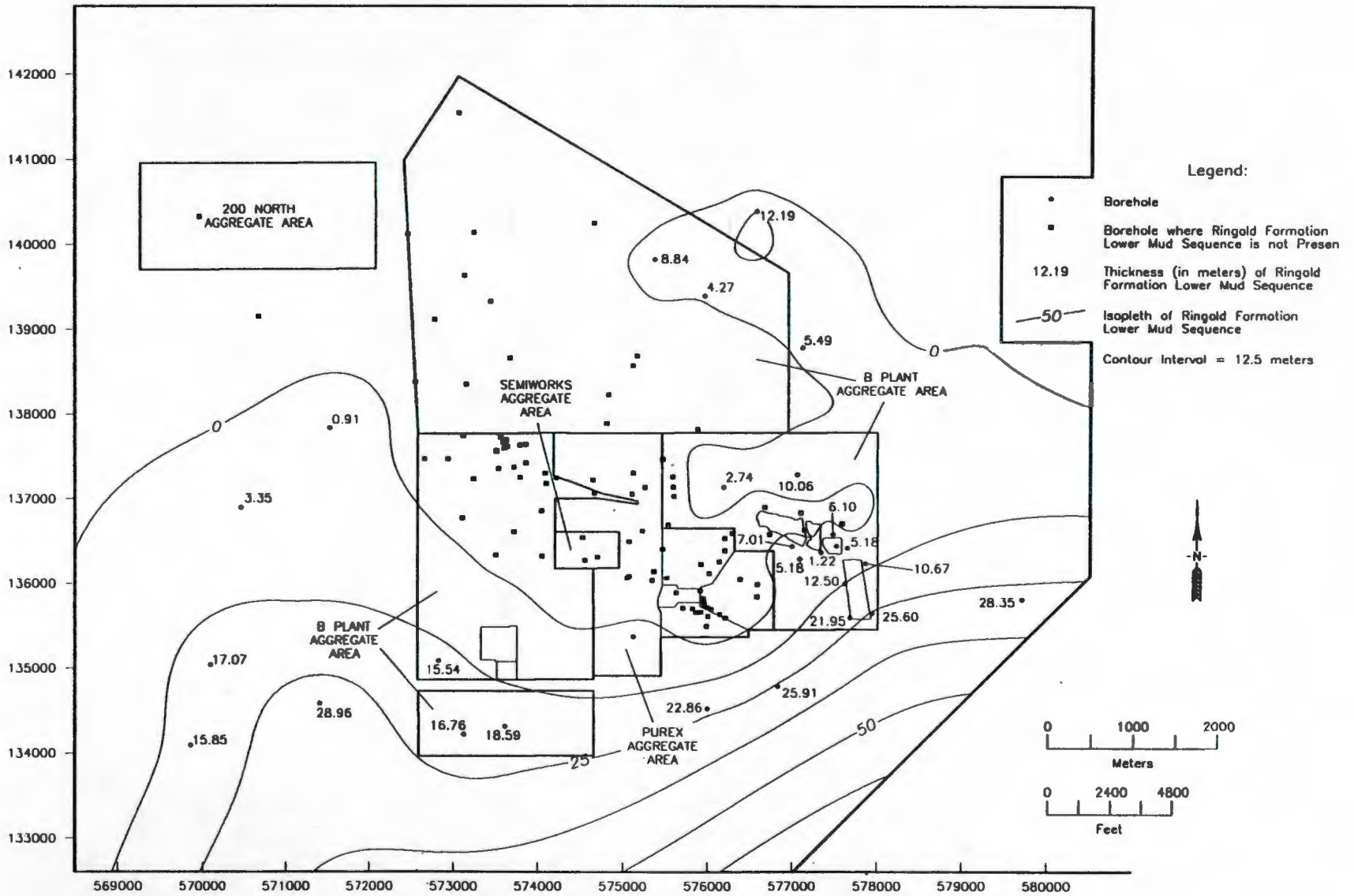

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Figure 3-30. Isopach Map of the Ringold Formation Lower Mud Sequence (Connelly et al. 1992a).

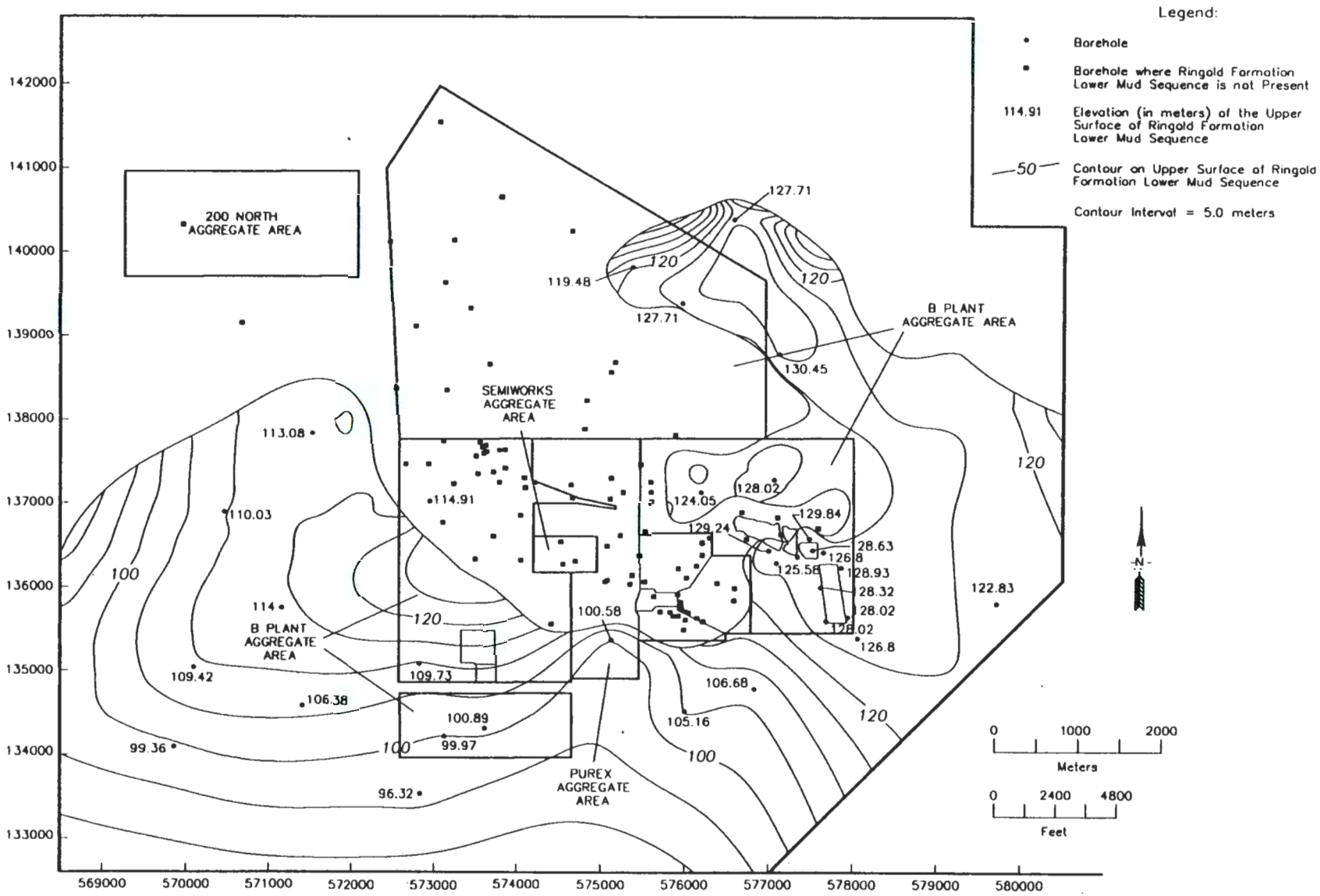
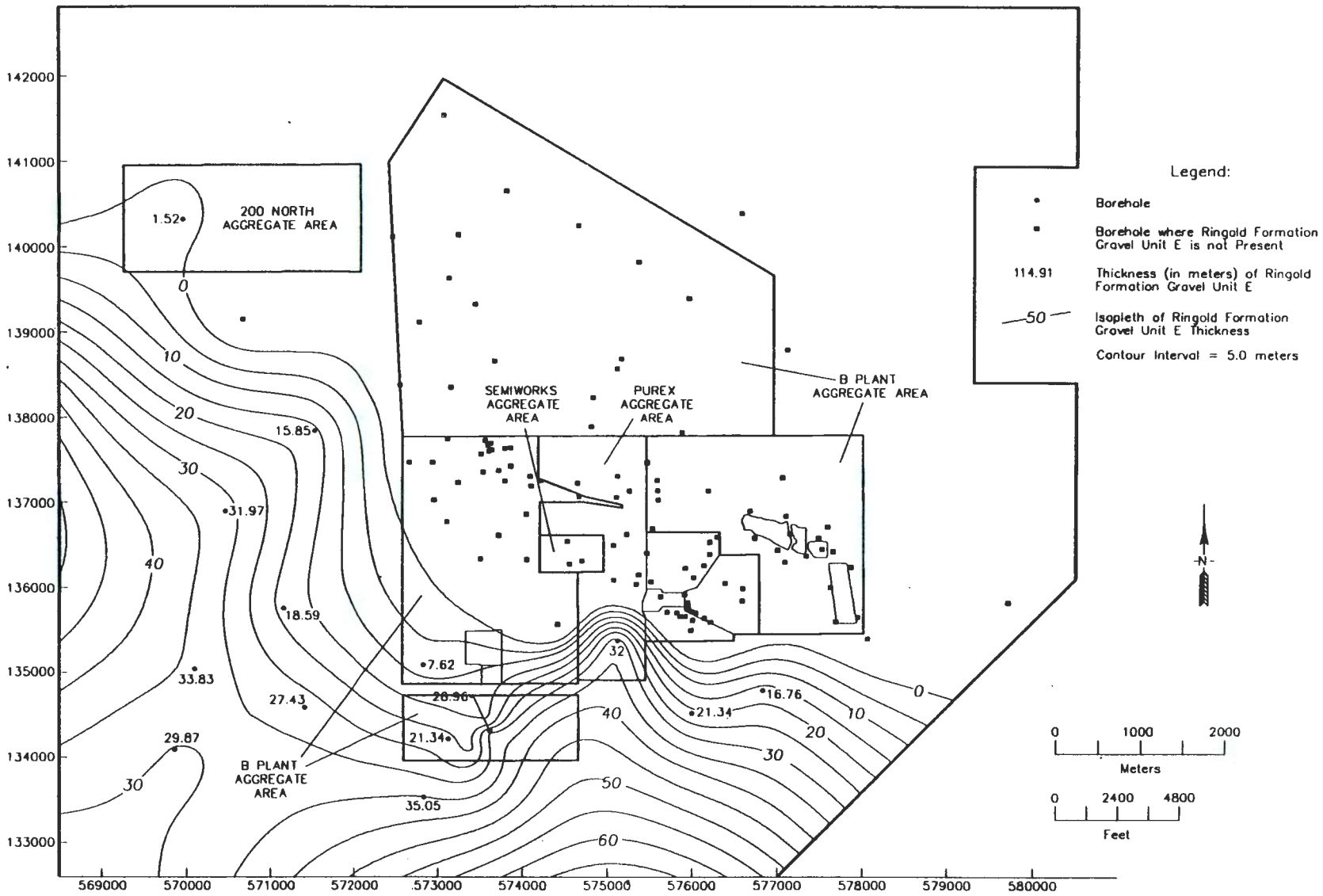


Figure 3-31. Structure Contour Map of the Top of the Ringold Formation Lower Mud Sequence (Connelly et al. 1992a).



200east/060292-a

Figure 3-32. Isopach Map of the Ringold Formation Gravel Unit E (Connelly et al. 1992a).

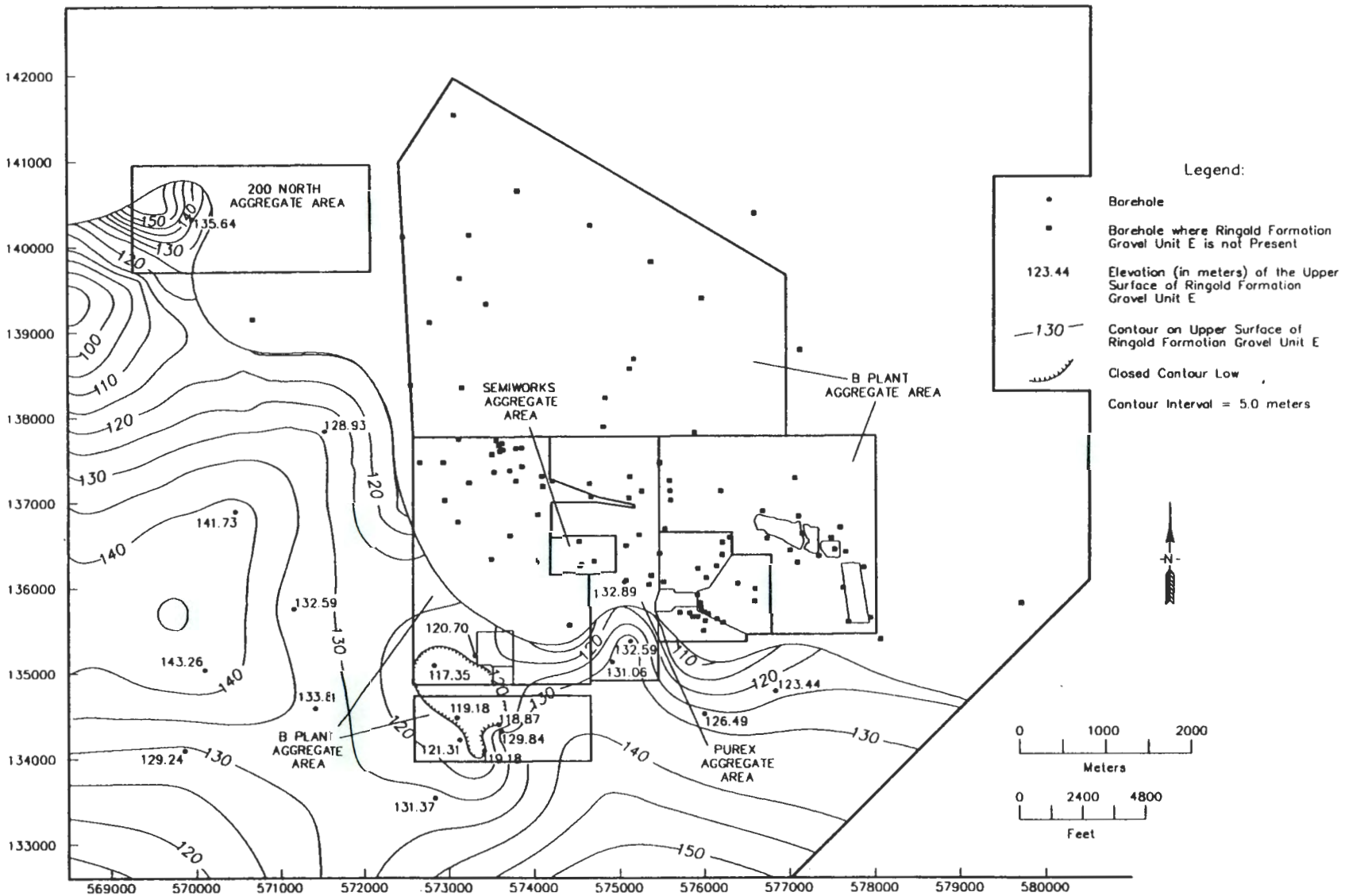


Figure 3-33. Structure Contour Map of the Top of the Ringold Formation Gravel Unit E (Connelly et al. 1992a).

200east/re-top

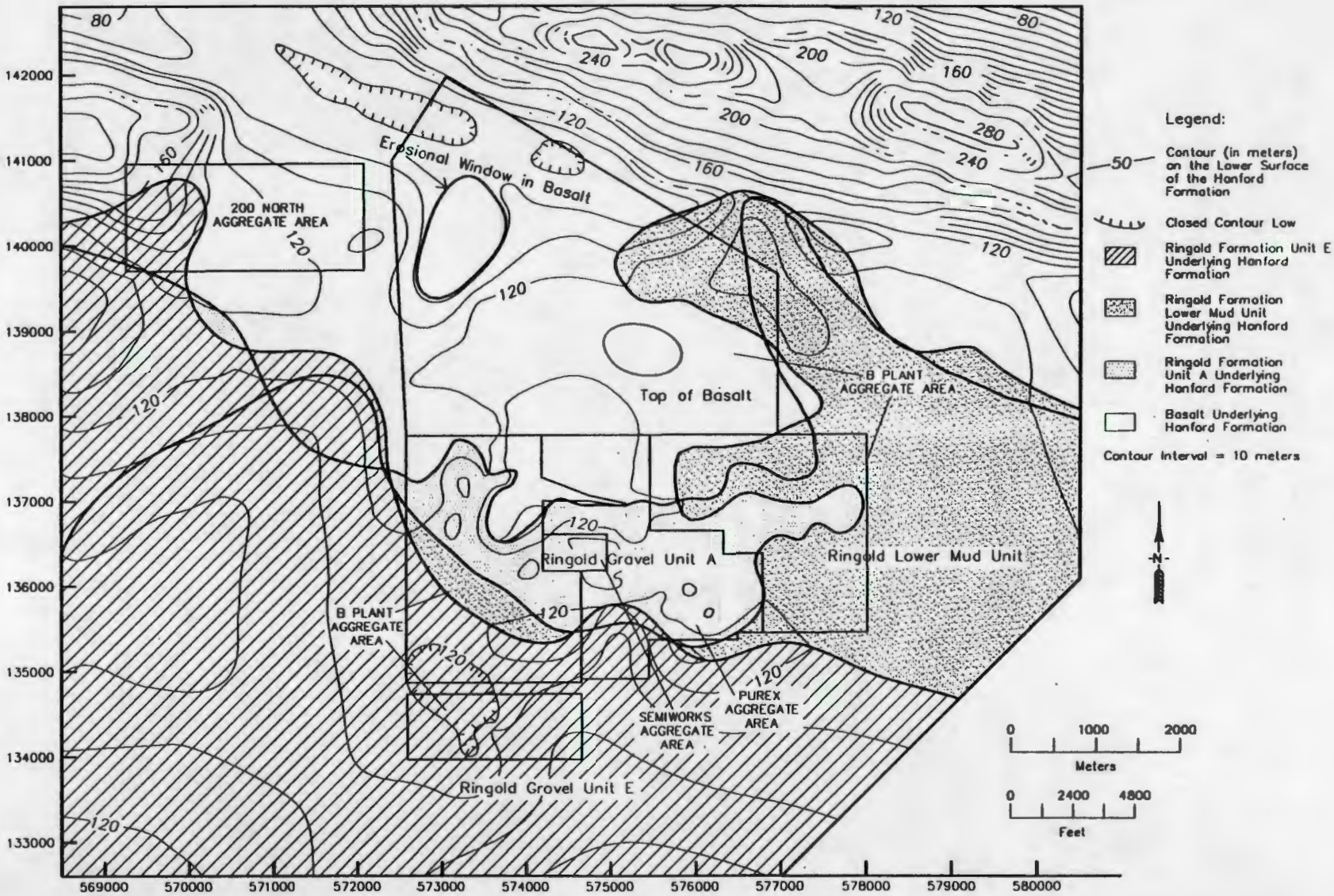


Figure 3-34. Structure Contour Map of the Pre-Hanford Formation Paleogeographic Surface (Connelly et al. 1992a).

