

Remedial Investigation/ Feasibility Study Work Plan for the 200-UP-1 Groundwater Operable Unit, Hanford Site, Richland, Washington

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EXECUTIVE SUMMARY

This work plan identifies the objectives, tasks, and schedule for conducting a Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit in the southern portion of the 200 West Groundwater Aggregate Area of the Hanford Site. The 200-UP-1 Groundwater Operable Unit addresses contamination identified in the aquifer soils and groundwater within its boundary, as determined in the *200 West Groundwater Aggregate Area Management Study Report (AAMSR)* (DOE/RL 1992b). The objectives of this work plan are to develop a program to investigate groundwater contaminants in the southern portion of the 200 West Groundwater Aggregate Area that were designated for Limited Field Investigations (LFIs) and to implement Interim Remedial Measures (IRMs) recommended in the *200 West Groundwater AAMSR*.

The purpose of an LFI is to evaluate high priority groundwater contaminants where existing data are insufficient to determine whether an IRM is warranted and collect sufficient data to justify and implement an IRM, if needed. A Qualitative Risk Assessment (QRA) will be performed as part of the LFI. The purpose of an IRM is to develop and implement activities, such as contaminant source removal and groundwater treatment, that will ameliorate some of the more severe potential risks of groundwater contaminants prior to the RI and baseline Risk Assessment (RA) to be conducted under the Final Remedy Selection (FRS) at a later date. This work plan addresses needs of a Treatability Study to support the design and implementation of an interim remedial action for the Uranium-⁹⁹Tc-Nitrate multi-contaminant IRM plume identified beneath U Plant.

LIMITED FIELD INVESTIGATION

The two primary data uses of the LFI are refinement of the operable unit conceptual model and support of the performance of a QRA. The areas of refinement of the conceptual model identified in the *200 West Groundwater AAMSR* include the following categories of general data needs:

- Hydrostratigraphy
- Aquifer Properties
- Groundwater Flow
- Source Contributions
- Nature and Extent of Contamination
- Groundwater Geochemistry.

The QRA relies on the development of the conceptual model to provide additional definition of contaminant plume concentrations to help identify which of the current LFI constituents are recommended for IRM designation.

Specific data needs are identified for all of the categories listed above, and the LFI activities planned to address these needs include the following general field activities:

- Soil sampling and analysis for physical and chemical properties
- Borehole geophysical surveys
- New well installation
- Sampling groundwater for contaminant concentrations
- Aquifer tests for new and existing wells
- Water level measurements
- Geophysical sampling and analysis
- Analytical data review
- Existing well survey and condition assessment.

Soil sampling and analysis will address data needs of hydrostratigraphy and aquifer properties through physical properties analysis, as well as data needs of groundwater geochemistry and source contributions through chemical analysis. Geophysical logging of wells will help define source contributions and nature and extent of contamination. New monitoring wells will help define aquifer properties, groundwater flow, nature and extent of contamination, and groundwater geochemistry. Aquifer testing results address general data needs for identifying aquifer properties necessary to evaluate groundwater flow and contaminant mobility. Water level measurements will assist calculation of horizontal and vertical hydraulic gradients required to evaluate groundwater flow. Groundwater sampling will address data needs for defining the nature and extent of contamination and groundwater geochemistry. Analytical data review will help fill data gaps in the nature and extent of contamination and help evaluate data acquired on groundwater geochemistry. Existing well survey and condition assessment will address deficiencies associated with suspect well surveys and well construction and materials in support of evaluating groundwater flow and the nature and extent of contamination.

Specific field activities are identified in the work plan. To the fullest extent possible, existing monitoring wells are used for additional data collection. Up to 13 new wells are identified to achieve data collection goals, with the actual number dependent upon the suitability of some existing wells. New well locations have all been selected based on needs to determine the horizontal and vertical extent of contaminants and vertical and horizontal hydraulic gradients in support of groundwater flow determination. Other data collection activities rely on the new well installations, but do not factor into the selection of well locations. New wells for the confined Rattlesnake Ridge interbed aquifer, which is the deepest aquifer to be investigated, will be addressed on a 200 West Groundwater Aggregate Area basis and will follow completion of IRM remedial activities at a later date; one such well is identified for the 200-UP-1 Groundwater Operable Unit and two wells for the 200-ZP-1 Groundwater Operable Unit. Field activities selected to meet general data needs are summarized below.

Hydrostratigraphy

A few outstanding hydrostratigraphic issues identified in the *200 West Groundwater AAMSR* will be addressed through data collected from boreholes drilled for well installation. This will be accomplished through borehole logging and physical analysis of samples.

Aquifer Properties

Determination of aquifer physical properties through sample collection and analysis, aquifer testing, and geophysical logging will provide further characterization of the operable unit hydrology for the conceptual model. This characterization will support evaluation of groundwater flow, including flow rates and aquifer intercommunication, and contaminant migration. The primary parameters of interest include hydraulic conductivity, transmissivity, porosity, and grain size distribution. Soil sampling will allow laboratory determination of grain size, porosity, and density. Aquifer testing of new and some existing wells will use slug tests on all wells and pumping tests of wells for which groundwater is not considered to be contaminated.

Groundwater Flow

The direction and magnitude of hydraulic gradients will be evaluated for the subject aquifers to allow evaluation of groundwater flow. Horizontal hydraulic gradients at the water table are well established, but little information is available for vertical gradients and horizontal gradients below the water table. The installation of new wells to provide at least three wells at similar depths for different water-bearing zones will allow slope determination of hydraulic head, as well as providing vertical gradient data in areas of clustered wells. Water level measurements will be conducted at new and existing wells and well survey information will be updated, as necessary.

Source Contributions

Evaluation of continuing source contributions of contaminants to the unconfined aquifer contributes to the conceptual model by allowing better prediction of future contaminant plume extent and concentration. This evaluation primarily is the subject of source area operable units (e.g., 200-UP-2 Operable Unit), although data collection activities for the groundwater operable unit pass through areas of vadose zone contamination by necessity and, thereby, present the opportunity to further refine this portion of the conceptual model. New data will be collected through soil sampling and chemical analysis and geophysical analysis. Logging of boreholes for new wells will include observations of any perched water encountered. In addition, evaluation of existing well conditions will include assessment of evidence for failed annular seals, which may identify potential pathways for downward vertical migration of fluids containing contaminants.

Nature and Extent of Contamination

Four specific data needs are identified for addressing the nature and extent of contamination. The first two needs are determining the maximum contaminant concentrations and the horizontal and vertical contaminant distributions. These needs will be addressed by using existing wells and installing new wells where necessary to conduct groundwater sampling and analysis. The two other data needs include reviewing existing data quality and verification of monitoring well screen intervals and condition, both of which will be addressed prior to conducting other field activities. New well locations have been selected to fill key gaps in identification of the horizontal extent of particular high-priority contaminant plumes, as well as provide data that will allow evaluation of the vertical extent of recognized contaminant plumes. Groundwater sampling will begin with 1 year of quarterly analysis for the selected well set and analytical program, with review to determine the need for expansion or termination of analysis. Review of existing analytical data will attempt to assess data that may be questionable or inadequate due to varying analytical methods, poor quality control, different sampling methods, or errors included in the data set. Existing well quality will be examined to determine the potential for transport of contaminants by inadequately sealed well casings and the potential influence of well material on analytical results.

Groundwater Geochemistry

Groundwater geochemistry contributes to the conceptual model by providing the context in which contaminant characteristics can be determined or inferred with respect to their mobility and fate. Contaminant fate and transport considerations will support the evaluation of feasibility and effectiveness of design alternatives for interim remedial action of IRM plumes and will assist the conduct of migration risks for the baseline RA to be conducted at a later date. Data needs are divided between groundwater chemical conditions and aquifer chemical conditions, with a minor consideration required for well construction materials due to their potential impact on data collection. Data collection activities are identified to conduct groundwater sampling and analysis of new and existing wells, as well as soil sampling and analysis of new well boreholes.

The work plan identifies the general work scope to be accomplished in the LFI, as summarized above. Specific details of the field activities are left for final determination in Descriptions of Work (DOWs). A DOW will be prepared for each of the primary fieldwork activities.

INTERIM REMEDIAL MEASURE

The *200 West Groundwater AAMSR* identifies the Uranium-⁹⁹Tc-Nitrate multi-contaminant plume identified beneath U Plant as IRMs. This work plan addresses needs of a Treatability Study to support the selection, design, and implementation of an interim remedial action for the IRM plume. Upon completion of the Treatability Study, remaining IRM activities will be

conducted. These activities include the preparation of the IRM Proposed Plan, the Interim Record of Decision (IROD), and implementation of the IRM.

A Treatability Test Plan will be developed to conduct a pilot-scale treatability test for evaluating the effectiveness of pump and treat methodologies to remediate the Uranium-⁹⁹Tc-Nitrate IRM plume. The pilot-scale test will provide data to assess the projected performance, operating conditions, and costs of pump and treat remediation. The IRM Proposed Plan will be prepared following the pilot-scale treatability test that will integrate results of the LFI, Treatability Study, and QRA to support determination of the IROD.

CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1-1
1.1 PURPOSE, SCOPE, AND OBJECTIVES	1-2
1.2 PROJECT GOALS	1-3
1.3 ORGANIZATION OF THE WORK PLAN	1-4
1.4 QUALITY ASSURANCE	1-4
2.0 BACKGROUND AND SETTING	2-1
2.1 POTENTIAL GROUNDWATER CONTAMINANT SOURCES	2-1
2.1.1 Historical Operations, Disposal Practices and Waste Management Units	2-2
2.1.2 Potential for Liquid Discharge to the Unconfined Aquifer	2-2
2.2 PHYSICAL SETTING	2-3
2.2.1 Geological Features	2-3
2.2.2 Hydrogeologic Features	2-5
3.0 INITIAL EVALUATION	3-1
3.1 KNOWN AND SUSPECTED CONTAMINATION	3-1
3.1.1 Vadose Zone	3-2
3.1.2 Unconfined Portion of the Uppermost Aquifer	3-3
3.1.3 Confined Aquifers	3-20
3.2 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT	3-21
3.2.1 Conceptual Model	3-22
3.2.2 Characteristics of Contaminants	3-22
3.2.3 Potential Applicable or Relevant and Appropriate Requirements	3-22
4.0 WORK PLAN APPROACH AND RATIONALE	4-1
4.1 LIMITED FIELD INVESTIGATION DATA USES AND DATA NEEDS	4-2
4.2 LIMITED FIELD INVESTIGATION DATA COLLECTION PROGRAM	4-3
4.2.1 General Rationale for Developing Data Quality Objectives	4-4
4.2.2 Hydrostratigraphy	4-10
4.2.3 Aquifer Properties	4-11
4.2.4 Groundwater Flow	4-13
4.2.5 Source Contributions	4-14
4.2.6 Nature and Extent of Contamination	4-15
4.2.7 Groundwater Chemistry	4-24
4.3 INTERIM REMEDIAL MEASURE DATA NEEDS AND ACTIVITIES	4-25
4.3.1 Treatability Studies	4-26
4.3.2 Interim Remedial Measure Proposed Plan	4-27
5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS	5-1
5.1 LIMITED FIELD INVESTIGATION PROCESS	5-1
5.1.1 Work Breakdown Structure	5-2
5.1.2 Project Management (Task 1)	5-4

CONTENTS (cont.)

	<u>Page</u>
5.1.3 Limited Field Investigation Field Activities (Tasks 2 to 6)	5-7
5.1.4 Data Evaluation (Task 7)	5-18
5.1.5 Qualitative Risk Assessment (Task 8)	5-21
5.1.6 Identification of Potential Contaminant- and Location- Specific Applicable or Relevant and Appropriate Requirements (Task 9)	5-23
5.1.7 Limited Field Investigation Report (Task 10)	5-23
5.2 INTERIM REMEDIAL MEASURE PROCESS	5-23
5.2.1 Treatability Study	5-23
5.2.2 Interim Remedial Measure Qualitative Risk Assessment	5-24
5.2.3 Interim Remedial Measure Proposed Plan	5-25
5.2.4 Interim Record of Decision	5-25
5.2.5 Interim Remedial Measure Design Report	5-25
5.2.6 Interim Remedial Measure Design Implementation	5-25
6.0 PROJECT SCHEDULE	6-1
7.0 REFERENCES	7-1
APPENDIX A	QUALITY ASSURANCE PROJECT PLAN
APPENDIX B	SUMMARY OF LFI CONSTITUENT DETECTIONS FOR 200-UP-1 GROUNDWATER OPERABLE UNIT WELLS
APPENDIX C	LFI CONSTITUENT TIME VARIABILITY PLOTS FOR SELECTED 200-UP-1 GROUNDWATER OPERABLE UNIT WELLS
PLATE 1a, b	MAP OF THE 200-UP-1 GROUNDWATER OPERABLE UNIT

CONTENTS (cont.)

	<u>Page</u>
FIGURES:	
1-1 Hanford Site Map	1F-1
1-2 Water Table Map with Location of 200 West Area Groundwater Operable Units: 200-UP-1 and 200-ZP-1	1F-2
1-3 200 West Source Aggregate Areas and Associated Operable Units	1F-3
1-4 Framework for Conducting RI/FS at 200-UP-1 Groundwater Operable Unit	1F-4
2-1 Generalized Geologic and Hydrogeologic Column for the 200-UP-1 Groundwater Operable Unit	2F-1
2-2 Location of Cross Sections	2F-2
2-3 Legend for Cross Sections	2F-3
2-4 200 West Area Geologic Cross Section A-A'	2F-4
2-5 200 West Area Geologic Cross Section B-B'	2F-5
2-6 200 West Area Geologic Cross Section C-C'	2F-6
2-7 200 West Area Geologic Cross Section D-D'	2F-7
2-8 200 West Area Geologic Cross Section E-E'	2F-8
3-1 Technetium-99 Groundwater Plume Map	3F-1
3-2 Uranium Groundwater Plume Map	3F-2
3-3 Nitrate Groundwater Plume Map	3F-3
3-4 Carbon Tetrachloride Groundwater Plume Map	3F-4
3-5 Chloroform Groundwater Plume Map	3F-5
3-6 Trichloroethylene Groundwater Plume Map	3F-6
3-7 Iodine-129 Groundwater Plume Map	3F-7
3-8 Gross Alpha Groundwater Plume Map	3F-8
3-9 Gross Beta Groundwater Plume Map	3F-9
3-10 Arsenic Groundwater Plume Map	3F-10
3-11 Chromium Groundwater Plume Map	3F-11
3-12 Fluoride Groundwater Plume Map	3F-12
3-13 Conceptual Model of the 200 West Groundwater Aggregate Area	3F-13
4-1 Relationships between Data Uses, Data Needs, and Field Activities	4F-1
4-2 Proposed Location of New Monitoring Wells	4F-2
5-1 Schematic Diagram of Well UP1-1 and Depth of Sampling	5F-1
5-2 Schematic Diagram of Well UP1-6 and Depth of Sampling	5F-2
5-3 Schematic Diagram of Well UP1-7 and Depth of Sampling	5F-3
5-4 Schematic Diagram of Well UP1-12 and Depth of Sampling	5F-4
5-5 Schematic Diagram of Well UP1-13 and Depth of Sampling	5F-5
5-6 Schematic Diagram of Well UP1-2, -3, -4, and -5 and Depth of Sampling	5F-6
5-7 Schematic Diagram of Well UP1-8 and Depth of Sampling	5F-7
5-8 Schematic Diagram of Well UP1-9, -10, and -11 and Depth of Sampling	5F-8
5-9 Proposed Location of Monitoring Wells for Geophysical Surveys	5F-1
5-10 Proposed Location of Monitoring Wells for Aquifer Tests	5F-2
6-1 Schedule for LFI and Uranium- ⁹⁹ Tc-Nitrate IRM Activities	6F-1

CONTENTS (cont.)

Page

TABLES:

1-1	Disposition of Groundwater Contaminants in the 200-UP-1 Groundwater Operable Unit	1T-1
2-1	Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer	2T-1
3-1	Wells with the Highest (Average) Reported Constituent Concentration	3T-1
4-1	Data Quality Objectives for Soil Sampling and Analysis for Physical and Chemical Sampling	4T-1
4-2	Data Quality Objectives for Borehole Geophysical Surveys	4T-2
4-3	Data Quality Objectives for New Well Installation	4T-3
4-4	Data Quality Objectives for Aquifer Tests for New and Existing Wells	4T-4
4-5	Data Quality Objectives for Water Level Measurements	4T-5
4-6	Data Quality Objectives for Groundwater Sampling and Analysis	4T-6
4-7	Data Quality Objectives for Analytical Data Review	4T-7
4-8	Data Quality Objectives for Existing Well Survey and Condition Assessment	4T-8
4-9	Stratigraphic Units and Corresponding Data Parameters to be Collected During LFI Field Activities	4T-9
4-10	Waste Management Units that Potentially Have Contributed to Groundwater Contamination and Downgradient Wells and Investigations Associated with the Units	4T-10
4-11	Wells and Screen Depths for Critical Groundwater Analyses	4T-11
5-1	Relationship between Tasks and Field Activities	5T-1
5-2	Groundwater Sampling and Analyses	5T-2
5-3	Aquifer Testing Method and Well Summary	5T-3
5-4	200-UP-1 Groundwater Operable Unit Wells	5T-4
5-5	Detection Limit DQOs Based on 1E-6 Risk Level for Target Constituents	5T-5
5-6	Soil Sample Types and Analytes at New Groundwater Monitoring Wells	5T-6

ACRONYMS

AAMSR	aggregate area management study report
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
BWIP	Basalt Waste Isolation Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CLP	Contract Laboratory Program
CMS	Corrective Measures Study
DCG	derived concentration guide
DNAPL	dense non-aqueous phase liquid
DOE	U.S. Department of Energy
DOW	Description of Work
DQO	data quality objective
Ecology	Washington State Department of Ecology
EII	Environmental Investigation Instruction
EPA	U.S. Environmental Protection Agency
ERA	Expedited Response Action
FRS	Final Remedy Selection
HEIS	Hanford Environmental Information System
IRM	Interim Remedial Measure
IROD	Interim Record of Decision
LFI	Limited Field Investigation
MCL	maximum contaminant level
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
ppb	parts per billion
QA	quality assurance
QAPJP	Quality Assurance Project Plan
QC	quality control
QRA	Qualitative Risk Assessment
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RCW	Revised Code of Washington
RFI	Resource Conservation and Recovery Act Facility Investigation
RLS	Radionuclide Logging System
ROD	record of decision
SOW	Statement of Work
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TOC	total organic carbon
TDS	total dissolved solid
TSS	total suspended solid
UO ₃	Uranium Trioxide
WAC	Washington Administrative Code

1.0 INTRODUCTION

This work plan and attached or referenced supporting project plans establish the operable unit setting and the objectives, tasks, and schedule for conducting the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) Remedial Investigation/Feasibility Study for the 200-UP-1 Groundwater Operable Unit. As agreed upon by the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology), this work plan, while maintaining the title Remedial Investigation/Feasibility Study, presents the background and direction for conducting a Limited Field Investigation (LFI) and Interim Remedial Measure (IRM) for the 200-UP-1 Groundwater Operable Unit, which is the first part of the process leading to Final Remedy Selection (FRS).

The 200-UP-1 Groundwater Operable Unit is one of two groundwater operable units in the 200 West Groundwater Aggregate Area of the Hanford Site (Figures 1-1 and 1-2). The 200-UP-1 Groundwater Operable Unit underlies the U Plant and S Plant Aggregate Areas and the 6 source operable units these areas contain (Figure 1-3). The 200-UP-1 Groundwater Operable Unit includes all contamination found in the aquifer soils and water within its boundary. Source operable units include facilities and unplanned release sites that are potential sources of contamination. A separate work plan has been prepared for the 200-UP-2 Source Operable Unit (DOE/RL 1992a).

All work conducted under this work plan will conform to the conditions set forth in the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement, Ecology et al. 1990) and its amendments, signed by the Ecology, EPA, and DOE. In accordance with the Tri-Party Agreement, relevant EPA guidance documents were consulted in the preparation of the work plan, including the following:

- *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988)
- *Data Quality Objectives for Remedial Response Activities--Development Process* (EPA 1987)
- *Interim Guidance and Specifications for Preparing Quality Assurance Project Plans* (EPA 1983)

This chapter defines the general purpose, scope, and goals of the project. Detailed information regarding source terms, background information, physical setting, known and suspected contamination, conceptual model, and past-practice strategies is provided in the *200 West Groundwater Aggregate Area Management Study Report (AAMSR)* (DOE/RL 1992b) and the *U Plant Source AAMSR* and *S Plant Source AAMSR* (DOE/RL 1992c,d). The *200 West Groundwater AAMSR* also includes a Health and Safety Plan (DOE/RL 1992b, Appendix B) and a Project Management Plan (DOE/RL 1992b, Appendix C). A Community Relations Plan has been prepared for the Hanford Site (Ecology et al. 1989). These

documents are referenced to minimize redundant material and to create a concise work plan.

The primary supporting document for this work plan is the *200 West Groundwater AAMSR* (DOE/RL 1992b). The purpose of the AAMSR was to compile and evaluate the existing body of knowledge to support the *Hanford Site Past-Practice Strategy* (DOE/RL 1992e) decision making process. Groundwater contaminants/plumes were recommended to be addressed under one of four *Hanford Site Past-Practice Strategy* paths (i.e., Expedited Response Actions [ERAs], IRMs, LFIs, and FRS). Six contaminants/plumes were recommended for immediate interim action as either an ERA or IRM. Twenty-seven high priority groundwater contaminants/plumes were first recommended to undergo LFIs where additional information was needed to determine whether the contaminants/plumes actually warrant IRMs. Tritium was recommended directly for Risk Assessment (RA) under the FRS path to determine the need for a remedial action. The remaining contaminants detected in the groundwater were proposed for RI in the FRS path because they were generally considered to be low priority. Table 1-1 summarizes the disposition of groundwater contaminants in the 200-UP-1 Groundwater Operable Unit.

The near-term past practice strategy for the 200 Areas focuses on the implementation of interim actions (ERAs and IRMs) and LFIs for high priority groundwater contaminants and source sites. Following the implementation of interim actions the focus will shift to lower priority sites and plumes as part of the FRS process. At that point, all groundwater contaminants/plumes will be addressed in a comprehensive manner to reach final closure of an operable unit or aggregate area. The FRS path integrates all information accumulated from ERAs, IRMs, LFIs and Feasibility Studies, and identifies and collects additional data (if needed) to support a baseline RA from which a final Record of Decision (ROD) is made.

1.1 PURPOSE, SCOPE, AND OBJECTIVES

The objective of this work plan is to develop a program to investigate groundwater contaminants in the southern portion of the 200 West Groundwater Aggregate Area that were designated for LFIs (Table 1-1), and implement interim actions (i.e., uranium, ⁹⁹Tc, nitrate IRMs) recommended in the *200 West Groundwater AAMSR*. Although groundwater contaminants/plumes were individually recommended for one of the four *Hanford Site Past-Practice Strategy* paths in the AAMSR, this work plan consolidates all individual groundwater LFIs and IRMs beneath the S Plant and U Plant Source Aggregate Areas into a single LFI and IRM. The framework and process for performing the RI/FS at the 200-UP-1 Groundwater Operable Unit is shown in Figure 1-4 and begins with the operable unit work plan.

Groundwater LFIs are performed for high priority groundwater contaminants where existing data are currently considered insufficient to determine whether an IRM is warranted. The purpose of this LFI is to collect sufficient data to identify whether any additional IRMs are needed and to support the scope of the existing IRM. A Qualitative Risk Assessment (QRA) will be performed as

part of the LFI, which will be used to determine the need for additional IRMs and establish interim action goals.

In addition to the LFI, this work plan addresses Treatability Study needs to support the design and implementation of an interim remedial action for the Uranium-⁹⁹Tc-Nitrate multi-contaminant IRM plume identified beneath U Plant. The Treatability Study supporting this IRM will be conducted in parallel with the LFI, and will use refinements made by the LFI to the site conceptual model.

Specific recommendations for filling known data gaps are made in this work plan, with finalization of data collection activities reserved for Descriptions of Work (DOWs) to be prepared for each general field activity category. Results of the data collection activities conducted during the LFI, the QRAs, and the Treatability Study will be reported in supporting documents/data packages. The results of these work plan activities will be integrated in the IRM Proposed Plan. The IRM Proposed Plan is the primary document that provides the public with a summary of the LFI results and Treatability Study recommendations, and identifies the selected remedial alternative. Additional monitoring/characterization needs may be identified at this time. A single IRM Proposed Plan may be prepared for all IRMs, or multiple plans may be prepared for grouped and/or individual IRMs.

The IRM Proposed Plan will support the preparation of an Interim Record of Decision (IROD). The IROD is written and issued by the regulators and incorporates any changes to the selected IRM occurring as a result of public comment on the IRM Proposed Plan. The IROD presents a technical description of the IRM; interim engineering, institutional, and remedial action goals; and information regarding the site. A single IROD may be prepared for all IRMs, or multiple IRODs may be prepared for grouped and/or individual IRMs.

The IRM design report is a secondary document and provides engineering and technical specifications for implementing the IRM identified in the IROD.

1.2 PROJECT GOALS

The primary goals of the LFIs in the 200-UP-1 Groundwater Operable Unit are to provide sufficient information on the aquifers and contaminant distributions to refine the conceptual model and perform qualitative RAs for the purpose of identifying and implementing IRMs that expedite cleanup of high risk contaminants. These goals must be reached for each LFI contaminant studied. This will involve refinement of existing data to identify maximum concentrations, assess the nature and extent (vertical and horizontal) of contamination, and determine aquifer properties. Data collected should also be sufficient to select a viable remediation alternative if an IRM is justifiable.

The primary goals of the IRMs in the 200-UP-1 Groundwater Operable Unit are to incorporate the existing conceptual model, and refinements made in the LFI, into a Treatability Study for the IRM. The Treatability Study must follow a process that allows defensible cleanup decisions in support of

preparing a IRM Proposed Plan. Data collection and evaluation should be sufficient to implement a viable remedial action alternative.

Wherever possible, field investigations will be coordinated with other ongoing field activities in the 200 West Area to avoid duplication of efforts and maximize the use of resources. Coordination is expected to occur with such projects as the 200-UP-2 Source Operable Unit Resource Conservation and Recovery Act (RCRA) Facility Investigation/Corrective Measures Study (RFI/CMS), 200-ZP-1 Groundwater Operable Unit RI/FS, 200 West Area Carbon Tetrachloride IRM, and other Hanford Site groundwater sampling programs.

1.3 ORGANIZATION OF THE WORK PLAN

This work plan is made up of seven sections, including this introduction, and three appendixes. To avoid redundancy, applicable AAMSRs will be referenced whenever possible. New information that has become available subsequent to the AAMSRs will be discussed and incorporated, if applicable.

Section 2.0 provides a brief summary of background information provided in the *200 West Groundwater AAMSR* including sources of groundwater contamination, and the physical setting of the operable unit. Section 3.0 summarizes the contaminant distribution data, and the conceptual model. Section 4.0 presents the data needs and rationale for field activities proposed in this work plan. Section 5.0 describes the data collection activities that will be performed to address identified data needs. Recommended protocols and procedures for each activity are also provided in Section 5.0. Section 6.0 presents the project schedule for the work plan activities. References used in the work plan are provided in Section 7.0. Appendix A is the Quality Assurance Project Plan (QAPjP). Appendix B presents an updated revision of average IRM and LFI constituent concentrations for operable unit wells from the Hanford Groundwater Contaminant Database. Appendix B also presents representative plots of LFI constituent concentration variations discussed in Section 3.0. Appendix C presents constituent concentration time variability plots for selected 200-UP-1 Groundwater Operable Unit wells.

1.4 QUALITY ASSURANCE

The 200-UP-1 Groundwater Operable Unit Work Plan and its supporting project plans have been developed to meet specific EPA guidelines for format and structure, within the overall quality assurance (QA) program structure mandated by the DOE-Richland Operations Office for all activities at the Hanford Site. The 200-UP-1 Groundwater Operable Unit QAPjP (Appendix A) supports the field sampling program described in Section 5.0. It defines the specific means that will be used to ensure that the sampling and analytical data obtained as part of the LFIs will effectively support the purposes of the investigation. The LFI and any aggregate area studies will effectively support the purposes of the investigation. As required by the Westinghouse Hanford QA program plan for Remedial Investigation/Feasibility Study activities and the *Hanford Federal Facility Agreement and Consent Order*

(Ecology et al. 1990), the structure and content of the QAPjP are based on *Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans* (EPA 1983). Where required, the QAPjP invokes appropriate procedural controls selected from those listed in the Westinghouse Hanford QA program plan for Remedial Investigation/Feasibility Study activities or developed to accommodate the unique needs of this investigation.

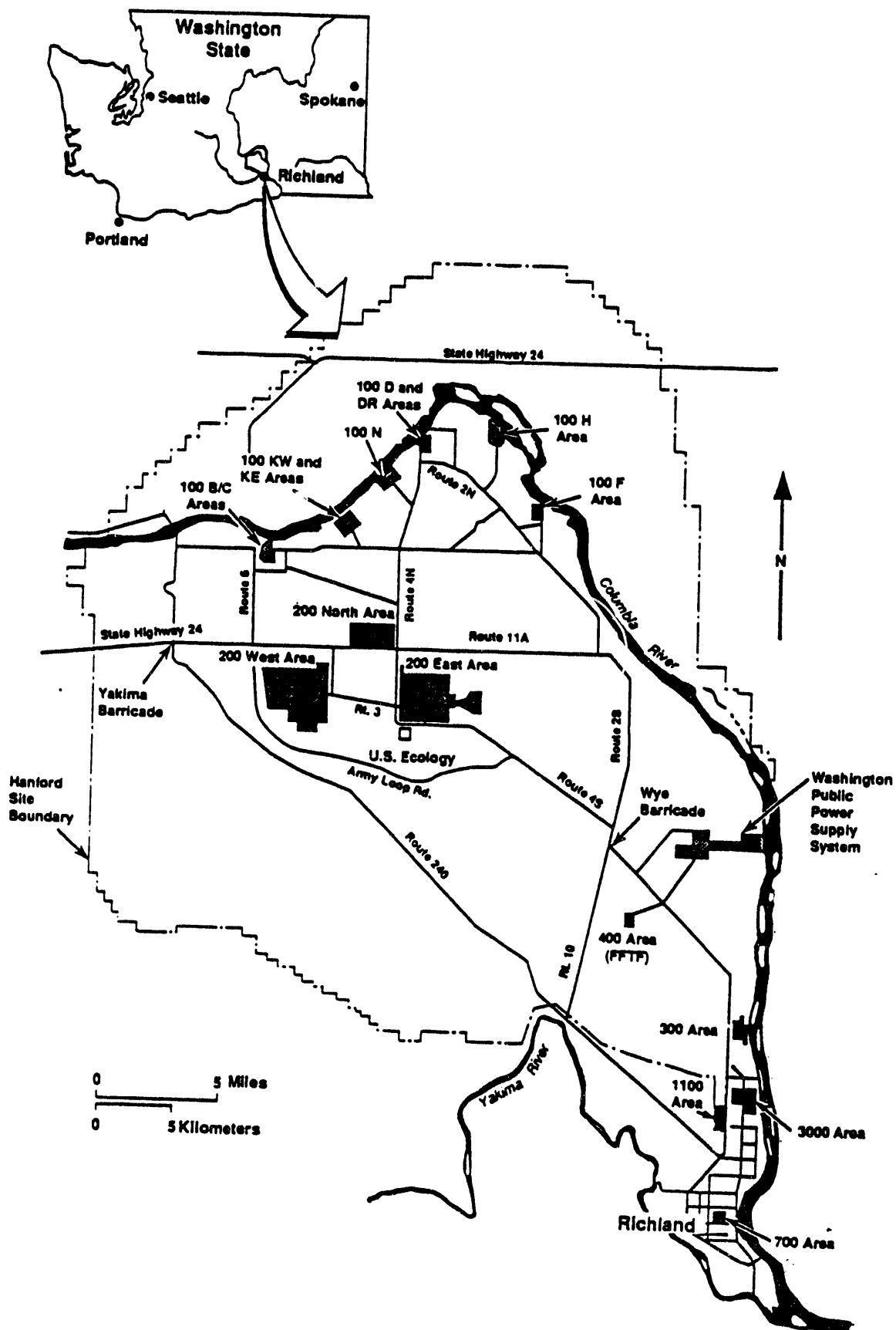
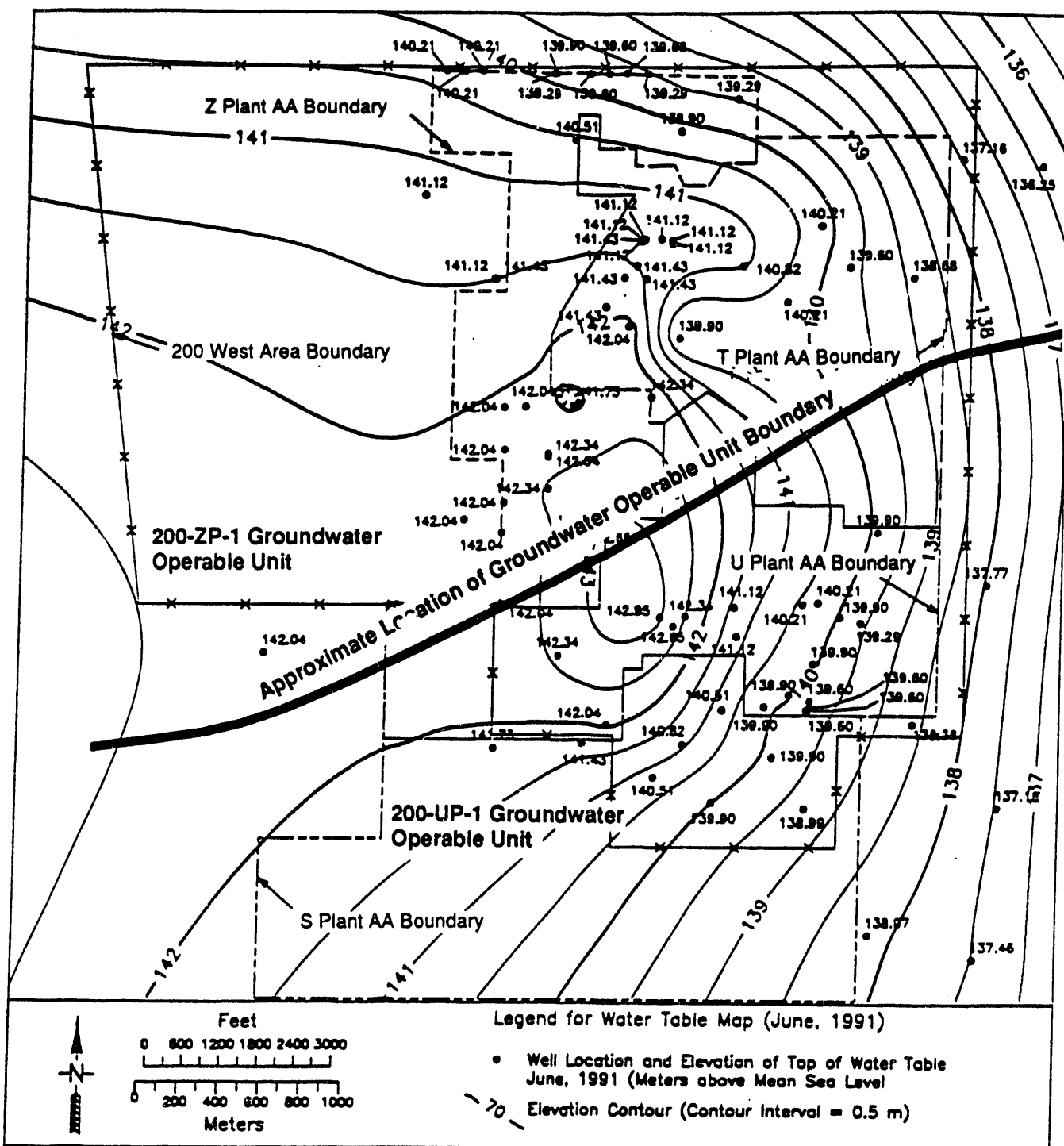


Figure 1-1. Hanford Site Map.

H9106036.3a



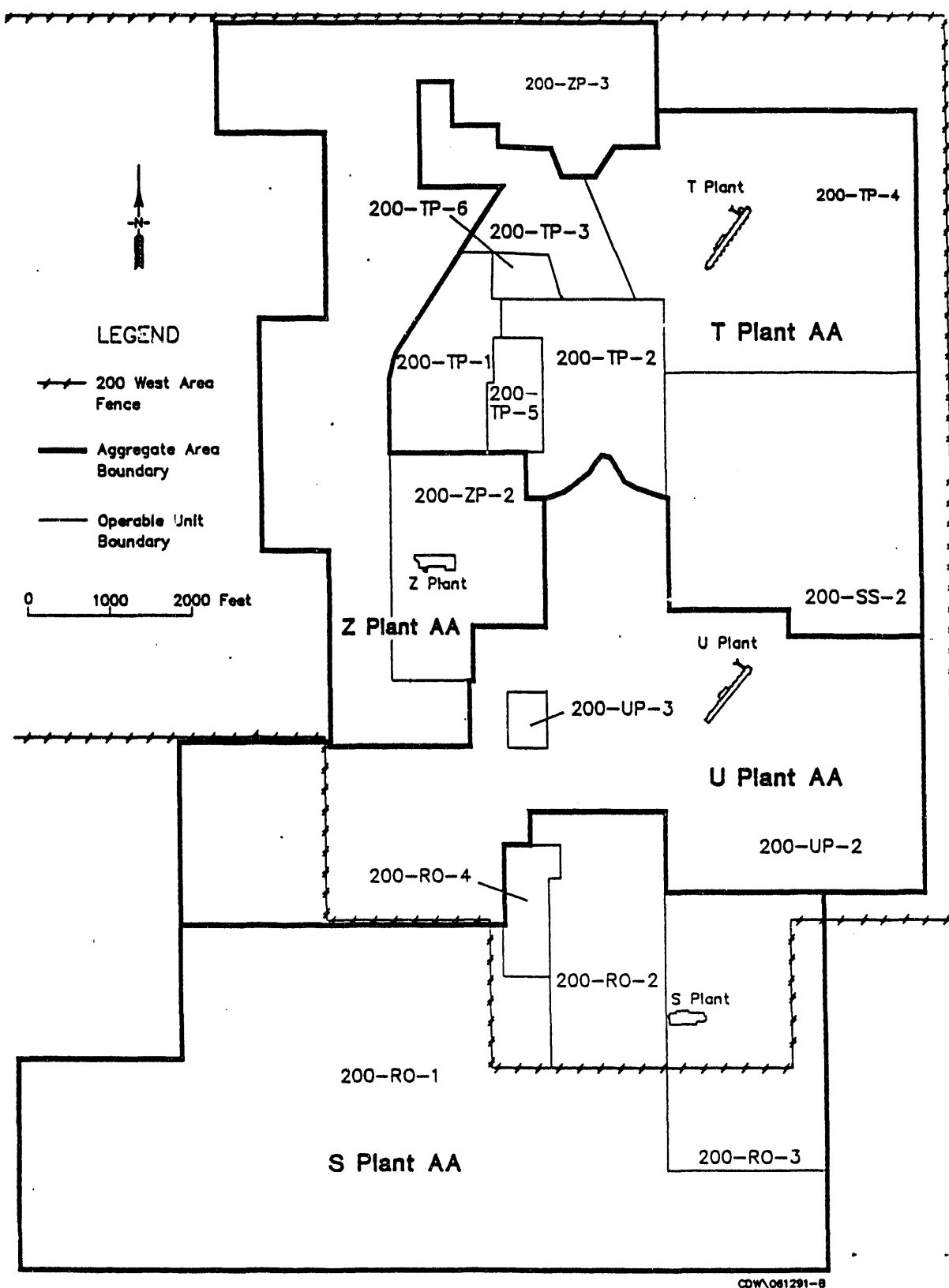


Figure 1-3. 200 West Source Aggregate Areas and Associated Operable Units.

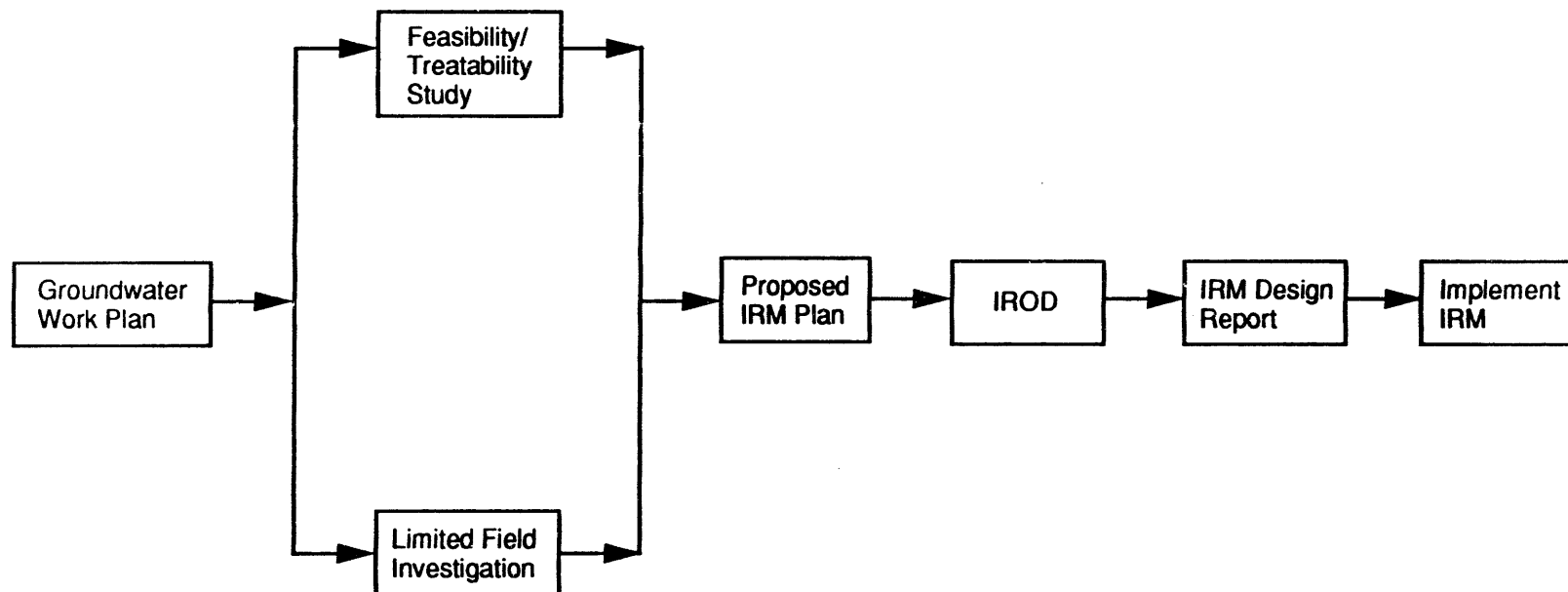


Figure 1-4. Framework for Conducting RI/FS
at 200-UP-1 Groundwater Operable Unit.

**Table 1-1. Disposition of Groundwater Contaminants in the
200-UP-1 Groundwater Operable Unit (200 West Groundwater AAMSR).**

Page 1 of 3

Detected Constituent ^a	ERA	IRM	LFI	RA	RI	Remarks
ORGANIC COMPOUNDS						
Chlorinated Aliphatics						
Chloroform (CHCl ₃)	--	--	X	--	--	
Carbon Tetrachloride (CCl ₄)	--	--	X	--	--	
Methylene Chloride	--	--	X	--	X	
1,1-dichloroethylene (DCE)	--	--	X	--	--	Single detection, not confirmed
1,2-dichloroethane (DCA)	--	--	X	--	--	Detected in one well only
1,1,1-trichloroethane (TCA)	--	--	--	--	X	
Trichloroethylene (TCE)	--	--	X	--	--	
Aromatics						
Toluene	--	--	--	--	X	Single detection, not confirmed
Phenols						
Phenol	--	--	--	--	X	
o-Nitrophenol	--	--	--	--	X	Single detection, not confirmed
Bisphenol A	--	--	--	--	X	Single detection, not confirmed
2,4,5-trichlorophenol	--	--	--	--	X	Single detection, not confirmed
2,6-Bis(1,1-dimethylethyl)-4 methyl-phenol	--	--	--	--	X	Not confirmed in any well detected
Pentachlorophenol	--	--	--	--	X	LFI in 200-ZP-1
2-sec-butyl-4,6-dinitrophenol	--	--	--	--	X	
Ketones						
Acetone	--	--	--	--	X	
Methyl ethyl ketone (MEK)	--	--	--	--	X	Not confirmed in any well detected
4-Methyl-2-pentanone	--	--	--	--	X	Single detection, not confirmed
Pesticides						
All pesticide detections collocated.						
Aldrin	--	--	X	--	--	Not confirmed in any well detected
DLD	--	--	X	--	--	Not confirmed in any well detected
DDT	--	--	X	--	--	Not confirmed in any well detected
Dieldrin	--	--	X	--	--	Not confirmed in any well detected
Endrin	--	--	X	--	--	Not confirmed in any well detected
Endrin Aldehyde	--	--	X	--	--	Not confirmed in any well detected
Gamma-BHC	--	--	X	--	--	Not confirmed in any well detected
Heptachlor	--	--	X	--	--	Not confirmed in any well detected

**Table 1-1. Disposition of Groundwater Contaminants in the
200-UP-1 Groundwater Operable Unit (200 West Groundwater AAMSR).**

Page 2 of 3

Detected Constituent ^a	ERA	IRM	LFI	RA	RI	Remarks
Miscellaneous Organics						
Bis(2-ethylhexyl) phthalate	--	--	X	--	--	Not confirmed in any well detected
1,2 Propandiol	--	--	--	--	X	Single detection, not confirmed
Carbon disulfide	--	--	--	--	X	Not confirmed in any well detected
N-nitrosodimethylamine	--	--	X	--	--	Single detection, not confirmed
RADIONUCLIDES						
Gross alpha	--	--	X	--	--	Indicator parameter
Gross beta	--	--	X	--	--	Indicator parameter
Tritium (H-3)	--	--	--	X	--	Treatment technology not available
Carbon(C)-14	--	--	--	--	X	
Potassium(K)-40	--	--	X	--	--	Potentially represents natural sources
Cobalt(Co)-60	--	--	--	--	X	
Nickel(Ni)-63	--	--	--	--	X	
Strontium(Sr)-90	--	--	X	--	--	
Zirconium/Niobium(Zr/Nb)-95	--	--	--	--	X	Not confirmed in any well detected
Technetium(Tc)-99	--	X	--	--	--	Associated with uranium
Silver(Ag)-110 Metastable	--	--	--	--	X	Single detection, not confirmed
Ruthenium(Ru)-106	--	--	--	--	X	
Antimony(Sb)-125	--	--	--	--	X	Not confirmed in any well detected
Iodine(I)-129	--	--	X	--	--	
Cesium(Cs)-137	--	--	--	--	X	
Europium(Eu)-154	--	--	--	--	X	Not confirmed in any well detected
Lead(Pb)-212	--	--	--	--	X	
Radium (Ra)	--	--	--	--	X	
Uranium (U)	--	X	--	--	--	
Uranium(U)-234	--	X	--	--	--	
Uranium(U)-235	--	X	--	--	--	
Uranium(U)-238	--	X	--	--	--	
Plutonium(Pu)-238	--	--	X	--	--	Not confirmed in any well detected
Plutonium(Pu)-239/40	--	--	--	--	X	

**Table 1-1. Disposition of Groundwater Contaminants in the
200-UP-1 Groundwater Operable Unit (200 West Groundwater AAMSR).**

Page 3 of 3

Detected Constituent ^a	ERA	IRM	LFI	RA	RI	Remarks
INORGANIC COMPOUNDS						Most inorganics require determination of background
Aluminum (Al)	--	--	--	--	X	
Ammonium ion (NH ₄)	--	--	--	--	X	
Arsenic (As)	--	--	X	--	--	
Barium (Ba)	--	--	--	--	X	
Beryllium (Be)	--	--	--	--	X	LFI in 200-ZP-1
Boron (B)	--	--	--	--	X	
Cadmium (Cd)	--	--	X	--	--	Not confirmed in any well detected
Chromium (Cr)	--	--	X	--	--	
Cobalt (Co)	--	--	--	--	X	Single detection, not confirmed
Copper (Cu)	--	--	--	--	X	
Cyanide (CN)	--	--	--	--	X	
Fluoride (F)	--	--	X	--	--	
Iron (Fe)	--	--	--	--	X	
Lead (Pb)	--	--	--	--	X	Toxicity value also needed
Lithium (Li)	--	--	--	--	X	
Magnesium (Mg)	--	--	--	--	X	
Manganese (Mn)	--	--	--	--	X	
Nickel (Ni)	--	--	--	--	X	
Nitrate (NO ₃)	--	X	--	--	--	
Nitrite (NO ₂)	--	--	--	--	X	
Potassium (K)	--	--	--	--	X	
Selenium (Se)	--	--	X	--	--	
Silver (Ag)	--	--	--	--	X	Single detection, not confirmed
Sodium (Na)	--	--	--	--	X	
Sulfate (SO ₄)	--	--	--	--	X	
Uranium (U), chemical	--	X	--	--	--	
Vanadium (V)	--	--	--	--	X	
Zinc (Zn)	--	--	--	--	X	

^a Data current through sampling conducted in September 1992.

2.0 BACKGROUND AND SETTING

Section 2.0 of the 200-UP-1 Groundwater Operable Unit Work Plan presents a summary description of historical operations, waste management units, and disposal practices with known or potential impacts to groundwater (Section 2.1). Section 2.2 briefly describes the physical setting, geology, and hydrogeology of the 200-UP-1 Groundwater Operable Unit. The information presented in Section 2.0 is condensed from detailed descriptions from the following *200 West Groundwater AAMSR* (DOE/RL 1992b) sections:

200 West Groundwater AAMSR Section	Topic
2.2	History of operations
2.3	Facilities and Structures Potentially Impacting Groundwater
2.4	Waste Generating Processes that Potentially Affect Groundwater Quality
3.1	Physiography and Topography
3.2	Surface Hydrogeology
3.3	Geology
3.4	Hydrogeology

These listed sections should be consulted for supporting detail. Reference sources for the information presented are cited in the appropriate sections of the *200 West Groundwater AAMSR* (DOE/RL 1992b). Additional text discussing meteorology, environmental resources, and human resources is also provided in the *200 West Groundwater AAMSR* (DOE/RL 1992b).

2.1 POTENTIAL GROUNDWATER CONTAMINANT SOURCES

The following text summarizes Historical Operations, Disposal Practices, and Waste Management Units (Section 2.1.1), and Potential for Liquid Discharge to the Unconfined Aquifer (Section 2.1.2) for U Plant and S Plant Source Aggregate Area facilities in the 200-UP-1 Groundwater Operable Unit. Waste management units, years of service, and their potential for discharging liquids to the unconfined aquifer are summarized in the *U Plant Source AAMSR* and *S Plant Source AAMSR* (DOE/RL 1992c,d) in Tables 2-1 and 2-4 in each of these documents, respectively.

2.1.1 Historical Operations, Disposal Practices, and Waste Management Units

The primary waste generating facilities in the U Plant Source Aggregate Area are associated with 221-U Building and its attendant facilities (Uranium Trioxide [UO_3]) Plant, 271-U Building, 222-U Laboratory, etc.). Processes at these facilities were related to uranium extraction and the conversion of uranyl nitrate hexahydrate to UO_3 . Wastes streams included process wastes and wastewater from uranium recovery that were discharged to cribs, french drains, ponds, and ditches. Spent solvents and carbonate scrub solutions from solvent treatment were discharged to trenches and cribs. Laboratory process wastes, reagents, and wastewaters were discharged to a reverse well and french drains. The waste management units in the U Plant Source Aggregate Area that discharge wastes to the soil and are still active include the following:

- 216-U-17 Crib
- 216-Z-20 Crib
- 216-U-14 Ditch
- All septic tanks/drain fields.

The S Plant Source Aggregate Area is the location of the S Plant (REDOX Plant) and its attendant facilities (202-S Building, 222-S Analytical Laboratory, etc.). At the S Plant Complex, the laboratory supports B Plant operations and research and development work. Primary waste streams from S Plant included dissolution wastes, aqueous process wastes, and organic process wastes that were discharged to tanks and cribs. Laboratory wastes were discharged to tanks. The waste management units in the S Plant Source Aggregate Area that discharge wastes to the soil and are still active include the following:

- 216-S-25 Crib
- 216-S-26 Crib
- Sanitary Crib
- 2607-W6 Septic Tank and Tile Field
- 2607-WZ Septic Tank.

Detailed information on discharges to these units is found in the *U Plant Source AAMSR* (DOE/RL 1992c) and the *S Plant Source AAMSR* (DOE/RL 1992d).

2.1.2 Potential for Liquid Discharge to the Unconfined Aquifer

The potential for each waste management unit to have contributed liquids to the unconfined aquifer in the past was assessed based on soil pore volume screening calculations and examination of geophysical logs (gross gamma ray and spectral gamma). Conclusions of this screening assessment are presented in Table 2-1. The basic purpose of this screening was to flag any waste management unit that received a volume of liquid waste greater than a conservatively high estimate of the soil pore volume beneath the unit or any unit where geophysical logging indicated radionuclides had been contributed to the groundwater. The rationale for these screening criteria is discussed in the *200 West Groundwater AAMSR* (DOE/RL 1992b), and screening criteria

assumptions and details are presented in Tables 2-2 and 2-3 of the *200 West Groundwater AAMSR* (DOE/RL 1992b). This analysis does not take into account long-term drainage that may be occurring at any of the sites that received liquid waste. For the U Plant Source Aggregate Area, the screening criteria indicate potential for liquids discharged to the following waste management units to have reached the groundwater table:

- All U Plant cribs
- All U Plant french drains
- 216-U-4 Reverse Well
- 216-U-10 Pond
- 216-U-5 and 216-U-6 Trenches
- 2607-W-5, 2607-W-9, and 2607-WUT Septic Tanks and Drain Fields.

For the S Plant Source Aggregate Area the following waste management units passed the screening criteria as possible past contributors to groundwater contamination:

- All cribs (except the 216-S-22 Crib)
- 216-S-3 French Drain
- 216-S-11, 216-S-16P, 216-S-17, and 216-S-19 Ponds
- 216-S-10D and 216-S-16D Ditches
- 216-S-8 Trench
- 2607-W6 Septic Tank and Tile field, and 2607-WZ Septic Tank.

2.2 PHYSICAL SETTING

The 200-UP-1 Groundwater Operable Unit occupies the southern portion of the 200 West Groundwater Aggregate Area. A detailed discussion of the geology and hydrogeology of the 200 West Groundwater Aggregate Area is presented in the *200 West Groundwater AAMSR* (DOE/RL 1992b). The following text summarizes the geologic and hydrogeologic features of the 200-UP-1 Groundwater Operable Unit.

2.2.1 Geologic features

The geology of the 200-UP-1 Groundwater Operable Unit is characterized by basalt bedrock and sedimentary interbeds overlain by a thick sequence of semiconsolidated late-Miocene to Pleistocene-aged gravels, sands, and silts. Figure 2-1 presents a conceptual geologic and hydrogeologic column of the major stratigraphic units. Geologic cross sections of the 200-UP-1 Groundwater Operable Unit are presented on Figures 2-2 through 2-8. Cross-sections and well locations are identified on Figure 2-2, and a legend is presented on Figure 2-3.

Within the 200-UP-1 Groundwater Operable Unit, basalt units of primary interest are members of the Saddle Mountains Basalt. These basalt units are part of the Columbia River Basalt Group, a thick sequence of regionally extensive basalt flows that were erupted during the Miocene epoch. The Elephant Mountain Member is the uppermost basalt flow unit of the Saddle

Mountains Basalt in the 200-UP-1 Groundwater Operable unit, and is approximately 18 to 36 m (59 to 118 ft) thick. This unit is separated from the underlying pomona flow by the Rattlesnake Ridge interbed, an approximately 24- to 29-m (80- to 95-ft) thick sedimentary unit composed of sandstone, siltstone, and clay. The Rattlesnake Ridge interbed and deeper interbeds between basalt flows comprise the Ellensburg Formation. These interbeds, and associated Saddle Mountains Basalt flow tops and bottoms, form water bearing zones between basalt flows.

Sediments overlying the basalt in the 200-UP-1 Groundwater Operable Unit are comprised of, from bottom to top, the Ringold Formation, the Plio-Pleistocene unit, the early "Palouse" soil, and the Hanford formation. Relatively thin surficial deposits of Eolian sand, loess, alluvium, and colluvium overlie the Hanford formation. Sediments overlying the basalt in the 200-UP-1 Groundwater Operable Unit are up to approximately 230 m (750 ft) thick. Figures 2-4 through 2-8 illustrate variations in unit thicknesses in the 200-UP-1 Groundwater Operable Unit.

Within the 200-UP-1 Groundwater Operable Unit, the Ringold Formation consists of fluvial gravels (Ringold Units A and E), and paleosol and lacustrine muds (Ringold lower mud sequence). The Ringold Unit A is the lowermost unit and is up to approximately 41 m (135 ft) thick. The Ringold lower mud sequence overlies the Ringold Unit A and is up to approximately 33 m (110 ft) thick. The Ringold Unit E overlies the Ringold lower mud sequence and is up to approximately 88 m (290 ft) thick. The Ringold upper unit (sands and minor muds) does not appear to be present in the 200-UP-1 Groundwater Operable Unit.

The Plio-Pleistocene unit contains calcium carbonate-cemented silt, sand, and gravel, and in places forms perched water zones. Thickness variations in the Plio-Pleistocene unit are very irregular. The Plio-Pleistocene unit is up to approximately 14 m (46 ft) thick and pinches out south and southwest of the 200 West Area. In addition, undocumented eroded zones though the Plio-Pleistocene unit may exist.

The early "Palouse" soil consists of loess-like silt and minor fine-grained sand. The early "Palouse" soil is up to approximately 17 m (54 ft) thick. The thickness of the early "Palouse" soil varies irregularly.

The Hanford formation consists of gravel to silt fluvial deposits up to approximately 65 m (210 ft) thick. The Hanford formation is divided into an upper coarse grained unit and a lower fine grained unit. Neither of these two units is continuous throughout the 200 West Area. Both units display marked changes in thickness and continuity, and are very heterogeneous.

In the 200-UP-1 Groundwater Operable Unit, basalt and overlying sediments dip gently to the southwest toward the axis of the Cold Creek syncline. The Cold Creek syncline is a broad structural depression associated with regional anticlinal uplifts and other folds.

2.2.2 Hydrogeologic Features

The primary hydrostratigraphic units of interest for the 200-UP-1 Groundwater Operable Unit are

- The Rattlesnake Ridge interbed and deeper interbeds of the Ellensburg Formation (confined water-bearing zones)
- The Elephant Mountain Member and deeper flows of the Saddle Mountains Basalt (confining horizons for Ellensburg Formation interbeds)
- The Ringold Formation (Ringold Unit A as a semiconfined to confined water bearing zone, Ringold lower mud sequence as a confining layer, and Ringold Unit E as an unconfined water-bearing zone and lower vadose zone)

A groundwater elevation contour map depicting June 1991 flow conditions for the unconfined aquifer in the Ringold Unit E gravels is provided on Figure 1-2. The remainder of this section briefly summarizes hydrogeologic features of the confined and uppermost aquifer systems.

In the 200-UP-1 Groundwater Operable Unit, limited borehole data are available for the regionally confined aquifers within the Saddle Mountains Basalt-Ellensburg Formation hydrostratigraphic unit. As discussed in the *Quarterly Report of RCRA Groundwater Monitoring Data for Period January 1, 1992 through March 31, 1992* (DOE/RL 1992f), few wells have penetrated the Rattlesnake Ridge interbed (the uppermost basalt sedimentary interbed aquifer) in the vicinity of the 200-UP-1 Groundwater Operable Unit, and limited information regarding hydraulic properties has been collected for this aquifer and deeper confined zones.

In the 200-UP-1 Groundwater Operable Unit, the uppermost aquifer system is comprised of the unconfined aquifer within the Ringold Unit E gravels, and the semiconfined to confined aquifer within the Ringold Unit A gravels. Hydraulic conductivities and transmissivities compiled for the unconfined portion of the uppermost aquifer in the Ringold Unit E gravels range from about 0.02 to 61 m/day (0.06 to 200 ft/day), and 1.9 to 4,740 m²/day (20 to 51,000 ft²/day), respectively. Hydraulic conductivity values from the semiconfined to confined Ringold Unit A gravels have a narrower range of 0.52 to 1.2 m/day (1.7 to 4 ft/day).

Depth to the water table ranges from approximately 50 m (165 ft) near the southwest corner of the S Plant Source Aggregate Area to more than 80 m (262 ft) near the southeast corner of the T Plant Source Aggregate Area. The thickness of the Ringold Unit A gravels varies from approximately 41 m (135 ft) near the southeast corner of the S Plant Source Aggregate Area to less than 6.4 m (21 ft) near the northeast corner of the U Plant Source Aggregate Area.

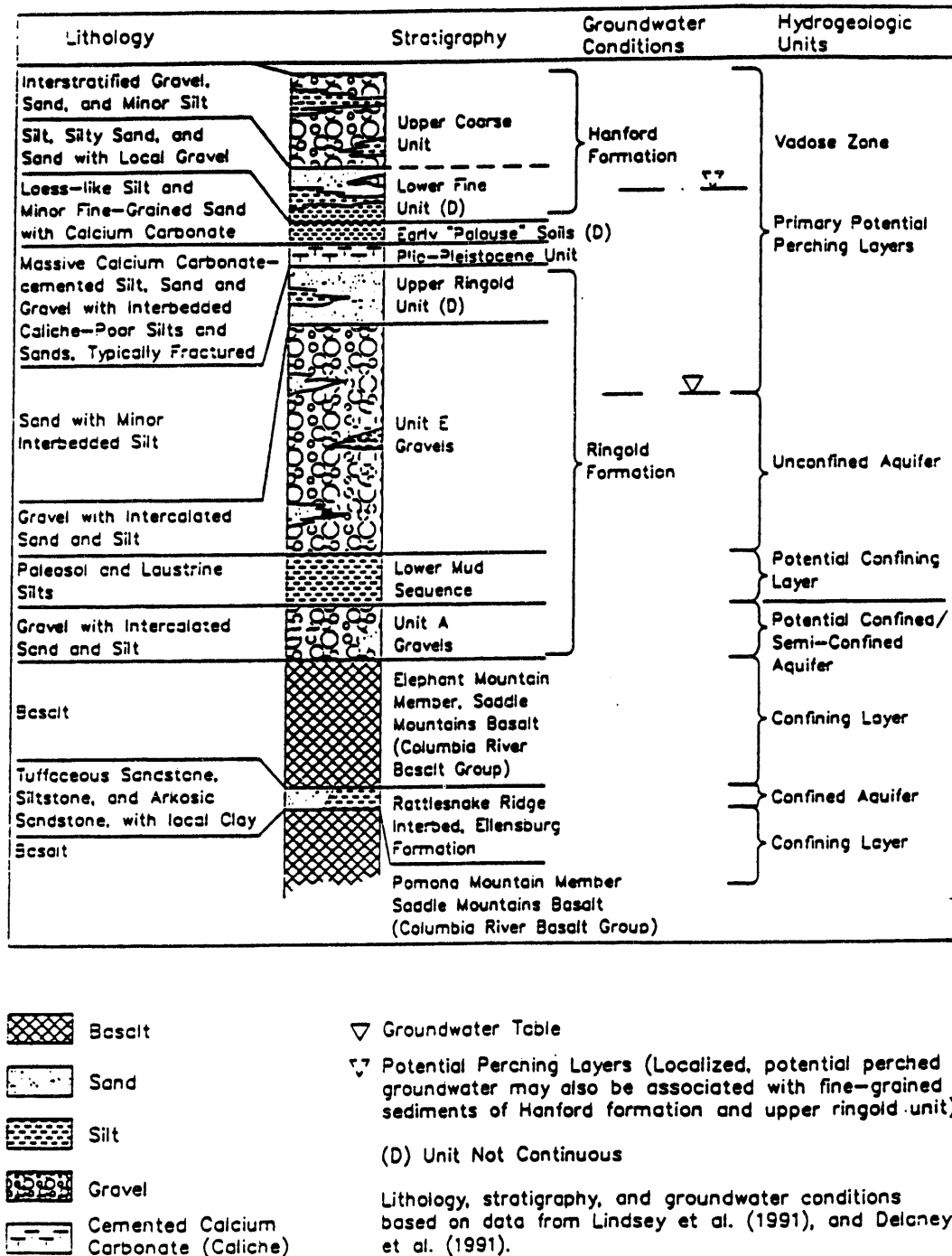


Figure 2-1. Generalized Geologic and Hydrogeologic Column for the 200-UP-1 Groundwater Operable Unit.

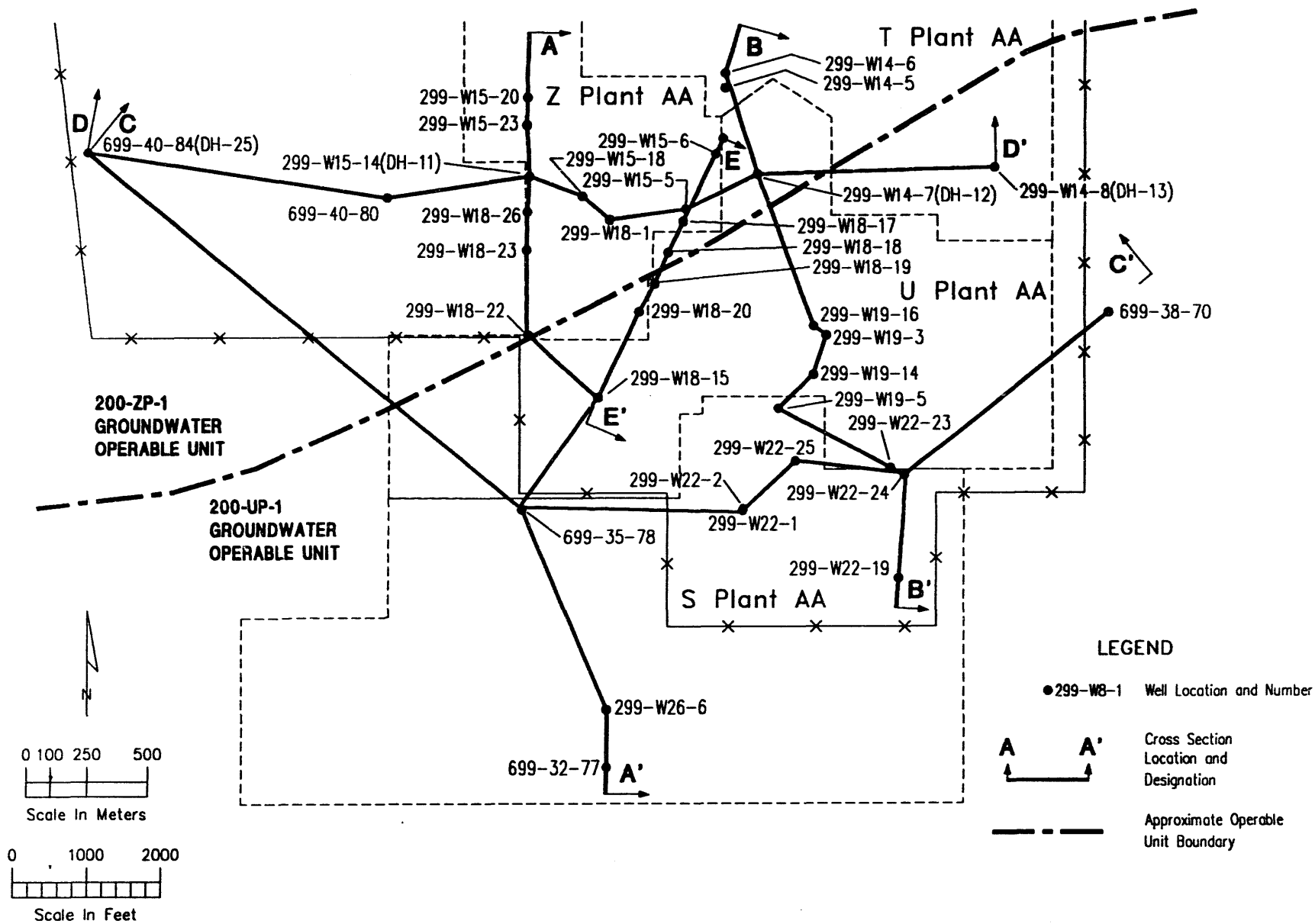
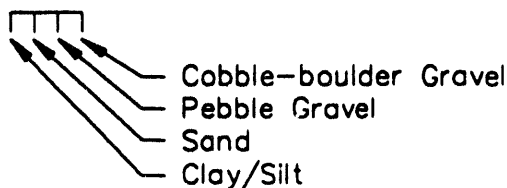


Figure 2-2. Location of Cross Sections.

Explanation

Grain Size Scale, Indicates
Dominant Grain Size in an Interval



Additional Lithologic Symbols
Includes Subordinate Lithologies

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

Other Symbols

- Formational contact, ? where inferred
- Unit contact, ? where inferred
- Water Table Elevation (December 1991)

Unit Abbreviations

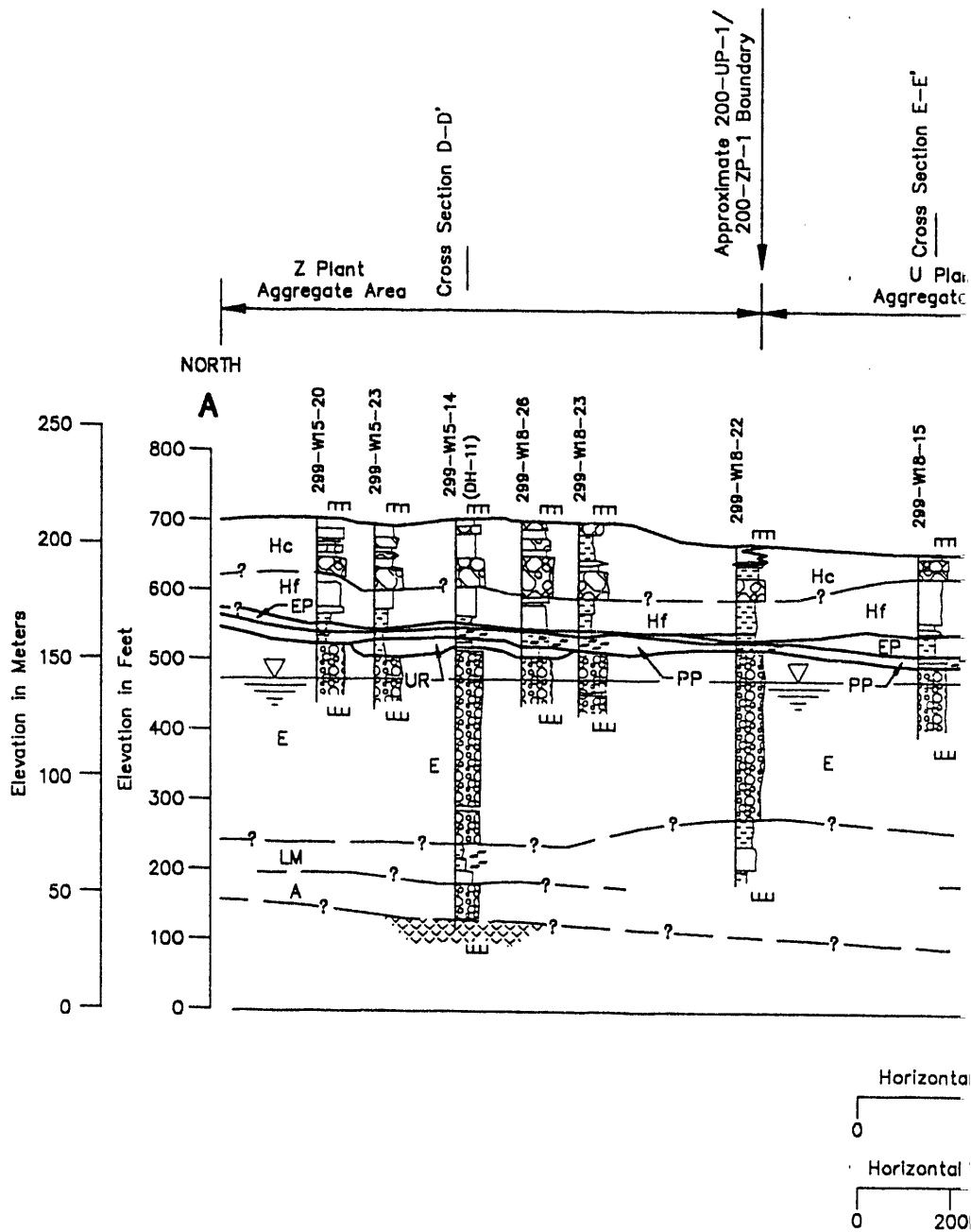
- Hc - Upper Coarse Unit, Hanford formation
- Hf - Lower Fine Unit, Hanford formation
- EP - Early "Palouse" Soil
- PP - Plio-Pleistocene Unit
- UR - Upper Unit, Ringold Formation
- E - Gravel Unit E, Ringold Formation
- LM - Lower Mud Sequence, Ringold Formation
- A - Gravel Unit A, Ringold Formation

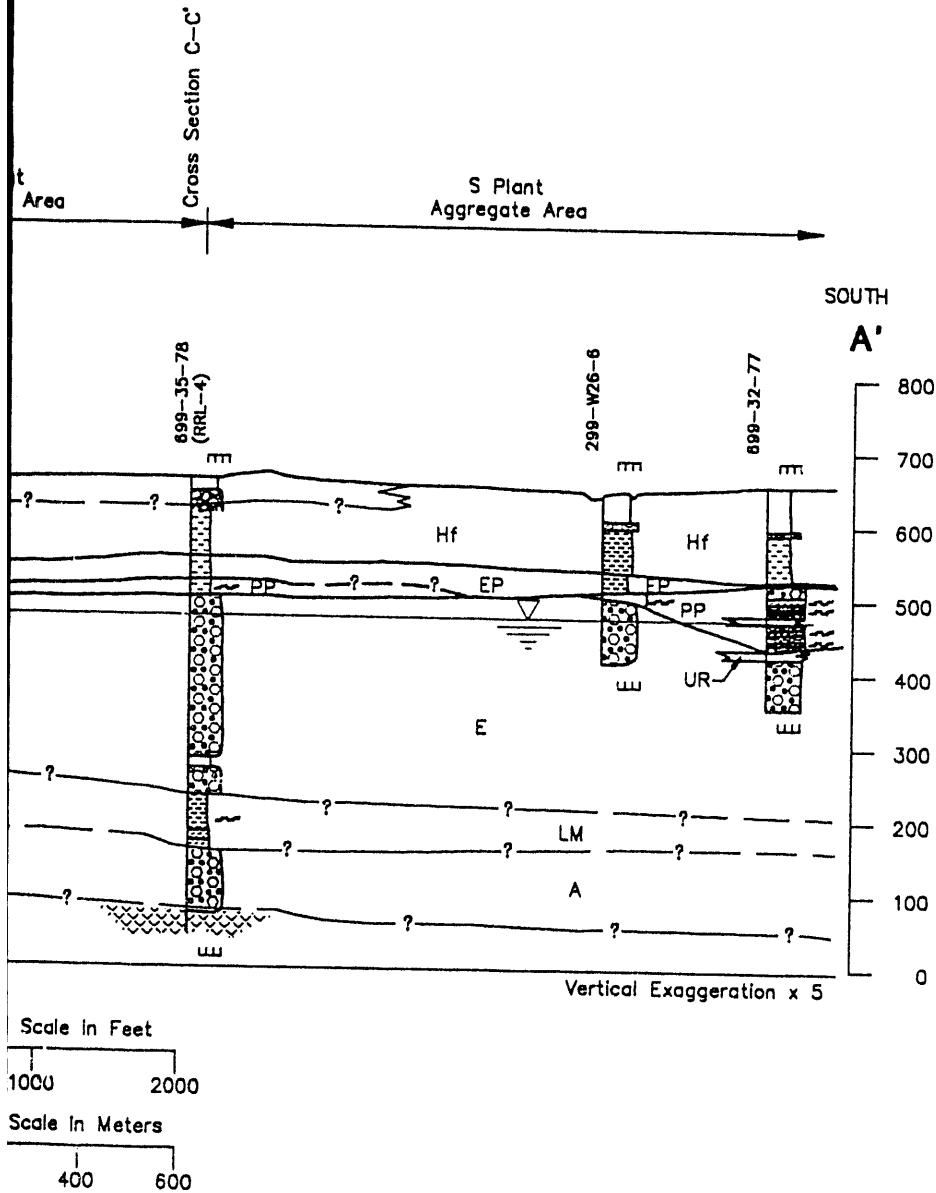
Blank portions of cross section well logs represent sediments (dominantly sand) which do not fit into sediment categories depicted by symbols listed above.

NOTE:

Figures based on Lindsey et al. 1991.

Figure 2-3. Legend for Cross Sections.



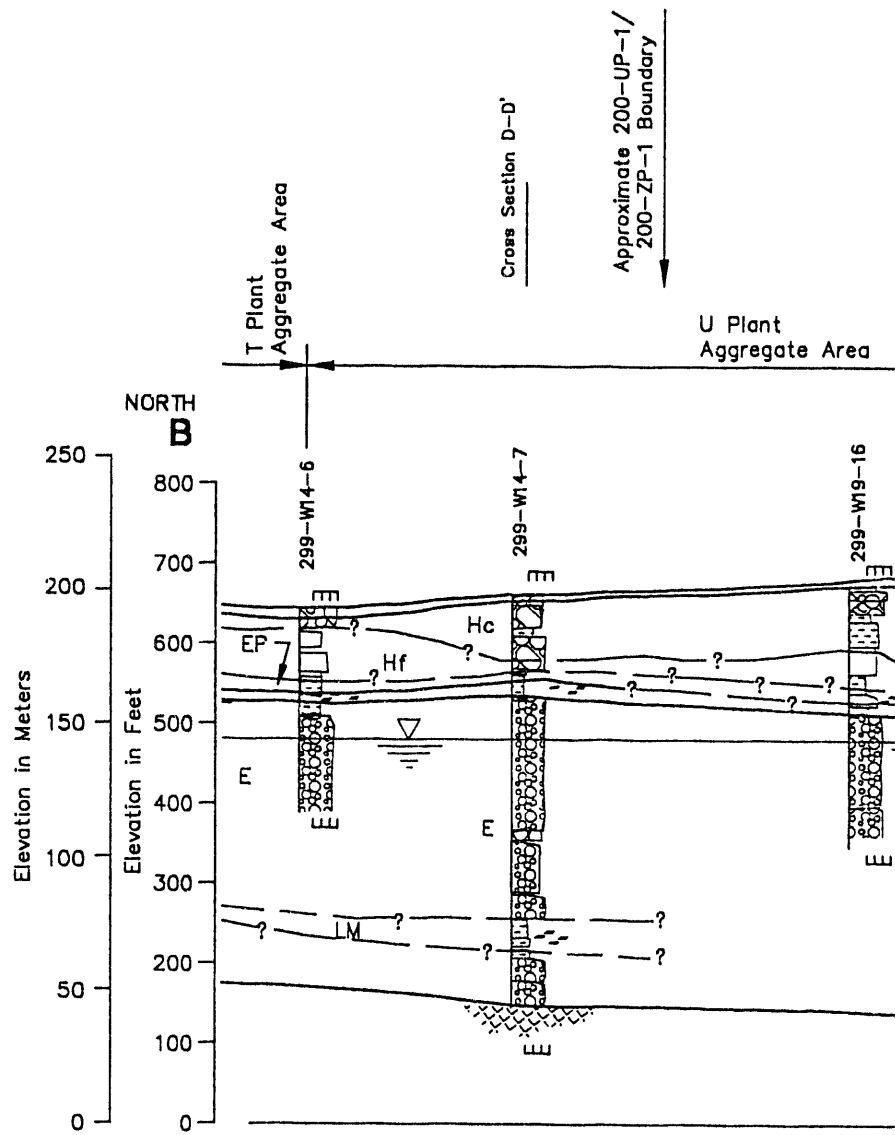
**NOTE**

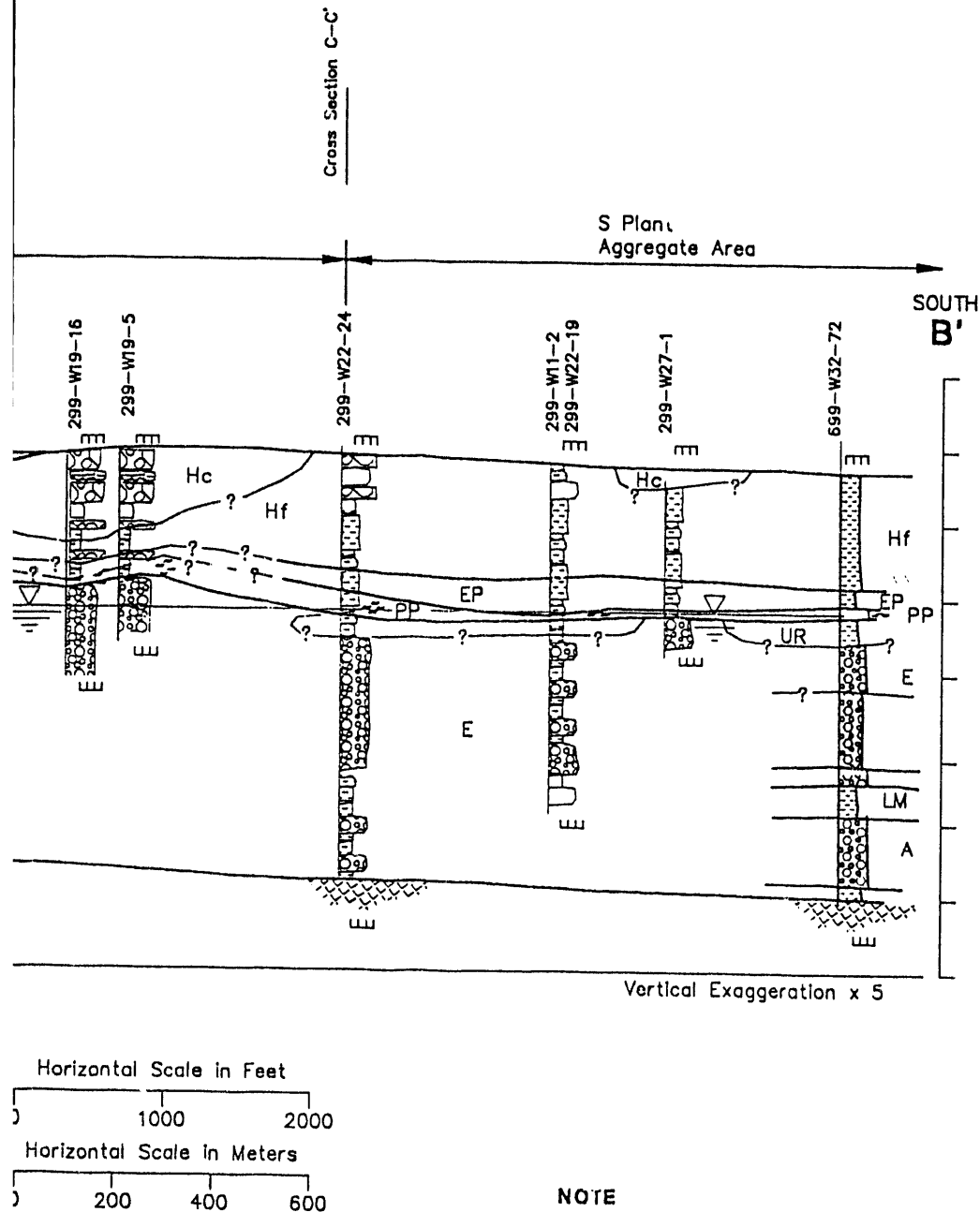
Refer to Figure 2-2 for cross section location and Figure 2-3 for legend. Figure based on Lindsey et al. 1991.

Figure 2-4. 200 West Area Geologic Cross Section A-A' (Modified).

2F-4

/cad/200w-h2o/200w-a - 1"=20'





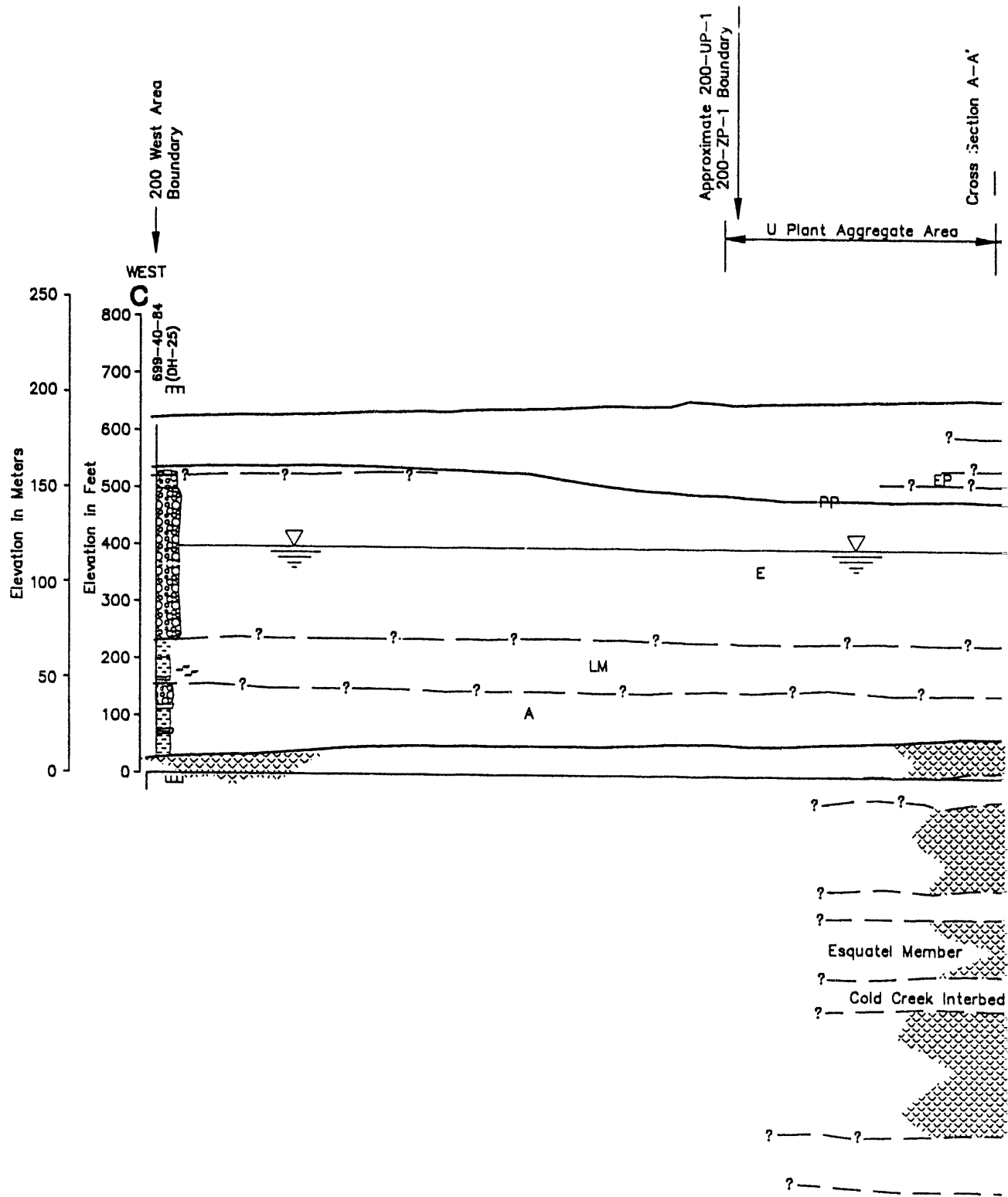
NOTE

Refer to Figure 2-2 for cross section location and Figure 2-3 for legend. Figure based on Lindsey et al. 1991.

Figure 2-5. 200 West Area Geologic Cross Section B-B' (Modified).

2F-5

/cad/200w-h2o/200w-b - 1"=20



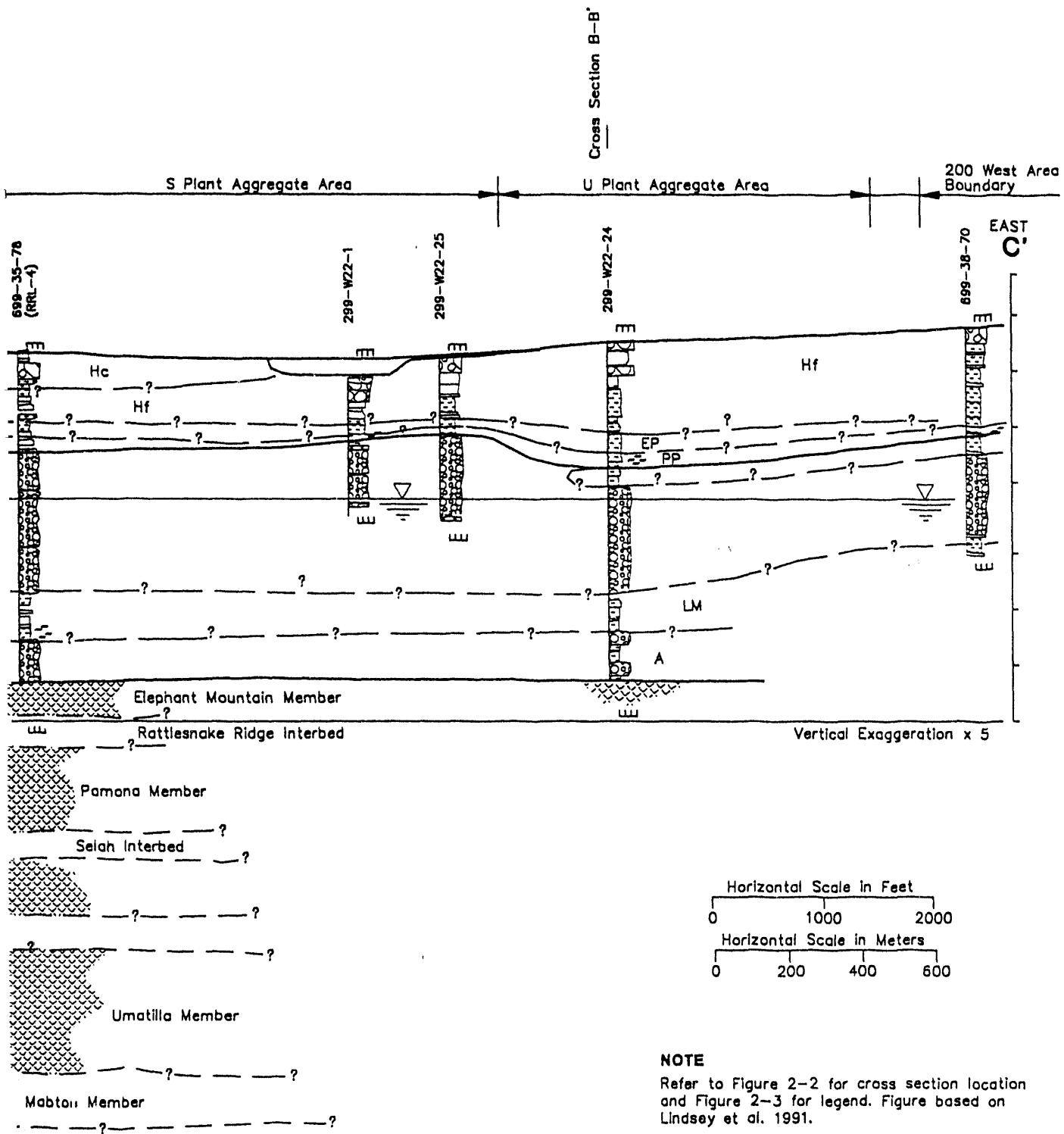
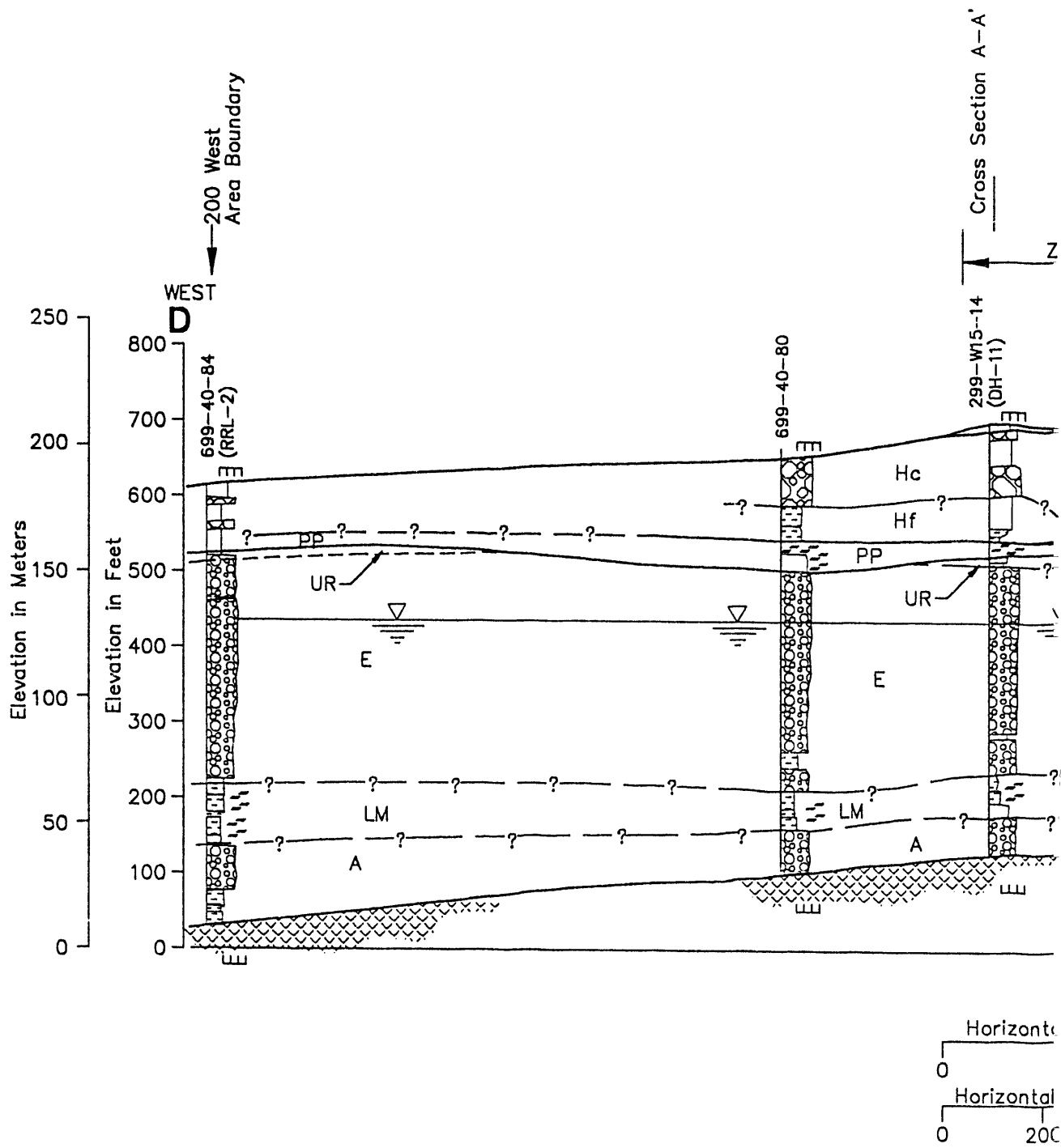
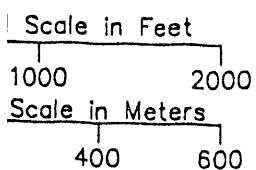
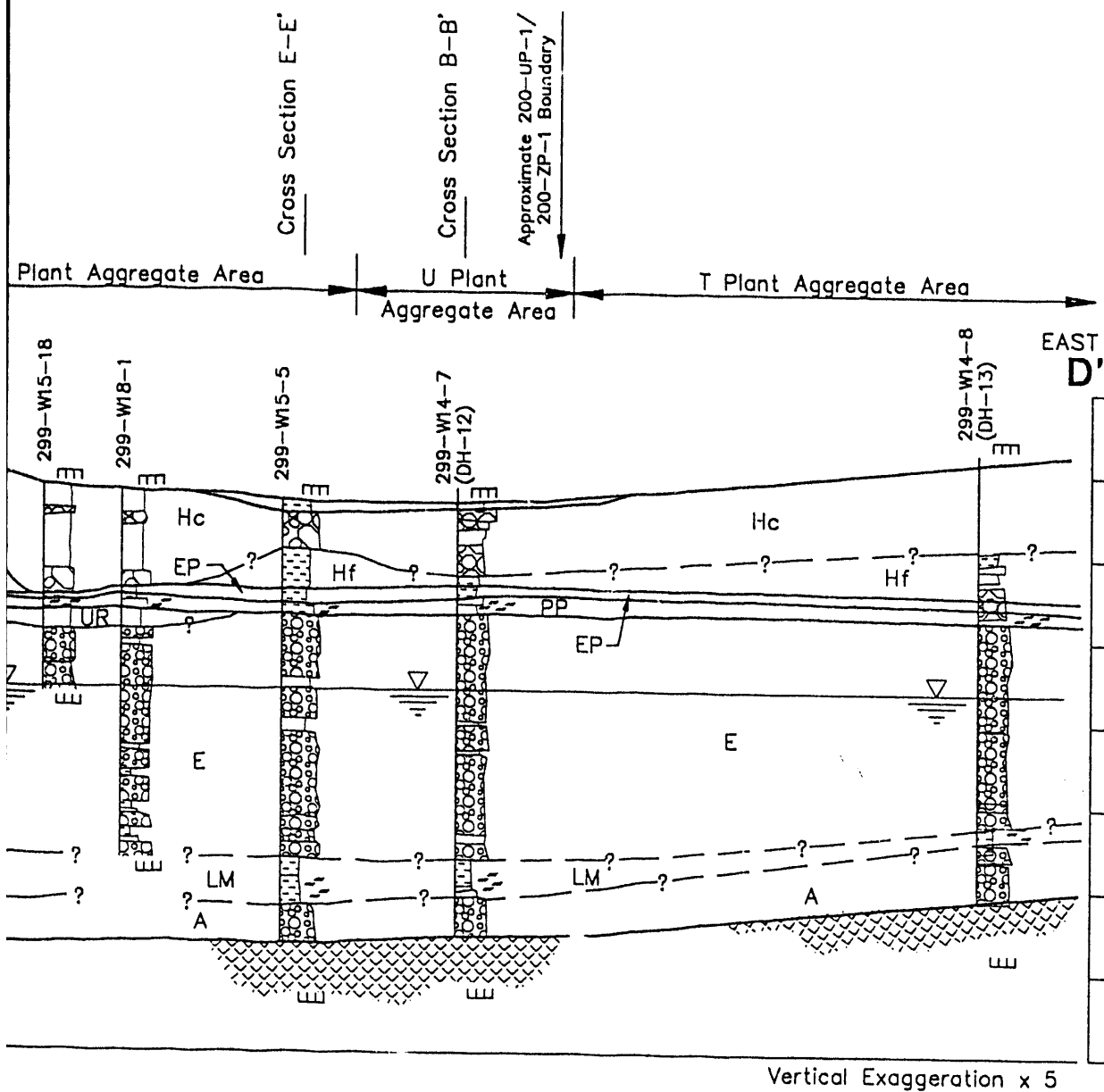


**Figure 2-6. 200 West Area
Geologic Cross Section C-C'.**

2F-6

/cad/200w-h2o/200w-c - 1"=20'

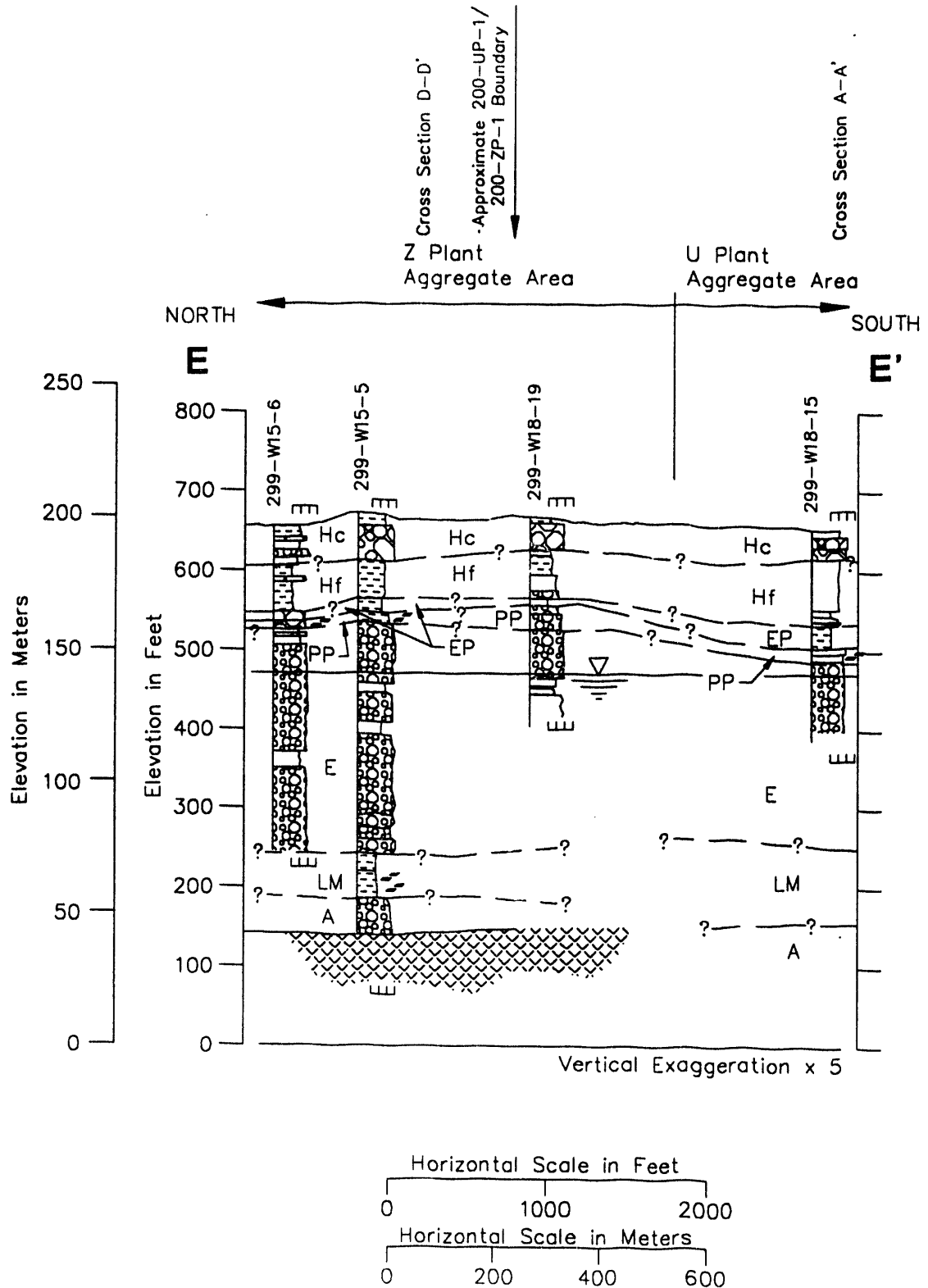


**NOTE**

Refer to Figure 2-2 for cross section location and Figure 2-3 for legend. Figure based on Lindsey et al. 1991.

**Figure 2-7. 200 West Area
Geologic Cross Section D-D'.**

2F-7

**NOTE**

Refer to Figure 2-2 for cross section location and Figure 2-3 for legend. Figure based on Lindsey et al. 1991.

Figure 2-8. 200 West Area Geologic Cross Section E-E' (Modified from G-G').

Table 2-1. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Page 1 of 3

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening	Potential Based on Geophysical Logs Confirmed by Geophysical Logs (gross gamma-ray)	Confirmed by Spectral Gamma-ray Logs	Criteria Indicates Possible Past Contribution to Uppermost Aquifer
U Plant Aggregate Area					
241-U-101 Single-Shell Tank	1949-1959	No	No	No logs	No
241-U-103 Single-Shell Tank	1947-1978	No	No	No logs	No
241-U-104 Single-Shell Tank	1947-1956	No	No	No logs	No
241-U-110 Single-Shell Tank	1946-1975	No	No	No logs	No
241-U-112 Single-Shell Tank	1947-1970	No	No	No logs	No
216-S-21 Crib	1954-1969	Yes	No	No	Yes
216-U-1 and 216-U-2 Cribs	1951-1968	Yes	No	Yes	Yes
216-U-8 Crib	1952-1960	Yes	No	No logs	Yes
216-U-12 Crib	1960-1968	Yes	No	No	Yes
216-U-16 Crib	1984-1987	Yes	No	No logs	Yes
216-U-17 Crib	1988-present	Yes	No	No logs	Yes
216-Z-20 Crib	1981-present	Yes	No logs	No logs	Yes
216-S-4 French Drain	1953-1956	Yes	No logs	No logs	Yes
216-U-3 French Drain	1954-1955	Yes	No	No logs	Yes
216-U-4A French Drain	1955-1970	Yes	No logs	No logs	Yes
216-U-4B French Drain	1960-1970	Yes	No logs	No logs	Yes
216-U-7 French Drain	1952-1958	Yes	No logs	No logs	Yes
216-U-4 Reverse Well	1947-1955	Yes	No logs	No logs	Yes
216-U-10 Pond	1944-1985	Yes	No	No logs	Yes
216-U-14 Ditch	1944-present	No	No	No logs	No
216-Z-10 Ditch	1944-1959	No	No logs	No logs	No
216-Z-11 Ditch	1959-1971	No	No logs	No logs	No
216-Z-19 Ditch	1959-1972	No	No logs	No logs	No
216-U-5 and 216-U-6 Trenches	1952	Yes	No logs	No logs	Yes

2T-1a

DOE/RL-92-76, Rev. 0

Table 2-1. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Page 2 of 3

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening	Potential Based on Geophysical Logs Confirmed by Geophysical Logs (gross gamma-ray)	Confirmed by Spectral Gamma-ray Logs	Criteria Indicates Possible Past Contribution to Uppermost Aquifer
216-U-11 Trench	1944-1985	No	No logs	No logs	No
216-U-13 Trench	1952-1956	No	No logs	No logs	No
216-U-15 Trench	1957	No	No logs	No logs	No
2607-W-5 Septic Tank/Drain Field	1944-present	Yes	No logs	No logs	Yes
2607-W-7 Septic Tank/Drain Field	1954-present	No	No logs	No logs	No
2607-W-9 Septic Tank/Drain Field	1950-present	Yes	No logs	No logs	Yes
2607-WUT Septic Tank/Drain Field	1951-present	Yes	No logs	No logs	Yes
S Plant Aggregate Area					
241-S-104 Single-Shell Tank	1953-1968	No	No	No logs	No
241-SX-104 Single-Shell Tank	1955-1980	No	No	No logs	No
241-SX-107 Single-Shell Tank	1956-1964	No	No	No logs	No
241-SX-108 Single-Shell Tank	1955-1962	No	No	No logs	No
241-SX-109 Single-Shell Tank	1955-1965	No	No	No logs	No
241-SX-110 Single-Shell Tank	1960-1976	No	No	No logs	No
241-SX-111 Single-Shell Tank	1956-1974	No	No	No logs	No
241-SX-112 Single-Shell Tank	1959-1969	No	No	No logs	No
241-SX-113 Single-Shell Tank	1958	No	No	No logs	No
241-SX-114 Single-Shell Tank	1956-1972	No	No	No logs	No
241-SX-115 Single-Shell Tank	1959-1965	No	No	No logs	No
Sanitary Crib	1944-present	Yes	No logs	No logs	Yes
216-S-1 and 216-S-2 Crib	1950-1983	Yes	Yes	No logs	Yes
216-S-5 Crib	1954-1957	Yes	No	No	Yes
216-S-6 Crib	1954-1972	Yes	No	No	Yes
216-S-7 Crib	1956-1965	Yes	Yes	Yes	Yes
216-S-9 Crib	1965-1969	Yes	Yes	No logs	Yes

2T-1b

DOE/RL-92-76, Rev. 0

Table 2-1. Summary of Screening for Potential to Contribute Contaminants to Unconfined Aquifer.

Page 3 of 3

Liquid Discharge Source	Years In Service	Potential Based on Pore Volume Screening	Potential Based on Geophysical Logs Confirmed by Geophysical Logs (gross gamma-ray)	Confirmed by Spectral Gamma-ray Logs	Criteria Indicates Possible Past Contribution to Uppermost Aquifer
216-S-13 Crib	1952-1972	Yes	No	No	Yes
216-S-20 Crib	1952-1973	Yes	No	No logs	Yes
216-S-22 Crib	1957-1967	No	No	No	No
216-S-23 Crib	1969-1972	Yes	No	No logs	Yes
216-S-25 Crib	1973-present	Yes	No	No logs	Yes
216-S-26 Crib	1984-present	Yes	No logs	No logs	Yes
216-S-3 French Drain	1953-1956	Yes	No logs	No logs	Yes
216-S-10P Pond	1954-1984	No	No	No logs	No
216-S-11 Pond	1954-1965	Yes	No	No logs	Yes
216-S-15 Pond	1951-1952	No	No logs	No logs	No
216-S-16P Pond	1957-1975	Yes	No logs	No logs	Yes
216-S-17 Pond	1951-1954	Yes	No logs	No logs	Yes
216-S-19 Pond	1952-1984	Yes	No logs	No logs	Yes
216-S-10D Ditch	1951-1991	Yes	No	No logs	Yes
216-S-16D Ditch	1957-1975	Yes	No logs	No logs	Yes
216-U-19 Ditch	1952-1954	No	No logs	No logs	No
216-S-8 Trench	1951-1952	Yes	No	No logs	Yes
216-S-12 Trench	1954-1975	No	No logs	No logs	No
216-S-14 Trench	1951-1952	No	No logs	No logs	No
216-S-18 Trench	1954	No	No logs	No logs	No
2607-W6 Septic Tank and Tile Field	1951-present	Yes	No logs	No logs	Yes
2607-WZ Septic Tank	1944-present	Yes	No logs	No logs	Yes

Source: 200 West Groundwater AAMSR (DOE/RL 1992b).

2T-1c

DOE/RL-92-76, Rev. 0

3.0 INITIAL EVALUATION

This section evaluates the known and suspected contamination in the 200-UP-1 Groundwater Operable Unit and summarizes issues related to potential human health and the environmental impacts. Section 3.1 summarizes the known and suspected IRM and LFI contaminants that will be investigated by this work plan. Details of contamination can be found in the *200 West Groundwater AAMSR* (DOE/RL 1992b) and the *U Plant Source AAMSR* and *S Plant Source AAMSR* (DOE/RL 1992c,d). In addition to summarizing the known and suspected contaminants in the uppermost aquifer, Section 3.1.2 presents time variance data for IRM and LFI contaminants. Section 3.2 provides a summary outline of issues related to the potential impacts to human health and the environment.

3.1 KNOWN AND SUSPECTED CONTAMINATION

This discussion focuses on the known and suspected contaminants of concern in the 200-UP-1 Groundwater Operable Unit area. All but one of these contaminants were previously identified in the *200 West Groundwater AAMSR* and include three constituents identified for IRMs (uranium, ⁹⁹Tc, and nitrate) and 26 constituents identified for LFIs. The LFI constituents include the following:

- Organic compounds: 1,2-dichloroethane, 1,1-dichloroethylene, pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, heptachlor), bis(2-ethylhexyl)phthalate, carbon tetrachloride, chloroform, trichloroethylene, and n-nitrosodimethylamine
- Radionuclides: ¹²⁹I, ⁴⁰K, ²³⁸Pu, and ⁹⁰Sr, and gross alpha and gross beta radiation as indicators of other radionuclides
- Inorganic compounds: arsenic, cadmium, chromium, fluoride, and selenium.

The portions of groundwater contaminant plumes with high concentrations of uranium, ⁹⁹Tc, and nitrate that have been defined in the upper portion of the unconfined aquifer are designated for IRMs, but the peripheral, lower-concentration LFI components of these plumes are also included in this work plan.

The *200 West Groundwater AAMSR* proposed the high-concentration portions of groundwater contamination by carbon tetrachloride as an ERA plume, and high-concentrations of chloroform and trichloroethylene for remediation under IRMs. Subsequently, the carbon tetrachloride plume has been designated for implementation as an IRM. These IRM designations in the AAMSR apply only to the 200-ZP-1 Groundwater Operable Unit, however, and will be addressed in the pilot-scale pump and treat project identified in revisions to Tri-Party Agreement (Ecology et al. 1990) for that operable unit. Within the 200-UP-1 Groundwater Operable Unit, these constituents will be treated as LFI

constituents because the concentrations detected are lower or the plume extents are not well delineated in comparison to the 200-ZP-1 Groundwater Operable Unit. Because the plumes for carbon tetrachloride and chloroform apparently extend into the 200-UP-1 Groundwater Operable Unit from the 200-ZP-1 Groundwater Operable Unit, the majority of the investigation for these two compounds will be deferred to the IRM Proposed Plan for the 200-ZP-1 Groundwater Operable Unit.

Methylene chloride, radium, $^{239/240}\text{Pu}$, and ^{241}Am have also been identified as LFI constituents in the *200 West Groundwater AAMSR*. These constituents have been detected at such low levels within the 200-UP-1 Groundwater Operable Unit, however, that they do not exceed maximum contaminant level (MCL) thresholds or other criteria for LFI designation and so are not considered likely candidates for IRM activities. Two other LFI constituents identified in the *200 West Groundwater AAMSR*, beryllium and pentachlorophenol, have been detected in the 200-ZP-1 Groundwater Operable Unit only, and are also not discussed further in this work plan.

Tritium was recommended for the FRS path in the *200 West Groundwater AAMSR* primarily due to a lack of a proven remediation technology at the scale of the tritium plume needed to implement an IRM. Tritium will be considered during work plan field activities with regard to health and safety, storage, and disposal concerns. Handling, storage, and potential treatment of tritiated water will also be addressed during subsequent remedial Treatability Studies and actions.

This section summarizes what is known about the contaminants designated for IRMs and LFIs in the 200-UP-1 Groundwater Operable Unit regarding their general distributions in the vadose zone, unconfined portion of the uppermost aquifer, and confined aquifers. Section 3.1.1 discusses the vadose zone; Section 3.1.2 discusses the unconfined portion of the uppermost aquifer; and Section 3.1.3 discusses the confined aquifers. More detailed descriptions of the distribution of these contaminants are presented in the *200 West Groundwater AAMSR* (DOE/RL 1992b) and *Groundwater Field Characterization Report for the 200 Aggregate Area Management Study* (WHC 1993a).

3.1.1 Vadose Zone

Chemical data for the vadose zone are evaluated as part of the source AAMSRs (e.g., U Plant and S Plant AAMSRs) and related work plans (e.g., 200-UP-2 Source Operable Unit) being conducted in the 200 West Area. The horizontal and vertical distribution and potential source areas for the chemical constituent are discussed as part of the current studies. These discussions also include identification of data gaps associated with these chemical compounds. Information obtained through these studies will be incorporated into the overall 200-UP-1 Groundwater Operable Unit evaluation, as needed for interpretation of results.

Potential vadose zone sources for chemicals detected in the unconfined aquifer are discussed in Sections 2.0 and 4.1.2 of the *200 West Groundwater AAMSR* and should be consulted for additional details regarding waste

inventories for the U Plant and S Plant Source Aggregate Areas process facilities and waste management units associated with the 200-UP-1 Groundwater Operable Unit. Even though the majority of the waste management units no longer receive waste discharges, the vadose zone beneath the waste management units may still be a source of groundwater contamination because of slow drainage through the vadose zone. A summary of these waste management units is provided in Section 2.1 of this work plan. The potential for these waste management units to have contributed contaminant discharges to the unconfined portion of the uppermost aquifer is presented in Table 2-1.

3.1.2 Unconfined Portion of the Uppermost Aquifer

This section describes the current distribution of IRM and LFI constituents within the unconfined portion of the aquifer. The uppermost portion of the unconfined aquifer beneath the 200 West Area occurs within fluvial/lacustrine sediments of the Ringold Unit E gravels. For each constituent, Table 3-1 identifies the 200-UP-1 Groundwater Operable Unit well with the maximum average concentration between January 1988 and September 1992. The maximum and lowest detected constituent values are also reported for each of these wells. The well locations are identified on Plates 1a and 1b.

Figures 3-1 to 3-12 present contaminant plume maps for IRM and LFI constituents. For those constituents for which a plume map is unavailable, chemical data contained in Table B-1 in Appendix B of this work plan was used to identify the distribution of the compound. Contaminant plume configurations were evaluated using the June 1991 water table map for the 200 West Area (Figure 1-2). The groundwater chemical data presented in Table 3-1, B-1, and on the corresponding contaminant plume maps discussed below represent information from an updated revision of the Hanford Site Groundwater Chemical Database (1988 through fall 1992). The contaminant concentration and plume distribution data, therefore, supersede contaminant data and plume maps presented in the *200 West Groundwater AAMSR*. The following evaluation also extends to the assessment of contaminant migration presented in the AAMSR.

The plume distributions on Figures 3-1 through 3-12 are the result of migration of IRM/LFI constituents due to several factors. These factors include groundwater flow patterns, location of surface (and vadose zone) source areas, release mechanisms, and time of release with respect to the current and historical groundwater flow regime. Contaminant plume distributions are also affected by the mode of contaminant transportation in the vadose zone, geochemical interaction with soil and groundwater, and dispersion/decay rates in groundwater.

For each of the IRM and LFI constituents, the text provides a generalized summary of the lateral extent of the constituent plume, the spatial relationship of the plume to overlying waste management units, and known or suspected source areas. These generalized summaries were derived from detailed discussions of plume distribution and source areas in the *200 West Groundwater AAMSR*.

This section also summarizes historical data for IRM and LFI constituents for selected wells near plume centers and other locations of interest in the 200-UP-1 Groundwater Operable Unit. The section qualitatively describes variations of constituent concentrations over time, with reference to known or suspected source areas where appropriate. The summary of historical trends provides additional background for developing work plan rationale and specific sampling and analytical data needs described in Section 4.0. The discussion of historical trends supplements the *200 West Area Groundwater AAMSR* description of known and suspected contamination, and is presented at a similar level of detail.

Historical trends were evaluated for selected wells using analytical information from the Hanford Site Groundwater Chemical Database. The trends were evaluated using the following procedure:

- For each IRM and LFI constituent, a time variation plot was produced for all wells in the 200-UP-1 Groundwater Operable Unit where the constituent was detected one or more times. The time variation plots present changes in constituent concentrations with time for each well where the constituent was detected. Example time variation plots are presented in Appendix C (Figures C-1 through C-18) for selected wells and IRM and LFI plumes discussed in the text.
- The time variation plots for each well were visually evaluated for general, qualitative changes in the concentration data over time. For the purposes of this effort, an increasing or decreasing data trend was considered to exist if the following criteria were met.
 - The constituent was detected three or more times in a well; or there is a single analysis where the constituent has been detected and at least two other analyses where the constituent was not detected.
 - The range of detected concentrations for a given constituent varied by about half an order-of-magnitude or more over time.
 - The data exhibited minimal scatter or "noise" within the apparent data trend.

For most of the IRM and LFI constituents, analytical records are reported in the database beginning in the mid- to late-1980's, when sampling was initiated or expanded for wells within the 200-UP-1 Groundwater Operable Unit wells. Two exceptions are ⁹⁰Sr and gross beta radiation, which have analytical records reported in the database beginning in the 1950's. Gross beta is a readily quantified indicator of the presence of radionuclide contaminants. Several other constituents (e.g., pesticides) have only single, unconfirmed detections reported in the database. Other compounds such as arsenic have limited analytical data from the late 1980's and early 1990's that are insufficient for determining historical trends.

3.1.2.1 IRM Compounds.

3.1.2.1.1 Technetium-99. Three ^{99}Tc plumes have been identified within the 200-UP-1 Groundwater Operable Unit (Figure 3-1). Plume B has the highest maximum average concentrations of ^{99}Tc (28,262 pCi/L at Well 299-W19-24) (Table 3-1). This plume is located in the vicinity of the 216-U-1, 216-U-2, and 216-U-17 Cribs in the eastern U Plant Source Aggregate Area. Groundwater beneath this area flows toward the east-southeast (Figure 1-2).

Two smaller, lower concentration plumes, plume A and an unnamed plume southeast of plume A, were recommended for a final remedy RI (Figure 3-1). Plume A is located beneath the 216-S-1, 216-S-2, 216-S-7, and 216-S-8 Cribs and the 241-S and 241-SX Tank Farm. The highest concentration in plume A was 2,761 pCi/L detected in Well 299-W23-2. The unnamed plume is defined from a single detection in Well 299-W22-21 (637 pCi/L) located west of the main S Plant operations facility. Groundwater beneath the plume A and unnamed plume areas flows toward the southeast. Technetium-99 is not included in the radiological waste inventory, but is a fission product that is likely associated with numerous operations processes, which contributed wastes to the cribs listed. Some of the ^{99}Tc contamination in plume A may be associated with effluent from a pump-and-treat remediation of the uranium plume B conducted in 1985 (see Section 3.1.2.1.2).

Technetium-99 data for the 200-UP-1 Groundwater Operable Unit are reported in the database beginning in 1985. Wells 299-W19-3 and 299-W19-18 in the 216-U-1 and 216-U-2 Crib area (western center of plume B) have steadily decreasing ^{99}Tc activities beginning in 1987. As an example, the time variation plot for the latter well (Appendix C; Figure C-1) illustrates decreasing activities from about 10,000 to 100 pCi/L between 1988 and 1992. This decreasing trend represents detections in each of the 18 analyses for this well. In the same area, similar trends over the same time period exist for Wells 299-W19-3, 299-W19-15, 299-W19-16, 299-W19-17, and possibly Well 299-W19-6. As discussed for uranium (Section 3.1.2.1.2), the general downward trending activities may be related to dissipation and cleanup of radionuclides following a mobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs in 1985. Well 299-W19-9 also shows decreasing activities from about 2,000 pCi/L to just under 300 pCi/L by late 1988. Activities for ^{99}Tc in the well subsequently increased to about 900 pCi/L in early 1989, and then decreased back to near 300 pCi/L based on a single sample in late 1990. The analytical results for Well 299-W19-9 represent a total of six detections in each of the six analyses for this well since 1987. The slight increase in ^{99}Tc activities in this well could indicate that localized fluctuations in the overall downward trends for this area are present due to renewed source contributions. A similar trend is also apparent for Well 299-W19-19 (216-U-17 Crib) although post 1989 sampling has not been conducted to document the activity decrease.

In contrast to the 216-U-1 and 216-U-2 Crib Area, wells in the central part of plume B near the 216-U-17 Crib showed increasing ^{99}Tc activities through 1990 followed by subsequent decreases. As shown on Figure C-2, activities on the time variation plot for Well 299-19-26 increased from about

1,000 to 7,000 pCi/L between 1988 and 1990, and then subsequently decreased to under 300 pCi/L in 1992 based on a single analysis from that year. These results represent detections in each of twelve analyses for the well over the time period indicated. A similar response in Well 699-W38-70 (eastern, distal portion of plume B) may also be discernable, with activity increases reaching about 4,000 pCi/L in 1990. These results could indicate eastward movement of the ^{99}Tc plume following the 1985 uranium release to the 216-U-1 and 216-U-2 Cribs, or contribution from other (local) sources.

Decreasing ^{99}Tc activities through 1988 to 1989 were noted for three wells in the 241-SX Tank Farm Area (plume A): Wells 299-W23-1, 299-W23-2, and 299-W23-7. The time variation plot for Well 299-W23-2 presented on Figure C-3 illustrates this trend, with activities decreasing from about 6,000 to 1,000 pCi/L between late 1987 and early 1989. An additional analysis in early 1989 for this well had an activity of near 100 pCi/L, but may be outside of the overall activity trend. Activities in Well 299-W23-2 then increased to near the original level by late 1989. The trends in this well are based on detections in each of the 17 analyses. Similarly, ^{99}Tc activities in Well 299-W23-7 increased from about 1,000 pCi/L in late 1988 to 4,000 pCi/L by late 1989, and then decreased to near 1,000 pCi/L based on a single sample in 1991. These fluctuations may indicate either localized areas of dissipation within the plume followed by renewed contributions local sources or temporal variation in the discharge rate of contaminants from the source area.

Well 699-35-70, east of the S Plant Source Aggregate Area had an increasing ^{99}Tc activity trend from about 40 to over 100 pCi/L from 1985 to 1989, followed by a decreasing trend to the 30 to 40 pCi/L level in 1989 and 1992.

3.1.2.1.2 Uranium. Uranium plume B is located in the vicinity of U Plant near the 216-U-1, 216-U-2, 216-U-17, and the 216-U-12 Cribs (Figure 3-2). The maximum average concentration of uranium is identified in Well 299-W19-18 (2,257 pCi/L) (Table 3-1). Groundwater beneath this plume flows toward the east-southeast. An unnamed, diffuse, lower concentration plume recommended for FRS is located in the area of the former 216-U-10 Pond and southwestern S Plant Source Aggregate Area. The maximum average concentration in this plume was 60 pCi/L detected in Well 299-W23-4.

Figure 3-2 plume map revisions from the *200 West Groundwater AAMSR* for uranium reflect inclusion of chemical uranium data from the database. For the purposes of revising the plume map, the chemical uranium data were converted to the radiological equivalent for the known mixture uranium isotope species.

Uranium was a radiological waste that was disposed at U Plant Source Aggregate Area waste management units, and was also associated with S Plant Source Aggregate Area processing activities. Notable discharges included those to the 216-U-10 Pond, and the 216-U-1 and 216-U-2 Cribs. A secondary release from the 216-U-1 and 216-U-2 Cribs was detected in early 1985 when uranium from the cribs was remobilized via discharge of acidic wastes (*200 West Groundwater AAMSR*).

Uranium data for the 200-UP-1 Groundwater Operable Unit are reported in the database beginning in 1980. Uranium activity trends are generally analogous to those for ^{99}Tc for wells near the 216-U-1 and 216-U-2 Crib (west central portion of uranium plume B). As an example, the time variation plot for Well 299-W19-2 (Appendix C; Figure C-4) shows uranium activities increasing from less than 1 pCi/L to about 100 pCi/L between 1985 and 1988 based on numerous detections. This increase is likely related to the remobilization of uranium beneath the 216-U-1 and 216-U-2 Crib in early 1985. A groundwater pump and treat remediation program conducted between June and August 1985 removed 685 kg (1,510 lb) of uranium from the 216-U-1 and 216-U-2 Crib area. Uranium activities for Well 299-W19-2 and other wells in this area then steadily decreased through the late 1980's. Levels of other radionuclides including ^{99}Tc , ^{90}Sr , and ^{129}I also decreased in this area through the late 1980s, and similar trends are apparent for gross alpha and gross beta radiation as radionuclide indicators (see Figure C-16 time variation plot for gross alpha radiation for Well 299-W19-3). These activity decreases presumably resulted from dissipation of radionuclide contaminants which, at least in part, may be attributable to the 1985 remedial efforts.

Other wells in the 200-UP-1 Groundwater Operable Unit with generally decreasing historical uranium activity trends include the following:

- Well 699-32-72 - just east of southeast corner of S Plant Aggregate Area (1987 through 1991, plus single 1981 analysis).
- Well 299-26-12 - 216-S-10 Ditch area (1991 and 1992).
- Well 299-22-26 - 216-S-9 Crib area (1987 through 1991).
- Well 299-W23-1 - 241-SY Tank Farm (plume C) (1987 and 1988).

The decreasing trends for these wells are based on up to seven detections in each well over the time periods listed, with maximum activities typically less than 10 pCi/L.

Like ^{99}Tc , uranium activities in wells near the 216-U-17 Crib in the central part of the IRM plume increased during the late 1980's, and then subsequently decreased. The time variation plot for Well 299-W19-26 (Figure C-5) illustrates this trend, with activities increasing from about 90 pCi/L to over 300 pCi/L between 1987 and 1990. The activities then dropped off to the 10 pCi/L range in 1992. These results were based on detections in each of 17 analyses for the well since 1987.

Analytical data for other wells such as Well 299-W22-22 near the 216-U-12 Crib, and Well 299-W23-4 west of the 241-SX Tank Farm (plume C) indicates the possible presence of several uranium activity peaks in the 1980's. These results are based on numerous analytical records for the wells beginning in 1981 and 1980, respectively. The time variation plot for Well 299-W22-22 (Figure C-6) has apparent activity peaks in 1983 and possibly in 1985 and 1988, with peak activities in the 5 to 10 pCi/L range. These peaks could reflect distinct pulses from a localized source. Significant data scatter is

also present in the time variation plot for this well, however. Similarly, Well 699-35-78 southwest of the former 216-U-10 Pond has an approximate 50 pCi/L peak in 1984 following an increase from about 6 pCi/L in 1982. This peak was followed by an activity decrease to about 3 pCi/L in 1985, and then another increase to about 11 pCi/L from the most recent sample analysis in 1989. The uranium activity fluctuations in this well probably resulted from changing discharge conditions (and backfilling) of the 216-U-10 Pond.

3.1.2.1.3 Nitrate. Within the 200-UP-1 Groundwater Operable Unit, nitrate contamination has been identified in the north and eastern U Plant Aggregate Area, and the area to the east. This includes the area beneath the 216-U-17 Crib, the 216-U-4 Reverse Well, 216-U-4A and 216-U-4B French Drains, 216-S-20 Crib, 216-S-26 Crib, and 216-S-25 Crib. The maximum average concentration of nitrate identified is 1,321,667 $\mu\text{g/L}$ (1,322 mg/L) in Well 299-W19-19 (Table 3-1). This well is located southeast of the 216-U-4 Reverse Well, 216-U-4A and 216-U-4B French Drains, and west of the 216-U-17 Crib. Groundwater near the plume center in the eastern U Plant Aggregate Area flows toward the east-southeast.

The nitrate plume in the U Plant Source Aggregate Area is poorly delineated within the 45 mg/L contour south and east of the U Plant Aggregate Area (Figure 3-3). A second smaller plume, located east of the S Plant Aggregate Area REDOX Facility, has a maximum average concentration of 90,568 $\mu\text{g/L}$ (91 mg/L) measured in Well 299-W22-20.

Another small nitrate plume is located west of the 241-SX Tank Farm, and had a maximum average concentration of 113,990 $\mu\text{g/L}$ (114 mg/L).

Nitrate was discharged to U Plant and S Plant Source Aggregate Area waste management units, primarily in the form of neutralized nitric acid. The plume geometry depicted on Figure 3-3 reflects contributions of nitrate from many waste management unit sources, but particularly those in the central and eastern U Plant Source Aggregate Area.

Historical nitrate data are reported in the database beginning in 1985. Many of the wells near the 216-U-1 and 216-U-2 Crib in western center of the nitrate plume have decreasing historical concentration trends through the late 1980's, much like those for ^{99}Tc and uranium. These wells include Wells 299-W19-3 (Appendix C; Figure C-7) 299-W19-2, 299-W19-5, 299-W19-9, 299-W19-16, and 299-W19-18. The trend illustrated on the time variation plot for Well 299-W19-3 on Figure C-7 shows nitrate concentrations decreasing from about 100,000 $\mu\text{g/L}$ (100 mg/L) in 1987 to just over 20,000 $\mu\text{g/L}$ (20 mg/L) in 1989. These results represent detections in each of 30 analyses for the well beginning in 1987. The nitrate concentration decreases in the wells listed presumably resulted from dissipation and cleanup of wastes which were remobilized during the 1985 uranium release at the 216-U-1 and 216-U-2 Crib. Unlike the radionuclides however, nitrate concentrations in wells to the east near the main center of the nitrate plume are relatively constant and do not show readily discernable increasing or decreasing trends.

To the west, near the eastern fence line of the 241-U Tank Farm, nitrate concentrations in Well 299-W19-12 increased from about the 3,000 to 5,000 $\mu\text{g/L}$ (3 to 5 mg/L) level when sampling was initiated in 1987 to about 20,000 $\mu\text{g/L}$ (20 mg/L) in 1990 based on detections in each of nine analyses. The increase could be related to potential sources associated with the tank farm.

Wells in several areas in the S Plant and southern U Plant Source Aggregate Areas also have increasing nitrate concentration trends in the late 1980's. These areas include the 216-U-12 Crib (Well 299-W22-22), 241-SX Tank Farm (Well 299-W23-3 and possibly Well 299-W22-39) and the 216-S-1 and 216-S-2 Crib (Wells 299-W22-1 and 299-W22-2). The concentration increases for these wells were roughly from the 1,000 to 4,000 $\mu\text{g/L}$ (1 to 4 mg/L) range to about 8,000 $\mu\text{g/L}$ to 30,000 $\mu\text{g/L}$ (8 to 30 mg/L). As an example the time variation plot for Well 299-W23-3 is presented on Figure C-8 and is based on detections in each of 12 analyses for the well beginning in 1987. The time variation plot shows a nitrate concentrations decreasing from about 20,000 $\mu\text{g/L}$ (20 mg/L) in 1989 to less than 100 $\mu\text{g/L}$ (0.1 mg/L) in a single sample in 1990. Well 299-W22-2 has a similar concentration decrease between 1990 and 1992 based on a single sample from 1992. The validity of these decreases has not been confirmed with additional sampling.