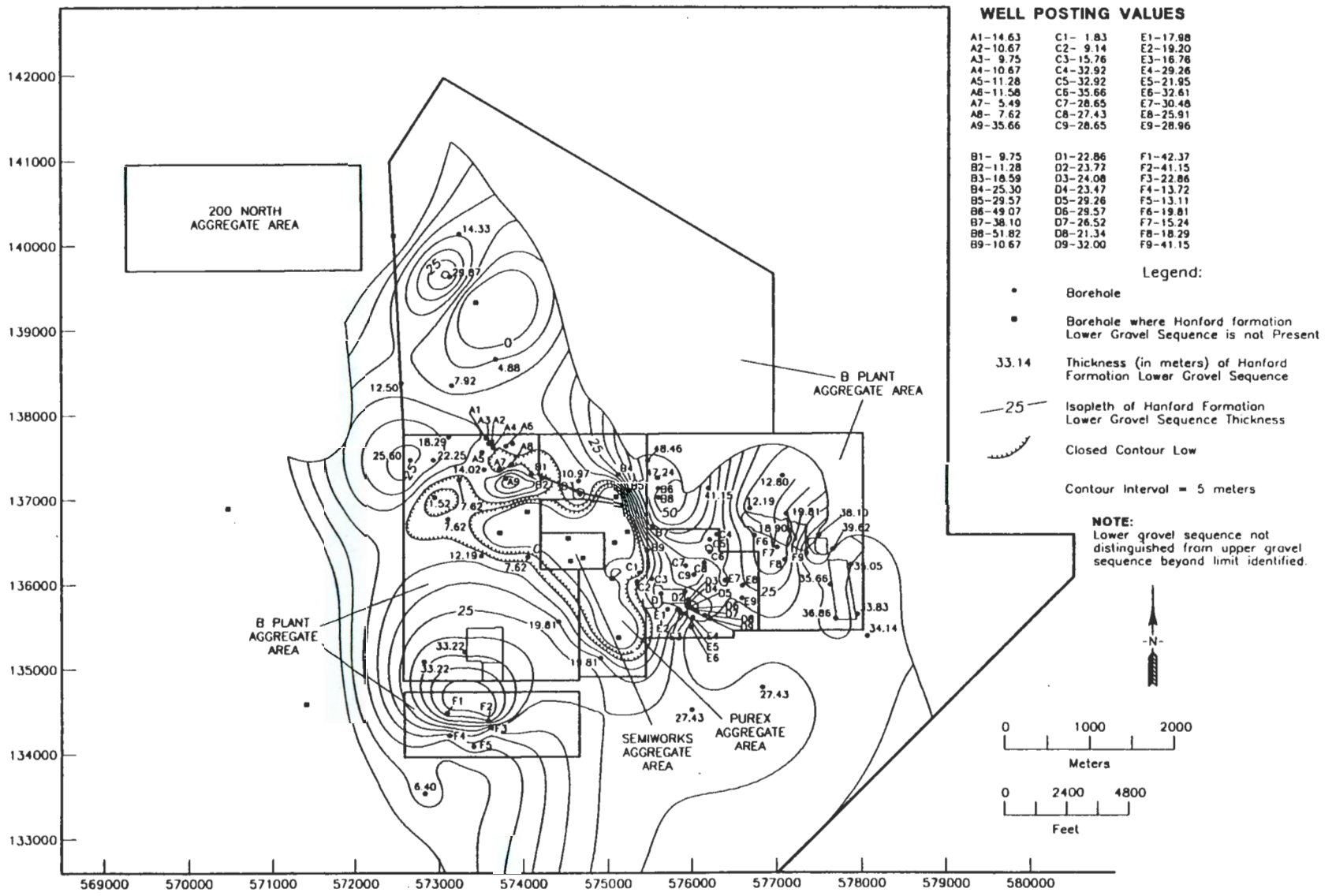


Figure 3-35. Isopach Map of the Hanford Formation Lower Gravel Sequence (Connelly et al. 1992a).

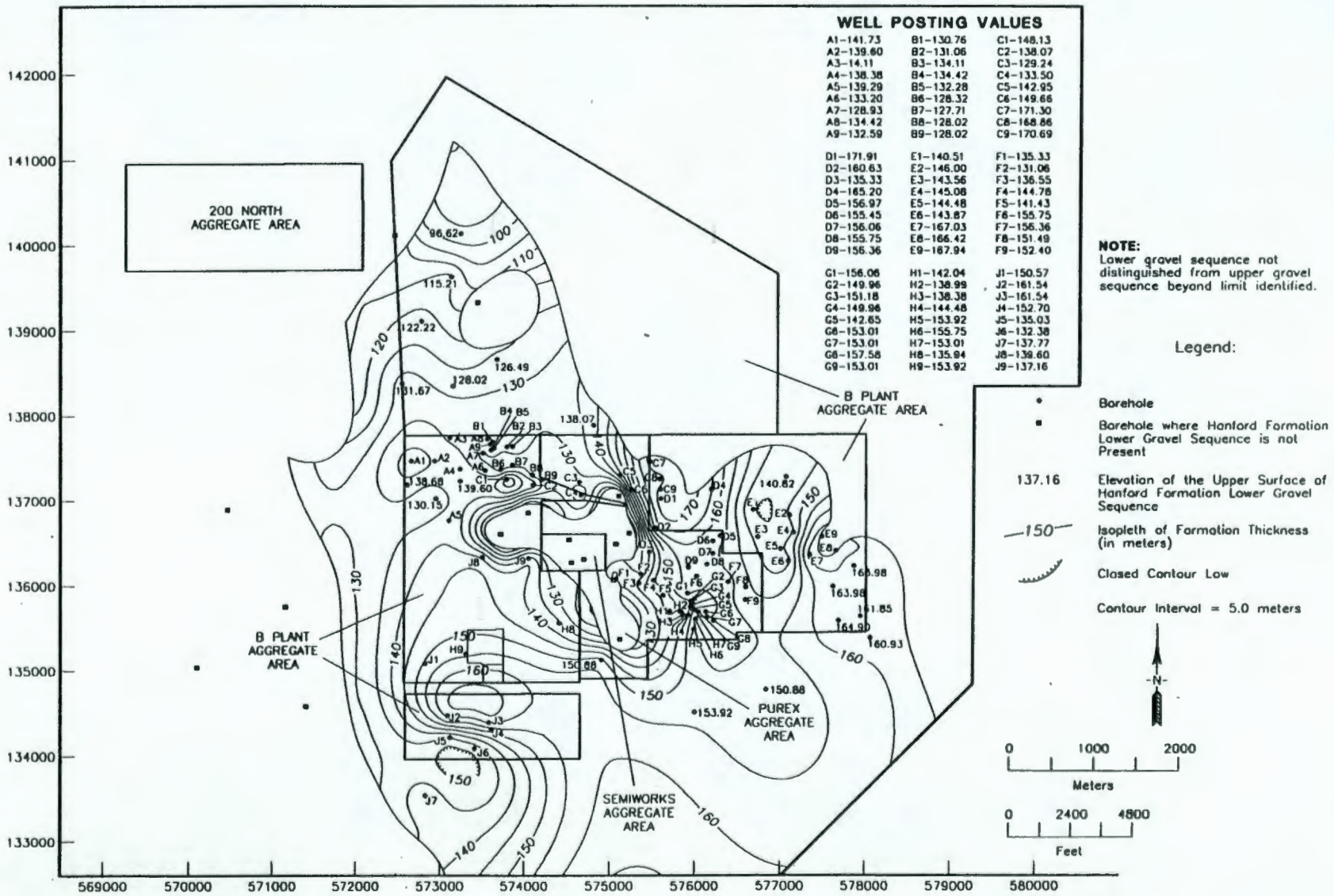


Figure 3-36. Structure Contour Map of the Top of the Hanford Formation Lower Gravel Sequence (Connelly et al. 1992a).

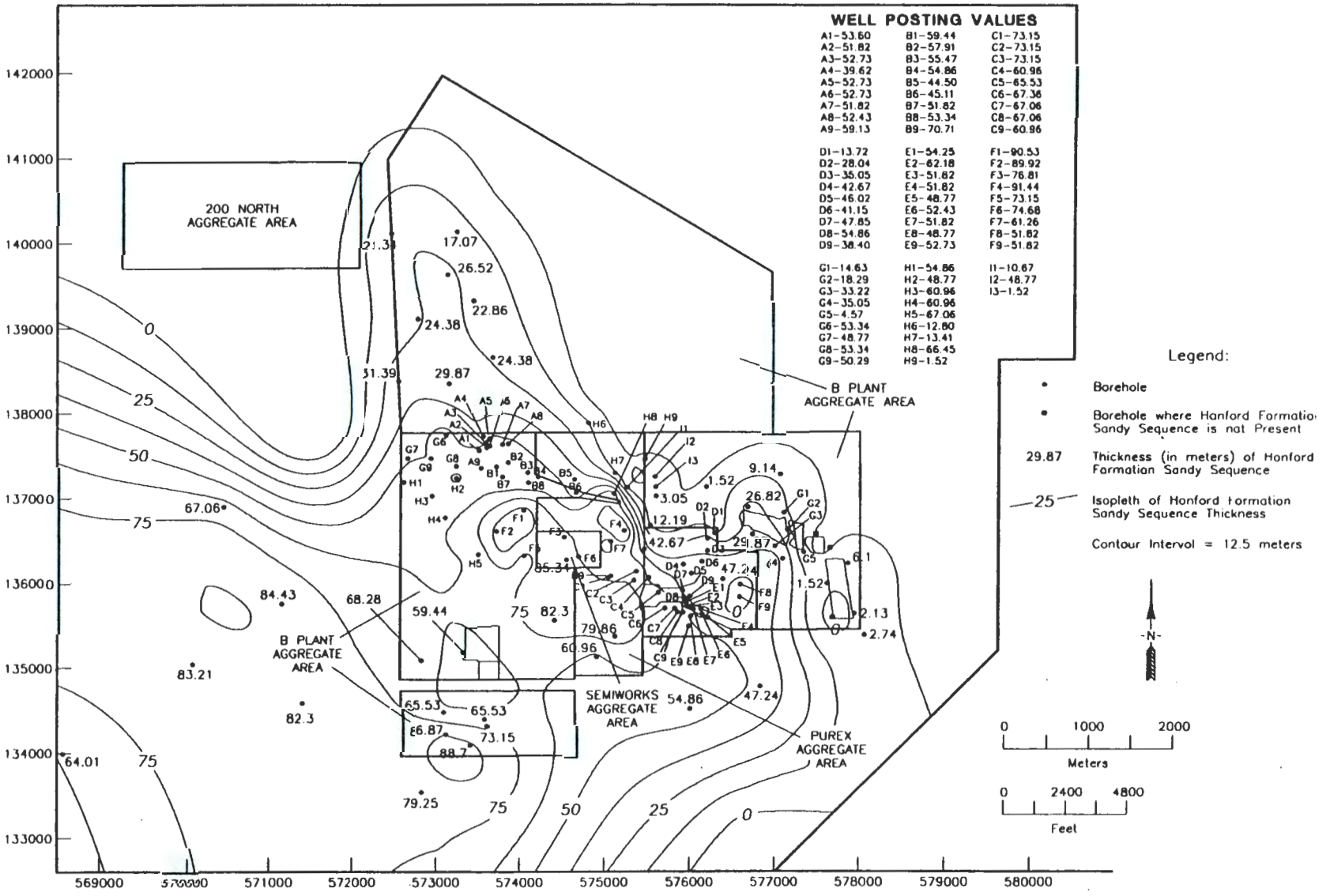


Figure 3-37. Isopach Map of the Hanford Formation Sandy Sequence (Connelly et al. 1992a).

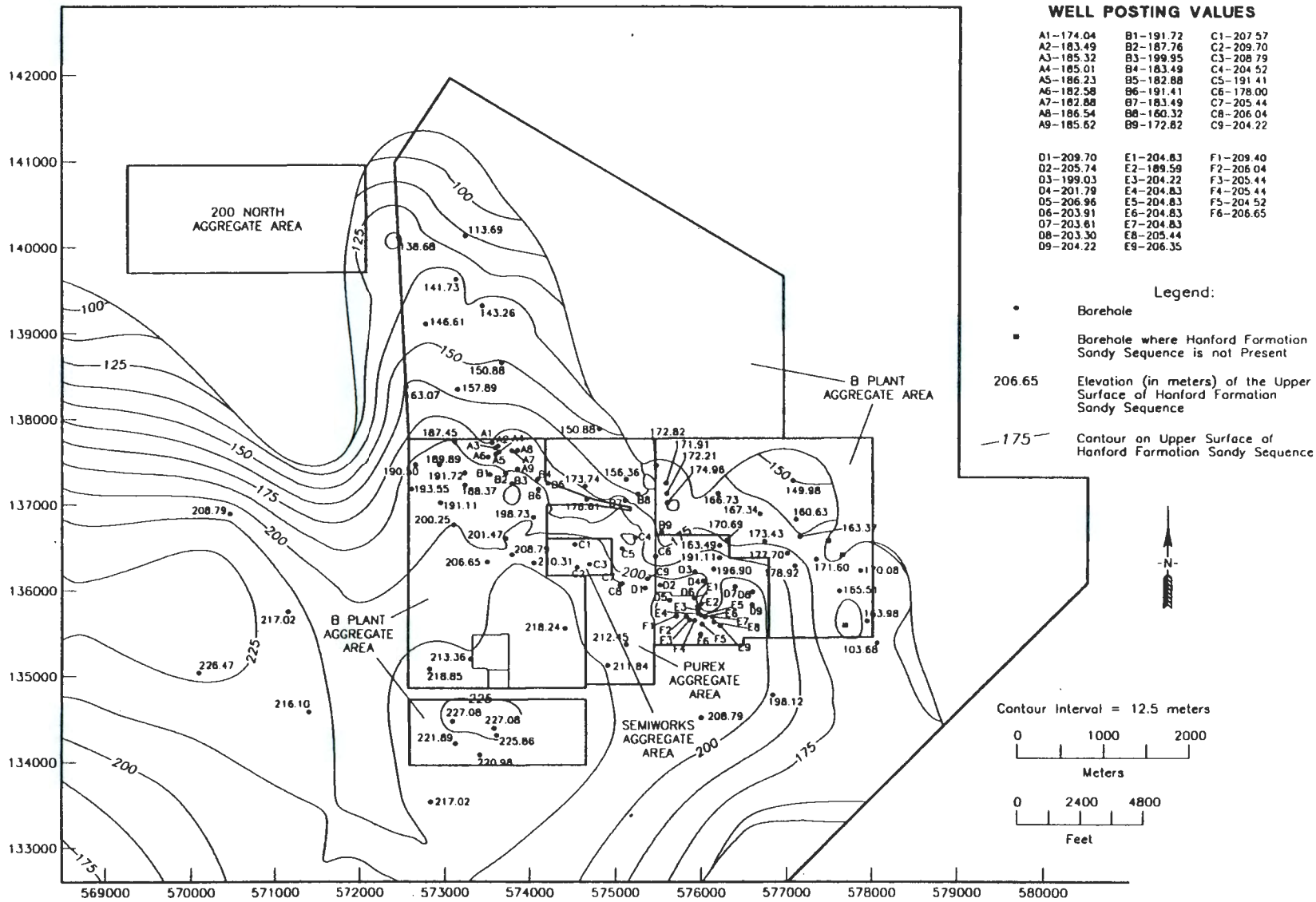


Figure 3-38. Structure Contour Map of the Top of the Hanford Formation Sandy Sequence (Connelly et al. 1992a).

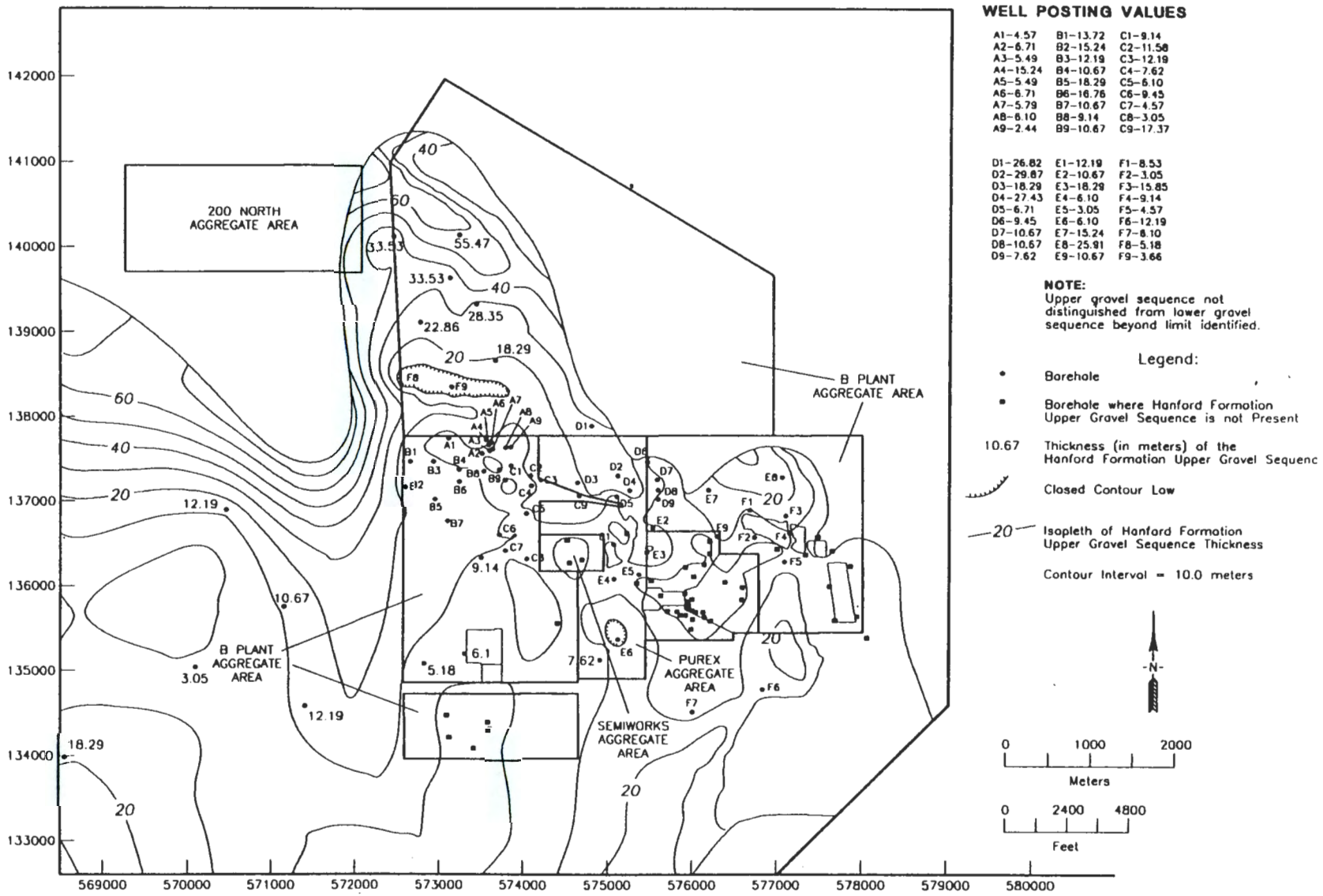


Figure 3-39. Isopach Map of the Hanford Formation Upper Gravel Sequence (Connelly et al. 1992a).

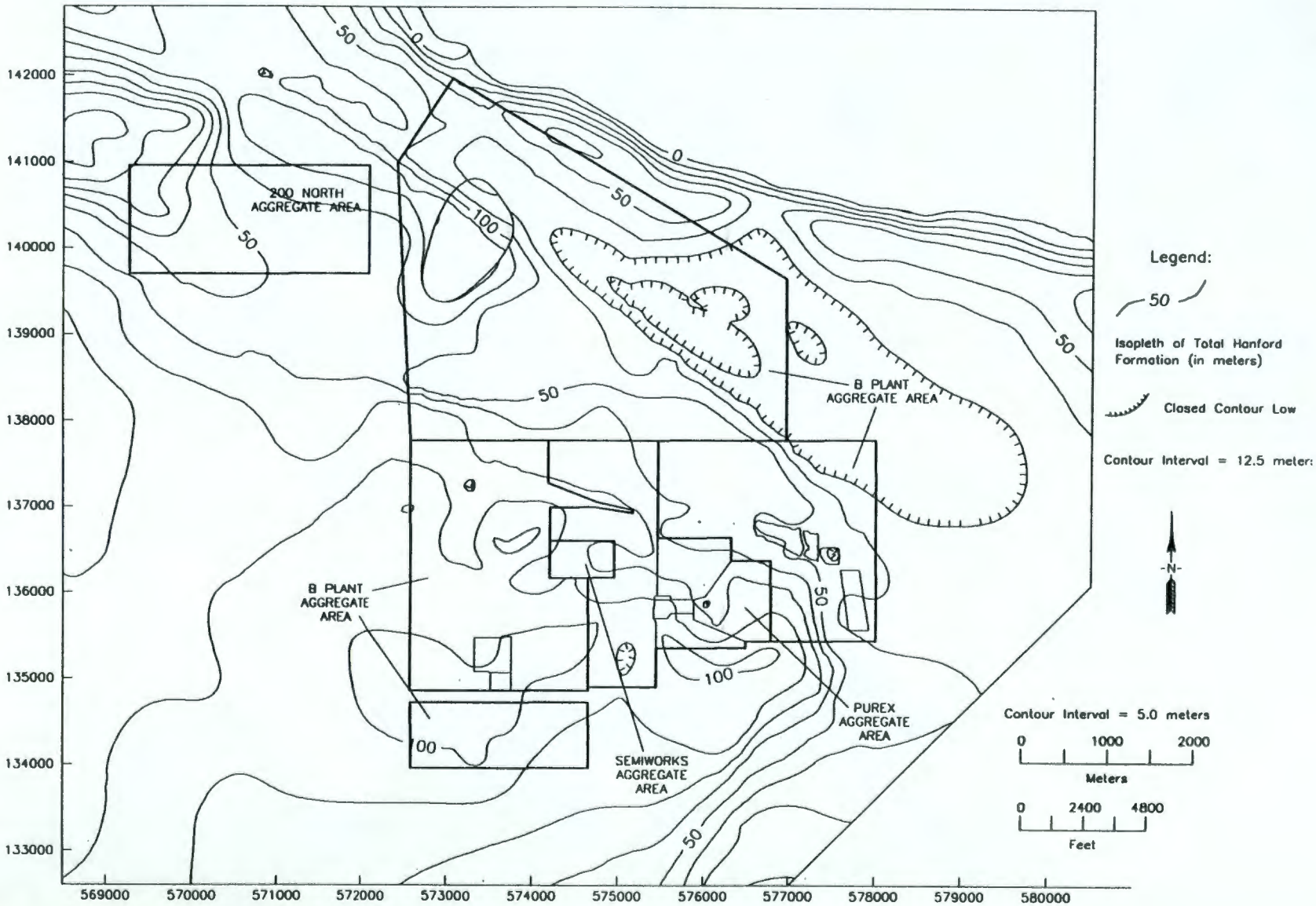


Figure 3-40. Isopach Map of the Entire Hanford Formation (Connelly et al. 1992a).