In contrast, two wells west of the 241-SX Tank Farm (Wells 299-W23-4 and 299-W23-9), and Well 299-W23-1 to the north in the 241-SY Tank Farm have distinct concentration decreases during the late 1980's, although some scatter is apparent in the data. These results are based on 9 to 25 detections for each well. Concentrations for Well 299-W23-9 decreased from roughly the 400,000 $\mu\text{g/L}$ (400 mg/L) level to about the 2,000 $\mu\text{g/L}$ to 4,000 $\mu\text{g/L}$ (2 to 4 mg/L) level, although a 1992 analysis showed a concentration increase to about 30,000 $\mu\text{g/L}$ (30 mg/L). This well is located in the small, unnamed plume west of the 241-SX Tank Farm. Decreases in Wells 299-W23-1 and 299-W23-4 were from about 50,000 $\mu\text{g/L}$ (50 mg/L) and 10,000 $\mu\text{g/L}$ (10 mg/L), respectively, to 1,000 $\mu\text{g/L}$ (1 mg/L) or less during this time period. Comparison of the contrasting historical trends from wells near the S Plant tank farms and 216-S-1 and 216-S-2 Crib area suggests potential releases from several localized sources in the mid- to late-1980's.

Nitrate concentrations in Well 299-27-1 near the 216-S-26 Crib showed a generally decreasing trend from roughly 100,000 $\mu\text{g/L}$ (100 mg/L) in 1987 to just over 10,000 $\mu\text{g/L}$ (10 mg/L) in 1992 (Figure C-9). This well is located within the small unnamed nitrate plume in the southwest S Plant Source Aggregate Area near the referenced crib. Concentrations temporarily increased in 1989 to 1990 from about 30,000 to 100,000 $\mu\text{g/L}$ (30 to 100 mg/L), and could reflect plume movement or pulse contributions associated with the crib, or possibly with potential upgradient sources at the S Plant tank farms and 216-S-1 and 216-S-2 Crib. These results represent detections in each of the 22 analyses from this Well 299-W27-1 since 1987.

Many of the outlying, downgradient 600-series wells have fairly consistent nitrate concentrations through the late 1980's and early 1990's.

Several of the wells, however, have one or two 1990 to 1991 sample analysis "outliers" which are several orders of magnitude lower than the overall, relatively flat pre-1990 trends. As an example, nitrate concentrations for Well 699-W35-70 (east of the S Plant Source Aggregate Area) are consistently near 30,000 $\mu\text{g/L}$ (30 mg/L) through early 1990. Two subsequent analyses in late 1990 and late 1991 are less than 100 $\mu\text{g/L}$ (0.1 mg/L), but four 1992 analyses are back near pre-1990 levels. This phenomenon also affects sample analyses from Wells 299-W22-20 (216-S-20 Crib), 299-22-26 (216-S-9 Crib), and possibly 299-W23-3 (241-SX Tank Farm). It is uncertain whether these fluctuations are indicative of actual plume movement, or are suggestive of a possible sampling or analytical artifact during the time period listed.

3.1.2.2 LFI Plumes. Fifteen organic constituents, six LFI radionuclides (including total alpha and total beta radiation indicator plumes), and five inorganic constituents were identified for the 200-UP-1 Groundwater Operable Unit. These constituents are identified in Table 1-1 of this report.

3.1.2.2.1 Organic Compounds. Carbon tetrachloride, trichloroethylene and chloroform are designated as IRM plumes in the 200-ZP-1 Groundwater Operable Unit. Each of the IRM plumes have an LFI component to address the horizontal and vertical extent of contamination that applies to the IRM classifications. Within the 200-UP-1 Groundwater Operable Unit these constituents are identified as LFI candidates. In addition to these three LFIs, there are eleven LFI organic compounds that are currently identified as LFIs based on single well detections. One additional LFI constituent, 1,2-dichloroethane, has been reported twice, but only in a single well.

Carbon Tetrachloride. The carbon tetrachloride plume extends across the 200-UP-1 Groundwater Operable Unit in two prominent lobes (Figure 3-4). The maximum average concentration measured was 162 $\mu\text{g/L}$ in Well 299-W19-16 near the 216-U-1 and 216-U-2 Cribs. Groundwater flow for the southeastern lobe of the plume is to the east-southeast (Figure 3-4). The southwestern lobe of the plume is spatially associated with a groundwater mound in the western U Plant Source Aggregate Area. The distal portions of the southeastern and southwestern lobes of the plume are not well defined. The southeastern lobe is also not well defined in the northern U Plant and southeastern T Plant Source Aggregate Areas because of lack of well coverage. Higher concentrations of carbon tetrachloride were detected in the Z Plant Source Aggregate Area to the west (near the boundary with the U Plant Source Aggregate Area) in Wells 299-W18-26 and 299-W18-21 (186 and 177 $\mu\text{g/L}$, respectively). These wells are nominally located in the 200-UP-1 Groundwater Operable Unit; however, because of their proximity to more central (proposed IRM) portions of the plume in the 200-ZP-1 Groundwater Operable Unit, they will be included with the Treatability Study for the latter area.

Carbon tetrachloride was discharged in relatively large quantities to Z Plant Source Aggregate Area waste management units. The current extent of the plume in the 200-UP-1 Groundwater Operable Unit is likely attributable to one or more migration mechanisms including vadose zone liquid, aqueous, or vapor-phase transport; migration as a dissolved phase in groundwater; and migration as a dense non-aqueous phase liquid (DNAPL). Transport of carbon

tetrachloride in the vadose zone and groundwater, and as a DNAPL is currently being addressed as part of proposed carbon tetrachloride IRM activities in the 200-ZP-1 Groundwater Operable Unit.

Carbon tetrachloride analytical data for evaluating historical trends are reported in the Westinghouse Hanford Site Groundwater Chemical Database beginning in 1985. A particular area of interest is the area near the 216-U-1 and 216-U-2 Cribs in the central U Plant Source Aggregate Area. Many of the wells in this area have slightly increasing carbon tetrachloride concentrations during the late 1980's and early 1990's. Carbon tetrachloride concentrations in Well 299-W19-16 for example, have steadily increased from about 90 to 200 $\mu\text{g/L}$ since 1987 and are typical for wells near the 216-U-1 and 216-U-2 Cribs (Appendix C; Figure C-10). These results are based on detections in each of the nine analyses for the well between 1987 and 1990. Other wells with similar trends in this area include Wells 299-W19-3, 299-W19-13, 299-W19-15, possibly 299-W19-18, and possibly 299-W19-29 (west of T Plant facility). Most of these concentrations reached maxima in the 40 to 200 $\mu\text{g/L}$ range in 1989 and 1990 but the wells have no analytical records reported in the database since that time.

Increasing carbon tetrachloride concentrations in the wells near the 216-U-1 and 216-U-2 Cribs could indicate the eastward passage of a higher concentration plume center through the central U Plant Source Aggregate Area. The shift of the groundwater mound to its present location near the southeastern corner of the Z Plant Source Aggregate Area could in part be a driving mechanism for eastward movement of this plume (Figure 1-2).

Other wells in the 200-UP-1 Groundwater Operable Unit have carbon tetrachloride concentration trends that are relatively flat over time, or have limited sampling data which are insufficient for determining historical trends. For example, carbon tetrachloride has been detected in each of the 10 analyses reported in the database for Well 699-38-70 (east of the U Plant Source Aggregate Area), beginning in 1986. These concentrations have remained consistently between about 30 and 60 $\mu\text{g/L}$, with no clear increasing or decreasing trends.

Chloroform. Chloroform plume B and the southern end of plume A are present within the 200-UP-1 Groundwater Operable Unit. Plume A is generally associated with carbon tetrachloride north of the 200-UP-1 Groundwater Operable Unit (Figure 3-5). The southern end of plume A in the 200-UP-1 Groundwater Operable Unit is an LFI plume and is an extension of the 200-ZP-1 Groundwater Operable Unit IRM to the north. Plume B is recommended for the FRS path. Concentrations of chloroform within plume A, which is co-located with high concentrations of carbon tetrachloride, are poorly defined because of lack of well coverage, particularly in the northern U Plant Source Aggregate Area. There is little chemical data between monitoring Well 299-W19-28 and wells to the northwest located near the plume center in the 200-ZP-1 Groundwater Operable Unit. The maximum average concentration in the southern part of plume B was 24 $\mu\text{g/L}$ detected in Well 299-W18-20 west of the 241-U Tank Farm.

The maximum average concentration of chloroform within plume B is 9 $\mu\text{g/L}$ in Monitoring Well 299-W22-20. This plume is spatially associated with the 216-S-16 and 216-S-20 Cribs southeast of the S Plant (REDOX) operation cribs. This plume is poorly defined due to limited well coverage to the north and east. Groundwater beneath the area of plume B flows toward the southeast.

Chloroform may be a degradation product from carbon tetrachloride and was reportedly not used during processing activities within the 200 West Area.

Chloroform analytical data for evaluating historical trends are reported in the Hanford Site Groundwater Chemical Database beginning in 1986. The historical data reported in the database do not indicate discernable increasing or decreasing trends for wells in the 200-UP-1 Groundwater Aggregate Area. Concentrations have rarely exceeded 10 $\mu\text{g/L}$, with detection limits in the 2 to 10 $\mu\text{g/L}$ range. The maximum number of individual detections for operable unit wells has been obtained from Well 299-W22-20 (216-S-20 Crib), with detections in each of the eight analyses since 1987. These concentrations have been consistently near 10 $\mu\text{g/L}$. The well defines chloroform plume B in this area.

Trichloroethylene. Figure 3-6 identifies the extent of trichloroethylene plume B within the 200-UP-1 Groundwater Operable Unit. Plume B is based on detections in a single well, Well 299-W22-20, and is approximately located beneath the 216-S-20 and 216-S-26 Cribs. The highest average concentration in this well was 32 $\mu\text{g/L}$ (Table 3-1). Groundwater in the area of this plume flows toward the southeast.

Trichloroethylene is not included in the chemical waste inventory for waste management units with discharges that potentially reached groundwater (Table 2-1). It is also not mentioned as a chemical used in plant processing operation, although its common use is as a cleaning and degreasing solvent.

Trichloroethylene analytical data for the 200-UP-1 Groundwater Operable Unit are reported in the database beginning in late 1985 and early 1986. The historical data trends are very similar to those for chloroform, and in general do not indicate discernable increasing or decreasing trends for wells in the 200-UP-1 Groundwater Operable Unit. With the exception of Well 299-W22-20, which defines trichloroethylene plume B near the 216-S-16 and 216-S-20 Cribs, trichloroethylene has not been detected more than twice in operable unit wells and concentrations have not exceeded 8 $\mu\text{g/L}$. For example, Well 699-38-70, east of the U Plant Source Aggregate Area, has 10 total analyses beginning in 1986, and a single detection (8 $\mu\text{g/L}$) since 1988. Detection limits for trichloroethylene analyses are similar in magnitude to many of the detected results and have varied from about 3 to 10 $\mu\text{g/L}$. Detections in Well 299-W22-20 in each of the eight analyses since 1987 for example, have consistently remained in the 25 to 40 $\mu\text{g/L}$ range (Appendix C; Figure C-11).

Other Organic Constituents. Eleven organic constituents were recommended for LFI consideration in the *200 West Groundwater AAMSR* that have single, unconfirmed detections. These constituents include the following:

- 1,1-dichloroethylene
- Pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, and heptachlor)
- Bis(2-ethylhexyl)phthalate
- N-Nitrosodimethylamine.

The historical analytical data reported from the database for these compounds are not indicative of potential historical trends.

One additional organic compound, 1,2-dichloroethane, has two detected concentrations in Well 299-W22-20 (1988 and 1990). The presence of this compound in this well and its LFI status need to be reconfirmed by resampling the well and completing additional chemical analyses.

The 1,2-dichloroethane and 1,1-dichloroethylene analytical results for 200-UP-1 Groundwater Operable Unit wells have been reported in the database since 1986. Well 299-W22-20 (near 216-S-20 Crib) has had 6 total analyses reported for 1,2-dichloroethane and 5 total analyses for 1,1-dichloroethylene beginning in 1987.

Endrin and gamma-BHC have analysis results reported in the database beginning in 1985. Aldrin, DDD, DDT, dieldrin and heptachlor have analysis results reported in the database beginning in 1986. Endrin aldehyde results are reported beginning in 1991. Pesticide detections were from a single-time sampling event in 1992 in Well 299-W19-18 (near the 2607-W-5 Septic Tank and Drain Field).

Bis(2-ethylhexyl)phthalate analysis results have been reported for the operable unit wells beginning in 1986. The compound has had only a single unconfirmed detection for Well 299-W14-10 at the extreme north end of the 200-UP-1 Groundwater Operable Unit.

The n-nitrosodimethylamine analysis results have been reported for the operable unit wells beginning in 1986. The compound has been detected only in the single analysis for Well 299-W23-10 near the 216-S-25 Crib in 1988.

3.1.2.2.2 Radionuclides.

Iodine-129. The ^{129}I LFI plume (plume B) extends from the east-central U Plant Source Aggregate Area and eastern S Plant Source Aggregate Area, to the eastern part of the 200-UP-1 Groundwater Operable Unit (Figure 3-7). The configuration of this plume is poorly defined because of sparse well coverage in the eastern part of this plume. The maximum average activity level identified for this plume is 30 pCi/L in Well 699-35-70 (Table 3-1). Groundwater in the area of plume B flows toward the east-southeast.

Iodine-129 is a fission product that is likely associated with process waste from fuel reprocessing. Although not an emitter of gross alpha radiation, ^{129}I is associated with process waste radionuclides which do emit

gross alpha radiation. Apparent sources include the 216-U-1 and 216-U-2 Cribs, 216-S-20 and 216-S-22 Cribs, and possibly the 216-U-4 Reverse Well.

Limited ^{129}I analytical data are reported in the database for 200-UP-1 Groundwater Operable Unit wells, beginning in 1987. Time variation plots for several wells may show possible trends however. Near the 216-U-1 and 216-U-2 Cribs in the central U Plant Source Aggregate Area, ^{129}I has been detected in each of three analyses for Well 299-W19-3 between 1987 and 1990. During that time, activities have decreased from about 30 to 6 pCi/L. A similar trend is possibly seen for Well 299-W19-15 in the same area. In this well, activities decreased from 10 pCi/L in 1987 to just over 1 pCi/L in 1988, but then rose slightly to 3 pCi/L in 1990. These trends coincide with decreasing activities of other radionuclides and gross alpha/gross beta activity in this area following the remobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs in 1985 and subsequent groundwater treatment.

Decreasing trends in the late 1980's were followed by subsequent increases in ^{129}I activities in Wells 699-35-70 and 699-38-70 east of the 200 West Area, and in Well 299-W22-20 near the 216-S-20 Crib. In Well 699-35-70 ^{129}I has been detected in each of eight analyses reported since 1987, with activities decreasing from the 50 to 90 pCi/L level in 1987-88 to near 10 pCi/L in late 1988 (Appendix C; Figure C-12). The activities remained at about the 10 pCi/L level through early 1990 and then increased to about 40 to 50 pCi/L in 1991. The well is located near the apparent center of the ^{129}I plume. Similar trends exist for Well 299-W22-20, with activities decreasing from about 2 to 0.3 pCi/L between 1987 and 1988, then increasing to about 1 to 2 pCi/L by 1990. This trend was defined detections in each of the six analyses for this well. Likewise, detected ^{129}I activities in Well 699-38-70 decreased from just over 1 pCi/L in 1988 to 0.3 pCi/L in 1989, and then increased to 20 to 30 pCi/L in 1990. The latter well had five detections and a single nondetection (1 pCi/L) in 1987. The ^{129}I activity fluctuations in these wells could indicate plume movement in the areas listed.

Plutonium-238. Plutonium-238 data reported in the database beginning in 1984 generally show only spotty single detections in 200-UP-1 Groundwater Operable Unit wells. A small plume is located near the 216-U-17 Crib in the eastern U Plant Source Aggregate Area. The maximum average concentration for this plume was 0.024 pCi/L detected in Well 299-W19-24. For individual analyses, minimum and maximum ^{238}Pu activities for the operable unit wells ranged from 0.00326 (Well 299-W27-1, near the 216-S-26 Crib) to 0.271 pCi/L (Well 299-W19-24, near 216-U-17 Crib). An exception is Well 299-W22-21 (near the 216-S-13 Crib) that had a higher (single) ^{238}Pu detection of 8.971 pCi/L in 1992. The reported data from the database are insufficient to determine historical trends.

Potassium-40. Potassium-40 has been detected in about 20 wells across the U Plant and S Plant Source Aggregate Areas. The highest level of ^{40}K was in the area adjacent to the 241-U Tank Farm and the 207-U Retention Basin. The maximum average level for ^{40}K was identified in Well 299-W19-32 at 373 pCi/L. Groundwater near this location flows toward the south or southeast.

Potassium-40 is not known to have been generated from process plant activities in the 200 West Area. Although no documentation was available, there may be some potential that ^{40}K could have historically been used for laboratory tracer studies and related work. In part, its elevated concentrations may be attributable to naturally occurring sources or contributions from offsite sources such as fallout from nuclear weapons testing. The background concentration of ^{40}K has not been confirmed via comparison with concentrations in upgradient or offsite wells near the Hanford Site, however.

Analytical records for ^{40}K are reported from the database for the 200-UP-1 Groundwater Operable Unit wells beginning in August 1990. The radionuclide has been detected in each of four analyses for Well 299-W22-20 (near the 216-S-20 Crib), and in four of six analyses each for Wells 699-38-65 and 699-35-70 east of the 200 West Area. No other 200-UP-1 Groundwater Operable Unit wells has had ^{40}K detected in more than a single analysis. Activities for Well 299-W22-20 decreased steadily from about 300 pCi/L in 1990 to just over 50 pCi/L in late 1991. Activities in Well 699-38-65 increased from below detection limit (30 to 40 pCi/L) in 1990 to values near 100 pCi/L through 1991. Similarly, activities in Well 699-35-70 remained near the 100 pCi/L level in late 1990 and 1991, but analysis results were nondetect at a 30 pCi/L detection limit in 1990 and late 1991.

Strontium-90. Strontium-90 has been detected in about 20 wells in the operable unit. The maximum average level of ^{90}Sr was 22 pCi/L detected in Well 299-W22-10 (Table 3-1). This well is located southwest of the 216-S-1 and 216-S-2 Cribs. Groundwater beneath this area flows toward the southeast. No other wells in the operable unit had ^{90}Sr concentrations exceeding the 8 pCi/L MCL threshold for LFI designation.

Strontium-90 data reported in the database extend back into the late 1950's for the 200-UP-1 Groundwater Operable Unit wells. Most of the older sampling histories are relatively incomplete, however, and have substantial gaps in data between the early 1960's and the late 1970's.

Time variability for ^{90}Sr in select wells has been evaluated, as supported by data presented in Appendix C. Near the 216-U-1 and 216-U-2 Cribs in the central U Plant Source Aggregate Area, a prominent ^{90}Sr activity peak is apparent for Well 299-W19-2 in 1987 (Appendix C; Figure C-13). The peak activity reached nearly 20 pCi/L following an increase from the 6 to 10 pCi/L range in 1986, and then steadily decreased to about 2 pCi/L by 1989. The time variation plot for this well includes analytical data between 1985 and 1993 only. A similar trend may be apparent for Well 299-W19-3 in the same area, with activities increasing from about 2 to 7 pCi/L between 1985 and 1987, and then decreasing to below a detection limit value of 0.2 pCi/L by 1989. More data scatter is apparent on the time variability plot for the latter well than for Well 299-W19-2, however, and detection limit values ranged up to about 0.6 pCi/L in 1987. The post-1987 decreases in ^{90}Sr for these wells coincide with the decreasing activity trends of other radionuclides and gross alpha/gross beta radiation observed in this area. These trends are associated with

remobilization of uranium beneath the 216-U-1 and 216-U-2 Cribs in 1985, followed by subsequent groundwater treatment and radionuclide dissipation.

Decreasing ^{90}Sr activity trends through the 1980's were noted for many of the S Plant Source Aggregate Area wells, although a significant degree of data scatter exists in some of these analytical records. These wells include Wells 299-W22-1 (216-S-1 and 216-S-2 Cribs), 299-W22-12 (216-S-7 Crib), 299-W22-20 (216-S-20 Crib), and possibly Well 299-W22-21 (216-S-13 Crib). As an example, the time variation plot for Well 299-W22-1 illustrates ^{90}Sr activities decreasing from over 20,000 pCi/L in 1980 to about 7 pCi/L in 1989 (Appendix C; Figure C-14). Possible secondary peaks may be present on this plot during the mid-1980's but are difficult to clearly discern because of the data scatter. Similar trends may exist for Wells 299-W22-2 (216-S-1 and 216-S-2 Cribs), 299-W22-26 (216-S-9 Crib), 299-W23-9 and 299-W23-10 (216-S-25 Crib) but are also subject to data scatter.

In contrast to many of the S Plant Source Aggregate Area wells, the time variability plot for Well 299-W22-10 (216-S-1 and 216-S-2 Cribs) illustrates a possible increasing trend through about 1987 to near 100 pCi/L, then a decrease through 1990 to the 10 to 20 pCi/L range (Figure C-15). Scatter in the data during the early 1980's makes the overall trend uncertain during this time. A total of 131 analytical records are reported for Well 299-W22-10 beginning in 1956, and all have had detected ^{90}Sr activities.

Gross Alpha Radiation. Gross alpha radiation levels are used as an indicator of high atomic number radionuclides, such as uranium and plutonium. This primary gross alpha radiation plume (plume D) in the 200-UP-1 Groundwater Operable Unit underlies the U Plant Source Aggregate Area in the area of the 216-U-1 and 216-U-2 Cribs (Figure 3-8). The maximum average activity level for this plume was identified in Well 299-W19-18 at 2,208.61 pCi/L (Table 3-1). Groundwater in the plume D area flows east-southeast.

Two smaller gross alpha radiation plumes are present in the 200-UP-1 Groundwater Operable Unit (Figure 3-8). Plume C is located near the 216-U-10 Pond, and a smaller unnamed plume is located west of the REDOX Facility in the S Plant Source Aggregate Area. The maximum average concentration for plume B was 40 pCi/L detected in Well 299-W18-15 north of the former 216-U-10 Pond area. The unnamed plume west of the REDOX Facility had a maximum average concentration of 15 pCi/L in Well 299-W22-21. Groundwater flow in the vicinity of plume C is affected by the existing groundwater mound to the northeast, with flow directions varying from west to south (Figure 1-1). Groundwater near the unnamed plume flows to the southeast.

Gross alpha radiation is reported in waste inventories for waste management units in the U Plant Source Aggregate Area, and is associated with uranium releases discussed in Section 3.1.2.1.2. Notable releases include those to the 216-U-1 and 216-U-2 Cribs (plume B) and the 216-U-10 Pond (plume C).

Gross alpha radiation data are reported in the database beginning in 1978 for 200-UP-1 Groundwater Operable Unit wells. The activity trends for gross

alpha radiation are generally flat with little variation over time. An area of exception includes wells near the 216-U-1 and 216-U-2 Cribbs, where time variability plots for gross alpha radiation are very similar to those for uranium, ^{99}Tc , ^{90}Sr , and ^{129}I . Figure C-16 in Appendix C presents the time variation plot for Well 299-W19-3. Gross alpha radiation activities increase from less than 100 pCi/L to about 10,000 pCi/L between 1985 and 1987 following the 1985 remobilization of uranium at the referenced cribbs. Activities then steadily decreased to about 2,000 pCi/L by early 1989. These data trends are based on detections in each of more than 50 analyses for this well.

Gross Beta Radiation. Gross beta radiation is an indicator of fission, activation, and decay products, such as, ^{60}Co , ^{90}Sr , ^{99}Tc , ^{106}Ru , ^{125}Sb , ^{137}Cs , ^{234}Th , and ^{234}Pa , and to a much lesser extent ^{129}I . (It should be noted that due to the methodology for gross beta analysis, the results of gross beta and specific radionuclide activities are not directly comparable.) With the exception of ^{99}Tc , ^{90}Sr , and ^{129}I , the radionuclides listed are not IRM or LFI constituents for the 200-UP-1 Groundwater Operable Unit and are not discussed further in this work plan. The maximum average gross beta activity in plume B was 3,272 pCi/L detected in Well 299-19-25 (Table 3-1; Figure 3-9). Groundwater in this area flows toward the east and southeast (Figure 1-2). Plume C is located beneath the western S Plant Source Aggregate Area and has a maximum average concentration of 396 pCi/L detected in Well 299-W23-2. Groundwater near plume C flows to the southeast.

Contributing sources to plume B appear to include discharges to U Plant Source Aggregate Area waste management units (216-U-1, 216-U-2, and 216-U-17 Cribbs). Plume C appears to be related to discharges to the 216-S-1, 216-S-2, and 216-S-7 Cribbs.

Gross beta radiation data are reported in the database beginning in 1951 for 200-UP-1 Groundwater Operable Unit wells. Many of the older sampling histories have notable data gaps in the 1960's and 1970's. In general, gross beta radiation activity trends in the 1980's at many locations in the operable unit reflect those for ^{90}Sr . Examples are the areas near the 216-U-1 and 216-U-2 Cribbs, and the 216-S-1 and 216-S-2 Cribbs. In addition to reflecting ^{90}Sr trends, gross alpha radiation records for wells in these areas are also similar to activity trends for ^{99}Tc , uranium, and ^{129}I .

3.1.2.2.3 Inorganic Compounds.

Arsenic. Arsenic plume C is located in the southwestern U Plant Source Aggregate Area (Figure 3-10). The maximum average concentration of arsenic in this plume was 16 $\mu\text{g/L}$ identified in Well 299-W19-21 (Table 3-1). This well is located in the area south of the 207-U Retention Basin and east of the active branch of the 216-U-14 Ditch. The plume is poorly defined toward the southeast. Groundwater beneath this area flows toward the southeast (Figure 1-2).

A second, unnamed plume is located in the south-central S Plant Source Aggregate Area, but is poorly defined due to limited well coverage in the southeastern part of the plume. The highest maximum average concentration was

8 $\mu\text{g/L}$ detected in Well 299-W26-12 at the northern end of the plume. Groundwater in this area flows to the southeast.

Limited analytical data for total arsenic (total) are reported in the database for 200-UP-1 Groundwater Operable Unit wells beginning in 1985. Arsenic has been detected two or more times in ten of the operable unit wells. With the exception of Well 299-W19-21, wells with multiple arsenic detections have analytical records beginning in 1991. Concentration trends for nearly all of these wells, including those defining plume C, are relatively flat and have values in the 10 $\mu\text{g/L}$ range. Well 299-W19-21 (south of the 207-U Retention Basin, along the 216-U-14 Ditch) had detected concentrations of 14 and 18 $\mu\text{g/L}$ in 1988 and 1989, respectively. Six other wells had single detections between 1987 and 1992, with concentrations in the 10 $\mu\text{g/L}$ range. The arsenic analytical data are insufficient to determine historical trends.

Cadmium. Cadmium (total) concentrations in excess of the 5 $\mu\text{g/L}$ MCL threshold for LFI designation are present at several wells in the 200-UP-1 Groundwater Operable Unit. These wells include Well 299-W19-1 near the 216-U-1 and 216-U-2 Cribs (94 $\mu\text{g/L}$), Well 299-W18-20 near the U Plant/Z Plant Source Aggregate Area boundary (13 $\mu\text{g/L}$), and Well 299-W14-10 in the southern T Plant Source Aggregate Area (7 $\mu\text{g/L}$). These concentrations represent single detections in each of these wells, which may not constitute actual "plumes," and need to be reconfirmed with additional sampling to verify their LFI status. No operable unit wells had dissolved (filtered) cadmium analytical data exceeding LFI designation criteria.

Analytical data for total cadmium are reported in the database for 200-UP-1 Groundwater Operable Unit wells beginning in 1985. Cadmium has been detected once in four analyses for Well 299-19-1 (southwest of the 207-U Retention Basin), with analytical data reported for this well beginning in 1990. Cadmium has been detected once in two analyses beginning in 1989 for Well 299-W19-26 (near the 216-U-17 Crib). The detected concentrations for each of these wells were 94 and 6 $\mu\text{g/L}$, respectively.

Chromium. Two distinct LFI chromium (dissolved) plumes are present in the 200-UP-1 Groundwater Operable Unit (Figure 3-11). Plume B is located in the eastern part of the S Plant Source Aggregate Area, with highest concentrations apparently near the 216-S-20 and 216-S-26 Cribs (323 $\mu\text{g/L}$ - Well 299-W22-20). Plume C is located in the southern part of the S Plant Source Aggregate Area east of the S Plant pond complex. The highest concentration in plume C was 154 $\mu\text{g/L}$ detected in Well 299-W26-7. No other wells in the 200-UP-1 Groundwater Operable Unit had chromium concentrations exceeding LFI criteria, including wells defining a small unnamed plume located in the west-central U Plant Source Aggregate Area. The unnamed plume is deferred to the FRS path. Groundwater flow in the vicinity of plume B and plume C is generally to the southeast.

Chromium may be associated with several waste streams discharged to 200-UP-1 Groundwater Operable Unit waste management units; however, waste inventories were specifically noted only for the 241-S Tank Farm. The source

of the tank farm chromium wastes was reportedly sodium dichromate and chromic nitrate feed preparation materials from S Plant processing operations.

Chromium (dissolved) data are reported in the database for 200-UP-1 Groundwater Operable Unit wells beginning in 1987. Nine operable unit wells have analytical data with multiple chromium detections since that time. Of these wells only Wells 299-W26-7 (216-S-10 Ditch area) and 299-27-1 (216-S-26 Crib) have time variability plots which show possible increasing concentration trends. Concentrations in Well 299-W26-7 increased from 100 $\mu\text{g/L}$ in early 1992 to just under 200 $\mu\text{g/L}$ by the end of the year, based on detections in each of five analyses. Concentrations in Well 299-W27-1 increased from about 10 $\mu\text{g/L}$ to just over 20 $\mu\text{g/L}$ between 1987 and 1988, decreased to the 10 to 20 $\mu\text{g/L}$ through early 1990, and then were undetected at values of 10 and 20 $\mu\text{g/L}$ in 1990 and 1992, respectively. The results for this well were based on nine detections in twelve total analyses. The chromium analytical data for these wells are insufficient to confirm possible increasing trends.

The chromium analytical data for other operable unit wells with detections is relatively flat with no discernable increasing or decreasing trends. As an example, chromium concentrations in each of five analyses for Well 299-W22-20 (216-S-20 Crib) between 1988 and 1992 were in the 300 to 350 $\mu\text{g/L}$ range. This well has the highest maximum average chromium concentration in the operable unit. Analytical results for some of the operable unit wells include nondetections that are in the same range as the detected concentrations (5 to 20 $\mu\text{g/L}$).

Fluoride. Fluoride has been identified at relatively low concentrations beneath the U Plant and S Plant Source Aggregate Areas (Figure 3-12). The highest concentration areas (exceeding 1,000 $\mu\text{g/L}$) are located in a plume in the eastern U Plant Source Aggregate Area near the 216-U-4A and 216-U-4B French Drains, the 216-U-4 Reverse Well, and the 216-U-17 Crib. The maximum average concentration was 2,550 $\mu\text{g/L}$ detected in Well 299-W19-30. Groundwater flows toward the east-southeast beneath this area.

Documented disposal areas for fluoride process wastes include Z Plant and T Plant Source Aggregate Area waste management units, north of the 200-UP-1 Groundwater Operable Unit. The fluoride plume in the eastern U Plant Source Aggregate Area suggests a possible relationship to cribs and other waste management units in this aggregate area. Fluoride is also a relatively mobile, common minor constituent in groundwater that may contribute to the overall concentrations detected. Possible background contributions from regionally extensive volcanic rocks are also not established.

Fluoride data are reported in the database for 200-UP-1 Groundwater Operable Unit wells beginning in 1985. Fluoride has been detected multiple times in many of the operable unit wells, but few clearly discernable increasing or decreasing trends are apparent. A possible increasing trend is present for Well 299-W19-26 (216-U-17 Crib), with concentrations increasing from about 400 $\mu\text{g/L}$ in late 1989 to just under 2,000 $\mu\text{g/L}$ in 1992 (Appendix C; Figure C-17). (A duplicate analysis of the late 1989 sample reported at

400 $\mu\text{g/L}$ was indicated only as below the detection limit for the duplicate sample of 1,000 $\mu\text{g/L}$.) The well is located in the unnamed fluoride plume in the east-central U Plant Source Aggregate Area. Just to the northwest, fluoride concentrations may be decreasing in Well 299-W19-29, based on detections in each of three analyses for the well between 1991 and early 1992 (Figure C-18). These concentrations decreased from about 2,000 to 600 $\mu\text{g/L}$ during this time period, but the validity of the trend has not been confirmed with additional sampling.

Other possible decreasing fluoride concentration trends may exist for Wells 299-W26-7, 299-W26-8, and 299-W26-12 in the 216-S-10 Ditch area. Concentrations in these wells decreased from the 700 to 1200 $\mu\text{g/L}$ level in 1991 to about 300 to 500 $\mu\text{g/L}$ in late 1992. These results are based on detections in a total of seven, six, and four total analyses for each of these respective wells during this time period.

Selenium. Selenium concentrations in excess of LFI criteria are present in two separate plumes in the 200-UP-1 Groundwater Operable Unit. The highest selenium concentration (20 $\mu\text{g/L}$) was detected in the southernmost plume in Well 299-W27-1 near the 216-S-20 Crib. Selenium was also detected in Well 299-W22-20 (9 $\mu\text{g/L}$) near this location. The southernmost plume is poorly delineated on the southeast side; groundwater in this area flows to the southeast. Selenium was detected in two wells defining the northernmost plume near the 216-U-17 Crib/U Plant Source Aggregate Area. These wells are Well 299-W19-23 (10 $\mu\text{g/L}$), Well 299-W19-28 (7 $\mu\text{g/L}$), and Well 299-W19-26 (6 $\mu\text{g/L}$). Groundwater in this area flows to the east-southeast.

Selenium (total) data are reported in the database for 200-UP-1 Groundwater Operable Unit wells beginning in 1985. Only Well 299-W27-1 (near the 216-S-26 Crib) had multiple (two) detections out of a total of three analyses. These concentrations were 21 and 35 $\mu\text{g/L}$ in 1988 and 1990, respectively. Analytical data are reported for the well beginning in 1988. Selenium has been detected once in the following additional wells:

- Eastern U Plant Source Aggregate Area: Wells 299-W19-20, 299-W19-23, and 299-W19-26 (216-U-17 Crib), and 299-W19-28 (224-UA Building)
- Southeastern S Plant Source Aggregate Area: Well 299-W22-20 (216-S-20 Crib).

Concentrations in these wells have ranged from 6 to 14 $\mu\text{g/L}$. No historical trends for selenium are apparent for operable unit wells based on the database information.

3.1.3 Confined Aquifers

Limited chemical data are available for the confined aquifers present in the Ringold Unit A gravels, the Rattlesnake Ridge interbed, and deeper zones of confined groundwater beneath the 200-UP-1 Groundwater Operable Unit. Much

of the information available was obtained during previous activities associated with the Basalt Waste Isolation Project (BWIP), and primarily includes data for major ionic species and other non-IRM/LFI constituents. Additional characterization of the confined aquifers is recognized as a significant data need, and will be addressed as part of the limited field activities described in this work plan. In addition to the chemical data that will be gathered, data will be collected to define the vertical interactions between the confined aquifers, and between the Ringold Unit A confined aquifer and the overlying unconfined system. Rattlesnake Ridge interbed wells (three in the 200 West Area) are anticipated to be installed following completion of operable unit IRM activities. This will avoid the creation of a direct path for contaminants to enter the Rattlesnake Ridge interbed until after concentrations have been reduced by the IRM.

3.2 POTENTIAL IMPACTS TO HUMAN HEALTH AND THE ENVIRONMENT

Section 3.2 presents a brief outline of several factors affecting potential human health and environmental hazards discussed in detail in the *200 West Groundwater AAMSR* (DOE/RL 1992b). The AAMSR assessment describes release mechanisms and potential transport pathways, develops a conceptual model of human exposure based on these pathways, and presents the physical, radiological, and toxicological characteristics of the known or suspected contaminants.

The primary transport pathways described in the AAMSR include the following:

- Drainage and leaching of bulk fluids and dissolved contaminants from soil to perched water and groundwater
- Transport within the groundwater
- Migration between groundwater and surface water.

Transport of some organic constituents as DNAPLs, and some inorganic constituents as high-salt density flows is also possible, but no data have been obtained to assess the potential. Vapor transport in the subsurface, and other potential release mechanisms are discussed in detail in source area AAMSRs.

A qualitative RA will be completed for the 200-UP-1 Groundwater Operable Unit Work Plan using groundwater contaminant data collected during activities described in Section 5.0. Ecological RA issues are currently being addressed in an ecological characterization plan for the 200 Aggregate Area Management Study (in preparation), and are not considered part of the 200-UP-1 Groundwater Operable Unit Work Plan. In general, there are few pathways of high likelihood by which biota can be currently exposed to contaminated groundwater in the 200-UP-1 Groundwater Operable Unit due to the depth to groundwater.

3.2.1 Conceptual Model

Figure 3-13 presents a graphical summary of the contaminant sources, release mechanisms, affected media, exposure routes, and receptors. Waste management units that are known or suspected contributors of waste liquids (and, therefore, potential contaminants) to the unconfined aquifer were summarized in Section 2.1. Once contaminants reach the unconfined aquifer, their primary mode of migration is expected to be via advective transport as dissolved chemicals based on available data for subsurface conditions summarized in the *200 West Groundwater AAMSR*. The potential for transport as DNAPL or high-salt density flows has not been evaluated, however.

Four general routes by which direct or indirect human and biota exposure to contaminants in groundwater can occur include the following:

- Inhalation of airborne volatiles or fugitive dusts from surface soils contaminated through irrigation with ground (or surface water)
- Ingestion of water, fugitive dust, surface soils, agricultural products, or other biota (either directly or through the food chain)
- Direct contact with waterborne contaminants or contaminated surface soils
- External exposure to radionuclides in water, surface soils, or fugitive dusts.

3.2.2 Characteristics of Contaminants

Characteristics of the IRM and LFI contaminants of concern for the 200-UP-1 Groundwater Operable Unit were identified and discussed in the *200 West Groundwater AAMSR*. These contaminants were selected for the work plan based upon concentrations detected from groundwater samples that exceeded regulatory criteria, and their relative risk due to toxicity and carcinogenicity.

3.2.3 Potential Applicable or Relevant and Appropriate Requirements

The Superfund Amendments and Reauthorization Act of 1986 amended the CERCLA by requiring that all applicable or relevant and appropriate requirements (ARARs) be employed during implementation of a hazardous waste management cleanup. A detailed discussion of the potential ARARs is presented in the *200 West Groundwater AAMSR* and is incorporated by reference herein.

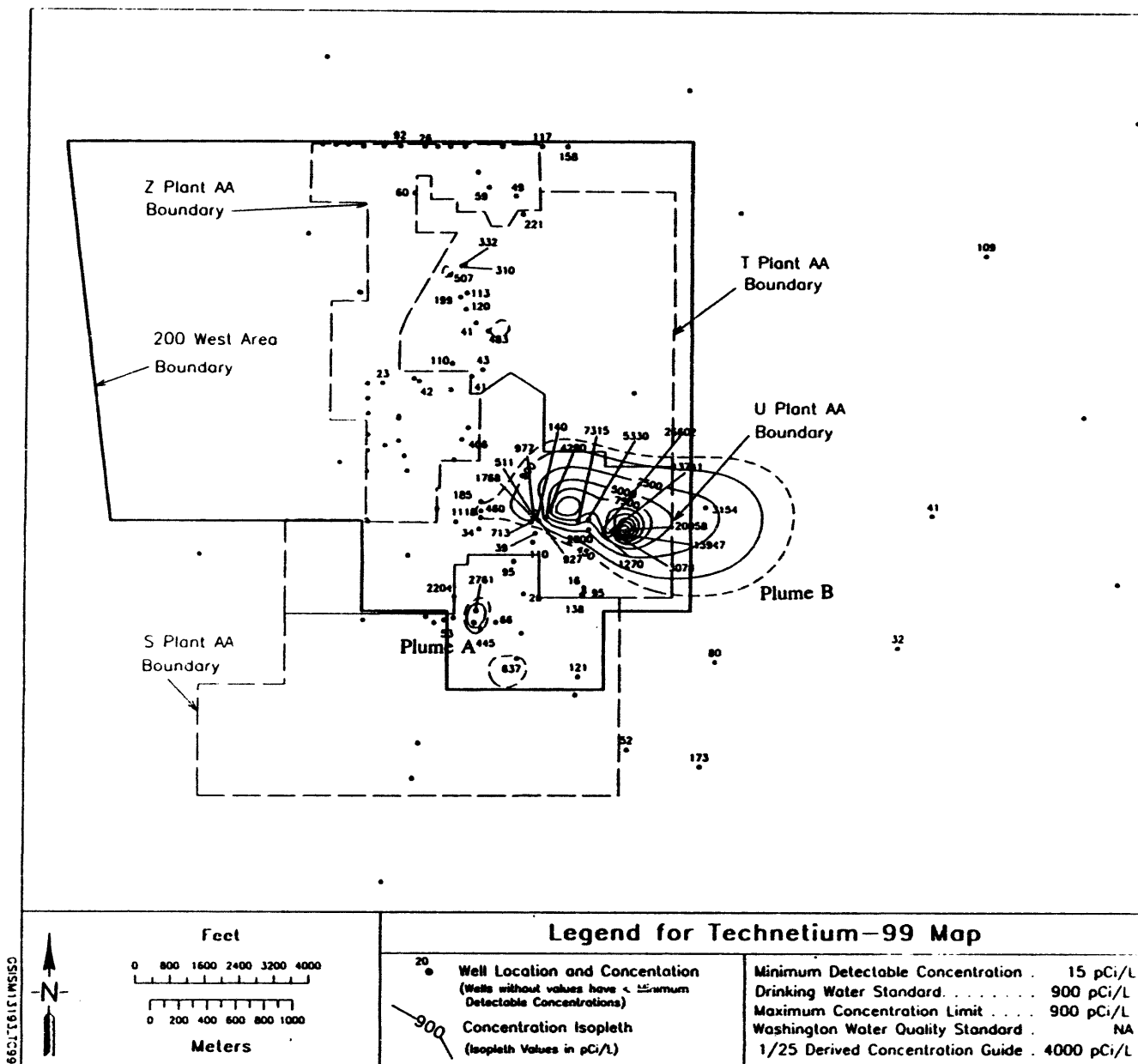


Figure 3-1. Technetium-99 Groundwater Plume Map.

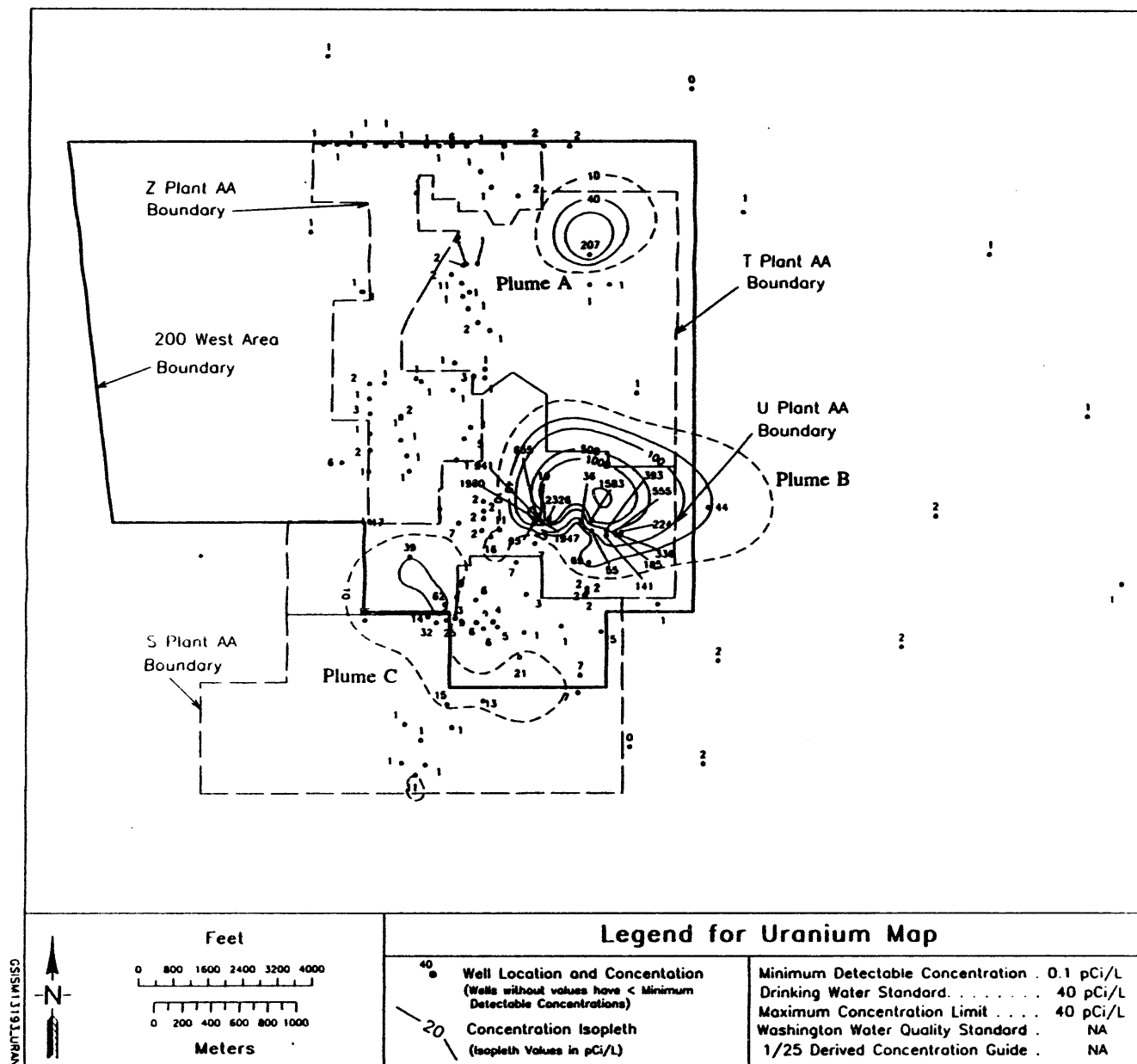


Figure 3-2. Uranium Groundwater Plume Map.



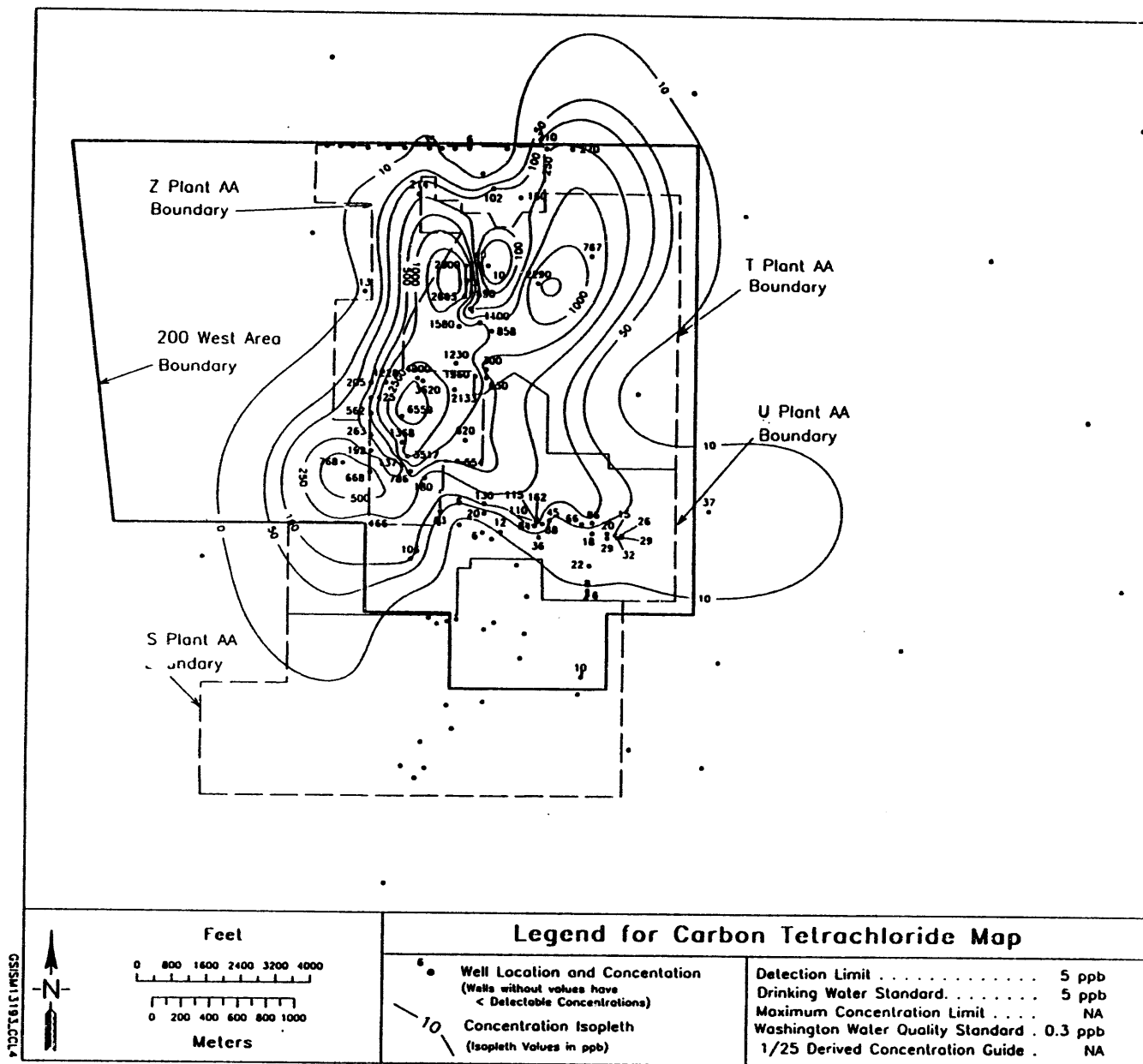


Figure 3-4. Carbon Tetrachloride Groundwater Plume Map.

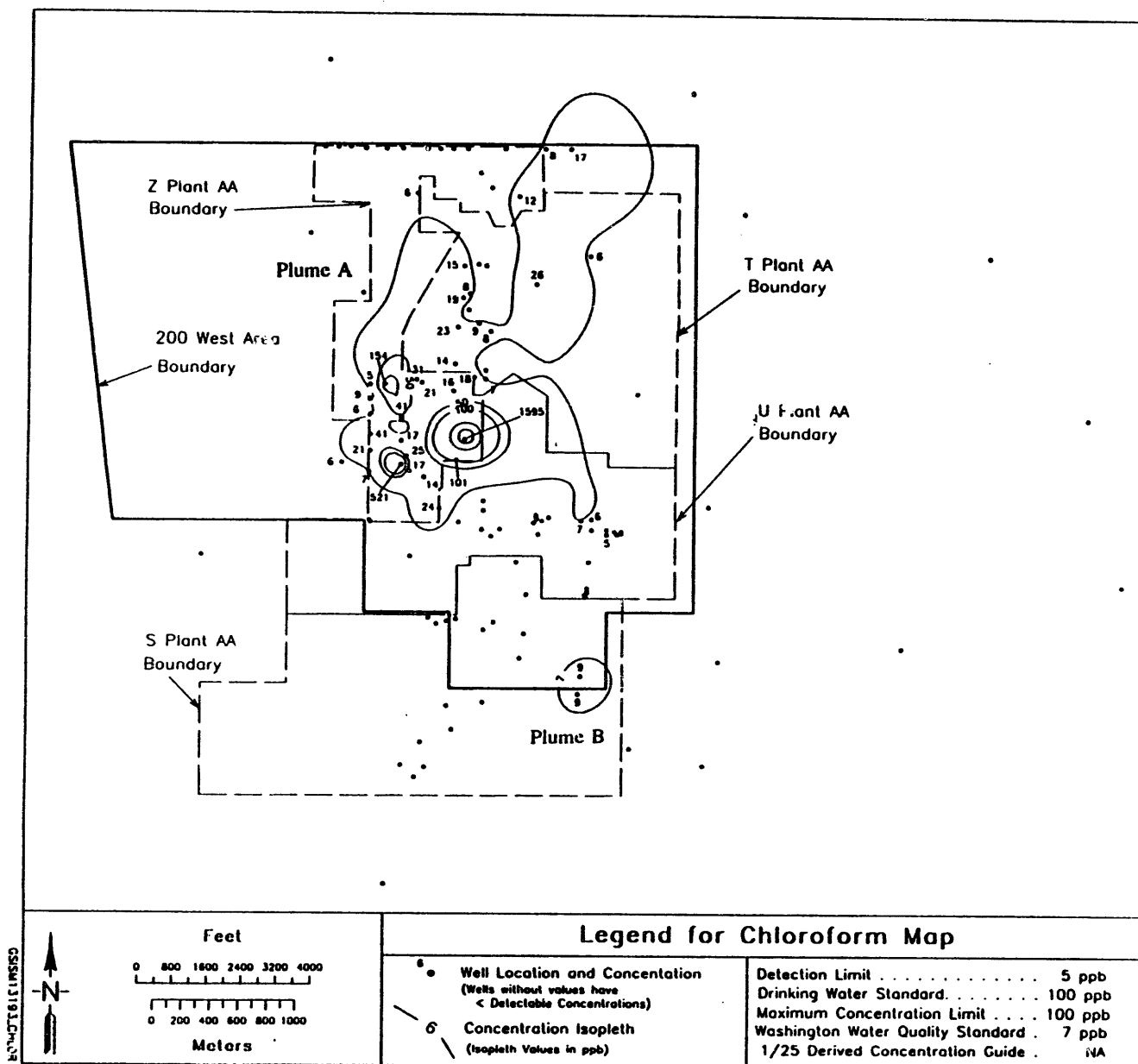


Figure 3-5. Chloroform Groundwater Plume Map.

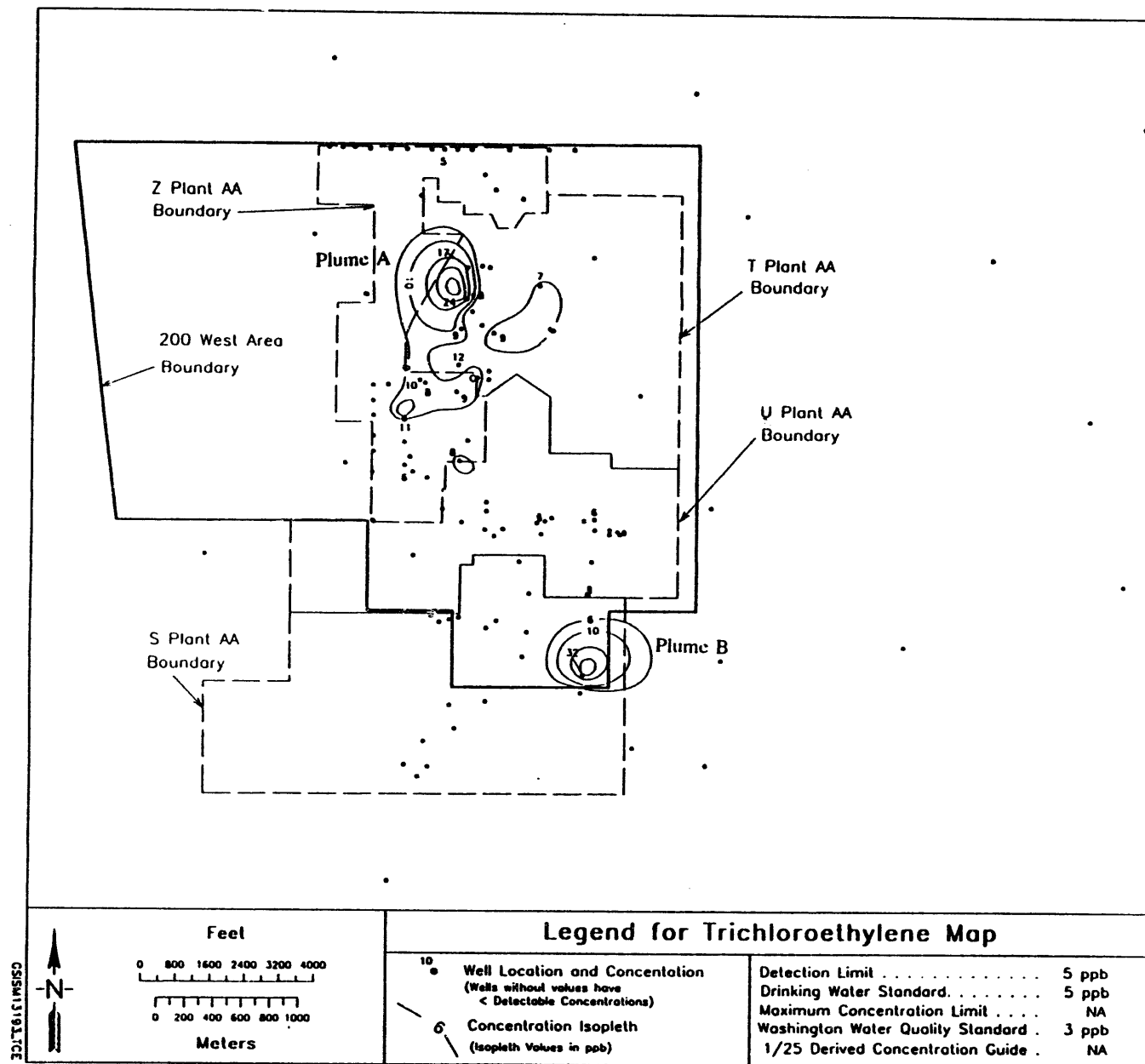


Figure 3-6. Trichloroethylene Groundwater Plume Map.

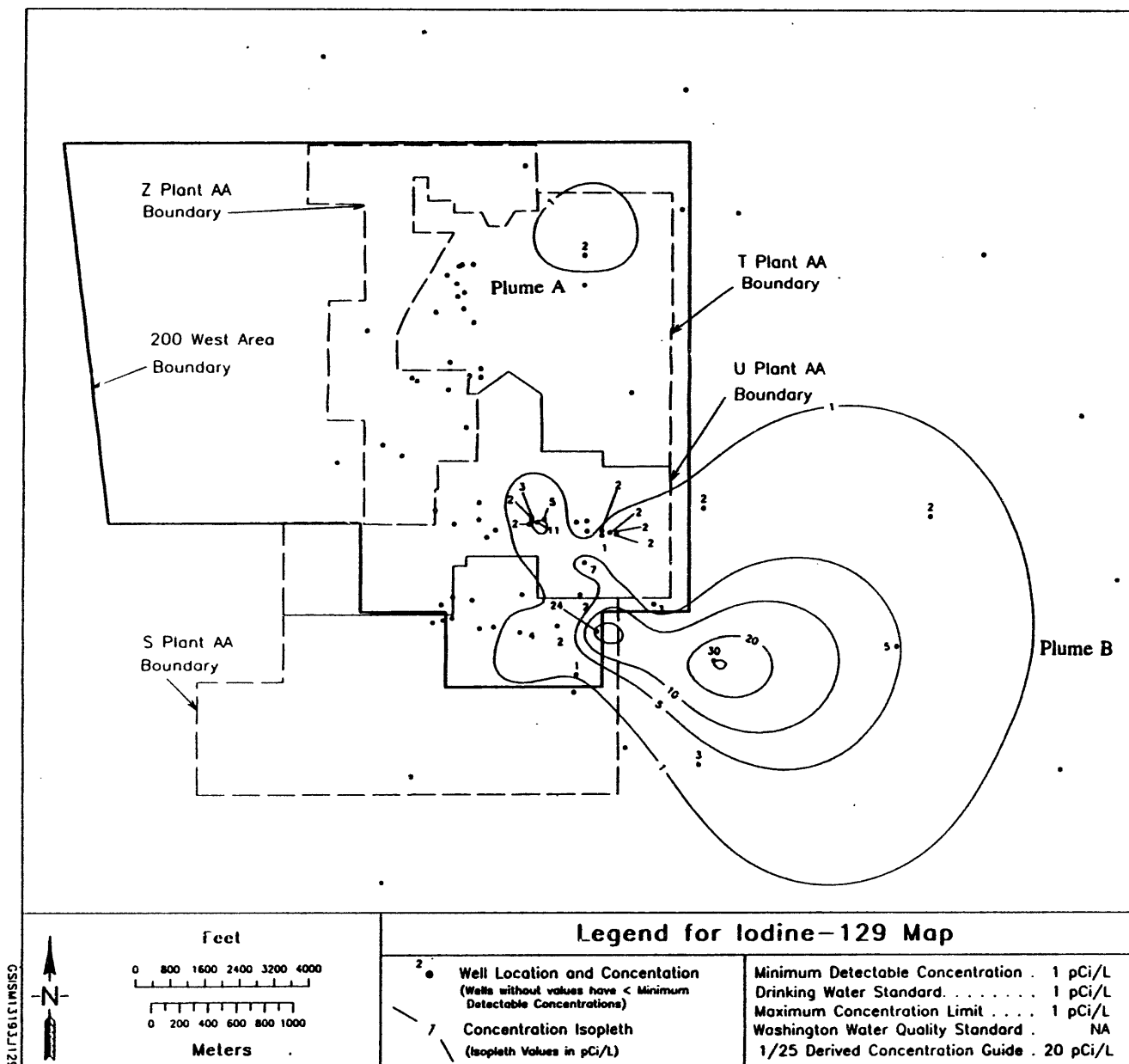
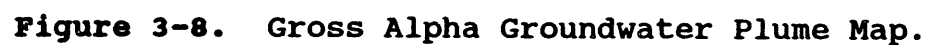


Figure 3-7. Iodine-129 Groundwater Plume Map.



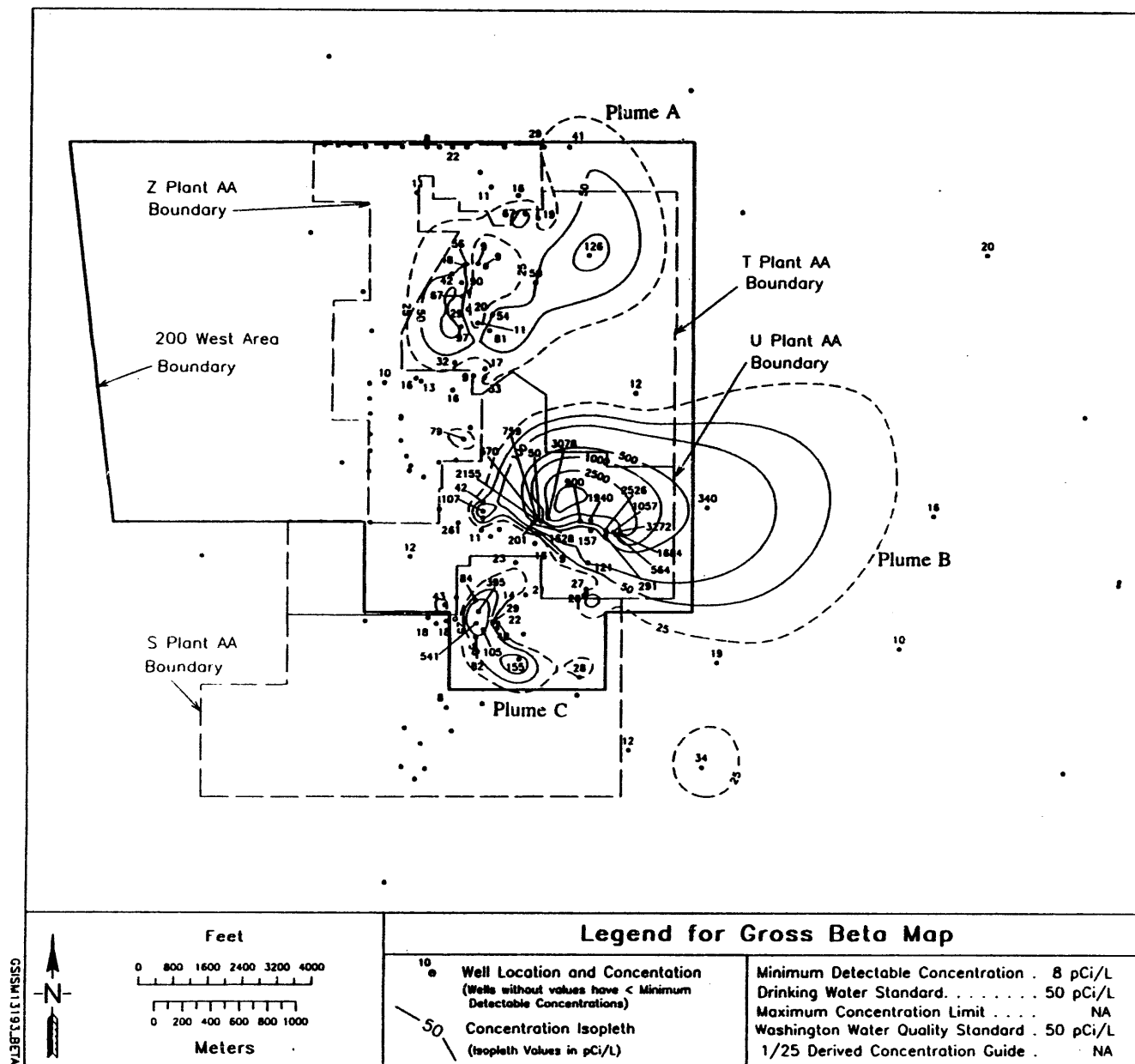


Figure 3-9. Gross Beta Groundwater Plume Map.