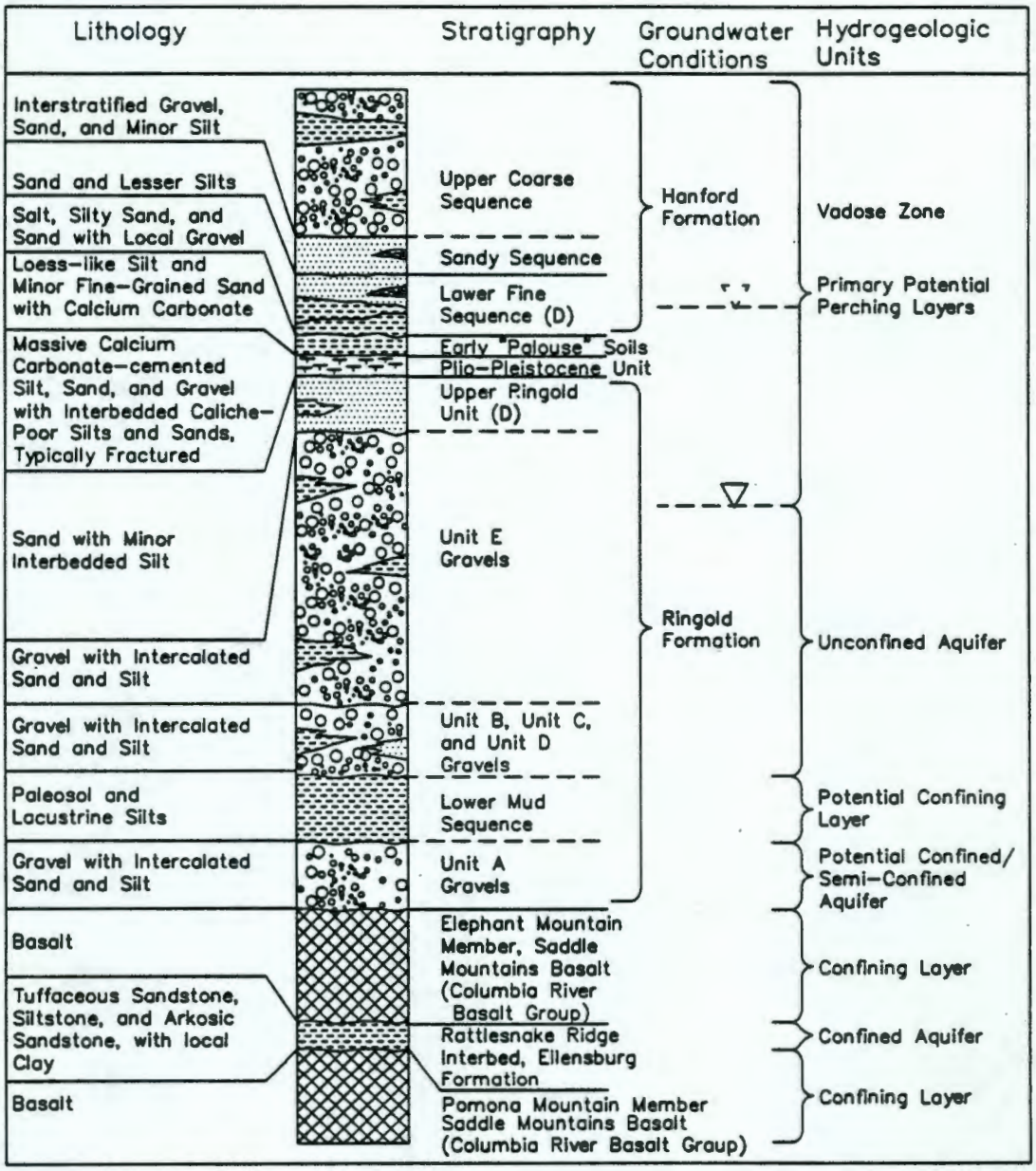
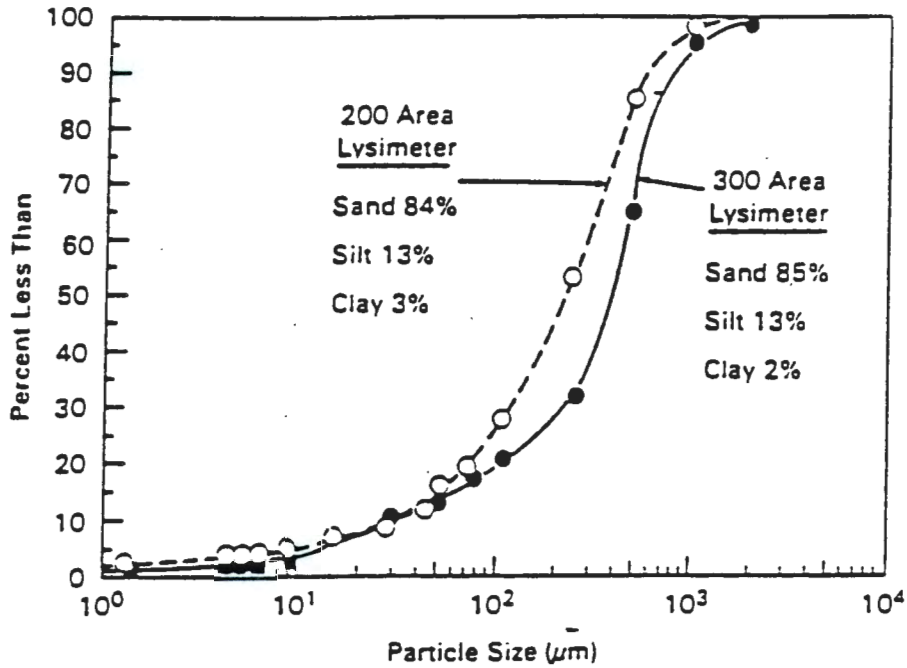
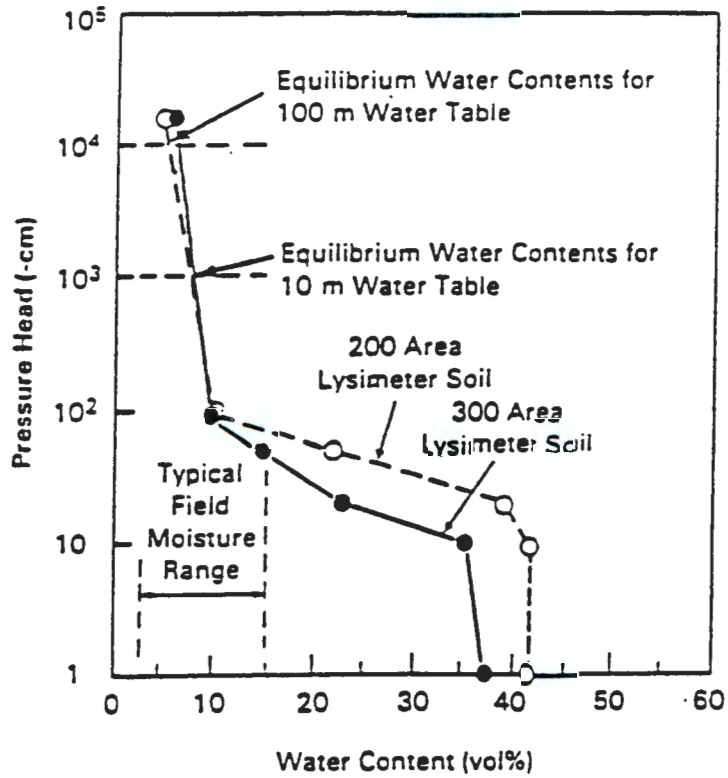


Figure 3-41. Conceptual Hydrogeologic Column for the Hanford Site.

9 3 1 2 9 7 1 3 5 9



a. Particle-Size Distribution



b. Water Retention Characteristics

Figure 3-42. Particle-Size Distribution and Water Retention Characteristics of Soils from Hanford Site Lysimeters (Gee and Heller 1985).

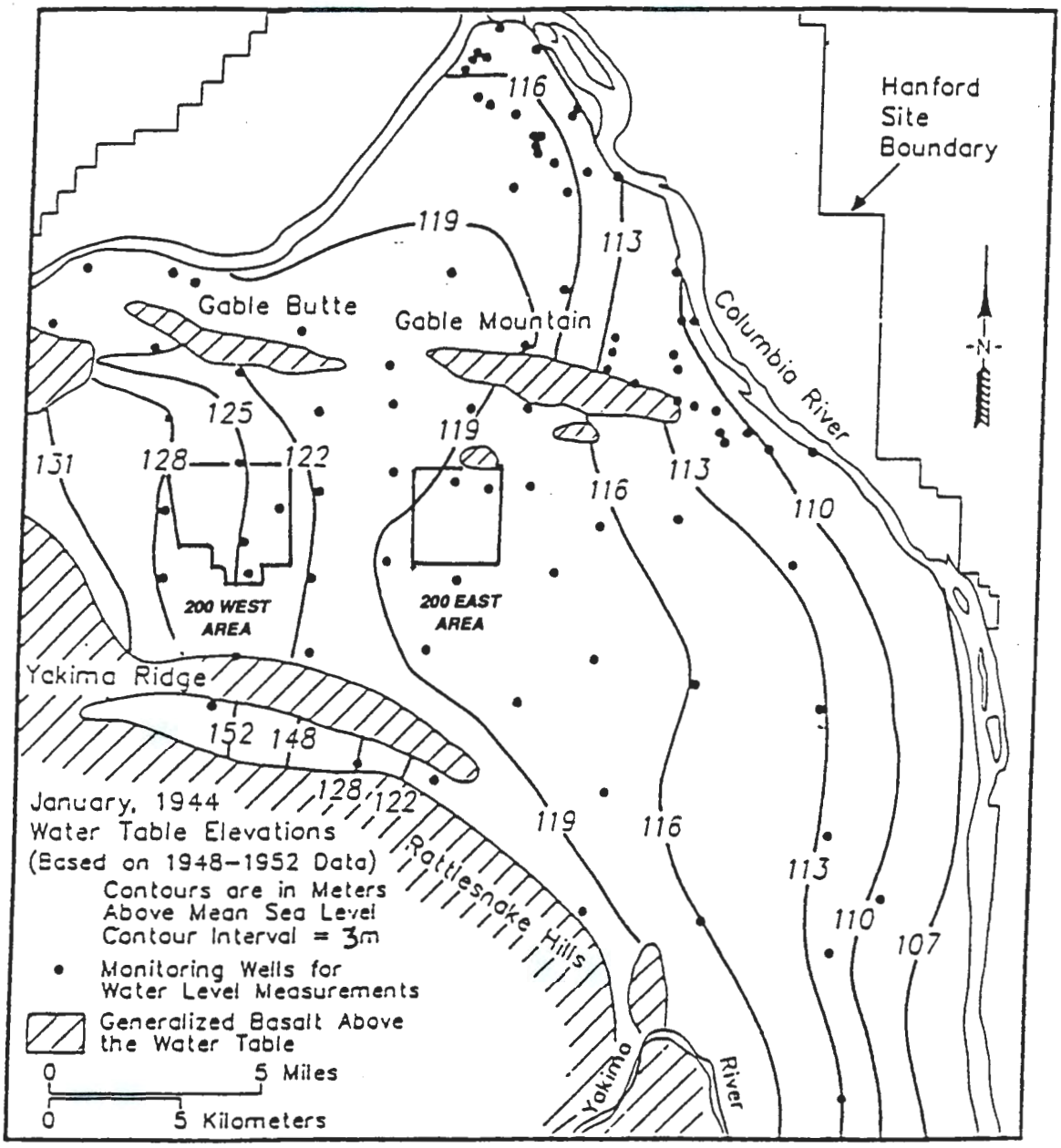
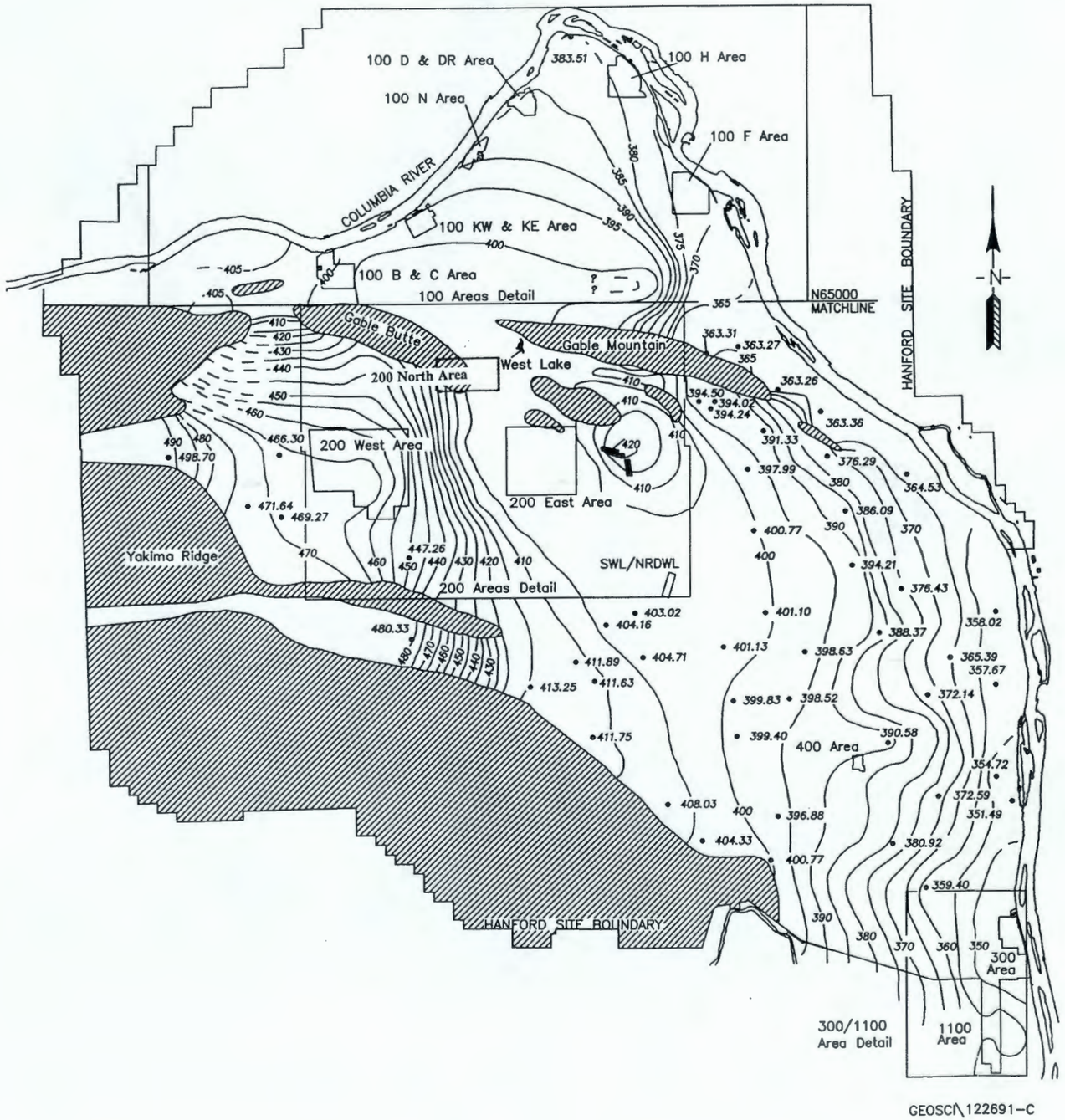


Figure 3-43. Hindcast Water Table Map of the Hanford Site, January 1944 (ERDA 1975).



Hanford Site Water Table Map

411.49 • Water table elevation (feet above mean sea level)

400 Water table contours in feet above mean sea level Contour Interval = 5 ft

Contour Lines are dashed where approximated.

Ponds

Areas where the basalt surface is generally above the water table

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

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

From: Kasza, et al., 1991

0 1 Mile
0 1 Kilometer

Figure 3-44. Hanford Site Water Table Map, June 1991 (Kasza et al. 1991).

9 3 1 2 9 - 7 1 3 6 2

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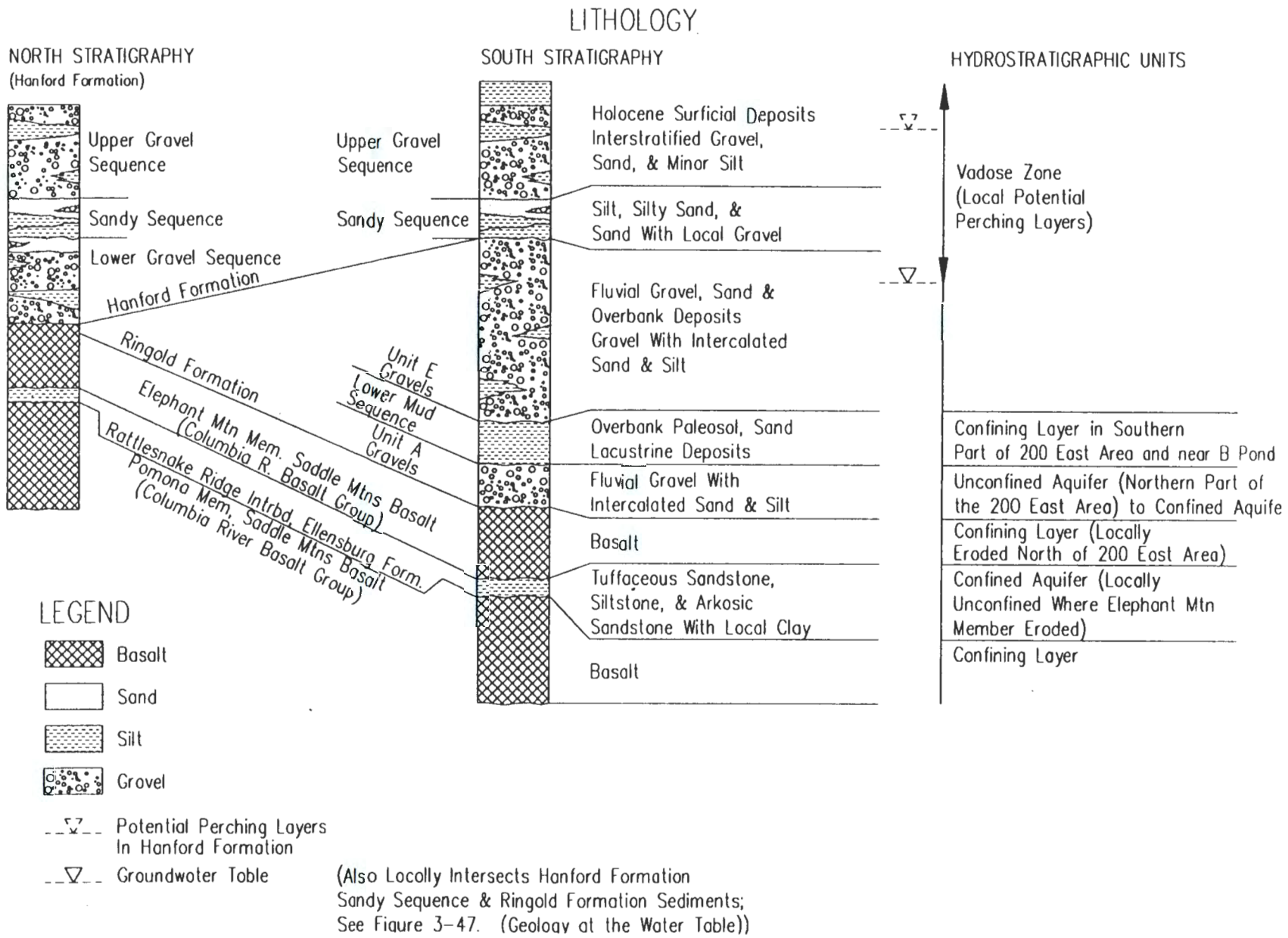


Figure 3-45. Conceptual Hydrogeologic Column for the 200 East Area (Lindsey et al. 1992; Connelly et al. 1992a; Delaney et al. 1991).