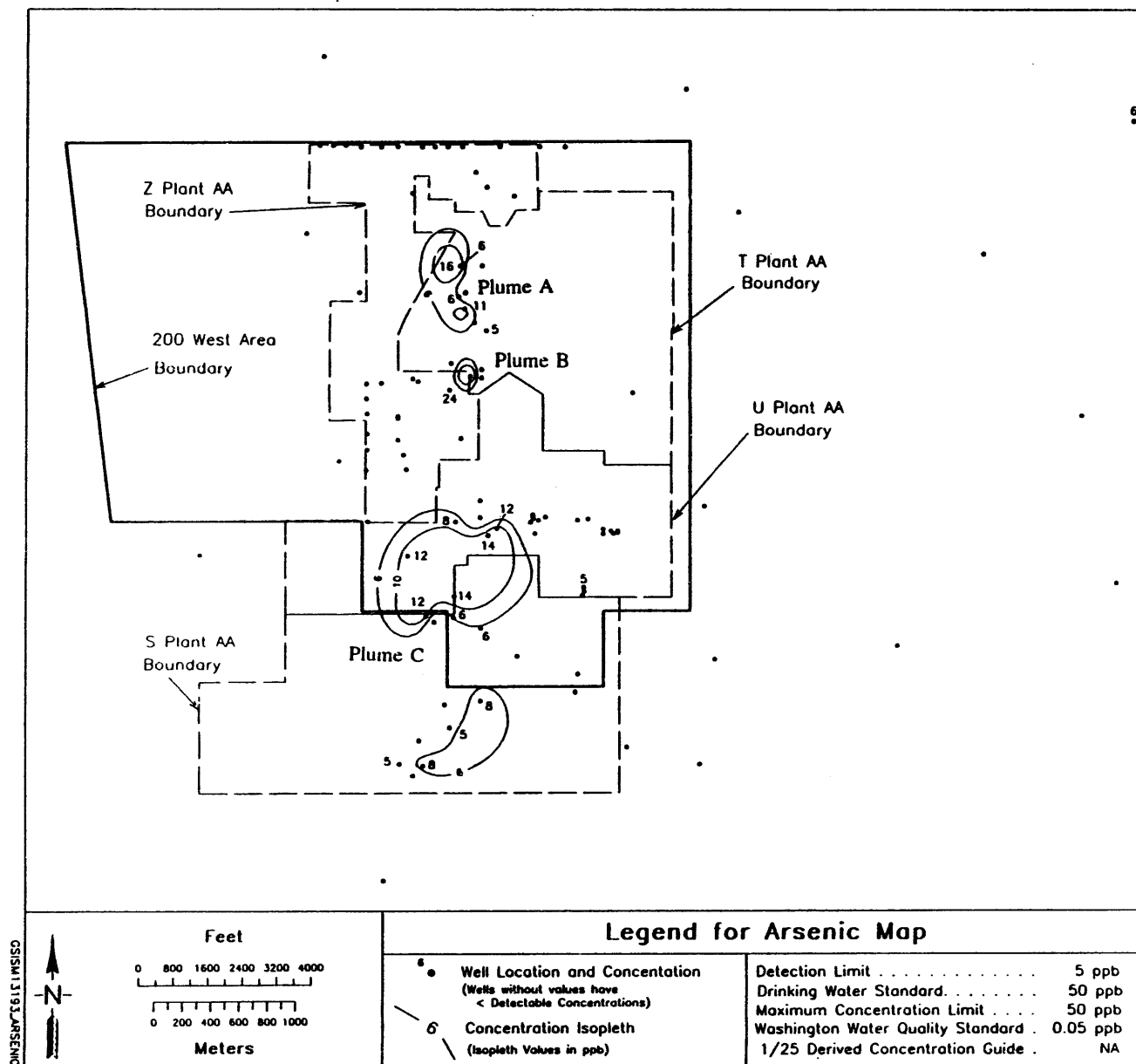


Figure 3-10. Arsenic Groundwater Plume Map.

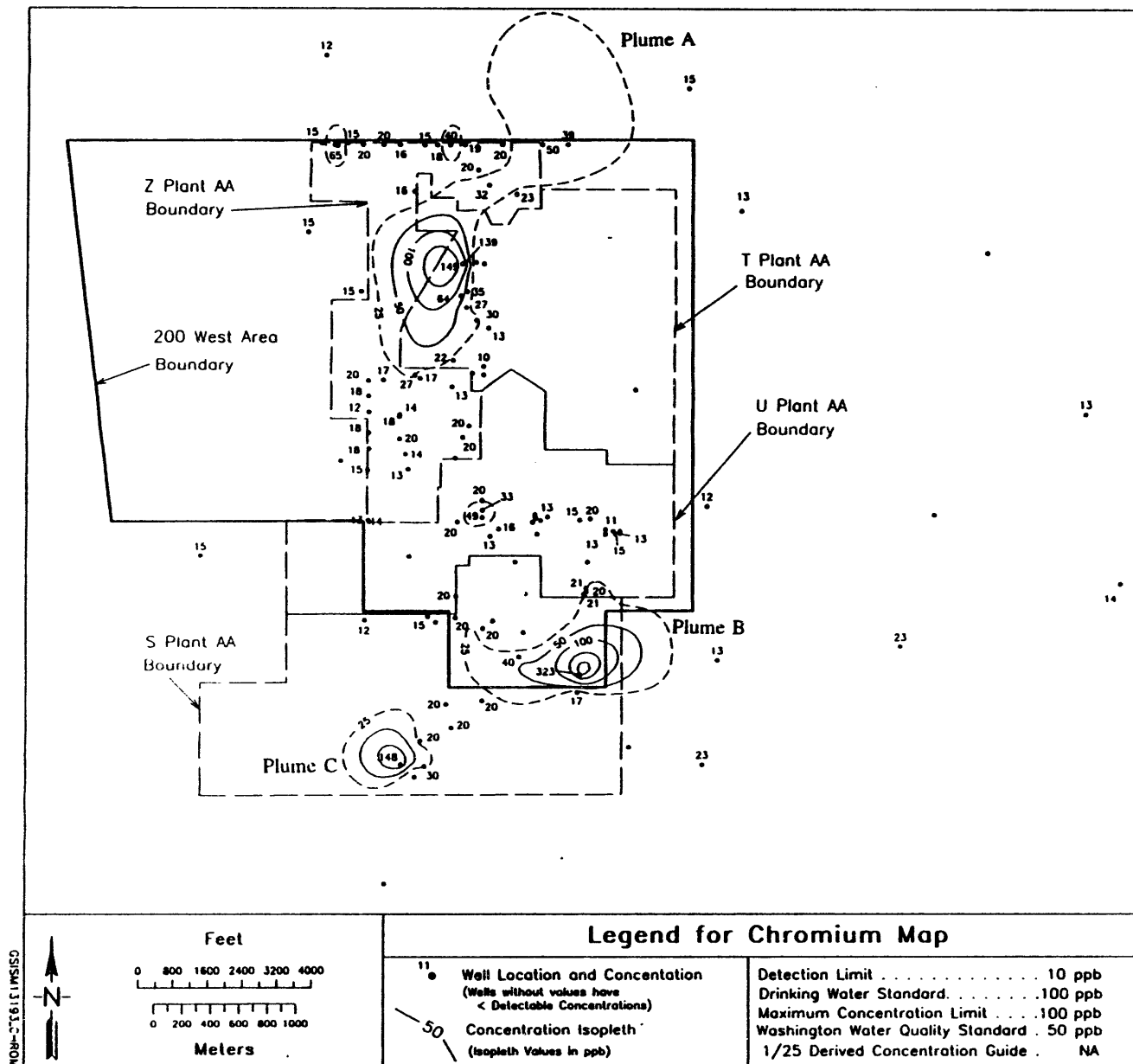


Figure 3-11. Chromium Groundwater Plume Map.

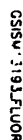
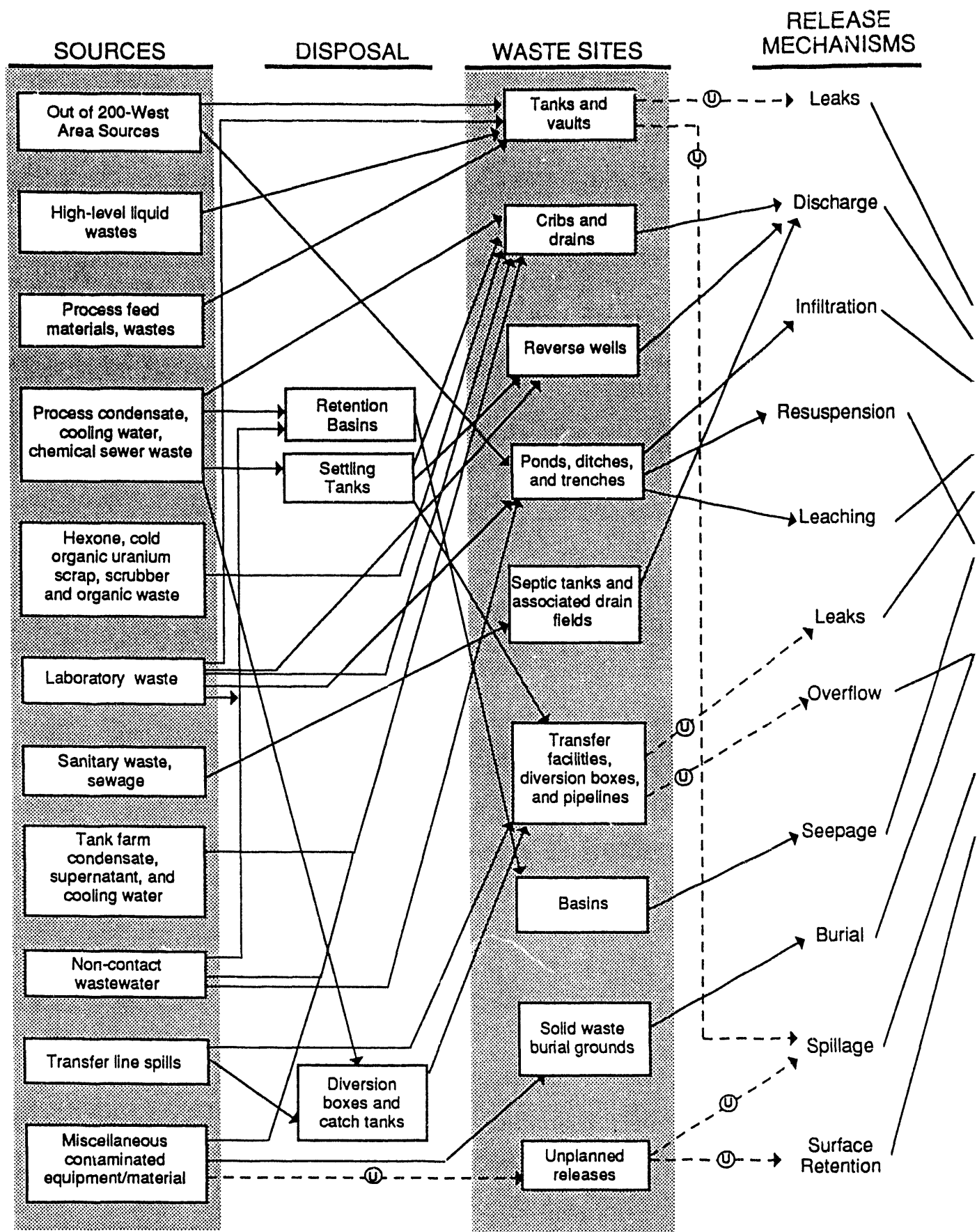


Figure 3-12. Fluoride Groundwater Plume Map.



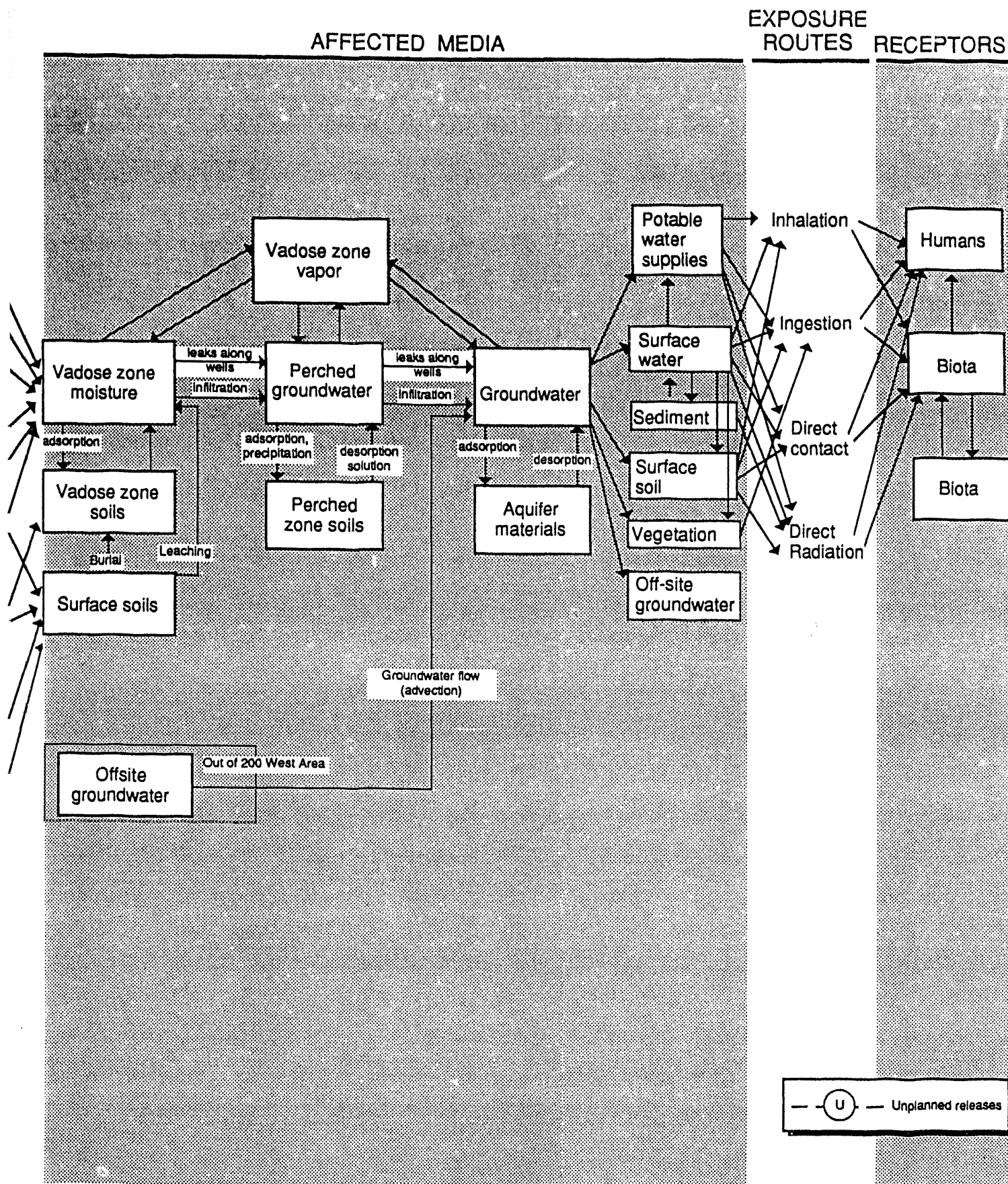


Figure 3-13. Conceptual Model of the 200 West Groundwater Aggregate Area.

Table 3-1. Wells with the Highest (Average) Reported
Constituent Concentration.

Page 1 of 2

Constituent	Well Number	Average of Reported Values for Well ^{a/}	Maximum Single Detection for Well	Minimum Single Detection for Well	Number of Detections for Well	Number < Detection for Well
ORGANIC COMPOUNDS (µg/L)						
Bis(2-ethylhexyl) phthalate	299-W14-10	10.00	15	15	1	1
Carbon Tetrachloride by GC/MS	299-W18-26 ^{b/}	185.83	250	140	6	0
Chloroform	299-W18-20 ^{b/}	23.67	26	20	3	0
1,2-dichloroethane	299-W22-20 ^{b/}	5.25	6	5	2	2
1,1-dichloroethylene	299-W22-20	5.23	5.7	5.7	1	2
Trichloroethylene	299-W22-20 ^{b/}	32.20	41	25	5	0
Aldrin	299-W19-18	1.80	1.8	1.8	1	0
DDT	299-W19-18	4.20	4.2	4.2	1	0
Dieldrin	299-W19-18	3.80	3.8	3.8	1	0
Endrin	299-W19-18	4.40	4.4	4.4	1	0
Endrin Aldehyde	299-W19-18	0.67	0.67	0.67	1	0
Gamma-BHC	299-W19-18	1.70	1.7	1.7	1	0
Heptachlor	299-W19-18	1.70	1.7	1.7	1	0
N-nitrosodimethylamine	299-W23-10	27.00	27	27	1	0
RADIONUCLIDES (pCi/L)						
Gross alpha	299-W19-18 ^{b/}	2208.61	3710	515	18	0
Gross beta	299-W19-25	3271.88	5110	1910	16	0
Plutonium-238	299-W19-24	0.02	0.17	0.17	1	6
Potassium-40	299-W19-32	373.00	373	373	1	0
Strontium-90	299-W22-10	21.95	29.8	13.1	6	0
Technetium-99	299-W19-24	28262.50	41000	19100	16	0

3T-1a

DOE/RL-92-76, Rev. 0

**Table 3-1. Wells with the Highest (Average) Reported
Constituent Concentration.**

Page 2 of 2

Constituent	Well Number	Average of Reported Values for Well ^{a/}	Maximum Single Detection for Well	Minimum Single Detection for Well	Number of Detections for Well	Number < Detection for Well
Iodine-129	699-35-70 ^{b/}	30.06	87.8	10.3	7	0
Uranium	299-W19-18	2257.47	3910.464	552.6246	19	0
INORGANIC COMPOUNDS (µg/L)						
Arsenic	299-W19-21	16.00	18	14	2	0
Arsenic, filtered	299-W23-13	14.75	17	13	4	0
Cadmium	299-W19-1	94.00	94	94	1	0
Cadmium, filtered	299-W22-20	2.20	3	3	1	4
Chromium	299-W22-20	375.33	500	310	3	0
Chromium (filtered)	299-W22-20	322.60	350	296	5	0
Fluoride	299-W19-30 ^{b/}	2550.00	4000	1100	2	0
Nitrate	299-W19-19 ^{b/}	1321666.67	1450000	1220000	18	0
Selenium	299-W27-1	20.33	35	21	2	1
Selenium, filtered	299-W27-1	20.67	33	24	2	1

D.L. Detection Limit
µg/L micrograms per liter

pCi/L picocuries per liter

a/ Averages for each constituent were calculated using one-half of the detection limit values. Maximum and minimum of detections are presented as they are reported in the database. Average of the reported values were calculated from the database information and rounded to two decimal places. For some constituents, varying analytical detection limits over time have been high enough to result in a calculated average (including nondetections at one-half detection limit value) to exceed detected concentrations.

b/ Chemical data combined from two chemical constituent codes in database or from more than one analytical method. Chemical constituent data codes from the Hanford Site Groundwater Chemical Database.

3T-1b

DOE/RL-92-76, Rev. 0

4.0 WORK PLAN APPROACH AND RATIONALE

The overall approach to the 200-UP-1 Groundwater Operable Unit investigation is based on the process set forth in the *Hanford Site Past-Practice Strategy* (DOE/RL 1992e) and recommendations made in the *200 West Groundwater AAMSR*. The *Hanford Site Past-Practice Strategy* identifies the need to accelerate the cleanup process by favoring interim cleanup activities for high priority groundwater contaminant plumes. The *200 West Groundwater AAMSR* initiated the implementation of the *Hanford Site Past-Practice Strategy* by identifying high priority groundwater contamination to be addressed either by limited characterization conducted under an LFI or by interim remediation conducted under an IRM, as identified in Section 1.0. As a result, the near-term strategy for the 200-UP-1 Groundwater Operable Unit is to conduct LFI and IRM activities that will lead to decisions on interim remedial actions. The strategy for conducting these activities can be summarized as follows:

- LFIs will be performed for high priority groundwater contaminants where existing data are considered insufficient to make decisions for determining the need for an IRM.
- IRMs will be implemented where existing data are sufficient to indicate that contamination poses a risk through one or more pathways and additional investigations are not needed to select and initiate an appropriate technology. This determination has been made for the Uranium-⁹⁹Tc-Nitrate multicontaminant plume for which a Treatability Study can be initiated to support technology selection.

This section develops the rationale used to design the field program for the 200-UP-1 Groundwater Operable Unit LFI and define a Treatability Study program to support the 200-UP-1 Groundwater Operable Unit IRM. Data are needed to refine the existing conceptual model and to conduct a QRA to support additional IRM determinations following the *Hanford Site Past-Practice Strategy* decision-making process. Other data quality needs for IRM implementation will be determined after completion of the LFIs and Treatability Study.

Section 4.1 of this work plan describes the data uses defined by the *Hanford Site Past-Practice Strategy* and the data needs identified in Section 8.0 of the *200 West Groundwater AAMSR*. Section 4.2 discusses the rationale for selecting specific LFI field activities to fill data gaps. Data needs for evaluating remedial alternatives for the Uranium-⁹⁹Tc-Nitrate IRM are addressed in Section 4.3 based on the screening of alternatives presented in Section 7.0 of the *200 West Groundwater AAMSR* and recommendations in Section 9.0 of the *200 West Groundwater AAMSR*.

The uranium, ⁹⁹Tc, and nitrate plumes are recognized as having both an LFI and an IRM component because of gradations in contaminant concentrations. The data collection program for the LFI portion is addressed in Section 4.2. The IRM portion of the plumes, which focuses on the area of the highest

concentrations of uranium, ^{99}Tc , and nitrate in the upper unconfined aquifer, is addressed in Section 4.3.

4.1 LIMITED FIELD INVESTIGATION DATA USES AND DATA NEEDS

The LFI, as defined in the *Hanford Site Past-Practice Strategy*, addresses two primary data uses: refinement of the operable unit conceptual model and support of the performance of a QRA. The QRA will support determinations for LFI plumes to identify additional IRMs or other appropriate pathways. The primary areas for refinement of the conceptual model are indicated in Section 8.0 of the *200 West Groundwater AAMSR*. The data needs for refinement of the conceptual model can be expressed in the following categories:

- Hydrostratigraphy
- Aquifer Properties
- Groundwater Flow
- Source Contributions
- Nature and Extent of Contamination
- Groundwater Geochemistry.

The QRA relies on the development of the conceptual model to conduct a preliminary human health RA following the guidelines presented in the *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1992g) (see Section 5.5). Primarily, the QRA requires additional definition of contaminant plume concentrations to help identify which of the current LFI constituents are recommended for IRM designation. Ecological risks will be evaluated through an ecological characterization plan separate from this work plan that will address the 200 Areas as a whole.

The data uses for the LFI (refinement of the conceptual model and completion of a QRA) and corresponding general data needs for the 200-UP-1 Groundwater Operable Unit are shown on Figure 4-1, along with specific data needs for each general category. Figure 4-1 also indicates the activities planned to address these needs, which are discussed in Section 4.2. All of these data needs are considered essential to fill LFI data gaps previously identified in the *200 West Groundwater AAMSR*. The most important need for the IRM decision process is to further define the nature and extent of contamination. This need is followed in importance by the need to further define aquifer properties, groundwater flow, and groundwater geochemistry. Further definition of hydrostratigraphy and source contributions are important gaps to fill, but are not the main drivers of field activities proposed in this work plan.

The *200 West Groundwater AAMSR* developed specific data needs for the data uses for the groundwater operable units, as presented in Section 8.2.2 of the AAMSR. During the AAMSR process, the available data were compiled and reviewed to determine usefulness and to identify data gaps. These data gaps are derived from information presented in Sections 2.0, 3.0, and 4.0 of the *200 West Groundwater AAMSR* and are described in detail in Section 8.0 of the AAMSR. General data needs identified in the *200 West Groundwater AAMSR* fall into the categories shown on Figure 4-1. The general data needs are divided

into two or more specific data needs that describe individual parameters or groups of parameters to be obtained in this field program. Figure 4-1 identifies the relationship between the data uses and data needs and illustrates the determination of field activities required to obtain specific parameters necessary to fill those needs.

The relationship between data uses and general and specific data needs described herein and outlined in Table 4-1 forms the basis for planning field and other activities to collect required data for the LFI, as presented in Section 4.2. The data collection program is developed using a data quality objective (DQO) process consistent with EPA guidance (EPA 1987) and with DQOs discussed in the *200 West Groundwater AAMSR*. The DQO process is discussed in Section 4.2.1, with subsequent sections addressing the selection of field activities necessary to fill the data needs.

4.2 LIMITED FIELD INVESTIGATION DATA COLLECTION PROGRAM

This section presents the approach and rationale used in selecting the types of LFI data collection programs for the 200-UP-1 Groundwater Operable Unit Work Plan. The field programs and other data collection activities are designed to effectively address general data needs for the operable unit derived from Section 8.0 of the *200 West Groundwater AAMSR* using the DQO process discussed in Section 4.2.1. As discussed above in Section 4.1, data needs for the work plan were identified as the primary information necessary to further develop and refine the operable unit conceptual model and to complete a QRA.

To address general data needs, Section 8.0 of the *200 West Groundwater AAMSR* presents a data collection strategy that is applicable to the 200-UP-1 Groundwater Operable Unit. The general investigation strategies presented in the AAMSR include plume nature and extent investigation, groundwater transport investigation, source release investigation, geologic investigation, and geodetic surveying and well quality assessment. This section builds on these strategies by providing the rationale and specific DQOs for the data collection program presented in Section 5.0, which follows. As part of the overall work plan rationale, the data collection program also focuses on providing information needed to address current data gaps associated with the conceptual model. In this way, the data collection program is designed to address work plan data needs by resolving data gap issues using the current understanding of existing physical conditions and contaminant distribution.

Section 4.2.1 summarizes the rationale for developing specific DQOs for the field and other data collection activities. Sections 4.2.2 through 4.2.7 describe the rationale associated with the DQO process for each of the data collection activities.

4.2.1 General Rationale for Developing Data Quality Objectives

The DQO process is used as a planning tool to develop a data collection strategy that is compatible with intended work plan data needs and uses. The DQO process helps ensure that the right type and quality of data are collected to fulfill informational requirements for refining the conceptual model, completing a QRA, and ultimately for determining the status of the LFI constituents according to the *Hanford Site Past-Practice Strategy* (DOE/RL 1992e) pathway alternatives. Within this context, DQOs represent qualitative and quantitative statements and criteria used to develop the strategy for data collection and to determine the specific data parameters to be measured or collected. The DQO process was used to optimize the number of samples, measurements, chemical analyses, etc. necessary to meet the work plan data needs, and to obtain these data at an acceptable level of uncertainty. The DQO process also helps to make data collection activities more efficient and cost effective.

Criteria used to define DQOs for each of the field activities listed on Figure 4-1 are detailed in Tables 4-1 through 4-8, respectively. Each table lists the investigation objectives for addressing work plan data needs. Based on these objectives, the prioritized use of the information obtained is described in terms of site characterization issues related to refinement of the conceptual model and completion of a QRA based on the refined model. Individual parameters to be obtained are listed in Tables 4-1 through 4-8, along with appropriate DQO guidelines for implementing the testing method or gathering the data. Implementation guidelines for many of the field activities are expected to rely heavily on existing Environmental Investigation Instructions (EII's; WHC 1988), which discuss in detail common testing methods and procedures used at the Hanford Site. Implementation guidelines for some field activities presented in the DQO tables (e.g., aquifer testing) also include reference to follow-on DOW documents that are planned to provide supplementary detail to the work plan field investigations. The DOWs will finalize DQOs, well selection, and methods of investigation once specific decisions regarding drilling methods, aquifer pump types/sizes, and similar issues have been made.

Tables 4-1 through 4-8 also describe or reference the required data parameter measurement limits and quality criteria such as the Precision, Accuracy, Representativeness, Completeness, and Comparability (PARCC) parameters for groundwater sample analytical data (Table 4-6). The DQO tables list critical values or samples for data parameters to identify in general terms geographic areas, stratigraphic horizons, or other requirements where data are needed to address data needs or specific data gaps in the conceptual model. Critical samples or other parameters for some field activities such as existing well survey and condition assessment (Table 4-8) are prioritized with regard to the intended use of the well; that is, plume area wells have higher priority for resurvey and remediation (where needed) than outlying 600-series wells. Constraints affecting field testing methods and the parameters to be collected are also listed in Tables 4-1 through 4-8 as important DQO considerations. As an example, slug tests will be emphasized to collect aquifer properties data in the shallow unconfined aquifer in contaminated areas because of logistical and regulatory constraints for handling and

disposing of contaminated groundwater (Table 4-4). Additional DQOs in support of a QRA include specification of analytical detection limits sufficiently low to satisfy ARARs and risk-derived limits and providing unfiltered groundwater samples for inorganic compound analyses.

Data collection parameters developed through the DQO process for field activities testing are listed in Table 4-9 and are summarized according to the stratigraphic horizons where information is needed to address work plan data needs. The rationale for targeting data collection in specific hydrostratigraphic units is presented in the data need discussions of Sections 4.2.2 through 4.2.7.

4.2.1.1 LFI Field Activities and Analyses. This section summarizes the rationale for general LFI field activities and analyses developed for the 200-UP-1 Groundwater Operable Unit Work Plan.

4.2.1.1.1 Field Activities. Each data need has certain requirements best fulfilled by specific field activities. For example, the vertical extent of contamination in the saturated zone is best assessed by sampling monitoring wells with isolated screen intervals placed at discrete depths, with supplemental information provided by borehole geophysics. As shown on Figure 4-1, each field activity generally addresses more than one data need. For example, the data needs addressed by boreholes drilled for monitoring well installation include hydrostratigraphy (unit thickness, soil and rock descriptions, etc.), aquifer properties (porosity, bulk density, etc.), source contributions (perched water identification, soil contaminant concentrations), and groundwater geochemistry (cation exchange capacity, organic carbon content, grain and cement mineralogy, etc.).

The proposed field activities described in Sections 4.2.2 to 4.2.7 are summarized below.

- Borehole geologic logging and soil sampling during monitoring well installation and subsequent physical, chemical, and radionuclide laboratory analysis will provide more data to assess operable unit stratigraphy and to evaluate soil physical and chemical properties. Selected samples will be used to characterize subsurface soil mineralogy, chemistry, hydrologic characteristics, and sorption characteristics where needed to support aquifer media physical and chemical property data needs. Limited vadose zone soil sampling will address potential source contributions.
- If encountered during the drilling program, perched groundwater will be noted and referred to appropriate source area investigations. Drilling and well installation procedures will be adjusted to ensure isolation of perched water zones and avoid releases from these zones.
- Subsurface (borehole) geophysical surveys, especially those to obtain spectral gamma data, will support the plume delineation effort. Existing and new wells proposed in this work plan will be sampled to provide more data for estimating the lateral and vertical

extent of contamination. This may include vadose zone screening to identify whether potential source area contaminants are present.

- New wells are proposed to be installed in the three aquifers of concern to provide refinement of horizontal and vertical contaminant extent, horizontal and vertical hydraulic gradients, and determination of aquifer properties. The wells are intended for multiple-use groundwater installations and may be used for sampling and analysis, borehole geophysics, water level measurements, and aquifer tests. New wells for the Rattlesnake Ridge interbed aquifer will be addressed on a 200 West Groundwater Aggregate Area basis and will follow completion of IRM activities at a later date. Information provided by wells completed in the Rattlesnake Ridge interbed is not required to support the IRM and, therefore, can be delayed until a later time. The vertical extent of contamination will be addressed to the base of the Ringold Unit A. Discovery of contamination at this depth would indicate a possibility of detrimental impact to deeper aquifers, which may dictate further investigation, as needed. Deep wells will be installed in such a way as to avoid migration and contamination across aquifers, as detailed in Section 5.1.3.2.2.
- Aquifer testing is proposed for new and select existing wells to obtain aquifer hydraulic parameters and to evaluate aquifer interconnection. Slug tests and pumping tests will be conducted as appropriate, with the use of pumping tests, depending on the practicality of disposing of discharge water. A portion of the aquifer testing was conducted in 1993 as part of accelerated LFI field activities necessary to properly support the Treatability Study. The opportunity presented by pumping of wells during the Treatability Study may be used to the extent possible to conduct further aquifer tests.
- Water level measurements in appropriately constructed monitoring wells will provide information regarding horizontal and vertical hydraulic gradients.
- Groundwater sampling for chemical and radionuclide analysis will provide information regarding the nature and extent of groundwater contamination. Although the horizontal extent of plume migration is generally known, there are insufficient specific data necessary to define the limits and movement of particular LFI contaminants of concern. General water chemistry data will help to assess the chemical form and mobility of constituents of concern to address the partitioning of contaminants between soil and water along with contaminant fate and transport considerations. A limited vertical extent sampling program of existing wells with long or multiple screens was begun in 1993 as part of accelerated LFI field activities necessary to support the Treatability Study, but will not be completed prior to the issuance of this work plan.

- Analytical data review will examine apparent anomalies and incongruities of existing analytical data for determination of appropriate uses or significance of results. The review will include evaluation of laboratory reports (where available) for PARCC parameters, potential well material or sampling influences, and variances of individual results with historical trends (outliers). The analytical data review will help fill data gaps in the nature and extent of contamination and help evaluate data acquired on groundwater geochemistry.
- Existing wells targeted for use in groundwater sampling and water level measurements will be evaluated to determine the adequacy of existing survey data and fitness-for-use. Wells with outdated or suspect surveys will be resurveyed and wells determined to be deficient for groundwater sampling will be remediated or considered for replacement.
- As part of ongoing data evaluation activities separate from this work plan, groundwater model calibration will be conducted to field check models describing contaminant migration in the saturated zone. The work will be conducted using supporting data from the 200-UP-2 Source Operable Unit Work Plan. This activity requires that soil chemistry, hydrogeology, and contaminant plume distribution data be collected. Specific analytical techniques and characterization tools will be selected as part of the overall data evaluation program. The results of this study will also support the Uranium-⁹⁹Tc-Nitrate IRM Proposed Plan.

Data collection must also be completed in a sequential manner so that activities that provide data to support other testing efforts are completed first. For example, soil sampling during monitoring well drilling will be used for stratigraphic and chemical characterization of soil and the installed monitoring wells will be used for plume evaluation, water level measurement, and aquifer testing. Activities of longer duration such as well drilling should be scheduled (through DOWs) to yield the highest priority data as early as possible. As an example, high priority should be given to completing a DOW for aquifer properties testing using selected existing wells in the uppermost portion of the unconfined aquifer. The information is needed to refine the 200 West Area hydrogeologic model (Connelly et al. 1992) in support of the planned Treatability Study for the Uranium-⁹⁹Tc-Nitrate IRM. Similarly, high priority should also be given to completing a DOW for vertical profiling of contamination in the IRM plume area using existing operable unit wells. Information from the vertical profiling DOW fulfills key data needs related to refining the operable unit conceptual model and facilitating the IRM Treatability Study.

4.2.1.1.2 Analyses. Soil and groundwater samples will be collected in conjunction with many of the activities listed above. These samples will be analyzed to assess contaminant concentrations and/or to characterize their physical properties. The list of analyses for these samples is derived from the LFI contaminants of concern listed in Section 3.1.

4.2.1.2 Physical Model of Contaminant Distribution. Figure 3-13 presents a graphical summary of the conceptual model for the 200-UP-1 Groundwater Operable Unit and identifies contaminant sources, release mechanisms, affected media, exposure routes, and receptors. Large-scale liquid disposal sites such as cribs, ponds, ditches, and french drains have affected surface and deeper vadose zone soils and in some cases have affected underlying groundwater quality and flow direction. Field work to be completed at these sites during the source Remedial Investigations, such as that in the 200-UP-2 Source Operable Unit, will collect data for surface exposure RA and vadose zone migration assessment. The field work described by this work plan for the 200-UP-1 Groundwater Operable Unit is designed to collect data for refining the groundwater conceptual model and completing a groundwater QRA.

All waste management units that were indicated to potentially have contributed contaminants to the groundwater, as determined in screening performed in the *200 West Groundwater AAMSR* (Table 2-1), are addressed either by previous or proposed data collection activities. Table 4-10 shows the means by which potential groundwater contamination from each of these units is addressed. In some cases, the analogous group concept presented in the *Hanford Site Past-Practice Strategy* is used to assess particular units, as shown by the last column in Table 4-10. This concept emphasizes that characterization activities can be reduced by identifying select sites (analog) for characterization that are representative of a group of sites (analogous group). It is particularly applicable to operable units that contain a number of waste management units that are similar in design, disposal history, and geology. Appropriate confirmatory characterization, as necessary to support remedial action, can then be performed at the sites within each analogous group during remediation.

Results of previous groundwater monitoring programs and other studies are described in the *200 West Groundwater AAMSR*. Several general conclusions may be drawn from this work.

- While the highest concentrations in most locations in most contaminant plumes are probably near the top of the uppermost aquifer (at the water table), downward vertical groundwater gradients from recharge and vertical hydrodynamic dispersion may lead to detectable contaminant concentrations at some depth below the water table. In such a case, monitoring well networks that are screened near the top of the water column may underestimate the highest contaminant concentrations present and may fail to detect a downward migrating contaminant plume. Conversely, wells screened across the entire saturated zone or with more than 7 to 10 m (20 to 30 ft) of well screen and sandpack may also underestimate the maximum contaminant concentrations present near the water table due to dilution by water with lower concentrations.
- The highest concentrations of many constituents at the top of the unconfined aquifer will generally be found directly below source areas (i.e., the cribs, ponds, trenches, and other facilities used to dispose of the wastewater containing the constituents to the subsurface). However, depending on the relationship between decay

rate, groundwater migration rate, and other factors, the concentrations of daughter products from biological, radioactive, or chemical decay (e.g., carbon tetrachloride breakdown to chloroform) may be higher downgradient of the area with the highest concentrations of the parent compound.

- There may be background concentrations for certain constituents detected in the 200-UP-1 Groundwater Operable Unit groundwater (e.g., nitrate, tritium, arsenic, and other metals), which are unrelated to historic operations at the Hanford Site. Some background concentration of nitrate may be present in groundwater due to irrigated agriculture west (upgradient) of the 200 West Area. In addition to tritium from onsite operations, tritium may be present in groundwater due to historic atmospheric nuclear weapons testing. Like tritium, fallout from offsite sources such as (world-wide) atmospheric nuclear weapons testing or naturally occurring levels in soil and rocks may also be contributing to elevated levels of ⁴⁰K observed in the 200-UP-1 Groundwater Operable Unit. Potassium-40 is not historically associated with production activities and processing wastes at the Hanford Site. Arsenic and other inorganic compounds may be present in groundwater due to the natural dissolution of the minerals making up the sediments underlying the Hanford Site. Delineation of background concentrations for chemical constituents at the Hanford Site has been initiated by Hoover and Legore (1991) and DOE/RL (1992h) and is currently the subject of ongoing work intended to estimate the contribution from sources other than historic Hanford Site operations. If specific data regarding background ⁴⁰K concentrations are not collected during these programs it is recommended that this data be obtained from upgradient and offsite wells during evaluation of the nature and extent of contaminant plumes for the 200-UP-1 Groundwater Operable Unit Work Plan.
- Organic complexing agents such as tributyl phosphate, if present, could significantly enhance the mobility of generally low mobility constituents like plutonium. Other factors such as low pH or Eh related to the discharge of acidic wastewater may enhance the mobility of certain metals such as cadmium or chromium or may remobilize previously precipitated constituents such as uranium. Also, natural biodegradation of nitrate or petroleum hydrocarbons below the water table can create reducing conditions that favor the dissolution of arsenic, beryllium, and other metals from native soils.
- If vapor-phase migration in the vadose zone is a significant migration pathway, then the highest concentrations of volatile organic constituents such as carbon tetrachloride in the vapor phase would be expected to occur near the water table. This is thought to be a less likely contaminant transport mode in the 200-UP-1 Groundwater Operable Unit than it may be in the 200-ZP-1 Groundwater Operable Unit, to the north, where volatile organics such as carbon tetrachloride are found at higher concentrations.

- If mobile DNAPLs such as liquid carbon tetrachloride are present in the subsurface, detectable dissolved concentrations may be present at substantial depth below the water table. The highest concentrations would likely occur on top of low permeability units such as silt and clay lenses or layers and basalt. The direction of free-phase DNAPL migration is controlled by the bedding dip of low permeability units and DNAPL transport may have no relation to the groundwater flow direction in the area. This is again more likely on the 200-ZP-1 Groundwater Operable Unit than the 200-UP-1 Groundwater Operable Unit. Similar considerations apply to high-salt density plume contaminants such as those postulated for the 200 East Area. The presence of DNAPL and high-salt density plumes has not been confirmed in the 200 West Groundwater Operable Unit, however, but remains an issue of concern, particularly for carbon tetrachloride.

4.2.2 Hydrostratigraphy

The *200 West Groundwater AAMSR* indicates that a few outstanding issues remain related to hydrostratigraphic interpretation and identification of major units within the 200-UP-1 Groundwater Operable Unit. For example, additional stratigraphic depth and thickness data are needed to delineate the lateral and vertical extent of potentially important units such as the early "Palouse" soil and the Plio-Pleistocene unit in the vadose zone, and the Elephant Mountain Basalt and underlying Rattlesnake Ridge interbed (Figure 2-1). Confirmation of the depth and thickness of major facies or lithologic changes for the unsaturated Ringold Unit E gravels and underlying saturated units and is an additional consideration of importance. The DQOs for stratigraphic depth and thickness, and soil sample collection for lithologic description are presented in Table 4-1, and are listed by stratigraphic unit in Table 4-9. Stratigraphic data will be collected as part of the overall soil sampling for physical and chemical properties from the recommended borings for well installation.

The collection of hydrostratigraphic unit depth, thickness, and lithologic descriptions are primarily driven by data needs related to confirming or refining the current understanding of the hydrostratigraphic setting of the operable unit. As general data needs, depth, thickness, and lithologic description data are needed for the Ringold Formation units to provide the context for interpreting aquifer test results (Section 4.2.3), potential perched water zones associated with the early "Palouse" soil and Plio-Pleistocene unit (Section 4.2.5), water level data and groundwater flow (Section 4.2.4), and soil and groundwater chemical and physical sampling results (Sections 4.2.7 and 4.2.6, respectively). As an example, the information will be used to further evaluate the role of the early "Palouse" soil and the Plio-Pleistocene unit as physical barriers impeding the downward migration of vadose zone contaminants like carbon tetrachloride, and the relationship to underlying groundwater contamination. Lithologic descriptions for the Rattlesnake Ridge interbed represent an important data need because existing descriptions of this unit from previous work on the BWIP are extremely limited. For the Rattlesnake Ridge interbed, the general lithology

and physical competency and integrity are important considerations for evaluating aquifer properties and groundwater flow.

The hydrostratigraphic data and lithologic descriptions for the units listed in Table 4-9 will be obtained during logging and sample collection activities associated with new well installation. Borehole logging and sampling procedures will be collected in accordance with procedures detailed in EII 5.2 and EII 11.1 (WHC 1988). For the purposes of collecting the geologic and hydrostratigraphic data described in this section, the sampling schemes for obtaining soil samples for chemical sampling and physical properties testing (Sections 4.2.6 and 4.2.7; and Table 5-3) are considered to be sufficient for the purposes of stratigraphic characterization. The planned Rattlesnake Ridge interbed well is not anticipated to be installed until operable unit IRM activities have been completed.

4.2.3 Aquifer Properties

As shown on Figure 4-1, determination of physical aquifer properties are needed to address existing data gaps described in the *200 West Groundwater AAMSR* and further characterize hydrologic aspects of the operable unit conceptual model. Collection of these data will improve understanding of the groundwater flow system, assess issues of aquifer intercommunication, and help evaluate horizontal and vertical contaminant migration. The primary parameters of interest include hydraulic conductivity, transmissivity, porosity, and grain size distribution. These properties generally limit how fast groundwater flows, and in cases of extreme spatial variability, can affect the direction of flow. Comparison of hydraulic conductivity values in two different aquifers is a particularly important parameter for describing aquifer intercommunication (e.g., unconfined portions of the uppermost aquifer, represented by the Ringold Unit E, and confined portions represented by the Ringold Unit A). Specific physical aquifer properties that are proposed to be collected for this work plan and the targeted hydrostratigraphic units for obtaining these data are shown in Table 4-9.

To fulfill data needs for physical aquifer property data, estimates of hydraulic conductivity and transmissivity information will require field aquifer properties testing. Grain size information would be provided from laboratory analysis of soil samples collected during the recommended soil boring program for new well installation. Porosity data would also be compared to estimates from previous operable unit and Hanford Site investigations.

The DQOs for hydraulic conductivity and transmissivity data collection from in situ aquifer testing are described in Table 4-4. The comparison of hydraulic conductivities for the Unit E gravels (unconfined system) and the Ringold Unit A gravels and Rattlesnake Ridge interbed (confined aquifers) are of particular interest because of the importance of these parameters for interpreting gradients and contaminant migration potential. The planned Rattlesnake Ridge interbed well is anticipated to be installed after completion of operable unit IRM activities.

The recommended approach to aquifer testing is to conduct single well slug tests on all units, and to conduct pumping tests on portions of units that are not expected to be contaminated (i.e., deep portions of the unconfined system, confined aquifer in the Ringold Unit A gravels, and Rattlesnake Ridge interbed confined aquifer). The difficulty associated with handling large volumes of contaminated water generated by pumping tests in contaminated portions of the unconfined aquifer represents a significant constraint. The pilot-scale treatability test for the Uranium-⁹⁹Tc-Nitrate IRM plume may provide an opportunity to conduct aquifer tests while the pump and treat evaluation is being conducted (see Section 4.3). Slug tests, which pose minimal problems for decontamination and generate no wastewater, therefore, are presented as the preferred testing method for contaminated portions of the unconfined system even though they are more limited in accuracy. Slug tests are also a relatively quick and inexpensive method. The comparability of the two testing methods will be evaluated on units where both tests are conducted to develop a correlation curve, if possible. Using both slug and long-term pumping tests, estimates of hydraulic conductivity and transmissivity can be made for each hydrostratigraphic unit.

A key limitation of single well slug tests is that they preferentially stress the aquifer immediately surrounding the well, and tend to be less representative of aquifer materials farther away from the well. Additionally, hydraulic conductivity data from single well pumping tests may reflect "well loss" effects from drawdown within the casing and sandpack, and turbulence effects of down-hole pumps. To provide more representative hydraulic conductivity data needed to improve the characterization of aquifer properties for the conceptual model, the testing program should also include a limited number of slug and pumping tests with observation wells. The proposed approach is to use slug interference tests in the upper, intermediate, and deep unconfined portions of the uppermost aquifer system. The slug interference tests should be supplemented for comparability by pumping tests with observation wells in the deep unconfined portion of the uppermost aquifer.

For the well which is planned to be completed in the Rattlesnake Ridge interbed, short-term pressure buildup tests are proposed for successively deeper packed-off intervals in the Elephant Mountain Basalt and the Rattlesnake Ridge interbed, as the competency of the latter unit allows. These tests would be conducted during or directly following drilling to identify zones of higher permeability, to roughly characterize the hydraulic conductivity of the basalt aquitard and the confined aquifer, and to identify the optimal screen interval for each Rattlesnake Ridge interbed well. The planned Rattlesnake Ridge interbed well is anticipated to be installed following completion of operable unit IRM activities.

The proposed aquifer testing program should be implemented for each of the well clusters recommended in Section 4.2.6 and described in detail in Section 5.0 to provide adequate data for characterizing the variability of testing results.

Aquifer properties data are also needed to fulfill data needs related to completion of the IRM Treatability Study for the Uranium-⁹⁹Tc-Nitrate plume.

The Treatability Study data needs include supplementary hydraulic conductivity and transmissivity data to refine the 200 West Groundwater Aggregate Area hydrogeologic model for the uppermost portion of the unconfined aquifer (Connelly et al. 1992). Accelerated aquifer test field activities, which were begun in 1993, are identified to support the Treatability Study. Due to the high priority of these data needs, a DOW was prepared to describe field activities for aquifer testing. The DOW identifies initial examination of the wells to verify their suitability and aquifer testing consisting of slug tests, and single-well and possibly multiple-well constant discharge tests. Step-drawdown tests would be completed to determine optimal pumping rates for the constant discharge tests.

To date, slug testing and single well pump testing has been performed on Wells 299-W12-1 and 299-W11-10 in support of the DQOs for aquifer tests. In addition, slug testing has been performed on Wells 299-W42-41, 699-W38-70, 699-W35-70, and 699-37-82A. These and additional slug and pumping tests intended for accelerated field activities are located in areas where additional coverage is needed to refine the 200 West Area hydrogeologic model. The wells are also located in relatively uncontaminated portions of the unconfined aquifer. Additional aquifer testing may be performed in conjunction with Uranium-⁹⁹Tc-Nitrate IRM Treatability Study activities, and the aquifer testing DOW will be updated as necessary.

4.2.4 Groundwater Flow

The direction and magnitude of hydraulic gradients is a fundamental part of refining the understanding of groundwater flow for the conceptual model of the 200-UP-1 Groundwater Operable Unit. As indicated on Figure 4-1, specific data needs for refining groundwater flow evaluations include defining horizontal and vertical hydraulic gradients, which also requires valid monitoring well casing elevations. In general, vertical gradients are not well characterized primarily due to the lack of wells with discretely screened intervals in the deep unconfined aquifer (lower Ringold Unit E gravels) and the confined aquifers (Ringold Unit A gravels and the Rattlesnake Ridge interbed). Horizontal hydraulic gradients are not documented for the deep unconfined and confined aquifer systems. Knowledge of these gradients is required to understand future migration pathways and assess aquifer intercommunication. Hydraulic gradients, if present, are also used in conjunction with aquifer properties to determine flow rates. Downward vertical hydraulic gradients could potentially provide a driving force by which contaminated groundwater of the uppermost portion of the unconfined aquifer can be transported to lower levels of the unconfined aquifer. An additional concern is potential for vertical transport of contaminated groundwater into the underlying semi-confined or confined systems if hydraulic connections exist such as fracture systems or erosional windows (neither is documented in the 200 West Area). Groundwater elevation measurements are also important for documenting dropping water levels and changes in configurations of groundwater mounds such as the mound present northeast of the former 216-U-10 Pond.

The DQOs for the water level measurements are summarized in Table 4-5, and target aquifers for this field activity are summarized in Table 4-9. The work plan DQOs are driven from the current gaps in vertical hydraulic gradient data for the unconfined aquifer and between the unconfined and confined system, as discussed above. The data needs associated with these DQOs necessitate that water level measurements are collected from three clustered well installations, with each individual well in a cluster completed in a vertically discrete zone. Three wells represent the minimum number of installations needed to geometrically calculate a horizontal flow direction in each aquifer. Each well in the clustered installations must be hydraulically isolated from its neighbor by installing wells in separate boreholes and carefully placing grout seals to minimize the potential for hydraulic communication between the wells. The discrete vertical zones for each cluster include the shallow, intermediate and deep unconfined aquifer, and confined aquifers in the Ringold Unit A gravels and for one location in the Rattlesnake Ridge interbed. A single Rattlesnake Ridge interbed well is recommended for the 200-UP-1 Groundwater Operable Unit and would be used in conjunction with two Rattlesnake Ridge interbed wells planned for completion in the 200-ZP-1 Groundwater Operable Unit to obtain horizontal flow data. Quarterly measurements of groundwater levels will be collected to provide time variant measurements to account for any short-term fluctuations. The planned Rattlesnake Ridge interbed well is anticipated to be installed after operable unit IRM activities are completed.

Another important DQO associated with groundwater level measurements is confirming that accurate geodetic survey data exists for each well where elevation data are collected. This assessment is planned to be completed together as part of the existing well condition assessment described in Section 4.2.6.4. In general, past Hanford Site geodetic surveys (e.g., approximately pre-1987) are of suspect accuracy for calculating groundwater flow directions and hydraulic gradients needed for this work plan. Because of their age or questionable survey quality, approximately half of groundwater monitoring wells recommended for sampling in the 200-UP-1 Groundwater Operable Unit (Table 5-2) are currently scheduled for resurvey in 1993/1994. Priority should also be given to resurveying the remaining wells in Table 5-2 that exhibit suspect survey data. Priority for resurvey should then be given to other operable unit wells exhibiting suspect survey data where contaminant constituents have been detected. Survey measurement DQOs will use criteria described in EII 12.1 (WHC 1988).

4.2.5 Source Contributions

Evaluation of continuing source contributions of contaminants from the vadose zone to the unconfined aquifer contributes to the conceptual model through allowing better prediction of future contaminant plume maximum concentrations and extent. This evaluation is primarily the subject of source area operable units (e.g., 200-UP-2 Operable Unit), although data collection activities for the groundwater operable unit by necessity pass through areas of vadose zone contamination and, thereby, present the opportunity to further refine this portion of the conceptual model.

As indicated on Figure 4-1, source contribution data needs are divided between perched water or saturated vadose zone conditions, soil contaminant concentrations, and monitoring well seals. Areas of perched water or saturated conditions in the vadose zone, which indicate a potential for downward migration of contaminants to the groundwater, are poorly constrained by current data. Soil concentrations for contaminants in the lower portion of the vadose zone also may indicate a potential for contaminant migration, but are poorly constrained. Finally, all older wells in source areas that potentially have poor annular seals may have provided conduits for vertical contaminant migration and need to be identified.

Several proposed new wells will pass through the vadose zone in source areas. Borehole geological logging will include observation of moisture and the presence of water, with notations made in the record (Table 4-1). This will provide direct observations from the boreholes. The collection of specific data parameters for stratigraphic units is indicated in Table 4-9.

Soil contaminant concentrations will be evaluated by two means: soil collection and analysis (Table 4-1) and geophysical logging (Table 4-2). Soil sample collection will occur in the early "Palouse" soils and Plio-Pleistocene Unit and in the Ringold Unit E directly above the water table for organic compounds, inorganic compounds, and radionuclides. Soil analyses in these locations will help identify past or present migration of contaminants below the caliche layer and to the water table for organic compounds, inorganic compounds, and radionuclides. Two geophysical surveys will be conducted through the vadose zone to assist in evaluating the extent of contamination for particular radionuclides: gross gamma and Radionuclide Logging System (RLS) spectral gamma surveys. The collection of specific data parameters for stratigraphic units is indicated in Table 4-9.

Finally, evaluation of existing well conditions (Table 4-8) will include assessment of evidence for failed annular seals. Identification of wells in source areas with questionable seals may aid in evaluation of present and future contaminant plume extent.

4.2.6 Nature and Extent of Contamination

The conceptual model and QRA will be supported by gaining a better understanding of the nature and the extent of contamination. Information on the nature and extent of contamination will support interim remedial actions on IRM plumes and provide the necessary data for making interim action decisions on LFI plumes.

As indicated on Figure 4-1, there are four specific data needs for addressing the nature and extent of contamination. The maximum contaminant concentrations and the horizontal and vertical contaminant distribution will be addressed by the installation of new monitoring wells and groundwater sampling and analysis. Before this work begins, two other specific data needs need to be addressed: existing data quality review and verification of monitoring well screen intervals.

The new wells, along with existing wells, should be sampled for specific contaminants to assess the extent of contamination or confirm the presence of contamination for individual chemical constituents. Table 4-6 identifies the DQOs for groundwater sampling and analysis. Table 4-11 lists the wells and critical chemical constituents for which they should be analyzed. This sampling and analysis will be directed at addressing specific data needs for individual constituents. In addition to the sampling and analysis discussed in the following sections and summarized in Table 4-11, the wells identified in Table 4-11 will also be analyzed for a general suite of contaminants appropriate to those wells to assist refinement of the conceptual model. These general sampling assignments will be developed in DOWs.

The rationale for the location of the new wells is provided in Section 4.2.6.1. The rationale for which wells will be sampled is provided in Section 4.2.6.3 for IRM plumes, and Section 4.2.6.4 for LFI plumes. Section 4.2.6.5 discusses the existing well quality, and Section 4.2.6.6 discusses the analytical data review.

4.2.6.1 Installation of New Wells. A total of 13 new wells may be installed as part of this operable unit work plan, following the DQOs presented in Table 4-3. Wells are targeted for completion in the upper, mid, and lower saturated portions of the Ringold Unit E, in the Ringold Unit A, and on the Rattlesnake Ridge interbed. New wells for the Rattlesnake Ridge interbed aquifer will be addressed on a 200 West Groundwater Aggregate Area basis and will follow completion of IRM remedial activities at a later date. One such well is identified for the 200-UP-1 Groundwater Operable Unit and two wells for the 200-ZP-1 Groundwater Operable Unit. The new wells are tentatively named 'P1-1 through UP1-13. Standard Hanford Site numbers will be assigned after completion of the wells. The proposed locations of the wells are shown on Figure 4-2 while actual site locations will be finalized in the development of DOWs.

Groundwater data on the horizontal and vertical extent of the contaminant plumes is needed in order to better delineate the extent of the plumes. The horizontal extent data needs will be met by the installation and sampling of several new wells and the sampling of already existing wells. New wells that should be installed specifically for the purpose of defining the horizontal extent of contaminant plumes are Wells UP1-1, -6, -7, -12, and -13. These wells are located in areas where contaminant plumes are poorly delineated because of a lack of wells that are suitable for sampling.

The vertical extent of contaminant plumes will be addressed by the installation and sampling of wells at mid and lower levels in the unconfined portion of the uppermost aquifer, in the confined portion of the uppermost aquifer, and in the confined aquifer. The deeper wells will also provide data on vertical hydraulic gradients and aquifer flow directions. These data also will be useful in modeling contaminant transport.

Wells UP1-2 through -5 will be required in a cluster adjacent to Well 299-W19-24 to gain data on the vertical extent of constituents in the groundwater, particularly the IRM plumes of uranium, ⁹⁹Tc, and nitrate. Well UP1-2, if required, will be screened at the mid-level of the unconfined

portion of the uppermost aquifer between the water table and the base of Ringold Unit E, Well UP1-3 will be screened at the base of Unit E, Well UP1-4 will be screened in the confined portion of the uppermost aquifer in the Ringold Formation Unit A, and Well UP1-5 will be screened in the confined aquifer within the Rattlesnake Ridge interbed. Well UP1-5 will not be installed until after IRM activities are completed.

Well UP1-8 will be installed adjacent to Well 299-W23-14 and will be screened in the confined portion of the uppermost aquifer within Ringold Unit A. In addition to providing data on the vertical distribution of constituents, this well will provide data on the groundwater flow direction in the aquifer within Ringold Unit A and information on the hydraulic gradient between the unconfined and confined portions of the uppermost aquifer.

Wells UP1-9 through -11 will be required in a cluster adjacent to Well 299-W22-20. Well UP1-9, if required, will be screened at the mid-level of the unconfined portion of the uppermost aquifer between the water table and the base of Unit E, Well UP1-10 will be screened at the base of Unit E, and Well UP1-11 will be screened within the confined portion of the uppermost aquifer in the Ringold Formation Unit A.

Limited vertical contaminant profiling was begun in 1993 as an accelerated LFI field activity to support the Treatability Study, but is not yet complete. Depending on the results of the vertical contaminant profiling activity, two of these wells, UP1-1 and UP1-9, may not need to be installed. The vertical profiling activity is performing an assessment of four wells to determine their suitability for sampling discrete vertical intervals within the groundwater. The vertical profiling test involves the isolation of a discrete interval in the well by using straddle packers to isolate the test zone and sampling groundwater removed from the test interval for a tracer. The details of the vertical testing are described in a *Description of Work for the 200-UP-1 Groundwater Contaminant Vertical Profiling Activity* (WHC 1993a). The wells that have been included in this activity are Wells 299-W19-4, 699-W38-70, 299-W22-20, and 299-W19-18. Well UP1-1 may not be installed if Well 299-W19-4 proves to be suitable for sampling the top of the uppermost aquifer. If any of the existing wells are suitable, the same sampling program as that proposed for the corresponding new well should be adopted.

4.2.6.2 IRM Plumes. There are three IRM plumes in the 200-UP-1 Groundwater Operable Unit: uranium, ⁹⁹Tc, and nitrate. Carbon tetrachloride is an IRM plume in the 200-ZP-1 Groundwater Operable Unit, but the portion of the carbon tetrachloride plume that extends into the 200-UP-1 Groundwater Operable Unit will be addressed as an LFI plume, as discussed in Section 4.2.6.3. This section gives a rationale for the field activities that will be carried out during the LFI portion for the three IRM plumes. The uranium and ⁹⁹Tc plumes are centered around the 216-U-1 and 216-U-2 and 216-U-17 Cribs and are defined by existing monitoring wells that monitor these cribs. The nitrate plume, which is much more extensive than the uranium and ⁹⁹Tc plumes, also has its highest concentrations centered around these same cribs. Because of the lack of currently usable wells to the north and the wide spacing of wells to the east of the crib areas, these plumes are not well delineated to the north or

east. The vertical extent of these plumes is also poorly delineated because the monitoring wells do not sample from discrete deeper levels of the uppermost aquifer or from confined aquifers.

The horizontal extent of the IRM plumes can be better delineated by the installation of two or possibly three wells. Two of these wells will be installed downgradient, to the east of the crib areas. Well UP1-6, located approximately 275 m (900 ft) east of the 216-U-17 Crib, will be used to further delineate the uranium plume front and will provide data on the concentration ranges in the nitrate and ⁹⁹Tc plumes. Well UP1-7, located approximately 1,500 m (5,000 ft) further to the east of Well UP1-6, will be used to more accurately delineate the ⁹⁹Tc plume front. This well also will provide data on the nitrate plume and will be useful in tracking the uranium plume front. The northern extent of the plumes can be better delineated by sampling from Well 299-W19-4. However, this well is being evaluated for usability in the *Description of Work for the 200-UP-1 Groundwater Contaminant Vertical Profiling Activity* (WHC 1993b). If this well proves to be unsuitable for sampling or provides inconclusive data, a new well, UP1-1, should be installed approximately 450 m (1,500 ft) northeast of the 216-U-1 and 216-U-2 Cribs.

The vertical extent of the three plumes will be addressed by sampling of discrete intervals within the unconfined portion of the uppermost aquifer, the confined portion of the uppermost aquifer, and the confined aquifers (Ringold Unit A and Rattlesnake Ridge interbed). Sampling of these discrete intervals will be done by installing four wells (UP1-2, UP1-3, UP1-4, and UP1-5). These four wells will be installed adjacent to Well 299-W19-24. Well 299-W19-24 is located downgradient from the 216-U-1 and 216-U-2 Cribs and has the highest average concentrations for ⁹⁹Tc in the 200-UP-1 Groundwater Operable Unit. Well UP1-2 will be screened in the middle of the unconfined aquifer, and Well UP1-3 will be screened at the base of the unconfined aquifer. Well UP1-4 will be screened in the semi-confined Ringold Unit A gravels, and Well UP1-5 will be screened in the Rattlesnake Ridge interbed confined aquifer. Both Wells UP1-4 and UP1-5 will be located next to Well 299-W19-24 so that the difference in head between the three aquifers can be compared at this location. Well UP1-5 is part of a 200 West Groundwater Aggregate Area evaluation of the Rattlesnake Ridge interbed and will not be installed until after IRM activities are completed.

Several additional wells will be sampled both within and without the known plume areas to confirm levels of contamination of one or more IRM contaminants and to assess trends in the concentrations. The wells to be sampled are Wells 699-36-61, 699-38-70, 699-32-62, 699-40-63, 299-W19-18, 299-W19-19, 299-W19-2, 299-W19-24, and 299-W21-1. Wells 699-36-61, 699-32-62, and 699-40-63 will be sampled to monitor for increasing nitrate concentrations as the nitrate plume moves towards the 200 East Area. Wells 699-38-70, 299-W19-18, 299-W19-19, and 299-W19-24 will be sampled to monitor concentrations within the plumes. Wells 299-W19-2 and 299-W21-1 will be sampled to monitor the southern edge of the plumes.

4.2.6.3 LFI Plumes. Twenty-six other constituents will undergo LFI activities as part of this work plan. The constituents to be investigated are 1,2-dichloroethane, 1,1-dichloroethylene, aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, heptachlor, bis(2-ethylhexyl)phthalate, n-nitrosodimethylamine, ^{40}K , ^{90}Sr , ^{129}I , ^{99}Tc , ^{238}Pu , uranium, arsenic, cadmium, chromium, fluoride, selenium, carbon tetrachloride, chloroform, and trichlorethylene. The investigation of these constituents will involve sampling existing wells and installing new monitoring wells. The new monitoring wells will be located in areas where there is a lack of well coverage and where existing well data suggest that contamination may be present.

Background levels for several constituents such as arsenic, nitrate, chromium, cadmium, fluoride, selenium, and ^{40}K need to be determined to gage the significance of the detected levels of these constituents. A program is currently underway to determine the site background levels (Hoover and LeGore 1991; DOE/RL 1992h). If this program is not completed, and no other suitable project specific background data is available, the 200-UP-1 Groundwater Operable Unit LFI should include a background investigation. This background investigation may also be designed to support the 200-ZP-1 Operable Unit LFI.

Detection of twelve of the LFI constituents occurred in only single wells. These constituents are DCA, DCE, the eight pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, and heptachlor), bis(2-ethylhexyl)phthalate, and n-nitrosodimethylamine. This fact leads to the concern that the detections are spurious, laboratory artifacts. The wells where these constituents were previously detected should be resampled and reanalyzed to confirm (or indicate against) the presence of the constituent. If these detections are confirmed, wells near the confirmed detection will be sampled for these constituents.

Well 299-W22-20 will be sampled for DCA and DCE. If the previous single detection of DCA or DCE in Well 299-W22-20 is confirmed, Wells 299-W22-19, 299-W27-1, and UP1-12 will be sampled for DCA and DCE. Well 299-W19-18 will be sampled for pesticides (aldrin, DDD, DDT, dieldrin, endrin, endrin aldehyde, gamma-BHC, and heptachlor). If the previous single detection of pesticides in Well 299-W19-18 is confirmed, Wells 299-W19-3, 299-W19-9, and 299-W19-11 will be sampled for pesticides. Well 299-W14-10 will be sampled for DDT and bis(2-ethylhexyl)phthalate. Well 299-W23-10 will be sampled for n-nitrosodimethylamine. If the previous single detection of n-nitrosodimethylamine in Well 299-W23-10 is confirmed, Wells 299-W23-9 and 299-W23-11 will be sampled for n-nitrosodimethylamine.

Strontium-90 has an average detection above its MCL of 8 pCi/L in only one well in the 200-UP-1 Groundwater Operable Unit. This well, 299-W22-10, will be sampled for confirmation purposes and to see if there has been any notable trend in the concentrations in the well. Wells 299-W22-1 and 299-W22-2 will also be sampled for ^{90}Sr . Both of these wells have had ^{90}Sr detections. All three wells monitor the groundwater in the vicinity of the 216-S-1 and 216-S-2 Cribs. Wells 299-W22-1 and 299-W22-2 are located at the cribs, and Well 299-W22-10 is located downgradient from the cribs. Well

299-W22-21 is further downgradient and will be sampled to see if ^{90}Sr has reached that well. Wells 299-W19-2, 299-W19-18, and 299-W19-24 have had detections for ^{90}Sr , and samples from these wells will be analyzed for ^{90}Sr to see if any significant trends can be determined in concentrations detected from these wells. Wells 299-W38-70 and 299-W21-1 are downgradient from these wells and will be sampled for ^{90}Sr to see if detectable levels of ^{90}Sr are migrating from the area of detections.

Plutonium-238 has had only one unconfirmed detection above its MCL equivalent. The well with the detection, 299-W22-21, will be sampled for confirmation. In addition, Well 299-W22-10, which is upgradient from Well 299-W22-21 and has had detections for ^{90}Sr , will be sampled for ^{238}Pu . Two wells that are downgradient from Well 299-W22-21 will be sampled as well. The two downgradient wells that will be sampled are 299-W27-1 and UP1-13. Well UP1-13 will be installed approximately 300 m (1,000 ft) south of Well 299-W22-21 and will be screened across the top of the uppermost aquifer. This well will be installed at this location because of the lack of groundwater monitoring wells in this area.

Potassium-40 has had one unconfirmed detection above its MCL equivalent (DOE Order 5400.5, 4% ingested water derived concentration guide [DCG]) of 280 pCi/L. The well, 299-W19-32, with the detection will be sampled to confirm (or indicate against) the high concentration previously reported. Other nearby wells, 299-W19-12, 299-W19-27, and 299-W19-21, will be sampled for ^{40}K as well.

Arsenic has been detected with an average concentration above 10 parts per billion (ppb) in Wells 299-W19-21, 299-W18-15, 299-W19-27, and 299-W23-11. These wells will be sampled for arsenic to confirm these elevated levels.