200east/2east001

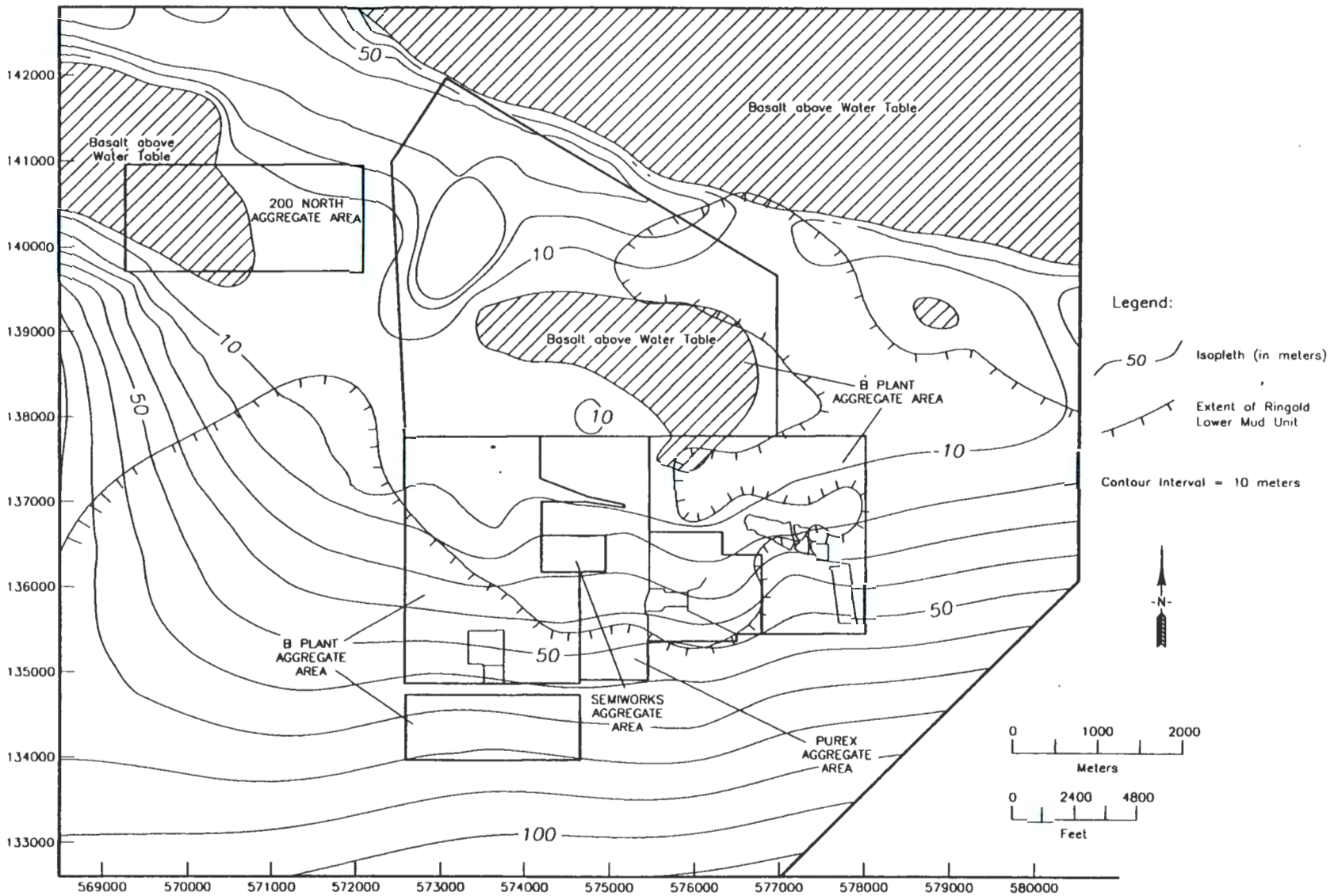


Figure 3-46. Isopach Map of the Uppermost Aquifer Saturated Zone in the 200 East Area (Connelly et al. 1992a).

9 3 1 2 9 7 1 3 6 5

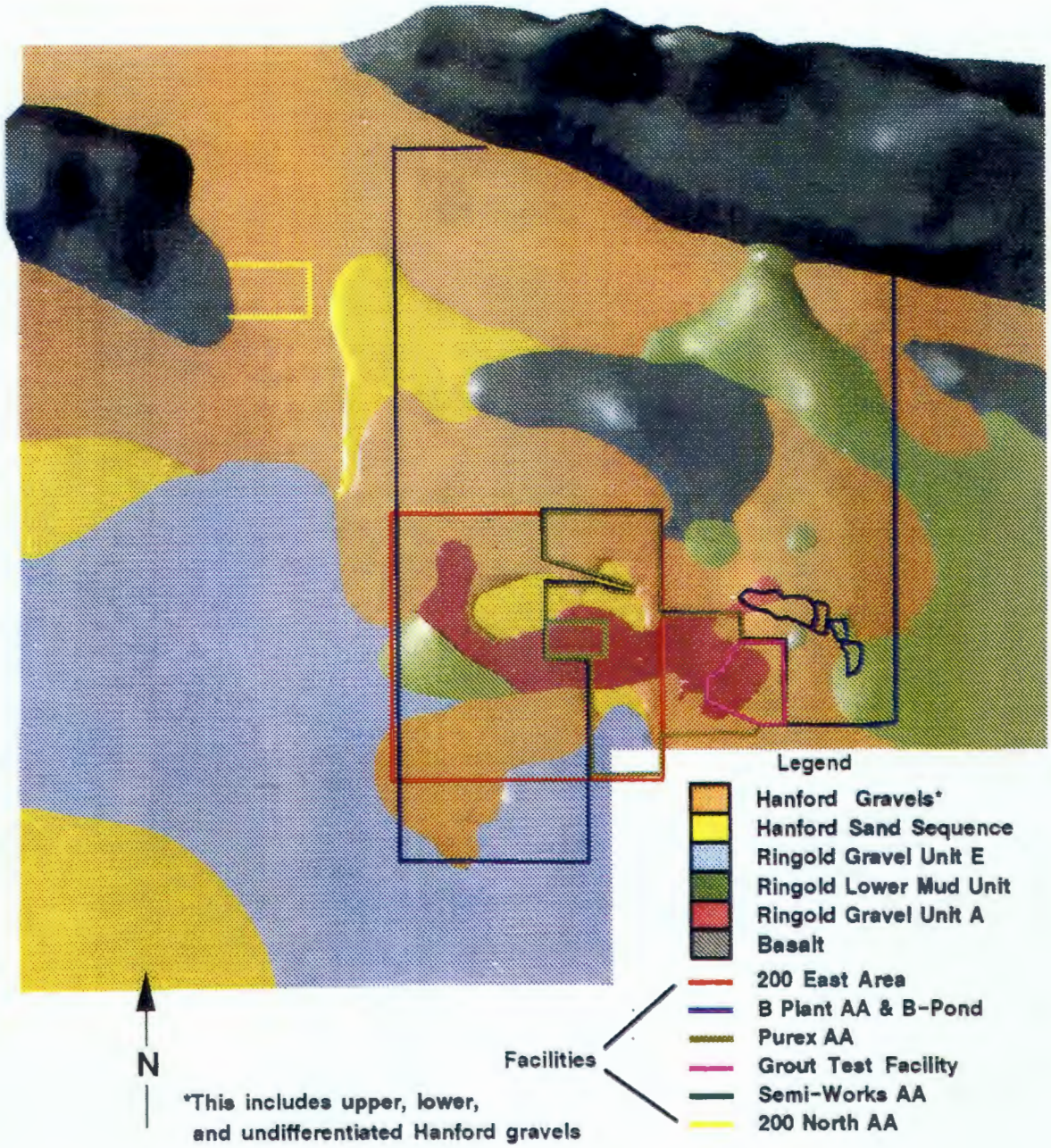


Figure 3-47. Geology of the Water Table for 1991 (Connelly et al. 1992a).

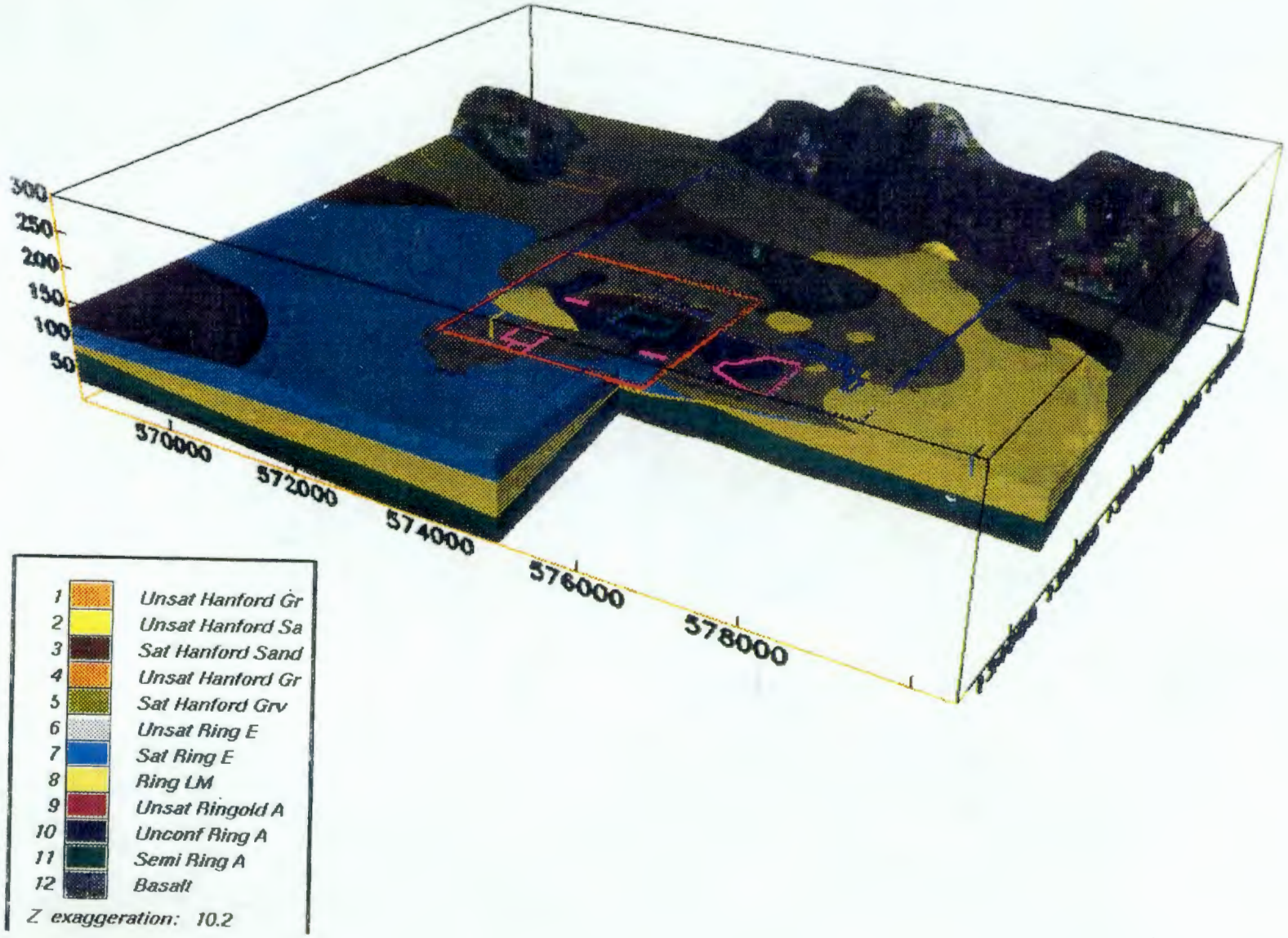
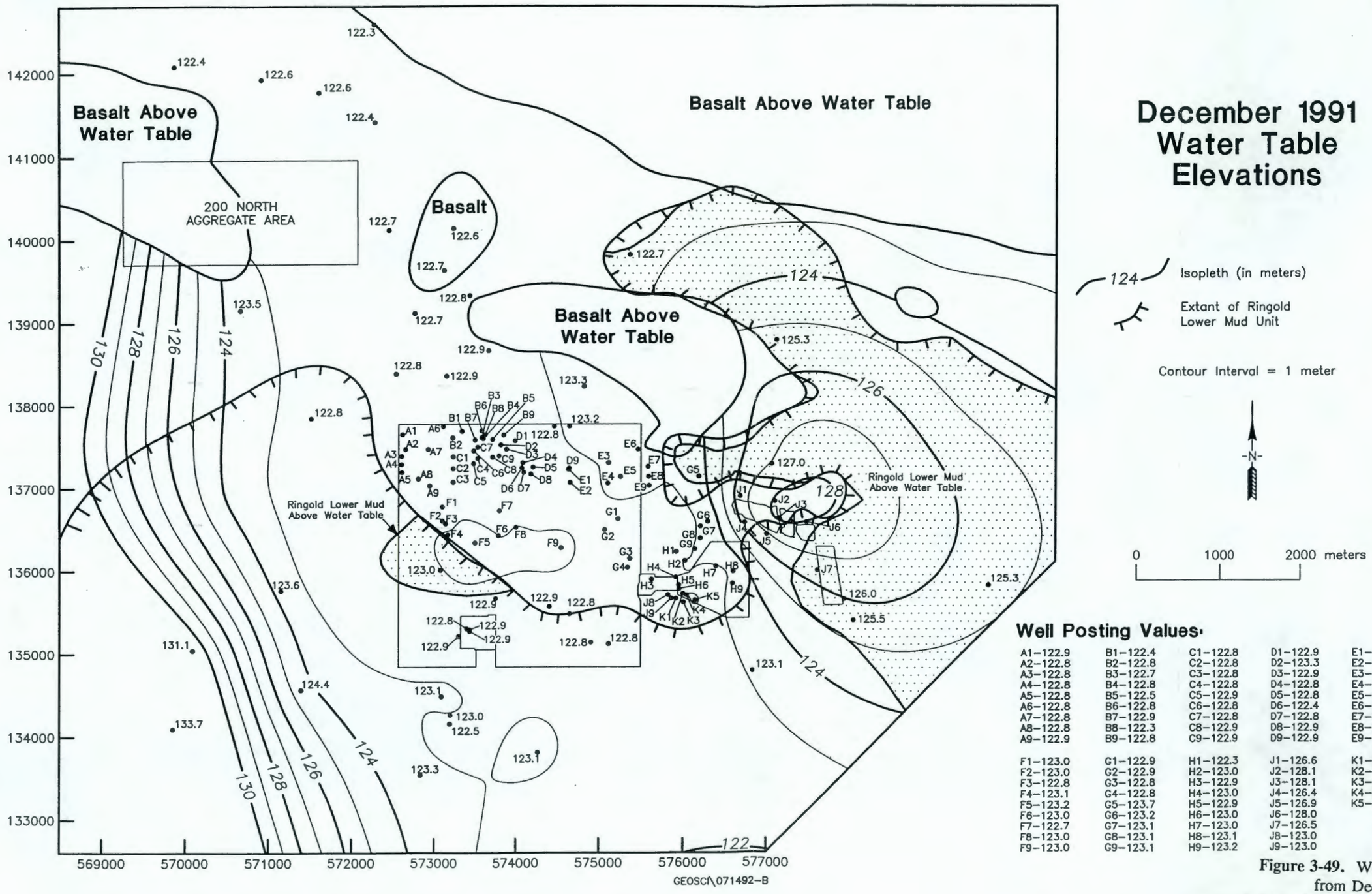


Figure 3-48. Uppermost Aquifer System (Connelly et al. 1992a).

9 3 1 2 9 7 1 3 6 7



Well Posting Values

A1–122.9	B1–122.4	C1–122.8	D1–122.9	E1–122.9
A2–122.8	B2–122.8	C2–122.8	D2–123.3	E2–122.9
A3–122.8	B3–122.7	C3–122.8	D3–122.9	E3–123.0
A4–122.8	B4–122.8	C4–122.8	D4–122.8	E4–123.0
A5–122.8	B5–122.5	C5–122.9	D5–122.8	E5–123.1
A6–122.8	B6–122.8	C6–122.8	D6–122.4	E6–123.1
A7–122.8	B7–122.9	C7–122.8	D7–122.8	E7–123.1
A8–122.8	B8–122.3	C8–122.9	D8–122.9	E8–123.1
A9–122.9	B9–122.8	C9–122.9	D9–122.9	E9–123.1
F1–123.0	G1–122.9	H1–122.3	J1–126.6	K1–122.9
F2–123.0	G2–122.9	H2–123.0	J2–128.1	K2–122.8
F3–122.8	G3–122.8	H3–122.9	J3–128.1	K3–122.9
F4–123.1	G4–122.8	H4–123.0	J4–126.4	K4–123.0
F5–123.2	G5–123.7	H5–122.9	J5–126.9	K5–123.0
F6–123.0	G6–123.2	H6–123.0	J6–128.0	
F7–122.7	G7–123.1	H7–123.0	J7–126.5	
F8–123.0	G8–123.1	H8–123.1	J8–123.0	
F9–123.0	G9–123.1	H9–123.2	J9–123.0	

Figure 3-49. Water Table Elevations from December 1991 for the 200 East Area (Kasza et al. 1992).

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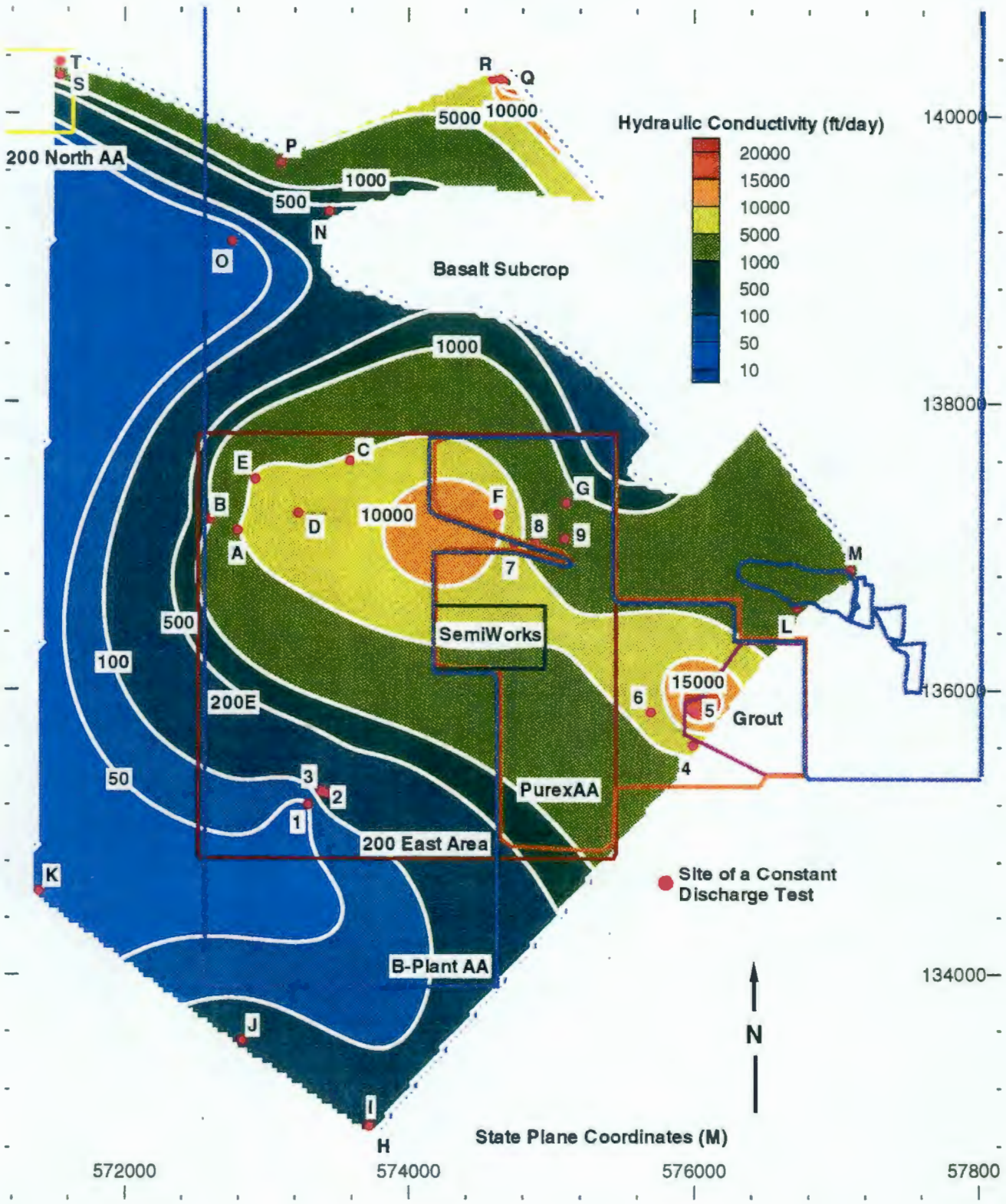
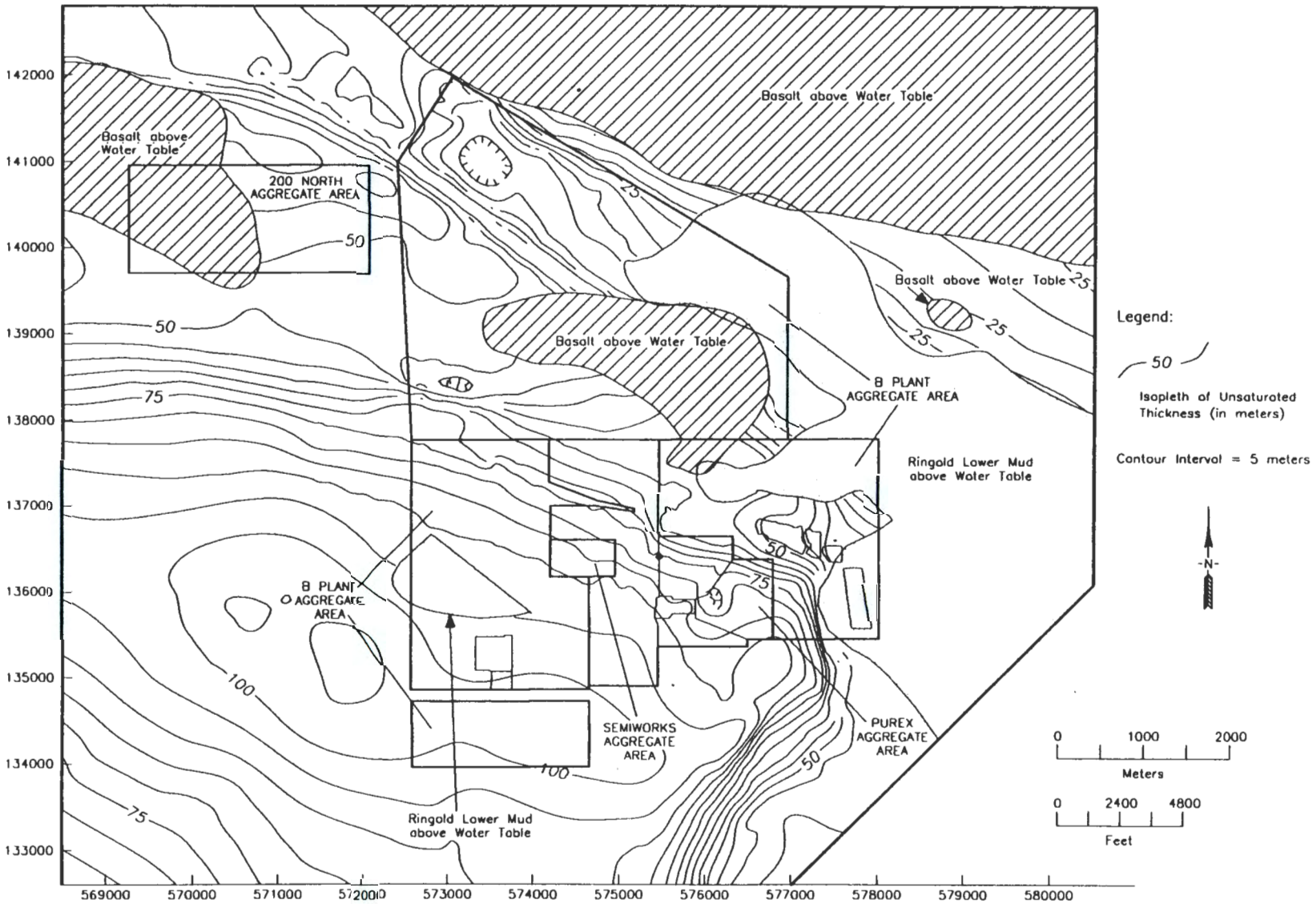
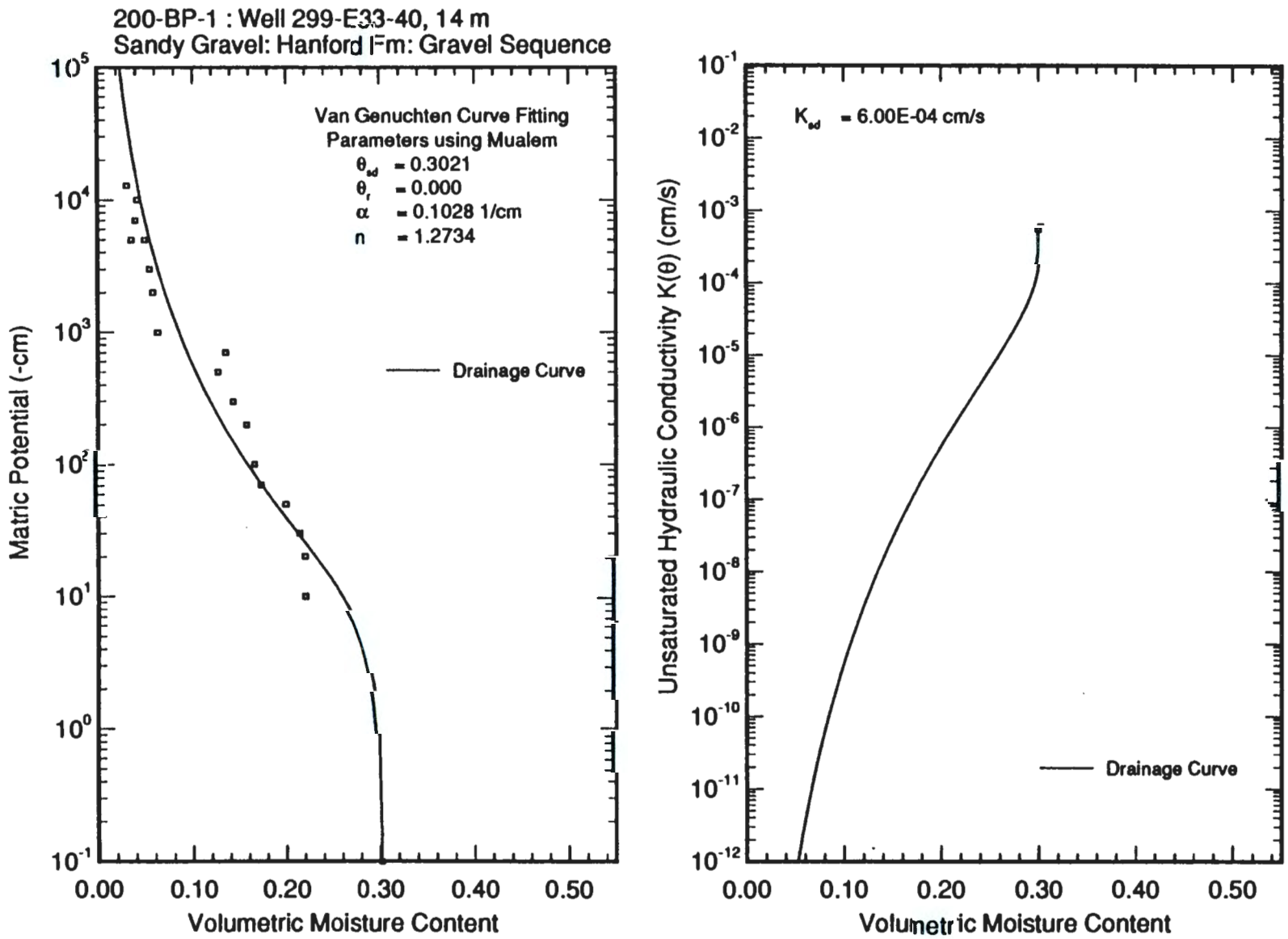


Figure 3-50. Hydraulic Conductivities of the Uppermost Aquifer in the 200 East Area (Connelly et al. 1992a).



200east/070892-b

Figure 3-51. Isopach Map of the Vadose Zone in the 200 East Area (Connelly et al. 1992a).



ETGTEC043003-4ETC

Figure 3-52. Wetting and Drying Curves with Matric Potential and Hydraulic Conductivity for Well 299-W18-21 (Connelly et al. 1992a).

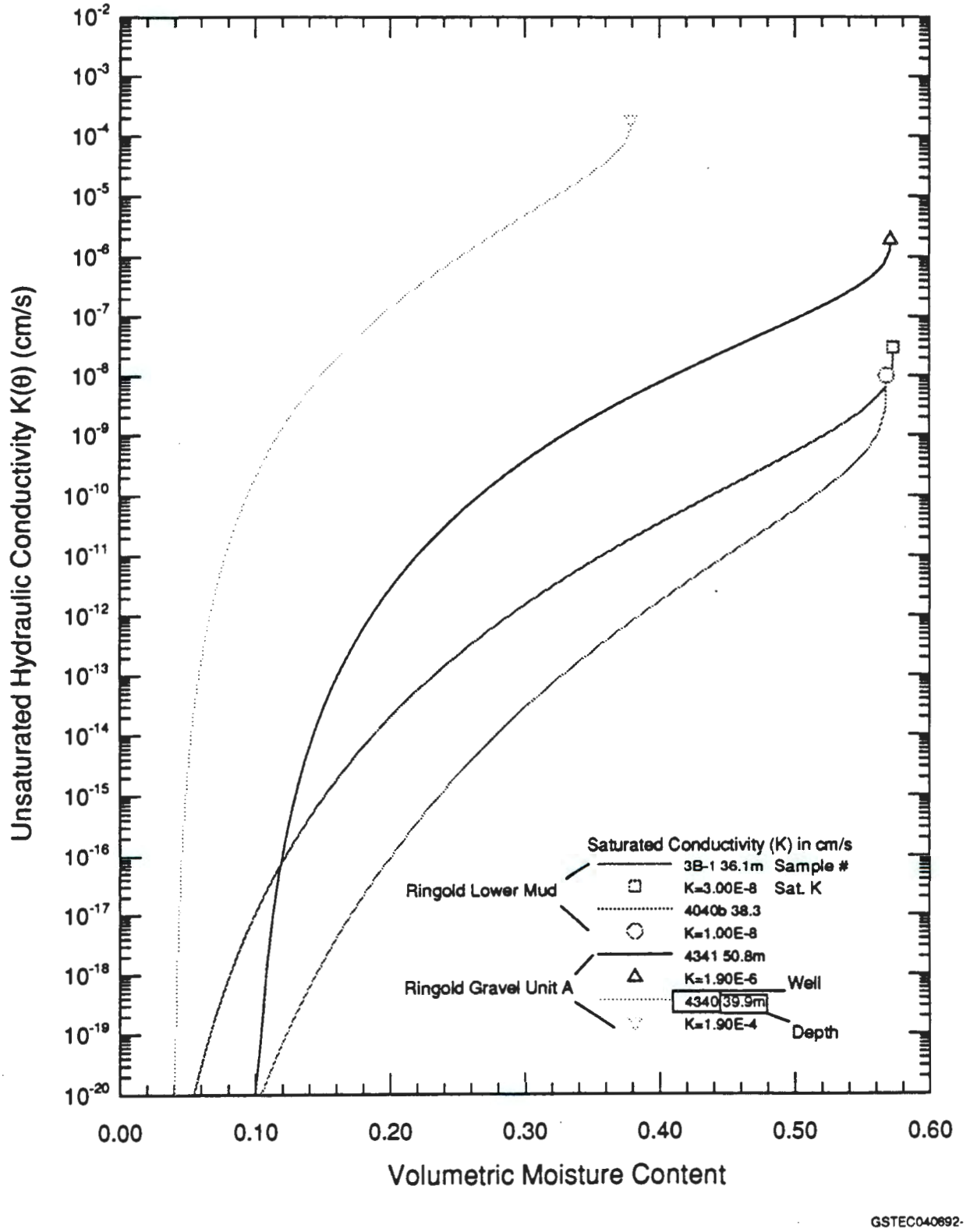


Figure 3-53. Ringold Unit A and Lower Mud Sequence Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992a).

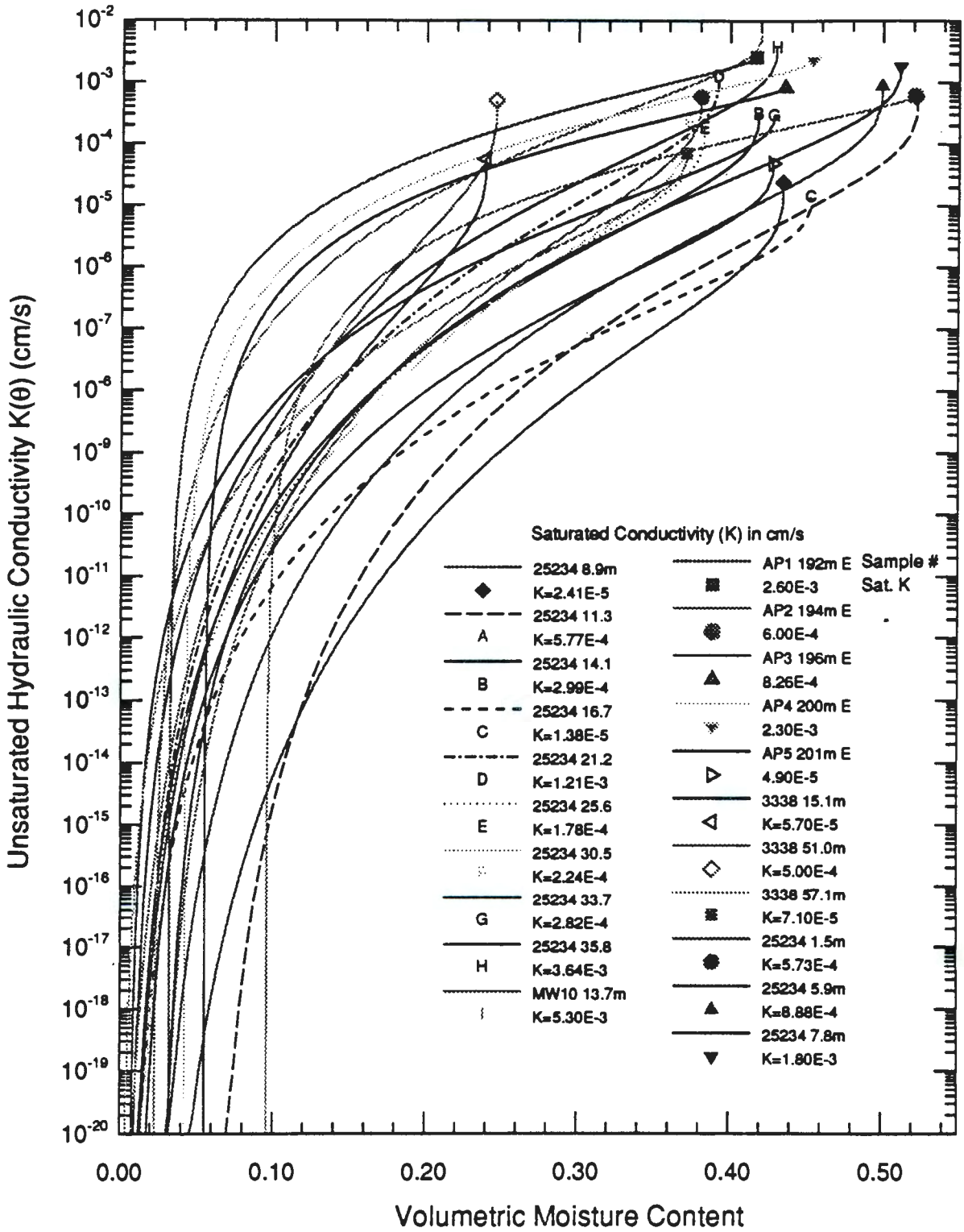


Figure 3-54. Hanford Formation Sandy Sequence Unsaturated Hydraulic Conductivity Curves for Drying Conditions--Drainage Set 1 (Connelly et al. 1992a).

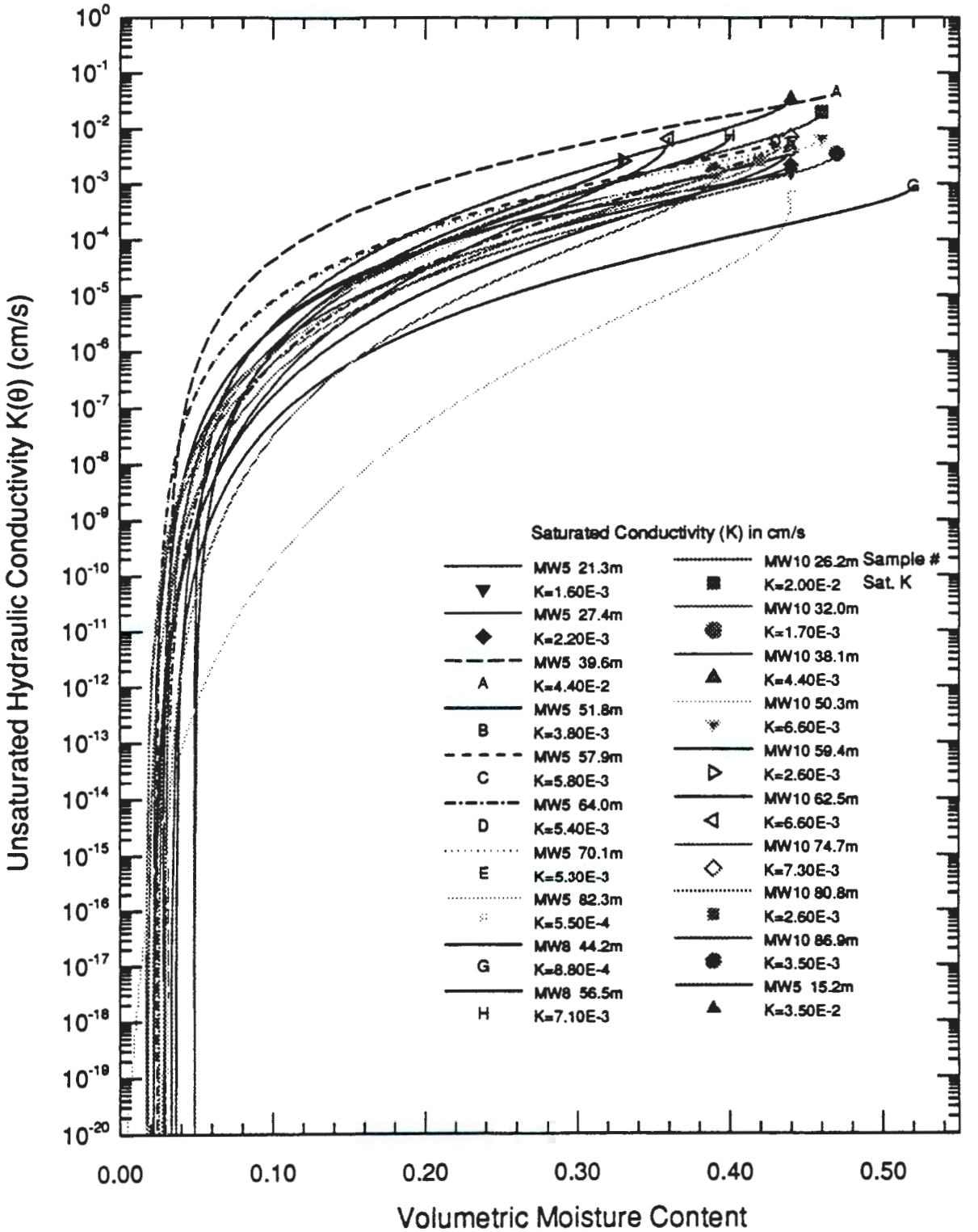


Figure 3-55. Hanford Formation Sandy Sequence Unsaturated Hydraulic Conductivity Curves for Drying Conditions--Drainage Set 2 (Connelly et al. 1992a).