Chromium has been detected above its MCL in two wells in the 200-UP-1 Groundwater Operable Unit, but has also been detected at levels just below its MCL in other wells. Wells 299-W22-20 and 299-W26-7 will be sampled to confirm the chromium concentrations above the MCL detected previously. Wells that previously detected chromium above 50% of the MCL will be sampled for confirmation. These wells are 299-W19-12, 299-W22-21, 299-W19-32, and 299-W26-9. In addition to these wells, wells in the vicinity of these high detections will be sampled to delineate and confirm the extent of the chromium concentrations. These wells are 299-W26-6, 299-W26-1, 299-W22-19, 299-W27-1, 299-W19-31, 299-W19-27, and 299-W22-9. Several new wells will be installed in the vicinity of the S Plant Source Aggregate Area to delineate the extent of chromium and other LFI constituents that have been detected in the S Plant Source Aggregate Area. Wells UP1-9 and UP1-10 will be installed adjacent to Well 299-W22-20. Well UP1-9 will be screened in the middle of the unconfined portion of the uppermost aquifer, and Well UP1-10 will be screened at the base of the unconfined portion of the uppermost aquifer. These wells will be sampled for chromium to determine the vertical extent of chromium concentrations in the unconfined portion of the uppermost aquifer at this location. The confined portion of the uppermost aquifer in Ringold Unit A will be sampled at this location by installing Well UP1-11.

The delineation of the horizontal extent of the chromium plume and other LFI plumes in the S Plant Source Aggregate Area will be greatly improved by the installation of two new wells that will be screened across the water table. Well UP1-12 will be installed approximately 365 m (1,200 ft) east of Well 299-W22-20, and Well UP1-13 will be installed approximately 610 m (2,000 ft) southwest of Well 299-W22-20.

Iodine-129 will be sampled from several wells because the 1 pCi/L contour for the ^{129}I plume is not well defined along its southwest and northern edges. This bounding contour will be improved by sampling from Wells 299-W22-21, 299-W26-8, UP1-13, UP1-12, and 299-W19-4. If Well 299-W19-4 is not suitable for sampling, Well UP1-1 will be installed and sampled. Wells 699-40-62, 699-32-62, and 699-36-61 will be sampled to determine if ^{129}I levels are increasing as the plume moves towards the 200 East Area.

Gross alpha and gross beta are indicators of the presence of radionuclides. The highest concentrations of both these indicator parameters corresponds with the uranium and ^{99}Tc plumes. Wells 299-W19-18 and 299-W19-25, which are within the IRM uranium and ^{99}Tc plumes, will be sampled for both gross alpha and gross beta to see if any significant changes in the concentrations of these parameters has occurred. Well 299-W19-4 will be sampled to delineate the northern extent of the plumes. If Well 299-W19-4 is not suitable for sampling, UP1-1 will be installed to delineate the northern extent of these and other plumes. The vertical extent of the gross alpha and gross beta plumes associated with the IRM plumes will be investigated by sampling Wells 299-W19-24, UP1-2, UP1-3, UP1-4, and UP1-5.

The horizontal extent of the gross beta plume in the S Plant Source Aggregate Area will be investigated by sampling from Wells UP1-13, 299-W22-7, and 299-W22-19. Wells 299-W22-21, 299-W23-2, and 299-W23-7 within the plume will be sampled to monitor for any significant changes in concentrations. Well 299-W23-4 is outside the S Plant Source Aggregate Area gross beta plume, but has had an average reported well concentration just below the drinking water standard of 50 pCi/L. This well will also be sampled. The vertical extent of the gross beta plume will be investigated by sampling from Wells UP1-8, -9, -10, and -11.

Gross alpha concentrations have exceeded the drinking water standard in the vicinity of the 216-U-10 Pond and in Well 299-W22-21 in the S Plant Source Aggregate Area. Wells 299-W18-15, 299-W23-4, and 299-W22-21 will be sampled to monitor for any significant changes in gross alpha concentrations. Well UP1-13 will be sampled to see if elevated gross alpha concentrations extend into that area of the S Plant Source Aggregate Area.

Outside of the ^{90}Sr IRM plume, ^{99}Tc average concentrations exceed the MCL in three wells: 299-W23-2, 299-W23-7, and 299-W19-12. Wells 299-W23-2 and 299-W23-7 monitor the S Plant Source Aggregate Area tanks. These two wells will be sampled for ^{99}Tc along with Wells 299-W23-3 and 299-W23-5, which are a short distance downgradient, and Wells 299-W22-21 and UP1-13, which are further downgradient. Well 299-W19-12 monitors the U Plant Source Aggregate Area Tank Farm. This well and Wells 299-W19-31, 299-W19-32, and 299-W19-27

will be sampled to see if any significant trends in ^{99}Tc concentrations have occurred in these wells.

Outside of the uranium IRM plume, uranium has been detected with an average concentration above its MCL in one well and very near its MCL in another well. These two wells, 299-W18-15 and 299-W23-4, will be sampled to monitor for any significant changes in uranium concentrations.

Carbon tetrachloride is an ERA plume in the 200-ZP-1 Groundwater Operable Unit. The maximum carbon tetrachloride concentration in the 200-UP-1 Groundwater Operable Unit is 162 ppb in Well 299-W19-16 next to the 216-U-1 and 216-U-2 Cribs. This well will be sampled to determine if carbon tetrachloride concentrations are increasing. Well 299-W19-4 will be sampled to determine if the concentrations observed in the wells around the 216-U-1 and 216-U-2 Cribs extend to the north. If Well 299-W19-4 is not suitable for sampling, Well UP1-1 will be installed and sampled. Well 699-38-70, which is downgradient from the 216-U-1 and 216-U-2 Cribs, will be sampled to determine if carbon tetrachloride levels are increasing as the plume moves out of the 200 West Area. The plume is poorly delineated to the south due to a lack of wells in some areas and a lack of sampling. The delineation of the plume to the south will be improved by samplings from Wells 699-35-78, 299-W26-8, 299-W22-19, 299-W22-20, and UP1-13. Because carbon tetrachloride is a DNAPL, deep wells will be sampled. The deep wells to be sampled for carbon tetrachloride are UP1-2 and UP1-3, UP1-4, UP1-5, UP1-8, UP-10, and UP1-11.

Trichloroethylene is an IRM plume in the 200-ZP-1 Groundwater Operable Unit. Trichloroethylene has been detected above the detection limit (and MCL) of 5 ppb in two wells (299-W19-29 and 299-W22-20) in the 200-UP-1 Groundwater Operable Unit. Well 299-W22-20 has the highest trichloroethylene concentrations of any well in the 200 West Area. This well will be sampled to determine if the concentration has undergone any significant change. Wells 299-W22-9, 299-W22-19, UP1-12, UP1-13, and 299-W22-21 will be sampled to gather data on the extent of trichloroethylene in the area around Well 299-W22-20. Because trichloroethylene is a DNAPL, sampling from deep wells will be performed near Well 299-W22-20. Deep wells that will be sampled are UP1-10, and UP1-11.

Well 299-W19-29 will be sampled for trichloroethylene to determine if the concentration in this well has undergone any significant changes. Well 299-W19-4 will also be sampled for trichloroethylene to determine the concentration in that area of the operable unit. If Well 299-W19-4 is not suitable for sampling, Well UP1-1 will be installed and sampled.

Chloroform is an IRM plume in the 200-ZP-1 Groundwater Operable Unit. The southeast end of this IRM plume extends into the 200-UP-1 Groundwater Operable Unit and has been recommended for a LFI in the *200 West Groundwater AAMSR*. Two wells, 299-W19-28 and 299-W18-20, will be sampled to see if any significant changes in chloroform have occurred. Well 299-W19-4 will be sampled to further define the extent of the plume to the north of the 216-U-1 and 216-U-2 Cribs. If Well 299-W19-4 is not suitable for sampling, Well UP1-1 will be installed and sampled. Because chloroform is a DNAPL, sampling from

deep wells will be performed near Well 299-W22-20. Deep wells that will be sampled are UP1-10 and UP1-11.

In addition to the previously described sampling and analysis, which is directed at addressing specific data needs, samples that are taken at the wells identified will also be analyzed for a general suite of contaminants appropriate to those wells to assist refinement of the conceptual model. These general sampling assignments are recommended in Section 5.1 will be developed in DOWs.

4.2.6.4 Existing Well Quality. Resource protection wells in the 200-UP-1 Groundwater Operable Unit vary considerably in construction, age, and accuracy of geodetic survey information. Compatibility of historical well construction materials with the intended chemical and radionuclide analyte sampling program will also need to be evaluated. The DQOs for assessing the quality of the existing well survey and condition are summarized in Table 4-8. Specific parameters associated with the current well condition assessment will rely primarily on fitness-for-use criteria described in EII 6.6, "Resource Protection Well Characterization and Evaluation" (WHC 1988). Survey information accuracy is also discussed as a data need for groundwater flow evaluation (Section 4.2.4).

Well condition and survey data will need to be addressed on a well-by-well basis to determine the suitability of existing monitoring wells for data collection purposes. In general, wells not compliant with RCRA or the Washington Administrative Code (WAC) compliant wells (commonly pre-1987) wells are considered suspect; however, many of these earlier wells may be adequate for sampling certain analytes depending on screen interval, construction materials, location, etc. Wells with deficient survey data or construction materials will be recommended for remediation prior to their use for groundwater level elevation data collection or groundwater sampling. Well quality evaluation (and resurvey/remediation as necessary) should be completed in a prioritized manner to initially focus on existing operable unit wells that are recommended for groundwater sampling (Section 5.1.3), followed by wells with detected LFI constituents, followed by the remaining 200- and 600-series wells.

4.2.6.5 Analytical Data Review. Historic groundwater concentrations data vary in quality from questionable to adequate. Different analytical methods and detection limits plus poor quality control compromise the results. Sampling methods, such as the use of a bailer instead of a pump, can affect the quality of the samples obtained. Errors also appear to be present in the recording of data in the data set.

The historical analytical data should be reviewed carefully as part of the sampling process. As noted in the *200 West Groundwater AAMSR* (DOE/RL 1992b), these historical data have not been validated. Review of historical data has already been started in the selection of wells to be sampled. This review will help fill data gaps in the nature and extent of contamination and help evaluate data acquired on groundwater geochemistry. As stated in Table 4-7, the critical data to review are analyses that yielded single detections, results with a single detection that is much greater than previous or

subsequent sampling results, and results from wells with carbon steel casing. Situations where the data appear to be inaccurate should be checked and wells resampled if necessary.

4.2.7 Groundwater Chemistry

Groundwater chemistry contributes to the conceptual model by providing the context in which contaminant characteristics can be determined or inferred with respect to their mobility and fate. Contaminant fate and transport considerations support the evaluation of feasibility and effectiveness of design alternatives for interim remedial actions of IRM plumes. In addition, these considerations will assist the evaluation of migration (long-term) risks for the baseline RA to be conducted at a later date.

As indicated on Figure 4-1, groundwater chemistry data needs are divided between groundwater chemical conditions and aquifer chemical conditions, with a minor consideration required for well construction materials due to their potential impact on data collection. Quantification of groundwater chemical parameters are necessary to establish the primary conditions in which to evaluate the nature of contaminants. Identification of aquifer matrix chemical properties or composition are required to assist in evaluating processes such as contaminant sorption and potential effects of various remedial options. Review of well materials for possible interaction with water within casings is needed to assess the potential impact to measured values of existing analytical data. Specific needs to fill these gaps are identified below, with the proposed field program to address these needs presented in Section 5.1.3.

Gathering of new groundwater chemical data will assist in determining the chemical form of many of the contaminants, sorption potential, and mobility. Data that are required to assess these conditions include common ions, pH, Eh, temperature, total dissolved solids, total suspended solids, total organic carbon, alkalinity, specific conductance, and trace organic compounds. Groundwater sampling should include measurement of pH and Eh to determine the redox potential and temperature to allow estimation of reaction rates. Common ions, alkalinity, and total dissolved solids should be analyzed to help define the general water chemistry, with total suspended solids providing an indication of particulates included through turbulent sampling methods. Trace organic compounds should be analyzed (both volatile organics and semivolatile organics) to assess the potential for chemical complexing by contaminants. These parameters should be collected for wells screened in the unconfined portion of the uppermost aquifer (Ringold Unit E), confined portion of the uppermost aquifer (Ringold Unit A), and confined aquifer (Rattlesnake Ridge), as indicated in Tables 4-6 and 4-11. Sample collection in the unconfined portion of the uppermost aquifer should be conducted for the different screen depths in nested well clusters to assess vertical variability. Sampling for these parameters should be conducted in 20 percent of wells sampled near the water table (approximately 12) and in all deeper wells to provide a representative data set. The selection of 20% at shallow wells for this analysis is based on the expectation that geochemical parameters are relatively uniform across the operable unit and that analysis for all wells is

unnecessary, but the number of wells will be increased if high variability is observed in the first sampling round.

Aquifer media (matrix) samples should be collected in the borehole soil sample collection effort for recommended well installations. Soil analyses will provide data to assess sorption potential and possible reactions occurring for various remedial technologies. Cation exchange capacity and total organic carbon will allow evaluation for sorption of inorganic and organic compounds. Grain and cement mineralogy will provide further ability to assess sorption and also allow consideration of reactions that may occur through use of certain remedial technologies. Matrix samples from well screen intervals analyzed for organic compounds, inorganic compounds, and radionuclides should be compared to results of groundwater analyses to provide estimates of soil partitioning ratios. This analysis should be done for soil samples collected during drilling for new wells (Table 4-1). Samples should be collected from all aquifers, as indicated in Table 4-9. Samples collected from just above the water table (see Section 4.2.5) may also provide information on soil/water partitioning where sample collection occurs in an area of rapidly declining water levels (resulting from cessation of discharges to the 216-U-10 Pond).

Well casing materials potentially can affect analyses through changing water conditions within the wells. The most likely alterations to groundwater are contributions of trace metals to water within the casing and adsorption of radionuclides from the groundwater to the casing. Well casings used at the site with the greatest potential to alter water conditions are carbon steel casings. Such conditions should be evaluated in the analytical data review (Table 4-7) and in the existing well survey and condition assessment that is outlined in Table 4-8.

4.3 INTERIM REMEDIAL MEASURE DATA NEEDS AND ACTIVITIES

The *200 West Groundwater AAMSR* identified the combined plumes of uranium, ^{99}Tc , and nitrate that are present beneath the U Plant Source Aggregate Area as a candidate multi-contaminant IRM. The IRM designation indicates that sufficient data exist to formulate a conceptual model and that an unacceptable potential risk exists such that an interim action is warranted. As discussed in Section 9.0 of the *200 West Groundwater AAMSR*, IRMs should not be designed to specifically meet ARARs (e.g., drinking water standards such as MCLs) but should be based on risk reduction. Groundwater remediation should proceed until the response objective is met (e.g., reduction in risk or contaminant) or until a point of diminishing return is reached or natural attenuation exceeds active treatment. After one of these conditions is reached, the IRM should be discontinued and any residual contamination be addressed in the FRS path.

An IRM is recommended for the center of the Uranium- ^{99}Tc -Nitrate multi-contaminant plume where the highest contamination levels exist in the uppermost portion of the unconfined aquifer. Although the contaminants of concern and an area of concern within the uppermost portion of the unconfined

aquifer have been identified for this IRM, it is recognized that the plume geometry, aquifer properties, and vertical extent of contamination require additional definition to fully define the scope of the IRM. The plume and its associated risks, however, were sufficiently understood based on existing data to be selected as an IRM in the *200 West Groundwater AAMSR* such that the Treatability Study process could be initiated. In this manner, implementation of the IRM can be accelerated by conducting the evaluation of the selected interim remedy specific to the IRM in parallel with LFI activities.

There are a number of data needs that must be satisfied before fully implementing the IRM. One need is the development of remediation goals to define the objectives of the IRM. Another need is to acquire performance data on the preferred remedial technology to support implementation of this technology. IRM activities addressing these data needs should include treatability tests and a QRA using existing groundwater data. The QRA (of existing data) can be used to make remedial action decisions and develop remedial action objectives. The Treatability Study will be conducted to acquire cost and performance data for the IRM contaminants.

Field data acquired through the LFI activities defined in this work plan will refine the conceptual model and the scope of the IRM. These elements may then be integrated into the IRM as needed based on a QRA and Feasibility Study using the newly acquired data.

The IRM remediation goals and objectives will be identified in the IRM Proposed Plan. An initial remediation goal is proposed as 10 times the value of either MCLs or 4% DCGs. In addition, goals must be established that consider the effectiveness of continued operation if conditions stabilize or contaminant recovery and reduction becomes greatly reduced. The observational approach will be used whereby the effort is defined based upon knowledge gained as work progresses. The IROD will include decision points and criteria for continuation, expansion, or cessation of the IRM.

4.3.1 Treatability Studies

Section 7.0 of the *200 West Groundwater AAMSR* provided an initial Feasibility Study that screened technologies for groundwater remediation in the 200 West Area and developed preliminary remedial action alternatives. Of these alternatives, pump and treat is considered to be particularly promising considering the risk reduction goal of the IRM. The pump and treat alternative meets the IRM goals through limited extraction of groundwater, treatment of high priority contaminants, and reintroduction of treated water into the aquifer.

Under the pump and treat alternative, groundwater is extracted from a contaminant plume and treated for target contaminants, which represent the highest risk. Following treatment the groundwater is reintroduced to the same groundwater regime. The extraction and reintroduction system could also be designed to enhance the IRM by hydraulically controlling the movement of the plume. The evaluation of other alternatives in the *200 West Groundwater AAMSR*--including no action, institutional controls, physical or hydraulic

containment/controls, and treatment at the point of use or discharge-- concluded that they do not meet the goal of an IRM and/or are considered to be less effective. For example, the sole use of groundwater barriers is considered to be less effective because there may be little, if any, risk reduction or mitigation of environmental impacts. Furthermore, previous groundwater remediation activities in the vicinity of U Plant have demonstrated that pump and treat can effectively remove high uranium concentrations, which is one of the primary contaminants of concern.

An agreement in principal between the DOE, EPA, and Ecology defined the need to conduct a pilot-scale treatability test using pump and treat technology that focuses on uranium and ⁹⁹Tc as the primary contaminants of concern, and laboratory and bench scale tests for nitrate. Following successful laboratory/bench scale tests for nitrate this IRM contaminant will be included in the pilot scale testing prior to initiation of the full scale IRM. This is consistent with the *200 West Groundwater AAMSR* that recommended actions for treatability testing. Because pump and treat is considered to be a viable and proven technology, expediting the feasibility/treatability process to a pilot-scale test is considered appropriate. The pilot-scale test will be designed to achieve two primary objectives: 1) determination that pump and treat technology will provide adequate interim remediation, and 2) acquisition of sufficient data to allow detailed remedial design. Information gathered from the Treatability Study will allow for the conduct of informed decisions regarding the treatment system, for identification of potential implementation difficulties, and for assessment of resource and schedule needs required to achieve IRM remediation goals.

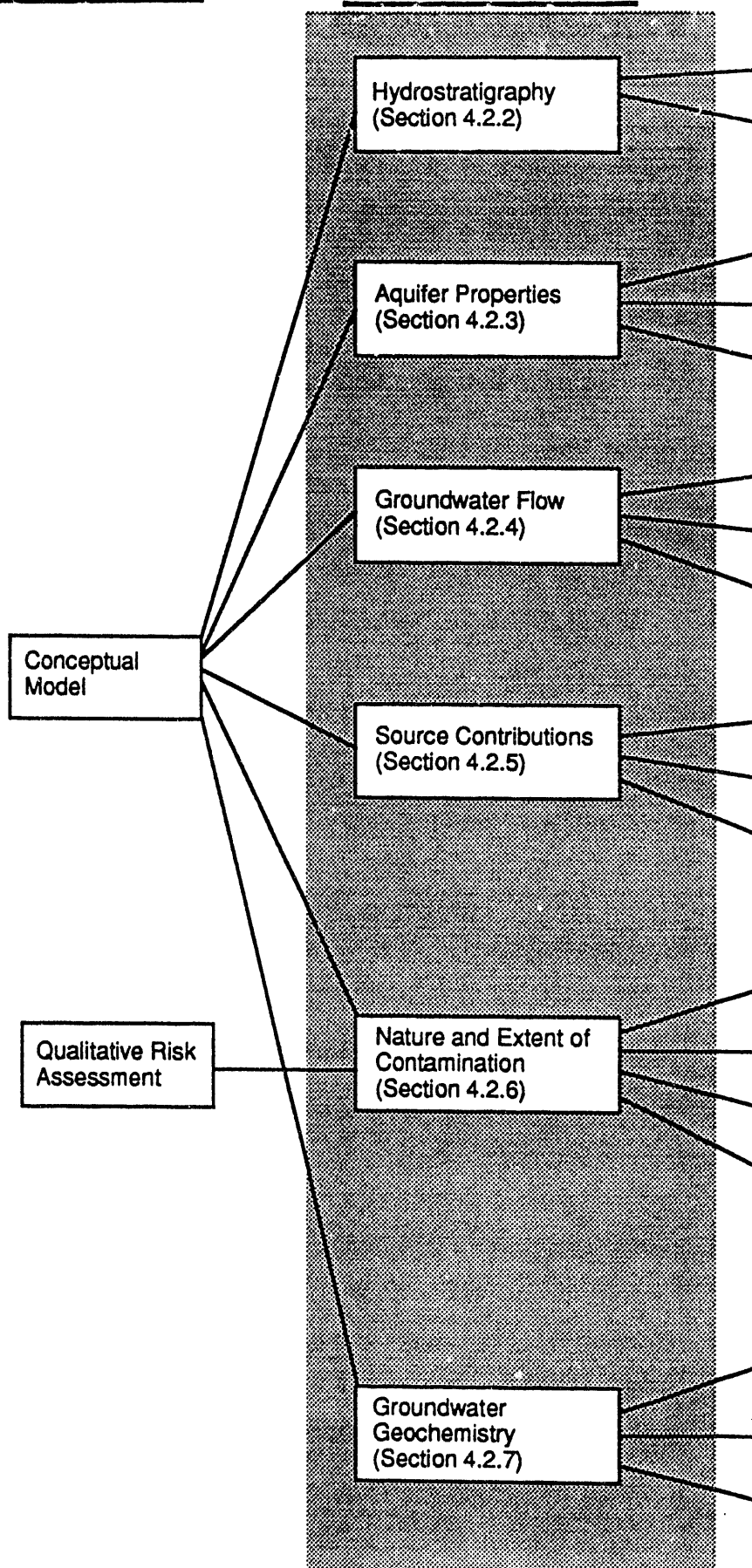
Presuming successful results from the Treatability Study, no additional Feasibility Studies supporting the Uranium-⁹⁹Tc-Nitrate IRM have been identified. Feasibility/Treatability Study needs for other LFI contaminants/plumes will be addressed in the LFI report.

4.3.2 Interim Remedial Measure Proposed Plan

A preferred alternative for remediation of the Uranium-⁹⁹Tc-Nitrate IRM plume will be recommended in the IRM Proposed Plan as supported by the pilot-scale treatability test and QRA. LFI data acquisition through field investigations will run concurrently with these studies. The data and recommendations obtained from these activities should also be summarized and integrated in the IRM Proposed Plan, if applicable, as one purpose of this plan will be to compile the acquired data to demonstrate fulfillment of the identified data needs. This will support the recommendation of a preferred alternative on which the IROD will be based. Preparation of the remedial design and implementation of the IRM will follow determination of the IROD. Additional IRMs also may be identified based on results of the LFIs and the QRA for the non-IRM contaminants, which could lead to additional Feasibility/Treatability Studies.

DATA USES

GENERAL DATA NEEDS



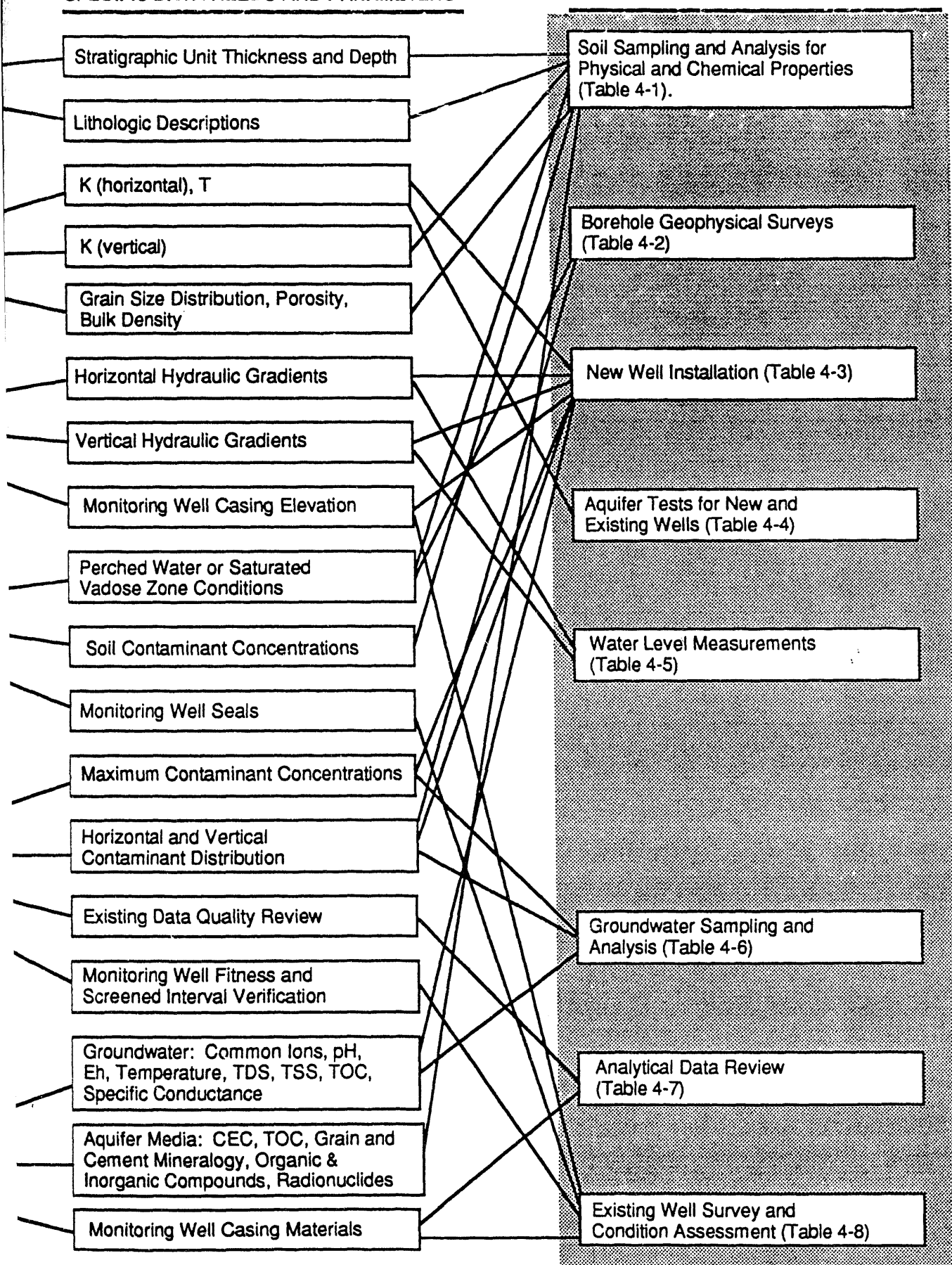
SPECIFIC DATA NEEDS AND PARAMETERS**FIELD AND OTHER PLANNED ACTIVITIES**

Figure 4-1. Relationships Between Data Uses, Data Needs, and Field Activities for the LFI.

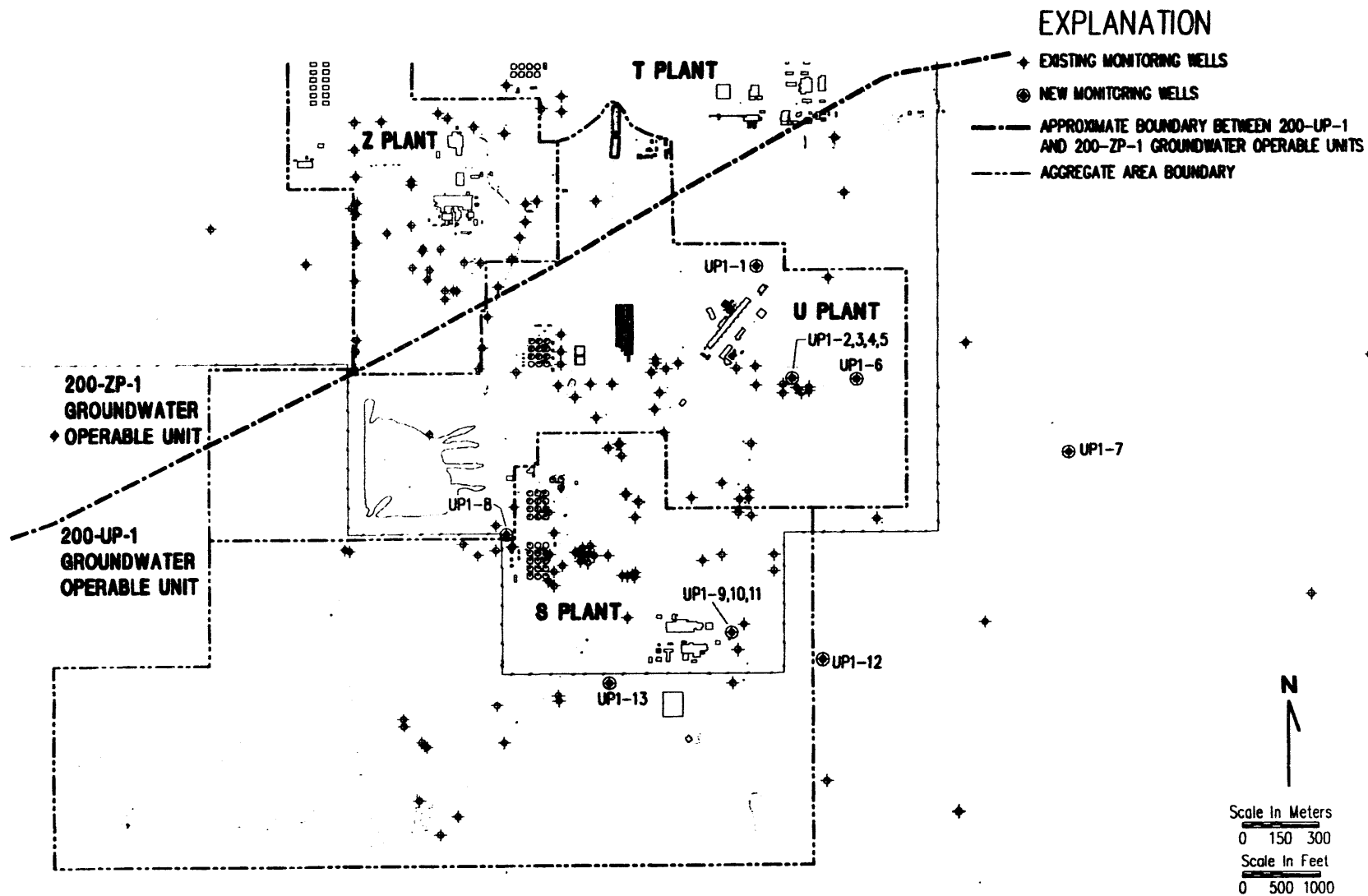


Figure 4-2. Proposed Location of New Monitoring Wells.

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Table 4-1. Data Quality Objectives for Soil Sampling and Analysis for Physical and Chemical Sampling.

Activity	Collect soil samples during well drilling and analyze samples for physical and chemical properties.
Objectives	Soil sampling and analysis will address data needs of hydrostratigraphy and aquifer properties through physical property analyses and data needs of groundwater geochemistry and source contributions through chemical analyses.
Prioritized Data Use(s)	The priority data uses are to support characterization of geology and hydrostratigraphy, aquifer properties and groundwater flow, and contaminant characteristics and transport for refining the conceptual model.
Appropriate Analytical Level or Implementation Guidelines	Samples will be collected according to procedures outlined in EII 5.2 (WHC 1988) and DOWs.
Parameters to be Obtained	Bulk density, particle size distribution, moisture content, pH/Eh, CaCO ₃ content, cation exchange capacity, organic carbon content, porosity, vertical hydraulic conductivity, grain and cement mineralogy, volatile organics, semivolatile organics, radionuclides.
Required Detection or Measurement Limits	Analytical detection limits and DQO requirements are identified in the QAPjP (Appendix A).
Critical Samples or Values	• One sample from each unit encountered in the saturated zone at a given well site. • One sample from the depth at which the well will be screened.
Constraints	• Single samples can be assessed statistically only with comparison to data from previous investigations or other boreholes, or where field duplicates are collected. • Samples for the Elephant Mountain Basalt and Rattlesnake Ridge interbed will be collected during drilling of wells that are anticipated to be installed in the Rattlesnake Ridge interbed following completion of operable unit IRM activities.

Table 4-2. Data Quality Objectives for Borehole Geophysical Surveys.

Activity	Perform RLS spectral gamma and gross gamma logging, on all new well locations (only the deepest wells where wells are clustered) and RLS spectral gamma and gross gamma logging on selected existing wells.
Objectives	Geophysical logging of wells will help define source contributions and nature and extent of contamination.
Prioritized Data Use(s)	The priority data uses are to support characterization of plume extent and hydrostratigraphy in support of refining the conceptual model.
Appropriate Analytical Level or Implementation Guidelines	Boreholes will be logged according to EII 11.1 (WHC 1988) and DOWs.
Parameters to be Obtained	Depth of logging, logging speed, base calibration date, and date and time of logging.
Required Detection or Measurement Limits	Surveys will follow standard operating procedures, as identified in EII 11.1.
Critical Samples or Values	• All new wells installed should be logged with RLS spectral gamma and gross gamma. • Existing wells that have shown migration of gross gamma peaks. • Existing wells that indicate that groundwater has been contaminated.
Constraints	• Existing well construction may affect results. • Borehole logging for the Elephant Mountain Basalt and Rattlesnake Ridge interbed will be conducted during drilling of wells that are anticipated to be installed in the Rattlesnake Ridge interbed following completion of operable unit IRM activities.

Table 4-3. Data Quality Objectives for New Well Installation.

Activity	Install new monitoring wells in boreholes to screen target aquifers at desired depth.
Objectives	New monitoring wells will help define aquifer properties, groundwater flow, nature and extent of contamination, and groundwater geochemistry.
Prioritized Data Use(s)	The priority data uses are to support refining the operable unit conceptual model and performing a QRA.
Appropriate Analytical Level or Implementation Guidelines	Wells will be installed according to procedures outlined in EII 6.8 and WAC Chapter 175-160 and following DOWs.
Parameters to be Obtained	Not applicable.
Required Detection or Measurement Limits	Not applicable.
Critical Samples or Values	• Wells must be completed in each aquifer of concern to allow sample collection for analysis and to allow aquifer testing. • Three wells must be installed in each aquifer to allow triangulation for hydraulic gradient calculation. • Wells completed in each aquifer must be clustered to determine vertical hydraulic gradients. • Wells need to show maximum contaminant values and the extent of contaminant plumes, both horizontally and vertically.
Constraints	• Improper well seals may provide a flow conduit along well annulus, thereby allowing vertical flow and possible contaminant transport. • Well design should consider contingencies for multiple use (i.e., pump and treat systems, DNAPL recovery, etc.) • Wells to be installed in the Rattlesnake Ridge interbed are anticipated to be drilled following completion of operable unit IRM activities.

Table 4-4. Data Quality Objectives for Aquifer Tests for New and Existing Wells. Page 1 of 2.

Activity	Complete aquifer properties testing in the unconfined and confined aquifers utilizing pumping and slug tests.
Objectives	Aquifer testing results address general data needs for identifying aquifer properties necessary to evaluate groundwater flow and contaminant mobility.
Prioritized Data Use(s)	The priority data uses are to support groundwater flow characterization and contaminant transport evaluation needed to refine the operable unit conceptual model and support project treatability test operations.
Appropriate Analytical Level or Implementation Guidelines	Aquifer tests will be completed according to procedures outlined in EII 10.1 (WHC 1988) and follow-on DOWs.
Parameters to be Obtained	Hydraulic conductivity, transmissivity, and vertical conductivity ratio for existing and recommended wells screened in the stratigraphic units listed on Table 4-9.
Required Detection or Measurement Limits	Hydraulic parameter estimates are constrained by the limitations of available testing methodologies to approximate order-of-magnitude values.
Critical Samples or Values	Proposed testing wells for the unconfined and confined aquifers, and corresponding observation wells are detailed in Table 5-3. Proposed wells include installations for the Ringold Unit E deep unconfined portion of the uppermost aquifer, Ringold Unit A confined aquifer, and the Rattlesnake Ridge interbed confined aquifer (Tables 4-5 and 4-6 DQOs for Water Level Measurements and Groundwater Sampling and Analysis, respectively.) Single well slug and pumping tests should be supplemented by limited numbers of slug interference and pumping tests with observation wells to characterize test results variability.

4T-4a

DOE/RL-92-76, Rev. 0

Table 4-4. Data Quality Objectives for Aquifer Tests for New and Existing Wells. Page 2 of 2.

Constraints

- Emphasize slug tests in contaminated areas (e.g., shallow unconfined aquifer: Uranium-⁹⁹Tc-Nitrate IRM plume).
- Use clustered installations for testing and observation wells to obtain vertical hydraulic conductivity data and monitor aquifer intercommunication.
- For observation wells in the uppermost portion of the unconfined aquifer, use temporary screens with wells being drilled to deeper final completions.
- The recommended well for aquifer tests in the Rattlesnake Ridge interbed is anticipated to be installed following completion of operable unit IRM activities.

Table 4-5. Data Quality Objectives for Water Level Measurements.

Activity	Obtain water level measurements from existing and new wells.
Objectives	Water level measurements are needed to calculate horizontal and vertical hydraulic gradients required to evaluate groundwater flow.
Prioritized Data Use(s)	The priority data uses are to support groundwater flow evaluations for refining the operable unit conceptual model.
Appropriate Analytical Level or Implementation Guidelines	Water level measurements and related tape calibration will be completed according to procedures outlined in EII 10.2 (WHC 1988).
Parameters to be Obtained	Depth to water measurements for existing and recommended new wells.
Required Detection or Measurement Limits	Reference point (top of well casing); measurement point (top of well head, well seal, pump plate, etc.); and depth to water should be measured to nearest 0.01 foot (EII 10.2 [WHC 1988]).
Critical Samples or Values	Wells should include all existing wells for the Ringold Unit E shallow unconfined aquifer and deeper installations recommended for the Ringold Unit E deep unconfined aquifer, Ringold Unit A confined aquifer, and the Rattlesnake Ridge confined aquifer. Periodic water level measurements should also be obtained as borings for the recommended wells are drilled.
Constraints	• Wells in the Ringold Unit E unconfined aquifer with screened intervals exceeding 20 m (66 ft) should be excluded. • Accurate surveys of measurement points are required. • The planned Rattlesnake Ridge interbed well will be used in conjunction with two Rattlesnake Ridge interbed wells planned for the 200-ZP-1 Groundwater Operable Unit to obtain horizontal flow data. • The recommended Rattlesnake Ridge interbed well will be installed following completion of operable unit IRM activities.

Table 4-6. Data Quality Objectives for Groundwater Sampling and Analysis.

Activity	Groundwater sampling and analysis.
Objectives	Groundwater sampling will address general data needs for defining nature and extent of contamination and groundwater geochemistry.
Prioritized Data Use(s)	The priority data uses are to support characterization of plume extent and contaminant characteristics and transport in refining the operable unit conceptual model and performing a QRA.
Appropriate Analytical Level or Implementation Guidelines	Groundwater sampling will be carried out under the guidance of EII 5.8 (WHC 1988).
Parameters to be Obtained	Water level, Eh, temperature, pH, specific conductance, at the time of sampling, volatile organics, semivolatile organics, pesticides/PCBs, inorganics, radionuclides, alkalinity, total organic carbon (TOC), total suspended solid (TSS), total dissolved solid (TDS), and common ions through laboratory analysis.
Required Detection or Measurement Limits	Analytical detection limits and DQO requirements (PARCC parameters) are identified in the QAPjP (Appendix A).
Critical Samples or Values	• Samples for all new wells and targeted existing wells are considered critical, with essential analyses indicated in Table 4-10. • The confined aquifer in the Rattlesnake Ridge interbed and the semiconfined aquifer in Ringold unit A must be sampled. • Wells that have had the maximum contaminant values and will delineate the extent of contaminant plumes, both horizontally and vertically.
Constraints	• Collection of accurate Eh measurements can be problematic and should be checked against concentrations of chemical species. • Existing wells targeted for analysis should be evaluated for fitness-of-use prior to initial sampling. Wells may not be screened at appropriate depths or lengths to provide representative data or information about vertical extent. • Method detection limits in some cases cannot be lowered sufficiently to determine concentrations that may be significant to RAs. • Wells for obtaining groundwater samples from the Rattlesnake Ridge interbed are anticipated to be installed following completion of operable unit IRM activities.

Table 4-7. Data Quality Objectives for Analytical Data Review.

Activity	Review apparent anomalies and incongruities of existing analytical data (outliers) for determination of the data use or significance of results.
Objectives	Analytical data review will help fill data gaps in the nature and extent of contamination and help evaluate data acquired on groundwater geochemistry.
Prioritized Data Use(s)	The priority data uses are to support characterization of plume extent and contaminant characteristics and mobility in refining the operable unit conceptual model and a QRA.
Appropriate Analytical Level or Implementation Guidelines	Not applicable.
Parameters to be Obtained	Evaluate complete laboratory reports where available for PARCC parameters, potential well material or sampling influences, variances of individual results from historical trends (outliers).
Required Detection or Measurement Limits	Not applicable.
Critical Samples or Values	• Review analyses that yielded single detections • Review results with a single detection that is much greater than previous or subsequent sampling. • Review results for wells with carbon steel casing.
Constraints	• Laboratory reports may be incomplete or difficult to acquire. • Conclusions will be qualitative only.

Table 4-8. Data Quality Objectives for Existing Well Survey and Condition Assessment.

Activity	Determine the adequacy of existing survey data and resurvey wells for existing operable unit wells with old or suspect data. Determine the fitness-for-use of wells identified for groundwater sampling, and remediate the wells where they are deficient for sampling purposes.
Objectives	Mitigating deficiencies associated with suspect well surveys and construction will address potential concerns related to the quality of groundwater samples collected as part of this work plan. Wells that potentially provide vertical migration contaminants should be evaluated for proper well seals. Accurate survey data are also needed for measuring groundwater levels and calculating groundwater flow directions and gradients. The potential impact of casing materials on analytical results also will be assessed.
Prioritized Data Use(s)	The priority data uses are to support the evaluation of groundwater flow, source contributions, nature and extent of contamination and groundwater geochemistry needed to refine the operable unit conceptual model and to conduct a QRA.
Appropriate Analytical Level or Implementation Guidelines	Horizontal and vertical location surveys should be performed according to EII 12.1, "Well Survey Procedure" (WHC 1988) and DOWs. Fitness-for-use parameters and criteria should be assessed using EII 6.6, "Resource Protection Well Characterization and Evaluation" (WHC 1988).
Parameters to be Obtained	Well survey data and well condition criteria data as listed on fitness-for-use checklist of EII (WHC 1988).
Required Detection or Measurement Limits	Survey location and elevation measurement criteria are described in EII 12.1 (WHC 1988).
Critical Samples or Values	The adequacy of the surveys and well construction should be determined for all existing operable unit wells. Deficient wells should be resurveyed or remediation based on the following prioritization (in decreasing level of priority): 1) Wells where groundwater sampling is recommended (Table 5-2); 2) wells with detected LFI/IRM constituents; 3) remaining 200-series operable unit wells; and 4) remaining 600-series operable unit wells.
Constraints	Resurvey and remediation work for the wells identified during the assessment should be completed prior to groundwater sampling. Survey for all pre-1987 wells are considered suspect. Well condition adequacy for groundwater sampling should be assessed based on the specific chemical constituents to be analyzed (Table 5-2 and 5-3).

**Table 4-9. Stratigraphic Units and Corresponding Data Parameters
to be Collected During LFI Field Activities.**

Page 1 of 2

Stratigraphic Unit	Unit Depth/ Thickness	Lith Descrip.	Bulk Density	Particle Size Dist	Moisture Content	Groundwater pH/Eh	Soil pH/Eh	CEC	CaCO ₃ Content	Drill Rate/Circ etc.	Static Water Levels	Hydraulic Conductivity (K)	Vertical Hydraulic Conductivity (Kv)
Units Above Water Table													
Hanford Formation	X	X								X			
Early "Palouse" Soil	X	X			X		X		X	X	X		
Plo-Pleistocene Unit	X	X			X		X		X	X	X		
Ringold E Gravels above Water Table	X	X			X		X		X	X			
Units Below Water Table													
Ringold E Gravels	X	X	X	X		X		X	X	X	X	X	
Ringold Lower Mud Unit	X	X	X	X	X				X	X			X
Ringold A Gravels	X	X	X	X		X		X	X	X	X	X	
Elephant Mountain Basalt	X	X								X			
Rattlesnake Ridge Interbed	X	X	X	X		X		X	X	X	X	X	

4T-9a

DOE/RL-92-76, Rev. 0

**Table 4-9. Stratigraphic Units and Corresponding Data Parameters
to be Collected During LFI Field Activities.**

Page 2 of 2

Stratigraphic Unit	Transmis- sivity	RLS Geophysical Parameters	PID Field Data (Soil & Gw)	Rad. Screen Data (Soil & Gw)	TOC (Soil & Gw)	Chemical and Rad. Analysis (Soil)	Chemical and Rad. Analysis (Gw)	Gw Alkalinity, TDS, TSS, Ions	Well Resurvey ^{a/}	WAC Compliance Assessment ^{a/}
Units Above Water Table										
Hanford Formation		X	X	X		X	X			
Early "Palouse" Soil		X	X	X		X	X			
Upper Ringold		X								
Ringold E Gravels above Water Table		X	X	X		X	X			
Units Below Water Table										
Ringold E Gravels	X	X	X	X	X	X	X	X		
Ringold Lower Mud		X	X	X	X					
Ringold A Gravels	X	X	X	X	X	X	X	X		
Elephant Mount Basalt		X								
Rattlesnake Ridge Interbed ^{b/}	X	X	X	X	X	X	X	X		

a/ see Table 5-2

b/ Rattlesnake Ridge interbed wells are anticipated to be installed following completion of operable unit IRM activities

4T-9b

DOE/RL-92-76, Rev. 0

Table 4-10. Waste Management Units that Potentially Have Contributed to Groundwater Contamination and Investigations Associated with the Units.
Page 1 of 4

Liquid Discharge Source	Existing/Planned Downgradient Wells	Planned/Recent 200-UP-2 Borings	Gross Gamma Logs	RLS Spectral Logs	Analogous Units ^{a/} / Remedial Path
216-S-21 Crib	299-W23-7 299-W23-4		299-W23-4	299-W23-4	S Plant Crib analogous unit
216-U-1 and -2 Cribs	299-W19-3; -9, -11, -17, -18, -24, -28, -29, -32, UP1-2, -3, -4, -5	299-W19-96, -95, -97	299-W19-3, -9, -11, -15, -16, -17, -18	299-W19-11 299-W19-9 299-W19-3	U Plant Crib analogous unit
216-U-8 Crib	299-W19-2	299-W19-94	299-W19-2, -70, -71	299-W19-69, -70, -71	U Plant Crib analogous unit
216-U-12 Crib	299-W22-40	299-W22-78	299-W22-22, -23, -28, -40, -41, -42, -43, -60, -73, -75	299-W22-75 299-W22-62	U Plant Crib analogous unit
216-U-16 Crib	299-W19-13 299-W19-32 299-W19-23		299-W19-7, -13, -14		U Plant Crib analogous unit
216-U-17 Crib	699-38-70, UP1-6, UP1-7		299-W19-19, -20, -23, -24, -25, -26, -28, -89, -90		U Plant Crib analogous unit
216-Z-20 Crib	299-W18-25				Z Plant Crib analogous unit
216-S-4 French Drain	299-W23-4 299-W23-13				S Plant Crib analogous unit
216-U-3 French Drain	299-W19-1		299-W18-177 299-W19-1		U Plant Crib analogous unit
216-U-4A French Drain	299-W19-29 299-W19-4 699-38-70	299-W19-98			U Plant French Drain/Reverse Well analogous unit
216-U-4B French Drain	299-W19-29 299-W19-4 699-38-70				U Plant French Drain/Reverse Well analogous unit
216-U-7 French Drain	299-W19-4 699-38-70				U Plant French Drain/Reverse Well analogous unit
216-U-4 Reverse Well	299-W19-29 299-W19-4 699-38-70	299-W19-98			U Plant French Drain/Reverse Well analogous unit

4T-10a

DOE/RL-92-76, Rev. 0

Table 4-10. Waste Management Units that Potentially Have Contributed to Groundwater Contamination and Investigations Associated with the Units. Page 2 of 4

Liquid Discharge Source	Existing/Planned Downgradient Wells	Planned/Recent 200-UP-2 Borings	Gross Gamma Logs	RLS Spectral Logs	Analogous Units ^{a/} / Remedial Path
216-U-10 Pond	299-W18-15 299-W18-21, -22 699-35-78A, -78B 299-W23-4 299-W23-13	216-U-10-TP-2	299-W18-15		IRM
216-U-5 and -6 Trenches	299-W19-4				RI
2607-W-5 Septic Tank/ Drain Field	299-W19-18, -28, -29				RI
2607-W-9 Septic Tank/ Drain Field					RI
2607-WUT Septic Tank/ Drain Field	299-W19-31				RI
Sanitary Crib					RI
216-S-1 and -2 Cribs	299-W22-4 299-W22-10 299-W22-16 299-W22-5		299-W22-1, -2, -5, -6, -10, -11, -15, -16, -17, -18, -29, -30, -31, -36, -67	299-W22-2 299-W22-30	S Plant Crib analogous unit
216-S-5 Crib	299-W26-6		299-W26-1, -3, -4, -5	299-W26-1	216-S-1 and -2 Cribs 216-S-6 Crib S Plant Crib analogous unit
216-S-6 Crib	299-W26-1, -2, -3, -4, -5		299-W26-2, -51	299-W26-51	S Plant Crib analogous unit
216-S-7 Crib	299-W22-14 299-W22-7 299-W22-21 UP1-13		299-W22-12, -13, -14, -32, -33	299-W22-32 299-W22-13	216-S-1 and -2 Cribs 216-S-6 Crib S Plant Crib analogous unit
216-S-9 Crib	299-W22-25 299-W22-28 299-W22-43		299-W22-25, -26, -34, -35	299-W22-25	216-S-1 and -2 Cribs 216-S-6 Crib S Plant Crib analogous unit
216-S-13 Crib	299-W22-21 UP1-13		299-W22-21	299-W22-21	216-S-1 and -2 Cribs 216-S-6 Crib S Plant Crib analogous unit

4T-10b

DOE/RL-92-76, Rev. 0

Table 4-10. Waste Management Units that Potentially Have Contributed to Groundwater Contamination and Investigations Associated with the Units. Page 3 of 4

Liquid Discharge Source	Existing/Planned Downgradient Wells	Planned/Recent 200-UP-2 Borings	Gross Gamma Logs	RLS Spectral Logs	Analogous Units ^{a/} / Remedial Path
216-S-20 Crib	299-W22-19 299-W22-20 UP1-9, 10, 11, 12		299-W22-20, -74 UP1-11	299-W22-74 UP1-11	216-S-1 and -2 Crib 216-S-6 Crib S Plant Crib analogous unit
216-S-23 Crib	299-W22-38 299-W19-5, -6, -7		299-W19-5, -6, -7 299-W22-37, -38		S Plant Crib analogous unit
216-S-25 Crib	299-W23-10 299-W23-9 299-W23-8 299-W23-14 UP1-8		299-W23-9, -10, -11		S Plant Crib analogous unit
216-S-26 Crib	299-W27-1 699-32-72P UP1-12				S Plant Crib analogous unit
216-S-3 French Drain	299-W22-11				S Plant Crib analogous unit
216-S-11 Pond					S Plant Pond analogous unit
216-S-16P Pond	699-29-78				S Plant Pond analogous unit
216-S-17 Pond	699-29-78 299-W26-9 699-32-37				S Plant Pond analogous unit
216-S-10D Ditch	UP1-13		299-W26-8, -9, -11		S Plant Ditch analogous unit
216-S-16D Ditch					S Plant Ditch analogous unit
216-S-8 Trench	299-W22-16		299-W22-39		RI
2607-W6 Septic Tank and Tile Field	299-W27-1 699-32-72P				RI

4T-10c

DOE/RL-92-76, Rev. 0

Table 4-10. Waste Management Units that Potentially Have Contributed to Groundwater Contamination and Investigations Associated with the Units.
Page 4 of 4

Liquid Discharge Source	Existing/Planned Downgradient Wells	Planned/Recent 200-UP-2 Borings	Gross Gamma Logs	RLS Spectral Logs	Analogous Units ^{a/} / Remedial Path
2607-WZ Septic Tank	299-W27-1 699-32-72P				RI

Sources: *200 West Groundwater AAMSR (DOE/RL 1992b)*

U Plant Source AAMSR (DOE/RL 1992c)

S Plant Source AAMSR (DOE/RL 1992d)

Z Plant Source AAMSR (DOE/RL 1992i)

200-UP-2 Source Operable Unit Work Plan (DOE/RL 1992a)

a/ Some of the liquid discharge sources may not be directly investigated. The results of investigations of units that have a similar design and history of use will be used to assess the potential impact of the source unit. The analogous group concept is presented in the Hanford Past-Practice Strategy (DOE/RL 1992e).

Table 4-11. Wells and Screen Depths for Critical Groundwater Analyses.

Page 1 of 3

Well	Notes	Well Screen Depth (ft)	Critical Groundwater Analysis
299-W14-10	a, LFI	195-230	DDT, Bis(2-ethylhexyl)phthalate
299-W18-15	a, LFI	170-243	Arsenic, Gross alpha, U
299-W18-20	LFI	220-249	Chloroform
299-W19-2	a, IRM, LFI	235-295	U, Tc-99, Nitrate, Sr-90
299-W19-3	b, LFI	230-280	(Pesticides)
299-W19-4	c, IRM, LFI	255-535	U, Tc-99, Nitrate, I-129, Gross alpha, Gross beta, Carbon tetrachloride, Trichloroethylene, Chloroform
299-W19-9	b, LFI	214-244	U, Tc-99, Nitrate, (Pesticides)
299-W19-11	a, b, LFI	220-250	U, Tc-99, Nitrate, (Pesticides)
299-W19-12	a, LFI	210-250	Tc-99, K-40, Chromium
299-W19-16	a, b, LFI	225-275	(Pesticides)
299-W19-18	a, IRM, LFI	230-355	U, Tc-99, Nitrate, Sr-90, Pesticides, Chloroform, Gross alpha, Gross beta, Carbon tetrachloride
299-W19-19	IRM	230-250	U, Tc-99, Nitrate
299-W19-21	a, LFI	201-226	Arsenic, K-40
299-W19-24	a, d, IRM, LFI	235-255	U, Tc-99, Nitrate, Sr-90
299-W19-25	a, d, LFI	226-246	Chloroform, Gross alpha, Gross beta
299-W19-27	a, d, LFI	208-228	Arsenic, Chromium
299-W19-28	a, d, LFI	236-256	Chloroform
299-W19-29	LFI	235-255	Trichloroethylene
299-W19-31	LFI	201-222	Tc-99, Chromium
299-W19-32	d, LFI	201-222	Tc-99, K-40, Chromium
299-W21-1	a, IRM	221-290	U, Tc-99, Nitrate, Sr-90
299-W22-1	LFI	190-280	Sr-90
299-W22-2	LFI	195-285	Sr-90
299-W22-7	LFI	223-308	Gross beta
299-W22-9	a, LFI	220-299	Trichloroethylene, Chromium
299-W22-10*	a, LFI	203-311	Sr-90, Pu-238
299-W22-19	f, LFI	222-330	Gross beta, Chromium, Carbon tetrachloride, Trichloroethylene, (DCA, DCE)

4T-11a

DOE/RL-92-76, Rev. 0

Table 4-11. Wells and Screen Depths for Critical Groundwater Analyses.

Page 2 of 3

Well	Notes	Well Screen Depth (ft)	Critical Groundwater Analysis
299-W22-20	a, LFI	205-299	DCE, DCA, Trichloroethylene, Carbon tetrachloride, Chromium
299-W22-21	a, LFI	200-285	Pu-238, I-129, Trichloroethylene, Chromium, Sr-90, Gross beta, Gross alpha, Tc-99
299-W23-2	LFI	184-235	Gross beta, Tc-99
299-W23-3	LFI	176-228	Tc-99
299-W23-4	LFI	180-300	Gross alpha, Gross beta, U
299-W23-5	LFI	215-245	Tc-99
299-W23-7	LFI	170-248	Gross beta, Tc-99
299-W23-9	g, LFI	164-230	(N-nitrosodimethylamine)
299-W23-10	a, LFI	165-230	N-nitrosodimethylamine
299-W23-11	a, g, LFI	165-230	Arsenic, (N-nitrosodimethylamine)
299-W26-1	LFI	NA	Chromium
299-W26-6	LFI	191-221	Chromium
299-W26-7	LFI	184-205	Chromium
299-W26-8	d, LFI	195-215	I-129, Carbon tetrachloride
299-W26-9	LFI	184-204	Chromium
299-W27-1	a, f, LFI	216-236	Pu-238, Chromium, Chloroform, (DCA, DCE)
699-32-62	IRM, LFI	365-370	Nitrate, I-129
699-35-78	LFI	330-389	Carbon tetrachloride
699-36-61A	IRM, LFI	330-389	Nitrate, I-129
699-38-70	IRM, LFI	255-380	U, Tc-99, Sr-90, Carbon tetrachloride
699-40-62	LFI	335-374	I-129
699-40-63	IRM	NA	Nitrate
UP1-1	c, IRM, LFI	245-275	U, Tc-99, Nitrate, I-129, Carbon tetrachloride, Chloroform, Gross alpha, Gross beta, Trichloroethylene
UP1-2*	IRM, LFI	320-330	U, Tc-99, Nitrate, Carbon tetrachloride, Chloroform, Gross alpha, Gross beta
UP1-3*	IRM, LFI	400-410	U, Tc-99, Nitrate, Carbon tetrachloride, Gross alpha, Gross beta
UP1-4*	IRM, LFI	440-450	U, Tc-99, Nitrate, Carbon tetrachloride, Gross alpha, Gross beta
UP1-5*	h, LFI	545-555	U, Tc-99, Nitrate, Carbon tetrachloride, Gross alpha, Gross beta
UP1-6	IRM	235-265	U, Tc-99, Nitrate

4T-11b

DOE/RL-92-76, Rev. 0

Table 4-11. Wells and Screen Depths for Critical Groundwater Analyses.

Page 3 of 3

Well	Notes	Well Screen Depth (ft)	Critical Groundwater Analysis
UP1-7	IRM	245-275	U, Tc-99, Nitrate
UP1-8*	LFI	470-480	Gross alpha, Gross beta, Carbon tetrachloride
UP1-9*	LFI	300-310	Chromium, Carbon tetrachloride, Trichloroethylene, Gross beta
UP1-10*	LFI	350-360	Chromium, Carbon tetrachloride, Trichloroethylene, Gross beta
UP1-11*	LFI	400-410	Chromium, Carbon tetrachloride, Trichloroethylene, Gross beta
UP1-12	LFI	225-255	I-129, Chromium, Carbon tetrachloride, Trichloroethylene, (DCA, DCE)
UP1-13	LFI	210-230	Sr-90, Tc-99, I-129, Chromium, Carbon tetrachloride, Trichloroethylene, Gross alpha, Gross beta

* Indicates wells screened below the uppermost portion of the water table.

a: These wells have been scheduled for resurvey in 1993/1994 by Westinghouse Hanford.

b: These wells will be sampled for pesticides only if the previous single detection of pesticides in Well 299-W19-18 is confirmed.

c: If 299-W19-4 is not suitable for sampling the top of the uppermost aquifer, UP1-1 will be installed.

d: These wells are RCRA compliant.

e: Well 299-W19-97 is planned for the 200-UP-2 Source Operable Unit field investigation. This boring is targeted to intercept perched water. It will be extended to the water table if the boring does not encounter perched water.

f: These wells will be sampled for DCA and DCE only if the previous single detections of DCA or DCE in Well 299-W22-20 is confirmed.

g: These wells will be sampled for N-nitrosodimethylamine only if the previous single detection of N-nitrosodimethylamine in Well 299-W23-10 is confirmed.

h: UP1-5 will be installed after IRM activities are completed.

NA: Not available.

IRM: Indicates that this well will be part of an IRM investigation.

LFI: Indicates that this well will be part of an LFI investigation.

4T-11c

DOE/RL-92-76, Rev. 0

5.0 REMEDIAL INVESTIGATION/FEASIBILITY STUDY TASKS

This section describes the Remedial Investigation activities supporting the LFI and Treatability Study activities for the IRM in the 200-UP-1 Groundwater Operable Unit. The activities are designed to provide information to meet DQOs identified in the *200 West Groundwater AAMSR* (DOE/RL 1992b) and discussed in Section 4.0 of this work plan.

Section 5.1 outlines the project framework tasks recommended to be implemented during the LFI. These tasks are designed to provide information needed to meet the DQOs identified in Section 4.0. The final determination of field activities and detailed information needed to carry out these tasks will be presented in DOWs for the operable unit (see Section 5.1.2.4, Subtask 1d).

The Treatability Study for the Uranium-⁹⁹Tc-Nitrate IRM plume that will be conducted in support of refining the preferred remedial alternative of the *200 West Groundwater AAMSR* remedy is described in Section 5.2. The Treatability Study will be conducted, to determine efficacy and to support remedial design for the preferred alternative.

Following approval, this work plan will not be modified. The finalization of investigation activity details will be made in the DOWs. Any changes to the scope of work that may be needed will be documented through change requests in accordance with the procedures identified in the QAPjP (Appendix A).

5.1 LIMITED FIELD INVESTIGATION PROCESS

The necessary activities and program framework required to accomplish the LFI goals are presented in Section 5.1. The activities are designed to provide information necessary to meet the DQOs identified in the *200 West Groundwater AAMSR* and discussed in Section 4.0 of this work plan.

Section 5.1.1 describes the work breakdown structure by which the LFI activities will be implemented. The tasks designated by the work breakdown structure will be used to manage the budget and schedule the LFI activities. Section 5.1.2, Project Management (Task 1), summarizes the management activities associated with implementing the data gathering and interpretation tasks of the 200-UP-1 Groundwater Operable Unit Remedial Investigation/Feasibility Study Work Plan. Section 5.1.3, Field Activities (Tasks 2 to 6), describes the proposed field data gathering activities. This section identifies specific activities recommended to be conducted for the LFI. Final determination of field activities will be made through the issuance of DOW documents. Sections 5.1.4 through 5.1.7 describe the data interpretation tasks leading to the production of an LFI report. These tasks include: data evaluation (Section 5.1.4), QRA (Section 5.1.5), identification of potential contaminant- and location-specific ARARs (Section 5.1.6), and production of the LFI report (Section 5.1.7).

5.1.1 Work Breakdown Structure

This section summarizes the tasks planned during LFI studies at the 200-UP-1 Groundwater Operable Unit. Tasks are the primary controlling framework within which the LFI is conducted. Each task describes a primary need or goal of the LFI. The tasks control and are implemented by a series of associated subtasks and activities. Ten distinct tasks are described in this section: project management (Task 1), source characterization (Task 2), geologic investigation (Task 3), vadose zone investigation (Task 4), groundwater investigation (Task 5), air investigation (Task 6), data evaluation (Task 7), QRA (Task 8), identification of potential contaminant- and location-specific ARARs (Task 9), and completion of the LFI report (Task 10). Information is provided on each task to help estimate project schedules and costs.

Tasks 2 through 6 control data collection and field activities. Each of these field-related tasks is broken down into four subtasks: data compilation and review, field investigation, laboratory analysis, and data evaluation.

Data compilation and review for each of the field-related tasks was largely completed during the production of the *200 West Groundwater AAMSR* (DOE/RL 1992b). The AAMSR presents a compilation of the historical, physical, and chemical and radiological data for the 200-UP-1 and 200-ZP-1 Groundwater Operable Units. Sections 2.0 and 3.0 of this work plan summarize the AAMSR data. The field investigation and laboratory analysis subtasks are described in detail in Section 5.1.3 of this work plan. Data that are planned to be collected during field activities described in this work plan should be integrated with the existing data described in the AAMSR and in topical reports and evaluated. Data collected during nonintrusive activities such as existing well surveys, groundwater sampling, borehole geophysical surveys, and water level measurements should be evaluated immediately to help define subsequent field activities such as surface soil sampling and borehole locations. The overall data evaluation strategy is outlined in Section 5.1.4.

The relationship between the field-related tasks and field activities is summarized in Table 5-1. Many of the field activities are associated with more than one task. For example, the boring field activity will yield data for the source characterization, geologic investigation, groundwater investigation, and vadose zone investigation tasks.

The following sections briefly outline the nature of each task and subtask, and the activities with which they are associated.

5.1.1.1 Project Management (Task 1). The objectives of project management during the implementation of the LFI work plan are to direct and document project activities, to ensure that data and evaluations generated meet the goals and objectives of the work plan, and to administer the LFI/Treatability Study within budget and schedule. The initial project management activities will be to assign individuals to roles established in the Project Management Plan of the *200 West Groundwater AAMSR* (DOE/RL 1992b). The project management task is detailed in Section 5.1.2.

5.1.1.2 Source Characterization (Task 2). The purpose of the source characterization is to determine whether former liquid disposal sites continue to release contamination to groundwater after disposal has been terminated and if still active disposal sites are causing the release of contamination to the groundwater. Most of the information on this issue should be obtained by field activities conducted under the source operable unit work plans (e.g., 200-UP-2), and should be integrated with the results of the 200-UP-1 Groundwater Operable Unit LFI to address continuing releases more completely.

The majority of source characterization data is planned to be collected during nonintrusive activities such as subsurface geophysics and groundwater sampling, but also will include soil sampling during new monitoring well installation. The proposed source characterization activities for the 200-UP-1 Groundwater Operable Unit are described in detail in Section 5.1.3.

5.1.1.3 Geologic Investigation (Task 3). The primary purpose of the geologic investigation is to characterize the stratigraphic constraints on groundwater flow, and to collect other geologic data that can be used to estimate the rate of water movement through the vadose zone. The geologic investigation activities for the 200-UP-1 Groundwater Operable Unit are detailed in Section 5.1.3.

The majority of geologic data are planned to be collected from borings from selected groundwater and vadose zone investigation sites under both this (200-UP-1) and source (e.g., 200-UP-2) investigations. This activity should produce information on the stratigraphy and its constraints on groundwater flow as well as producing information on the lateral extent, vertical extent, and surface geometry of aquitards in the vadose zone. These aquitards are significant because they may retard the downward movement of water and form zones of perched water that allow the lateral movement of contaminants. Samples collected during the boring activities for analysis of physical characteristics and properties should be used to characterize the hydraulic properties of various vadose and saturated zone media.