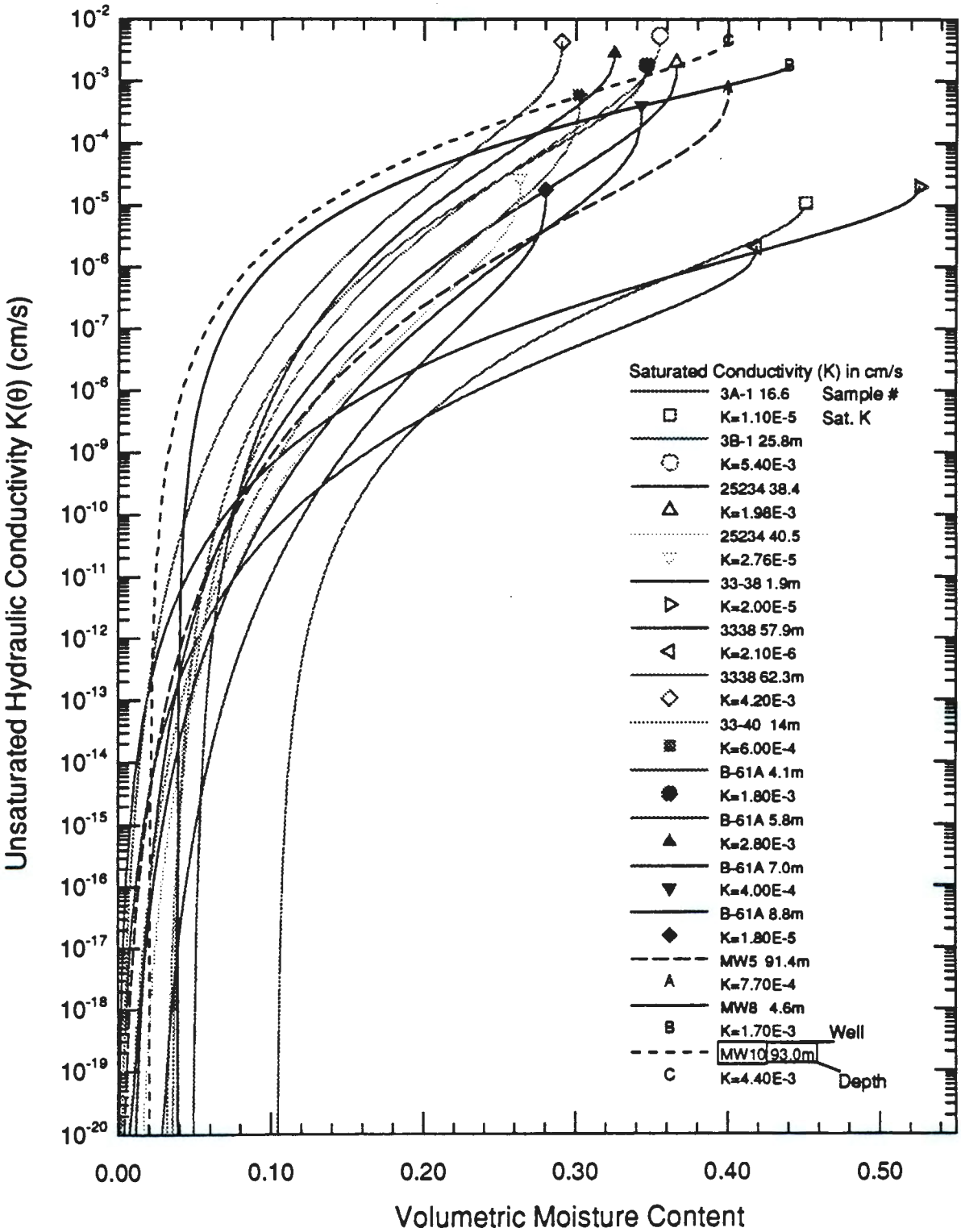


Figure 3-56. Hanford Formation Gravel Sequence Unsaturated Hydraulic Conductivity Curves for Drying Conditions (Connelly et al. 1992a).

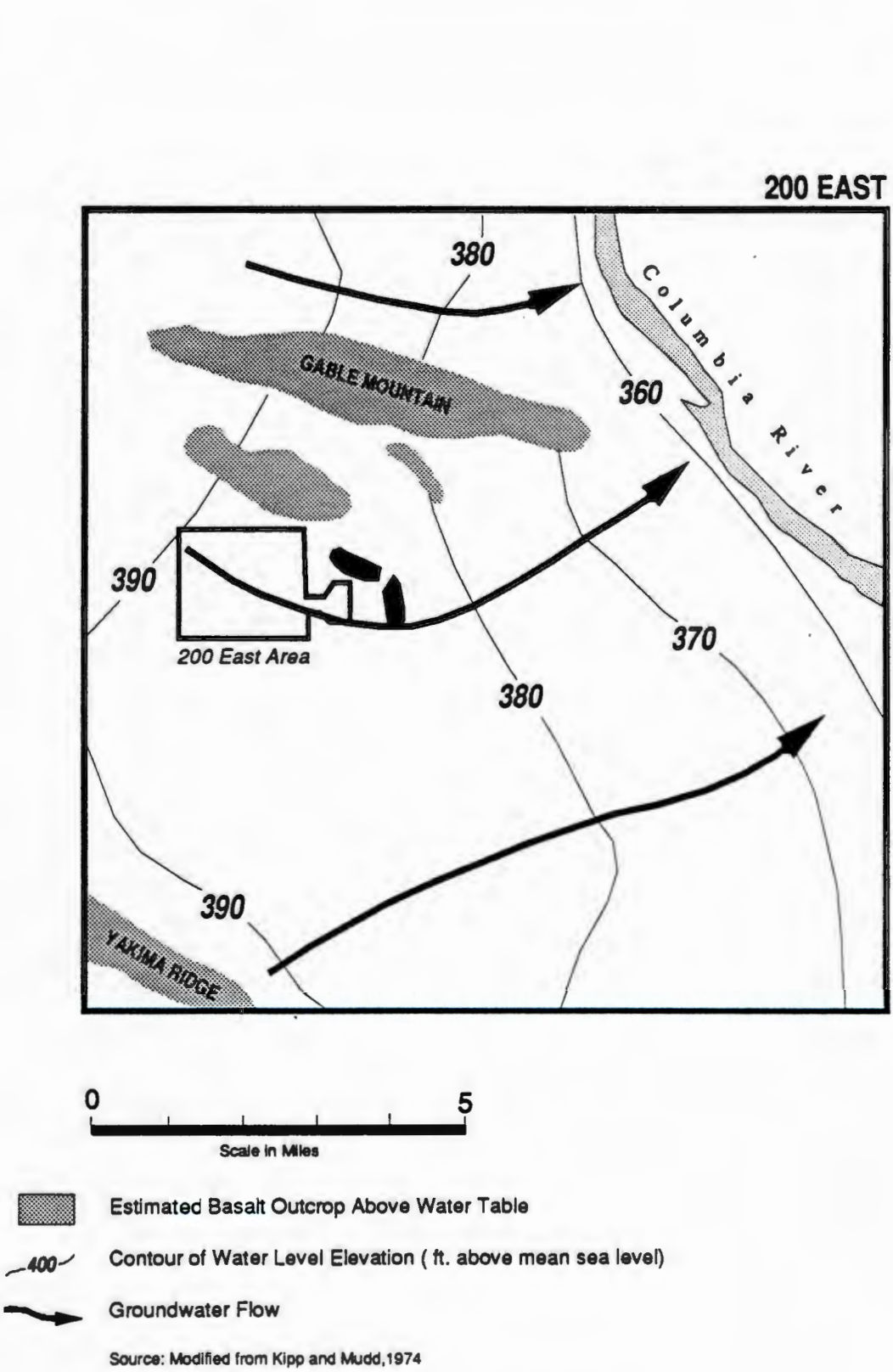


Figure 3-57. Water Table and Groundwater Flow in the Region of the 200 East Area for 1944.

9 3 1 2 9 7 1 3 7 5

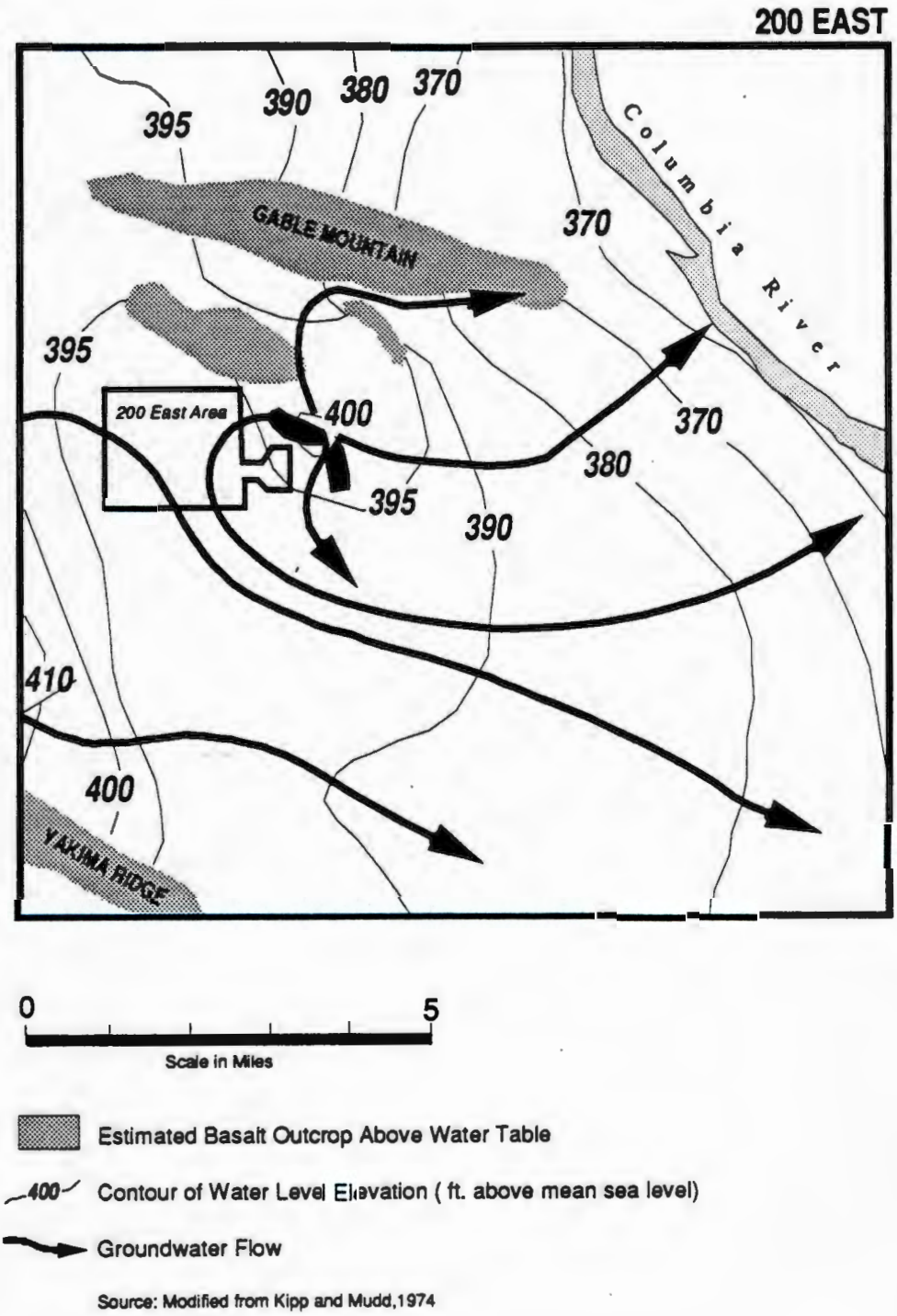


Figure 3-58. Water Table and Groundwater Flow in the Region of the 200 East Area for 1955.

9 3 1 2 9 7 1 3 7 6

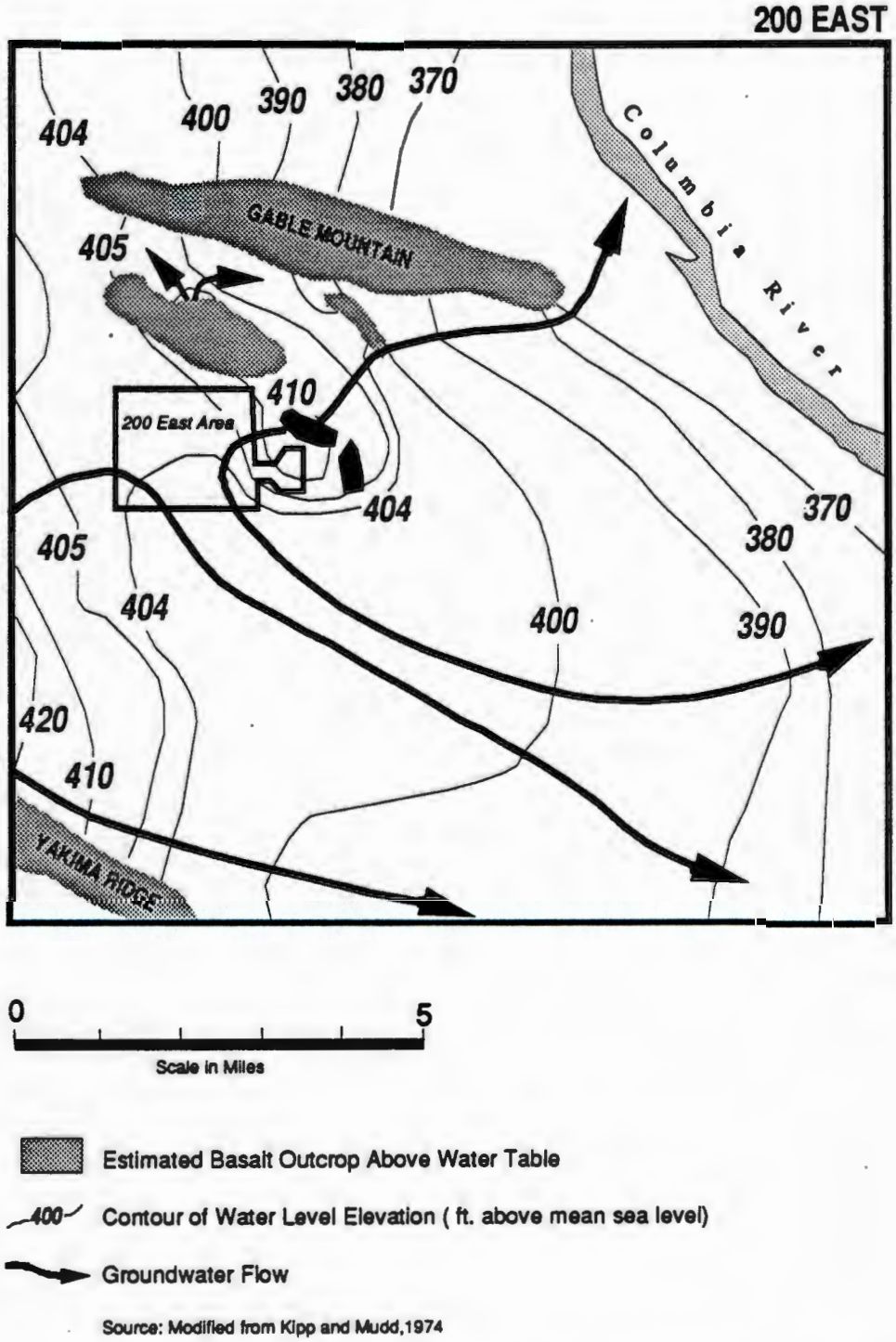


Figure 3-59. Water Table and Groundwater Flow in the Region of the 200 East Area for 1965.

9 3 1 2 9 7 1 3 7 7

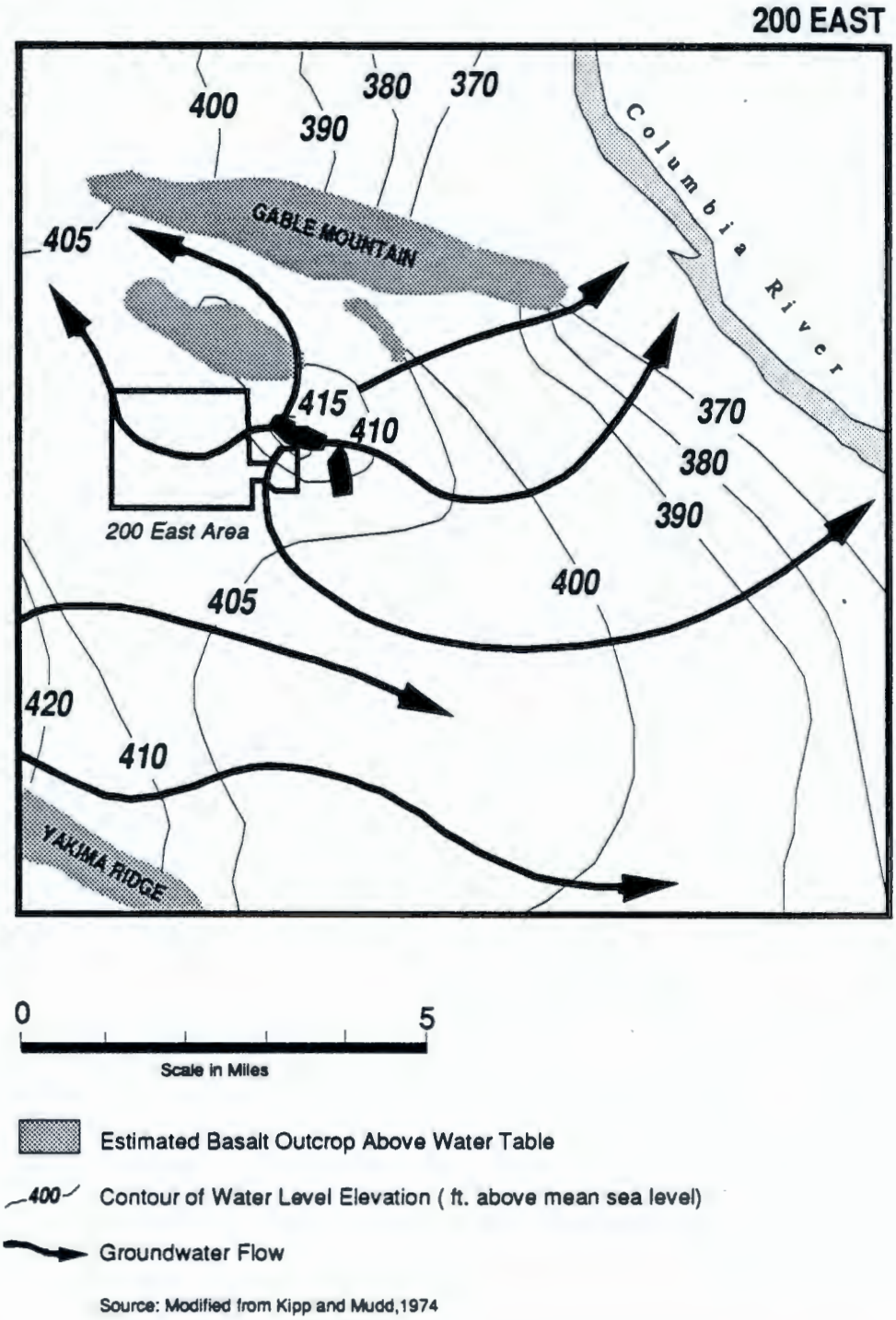


Figure 3-60. Water Table and Groundwater Flow in the Region of the 200 East Area for 1970.

9 3 1 2 9 7 1 3 7 8

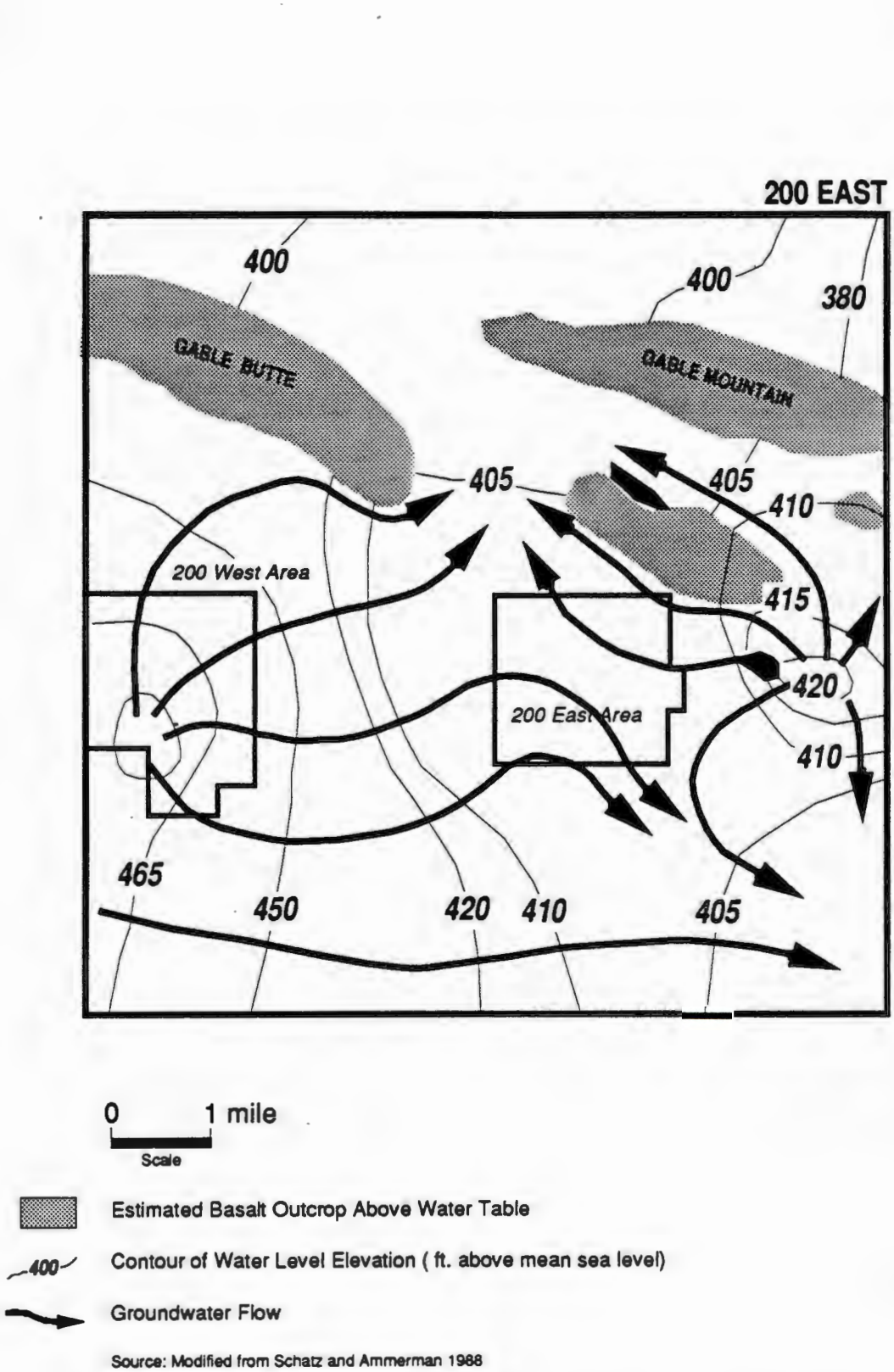


Figure 3-61. Water Table and Groundwater Flow in the Region of the 200 East Area for 1987.

9 3 1 2 9 7 1 3 7 9

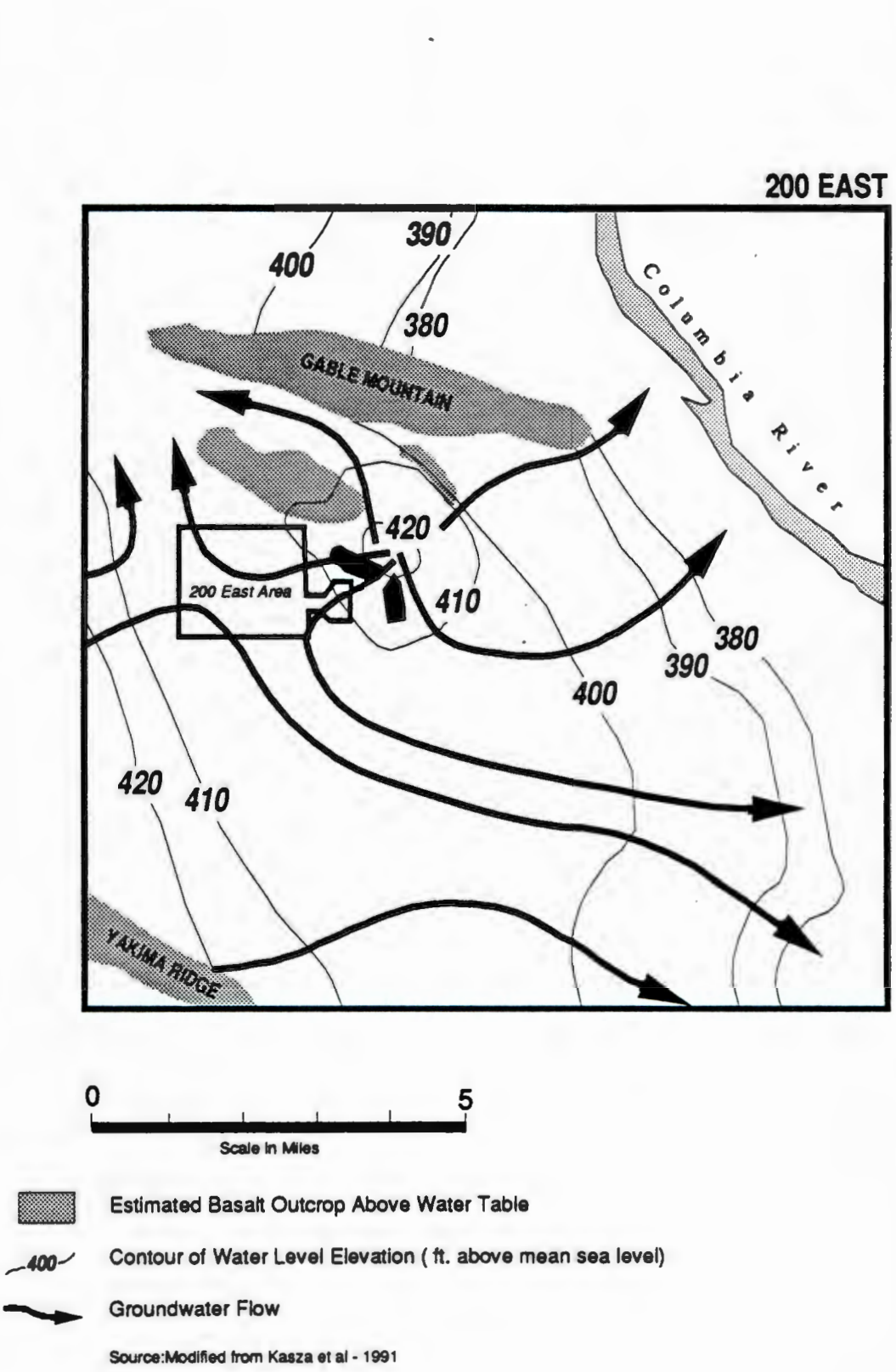


Figure 3-62. Water Table and Groundwater Flow in the Region of the 200 East Area for June 1991.

9 3 1 2 9 7 1 3 8 0

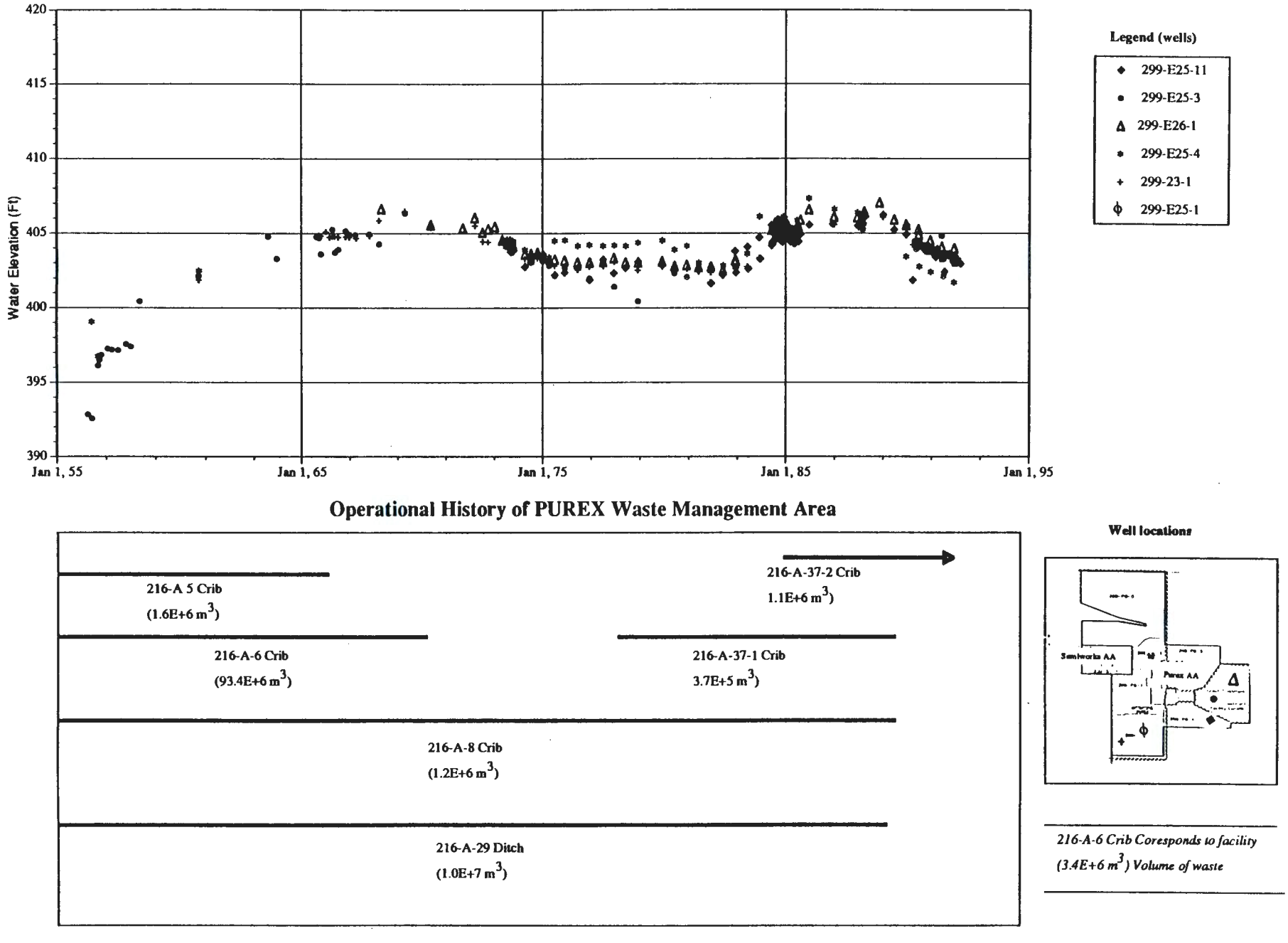


Figure 3-63. Well Hydrograph of the PUREX Plant Aggregate Area.

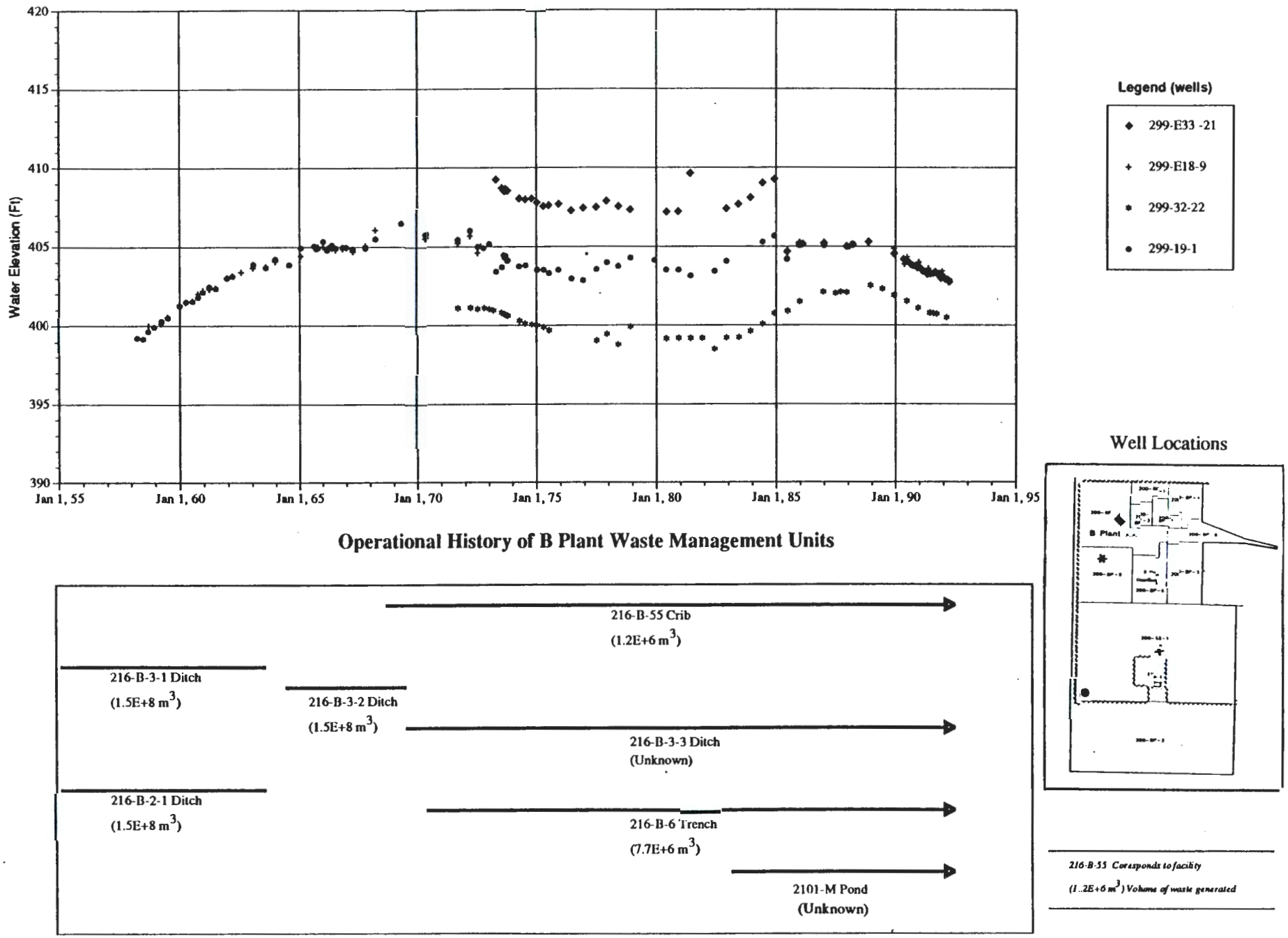


Figure 3-64. Well Hydrograph of the B Plant Aggregate Area (West of PUREX).

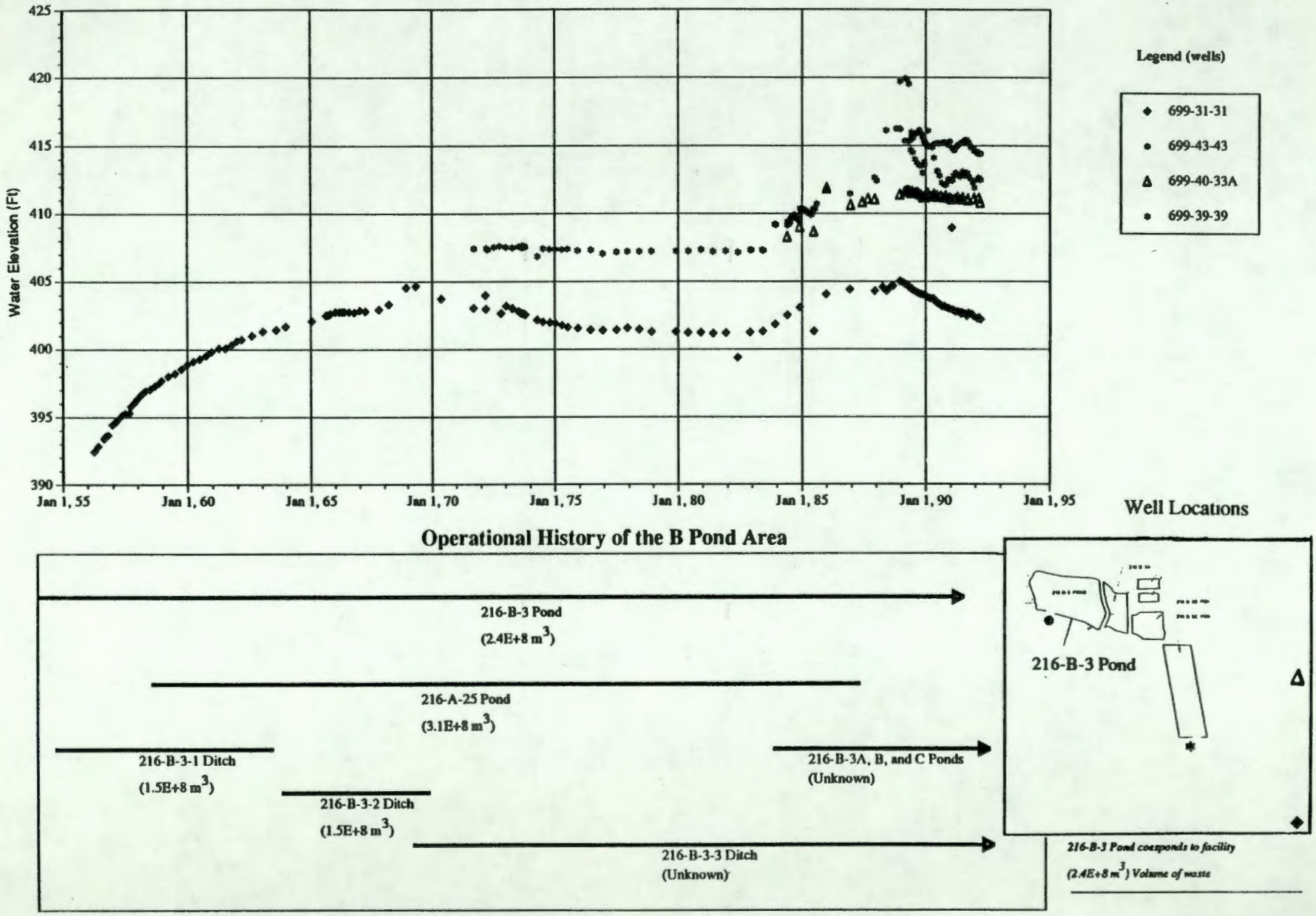


Figure 3-65. Well Hydrograph of the B Pond Area.

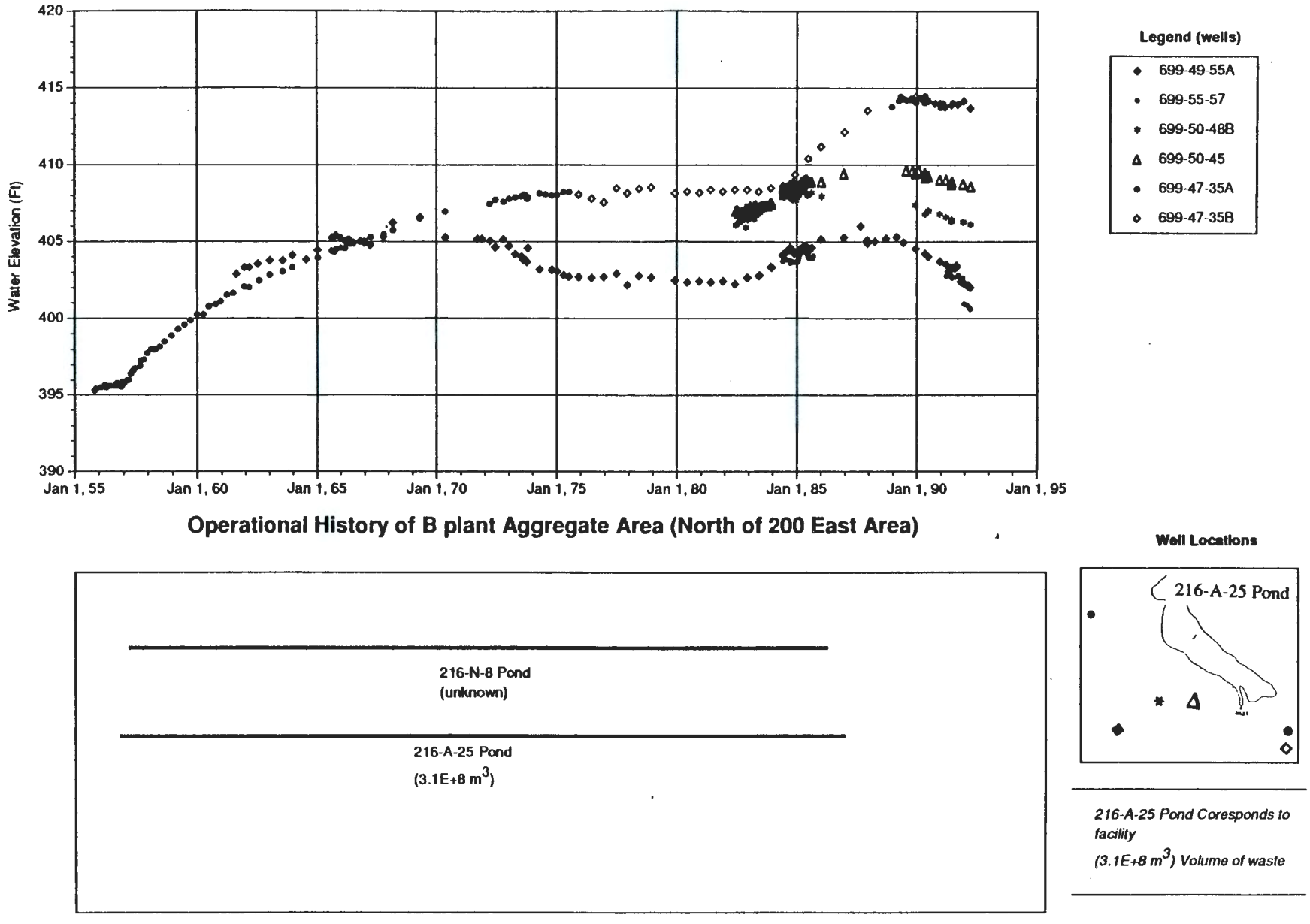


Figure 3-66. Well Hydrograph of the B Plant Aggregate Area (North of the 200 East Area).