5.1.1.4 Vadose Zone Investigation (Task 4). The primary objective of this task is to define the nature and vertical extent of contamination in the vadose zone. This topic will be addressed primarily in source operable unit work plans (e.g., 200-UP-2) and should include characterizing contamination in vadose zone soils and in perched water. Vadose zone data should also be collected by work described in this work plan during boring and subsurface geophysical field activities. However, the primary purposes of these activities will be for investigating groundwater and the geology. The proposed work plan vadose zone activities are detailed in Section 5.1.3. In addition, soil vapor sampling should be performed in accordance with the needs of the carbon tetrachloride vadose zone ERA, Arid ID (Rohay et al. 1993), and other ongoing Hanford Site projects.

5.1.1.5 Groundwater Investigation (Task 5). The purpose of the groundwater investigation is to characterize the plumes in the 200-UP-1 Groundwater Operable Unit and to gather further information on groundwater transport. Plume characterization involves determining the presence and concentrations of contaminants and the horizontal and vertical extent of the plume. The purpose

of gathering additional information on groundwater transport is to determine future plume directions, changes in concentrations, and potential impacts. The groundwater transport study is planned to emphasize transport in the lower aquifers and the vertical movement of groundwater between aquifers and within the uppermost aquifer. The proposed groundwater investigation activities are detailed in Section 5.1.3.

5.1.1.6 Air Investigation (Task 6). The scope of this task is to evaluate worker safety during field activities, to establish background concentrations of airborne contaminants, and to monitor the impacts of field activities on area-wide air quality. The majority of air-related data is planned to be collected from an existing high volume sampling network, and from job-site health and safety monitoring equipment. The air investigation activities are detailed in Section 5.1.3.2.8.

5.1.1.7 Data Evaluation (Task 7). Data generated during the LFI will be evaluated and integrated with existing data in an ongoing manner. Data from some field activities will be used to define later activities. The data evaluation task is described in detail in Section 5.1.4.

5.1.1.8 Qualitative Risk Assessment (Task 8). The QRAs are planned to be completed for contaminants in groundwater that are selected for IRMs. By focusing on the principal risk drivers in the operable unit. The results of these assessments may be used to help determine the need for IRMs, to select the IRMs, and to determine risk-based cleanup levels for the IRMs. The QRAs are discussed in detail in Section 5.1.5.

5.1.1.9 Identification of Potential Contaminant- and Location-Specific ARARs (Task 9). The identification of potential operable unit-specific ARARs is viewed as an ongoing effort during the LFI/IRM process and is described in more detail in Section 5.1.6.

5.1.1.10 LFI Report (Task 10). An interim report will be prepared as part of work plan activities to present the results of the LFI and QRA for each high priority contaminant plume. The LFI report is described in more detail in Section 5.1.7.

5.1.1.11 Other Tasks (Task 11). This task has been reserved in the event that additional tasks are identified during the course of the project.

5.1.2 Project Management (Task 1)

Section 5.1.2 presents a summary overview of project management subtasks associated with activities in this work plan. Specific project management activities include the following:

- Subtask 1a, Project Management (Section 5.1.2.1)
- Subtask 1b, Meetings (Section 5.1.2.2)
- Subtask 1c, Cost and Schedule Control (Section 5.1.2.3)
- Subtask 1d, Work Control (Section 5.1.2.4)
- Subtask 1e, Data Management (Section 5.1.2.5)

- Subtask 1f, Progress and Final Reports (Section 5.1.2.6)
- Subtask 1g, Quality Assurance (Section 5.1.2.7)
- Subtask 1h, Health and Safety (Section 5.1.2.8)
- Subtask 1i, Community Relations (Section 5.1.2.9).

Assignment of project management responsibilities will be made in specific DOWs.

5.1.2.1 Project Management (Subtask 1a). Project management includes the day-to-day supervision of, and communication with, project staff and subcontractors. Throughout the project, daily communication between office and field personnel will be emphasized, along with frequent communication with subcontractors. This frequent exchange of information will be necessary to assess progress, to identify potential problems quickly enough to make necessary corrections, and to keep the project within the budget and focused on the objectives and schedule. Details of project management are presented in the Project Management Plan, an attachment to the *200 West Groundwater AAMSR*. Organizational charts are expected to be developed as DOWs are generated for individual subtasks.

5.1.2.2 Meetings (Subtask 1b). Meetings should be held, as necessary, with members of the project staff, subcontractors, regulatory agencies, and other appropriate groups to communicate information, assess project status, and resolve problems. A kickoff meeting with designated project personnel is proposed along with weekly staff meetings. It is also proposed that the 200-UP-1 Groundwater Operable Unit project coordinators meet on a weekly basis to share information and to discuss progress and problems. Meeting minutes will be taken to document project status, potential issues, and decision points. Meeting decisions will be approved by the appropriate personnel, using applicable procedures. The frequency of other meetings will be determined based on need and on schedules in the Tri-Party Agreement (Ecology et al. 1990).

5.1.2.3 Cost and Schedule Control (Subtask 1c). Project costs, including labor, other direct costs, and subcontractor expenses will be tracked on a monthly basis using an earned value approach. The budget for tracking activities will be computerized and will provide the basis for invoice preparation and review and for preparation of progress reports. Scheduled milestones will be tracked monthly for each task of each project phase, in conjunction with cost tracking.

5.1.2.4 Work Control (Subtask 1d). The level of detail provided in this work plan is adequate for initial planning purposes. Detailed information needed to carry out the investigative tasks discussed in this chapter will be provided in the 200-UP-1 Groundwater Operable Unit DOWs. The DOWs will be provided to the lead regulatory agency for review. If field activities are initiated prior to work plan approval, then the DOWs will require approval by the lead regulatory agency. Where appropriate the DOWs will reference Westinghouse Hanford Company EIs rather than listing the entire procedure for a task. The EIs for field activities and laboratory analysis are also referenced in the QAPjP (Appendix A). Any reference to the DOWs or QAPjP as a source of additional information is inclusive of the EIs they reference.

5.1.2.5 Records and Data Management (Subtask 1e). The work activity file for the 200-UP-1 Groundwater Operable Unit will be kept organized, secured, and accessible to project personnel. The project file will be maintained to comply with the Information Management Overview, which is included in the *200 West Groundwater AAMSR*. All field reports, field logs, health and safety documents, QA/quality control (QC) documents, laboratory data, memoranda, correspondence and reports will be logged into the file upon receipt or transmittal. This task is also the mechanism for ensuring that data management procedures are carried out as documented in the *200 West Groundwater AAMSR*, Information Management Overview (DOE/RL 1992b).

5.1.2.6 Progress and Final Reports (Subtask 1f). Monthly progress will be documented at unit managers' meetings. Meeting minutes will be prepared, distributed to the appropriate personnel and entities (e.g., project and unit managers, coordinators, contractors, subcontractors), and entered into the project file. Other reporting requirements (e.g., DOE quarterly progress reports) are discussed in the *200 West Groundwater AAMSR*, Project Management Plan (Appendix C).

All LFI/Treatability Study and plans will be categorized as either primary or secondary documents. The process for document review and comment is covered by the Tri-Party Agreement Action Plan (Ecology et al. 1990). Administrative records must be maintained, as described in Section 9.4 of the Action Plan.

5.1.2.7 Quality Assurance (Subtask 1g). All work on the Hanford Site is subject to the requirements of DOE Order 5700.6C, *Quality Assurance* (DOE 1991), which establishes broadly applicable QA program requirements for all types of project activities. To ensure that the objectives of the work plan are met in a manner consistent with the DOE Order, proposed activities in the work plan which are conducted by Westinghouse Hanford will be performed in compliance with existing QA manuals and the Environmental Engineering, Technology, and Permitting Function QAPjP that specifically describes the application of manual requirements to environmental investigations. The 200-UP-1 Groundwater Operable Unit QAPjP (Appendix A) details the QA/QC protocols to be followed during the 200-UP-1 Groundwater Operable Unit Remedial Investigation/Feasibility Study process. The QAPjP defines the specific means that will be used to ensure that the sampling and analytical data are defensible and will effectively support the purposes of the investigation.

5.1.2.8 Health and Safety (Subtask 1h). The Health and Safety Plan (*200 West Groundwater AAMSR* attachment; DOE/RL 1992b) will be used to implement standard health and safety procedures for Westinghouse Hanford employees and contractors engaged in IRM activities in the 200-UP-1 Groundwater Operable Unit.

Activities associated with field sampling and sample transport may involve both external and internal exposure to ionizing radiation from adjacent tanks, piping, and contaminated soils. Sample collection activities may also involve exposure to hazardous chemicals. Review by Westinghouse Hanford Occupational Health and Safety and issuance of any Radiation Work

Permits and Hazardous Waste Operating Permits (EII 2.2, "Occupational Health Monitoring"[WHC 1988]) is planned to be performed prior to the start of any sampling activity. All personnel entering the job site will fulfill the minimum requirements for entry as discussed in EII 1.1., "Hazardous Waste Site Entry Requirements" (WHC 1988).

An as-low-as-reasonably-achievable (ALARA) plan that addresses the potential radiation exposure of task personnel during field tasks is planned to be completed prior to the commencement of field operations. Guidance on such assessments is found in WHC-CM-4-11 as referenced in EII 2.3, "Administration of Radiation Surveys to Support Environmental Characterization Work on the Hanford Site" (WHC 1988). A Radiation Dose Assessment evaluation may be performed for the anticipated soil samples and upon its completion may be used in conjunction with estimates of sample size and duration of exposure to prepare an ALARA plan.

5.1.2.9 Community Relations (Subtask 1j). Community relations activities are planned to be conducted in accordance with the Community Relations Plan for the Hanford Site (Ecology et al. 1989). All community relations activities associated with the 200-UP-1 Groundwater Operable Unit will be conducted under this overall Hanford Site Community Relations Plan.

5.1.3 Limited Field Investigation Field Activities (Tasks 2 to 6)

This section describes the proposed field activities to be performed for the LFI. The field activities are designed to accomplish the following tasks: source characterization (Task 2), geologic investigation (Task 3), vadose zone investigation (Task 4), groundwater investigation (Task 5), and air investigation (Task 6). These tasks are described in Section 5.1.1. Section 5.1.3 recommends specific activities to be conducted for the LFI, although final determination of field activities will be made through issuance of DOWs. Several DOWs will be required and will likely address the following topics:

- Accelerated vertical contaminant profiling (*Description of Work for the 200-UP-1 Groundwater Contaminant Vertical Profiling Activity* [WHC 1993b])--Indicates the locations, methodology, and analytical methods for the vertical contaminant profiling
- Soil sampling, monitoring well installation, groundwater sampling, and geophysical surveys--Identifies locations, frequencies, methodologies, and analytical methods for the subject field activities
- Aquifer testing, including accelerated 1993 aquifer testing (*Description of Work for the 200-UP-1 Aquifer Testing Activity* [WHC 1993c])--Identifies the locations, methodology, and analyses for aquifer tests.

Section 5.1.3.1 discusses the locations and frequencies of each activity, and is subdivided by waste management unit and unplanned release. The protocols and procedures for each type of field activity are described in

Section 5.1.3.2. Section 5.1.3.3 describes the laboratory analyses that each sample will undergo.

5.1.3.1 Sampling Locations and Frequencies. The following sections describe the recommended field activity for each data collection category.

5.1.3.1.1 Well Condition and Survey Assessment. Existing resource protection wells within the 200-UP-1 Groundwater Operable Unit should be used whenever possible to provide hydrogeologic and chemical information to support IRM/LFI activities. The suitability of wells used for these purposes should be assessed as part of the 200-UP-1 Groundwater Operable Unit Remedial Investigation/Feasibility Study. As a strategy to complete this assessment, information from an ongoing Westinghouse Hanford Environmental Field Services well remediation program should be incorporated, as available, to guide field activities and data analysis efforts.

Well remediation at the Hanford Site is currently implemented on a well-by-well basis as driven by specific requirements of individual site programs and characterization activities. Criteria for assessing the fitness-for-use of individual wells are described in EII 6.6 (WHC 1988). The intent of remediation is to bring wells constructed prior to incorporation of current Washington State well construction standards (Chapter 173-160 WAC) in line with new well regulations and current Hanford Site well construction practices. The objective is to remediate wells with documented deficiencies so that they may be used for resource protection wells or for other purposes where feasible. Generally, all pre-1987 wells are considered to be suspect.

For the purpose of the 200-UP-1 Groundwater Operable Unit, compliance status of existing wells under EII 6.6. and Chapter 173-160 WAC should first be reviewed during planned work plan activities. Based on results of this review a list of wells requiring further remediation should be prepared based on the intended purpose for groundwater sampling or water elevation measurements. Wells with high potential for transporting contaminants along poor or nonexistent annular seals should be given priority for remediation. Remediation efforts should be considered on a case-by-case basis. Remediation options include perforation and grout injection to create an annular seal. These wells should not be used for groundwater sampling unless it can be demonstrated that the deficiency is unlikely to affect analytical results. The wells may also be acceptable for other purposes such as water level elevation measurements or aquifer testing. Wells presenting a high risk for providing vertical pathways for contaminant transport will be scheduled for abandonment according to procedures in EII 6.7 (WHC 1988). As discussed in Section 4.2.6.4 (Existing Well Quality), it is recommended that the well fitness-for-use and survey quality evaluation be completed in a prioritized manner. Initial priority should be given to wells listed in Table 5-2 since sampling and analysis results of groundwater samples from these wells will be used to determine the disposition of the LFI constituents and further define the extent of IRM constituents. Operable unit wells with detected LFI/IRM constituents should then be evaluated, followed by the remaining 200-series wells, and lastly the remaining 600-series wells.

An additional component of the well suitability assessment is the verification of existing wellhead elevation and location surveys. Questions of survey accuracy are generally restricted to older (pre-1987) wells. Wells that are currently scheduled for resurvey are indicated in Table 5-2. Resurvey of existing wells should be staged in a similar manner to that described above for fitness-for-use.

In many cases, well construction records of older wells (1950's) are missing or incomplete. When available, completion records of existing wells would be reviewed to identify wells for which the screened interval is unknown or uncertain. In such cases, wells should be visually inspected with a downhole camera, as necessary, to determine screened intervals. In addition, continued dissipation of elevated water table levels in areas of mounding may lead to wells screened across the water table to go dry in such locations. Wells for which recent water level records indicate that the screen may become stranded above the water table should be identified as part of the proposed work plan effort, and monitoring of water levels should occur on a quarterly basis to verify that such wells would be permanently stranded rather than temporarily stranded because of seasonal fluctuations in the water table. Stranded wells in locations that are considered critical to water quality monitoring and water level elevation determination should then be recommended for replacement.

5.1.3.1.2 Borings and New Well Installation. Thirteen proposed new wells, UP1-1 through UP1-13, may be installed at eight locations as part of this work plan. The installation of these wells will meet the requirements of WAC 173-160, WAC 173-162, and Revised Code of Washington (RCW) 18.104 with the guidance of the Environmental Compliance Support Organization. The location of the proposed new wells are shown on Figure 4-2. The estimated depth and screen interval and the primary DQO for each well is summarized in Table 5-4. A graphical representation of each well showing the well depth, approximate depth of the lithologic units encountered, and sampling intervals is presented on Figures 5-1 through 5-8. In cases where more than one well at a location will be installed, only soil from the deepest well in each assemblage will be sampled during drilling (unless a well screen interval sample is needed). This approach is adopted to expedite drilling, with the understanding that wells are located sufficiently close so that stratigraphic variations are negligible. The purpose of these wells is to help further characterize contaminant plumes and groundwater flow in the 200-UP-1 Groundwater Operable Unit. Plans for new well installations will be finalized in a DOW.

Five wells (UP1-1, if required, -6, -7, -12, and -13) should be installed to better delineate the horizontal extent of the plumes in the 200-UP-1 Groundwater Operable Unit. These wells will be screened in the upper 10 m (30 ft) of the uppermost aquifer. The reason for screening the upper 10 m (30 ft) is to ensure that the water table will be intersected by the screen, even if water levels continue to fall in accordance with the recent trend. Samples collected during drilling will be used to analyze the physical and chemical properties of the vadose and saturated zones. Sampling recommendations are discussed in Section 5.1.3.3 and shown on Figures 5-1 through 5-5. If the Vertical Profiling Test Program (WHC 1993b) demonstrates that Well 299-W19-4

is suitable for sampling the top of the uppermost aquifer, Well UP1-1 may not be installed.

Four wells, UP1-2 (if needed), -3, -4, and -5, will be installed in a cluster adjacent to Well 299-W19-24. Well 299-W19-24 is screened from 72 to 77 m (235 to 255 ft) across the top of the uppermost aquifer. The current depth to the top of the uppermost aquifer in Well 299-W19-24 is 73 m (238 ft). Well UP1-2 should be screened from 98 to 101 m (320 to 330 ft). Well UP1-3 should be screened at the bottom of the uppermost aquifer at the base of Ringold Unit E. Well UP1-4 should be screened in the confined aquifer in Ringold Unit A. Well UP1-5 should be screened in the confined aquifer in the Rattlesnake Ridge interbed. This well will not be installed until after operable unit IRM activities are completed. In order to expedite drilling, samples will be collected during drilling of Well UP1-4 and from the depth of the screened interval in the other wells. The samples will be used to analyze the physical and chemical properties of the vadose and saturated zones. Sampling recommendations are discussed in Section 5.1.3.3 and shown on Figure 5-6. These four wells will provide data on the vertical extent of the uranium and ⁹⁹Tc plumes, groundwater flow, and the underlying stratigraphy.

Well UP1-8 should be installed adjacent to Well 299-W23-14. Well 299-W23-14 is screened from 59 to 66 m (193 to 215 ft) across the top of the uppermost aquifer. The current depth to the top of the uppermost aquifer in Well 299-W23-14 is 61 m (200 ft). Well UP1-8 will be screened in the confined portion of the uppermost aquifer in Ringold Unit A. Samples collected during drilling will be used to analyze the physical and chemical properties of the vadose and saturated zones. Sampling recommendations are discussed in Section 5.3.3 and shown on Figure 5-8.

Three wells, UP1-9, -10, and -11, should be installed in a cluster adjacent to Well 299-W22-20. The current depth to the top of the uppermost aquifer in Well 299-W22-20 is 67 m (219 ft). Well UP1-9 will be screened from 91 to 94 m (300 to 310 ft). Well UP1-10 will be screened at the bottom of the uppermost aquifer at the base of Ringold Unit E. Well UP1-11 will be screened in the confined portion of the uppermost aquifer in Ringold Unit A. In order to expedite drilling, samples will be collected during drilling of Well UP1-13 and at the depth of screened intervals in the other wells. The samples will be used to analyze the physical and chemical properties of the vadose and saturated zones. Sampling recommendations are discussed in Section 5.3.3 and shown on Figure 5-9. These three wells will provide data on the vertical extent of the chromium, nitrate, carbon tetrachloride, chloroform, and trichloroethylene plumes, as well as provide data to assist determination of groundwater flow and refine knowledge of stratigraphy.

5.1.3.1.3 Soil Vapor Sampling. Because large volumes of volatile chemicals were not disposed of in waste management units overlying the 200-UP-1 Groundwater Operable Unit, no soil vapor sampling is planned for the 200-UP-1 Groundwater Operable Unit investigation. Low concentrations of volatile organics in groundwater and information from process and disposal records indicate that testing for vapors in the vadose zone is not warranted because of the unlikelihood of a positive result. Soil vapor sampling may be used in

the 200-ZP-1 Groundwater Operable Unit investigation and in the source operable unit investigations.

5.1.3.1.4 Groundwater Sampling. Many of the existing wells in the 200-UP-1 Groundwater Operable Unit, and all the new wells to be installed, should be sampled and analyzed for appropriate constituents. Before groundwater sampling begins, the historical analytical data should be reviewed carefully. Upon completion of this review, changes in the recommended sampling requirements will be made, if needed. Table 5-2 summarizes the recommended sampling requirements (analytes in each well).

In all these wells, the sampling should be begun on a quarterly basis for one year. Subsequently, sampling will be continued according to need based on the results during the first year of sampling.

Unfiltered samples for inorganics are required to support the QRA. It is anticipated that wells being sampled may produce turbid samples containing suspended solids. Such materials likely originate from aquifer soils in the immediate vicinity of the well, rather than representing transported residues from disposed wastes. Because the sediment contains inorganic compounds, samples collected for inorganic analysis will be analyzed for both dissolved (filtered) and total (unfiltered) concentrations.

5.1.3.1.5 Water Level Measurements. To support work plan activities for the operable unit, it is recommended that static water levels in existing groundwater wells located in the 200-UP-1 Groundwater Operable Unit will be monitored on a quarterly basis throughout the duration of field and analytical activities discussed in the work plan. Wells to be monitored should include all new wells and wells identified on Plates 1a and 1b. Monitoring should incorporate measurements from wells installed as part of the current work plan, and measurements from groundwater monitoring efforts and aquifer testing will also be included.

Water level elevations are currently measured for many of the 200-UP-1 Groundwater Operable Unit wells. These measurements are obtained as part of on-going site-wide monitoring programs from RCRA, CERCLA, and Hanford Operational Groundwater Monitoring Network programs. These programs and the wells included within each program are discussed in Section 2.8 of the *200 West Groundwater AAMSR*. Many of these wells are monitored on a quarterly basis at a minimum. The proposed monitoring efforts for the 200-UP-1 Groundwater Operable Unit should, to a large extent, use groundwater elevation data obtained from these programs to optimize the use of this information. Wells within the operable unit that are not currently included in these programs will be identified and incorporated into the monitoring network. Wells scheduled for abandonment will be checked, and wells installed for other programs will be added to the monitoring network for the 200-UP-1 Groundwater Work Plan as needed.

5.1.3.1.6 Geophysical Surveys. Subsurface geophysics are recommended to be run in nine of the new well boreholes and on four existing wells. The locations of these wells are shown on Figure 5-9. Only the deepest new well at a location will be surveyed with the assumption that variability over the

close spacing is negligible. The list of wells and methods will be finalized in a DOW.

Geophysical surveys of the new wells should be performed as each casing string reaches its maximum depth to avoid surveying portions of boreholes through two casings and intervening grout. Gross gamma logging will be performed in Wells UP1-1 (if installed), -4, -5 (from the base of the Ringold Unit A through the Rattlesnake Ridge interbed), -6, -7, -8, -11, -12, and -13 in advance of the placement of casings. The RLS spectral gamma surveys will be conducted on these new wells following well installation. Although running both gross gamma logging and RLS spectral gamma logging in the new wells may be redundant, it is recommended that both techniques be used because of various limitations in both types of logging. These limitations include the length of time for running RLS logs, the length of the specialized cable for the RLS detector is not long enough to log the deepest new wells, and the inability of gross gamma logging to detect uranium. In addition gross gamma logging could save time by identifying intervals that would saturate an unshielded RLS detector, and gross gamma logs are more readily correlated with other wells in the area because of the historically more extensive use of gross gamma logging.

Gross gamma logging also should be conducted in Wells 299-W22-2 and 299-W22-30. These two wells monitor the 216-S-1 and 216-S-2 Cribs. Previous gross gamma logging of these well has shown elevated gross gamma levels throughout the vadose zone to the water table. These wells have not been logged since 1980. The new logs will be compared with the old logs to see if any appreciable changes have occurred in gross gamma levels in these wells.

The RLS spectral gamma logging should be conducted in four existing wells. The four existing wells are Wells 299-W22-2 and 299-W22-30, which monitor the 216-S-1 and 216-S-2 Cribs, 299-W22-25 which monitors the 216-S-9 Crib, and 299-W22-13, which monitors the 216-S-7 Crib. This logging should be coordinated with any future investigations of the S Plant Source Aggregate Area. The spectral gamma logs will provide information on the radionuclides responsible for the elevated gross gamma in these wells in the vadose zone immediately above the water table.

The 200-UP-2 Source Operable Unit field investigation calls for spectral gamma logging in eight existing monitoring wells and five new borings. The existing wells are Wells 299-W19-3, 299-19-9, 299-19-11, 299-W19-69, 299-W19-70, 299-W19-71, 299-W22-62, and 299-W22-75. Spectral gamma logging will be conducted during spring 1993 at Wells 299-W19-9, 299-W19-11, 299-W19-70, and 299-W22-75 as part of the *200 West Groundwater AAMSR* screening study (WHC 1991). The new borings that will be logged will be located near the 216-U-1, 216-U-2, and 216-U-8 Cribs, 216-U-4 Reverse Well, and 216-U-4A French Drain.

5.1.3.1.7 Aquifer Tests. The proposed aquifer tests to gather data on hydraulic properties data are based on the data needs and DQOs discussed in Section 4.2.3. Aquifer tests were conducted in 1993 for accelerated field activities and are planned along with other LFI activities following new well installation. Table 5-3 summarizes the recommended aquifer testing program for the 200-UP-1 Groundwater Operable Unit. The table identifies wells to be

tested for the unconfined portion of the uppermost aquifer (Ringold Unit E gravels), the confined portion of the uppermost aquifer (Ringold Unit A gravels), and the Rattlesnake Ridge interbed confined aquifer using a variety of testing methods. The wells identified for deeper aquifer tests should be installed as nested completions that will also be used to collect groundwater samples for chemical analysis and collect water level elevation data (see Sections 5.1.3.1.2 and 5.1.3.1.4). The Rattlesnake Ridge interbed well is planned to be installed following completion of operable unit IRM activities.

Proposed testing methods listed in Table 5-3 include slug, slug interference, constant rate drawdown/recovery pumping tests, and short term pressure buildup tests. Section 4.2.3 discusses the rationale, application, and the advantages and limitations for each type of test and their variations. Specific information regarding the anticipated screen intervals in the test wells, observation wells for each test, and methods of data analysis are presented in Table 5-3. Final determination of the scope and methodology of this field activity is planned in a follow-on DOW.

5.1.3.2 Protocols and Procedures.

5.1.3.2.1 Well Condition and Survey Assessment. To complete the operable unit well condition and survey assessment, a record search should initially be conducted to gather well completion and survey data for existing wells within the operable unit. Wells for which the depth of screen intervals is uncertain or unknown would be identified and assessed by use of a downhole camera. Wells for which survey data are uncertain or unknown will be recommended for resurvey using a licensed professional surveyor familiar with the Hanford Site. Vertical and horizontal measurements will be referenced to U.S. Geological Survey/National Geodetic Survey bench marks or other permanent reference points. As discussed in Section 5.1.3.1.1, this effort is intended to incorporate available information from well compliance status and remedial assessment work planned by Westinghouse Hanford in 1993/1994.

5.1.3.2.2 Soil Borings/Sampling. Thirteen proposed boreholes may be drilled during the 200-UP-1 Groundwater Operable Unit field investigation. The general locations of these well borings are discussed in Section 5.1.3.1.2 and shown on Figure 4-2. The depths and geologic units to which the well borings will extend are shown in Table 5-4. Schematic diagrams showing stratigraphic units, depth of well screen, and sampling intervals of the borings are shown on Figures 5-1 through 5-8.

Drilling. The suggested drilling technique used on the boreholes should be air rotary with a downhole hammer or one of other acceptable technologies, with selection of the method to be made in a DOW. Drilling operations will be conducted according to EII 6.7, "Resource Protection Well and Test Borehole Drilling," and EII 5.4, "Field Decontamination of Drilling, Well Development and Sampling Equipment" (WHC 1988). Drilling cuttings will be managed according to EII 4.2, "Interim Control of Unknown, Suspected Hazardous and Mixed Waste" and EII 4.3, "Control of CERCLA and Other Past-Practice Investigation Derived Waste" (WHC 1988). As drilling proceeds, the well-site geologist will complete the borehole geologic log in accordance with EII 9.1, "Geologic Logging" (WHC 1988).

Temporary casing will be advanced along with drilling. Casings will be telescoped through the various aquifers, perched water, if encountered, and intervals of contamination to prevent cross contamination. The approximate casing sizes to be used will likely be 20, 25, 30, and 40 cm (8, 10, 12, and 16 in.) casings. For the five plume delineation well borings and the three boreholes to Ringold Unit A, UPl-1, -4, -6, -7, -8, -11, -12, and -13, gross gamma logging will be performed whenever the casing is telescoped. Gross gamma logging will also be performed in the UPl-5 well boring. The survey procedures are outlined in Section 5.3.2.4. Each telescoped casing, when its total depth has been achieved, will be cut and left in place so that it extends about 0.2 m (0.5 ft) above the next larger diameter casing.

Sampling. The split-spoon and/or core sampler should be the primary device for collecting soil samples for chemical and physical analyses during drilling. Recommended intervals for collecting chemical and physical samples are shown on Figures 5-1 through 5-8 and the analyses are discussed in Section 5.1.3.3. Archive samples will be collected at 3 m (10 ft) intervals from cuttings. All depths will be recorded to the nearest 0.025 m (0.10 ft). Sample intervals may be extended by driving the sampler a second time if an insufficient sample is collected during the first attempt. If samples cannot be obtained due to lithologic conditions, material from the drive barrel or sediment trap will be collected. At locations where multiple wells will be installed, samples will be collected from the deepest well and from the depths of the screened interval in the shallower wells.

Chemical samples will be collected and handled in accordance with EII 5.1, "Chain of Custody" (WHC 1988) and EII 5.2, "Soil and Sediment Sampling" (WHC 1988). Chemical samples will be collected with a split-spoon and/or core sampler with stainless steel liners. The sampler and liners will be decontaminated before use according to EII 5.5, "1706 KE Laboratory Decontamination of Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act (RCRA/CERCLA) Sampling Equipment" (WHC 1988). Prior to sampling, slough in the borehole will be removed to the greatest extent possible. Sampling personnel will transfer samples from the sample liners to the appropriate sample containers and preserve them in accordance with the EPA guidelines set forth in *Test Methods for Evaluating Solid Wastes* (EPA 1986). All chemical samples will be geologically logged by the well-site geologist. Chemical samples will be labeled with the appropriate Hanford Environmental Information System (HEIS) number to accommodate sample tracking and data entry into the HEIS.

All samples and cuttings will be field screened for organic volatiles and radionuclides. Volatiles will be screened by a qualified technician using an organic vapor monitor. Radionuclides will be screened by alpha and gamma counting instruments. All instruments will be used, maintained, and calibrated in a manner consistent with EII 3.2, "Calibration and Control of Monitoring Instruments" (WHC 1988), and EII 3.4, "Field Screening" (WHC 1988). The field geologist will record screening results in the borehole log (EII 9.1, "Geologic Logging" [WHC 1988]). If contamination is indicated by field screening or perched water is encountered, additional chemical samples will be collected for analyses as described in Section 5.1.3.3.

Physical samples will be collected by the same procedures as for chemical samples. Portions of physical samples that have been unconditionally radiologically released will be sent to an existing storage facility to be archived. Contaminated samples will be sent to a long-term storage facility if one is available. If one is not available, such samples will not be retained. The nonradioactive samples will be archived according to EII 5.7A, "Hanford Geotechnical Sample Library Control" (WHC 1988).

5.1.3.2.3 Well Completion. Wells will be completed according to procedures outlined in EII 6.8, "Well Completion" (WHC 1988). The design of wells will be as described in "Generic Specifications - Groundwater Monitoring Wells" (WHC 1991). In general, wells will be constructed of 10 cm (4 in.) inner diameter 304 stainless steel, joint threaded casing, and wire-wrap well screen. The screen slot and pack sand size will be determined from the results of sieve analysis.

5.1.3.2.4 Groundwater Sampling. Groundwater sampling should be carried out under the guidance of EII 5.8, "Groundwater Sampling" (WHC 1988). The only modification will be the measurement of Eh (by probe) simultaneously with the measurements for the other parameters (temperature, pH, and specific conductivity) at the time of sampling (i.e., after purging is complete).

5.1.3.2.5 Geophysical Surveys. Subsurface geophysics should be run in the five plume delineation well boreholes (UP1-1, -6, -7, -12, and -13) and the three Ringold Unit A well boreholes (UP1-4, -8, and -11) as each casing string reaches its maximum depth. Subsurface geophysics will also be run in well borehole UP1-5 from the base of Ringold Unit A through the Rattlesnake Ridge interbed. Boreholes will be logged according to EII 11.1, "Geophysical Survey Work" (WHC 1988).

In addition to the new well boreholes schedule for surveying, subsurface geophysics will be run in four existing wells (Figure 5-9). Wells 299-W22-2 and 299-W22-30 will be logged for gross gamma. The RLS spectral gamma logs will be run in Wells 299-W22-2, 299-W22-30, 299-W22-25, and 299-W22-13. The RLS spectral logging will be done in other wells within the 200-UP-1 Groundwater Operable Unit as part of the 200-UP-2 Source Operable Unit field investigation and as part of the 200 Area AAMSR screening study (WHC 1991).

5.1.3.2.6 Water Level Measurements. Groundwater levels should be measured in accordance with procedures and protocols described in EII 10.2 (WHC 1988). All observations, water levels, well depths, and other measurements will be obtained using a pre-determined reference point and will be recorded in the field notebook. Groundwater level measurements will be compared with previous measurements from the same well for consistency. If the measurements differ by more than 0.15 m (0.5 ft), depth to groundwater will be remeasured for verification. Necessary repairs and concerns associated with the condition of the well will also be identified and recorded in a field notebook.

5.1.3.2.7 Aquifer Testing. The proposed approach for aquifer testing outlined in Table 5-3 includes both single well tests and slug and pumping tests with observation wells. As an initial strategy, the single well pumping

tests are planned to be completed for the aquifers identified during installation of the proposed well clusters listed in Table 5-3. Single well slug tests should be performed first, followed by pumping tests for applicable hydrostratigraphic units. A step drawdown test will be required to determine the optimal pumping rate for the longer term (constant discharge/recovery) pumping tests.

Slug interference and pumping tests with observation wells must be staged to use observation wells with temporary screens in the hydrostratigraphic unit being tested. Following completion of testing, the observation well would continue to be advanced to its target final completion depth. An example is the slug interference test proposed for Well UP1-3 (deep unconfined portion of the uppermost aquifer). This test should use a temporary screen for Well UP1-4 for an observation well in the same hydrostratigraphic unit as Well UP1-3 is being advanced to its target final completion depth in the Ringold Unit A gravels (confined aquifer). The projected final screen depths for the proposed testing wells are listed in Table 5-4.

Specific details regarding the staging of drilling for this testing program, and other details such as well diameter and screen design specification data, pump types, and other logistical constraints should be provided in follow-on DOW documents for aquifer testing. Testing will also be conducted in accordance with procedures and protocol described for slug tests and constant discharge/recovery tests in EII 10.1 (WHC 1988). The DOW testing plans should include contingency arrangements for containing, testing, and disposing contaminated discharge water during pumping tests, if encountered.

5.1.3.2.8 Air Sampling. There are four high-volume air samplers stationed within the 200-UP-1 Groundwater Operable Unit. The samplers contain filters, which collect particles entrained in the air. The sample filters are exchanged weekly and saved to be analyzed quarterly. The air sampling effort is an on-going activity that is independent of the other activities described in this work plan. However, during the field work at the 200-UP-1 Groundwater Operable Unit the air sampling results will be monitored more closely to see if the other field activities are impacting air quality. This monitoring will involve reviewing the data that are being generated by the on-going program to see if field operations have in any way impacted the local air quality. Air sampling will also be performed for carbon tetrachloride and other VOCs during the drilling process called for in drilling DOWs.

5.1.3.3 Laboratory Analysis. Vadose and saturated zone soil samples and groundwater samples will be submitted for chemical and radionuclide analysis, as discussed in Sections 5.1.3.1.2 and 5.1.3.1.4. Vadose and saturated zone soil samples will be sent to the laboratory for physical analyses as discussed in Section 5.1.3.3.2.

5.1.3.3.1 Chemical and Radionuclide Analyses. Table QAPjP-1 (Appendix A) lists the target analytes for the 200-UP-1 Groundwater Operable Unit and specifies the method of analysis. Chemical and radionuclide analyses will include the following for soil and water:

- Volatile organics

- Semivolatile organics
- Inorganics
- Radionuclides
- Common ions, alkalinity, total organic carbon (TOC), total dissolved solid (TDS), total suspended solid (TSS) (water only).

For soil, these analyses are recommended for the early "Palouse" soils, Plio-Pleistocene Unit, just above the water table, and from the depth of the screen interval for each well. If either unexpected soil contamination or perched water is encountered during drilling, then the supervising field engineer/scientist can decide to collect unscheduled samples for analysis. For groundwater, these analyses will vary according to well, as indicated in Table 5-2.

Detection levels for groundwater analyses will follow method standards for the analyses indicated in the QAPjP except where MCL and 4% DCGs and the QRA require lower levels. Detection limits necessary to support the QRA are shown in Table 5-5 and are derived based on a target 1E-6 risk level and groundwater ingestion. Where possible, analytical methods will be selected to meet these DQOs. In order to satisfy some of these requirements, the Low-level Contract Laboratory Program (CLP) Statements of Work (SOWs) for both organics (volatiles) and inorganics will be followed.

5.1.3.3.2 Physical Analyses. Three suites of proposed analyses (labeled as Type A to Type C) are identified below to distinguish between analyses appropriate for each hydrostratigraphic unit. A summary of the type of analyses selected for each unit is presented in Table 5-6. The recommended types of analyses and approximate depths where they should be collected are shown on schematic well diagrams on Figures 5-1 through 5-8.

Type A analyses will include the following:

- Moisture content
- Soil pH/Eh
- CaCO₃ content.

The Type A analyses are recommended for the early "Palouse" soils, Plio-Pleistocene Unit, and unsaturated portions of the Ringold Unit E gravels.

Type B analyses will include the following:

- Grain and cement mineralogy
- Bulk density
- Particle size distribution
- Porosity
- Soil pH/Eh
- Cation exchange capacity
- CaCO₃ content
- Organic carbon content.

The Type B analyses are recommended for the saturated portion of the Ringold Unit E, Ringold Unit A, and Rattlesnake Ridge interbed.

Type C analyses will include the following:

- Bulk density
- Particle size distribution
- Moisture content
- Vertical hydraulic conductivity.

The Type C analyses are recommended for the Ringold Lower Mud Unit.

5.1.4 Data Evaluation (Task 7)

Information generated during the IRM and LFI activities discussed in this work plan will be evaluated in Task 7 to address data needs described in Section 4.0. As an overall approach, the data will be evaluated to meet the data needs presented in Section 4.0 and in a context to support related IRM FSs and remedial actions. The following sections present a summary overview of Task 7, including a geologic and hydrostratigraphic evaluation (Section 5.1.4.1), aquifer properties and groundwater flow characterization (Section 5.1.4.2), plume delineation (Section 5.1.4.3), and contaminant characterization and transport (Section 5.1.4.4).

The IRM and LFI activities will be staged so that priority is given to tasks that must be completed to generate information critical to other tasks. As part of the data analysis strategy, results of the more-critical field activities will be assessed first where the information is needed to guide or refine subsequent work plan activities. Results from IRM and LFI activities will be made available to personnel responsible for subsequent tasks so that they are fully informed. Examples are results of shallow unconfined aquifer testing and vertical containment profiling needed to facilitate the IRM Treatability Study. Completion of DOWs for these activities was recommended as a priority issues in Section 4.2.1.

Analytical results will also support the QRA (Section 5.1.5) and the ongoing identification of potential ARARs (Section 5.1.6) for the 200-UP-1 Groundwater Operable Unit. Data analysis results, and results of other project activities will be detailed in an interim IRM/LFI work plan report (Section 5.1.7). Throughout the data evaluation process, an emphasis will be placed on determining whether DQOs have been attained, and identifying potential deficiencies.

5.1.4.1 Geologic and Hydrostratigraphic Evaluation. Subsurface soils and groundwater conditions will be logged and recorded along with other drilling conditions during the proposed well installation activities outlined in Section 5.3.1. The physical properties data from borehole and soil sample logging will be evaluated in conjunction with information from geophysical surveys and aquifer testing. Using this information, the current understanding of geology and hydrostratigraphy in the 200-UP-1 Groundwater Operable Unit will be refined.

An initial use of the borehole geologic data will be to verify that the anticipated screen intervals for well installations listed in Table 5-4 are acceptable. It is expected that many of the screen horizons may be adjusted slightly based on the local stratigraphy.

On a broader scale, the information will be used to further evaluate the lateral extent and thicknesses of geologic and hydrostratigraphic units presented on Figure 2-1. A key feature of this evaluation is the determination of the thickness and hydrologic properties of the Ringold lower mud unit and Ringold Unit A gravels at the locations of deep wells UP1-4/5, UP1-8, and UP1-11. This information is an important factor affecting the interpretation of aquifer testing data from the confined zones.

Additional data from vadose zone soil samples are expected to provide more-detailed delineation of the lateral thickness variability for the Plio-Pleistocene unit, early "Palouse" soil, and finer grained zones of the Hanford formation (potential perching layers). The vadose zone data will be useful for conducting of source area environmental assessment, evaluating potential future contributions to groundwater contamination, and developing and remediation work plans.

Information on subsurface conditions will be obtained from the geologist logs, grab samples, split-spoon samples, or core samples as specified in individual DOWs.

5.1.4.2 Aquifer Properties and Groundwater Flow Characterization. Aquifer properties will be evaluated through samples collected during borings, geophysical surveys, and aquifer tests proposed for the work plan. Soil samples will provide detailed lithologic information, and soil testing will quantify many of the soil characteristics needed for a complete hydrogeologic evaluation. Geophysical surveys will help refine stratigraphic interpretations.

Data from aquifer tests described in Section 5.1.3.1.7 will be analyzed using a variety of potential methods listed in Table 5-3. The analytical methods will be selected based on several criteria including:

- The overall quality and representativeness of the data obtained from the aquifer testing
- Appropriateness of the analytical method for hydrogeologic conditions encountered
- The intended application of data.

Aquifer testing data will be used to assess vertical anisotropy and possible leakage between the unconfined portion of the uppermost aquifer (Ringold Unit E), and the confined portion of the uppermost aquifer (Ringold Unit A). Water level elevation data obtained from 200-UP-1 Groundwater Operable Unit wells will allow for more detailed characterization of groundwater flow and horizontal/vertical hydraulic gradients. The data will also be used to assess possible perturbations in groundwater, flow and

gradients induced by changes in volume of effluent from 200 West Area discharge sources.

Aquifer test and water level elevation data obtained during proposed work plan field activities are also intended to support groundwater flow modeling activities. As an example, results of the aquifer test data analysis are useful for supplementing previous testing data from the unconfined portion of the uppermost aquifer (Ringold Unit E) described by Connelly et. al. (1992). The previous data were used to develop a hydrogeologic model of the unconfined aquifer for the 200 West Area, and were summarized in Section 3.5 of the *200 West Groundwater AAMSR*. Similar to the recommended 1993 shallow aquifer testing using existing operable unit wells (Section 4.2.1), results of proposed work plan aquifer testing should help support groundwater modeling studies by Westinghouse Hanford to evaluate remedial technologies related to the IRM.

An additional aspect of groundwater flow characterization is the identification of wells with potential to become dry due to falling water table elevations. As discussed in Section 5.3.1.1, wells in critical monitoring locations with potential for becoming stranded should be replaced with deeper installations if sampling is to be continued. To complete this evaluation, historic water table elevation records will be reviewed and extrapolated to predict locations where well screens will become stranded. The evaluation will use verified well screen and survey data.

5.1.4.3 Plume Delineation. Groundwater chemical data collected during the field sampling program discussed in Section 5.1.3.1.4.2 will be assessed to further delineate the extent of LFI constituent plumes (and LFI portions of IRM plumes) of concern in the 200-UP-1 Groundwater Operable Unit. The sampling program includes existing wells specified for each constituent, and new wells installed in areas that currently have sparse well coverage. As discussed in Section 5.1.3.1.4.2, the proposed locations and depths of the new wells were selected to provide data for assessing both the vertical and lateral extent of the constituent plumes.

A significant component of the plume delineation effort will involve comparison of the sampling data collected with existing groundwater chemical information. As part of this comparison, a detailed assessment of the overall quality of the historical analytical data is planned to evaluate analytical quality control, differing sampling and analytical methods, detection limits, and verification of "single detections." Other factors such as the potential influence of well construction materials on analytical results will also be considered (e.g., chromium contribution to groundwater from carbon steel well casings). The description of time variation trends of plume constituents in Section 3.1 (through April 1992) provides initial background information for the purposes of comparing changes in plume configurations over time.

5.1.4.4 Contaminant Characteristics and Transport. Another objective during the analysis of groundwater chemical data is to further assess contaminant transport characteristics. This assessment provides additional understanding of plume migration patterns over time, and information for operable unit remedial alternatives. Transport characterization is intended to primarily

focus on factors affecting contaminant mobility such as soil sorption, complexation and consolvation, chemical transformation and radioactive decay, and groundwater/soil physical properties.

Transport characterization will include examining the field data collected for indications of potential accumulations of DNAPLs and evidence of horizontal/vertical DNAPL movement. Sampling data that is planned to be collected from the lower unconfined aquifer will also be examined for indications of potential high-salt density plumes, similar to those associated with ^{90}Sr and ^{137}Cs in the 200 East Area. Direct (sampling) evidence of DNAPL and density plume phases has not been found in the 200-UP-1 Groundwater Operable Unit.

Other aspects of the contaminant characterization and transport effort include the following:

- Characterization of parent radionuclide species contributing to total alpha, beta, and gamma radiation (incorporating new laboratory radiological analysis and available Westinghouse Hanford RLS spectral gamma geophysics data)
- Evaluation of contaminant contribution from vadose zone sources
- Evaluation of contaminant and groundwater recharge sources from outside the operable unit
- Comparison of detected constituent concentrations to Hanford Site background levels being identified in ongoing studies.

Methodologies used to assess contaminant transport will consider those previously used for developing the plume model, as well as others supported by 200-UP-1 Groundwater Operable Unit data (e.g., hydraulic conductivity transmissivity model refinement for the Uranium- ^{99}Tc -Nitrate IRM Treatability Study).

5.1.5 Qualitative Risk Assessment (Task 8)

A QRA is defined in the *Hanford Site Past-Practice Strategy* (DOE/RL 1992e) as "a judgment not based solely on quantification, agreed to by the parties, based upon available site data regarding the threat posed by site contamination." While the QRA may have quantitative elements, including numerical risk estimates based on contaminant concentration data, it may also provide qualitative estimates of risk based on nonquantitative inputs. Unlike the baseline RA, the QRA is not intended to provide a final assessment of risk, instead it provides an early scoping assessment based on existing information.

A QRA may be performed on the basis of existing site data, or may be performed following evaluation of LFI data, and is intended to support the justification and implementation of the IRM. The LFI premise is that it is

not necessary, in all cases, to extensively characterize a site before cleanup decisions can be made. The QRAs will be conducted in accordance with the guidance provided in the *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1992g). The DQOs of the LFI will be established based on the use of the data in deciding on IRMs. The QRAs are currently planned for the group of groundwater plumes where IRMs may be appropriate. These are the plumes containing nitrate, uranium, ⁹⁹Tc, chloroform, and trichloroethylene. In those instances where these plumes may overlap or contain multiple contaminants, the QRA will examine both individual contaminant and aggregate risks. The IRM path is based on the *Hanford Site Past-Practice Strategy* (DOE/RL 1992e) of two-phased evaluation of these plumes. Following identification that an IRM may be appropriate based on existing contaminant characterization, remedial actions will be started, with additional sampling and characterization conducted during remediation. This additional data collection will be used to evaluate the plumes further after the IRM is complete to determine if additional site cleanup may be required.

One of the initial steps in proceeding with an IRM for these plumes will be the performance of QRAs to better characterize the potential risks associated with these plumes and their known contaminants. The QRAs will use existing contaminant data as input, with use of analogous data from similar disposal practices and geology to supplement these data and fill any significant data gaps. The QRA results may be used, in conjunction with other inputs, to help determine the need for IRMs, to select IRM, and to determine risk-based cleanup levels for the IRMs. As stated previously, the QRA provides an early "scoping" assessment of potential risks based on existing and potentially limited site data. It does not replace the baseline RA that will provide a quantitative assessment of potential risks based on comprehensive site characterization.

The QRA results will also be useful in judging the adequacy of existing data. Data gaps exist regarding the nature and extent of potential secondary contaminants. The need for further sampling and analyses to characterize potential secondary contaminants, primarily nonradioactive organic and inorganic compounds, will be evaluated in light of the QRA results. Additional characterization efforts may be determined to be unnecessary if the QRA results indicate that potential secondary contaminants are not likely to contribute to overall risks, or that primary contaminant concentrations are adequate predictors of secondary contaminant levels.

If additional characterization data are determined to be necessary, they will be collected and input to a qualitative reassessment of potential risks and target contaminant levels. Because data collected during the IRM process will be used to refine the conceptual model as cleanup progresses, QRAs may be performed at several stages during an IRM.

The QRA will implement the general methodology documented in *Hanford Site Baseline Risk Assessment Methodology* (DOE/RL 1992g). Consistent with the methodology, the commercial/industrial exposure scenario will be adapted based on the specific physical characteristics of the site, and applicable transport pathways, exposure routes, and receptors will be defined.

5.1.6 Identification of Potential Contaminant- and Location-specific Applicable or Relevant and Appropriate Requirements (TASK 9)

The formulation of operable unit-specific ARARs is an ongoing process throughout the LFI/Treatability Study. Potential ARARs were identified in the 200 West Groundwater AAMSR. In addition, potential ARARs for the 200 West Area are being currently developed. Following the evaluation of analytical data under Task 7, potential contaminant-specific and location-specific ARARs will be reviewed based upon the new knowledge of contamination at the site and the site setting. Once the potential ARARs for the 200-UP-1 Groundwater Operable Unit have been properly identified, EPA and Ecology will be asked to verify the potential contaminant- and location-specific ARARs.

5.1.7 Limited Field Investigation Report (Task 10)

An interim report will be prepared upon completion of the LFI work plan activities described in Tasks 1 through 9. The interim report will provide a preliminary summary of the results of these characterization activities and describe refinements to the operable unit conceptual model. A key aspect of the report will be to identify additional chemical and radionuclide constituents that are recommended for IRM consideration based on results of the QRA. Outstanding uncertainties and data gaps will be noted along with additional recommended actions (as appropriate) to clarify these issues as they relate to the operable unit IRM and other data needs. The recommendations may include proposed strategies for ongoing well sampling, groundwater level elevation monitoring, data quality review, additional well installation, and similar activities to address data needs related to operable unit IRM and FRS efforts. The LFI report draft iterations would be completed for DOE and regulatory review and would be phased to accommodate IRM scheduling requirements.

5.2 INTERIM REMEDIAL MEASURE PROCESS

The IRM process will include a sequence of activities to address the Uranium-⁹⁹Tc-Nitrate IRM plume. These include a pilot-scale (for uranium and ⁹⁹Tc) and laboratory/bench scale (for nitrate) treatability tests and QRA that will be conducted concurrently. These studies will then be followed by an IRM Proposed Plan, an IROD, and an IRM design report leading up to implementation. Details of these steps are described in the next sections.

5.2.1 Treatability Study

A pilot-scale treatability test will be conducted to evaluate the effectiveness of pump and treat to remediate the Uranium-⁹⁹Tc-Nitrate IRM plume. Pump and treat involves the extraction of contaminated groundwater and ex situ (above-ground) treatment using one or more treatment technologies (e.g., ion exchange, chemical precipitation, etc.).

The DOE, EPA, and Ecology have agreed to a tentative milestone to start pump and treat operations by March 31, 1994, pending approval of this work plan. The treatability test will focus on the uranium and ^{99}Tc plumes beneath the U Plant Source Aggregate Area and use existing wells. Although the treatment system will be optimized to remove uranium and ^{99}Tc from extracted groundwater including nitrate, the system will also be assessed for its effectiveness on secondary contaminants known to exist in the groundwater. Treated groundwater will be returned to the aquifer in the area of the IRM plume.

The purpose of the treatability test will be to assess the performance, operating conditions and costs of pump and treat remediation. Although pump and treat is considered a viable and proven technology, it is also recognized that numerous site-specific factors may influence the effectiveness of pump and treat as a remediation alternative. The test will also serve as a proof-of-principal demonstration, and establish engineering design values and functional costs to support the selection of a preferred alternative in the IRM Proposed Plan.

A treatability test plan will be prepared that describes the purpose, scope, and objectives of the test, test location, selected treatment technology, and system design. Following the completion of the test, a treatability test report will be prepared summarizing the results of the study. The pump and treat test is expected to be completed in 1994. However, if the pump and treat system is determined to be effective, groundwater treatment will continue until the IROD is issued. If treatment is continued, the pump and treat system (e.g., wells and equipment) may be modified/expanded to optimize remediation.

5.2.2 Interim Remedial Measure Qualitative Risk Assessment

A QRA is recommended to better assess the potential risks associated with the Uranium- ^{99}Tc -Nitrate IRM plume. Existing and new groundwater data should be used to assess the potential risks on an individual-contaminant and aggregate-contaminant basis. The assessment is intended to support the justification for implementing an IRM and assist in the establishment of remediation goals and objectives in the IRM Proposed Plan.

The QRA will be conducted in accordance with the *Hanford Site Baseline Risk Assessment Methodology* (DOE/R 1992g). A commercial/industrial scenario will be used which is consistent with the methodology and the *200 West Groundwater AAMSR*. The QRA may be updated through several iterations during the IRM as the conceptual model is refined using data collected during the IRM and supporting LFI. This approach is consistent with the observational approach.

5.2.3 Interim Remedial Measure Proposed Plan

The IRM Proposed Plan is a primary document that provides the public with background information including supporting Remedial Investigation/Feasibility Study activities (e.g., 200 West Groundwater AAMSR, LFIs) and identifies the IRM selected. Following the completion of the pilot-scale treatability test, an IRM Proposed Plan addressing the Uranium-⁹⁹Tc-Nitrate IRM plume will be prepared to support an IROD. The IRM Proposed Plan will integrate the results of the LFI, Treatability Study, and QRA to define the full scope of the IRM and identify a preferred remedial alternative. The extent of the plume will be investigated as part of the LFI. Selection of the preferred alternative for this IRM will be based on results of the treatability test, and remediation goals/objectives will be based on a QRA.

Based on the results of the LFI, additional IRMs may be identified for the 200-UP-1 Groundwater Operable Unit. As a result, additional plans may be required or the existing plan may be revised accordingly. Identification of any additional IRMs will be described in detail in the LFI report.

5.2.4 Interim Record of Decision

The IROD will summarize the treatability test report as well as any changes to the selected IRM occurring as a result of public comment on the IRM Proposed Plan. The IROD is a primary legal document certifying that the IRM selection process was carried out in accordance with CERCLA, and committing the three parties to perform the IRM(s) in accordance with its specifications. The IROD will present three primary subjects: 1) technical description of the IRM, 2) estimated costs, and 3) background information regarding the site. The IROD will include decision points and criteria for continuation, expansion, or cessation of the IRM. The IROD will be written and issued by the regulators.

5.2.5 Interim Remedial Measure Design Report

The IRM design report is a secondary document and provides engineering and technical specifications for implementing the IRM identified in the IROD.

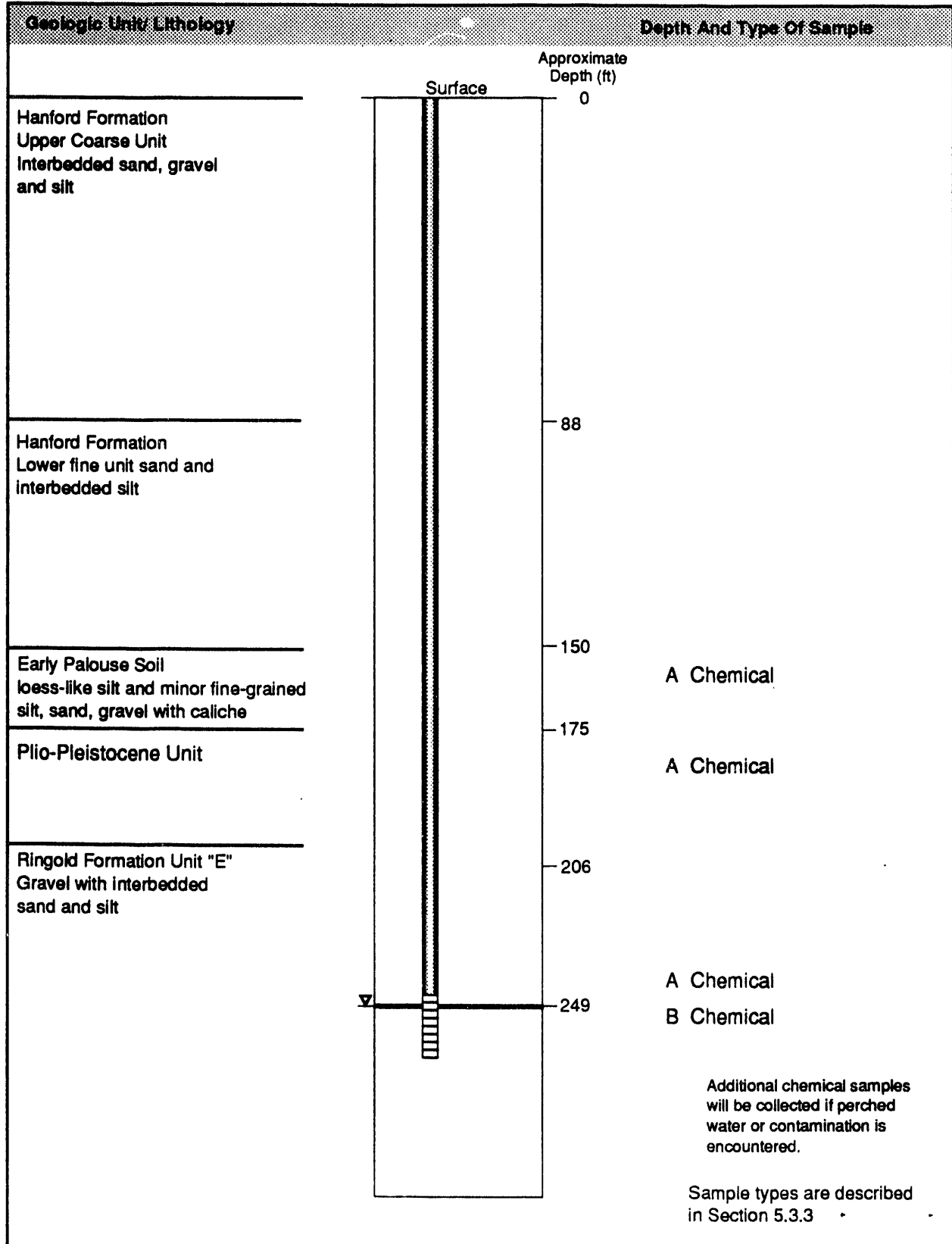
5.2.6 Interim Remedial Measure Implementation

The observational approach will be used to continually optimize the effectiveness of the IRM. The IRM should be implemented in phases starting with a modest effort and modifying/expanding the remedial design appropriately as the information base expands and refinements to the conceptual model are made. The IRM scope will include some level of characterization required to implement the observational approach such as measuring the response of the aquifer to the remedial action.

Data collected during IRM implementation may be used in the FRS. Although the IRM primarily addresses high priority groundwater contaminants, secondary contaminants may be incorporated into the implementation. Upon

completion of the IRM phase of site remediation, any further actions needed to achieve final cleanup objectives will be addressed under the FRS path.

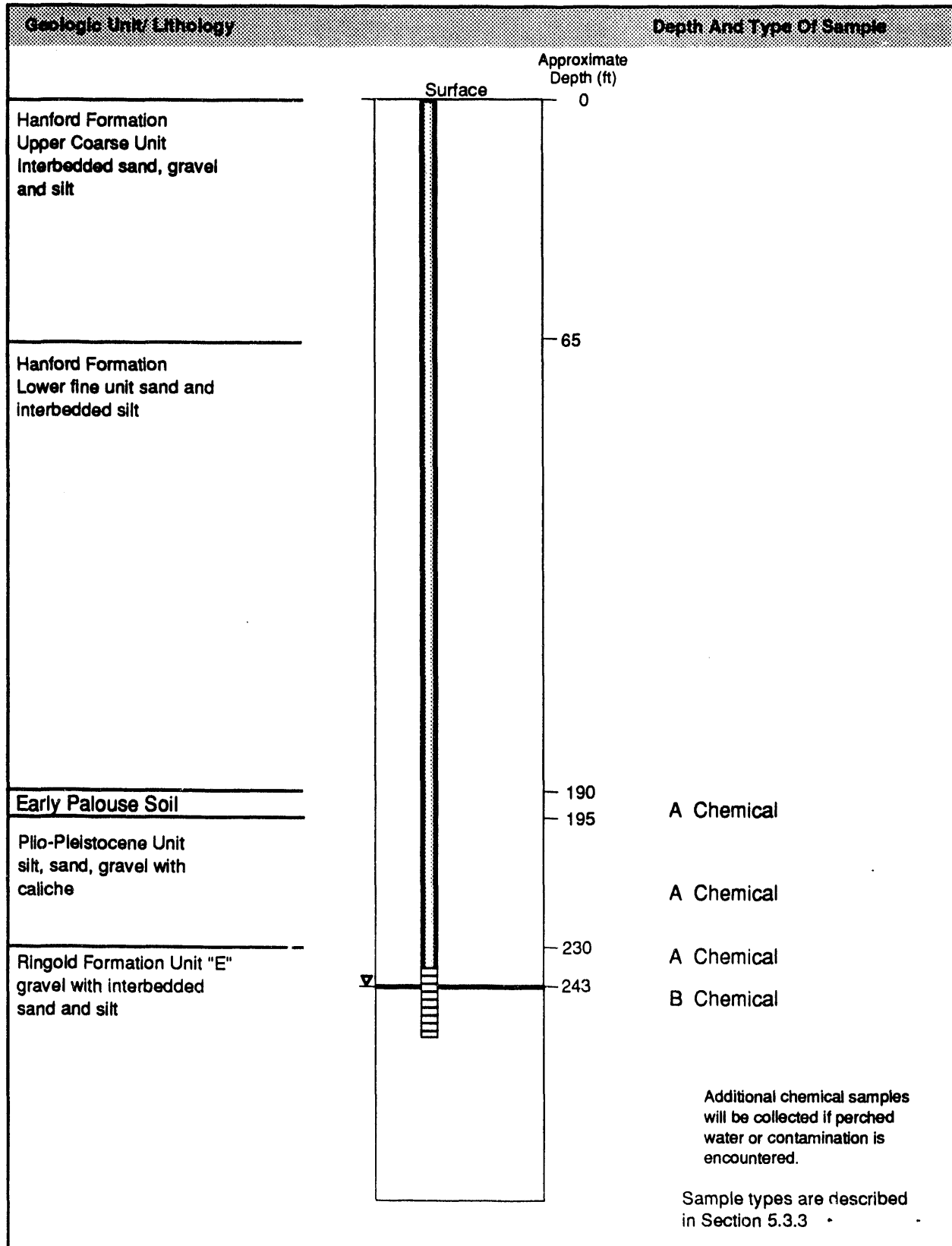
UP1-1



WHC405

Figure 5-1. Schematic Diagram of Well UP1-1 and Depth of Sampling.

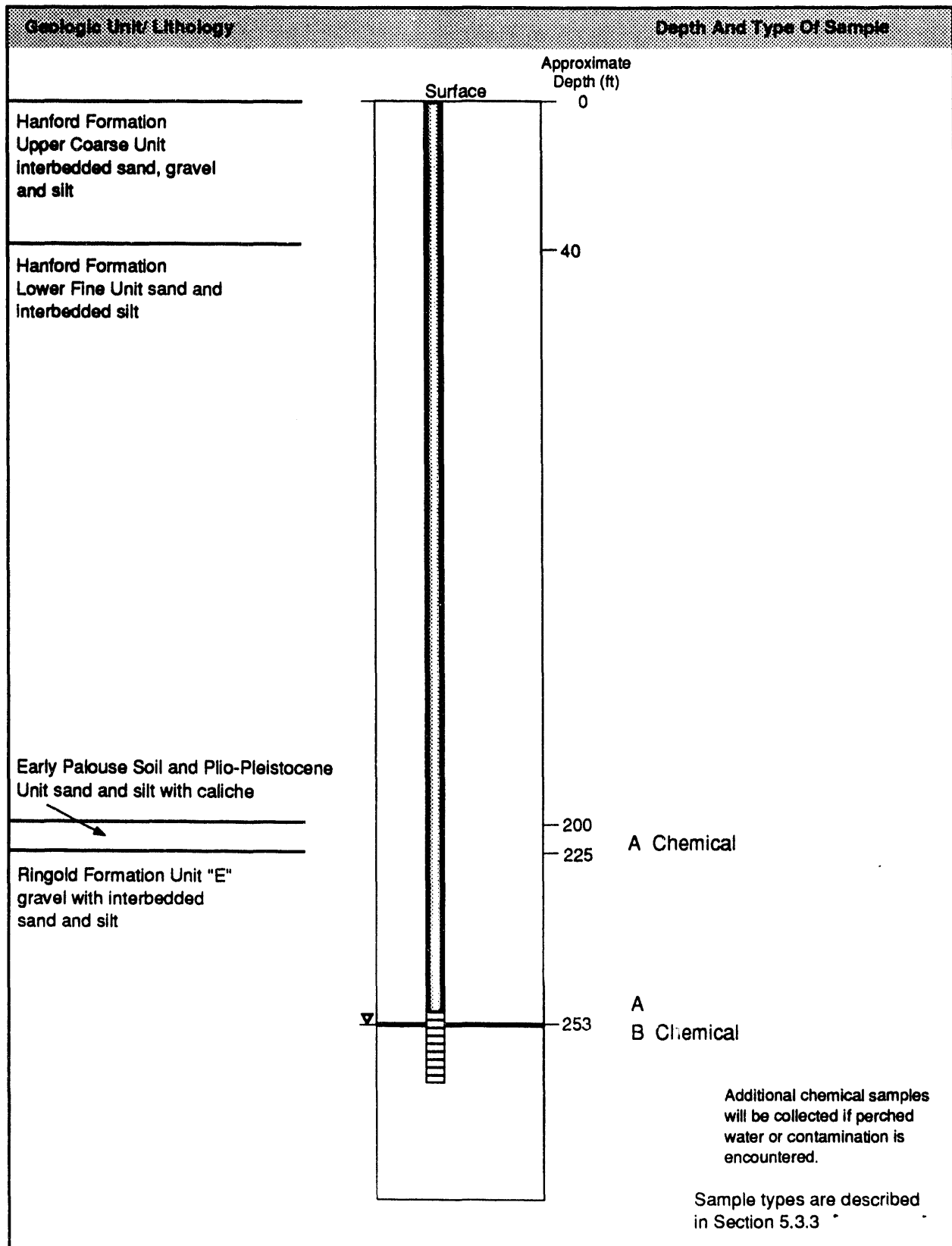
UP1-6



WHC405

Figure 5-2. Schematic Diagram of Well UP1-6 and Depth of Sampling.