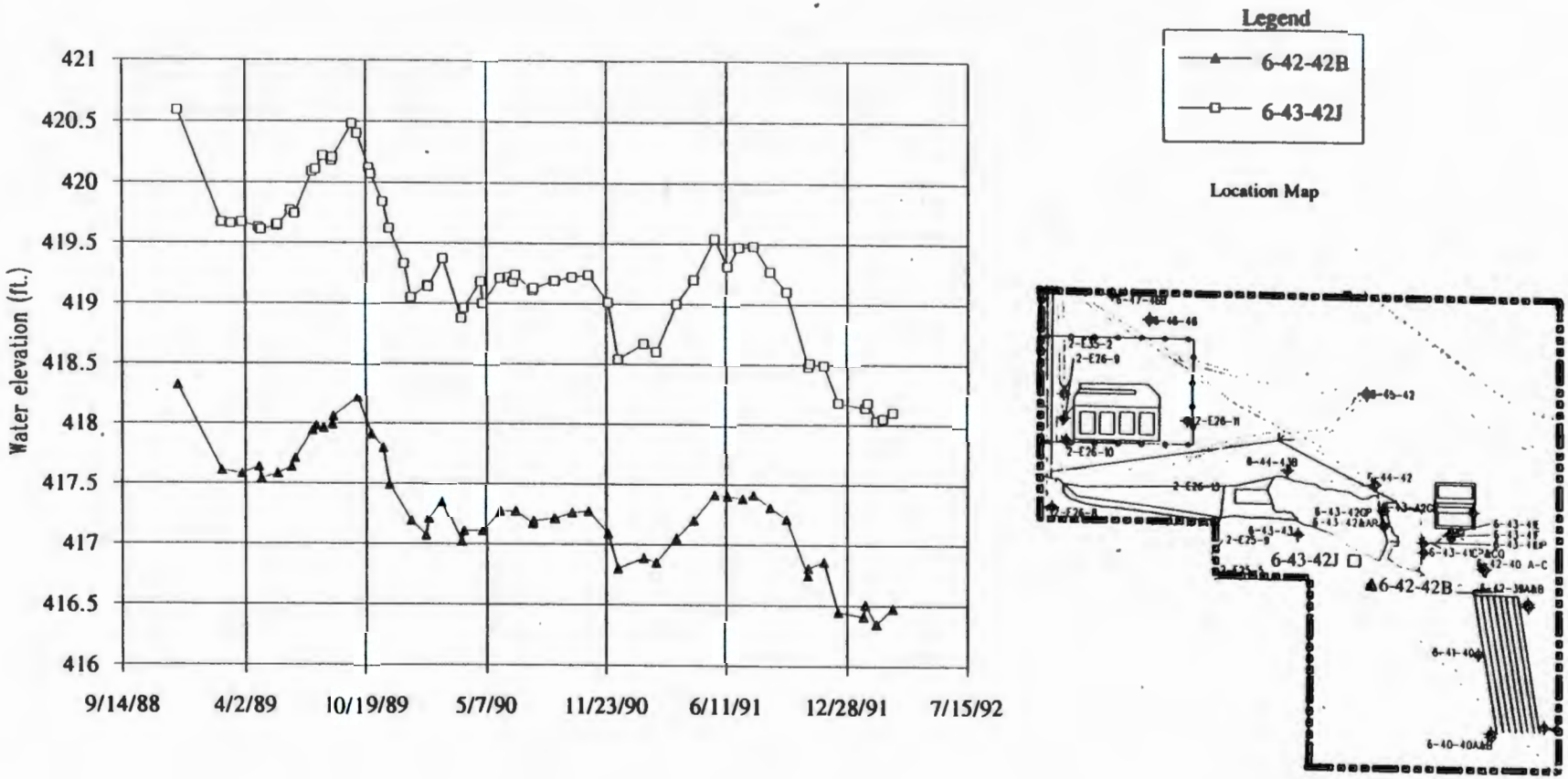


Figure 3-67. 600 Area Hydrograph Showing Declining Water Level.

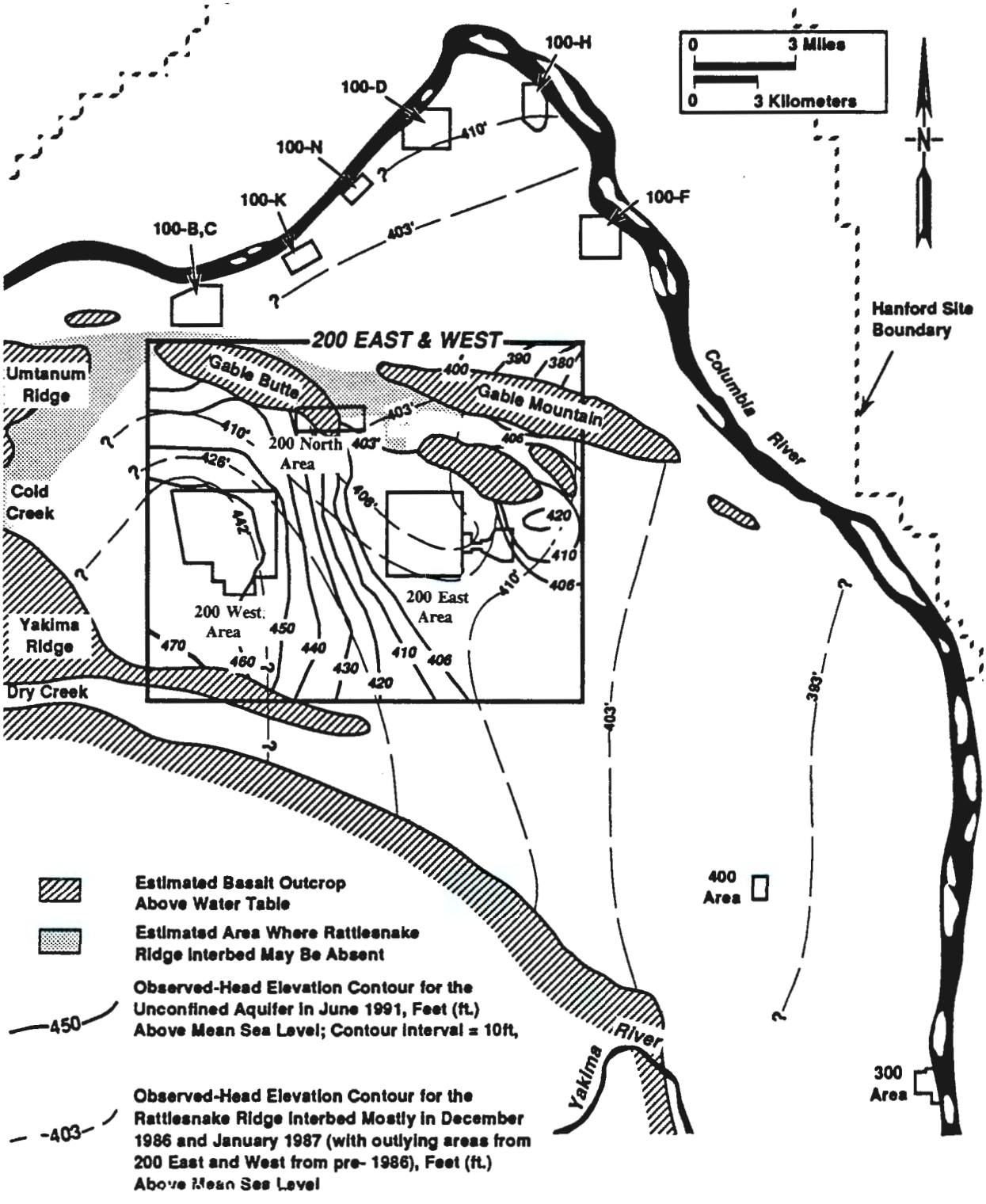


Figure 3-68. Potentiometric Surface Contour Map for the Unconfined and Rattlesnake Ridge Aquifers (Adapted from Kasza et al. 1991 and Jackson 1992).

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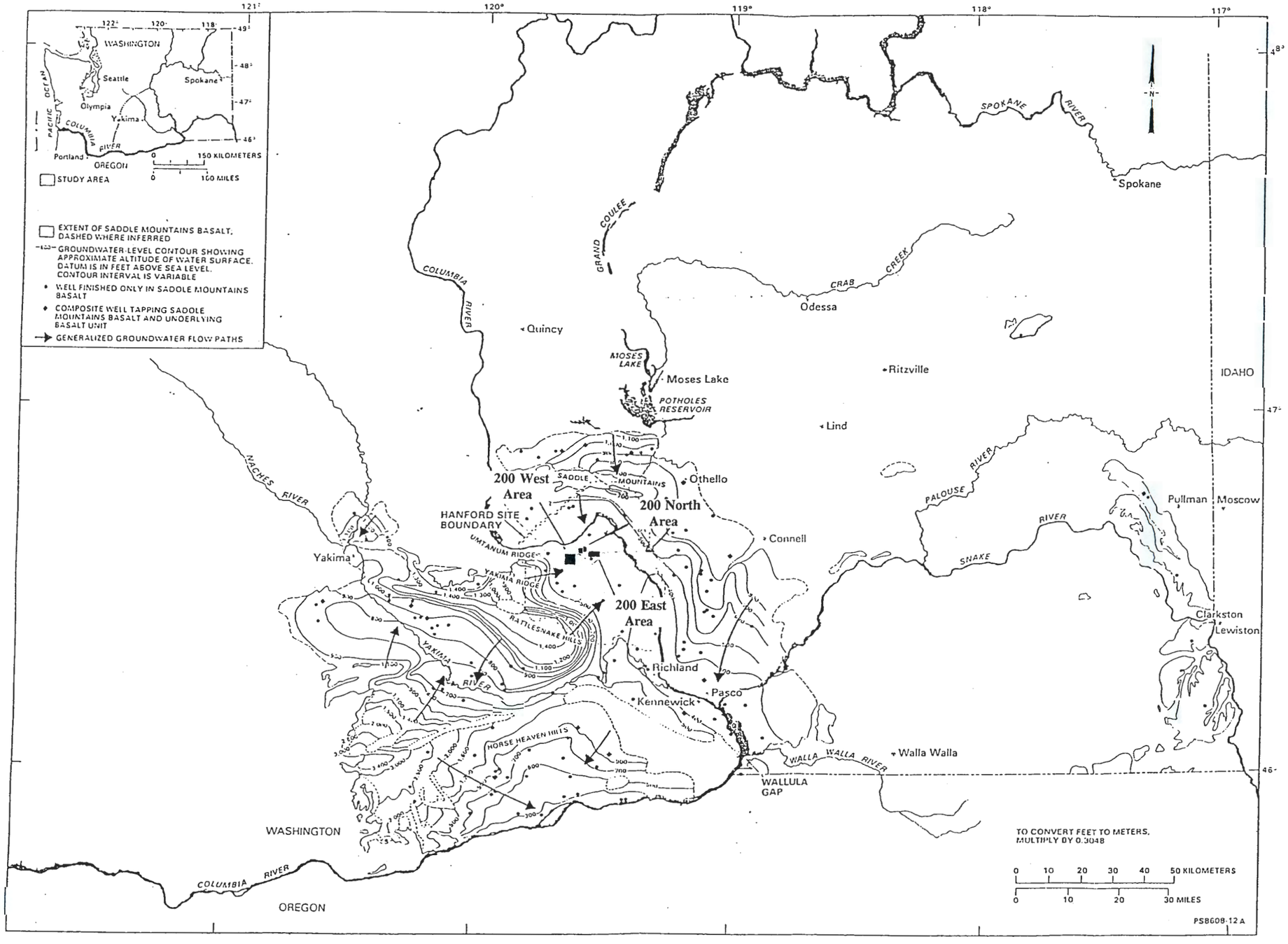
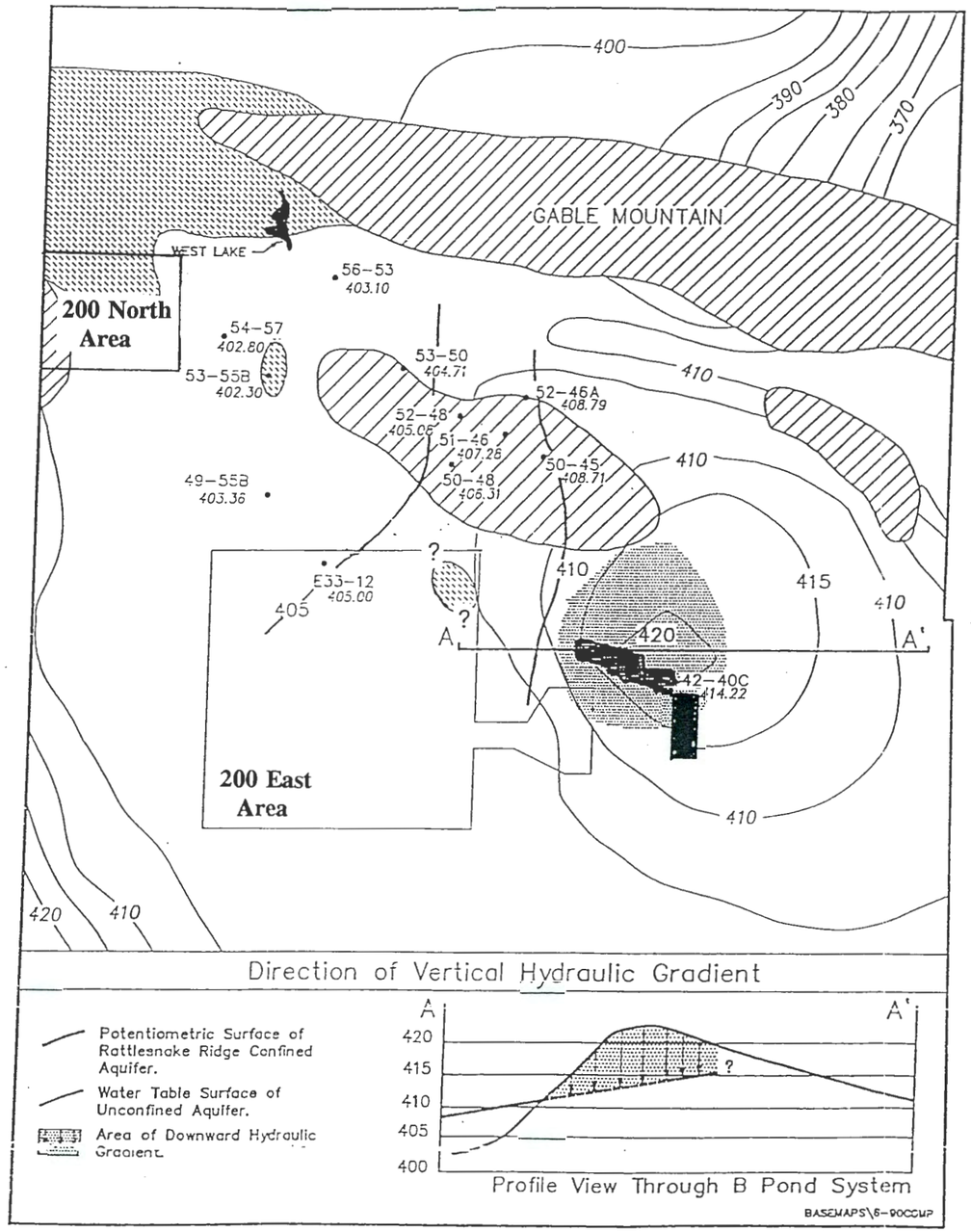


Figure 3-69. Generalized Areal Groundwater Flow Patterns in the Saddle Mountains Basalt within the Columbia Plateau (DOE 1988).

9 3 1 2 9 7 1 3 3 7



Potentiometric surface of the Rattlesnake Ridge confined aquifer in feet above mean sea level

Water table contours in feet above mean sea level

Areas of complete erosion of the Elephant Mountain Member (from RHO-RE-ST-12)

Area of downward hydraulic gradient

50-45 405 Wells in confined aquifer used to prepare map

Pond

Areas where the basalt surface is generally above the water table

The Rattlesnake Ridge aquifer, which is confined by the Elephant Mountain Member, is monitored quarterly in the eastern portion of 200 East Area. The June 1991 water level measurements in 12 wells completed in the Rattlesnake Ridge interbed were used to contour the potentiometric surface of the aquifer. Areal extent of downward hydraulic gradient from the unconfined aquifer to this confined aquifer is inferred from the water-table map and the contours of the potentiometric surface of the Rattlesnake Ridge. This area represents the zone in which downward flow might occur if a pathway is available due to complete erosion of the Elephant Mountain Member or sufficiently high hydraulic conductivity in the basalt. A profile view through the B Pond system shows the relationship between the unconfined water table and the potentiometric surface of the Rattlesnake Ridge confined aquifer.

T.13 N.
T.12 N.

The potentiometric surface of the Rattlesnake Ridge confined aquifer map has been prepared by the Geosciences Group, Environmental Division, Westinghouse Hanford Company.

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

-N-

0 1 Mile

0 1 Kilometer

Figure 3-70. Potentiometric Surface of the Rattlesnake Ridge Confined Aquifer and the Groundwater Level at the Unconfined Aquifer, Showing Area of Downward Hydraulic Gradient, June 1991 (Kasza et al. 1991 and Jackson 1992).

9 5 1 2 9 7 1 3 3 8

Table 3-1. Unconfined Aquifer Hydraulic Conductivities and Transmissivities for the Hanford Site.

Location	Interval Tested	Hydraulic Conductivity in m/s (ft/day)	Transmissivity in m^2/day (ft^2/day)
Hanford Site	Hanford Formation	$1.8x10^{-3}$ to $7.2x10^{-2}$ (500-20,300)	1,300-55,200 (14,000-594,000)
	Ringold Formation (Unit E)	$2.3x10^{-7}$ to $2.1x10^{-3}$ (0.06-600)	1.9-4,740 (20-51,000)
200 East Area	Unconfined Aquifer	$5.3x10^{-5}$ to $1.8x10^{-1}$ (15-25,000)	0.08-55,740 (0.9-694,000)

Notes: Hanford Site data compiled from Newcomer et al. (1992b), Connelly et al. (1992b), Bjornstad (1990), Delaney et al. (1991), and Last et al. (1989).

200 East Area data compiled from Newcomer et al. (1992a), Connelly et al. (1992a), Swanson et al. (1992), Delaney et al. (1991), and Last et al. (1989). Data from Newcomer et al. (1992a) and Connelly et al. (1992a) are provided as Tables A-8 and A-9.

9 3 1 2 9 7 1 3 8 9

Table 3-2. Well Clusters and Associated Barometric Efficiency and Vertical Hydraulic Gradient Data (Connelly et al. 1992a).

Well Cluster	Barometric Efficiency	Maximum Vertical Hydraulic Gradient	Direction of Vertical Flow Component (During Max. Vertical Hydraulic Gradient)
299-E33-07 Uppermost aquifer	N/A	0.0050 ft/ft	↑
299-E33-40 Rattlesnake Ridge aquifer	25%		
699-49-55A Uppermost aquifer	N/A	0.0023 ft/ft	↑
699-49-55B Rattlesnake Ridge aquifer	22%		
699-49-57A Uppermost aquifer	N/A	0.0015 ft/ft	↑
699-49-57B Rattlesnake Ridge aquifer	19%		
699-50-53A Uppermost aquifer	N/A	0.0037 ft/ft	↑
699-50-53B Rattlesnake Ridge aquifer	15%		
699-55-57 Uppermost aquifer	N/A	0.0038 ft/ft	↑
699-54-57 Rattlesnake Ridge aquifer	15%		

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

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

[a/] Indicates candidates on the 1991 Federal Register, Notice of Review.
Source: WHC (1992)

9 3 1 2 9 7 1 3 9 1

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

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

FE - Federal Endangered
FT - Federal Threatened
FC2 - Federal Candidate
SE - State Endangered
ST - State Threatened
SC - State Candidate
SM - State Monitor
Source: WHC (1992)