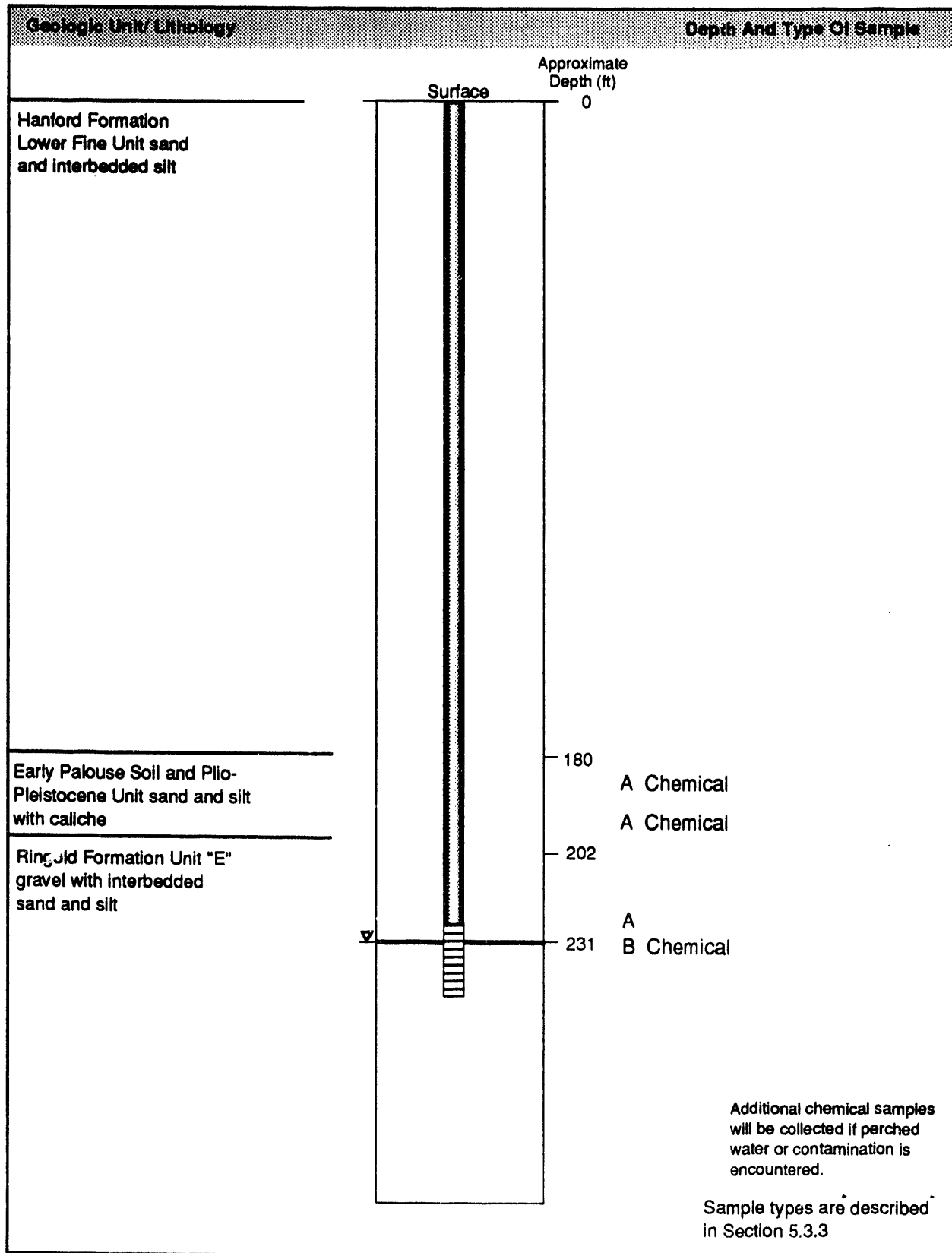
UP1-7



WHC405

Figure 5-3. Schematic Diagram of Well UP1-7 and Depth of Sampling.

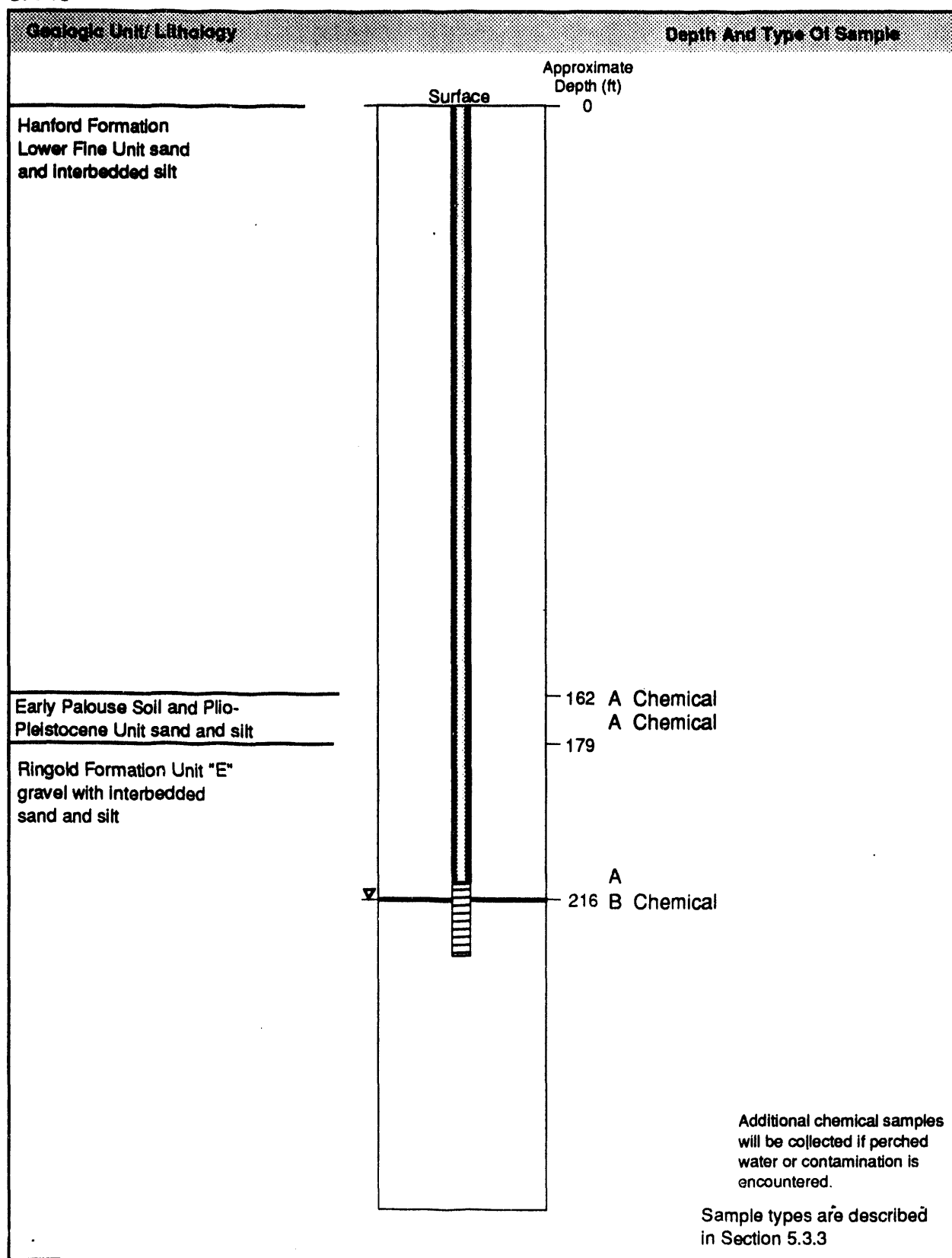
UPI-12



WHC405

Figure 5-4. Schematic Diagram of Well UPI-12 and Depth of Sampling.

UPI-13



WHC405

Figure 5-5. Schematic Diagram of Well UPI-13 and Depth of Sampling.

UP1-2, 3, 4, 5

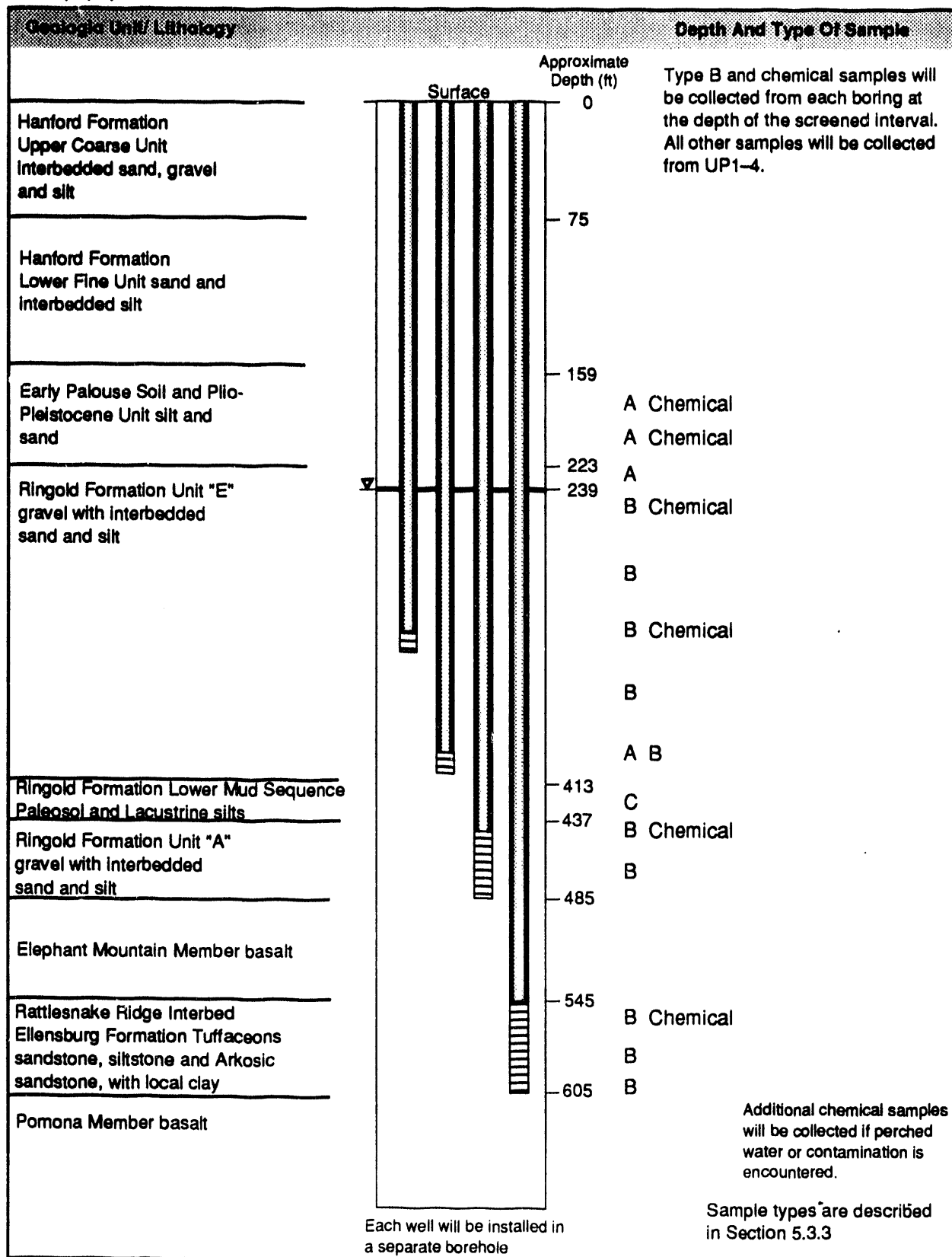
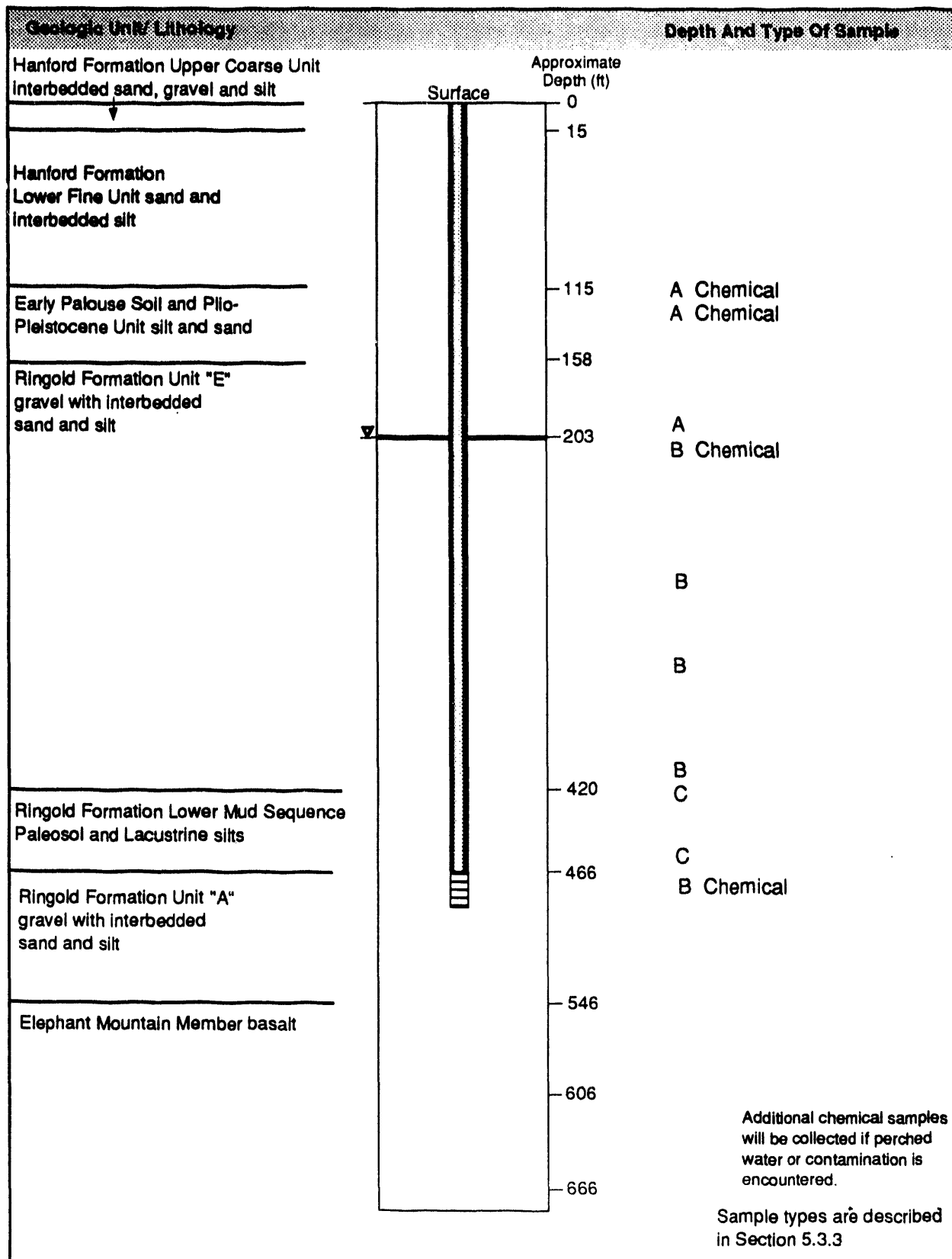


Figure 5-6. Schematic Diagram of Wells UP1-2, -3, -4, -5 and Depth of Sampling.

WHC405

UP1-8



WHC405

Figure 5-7. Schematic Diagram of Well UP1-8 and Depth of Sampling.

UP1-9, 10, 11

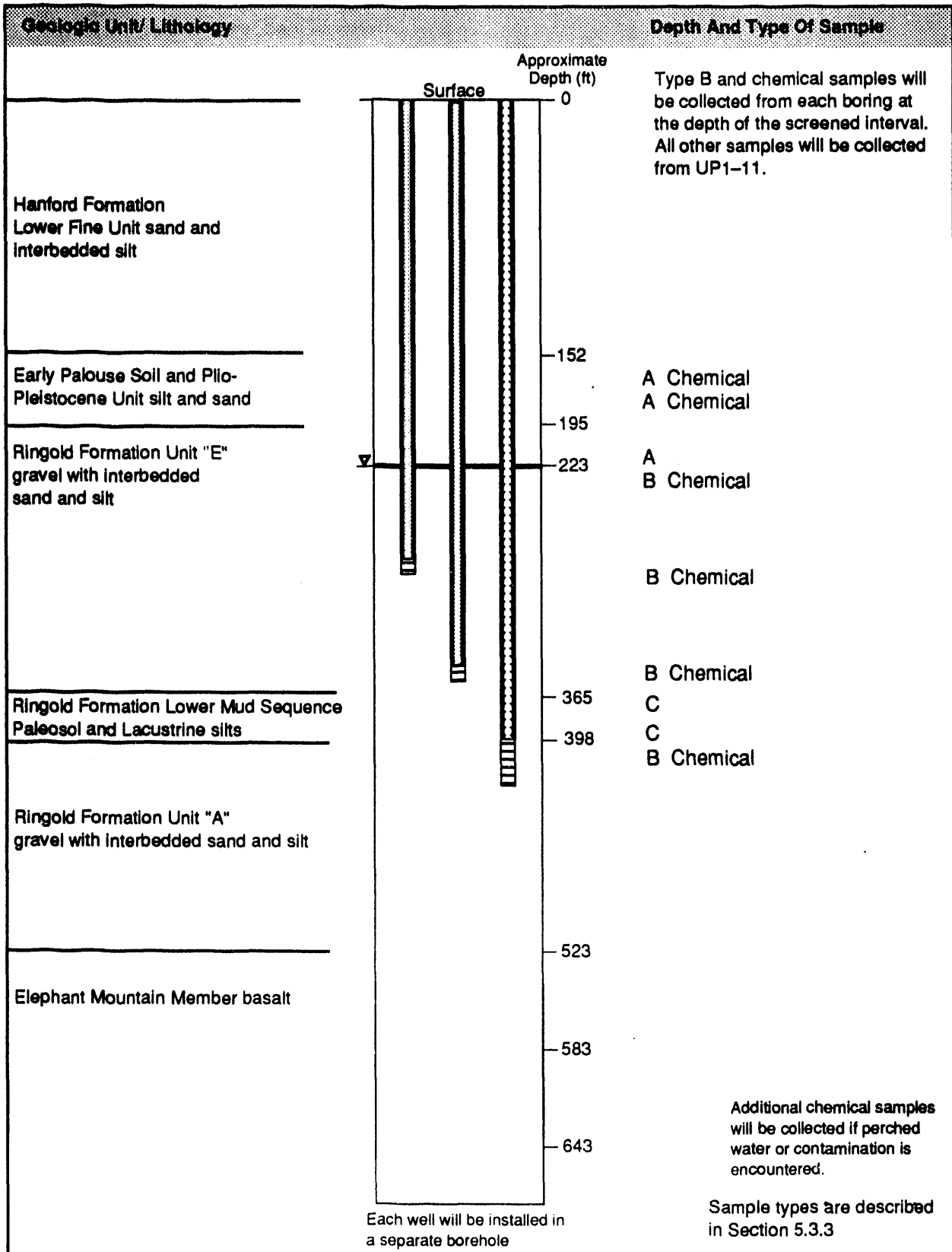


Figure 5-8. Schematic Diagram of Wells
UP1-9, -10, and -11 and Depth of Sampling.

WHC405

SF-9

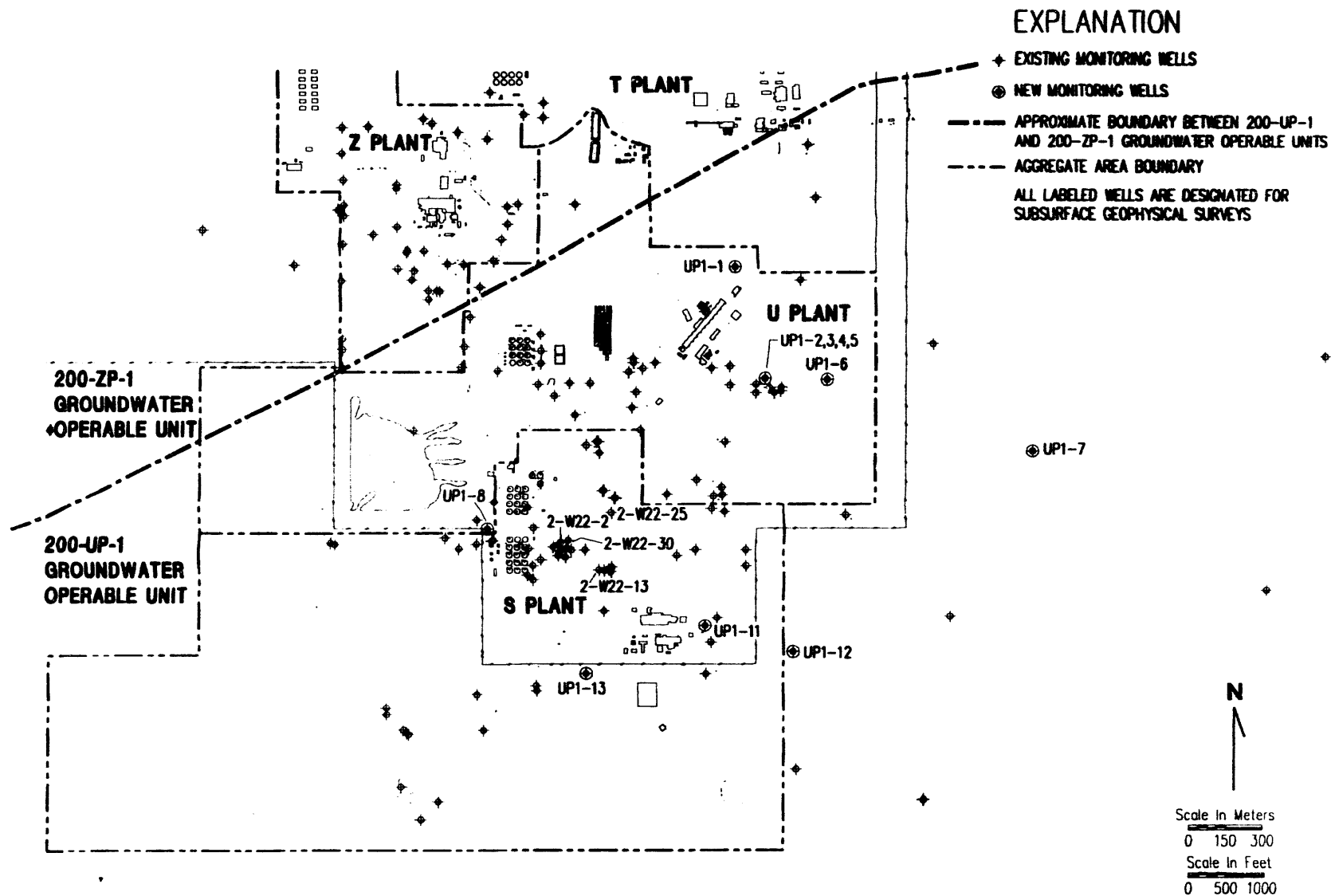


Figure 5-9. Proposed Location of Monitoring Wells for Geophysical Surveys.

c:\projects\wrc\200a7

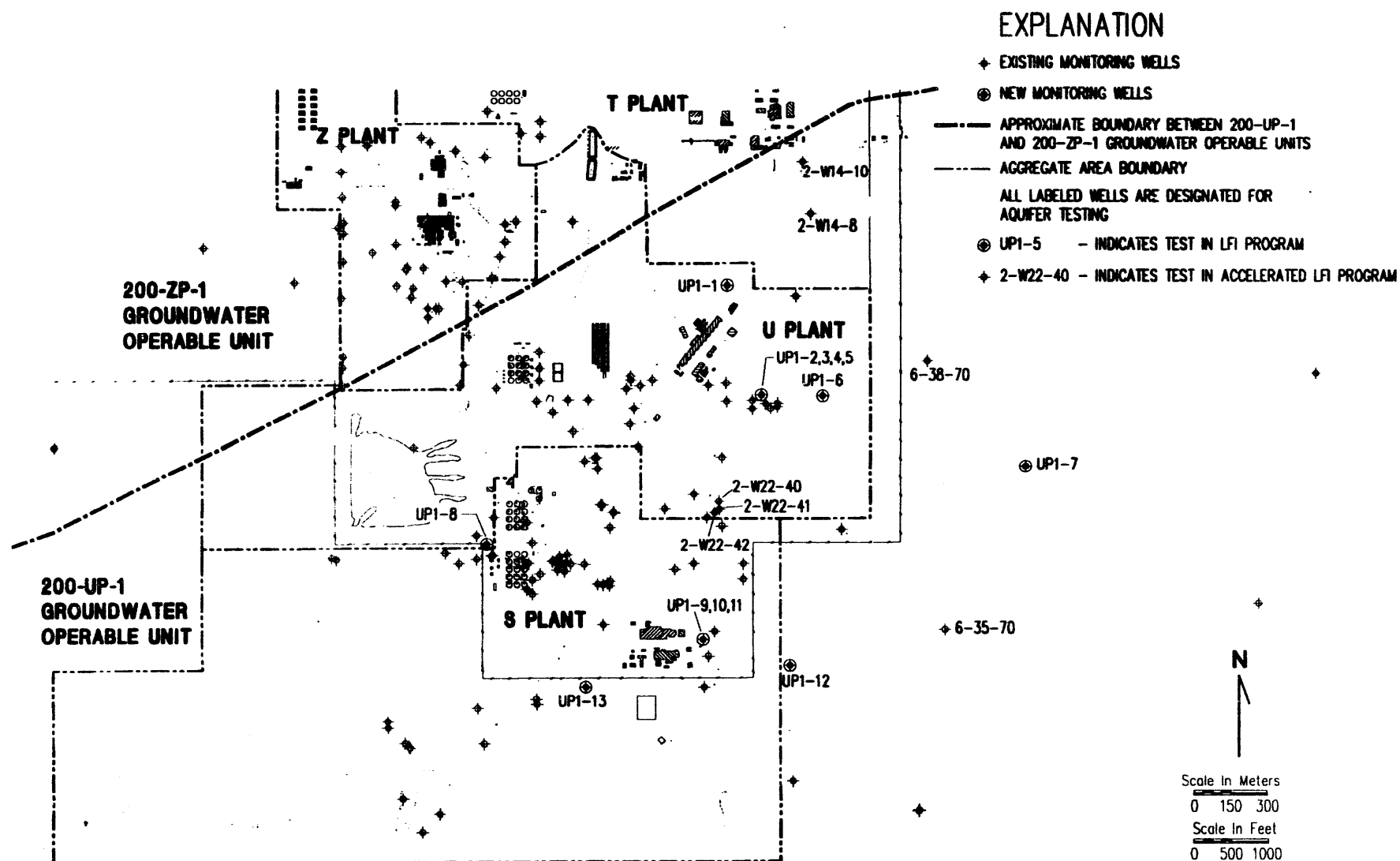


Figure 5-10. Proposed Location of Monitoring Wells for Aquifer Tests.

Table 5-1. Relationship Between Tasks and Field Activities.

Field Sampling Plan Tasks	Source Characterization (Task 2)	Geologic Investigation (Task 3)	Vadose Zone Investigation (Task 4)	Groundwater Investigation (Task 5)	Air Investigation (Task 6)
Primary Field Activities					
Borings	X	X	X	X	--
Subsurface Geophysics	X	X	X	X	--
Surface Soil Sampling	X	--	--	--	--
Source Sampling	X	--	--	X	--
Perched Water Sampling	--	--	X	--	--
Air Monitoring	--	--	--	--	X
Vadose Zone Model Calibration	--	--	X	--	--
Aquifer Tests	--	--	--	X	--
Well Condition Assessment	--	--	--	X	--
Groundwater Sampling	--	--	--	X	--
Water Level Measurements	--	--	--	X	--
Supporting Field Activities					
Geodetic Surveys	X	X	X	X	X
Sample Designation and Handling	X	X	X	X	X
Decontamination	X	X	X	X	X
Waste Disposal	X	X	X	X	X

Table 5-2. Groundwater Sampling and Analyses.

Page 1 of 3

Well	Notes	Screen	Analysis
299-W14-10	a, LFI	195-230	Semivolatiles, Pesticides
299-W18-15	a, LFI	170-243	Inorganics, Gross alpha, U
299-W18-20	LFI	220-249	Volatiles
299-W19-2	a, IRM, LFI	235-295	Nitrate, U, Tc-99, Sr-90
299-W19-3	b, LFI	230-280	(Pesticides)
299-W19-4	c, IRM, LFI	255-535	Volatiles, Nitrate, U, Tc-99, I-129, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
299-W19-9	b, LFI	214-244	(Pesticides), Nitrate, U, Tc-99
299-W19-11	a, b, LFI	220-250	(Pesticides), Nitrate, U, Tc-99
299-W19-12	a, LFI	210-250	Inorganics, Tc-99, K-40
299-W19-16	a, b, LFI	225-275	(Pesticides)
299-W19-18	a, IRM, LFI	230-355	Volatiles, Pesticides, Nitrate, U, Tc-99, Sr-90, Gross Alpha, Gross Beta, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
299-W19-19	IRM	230-250	Nitrate, U, Tc-99
299-W19-21	a, LFI	201-226	Inorganics, K-40
299-W19-24	a, d, IRM, LFI	235-255	Nitrate, U, Tc-99, Sr-90, Volatiles, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
299-W19-25	a, d, LFI	226-246	Volatiles, Gross Alpha, Gross Beta
299-W19-27	a, d, LFI	208-228	Inorganics
299-W19-28	a, d, LFI	236-256	Volatiles
299-W19-29	LFI	235-255	Volatiles
299-W19-31	LFI	201-222	Inorganics, Tc-99, Alkalinity, TDS, TSS, TOC, Common Ions
299-W19-32	d, LFI	201-222	Inorganics, Tc-99, K-40
299-W21-1	a, IRM	221-290	Nitrate, U, Tc-99, Sr-90
299-W22-1	LFI	190-280	Sr-90
299-W22-2	LFI	195-285	Sr-90
299-W22-7	LFI	223-308	Gross Beta
299-W22-9	a, LFI	220-299	Volatiles, Inorganics
299-W22-10	a, LFI	203-311	Sr-90, Pu-238

ST-2a

DOE/RL-92-76, Rev. 0

Table 5-2. Groundwater Sampling and Analyses.

Page 2 of 3

Well	Notes	Screen	Analysis
299-W22-19	LFI	212-330	Volatiles, Inorganics, Gross Beta
299-W22-20	a, LFI	205-299	Volatiles, Inorganics, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
299-W22-21	a, LFI	200-285	Volatiles, Inorganics, Pu-238, I-129, Sr-90, Tc-99, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
299-W23-2	LFI	184-235	Gross Beta, Tc-99
299-W23-3	LFI	176-228	Tc-99
299-W23-4	LFI	180-300	U, Gross Alpha, Gross Beta
299-W23-5	LFI	215-245	Tc-99
299-W23-7	LFI	170-248	Tc-99, Gross Beta
299-W23-9	f, LFI	164-230	Semivolatiles
299-W23-10	a, LFI	165-230	Semivolatiles
299-W23-11	a, f, LFI	165-230	Semivolatiles, Inorganics
299-W23-14	LFI	193-215	Volatiles, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
299-W26-1	LFI	NA	Inorganics
299-W26-6	LFI	191-221	Inorganics
299-W26-7	LFI	184-205	Inorganics, Alkalinity, TDS, TSS, TOC, Common Ions
299-W26-8	d, LFI	195-215	Volatiles, I-129
299-W26-9	LFI	184-204	Inorganics
299-W27-1	a, LFI	216-236	Volatiles, Inorganics, Pu-238
699-32-62	IRM, LFI	365-370	Nitrate, I-129
699-35-78	LFI	330-389	Volatiles
699-36-61A	IRM, LFI	330-389	Nitrate, I-129
699-38-70	IRM, LFI	255-380	Volatiles, Nitrate, U, Tc-99, Sr-90, Alkalinity, TDS, TSS, TOC, Common Ions
699-40-62	LFI	335-374	I-129
699-40-63	IRM	NA	Nitrate
UP1-1	c, IRM, LFI	245-275	Volatiles, Semivolatiles, Inorganics, Nitrate, U, Tc-99, I-129, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-2*	IRM, LFI	320-330	Volatiles, Semivolatiles, Inorganics, Nitrate, U, Tc-99, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-3*	IRM, LFI	400-410	Volatiles, Semivolatiles, Inorganics, Nitrate, U, Tc-99, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions

5T-2b

DOE/RL-92-76, Rev. 0

Table 5-2. Groundwater Sampling and Analyses.

Well	Notes	Screen	Analysis
UP1-4*	IRM, LFI	440-450	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, U, Tc-99, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-5*	g, LFI	545-555	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, U, Tc-99, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-6	IRM	235-265	Nitrate, U, Tc-99, Volatiles, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-7	IRM	245-275	Nitrate, U, Tc-99, Volatiles, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-8*	LFI	470-480	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, Gross Alpha, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-9*	LFI	300-310	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-10*	LFI	350-360	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-11*	LFI	400-410	Volatiles, Semivolatiles, Inorganics, Pesticides, Nitrate, Gross Beta, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-12	LFI	225-255	Volatiles, Inorganics, I-129, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions
UP1-13	LFI	210-230	Volatiles, Inorganics, Sr-90, Tc-99, I-129, Gross Alpha, Gross Beta, Semivolatiles, Alkalinity, TDS, TSS, TOC, Common Ions

* Indicates wells screened below the uppermost portion of the water table.

a: These wells have been scheduled for resurvey in 1993/1994 by Westinghouse Hanford.

b: These wells will be sampled for pesticides only if the previous single detection of pesticides in Well 299-W19-18 is confirmed.

c: If 299-W19-4 is not suitable for sampling the top of the uppermost aquifer, UP1-1 will be installed.

d: These wells are RCRA compliant.

e: Well 299-W19-97 is planned for the 200-UP-2 Source Operable Unit investigation. This boring is targeted to intercept perched water. It will be extended to the water table if perched water is not encountered.

f: These wells will be sampled for semivolatiles only if the previous single detection of N-nitrosodimethylamine in Well 299-W23-10 is confirmed.

g: UP1-5 will be installed after IRM activities are completed.

TDS = Total dissolved solids

TSS = Total suspended solids

TOC = Total organic carbon

NA = Information on screen interval not available

IRM : Indicates that this well will be part of an IRM investigation.

LFI: Indicates that this well will be part of an LFI investigation.

Table 5-3. Aquifer Testing Method and Well Summary.

Type of Aquifer Test	Data Determined from Test	Targeted Hydrostratigraphic Units for Testing and Recommended Wells (UP1-X)	Anticipated Analysis Methods	Recommended Observation Wells
Recommended LFI Aquifer Testing of New Wells				
Slug Test - Single Well	Hydraulic Conductivity (K)	RE-shallow (1,2,3,6,7,8,10,12,13) ^{b/}	BR,P	NA
		RE-intermediate (3,8,9) ^{b/}	BR,P	NA
		RE-deep (3,10) ^{b/}	BR,P	NA
		RA (4,8,11)	HV,K	NA
		RR (5) ^{d/}	HV,K	NA
Pumping Test (single well)	Transmissivity (T)	RE-deep (3,10) ^{a/}	N	NA
		RA (4,8,11)	JC,H,T	NA
		RR (5) ^{d/}	JC,H,T	NA
Pumping Test with Vertically Separated Observation Well	Vertical Hydraulic Conductivity (Kv) (within 1 unit)	RE-deep(10) ^{a/}	N	UP1-11 ^{c/}
Pumping Test with Observation Wells in Different Units	Hydraulic Conductivity (Kv) (between units)	RE-RA (3 or 10)	NW	UP1-4 ^{d/} or -11
		RR-RR (4)	NW	UP1-5 ^{d/}
Short Term Pressure Build-up	Relative Permeability	RR (5) ^{d/}	TBD	NA
Slug Interference Test with Observation Well in Same Unit	Hydraulic Conductivity (K)	RE-intermediate (2,9)	S	UP1-3, -11 ^{c/}
	Storativity (S)	RE-deep (3,10)	S	UP1-4, -11 ^{c/}
Pumping Test with Observation Well in Same Unit	Hydraulic Conductivity (K)	RE-deep (3,10)	N	UP1-4, -11 ^{c/}

NA Not Applicable

Key to Analysis Methods

N: Neuman (1972)

JC: Jacob-Cooper (1946)

TR: Theis Recovery-Driscoll (1986)

NW: Neuman-Witherspoon (1972)

T: Theis (1935)

H: Hantush-leaky aquifer (1956, 1960)

HV: Hvorslev (1951)

BR: Bouwer-Rice (1976)

K: Kipp (1985)

S: Spaine (1992)

P: possible new method to be developed for inertial effects in unconfined aquifers

TBD: To be determined

Key to Hydrostratigraphic Units

RE: Ringold E Gravels (shallow, intermediate, deep)

RA: Ringold A Gravels

RR: Rattlesnake Ridge Interbed

^{a/} Pumping test contingent on DQO constraints concerning pumping contaminated water outline in Table 5-4.^{b/} Utilize temporary screen for wells planned for deeper final completion.^{c/} Utilize temporary screen for observation wells planned for deeper completion^{d/} RR Well UP1-5 and associated aquifer testing are anticipated to be completed following completion of operable unit IRM activities.

Table 5-4. 200-UP-1 Groundwater Operable Unit Wells.

Well	Estimated Depth of Boring (ft)	Estimated Screen Interval (ft)	Geologic Unit Screened	Primary DQO	Location
UP1-1 ^{a/}	275	245-275	Ringold Unit E	Horizontal extent of plumes	Northern boundary of U Plant
UP1-2	330	320-330	Ringold Unit E	Vertical extent of plumes	Adjacent to 299-W19-24
UP1-3 ^{b/}	415	400-410	Ringold Unit E	Vertical extent of plumes	Adjacent to 299-W19-24
UP1-4	450	440-450	Ringold Unit A	Hydraulic gradients	Adjacent to 299-W19-24
UP1-5 ^{b/}	605	545-555	Rattlesnake Ridge Interbed	Hydraulic gradients	Adjacent to 299-W19-24
UP1-6	265	235-265	Ringold Unit E	Horizontal extent of plumes	Eastern boundary of U Plant
UP1-7	275	245-275	Ringold Unit E	Horizontal extent of plumes	3,000 ft east of U Plant boundary
UP1-8	480	470-480	Ringold Unit A	Hydraulic gradients	Adjacent to 299-W23-14
UP1-9	310	300-310	Ringold Unit E	Vertical extent of plumes	Adjacent to 299-W22-20
UP1-10	360	350-360	Ringold Unit E	Vertical extent of plumes	Adjacent to 299-W22-20
UP1-11	410	400-410	Ringold Unit A	Hydraulic gradients	Adjacent to 299-W22-20
UP1-12	255	225-255	Ringold Unit E	Horizontal extent of plumes	1,000 ft east of 299-W22-20
UP1-13	240	210-240	Ringold Unit E	Horizontal extent of plumes	2,000 ft southwest of 299-W22-20

- ^{a/} UP1-1 will be installed if Well 299-W19-4 is not suitable for sampling.
^{b/} UP1-5 will be installed after IRM activities are completed.

Table 5-5. Detection Limit DQOs Based on 1E-6 Risk Level for Target Constituents.

Radiological Constituent	Ingestion Slope Factor^{a/} (Risk per pCi)	Derived Concentration Associated with 1E-6 Risk^{b/} pCi/L
I-129	1.90E-10	1.05E+00
Am-241	2.40E-10	8.33E-01
K-40	1.10E-11	1.82E+01
Pu-238	2.20E-10	9.09E-01
Pu-239	2.30E-10	8.70E-01
Pu-240	2.30E-10	8.70E-01
Sr-90	3.30E-11	6.06E+00
Tc-99	1.30E-12	1.54E+02
Ra	1.20E-10	1.67E+00
U-234	1.60E-11	1.25E+01
U-235	1.60E-11	1.25E+01
U-238	1.60E-11	1.25E+01
Chemical Constituent	Ingestion Slope Factor^{a/} (Risk per mg/kg/day)	Derived Concentration Associated with 1E-6 Risk^{b/} mg/L
F	noncarcinogen	
NO ₂	noncarcinogen	
NO ₃	noncarcinogen	
Arsenic	inhalation only	
Chromium	inhalation only	
Beryllium	4.30E+00	8.32E-05
Cadmium	inhalation only	
Selenium	noncarcinogen	
Chloroform	6.10E-03	5.86E-02
Cyanide	noncarcinogen	
Bis(2-ethylehexyl) phthalate	1.40E-02	2.56E-02
DDT	3.40E-01	1.05E-03
1,2-Dichloroethane	9.10E-02	3.93E-03
n-Nitrosodimethylamine	5.10E+01	7.01E-06
1,1,1-Trichloroethane	inhalation only	
Trichloroethylene	no data	
Methylene chloride	7.50E-03	4.77E-02
1,1-Dichloroethylene	6.00E-01	5.96E-04
Aldrin	1.70E+01	2.10E-05
DDD	2.40E-01	1.49E-03
Dieldrin	1.60E+01	2.24E-05
Endrin	noncarcinogen	
Endrin aldehyde	no data	
Gamma-BHC	no data	
Heptachlor	4.50E+00	7.95E-05

Concentration Calculations:Radionuclides: $1E-6 \text{ risk} / (\text{Slope Factor (risk/pCi)} - 1 * 1 \text{ L/day} * 250 \text{ day/yr} * 20 \text{ yr}) = \text{pCi/L}$ Chemicals: $1E-6 \text{ risk} / (\text{Slope Factor (mg/kg/day)} - 1 * 1/70 \text{ kg} * 1 \text{ L/day} * 250 \text{ day/365 day} * 20 \text{ yr}/70 \text{ yr}) = \text{mg/L}$
g/ HEAST (EPA 1992)

b/ Values shown considered as detection limit DQOs to support QRA

Table 5-6. Soil Sample Types and Analytes at New Groundwater Monitoring Wells.

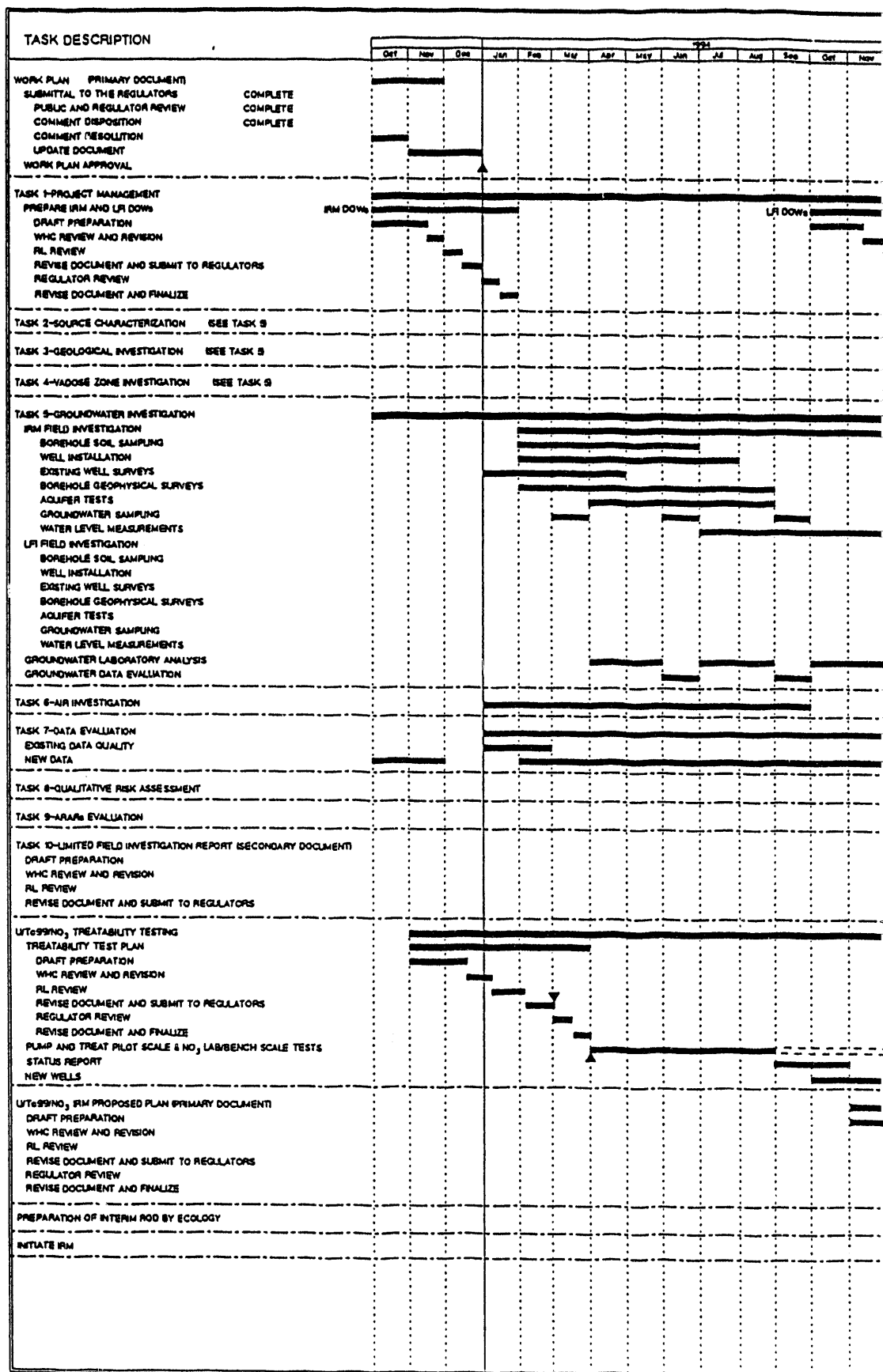
Stratigraphic Unit	Type of Sample to be Analyzed	Physical Analyses	Chemical Analyses
Early "Palouse" Soil	Vadose Zone Soil	Type A	Yes
Plio-Pleistocene Unit	Vadose Zone Soil	Type A	Yes
Ringold E Shallow	Vadose Zone Soil	Type A	Yes
Ringold E Intermediate	Saturated Zone Soil	Type B	Yes*
Ringold Lower Mud Unit	Saturated Zone Soil	Type C	No
Ringold A	Saturated Zone Soil	Types B	Yes
Rattlesnake Ridge Interbed ^{a/}	Saturated Zone Soil	Type B	Yes

Physical analysis types (A to C) are defined in text of Section 5.3.3.2.

^{a/} Rattlesnake Ridge interbed wells are anticipated to be installed following completion of operable unit IRM activities.

6.0 PROJECT SCHEDULE

The anticipated task schedules for the LFI and IRM activities are shown in Figure 6-1. These schedules should only be considered estimates and are based on numerous assumptions. Many variables exist that could affect the final schedule including resource commitments, availability of equipment and equipment downtime, changes in field activities after a review of the initial field results and federal, state, and public dispute resolutions.



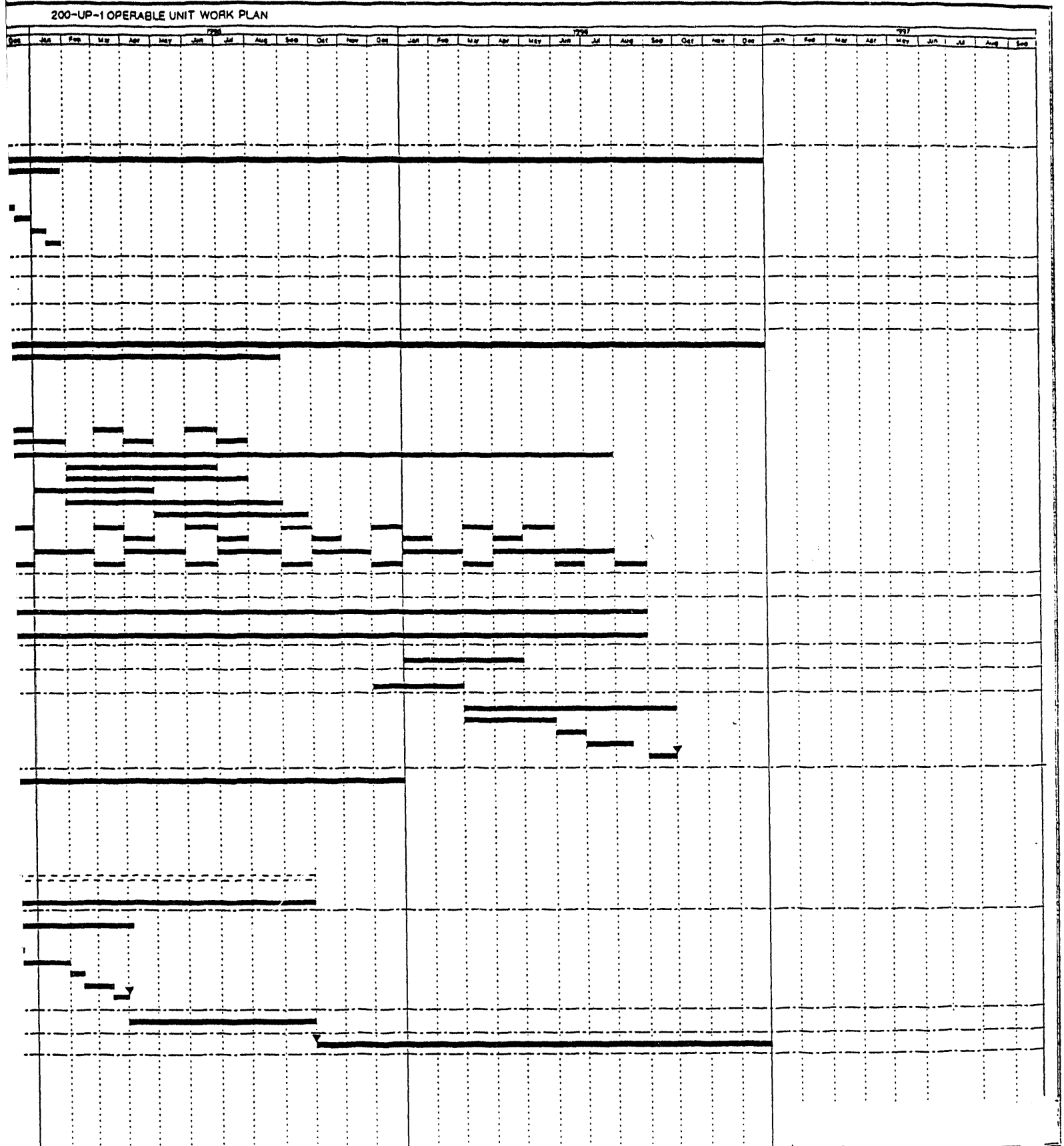


Figure 6-1. Schedule for LFI and Uranium-⁹⁹Tc-Nitrate IRM Activities.

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APPENDIX A
QUALITY ASSURANCE PROJECT PLAN (QAPjP)

CONTENTS

1.0	PROJECT DESCRIPTION	A-1
1.1	PROJECT OBJECTIVE	A-1
1.2	BACKGROUND INFORMATION	A-1
1.3	QUALITY ASSURANCE PROJECT PLAN SCOPE AND RELATIONSHIP TO WESTINGHOUSE HANFORD QUALITY ASSURANCE PROGRAM	A-1
1.4	PROJECT ACTIVITIES	A-2
2.0	PROJECT ORGANIZATION AND RESPONSIBILITIES	A-2
2.1	QUALITY ASSURANCE OFFICER RESPONSIBILITIES	A-2
2.2	TECHNICAL LEAD RESPONSIBILITIES	A-2
2.3	ANALYTICAL LABORATORIES	A-3
2.4	OTHER SUPPORT CONTRACTORS	A-3
3.0	QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS	A-4
4.0	SAMPLING PROCEDURES	A-15
4.1	PROCEDURE APPROVALS AND CONTROL	A-15
	4.1.1 Westinghouse Hanford Procedures	A-15
	4.1.2 Participant Contractor/Subcontractor Procedures	A-15
4.2	SAMPLING PROCEDURES	A-16
	4.2.1 Sample Acquisition	A-16
	4.2.2 Sample Container Selection	A-16
4.3	OTHER INVESTIGATIVE AND SUPPORTING PROCEDURES	A-16
4.4	PROCEDURE CHANGES	A-16
5.0	SAMPLE CUSTODY	A-20
6.0	CALIBRATION PROCEDURES	A-20
7.0	ANALYTICAL PROCEDURES	A-20
8.0	DATA REDUCTION, VALIDATION, AND REPORTING	A-21
8.1	DATA REDUCTION AND DATA PACKAGE PREPARATION	A-21
8.2	VALIDATION	A-22
8.3	FINAL REVIEW AND RECORDS MANAGEMENT CONSIDERATIONS	A-22
8.4	REQUIREMENTS FOR HANDLING UNACCEPTABLE OR SUSPECT DATA	A-22
9.0	INTERNAL QUALITY CONTROL	A-23
10.0	PERFORMANCE AND SYSTEM AUDITS	A-25
11.0	PREVENTIVE MAINTENANCE	A-26
12.0	DATA ASSESSMENT PROCEDURES	A-26
13.0	CORRECTIVE ACTION	A-26
	13.1 GENERAL REQUIREMENTS FOR CORRECTIVE ACTION	A-26
	13.2 CORRECTIVE ACTION REQUIREMENTS RELATED TO CALIBRATION ERRORS	A-27
	13.3 CORRECTIVE ACTION RELATED TO PROCEDURAL DEVIATIONS	A-27

13.4	CORRECTIVE ACTION REQUIREMENTS RELATED TO PURCHASED MATERIALS, ITEMS, OR EQUIPMENT	A-28
14.0	QUALITY ASSURANCE REPORTS	A-28
15.0	REFERENCES	A-28

LIST OF TABLES

QAPjP-1	Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit	A-5
QAPjP-2	Sampling and Investigative Procedures for Limited Field Investigations in the 200-UP-1 Groundwater Operable Unit . . .	A-16

GLOSSARY

Accuracy: For the purposes of environmental investigations, accuracy may be interpreted as the measure of the bias in a system. Sampling accuracy is normally assessed through the evaluation of matrix-spiked samples, reference samples, and split samples.

Audit: For the purposes of environmental investigations, audits are considered to be systematic checks to verify the quality of operation of one or more elements of the total measurement system. In this sense, audits may be of two types: (1) performance audits, in which quantitative data are independently obtained for comparison with data routinely obtained in a measurement system, or (2) system audits, involving a qualitative onsite evaluation of laboratories or other organizational elements of the measurement system for compliance with established quality assurance program and procedure requirements. For environmental investigations at the Hanford Site, performance audit requirements are fulfilled by periodic submittal of blind samples to the primary laboratory, or the analysis of split samples by an independent laboratory. System audit requirements are implemented through the use of standard surveillance procedures.

Bias: Bias represents a systematic error that contributes to the difference between a population mean of a set of measurements and an accepted reference or true value.

Blind Sample: A blind sample refers to any type of sample routed to the primary laboratory for performance audit purposes, relative to a particular sample matrix and analytical method. Blind samples are not specifically identified as such to the laboratory. They may be made from traceable standards, or may consist of sample material spiked with a known concentration of a known compound. See the glossary entry for Audit.

Comparability: For the purposes of environmental investigations, comparability is an expression of the relative confidence with which one data set may be compared with another.

Completeness: For the purposes of environmental investigations, completeness may be interpreted as a measure of the amount of valid data obtained compared to the total data expected under correct normal conditions.

Deviation: For the purposes of environmental investigations, deviation refers to an approved departure from established criteria that may be required as a result of unforeseen field situations or that may be required to correct ambiguities in procedures that may arise in practical applications.

Equipment Blanks: Equipment blanks consist of pure deionized, distilled water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples. They are used to verify the adequacy of sampling equipment decontamination procedures, and are normally collected at the same frequency as field duplicate samples.

Field Blanks: Field blanks for water analyses consist of pure deionized, distilled water, transferred to a sample container at the site and preserved with the reagent specified for the analytes of interest. They are used to check for possible contamination originating with the reagent or the sampling environment, and are normally collected at the same frequency as field duplicate samples.

Field Duplicate Sample: Field duplicate samples are samples retrieved from the same sampling location using the same equipment and sampling technique, placed in separate, identically prepared and preserved containers, and analyzed independently. Field duplicate samples are generally used to verify the repeatability or reproducibility of analytical data, and are normally analyzed with each analytical batch or every 20 samples, whichever is greater.

Matrix-Spiked Samples: Matrix-spiked samples are a type of laboratory quality control sample. They are prepared by splitting a sample received from the field into two homogenous aliquots (i.e., replicate samples) and adding a known quantity of a representative analyte of interest to one aliquot in order to calculate the percentage of recovery of that analyte.

Nonconformance: A nonconformance is a deficiency in the characteristic, documentation, or procedure that renders the quality of material, equipment, services, or activities unacceptable or indeterminate. When the deficiency is of a minor nature, does not effect a permanent or significant change in quality if it is not corrected, and can be brought into conformance with immediate corrective action, it shall not be categorized as a nonconformance. If the nature of the condition is such that it cannot be immediately and satisfactorily corrected, however, it shall be documented in compliance with approved procedures and brought to the attention of management for disposition and appropriate corrective action.

Precision: Precision is a measure of the repeatability or reproducibility of specific measurements under a given set of conditions. The relative percent difference (RPD) is used to assess the precision of the sampling and analytical method. RPD is a quantitative measure of the variability. Specifically, precision is a quantitative measure of the variability of a group of measurements compared to their average value. Precision is normally expressed in terms of standard deviation, but may also be expressed as the coefficient of variation (i.e., relative standard deviation) and range (i.e., maximum value minus minimum value). Precision is assessed by means of duplicate/replicate sample analysis.

Quality Assurance: For the purposes of environmental investigations, QA refers to the total integrated quality planning, quality control, quality assessment and corrective action activities that collectively ensure that the data from monitoring and analysis meets all end user requirements and/or the intended end use of the data.

Quality Assurance Project Plan: The QAPjP is an orderly assembly of management policies, project objectives, methods and procedures that defines how data of known quality will be produced for a particular project or investigation.

Quality Control: For the purposes of environmental investigations, QC refers to the routine application of procedures and defined methods to the performance of sampling, measurement and analytical processes.

Range: Range refers to the difference between the largest and smallest reported values in a sample, and is a statistic for describing the spread in a set of data.

Reference Samples: Reference samples are a type of laboratory quality control sample prepared from an independent, traceable standard at a concentration other than that used for analytical equipment calibration, but within the calibration range. Such reference samples are required for every analytical batch or every 20 samples, whichever is greater.

Replicate Sample: Replicate samples are two aliquots removed from the same sample container in the laboratory and analyzed independently.

Representativeness: For the purposes of environmental investigations, representativeness may be interpreted as the degree to which data accurately and precisely represent a characteristic of a population parameter, variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is most concerned with the proper design of a sampling program.

Split Sample: A split sample is produced through homogenizing a field sample and separating the sample material into two equal aliquots. Field split samples are usually routed to separate laboratories for independent analysis, generally for purposes of auditing the performance of the primary laboratory relative to a particular sample matrix and analytical method. See the glossary entry for Audit. In the laboratory, samples are generally split to create matrix-spiked samples (see the glossary entry).

VOA Trip Blanks: Volatile Organics Analysis (VOA) trip blanks are a type of field quality control sample, consisting of pure deionized distilled water in a clean, sealed sample container, accompanying each batch of containers shipped to the sampling site and returned unopened to the laboratory. Trip blanks are used to identify any possible contamination originating from container preparation methods, shipment, handling, storage or site conditions.

Validation: For the purposes of environmental investigations, validation refers to a systematic process of reviewing data against a set of criteria to provide assurance that the data are acceptable for their intended use. Validation methods may include review of verification activities, editing, screening, cross-checking or technical review.

Verification: For the purposes of environmental investigations, verification refers to the process of determining whether procedures, processes, data or documentation conform to specified requirements. Verification activities may include inspections, audits, surveillance or technical review.

ACRONYMS

ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract Laboratory Program
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
DOE	Department of Energy
DOW	Description of Work
DQO	data quality objective
Ecology	Washington State Department of Ecology
EE&T	Environmental Engineering and Technology
EII	Environmental Investigations Instruction
EPA	U.S. Environmental Protection Agency
GC	gas chromatography
HASM	Hanford Analytical Services Management
HEIS	Hanford Environmental Information System
IMO	Information Management Overview
LFI	limited field investigation
QA	quality assurance
QAPI	Quality Assurance Program Index
QAPJP	Quality Assurance Project Plan
QC	quality control
QI	Quality Instruction
QR	Quality Requirement
RCRA	Resource Conservation and Recovery Act
SOW	Statement of Work
TCL	target compound list
VOA	volatile organic analysis

1.0 PROJECT DESCRIPTION

1.1 PROJECT OBJECTIVE

The purpose of this Quality Assurance Project Plan (QAPjP) is to ensure the objectives described in of the work plan will be met. Data resulting from this investigation will be evaluated to determine the most feasible options for additional investigation, remediation, or closure.

1.2 BACKGROUND INFORMATION

The 200-UP-1 Groundwater Operable Unit is located within the 200 Areas of the Hanford Site, shown in Figure 1-1 of the work plan. The 200-UP-1 Groundwater Operable Unit Limited Field Investigation (LFI) will address groundwater contamination and related issues for the uppermost aquifer system and Rattlesnake Ridge aquifer underlying the site. Detailed background information regarding the history and current use of the operable unit is provided in Section 2.0 of the work plan.

1.3 QUALITY ASSURANCE PROJECT PLAN SCOPE AND RELATIONSHIP TO WESTINGHOUSE HANFORD QUALITY ASSURANCE PROGRAM

This QAPjP applies specifically to the field activities and laboratory analyses performed as part of the LFI for the 200-UP-1 Groundwater Operable Unit. It is prepared specifically for this phase of investigation, and is prepared in compliance with the requirements of the Westinghouse Hanford Company (Westinghouse Hanford) WHC-EP-0383 *Environmental Engineering, Technology, and Permitting Function Quality Assurance Program Plan* (WHC 1990a). WHC-EP-0383 describes the means selected to implement the overall Quality Assurance (QA) program requirements defined by the Westinghouse Hanford WHC-CM-4-2 *Quality Assurance Manual* (WHC 1991), as applicable to environmental investigations, while accommodating the specific requirements for project plan format and content agreed upon in the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1990). It contains a matrix of procedural resources from WHC-CM-4-2, the Westinghouse Hanford WHC-CM-7-7 *Environmental Investigations and Site Characterization Manual* (WHC 1988a), and other sources that have been drawn upon to support the 200-UP-1 Groundwater Operable Unit QAPjP. Final sampling locations, required sampling intervals, sample quantities, sampling frequency, and schedules for all technical activities addressed in this investigation shall be defined either by investigation-specific Descriptions of Work (DOWs), prepared in compliance with Environmental Investigations Instruction (EII) TBD, "Preparation of Descriptions of Work" (WHC 1988a), or by Test Plans, prepared in compliance with EPA guidance (EPA 1992). All EIIs included in the WHC-CM-7-7 and this QAPjP are subject to mandatory review and approval by the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology) before use. Distribution and revision control of the work plan and the QAPjP will be performed in compliance with Quality Requirement (QR)

QR 6.0, "Document Control" and other applicable procedures as identified in the QA Program Index (QAPI) included in WHC-EP-0383.

Interim changes to this QAPjP or the work plan shall be documented, reviewed, and approved as required by Section 6.6 of EII 1.9, "Work Plan Review" (WHC 1988a), and shall be documented in monthly unit managers' meeting minutes. QAPjP distribution shall routinely include all review/approval personnel indicated on the title page of the document and all other individuals designated by the Westinghouse Hanford technical lead. All plans and procedures referenced in the QAPjP are available for regulatory review on request at the direction of the technical lead.

1.4 PROJECT ACTIVITIES

Five separate investigations will be conducted in the 200-UP-1 Groundwater Operable Unit, including geological, groundwater, contaminant, and ecological investigations, as well as an investigation made up of other miscellaneous tasks. More detailed discussions of individual tasks are contained in Section 5.0 of the work plan. Procedures directly applicable to the tasks described here are discussed in Section 4.0 of the QAPjP.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 QUALITY ASSURANCE OFFICER RESPONSIBILITIES

The QA Officer is responsible for coordination and/or oversight of performance to the QAPjP requirements by means of internal auditing and surveillance techniques. The QA Officer has the necessary organizational independence and authority to identify conditions adverse to quality and to inform the technical lead of needed corrective action.

2.2 TECHNICAL LEAD RESPONSIBILITIES

Environmental Restoration Engineering of Westinghouse Hanford has primary responsibilities for conducting this investigation. Responsibility descriptions and individual Westinghouse Hanford field team descriptions are addressed in the governing project procedures identified in Section 4.0 of this QAPjP.

External participant contractors or subcontractors shall be evaluated and selected for certain portions of task activities at the direction of the technical lead in compliance with procedures QR 4.0, "Procurement Document Control", QR 7.0, "Control of Purchased Items and Services" (WHC 1991), and other procedures as identified under criteria four and seven of the QAPI included in WHC-EP-0383 (WHC 1990a). All contractor or subcontractor plans

and procedures shall be approved before their use, and shall be available for regulatory review after Westinghouse Hanford approval.

2.3 ANALYTICAL LABORATORIES

The Westinghouse Hanford field sampling team will be responsible for screening all samples for radioactivity in compliance with EII 2.3, "Administration of Radiation Surveys to Support Environmental Characterization Work on the Hanford Site" (WHC 1988a).

If the total activity of the sample is equal to or greater than 200 pCi/g, or if the alpha activity of the sample is equal to or greater than 60 pCi/g, samples shall be packaged and shipped in compliance with Section 6.3 of EII 5.11, "Sample Packaging and Shipping" (WHC 1988a) and routed to a Westinghouse Hanford or Hanford Site participant contractor or subcontractor laboratory equipped and qualified to handle the analysis of radioactive samples. Samples that do not exceed either of the above criteria may be routed to any approved participant contractor or subcontractor analytical laboratory. All analyses shall be coordinated through the Westinghouse Hanford Analytical Services Management (HASM) and shall be performed in compliance with Westinghouse Hanford-approved laboratory QA plans and analytical procedures; all analytical laboratories shall be subject to the surveillance controls described by Quality Instruction (QI) 10.4 "Surveillance" (WHC 1991). For subcontractors or participant contractors, applicable quality requirements shall be invoked as part of the approved procurement documentation or work order; see Section 3.0 and 4.1.2 of this QAPjP. Services of alternate qualified laboratories shall be procured for radioactive sample analysis if onsite laboratory capacity is not available, and/or for the performance of split sample analysis at the technical lead's discretion. If such an option is selected, the laboratory shall provide objective evidence of appropriate Nuclear Regulatory Commission or state radioactive materials handling licenses. The laboratory shall submit its QA plan and applicable analytical procedures for Westinghouse Hanford approval prior to their use, as noted in Section 4.1.2.

2.4 OTHER SUPPORT CONTRACTORS

Procurement of all other field services and supporting items, materials, or equipment shall comply with standard Westinghouse Hanford procurement procedures as discussed in Sections 2.1 and 4.1 of this QAPjP. All work shall comply with Westinghouse Hanford-approved QA plans and/or procedures, and is subject to the controls of QI 10.4, "Surveillance" (WHC 1991). Applicable QRs shall be invoked as part of the approved procurement documentation or work order as noted in Section 4.1.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENTS

The rationale for establishing data quality objectives (DQOs) and data needs for this investigation is presented in Sections 4.1.1 and 4.1.2 of the work plan.

All analytical parameters that have been selected the LFI portion of this investigation are listed in Table QAPjP-1, cross-referenced to analytical method requirements and maximum detection or quantitation limit values and maximum acceptable ranges for precision and accuracy, in both soil and water matrices. Data analysis for treatability study activities may use Hanford site laboratories for screening level analysis (QA Level 3), in which approximately 1 sample in 20 will be sent for confirmation to a laboratory conforming to the parameters in Table QAPjP-1. Where EPA Contract Laboratory Program (CLP) methods are specified, the Contract Required Detection Limits (CRDLs) for inorganic parameters, Contract Required Quantitation Limits (CRQLs) for organic parameters, and the maximum precision and accuracy ranges specified for each parameter by the appropriate CLP Statements of Work (SOWs) apply without modification; see *USEPA Contract Laboratory Program Statement of Work for Inorganics Analysis* (EPA 1991a) and *USEPA Contract Laboratory Program Statement of Work for Organics Analysis* (EPA 1991b). For non-CLP parameters, CRQLs and precision and accuracy ranges are provided that shall be considered maximum values that can be reliably achieved by analytical laboratories under routine conditions. The requirements of Table QAPjP-1 shall be considered a minimum performance standard for LFI groundwater and soil sampling activities, and shall be incorporated into the agreements for services established with individual Westinghouse Hanford, participant contractor, or subcontractor analytical laboratories. Any modification of Table QAPjP-1 requirements shall be justified by the requestor, and shall be considered a formal modification of this QAPjP, and is subject to regulatory review and approval. The QA Level 3 analytical methods for the Treatability Study will be addressed in the Treatability Test Plan.

Goals for data representativeness will be addressed qualitatively by the specification of sampling depths and intervals in the DOWs prepared for this investigation, as previously described in Section 1.3 of this QAPjP. Sampling locations will be specified in the DOW or work orders issued to the subcontractors or participating contractors responsible for conducting sampling activities. Objectives for the completeness of this investigation shall require that contractually or procedurally established requirements for precision and accuracy be met for at least 90% of the total number of requested determinations. Failure to meet this criterion shall be documented and evaluated in the validation process described in Section 8.0 of this QAPjP; corrective action shall be taken as warranted, as described in Section 13.0. Approved analytical procedures shall require the use of the reporting techniques and units specified in the EPA reference methods specified in Table QAPjP-1 to facilitate the comparability of data sets in terms of precision and accuracy.

Table QAPj2-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 1 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL volatile organics ^{d/}	Chloromethane	d	10	d	d	10	d	d
	Bromomethane	d	10	d	d	10	d	d
	Vinyl Chloride	d	10	d	d	10	d	d
	Chloroethane	d	10	d	d	10	d	d
	Methylene Chloride	d	10	d	d	10	d	d
	Acetone	d	10	d	d	10	d	d
	Carbon Disulfide	d	10	d	d	10	d	d
	1,1-Dichloroethene	d	10	d	d	10	d	d
	1,1-Dichloroethane	d	10	d	d	10	d	d
	1,2-Dichloroethene (total)	d	10	d	d	10	d	d
	Chloroform	d	10	d	d	10	d	d
	1,2-Dichloroethane	d	10	d	d	10	d	d
	2-Butanone	d	10	d	d	10	d	d
	1,1,1-Trichloroethane	d	10	d	d	10	d	d
	Carbon Tetrachloride	d	10	d	d	10	d	d
	Bromodichloromethane	d	10	d	d	10	d	d
	1,2-dichloropropene	d	10	d	d	10	d	d
	Trichloroethene	d	10	d	d	10	d	d
	Dibromochloromethane	d	10	d	d	10	d	d
	1,1,2-Trichloroethane	d	10	d	d	10	d	d
	Benzene	d	10	d	d	10	d	d
	trans-1,3-dichloropropene	d	10	d	d	10	d	d
	cis-1,3-Dichloropropene	d	10	d	d	10	d	d
	Bromoform	d	10	d	d	10	d	d

A-5

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 2 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL volatile organics ^{d/} (cont.)	4-Methyl-2-pentanone	d	10	d	d	10	d	d
	2-Hexanone	d	10	d	d	10	d	d
	Tetrachloroethene	d	10	d	d	10	d	d
	Toluene	d	10	d	d	10	d	d
	1,1,2,2-Tetrachloroethane	d	10	d	d	10	d	d
	Chlorobenzene	d	10	d	d	10	d	d
	Ethyl Benzene	d	10	d	d	10	d	d
	Styrene	d	10	d	d	10	d	d
	Xylenes (total)	d	10	d	d	10	d	d
CLP TCL semi-volatile organics ^{d/}	Phenol	d	330	d	d	10	d	d
	bis(2-Chloroethyl)ether	d	330	d	d	10	d	d
	2-Chlorophenol	d	330	d	d	10	d	d
	1,3-Dichlorobenzene	d	330	d	d	10	d	d
	1,4-Dichlorobenzene	d	330	d	d	10	d	d
	1,2-Dichlorobenzene	d	330	d	d	10	d	d
	2-Methylphenol	d	330	d	d	10	d	d
	2,2'-oxybis (1-Chloropropane)	d	330	d	d	10	d	d
	4-Methylphenol	d	330	d	d	10	d	d
	N-Nitroso-di-n-dipropylamine	d	330	d	d	10	d	d
	Hexachloroethane	d	330	d	d	10	d	d
	Nitrobenzene	d	330	d	d	10	d	d
	Isophorone	d	330	d	d	10	d	d
	2-Nitrophenol	d	330	d	d	10	d	d
	2,4-Dimethylphenol	d	330	d	d	10	d	d

A-6

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI.

Page 3 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL semi-volatile organics ^{d/} (cont.)	bis(2-Chloroethoxy)methane	d	330	d	d	10	d	d
	2,4-Dichlorophenol	d	330	d	d	10	d	d
	1,2,4-Trichlorobenzene	d	330	d	d	10	d	d
	Naphthalene	d	330	d	d	10	d	d
	4-Chloroaniline	d	330	d	d	10	d	d
	Hexachlorobutadiene	d	330	d	d	10	d	d
	4-Chloro-3-methylphenol	d	330	d	d	10	d	d
	2-Methylnaphthalene	d	330	d	d	10	d	d
	Hexachlorocyclopentadiene	d	330	d	d	10	d	d
	2,4,6-Trichlorophenol	d	330	d	d	10	d	d
	2,4,5-Trichlorophenol	d	800	d	d	25	d	d
	2-Chloronaphthalene	d	330	d	d	10	d	d
	2-Nitroaniline	d	800	d	d	25	d	d
	Dimethylphthalate	d	330	d	d	10	d	d
	Acenaphthylene	d	330	d	d	10	d	d
	2,6-Dinitrotoluene	d	330	d	d	10	d	d
	3-Nitroaniline	d	800	d	d	25	d	d
	Acenaphthene	d	330	d	d	10	d	d
	2,4-Dinitrophenol	d	800	d	d	25	d	d
	4-Nitrophenol	d	800	d	d	25	d	d
	Dibenzofuran	d	330	d	d	10	d	d
	2,4-Dinitrotoluene	d	330	d	d	10	d	d
	Diethylphthalate	d	330	d	d	10	d	d
	4-Chlorophenyl-phenylether	d	330	d	d	10	d	d

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 4 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL semi-volatile organics ^{d/} (cont.)	Fluorene	d	330	d	d	10	d	d
	4-Nitroaniline	d	800	d	d	25	d	d
	4,6-dinitro-2-methylphenol	d	800	d	d	25	d	d
	N-nitrosodiphenylamine	d	330	d	d	10	d	d
	4-Bromophenyl-phenylether	d	300	d	d	10	d	d
	Hexachlorobenzene	d	300	d	d	10	d	d
	Pentachlorophenol	d	800	d	d	25	d	d
	Phenanthrene	d	330	d	d	10	d	d
	Anthracene	d	330	d	d	10	d	d
	Carbazole	d	330	d	d	10	d	d
	Di-n-butylphthalate	d	330	d	d	10	d	d
	Fluoranthene	d	330	d	d	10	d	d
	Pyrene	d	330	d	d	10	d	d
	Butylbenzalpthalate	d	330	d	d	10	d	d
	3-3'-Dichlorobenzidine	d	330	d	d	10	d	d
	Benzo(a)anthracene	d	330	d	d	10	d	d
	Chrysene	d	330	d	d	10	d	d
	bis(2-Ethylhexyl)phthalate	d	330	d	d	10	d	d
	Di-n-octylphthalate	d	330	d	d	10	d	d
	Benzo(b)fluoranthene	d	330	d	d	10	d	d
	Benzo(k)fluoroanthene	d	330	d	d	10	d	d
	Benzo(a)pyrene	d	330	d	d	10	d	d
	Indeno(1,2,3-cd)pyrene	d	330	d	d	10	d	d
	Dibenz(a,h)anthracene	d	330	d	d	10	d	d

A-8

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 5 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL semi-volatile organics ^{d/} (cont.)	Benzo(g,h,i)perylene	d	330	d	d	10	d	d
CLP TCL Pesticides/ Araclors ^{d/}	alpha-BHC	d	1.7	d	d	0.05	d	d
	beta-BHC	d	1.7	d	d	0.05	d	d
	delta-BHC	d	1.7	d	d	0.05	d	d
	gamma-BHC (Lindane)	d	1.7	d	d	0.05	d	d
	Heptachlor	d	1.7	d	d	0.05	d	d
	Aldrin	d	1.7	d	d	0.05	d	d
	Heptachlor epoxide	d	1.7	d	d	0.05	d	d
	Endosulfan I	d	1.7	d	d	0.05	d	d
	Dieldrin	d	3.3	d	d	0.10	d	d
	4,4'-DDE	d	3.3	d	d	0.10	d	d
	Endrin	d	3.3	d	d	0.10	d	d
	Endosulfan II	d	3.3	d	d	0.10	d	d
	4,4'-DDD	d	3.3	d	d	0.10	d	d
	Endosulfan Sulfate	d	3.3	d	d	0.10	d	d
	4,4'-DDT	d	3.3	d	d	0.10	d	d
	Methoxychlor	d	17.0	d	d	0.50	d	d
	Endrin ketone	d	3.3	d	d	0.10	d	d
	Endrin aldehyde	d	3.3	d	d	0.10	d	d
	alpha-Chlordane	d	1.7	d	d	0.05	d	d
	gamma-Chlordane	d	1.7	d	d	0.05	d	d
	Toxaphene	d	170.0	d	d	5.0	d	d

A-9

DOE/RL-92-76, Rev. 0

Table QAPjP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 6 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TCL Pesticides/ Aroclors ^{d/} (cont.)	Aroclor-1016	d	33.0	d	d	1.0	d	d
	Aroclor-1221	d	33.0	d	d	1.0	d	d
	Aroclor-1232	d	67.0	d	d	2.0	d	d
	Aroclor-1242	d	33.0		d	1.0		d
	Aroclor-1248	d	33.0		d	1.0		d
	Aroclor-1254	d	33.0		d	1.0		d
	Aroclor-1260	d	33.0		d	1.0		d
CLP TAL Inorganics ^{d/}	Aluminum	d	20	d	d	200	d	d
	Antimony	d	6	d	d	60	d	d
	Arsenic	d	1	d	d	10	d	d
	Barium	d	20	d	d	200	d	d
	Beryllium	d	.5	d	d	5	d	d
	Cadmium	d	.5	d	d	5	d	d
	Calcium	d	500	d	d	5,000	d	d
	Chromium	d	1	d	d	10	d	d
	Cobalt	d	5	d	d	50	d	d
	Copper	d	2.5	d	d	25	d	d
	Iron	d	10	d	d	100	d	d
	Lead	d	.3	d	d	3	d	d
	Magnesium	d	500	d	d	5,000	d	d
	Manganese	d	1.5	d	d	15	d	d
	Mercury	d	.02	d	d	0.2	d	d
	Nickel	d	4	d	d	40	d	d
	Potassium	d	500	d	d	5,000	d	d
	Selenium	d	.5	d	d	5	d	d

A-10

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 7 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
CLP TAL inorganics (cont.)	Silver	d	1	d	d	10	d	d
	Sodium	d	500	d	d	5,000	d	d
	Thallium	d	1	d	d	10	d	d
	Vanadium	d	5	d	d	50	d	d
	Zinc	d	2	d	d	20	d	d
	Cyanide	d	10	d	d	10	d	d
Common Ions	Ammonia as Nitrogen	350.3 ^{a/}	NA	NA	NA	30	±20	75-125
	Chloride	EPA 300/modified ^{f/} 325.3 ^{a/} or 325.2 ^{a/}	NA	NA	NA	10,000	±20	75-125
	Fluoride	EPA 300/modified ^{f/} or 340.2	0.5	±35	75-125	100	±20	75-125
	Nitrate	EPA 300/modified ^{f/} , 352.1 ^{a/} , 353.3 ^{a/} , 353.2 ^{a/} , or 354.1 ^{a/}	1.0	±35	75-125	100	±20	75-125
	Nitrite	EPA 300/modified ^{f/} or 354.1 ^{a/}	0.1	±35	75-125	250	±20	75-125
	Phosphosphate	EPA 300/modified ^{f/} , 365.1 ^{a/} , 365.2 ^{a/} , 365.3 ^{a/}	NA	NA	NA	500	±20	75-125

A-11

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 8 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
Common Ions (cont.)	Sulfate	EPA 300/ modified ^{d/} , 375.2 ^{f/} , 375.3 ^{e/} , 375.4 ^{e/}	20.0	±35	75-125	2,000	±20	75-125
	Sulfide	9030 ^{g/}	NA	NA	NA	5	±20	75-125
Radionuclides	Hydrogen-3	Water 906.0 ^{f/} Pro-052- 57(S,O), RL-2320, EP-20 ^{k/}	NA	NA	NA	400 pCi/L	±20	75-125
	Carbon-14	h	h	h	h	h	h	h
	Strontium-90	PRO-032-38, PRO-032-25, RL-2314, PRO-032-16, RC-306, RC- 303, RC-309, RC-304 ^{k/}	1 pCi/g	±35	75-125	10 pCi/L	±20	75-125
	Technetium-99	PRO-032-78, RL-2317, RC- 24, RC-604 ^{k/}	15 pCi/g	±35	75-125	10 pCi/L	±20	75-125
	Alpha Spectrometry (uranium-235, uranium-238, plutonium-239, plutonium-240, and americium-241)	PRO-052-32, PRO-060-109, RL-2322, -2325, -2326, EP-80, -90, -91, -92, -93, -70, -71, -5 ^{k/}	1 pCi/g	±35	75-125	3 pCi/L	±20	75-125
	Gross alpha	Water 900 ^{i/} Soil ^{j/} PRO-032-15, 1, RL-2302, EP-10, EA-82 ^{k/}	10 pCi/g	±35	75-125	3 pCi/L	±20	75-125

A-12

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 9 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
Radionuclides (cont.)	Gross beta	Water 900 ^{h/} Soil ^{h/} PRO-032-15, 1, RL-2302, EP-10, EA-82 ^{k/}	15 pCi/g	±35	75-125	4 pCi/L	±20	75-125
	Gamma Spectrometry (report all identifiable and quantifiable isotopes)	Water 901.1 ^{h/} Soil ^{h/} PRO-042-5, RL-4303, 4304, RC-30	Radionuclide specific	±35	75-125	Radionuclide specific	±20	75-125
Other groundwater parameters	Alkalinity	310.1 ^{e/}	NA	NA	NA	10,000	±20	75-125
	Specific Conductance	^{h/} EII 5.8	NA	NA	NA	25	±20	NA
	pH	^{h/} EII 5.8	NA	NA	NA	NA	NA	NA
	Temperature	^{h/} EII 5.8	NA	NA	NA	NA	±1°C	NA
	Dissolved Oxygen	360.1 ^{e/}	NA	NA	NA	100	±20	NA
	Total Dissolved Solids	160.1 ^{e/}	NA	NA	NA	10,000	±20	NA
	Total Organic Carbon	415.1 ^{e/}	NA	NA	NA	1,000	±20	75-125
	Total Suspended Solids	160.1 ^{b/d/}	NA	NA	NA	10	±20	75-125
	Turbidity	180.1 ^e	NA	NA	NA	0.05 NTU ⁱ	±.05 NTU	NA

a/ Laboratory specific soil extraction procedures for "Common Ions" are on file with the Westinghouse Hanford Company's Hanford Analytical Services Management office. The contract Laboratories consider these procedures to be proprietary information.

b/ For all CLP analytical categories, CRDL refers to the Contract Required Detection Limit specified on the US EPA Contract Laboratory Program Statement of Work for Inorganics Analysis (EPA 1991a); CRQL refers to the Contract Required Quantitation Limit specified in the US EPA Contract Laboratory Program Statement of Work for Organics Analysis (EPA 1991b). CRQLs are provided for all other (non-CLP) categories, and represent maximum values that can be reliably achieved by analytical laboratories under routine normal conditions. Unless otherwise specified, all inorganic soil values are expressed in mg/Kg, and all organic soil values are expressed as µg/Kg; CLP Target Compound List (TCL) values for organic soil CRQLs are the lower of the values specified in the CLP SOW (EPA 1991a). All CRDL/CRQL values for water are expressed in µg/L. Laboratory agreements for services shall require updating as necessary to accommodate periodic updates of the CLP SOWs (EPA 1991a and 1991b). For TAL inorganics, the CRDLs are based on 2 g sample in a 200 ml final volume.

DOE/RL-92-76, Rev. 0

Table QAPJP-1. Analytical Methods, Analytical Parameters, Detection Limits, and Precision and Accuracy Requirements for the 200-UP-1 Groundwater Operable Unit LFI. Page 10 of 10

Analytical Category	Analytical Parameters	Analytical Method ^{a/}	CRDL or CRQL, soil ^{b/}	Precision ^{c/} , Soil	Accuracy ^{c/} , Soil	CRDL or CRQL, Water ^{b/}	Precision ^{c/} , Water	Accuracy ^{c/} , Water
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- c/ Acceptable ranges for precision and accuracy for EPA Contract Laboratory Program (CLP) TCL organics and TAL inorganic parameters shall be as specified for each analyte by the applicable CLP SOWs (see EPA 1991a and 1991b). For all other parameters, the ranges provided shall be considered maximum values that can be reliably achieved by the laboratories under routine normal conditions. Precision is expressed as Relative Percent Difference (RPD); accuracy is expressed as percent recovery (%R). In all cases, these limits apply to sample results greater than five times the CRDL or CRQL, and shall be considered requirements in the absence of known or suspected interferences which may hinder achieving the limit by the analytical laboratory.
- d/ As specified in the CLP SOWs for organic and inorganic analysis; all analytical methods, CRDLs, CRQLs, and precision and accuracy requirements shall be as specified therein without modification.
- e/ Methods specified are from Methods for Chemical Analysis of Water and Wastes (Kopp and McKee 1983).
- f/ Method specified is from Determination of Inorganic Anions in Aqueous and Solid Samples by Ion Chromatography (Lindahl 1984), and is a modification of EPA method 300.0.
- g/ Methods specified are from Test Methods for Evaluating Solid Waste (EPA 1986).
- h/ Methods, CRQLs, and maximum ranges for precision and accuracy shall be developed and approved in compliance with Westinghouse Hanford or Westinghouse Hanford-approved participant contractor or subcontractor procedures.
- i/ Method specified is from Prescribed Procedures for Measurement of Radioactivity in Drinking Water (Krieger and Whittaker 1980).
- j/ Method shall be based on the specific water method, modified to allow distillation of the parameter of interest in a soil sample and shall be submitted for Westinghouse Hanford review and approval prior to use.
- k/ The methods specified are from contracts with Roy F. Weston, Inc. (methods with prefix PRO- or RL), and Thermo-Analytical Inc. (all other methods listed).
- l/ Parameter shall be measured in the field in compliance with EII 5.8, "Groundwater Sampling" (WHC 1988).

A-14

DOE/RL-92-76, Rev. 0

4.0 SAMPLING PROCEDURES

4.1 PROCEDURE APPROVALS AND CONTROL

4.1.1 Westinghouse Hanford Procedures

The Westinghouse Hanford procedures cited in this QAPjP have been selected from the QAPI included in WHC-EP-0383 (WHC 1990a). Selected procedures include EIIs from WHC-CM-7-7, the *Environmental Investigations and Site Characterization Manual* (WHC 1988a), and QRs and QIs from WHC-CM-4-2, the *Quality Assurance Manual* (WHC 1991). Procedure approval, revision, and distribution control requirements applicable to EIIs are addressed in EII 1.2, "Preparation and Revision of Environmental Investigations Instructions" (WHC 1988a); requirements applicable to QIs and QRs are addressed in QR 5.0, "Instructions, Procedures, and Drawings" (WHC 1991). Other procedures applicable to the preparation, review, approval, and revision of other Westinghouse Hanford organizations shall be as defined in the various procedures and manuals identified in the QAPI under criteria 5.0 and 6.0. All procedures are available for regulatory review on request, at the direction of the Westinghouse Hanford technical lead.

4.1.2 Participant Contractor/Subcontractor Procedures

As previously noted in Section 2.1, participant contractor and/or subcontractor services shall be procured under the applicable requirements of QR 4.0, "Procurement Document Control", QR 7.0, "Control of Purchased Items and Services" (WHC 1991), and other procedures as identified under criteria four and seven of the QAPI included in WHC-EP-0383 (WHC 1990a). Submittal requirements of procedures for Westinghouse Hanford review and approval before use shall be included in the procurement document or work order, as applicable, when such services require procedural controls. Analytical laboratories shall be required to submit the current version of their internal QA program plans, in addition to analytical procedures. All analytical laboratory plans and procedures shall be reviewed and approved before use by qualified personnel from the Westinghouse Hanford Analytical Laboratories organization, or other qualified personnel, as directed by the technical lead. All reviewers shall be qualified under the requirements of EII 1.7, "Indoctrination, Training, and Qualification" (WHC 1988a). All participant contractor or subcontractor procedures, plans, and/or manuals shall be retained as project records in compliance with Section 9 of WHC-CM-3-5, "Document Control and Records Management Manual" (WHC 1990b). All such documents are available for regulatory review on request, at the direction of the Westinghouse Hanford technical lead.

4.2 SAMPLING PROCEDURES

4.2.1 Sample Acquisition

All soil and sludge sampling shall be performed in accordance with EII 5.2, "Soil and Sediment Sampling" (WHC 1988a). All drilling activities shall be in compliance with EII 6.7, "Resource Protection Well and Test Borehole Drilling" (WHC 1988a). All boreholes shall be logged in compliance with EII 9.1, "Geologic Logging" (WHC 1988a). Sampling procedure applicability to individual project tasks is shown in Table QAPjP-2. Sampling depths and intervals will be identified in the DOW prepared for this investigation as noted in Section 1.3 of this QAPjP. Sample locations will be detailed in the DOWs or work orders issued to the responsible subcontractors or participating contractors. Documentation requirements are defined within individual EIIs.

4.2.2 Sample Container Selection

Sample container types, preservation requirements, preparation requirements, and special handling requirements are defined in EII 5.2, "Soil and Sediment Sampling" (WHC 1988a); and EII 5.11, "Sample Packaging and Shipping" (WHC 1988a).

4.3 OTHER INVESTIGATIVE AND SUPPORTING PROCEDURES

Other procedures that will be required in this phase of the investigation are identified in Table QAPjP-2 referenced to individual tasks as applicable. Documentation requirements shall be addressed within individual procedures and/or the Information Management Overview (IMO) as appropriate. Analytical procedures required for Phase I of this investigation are listed in Table QAPjP-1. All computer software models developed for this investigation shall be documented and verified in compliance with the procedures identified under criterion three of the QAPI included in WHC-EP-0383 (WHC 1990a).

4.4 PROCEDURE CHANGES

Should deviations from established EIIs be required to accommodate unforeseen field situations, they may be authorized by the field team leader in accordance with the requirements specified in EII 1.4, "Deviation from Environmental Investigations Instructions" (WHC 1988a). Documentation, review and disposition of instruction change authorization forms shall be defined by EII 1.4. Other types of procedure change requests shall be documented as required by QR 6.0, "Document Control", (WHC 1988a) or other procedures as identified under criterion six of the QAPI included in WHC-EP-0383 (WHC 1990a).

**Table QAPJP-2. Sampling and Investigative Procedures for the Limited Field Investigations
in the 200-UP-1 Groundwater Operable Unit** Page 1 of 3

	Procedure Title or Subject ^{a,b}	Task 2 Source Investigation	Task 3 Geological Investigation ^c	Task 4 Vadose Zone Investigation	Task 5 Groundwater Investigation	Task 6 Air Investigation
EII 1.1	Hazardous Waste Site Entry Requirements	--	X	X	X	X
EII 1.2	Preparation and Revision of Environmental Investigations Instructions	--	X	X	X	X
EII 1.4	Deviation from Environmental Investigations Instructions	--	X	X	X	X
EII 1.5	Field Logbooks	--	X	X	X	X
EII 1.6	Records Management	--	X	X	X	X
EII 1.7	Indoctrination, Training, and Qualification	--	X	X	X	X
EII 1.9	Work Plan Review	X	X	X	X	X
EII 1.10	Identifying, Evaluating, and Documenting Suspect Waste Sites	X	--	--	--	--
EII 1.11	Technical Data Management	X	X	X	X	X
EII 1.12	Performance Audits ^d	--	X	X	X	X
EII 1.13	Readiness Review	--	X	X	X	X
EII 2.1	Preparation of Hazardous Waste Operations Permits	--	X	X	X	X
EII 2.2	Occupational Health Monitoring	--	X	X	X	X
EII 2.3	Administration of Radiation Surveys to Support Environmental Characterization Work on the Hanford Site	--	X	X	X	--
EII 3.2	Health and Safety Monitoring Instruments	--	X	X	X	X
EII 4.2	Interim Control of Unknown, suspected Hazardous and Mixed Waste	--	X	X	X	--
EII 5.1	Chain of Custody	--	X	X	X	--

A-17

DOE/RL-92-76, Rev. 0

**Table QAPJP-2. Sampling and Investigative Procedures for the Limited Field Investigations
in the 200-UP-1 Groundwater Operable Unit**

Page 2 of 3

	Procedure Title or Subject ^{a,b}	Task 2 Source Investigation	Task 3 Geological Investigation ^c	Task 4 Vadose Zone Investigation	Task 5 Groundwater Investigation	Task 6 Air Investigation
EII 5.2	Soil and Sediment Sampling	--	X	X	X	--
EII 5.4	Field Decontamination of Drilling, Well Development, and Sampling Equipment	--	X	X	X	--
EII 5.5	1706 KE Laboratory Decontamination of RCRA/CERCLA Sampling Equipment	--	X	X	X	--
EII 5.7A	Hanford Geotechnical Sample Library Control	--	X	X	X	--
EII 5.10	Sample Identification and Data Entry into HEIS Database ^d	--	X	X	X	--
EII 5.11	Sample Packaging and Shipping	--	X	X	X	--
EII 5.12	Air Quality Sampling of Ambient and Downwind Air at Waste Sites	--	--	--	--	X
EII 6.1	Activity Reports of Field Operations	--	X	X	X	--
EII 6.7	Resource Protection Well and Test Borehole Drilling	--	X	X	X	--
EII 6.9	Groundwater Well and Borehole Identification and Tracking ^d	--	X	X	X	--
EII 9.1	Geologic Logging	--	X	X	X	--
EII 11.1	Geophysical Logging	--	X	X	X	--
EII 12.1	Surveying ^d	--	X	X	X	--
EII 14.1	Analytical Laboratory Data Management	--	X	X	X	X
EII (TBD)	Preparation of Descriptions of Work	--	X	X	X	X
e	Data Validation	--	--	X	X	--

A-18

DOE/RL-92-76, Rev. 0

**Table QAPJP-2. Sampling and Investigative Procedures for the Limited Field Investigations
in the 200-UP-1 Groundwater Operable Unit**

Page 3 of 3

	Procedure Title or Subject ^{a,b}	Task 2 Source Investigation	Task 3 Geological Investigation ^c	Task 4 Vadose Zone Investigation	Task 5 Groundwater Investigation	Task 6 Air Investigation
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- a/ Procedures are latest versions of Westinghouse Hanford Environmental Investigations Instructions (EII) selected from WHC-CM-7-7, Environmental Investigations and Site Characterization Manual (WHC 1988), unless otherwise indicated.
- b/ Companion document is Operational Health Physics Practice Manual, WHC-CM-4-12 (WHC 1988).
- c/ Geologic activities will be conducted under the Task 3 Vadose Zone Investigation and related groundwater operable unit investigations.
- d/ In preparation.
- e/ WHC-CM-5-3, Sample Management Administration Manual (WHC 1990c).

Legend:

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act of 1980
 HEIS = Hanford Environmental Information System
 RCRA - Resource Conservation and Recovery Act of 1976

5.0 SAMPLE CUSTODY

All samples obtained during the course of this investigation shall be controlled as required by EII 5.1, "Chain of Custody" (WHC 1988a), from the point of origin to the analytical laboratory. Laboratory chain-of-custody procedures shall be reviewed and approved in compliance with the requirements of Section 4.1 of this QAPjP, and shall ensure the maintenance of sample integrity and identification throughout the analytical process. At the direction of the technical lead, requirements for the return of residual sample materials after completion of analysis shall be defined in accordance with procedures described in the procurement documentation to subcontractor or participant contractor laboratories. Chain-of-custody forms shall be initiated for returned residual samples as required by the approved procedures applicable within the laboratory. All analytical results shall be controlled as permanent project quality records as required by Section 9 of WHC-CM-3-5 (WHC 1990b).

6.0 CALIBRATION PROCEDURES

Calibration of all Westinghouse Hanford measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by QR 12.0, "Control of Measuring and Test Equipment", (WHC 1991), other procedures as identified under criterion 12 of the QAPI included in WHC-EP-0383 (WHC 1990a), and/or specific requirements incorporated in the text of investigation-specific DOWs prepared in compliance with EII TBD. Routine operational checks for Westinghouse Hanford field equipment shall be as defined within applicable EIIs or procedures; similar information shall be provided in Westinghouse Hanford-approved participant contractor or subcontractor procedures or included in the text of applicable DOWs as indicated above. All calibration requirements applicable to analytical laboratory equipment shall be as defined by laboratory QA plans and/or applicable standard analytical methods, subject to Westinghouse Hanford review and approval.

7.0 ANALYTICAL PROCEDURES

All analytical methods that have been selected for this investigation are listed in Table QAPjP-1, cross-referenced to the parameters of interest and the maximum detection or quantitation limit values and maximum acceptable ranges for precision and accuracy for both soil and water matrices. Where EPA CLP methods are specified, the CRDLs for inorganic parameters, the CRQLs for organic parameters, and the maximum precision and accuracy ranges specified for each parameter by the appropriate CLP SOWs apply without modification (see

EPA 1991a and 1991b). For non-CLP parameters, CRQLs and precision and accuracy ranges are provided that shall be considered maximum values, which can be reliably achieved by analytical laboratories. Applicable physical testing parameters for soils acquired in this investigation are defined in Table QAPjP-3. In order to facilitate the comparability of data sets in terms of precision and accuracy, all analytical data shall be reported in the standard units specified in the applicable reference method. The reporting requirements so defined and the applicable requirements of Tables QAPjP-1 and QAPjP-3 shall be considered minimum performance standards that shall be incorporated into the agreements for services established with individual Westinghouse Hanford, participant contractor, or subcontractor analytical laboratories. As previously noted in Section 3, any modification of Table QAPjP-1 requirements shall be justified by the requestor, and shall be considered a formal modification of this QAPjP, and is subject to regulatory review and approval.

**Table QAPjP-3. Soil Physical Parameters
for the 200-UP-1 Groundwater Operable Unit.**

Parameter	ASTM or Other Standard Method
Bulk density/Porosity	D-2216, D-854, C-127, C-128 ^a
Particle size distribution	D-422 ^b
Permeability	D-2434 ^b
Moisture content	D-2216 ^b
Soil pH/Eh	EPA 9045/TBD
Cation Exchange Capacity	EPA 9081
Organic Carbon Content	EPA SM5310B
CaCO ₃ Content	D-4373 ^b

^a Method shall be developed by the laboratory contractor and submitted for Westinghouse Hanford review and approval before use.

^b Method is from the *1991 Annual Book of ASTM Standards* (ASTM 1991).

All analytical procedures approved for use in this investigation shall require the use of the standard units specified by the analytical methods referenced in Table QAPjP-1, to facilitate the comparability of data sets in terms of precision and accuracy. All approved procedures shall be retained in the project quality records and shall be available for review on request.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

8.1 DATA REDUCTION AND DATA PACKAGE PREPARATION

All analytical laboratories shall be responsible for preparing a report summarizing the results of analysis and for preparing a detailed data package that includes identifying samples, sampling and analysis dates, raw analytical data, reduced data, data outliers, reduction formulas, recovery percentages,

quality control (QC) check data, equipment calibration data, supporting chromatogram or spectrograms, and documentation of any nonconformances affecting the measurement system in use during the analysis of the particular group of samples. Data reduction schemes shall be contained within individual laboratory analytical methods and/or QA manuals, submitted for Westinghouse Hanford review and approval as discussed in Section 4.1. The completed data package shall be reviewed and approved by the analytical laboratory's QA manager (or field team leader for field screening type analysis) before its submittal to the Westinghouse Hanford technical lead. Completed data packages shall be submitted to the HASM for tracking and data validation functions. The requirements of this section shall be included in procurement documentation or work orders, as appropriate, to comply with the standard Westinghouse Hanford procurement control procedures noted in Section 4.1.

8.2 VALIDATION

Validation of the completed data package will be performed by qualified Westinghouse Hanford HASM personnel or by a qualified independent participant contractor. Subcontracted validation responsibilities shall be defined in procurement documentation or work orders as appropriate. All validation shall be performed in compliance with WHC-CM-5-3 Westinghouse Hanford *Sample Management Administration Manual* (WHC 1990b), Section 2.1 for inorganics analyses, Section 2.2 for organics analyses, and Sections 2.3 and 2.4 for radionuclide analysis. All data packages shall be verified; 10% shall receive full validation in compliance with WHC-CM-5-3 requirements. Data packages requiring full validation shall be specified by the Westinghouse Hanford technical lead.

8.3 FINAL REVIEW AND RECORDS MANAGEMENT CONSIDERATIONS

All verification and validation reports and supporting analytical data packages shall be subject to a final technical review by a qualified reviewer at the direction of the Westinghouse Hanford technical lead, before their submittal to regulatory agencies; prior to entry into the Hanford Environmental Information System (HEIS) in compliance with EII 14.1, "Analytical Laboratory Data Management," (WHC 1988a); or before inclusion in reports or technical memoranda. All verification and validation reports, data packages, and review comments shall be retained as permanent project quality records in compliance with Section 9 of WHC-CM-3-5 (WHC 1990b).

8.4 REQUIREMENTS FOR HANDLING UNACCEPTABLE OR SUSPECT DATA

The analytical data flow and data management process is described in detail in EII 14.1, "Analytical Laboratory Data Management" (WHC 1988a). Data errors or procedural discrepancies related to laboratory analytical processes shall prompt data requalification by the validator, requests for reanalysis, or other appropriate corrective action by the responsible laboratory as required by governing HASM or approved subcontractor data validation procedures. If sample holding time requirements are compromised, insufficient

sample material is available for reanalysis, or any other condition prevents compliance with governing analytical methods and data validation protocols, the situation shall be formally documented as a nonconformance in compliance with QR 15.0, "Control of Nonconforming Items" (WHC 1991). A corrective action request shall be prepared in compliance with requirements of QR 16.0, "Corrective Action" (WHC 1991), and brought to the immediate attention of the Westinghouse Hanford technical lead and QA Coordinator for their appropriate action. If problems are observed with validated data, either as part of the data assessment process described in Section 12 of this QAPjP or if separately observed by any of the operable unit managers, the data shall be documented as a nonconformance and corrective action initiated as previously noted; if the data have been entered in the HEIS, the HEIS Data Custodian shall be immediately notified in order that the data may be flagged [in compliance with EII 14.1 and WHC-EP-0372 *HEIS User's Manual* (WHC 1990d)] as suspect, pending resolution of the nonconformance and completion of all required corrective actions.

9.0 INTERNAL QUALITY CONTROL

All analytical samples shall be subject to in-process QC measures in both the field and laboratory. Unless otherwise specified in the approved SOWs or work orders for sampling activities, or in applicable EIIs, the following minimum field QC requirements shall apply. These requirements are adapted from *Test Methods for Evaluating Solid Waste* (EPA 1986), as modified by the proposed rule changes included in the *Federal Register*, 1989, Volume 54, No. 13, pp 3212-3228, and 1990, Volume 55, No. 27, pp 4440-4445.

- Field duplicate samples. For each shift of sampling activity under an individual sampling subtask, a minimum of 5% of the total collected samples shall be duplicated, or one duplicate shall be collected for every 20 samples, whichever is greater. Duplicate samples shall be retrieved from the same sampling location using the same equipment and sampling technique, and shall be placed into two identically prepared and preserved containers. All field duplicates shall be analyzed independently to assess the magnitude of field variability and the need for more duplicates.
- Split samples. Upon specific Westinghouse Hanford or regulator request, and at the technical lead's direction, field or field duplicate samples may be split in the field and sent to an alternative laboratory as a performance audit of the primary laboratory. Frequency shall meet the minimum schedule requirements of Chapter 10.0 below or the specific needs of the requesting organization.
- Blind samples. At the technical lead's discretion, blind reference samples may be introduced into any sampling round as a QC check of the primary laboratory. Blind sample type shall be as directed by

the technical lead; frequency shall meet the minimum schedule requirements in Chapter 10.0.

- Field blanks. Field blanks shall consist of pure deionized distilled water, transferred into a sample container at the site and preserved with the reagent specified for the analytes of interest. Field blanks are used as a check on reagent and environmental contamination, and shall be collected at the same frequency as field duplicate samples.
- Equipment rinsate blanks. Equipment blanks shall consist of pure deionized distilled water washed through decontaminated sampling equipment and placed in containers identical to those used for actual field samples. Equipment blanks are used to verify the adequacy of sampling equipment decontamination procedures, and shall be collected at the same frequency as field duplicate samples where applicable.
- Volatile organic analysis trip blanks. Volatile organic analysis (VOA) trip blanks consist of pure deionized distilled water added to one clean sample container, accompanying each batch (cooler) of containers shipped to the sampling facility. Trip blanks shall be returned unopened to the laboratory, and are prepared as a check on possible contamination originating from container preparation methods, shipment, handling, storage or site conditions. The trip blank shall be analyzed for volatile organic compounds only, as shown on EPA's target compound list (TCL; see EPA 1991b). In compliance with standard Westinghouse Hanford procurement procedures, requirements for trip blank preparation shall be included in procurement documents of work orders to the sample container supplier and/or preparer.

Unless otherwise specified in Westinghouse Hanford-approved analytical methods, internal QC checks performed by analytical laboratories shall meet the following minimum requirements.

- Matrix-spike/matrix-spike duplicate samples. Matrix-spiked samples require the addition of a known quantity of a representative analyte of interest to the sample as a measure of recovery percentage and as a test of analytical precision. The spike shall be made in a replicate of a field duplicate sample. Replicate samples are separate aliquots removed from the same sample container in the laboratory. Spike compound selection, quantities, and concentrations shall be described in the analytical procedures submitted for Westinghouse Hanford review and approval. One sample shall be spiked per analytical batch, or once every 20 samples, whichever is more frequent.
- Quality control reference samples. A QC reference sample shall be prepared from an independent standard at a concentration other than that used for calibration, but within the calibration range. Reference samples are required as an independent check on

analytical technique and methodology, and shall be run with every analytical batch, or every 20 samples, whichever is more frequent.

Other requirements specific to laboratory analytical equipment calibration are included in Section 6.0 of this QAPjP. For field screening gas chromatography (GC) analysis, at least one duplicate sample per shift shall be routed to a qualified laboratory as an overcheck on the proper use and functioning of field GC procedures and equipment. Duplicates shall be selected, whenever possible, from samples in which significant readings have been observed during field analysis. The minimum requirements of this section shall be invoked in procurement documents or work orders in compliance with standard Westinghouse Hanford procedures as noted in Section 4.1 of this QAPjP.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance, system, and program audits are scheduled to begin early in the execution of this work plan and continue through work plan completion. Collectively the audits address quality affecting activities that include, but are not limited to, measurement system accuracy, intramural and extramural analytical laboratory services, field activities, and data collection, processing, validation and management.

Performance audits of the accuracy of laboratory analysis are implemented in accordance with Standard Operating Procedure EII 1.12 "Laboratory Analysis Performance Audits" (WHC 1988a). System audit requirements are implemented in accordance with Standard Operating Procedure QI 10.4, "Surveillance" (WHC 1991). Surveillances will be performed regularly throughout the course of the work plan activities. Additional performance and system "surveillances" may be scheduled as a consequence of corrective action requirements, or may be performed upon request. All quality affecting activities are subject to surveillance.

All aspects of inter-operable unit activities will also be evaluated as part of routine environmental restoration program-wide QA audits under the Standard Operating Procedure requirements of WHC-CM-4-2 (WHC 1991). Program audits shall be conducted in accordance with QR 18.0, "Audits," QI 18.1, "Audit Programming and Scheduling," and QI 18.2, "Planning, Performing, Reporting, and Follow-up of Quality Audits" by auditors qualified in accordance with QI 2.5, "Qualification of Quality Assurance Personnel" (WHC 1991).

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratories that directly affect the quality of the field and analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime and corresponding schedule delays. Laboratories shall be responsible for performing or managing the maintenance of their analytical equipment. Maintenance requirements, spare parts lists and instructions shall be included in individual laboratory QA plans, subject to Westinghouse Hanford review and approval as noted in Sections 2.1, 2.2, and 4.1.2 of this QAPjP. When samples are analyzed using EPA reference methods, the preventative maintenance requirements for laboratory analytical equipment are as defined in the procured laboratory's QA plan(s). Westinghouse Hanford field equipment shall be drawn from inventories subject to standard preventive maintenance and calibration procedures as noted under criterion 12 of the QAPI included in WHC-EP-0383 (WHC 1990a). Any field procedures submitted for Westinghouse Hanford approval by participant contractors or subcontractors shall contain, as appropriate, provisions for preventive maintenance schedules and spare parts lists to ensure minimization of equipment downtime.

12.0 DATA ASSESSMENT PROCEDURES

All analytical data shall be compiled, reduced, and reviewed by the laboratory prior to presentation to HASM or subcontractor personnel for validation as described in Section 8 of this QAPjP. Assessment of the validated data will follow the general guidelines established in Section 5.1.1.7 of the work plan; depending on the distribution and statistical characteristics of the validated data and other unit- or area-specific considerations, various statistical and/or probabilistic techniques may be selected for use in the process of data comparison or analysis. The selection of any such methodology shall be subject to the approval and authorization of the Westinghouse Hanford technical lead. Methods shall be documented, signed, dated, retained as project records in compliance with Section 9 of WHC-CM-3-5 (WHC 1990b), and, as appropriate, considered in the risk assessment and field report preparation tasks described in Sections 5.1.1.8 and 5.1.1.10 of the work plan.

13.0 CORRECTIVE ACTION

13.1 GENERAL REQUIREMENTS FOR CORRECTIVE ACTION

Corrective action requests required as a result of surveillance reports, nonconformance reports, program audit activities, or as a result of the

specific request of the operable unit manager, shall be documented and dispositioned by the Westinghouse Hanford technical lead and QA Coordinator as required by QR 16.0, "Corrective Action" (WHC 1991). Corrective action reports prepared under QR 16.0 requirements shall identify the affected requirement, the probable cause of the deviation, any data which may have been affected by the deviation, and the corrective action required both to resolve the immediate situation and to reduce or preclude its recurrence. Corrections of plans or procedures related to the overall measurement system that do not constitute nonconformances, but may be required as a result of data validation, data assessment, or routine review processes, shall be resolved as required by their governing procedures or shall be referred to the Westinghouse Hanford technical lead for resolution and appropriate management action. All documentation related to surveillances, audits, and corrective action shall be maintained in compliance with EII 1.6, "Records Management" (WHC 1991) and routed to the project quality records upon completion or closure for retention in compliance with Section 9 of WHC-CM-3-5 (WHC 1990d), and shall be made available for operable unit manager review upon request through the Westinghouse Hanford technical lead.

13.2 CORRECTIVE ACTION REQUIREMENTS RELATED TO CALIBRATION ERRORS

Field measuring and test equipment found to be out of calibration shall be documented as a nonconformance in compliance with QR 15.0, "Control of Nonconforming Items" (WHC 1991). Nonconforming items shall be tagged, removed from service, and segregated pending resolution of the nonconformance and initiation of appropriate corrective action in compliance with QR 16.0, "Corrective Action" (WHC 1991). Calibration errors related to laboratory analytical processes that may be observed in the data validation activities described in Section 8 shall prompt requests for reanalysis or other appropriate corrective action by the responsible laboratory as required by the governing HASM or approved subcontractor data validation procedures. If sample holding time requirements are compromised, insufficient sample material is available for reanalysis, or any other condition prevents compliance with governing analytical methods and data validation protocols, the situation shall be initiated in compliance with the requirements of QR 16.0 and brought to the attention of the Westinghouse Hanford technical lead and QA Coordinator for their appropriate action.

13.3 CORRECTIVE ACTION RELATED TO PROCEDURAL DEVIATIONS

Planned deviations from EII requirements shall be processed in compliance with EII 1.4, "Deviations from Environmental Investigations Instructions." Unplanned procedural deviations observed during system audit, surveillance, or program audit activities shall be documented as nonconformances, findings, or observations in compliance with the procedures described in Section 10. Corrective action shall be initiated in compliance with QR 16.0, "Corrective Action" (WHC 1991) as previously noted in Section 13.1.

13.4 CORRECTIVE ACTION REQUIREMENTS RELATED TO PURCHASED MATERIALS, ITEMS, OR EQUIPMENT

Purchased materials, items, and equipment found to be out of compliance with their governing procurement specifications shall be documented as a nonconformance in compliance with QR 15.0, "Control of Nonconforming Items" (WHC 1991). Nonconforming items shall be tagged and segregated pending resolution of the nonconformance and initiation of appropriate corrective action in compliance with QR 16.0, "Corrective Action" (WHC 1991).

14.0 QUALITY ASSURANCE REPORTS

As previously stated in Chapters 10.0 and 13.0, project activities shall be regularly assessed by performance and system audits, surveillances, and program audits. Surveillance, nonconformance, audit and corrective action documentation shall be routed to the project quality records on completion or closure of the activity. A report summarizing corrective action and instruction change authorization activity (see Sections 4.4 and 13.2), as well as any associated corrective actions, shall be prepared for the technical lead by QA at the completion of the field and laboratory investigations. Such information will become an integral part of the remedial investigation report prepared under Task 13 (see Section 5.1.1.10 of the work plan). The final report shall include an assessment of the overall adequacy of the total measurement system with regard to the data quality objectives of the investigation.

15.0 REFERENCES

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APPENDIX B

SUMMARY OF LFI CONSTITUENT
DETECTIONS FOR 200-UP-1 GROUNDWATER OPERABLE UNIT WELLS
(JANUARY 1988 TO SEPTEMBER 1992)

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Page 1

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections < D.L. in Well	Number in Well	Total Number of Analyses
1,1-dichloroethylene	299-W22-20	5.233	5.700	5.700	1	2	3
@ 1,2-dichloroethane	299-W22-20	5.250	6.000	5.000	2	2	4
Aldrin	299-W19-18	1.800	1.800	1.800	1	0	1
Arsenic	299-W19-21	16.000	18.000	14.000	2	0	2
	299-W23-13	15.250	17.000	14.000	4	0	4
	299-W23-11	14.000	14.000	14.000	1	0	1
	299-W19-27	12.000	12.000	12.000	1	0	1
	299-W18-15	10.000	10.000	10.000	1	0	1
	299-W26-12	8.525	10.000	7.000	4	0	4
	299-W26-9	7.400	10.000	7.600	4	1	5
	299-W23-14	6.040	7.000	5.200	5	0	5
	299-W19-31	5.825	13.000	5.300	2	2	4
	299-W22-39	5.350	5.800	5.100	4	0	4
	299-W22-20	4.750	7.000	7.000	1	1	2
	299-W22-40	3.617	5.900	5.800	2	4	6
	299-W26-7	3.575	5.600	5.200	3	5	8
	299-W26-10	3.020	5.100	5.100	1	4	5
Arsenic, filtered	299-W23-13	14.750	17.000	13.000	4	0	4
	299-W19-21	13.500	14.000	13.000	2	0	2
	299-W18-15	12.000	12.000	12.000	1	0	1
	299-W19-27	12.000	12.000	12.000	1	0	1
	299-W23-11	12.000	12.000	12.000	1	0	1
	299-W26-12	7.375	9.500	5.000	4	0	4
	299-W26-9	7.160	9.600	6.200	4	1	5
	299-W23-14	6.100	7.700	5.300	5	0	5
	299-W22-39	5.000	6.500	5.500	3	1	4
	299-W26-7	3.933	5.400	5.300	3	3	6
	299-W26-10	3.600	5.400	5.100	2	3	5
	299-W22-40	3.033	5.700	5.700	1	5	6
Bis(2-ethylhexyl) phthalate	299-W14-10	10.000	15.000	15.000	1	1	2
Cadmium	299-W19-1	94.000	94.000	94.000	1	0	1
	299-W14-10	7.000	13.000	13.000	1	1	2
	299-W19-26	3.500	2.000	2.000	1	1	2
Cadmium, filtered	299-W22-20	2.200	3.000	3.000	1	4	5
	299-W27-1	2.125	2.000	2.000	1	7	8
	699-38-70	1.833	2.000	2.000	1	5	6
	299-W22-26	1.500	2.000	2.000	1	1	2
@ Carbon Tetrachloride	299-W19-16	162.400	209.000	120.000	5	0	5
	299-W19-31	130.000	130.000	130.000	1	0	1
	299-W19-11	115.000	115.000	115.000	1	0	1
	299-W19-9	110.250	120.000	99.000	4	0	4
	299-W18-15	106.333	120.000	89.000	3	0	3
	299-W19-3	87.667	120.000	49.000	3	0	3
	299-W19-29	86.333	130.000	19.000	3	0	3

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
a Carbon Tetrachloride							
	299-W19-15	84.200	127.000	63.000	5	0	5
	299-W19-28	65.750	82.000	50.000	4	0	4
	299-W19-18	44.500	89.000	9.000	4	0	4
	699-38-70	39.667	58.000	29.000	6	0	6
	299-W19-13	36.000	39.000	33.000	3	0	3
	299-W19-26	31.667	33.000	30.000	3	0	3
	299-W19-20	29.000	42.000	17.000	8	0	8
	299-W19-23	28.500	37.000	20.000	2	0	2
	299-W19-25	26.000	31.000	21.000	2	0	2
	299-W19-2	22.000	22.000	22.000	1	0	1
	299-W19-12	20.000	20.000	20.000	1	0	1
	299-W19-24	19.833	24.000	14.000	6	0	6
	299-W19-30	18.000	18.000	18.000	1	0	1
	299-W19-19	15.000	20.000	10.000	2	0	2
	299-W19-27	12.000	17.000	7.000	6	0	6
	299-W22-20	10.160	13.000	7.800	5	0	5
	299-W22-40	7.883	9.000	7.000	6	0	6
	299-W22-41	6.680	7.700	5.000	5	0	5
	299-W22-42	5.090	6.800	4.000	4	1	5
	299-W19-1	4.750	7.000	7.000	1	1	2
	299-W19-21	2.169	3.200	2.700	2	6	8
	299-W26-8	2.083	1.300	1.300	1	5	6
a Chloroform							
	299-W22-20	9.400	12.000	8.000	5	0	5
	299-W27-1	8.688	14.000	6.000	7	1	8
	299-W19-28	7.375	10.000	5.200	4	0	4
	299-W19-29	5.000	6.300	6.200	2	1	3
	299-W19-23	4.500	7.000	7.000	1	1	2
	299-W26-12	4.100	6.000	3.900	3	1	4
	299-W19-16	3.800	5.000	5.000	3	2	5
	299-W19-20	3.400	6.000	5.400	3	5	8
	299-W19-25	3.250	5.000	5.000	1	1	2
	299-W19-24	3.233	6.000	5.900	2	4	6
	299-W19-9	2.500	5.000	5.000	1	3	4
	699-38-70	2.317	2.900	2.900	1	5	6
	299-W22-41	1.820	1.000	1.000	1	4	5
	299-W22-40	1.458	1.400	1.100	2	4	6
	299-W22-42	1.160	1.000	.840	3	2	5
Chromium (filtered)							
	299-W22-20	322.600	350.000	296.000	5	0	5
	299-W26-7	154.000	190.000	100.000	5	0	5
	299-W19-12	49.000	49.000	49.000	1	0	1
	299-W22-21	40.000	40.000	40.000	1	0	1
	299-W19-32	33.000	34.000	31.000	3	0	3
	699-32-708	22.750	25.000	20.000	4	0	4
	699-35-66	22.750	26.000	20.000	4	0	4
	299-W26-9	20.200	61.000	61.000	1	4	5
	299-W27-1	12.625	24.000	11.000	5	3	8
	299-W22-42	12.600	23.000	23.000	1	4	5
	299-W19-31	12.500	20.000	20.000	1	3	4
	299-W22-40	12.333	24.000	24.000	1	5	6
	699-36-61A	11.200	15.000	13.000	3	2	5

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Chromium (filtered)	699-35-78A	9.000	13.000	13.000	1	1	2
	299-W19-18	8.800	12.000	12.000	2	3	5
	299-W19-24	7.000	15.000	15.000	1	4	5
	299-W19-3	6.250	10.000	10.000	1	3	4
DDT	299-W19-18	4.200	4.200	4.200	1	0	1
	299-W14-10	.100	.100	.100	1	0	1
Dieldrin	299-W19-18	3.800	3.800	3.800	1	0	1
Endrin	299-W19-18	4.400	4.400	4.400	1	0	1
Endrin Aldehyde	299-W19-18	.670	.670	.670	1	0	1
a Fluoride	299-W19-30	2550.000	4000.000	1100.000	2	0	2
	299-W22-9	1950.000	3600.000	300.000	2	0	2
	299-W19-25	1190.000	1700.000	370.000	3	0	3
	299-W19-29	1166.667	2100.000	600.000	3	0	3
	299-W19-26	1094.000	1800.000	376.000	3	1	4
	299-W19-20	1052.500	1900.000	272.000	8	2	10
	299-W23-1	1000.000	1000.000	1000.000	1	0	1
	299-W26-12	925.000	1200.000	700.000	4	0	4
	699-32-62	800.000	800.000	800.000	1	0	1
	299-W22-41	700.000	1000.000	600.000	5	0	5
	299-W19-24	698.625	1850.000	322.000	4	4	8
	299-W22-42	636.000	880.000	500.000	5	0	5
	299-W19-28	625.000	1400.000	600.000	2	2	4
	299-W19-13	615.000	900.000	500.000	4	1	5
	299-W19-12	600.000	600.000	600.000	2	0	2
	299-W19-9	596.857	756.000	574.000	6	1	7
	299-W26-7	591.429	740.000	500.000	7	0	7
	299-W19-11	583.500	667.000	500.000	2	0	2
	299-W23-13	575.000	600.000	500.000	4	0	4
	299-W19-3	564.800	600.000	524.000	5	0	5
	299-W19-32	563.333	600.000	500.000	3	0	3
	699-32-77	545.000	676.000	487.000	6	1	7
	299-W22-40	541.667	750.000	500.000	6	0	6
	299-W26-10	528.000	640.000	400.000	5	0	5
	299-W19-31	527.500	600.000	500.000	4	0	4
	299-W22-2	525.000	800.000	800.000	1	1	2
	299-W22-39	525.000	600.000	500.000	4	0	4
	299-W19-16	522.375	892.000	500.000	6	2	8
	699-38-70	514.333	800.000	326.000	10	2	12
	299-W26-9	510.000	750.000	200.000	5	0	5
	299-W19-2	500.000	500.000	500.000	1	0	1
	299-W22-21	500.000	500.000	500.000	1	0	1
	299-W26-8	498.333	720.000	300.000	6	0	6
	299-W22-12	496.333	600.000	500.000	5	1	6
	699-29-78	474.429	625.000	433.000	6	1	7
	299-W23-14	442.000	510.000	400.000	5	0	5
	299-W19-1	437.500	800.000	300.000	3	1	4
	299-W19-18	427.500	655.000	410.000	4	2	6

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
a Fluoride							
	699-36-61B	425.000	600.000	600.000	1	1	2
	299-W19-15	422.750	705.000	390.000	5	3	8
	699-32-72	414.286	560.000	356.000	6	1	7
	299-W22-20	406.700	1100.000	217.000	6	4	10
	699-35-70	400.333	800.000	353.000	6	3	9
	299-W19-27	391.667	500.000	400.000	5	1	6
	299-W19-23	389.333	418.000	418.000	1	2	3
	299-W23-9	383.333	600.000	300.000	2	1	3
	299-W14-10	380.000	640.000	640.000	1	2	3
	299-W23-4	375.000	500.000	500.000	1	1	2
	699-32-70B	368.800	509.000	393.000	7	3	10
	699-40-62	365.400	547.000	300.000	9	1	10
	299-W19-19	363.667	341.000	341.000	1	2	3
	699-38-65	360.333	800.000	262.000	4	2	6
	699-35-66	333.875	521.000	309.000	5	3	8
	299-W22-22	328.500	504.000	467.000	2	4	6
	299-W22-10	325.000	400.000	400.000	1	1	2
	299-W19-5	323.000	469.000	469.000	1	2	3
	299-W22-26	323.000	469.000	469.000	1	2	3
	699-36-61A	311.000	400.000	315.000	5	4	9
	299-W22-1	305.250	471.000	471.000	1	3	4
	699-35-78A	303.600	400.000	368.000	2	3	5
	299-W18-22	298.889	490.000	300.000	3	6	9
	299-W26-6	275.000	300.000	300.000	1	1	2
	299-W27-1	266.700	300.000	267.000	4	6	10
	299-W18-15	257.250	279.000	279.000	1	3	4
	299-W23-10	253.250	283.000	240.000	3	5	8
	299-W19-21	228.600	231.000	200.000	5	5	10
	299-W23-11	175.000	100.000	100.000	1	1	2
Gamma-BHC							
	299-W19-18	1.700	1.700	1.700	1	0	1
a Gross alpha							
	299-W19-18	2208.611	3710.000	515.000	18	0	18
	299-W19-3	1968.389	3100.000	811.000	18	0	18
	299-W19-11	1959.250	2570.000	867.000	4	0	4
	299-W19-29	1359.333	2120.000	928.000	3	0	3
	299-W19-9	900.571	1360.000	613.000	7	0	7
	299-W19-16	675.417	989.000	407.000	12	0	12
	299-W19-19	453.429	594.000	170.000	21	0	21
	299-W19-24	338.737	489.000	189.000	19	0	19
	299-W19-20	315.857	452.000	157.000	21	0	21
	299-W19-26	221.364	315.000	100.000	11	0	11
	299-W19-25	206.250	285.000	154.000	16	0	16
	299-W19-23	149.624	208.000	94.600	17	0	17
	299-W19-15	127.463	235.000	24.800	8	0	8
	299-W19-2	79.400	114.000	10.200	17	0	17
	699-38-70	41.645	52.200	19.600	20	0	20
	299-W18-15	40.480	49.200	30.800	5	0	5
	299-W23-4	39.908	64.200	15.700	13	0	13
	299-W19-28	32.000	38.500	25.000	4	0	4
	299-W23-10	26.408	39.500	14.700	12	0	12
	299-W23-9	25.171	56.500	17.500	17	0	17

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Page 5

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
α Gross alpha							
	299-W19-17	22.925	36.100	17.100	4	0	4
	299-W22-21	15.233	20.500	11.600	3	0	3
	299-W19-21	14.189	18.200	11.500	9	0	9
	299-W23-11	13.929	17.200	10.400	7	0	7
	699-35-78A	13.019	15.400	9.730	7	0	7
	299-W26-8	10.507	15.700	6.630	6	0	6
	299-W19-27	9.900	14.900	4.250	11	0	11
	299-W23-13	8.720	9.340	7.960	4	0	4
	299-W23-14	8.574	10.400	6.120	5	0	5
	299-W22-20	7.931	22.100	4.300	7	2	9
	299-W27-1	7.170	13.000	4.240	10	0	10
	299-W19-13	6.552	8.480	3.110	5	0	5
	299-W22-2	6.123	9.940	4.930	6	0	6
	299-W22-39	5.248	7.550	4.400	3	1	4
	299-W19-1	4.425	6.260	6.110	2	1	3
	299-W22-1	4.025	5.780	1.740	4	0	4
	299-W23-8	3.780	3.780	3.780	1	0	1
	299-W14-10	3.556	5.760	2.770	3	1	4
	299-W19-12	3.087	3.500	2.770	3	0	3
	299-W19-14	2.982	4.370	2.390	4	1	5
	299-W22-40	2.445	4.790	2.200	3	3	6
	299-W22-42	2.329	5.690	1.780	2	3	5
	299-W22-41	2.316	4.970	2.750	2	3	5
	299-W22-18	2.048	5.710	1.020	5	0	5
	699-32-62	1.938	2.490	1.700	5	0	5
	699-40-62	1.885	3.680	1.560	7	2	9
	299-W22-12	1.885	1.960	1.810	2	0	2
	699-35-66	1.737	2.400	1.390	3	0	3
	299-W22-22	1.719	6.360	.684	6	1	7
	299-W26-3	1.554	2.760	.763	3	0	3
	699-32-77	1.522	2.160	.877	6	1	7
	699-35-70	1.517	3.040	1.650	3	5	8
	699-38-65	1.514	4.240	1.920	3	5	8
	299-W26-12	1.433	2.840	2.840	1	3	4
	299-W22-10	1.400	7.710	.469	2	4	6
	299-W26-10	1.278	2.870	1.770	2	3	5
	699-32-708	1.257	2.170	2.170	1	1	2
	699-29-78	1.223	2.000	.921	6	2	8
	299-W19-31	1.200	1.530	1.530	1	3	4
	699-36-61A	1.193	1.750	1.430	2	1	3
	699-25-70	1.059	1.360	.768	5	1	6
	299-W19-32	.975	1.390	1.390	1	2	3
	299-W26-6	.867	1.330	.954	3	1	4
	699-36-61B	.702	2.640	.449	2	3	5
	299-W18-22	.656	1.710	1.020	2	7	9
	299-W26-7	.427	1.030	1.030	1	6	7
	699-32-72	.207	.993	.993	1	7	8
Gross beta							
	299-W19-25	3271.875	5110.000	1910.000	16	0	16
	299-W19-18	3078.067	6180.000	86.200	18	0	18
	299-W19-24	2526.316	3900.000	1640.000	19	0	19
	299-W19-11	2154.500	3160.000	278.000	4	0	4

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Gross beta							
	299-W19-29	1940.000	2230.000	1480.000	3	0	3
	299-W19-20	1684.381	3990.000	753.000	21	0	21
	299-W19-3	1627.778	2870.000	239.000	18	0	18
	299-W19-19	1057.048	1750.000	533.000	21	0	21
	299-W19-28	900.000	2150.000	328.000	4	0	4
	299-W19-16	758.667	1540.000	286.000	12	0	12
	299-W19-9	669.714	1100.000	353.000	7	0	7
	299-W19-26	564.273	909.000	222.000	11	0	11
	299-W23-2	541.412	1180.000	102.000	17	0	17
	299-W23-7	394.882	1200.000	187.000	17	0	17
	699-38-70	340.200	437.000	252.000	20	0	20
	299-W19-23	308.176	632.000	134.000	17	0	17
	299-W19-12	261.333	339.000	108.000	3	0	3
	299-W19-15	201.475	325.000	78.200	8	0	8
	299-W19-30	157.000	157.000	157.000	1	0	1
	299-W22-21	155.000	170.000	131.000	3	0	3
	299-W19-2	120.900	163.000	66.500	17	0	17
	299-W19-32	107.367	127.000	88.100	3	0	3
	299-W22-39	104.750	122.000	92.400	4	0	4
	299-W23-1	84.367	404.000	11.400	6	0	6
	299-W23-3	82.450	131.000	33.700	6	0	6
	299-W19-31	52.500	61.500	46.000	4	0	4
	299-W19-17	50.250	63.600	45.700	4	0	4
	299-W22-10	48.217	64.800	32.800	6	0	6
	299-W23-4	43.246	77.700	7.500	13	0	13
	699-32-708	33.575	40.000	23.800	8	0	8
	299-W22-1	29.150	30.800	27.800	4	0	4
	299-W22-20	28.604	50.500	19.700	10	1	11
	299-W22-42	26.440	39.300	18.600	5	0	5
	299-W22-41	25.940	48.500	19.300	5	0	5
	299-W19-5	22.600	27.300	17.900	2	0	2
	299-W22-2	22.417	40.000	15.400	6	0	6
	299-W22-26	21.050	23.300	18.800	2	0	2
	699-35-70	18.717	32.800	11.700	12	0	12
	299-W23-9	18.006	51.100	10.100	17	0	17
	299-W23-10	17.977	44.100	8.450	11	0	11
	699-38-65	16.150	20.000	13.000	12	0	12
	299-W19-13	15.820	18.700	12.900	5	0	5
	299-W22-18	14.400	18.500	12.400	5	0	5
	299-W14-10	12.090	20.300	5.780	4	0	4
	699-32-72	12.044	18.700	2.510	8	0	8
	299-W18-15	12.016	16.600	7.160	5	0	5
	699-35-66	10.278	12.200	7.240	8	0	8
	299-W19-1	9.905	19.000	8.690	2	1	3
	299-W19-14	8.976	11.500	6.320	5	0	5
	299-W22-12	7.950	9.610	5.170	4	0	4
	699-40-62	7.614	11.900	4.380	9	0	9
	699-36-618	7.412	9.750	5.150	5	0	5
	699-32-62	7.280	9.020	6.040	5	0	5
	299-W27-1	6.870	9.710	4.960	9	1	10
	299-W23-14	6.751	11.100	4.030	4	1	5
	299-W22-40	6.737	14.100	8.520	3	3	6

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Page 7

Constituent	Well Number	Average of Reported Maximum of Values (Detections and Nondetections)*	Minimum of Detections	Number of Detections in Well	Number of Detections < D.L. in Well	Total Number of Analyses		

Gross beta	699-36-61A	6.637	9.800	7.040	2	1	3	
	299-W23-11	6.121	8.590	4.100	6	1	7	
	699-35-78A	6.046	9.880	4.240	7	0	7	
	299-W26-8	5.917	14.200	2.970	3	3	6	
	299-W19-27	5.874	13.600	3.710	7	4	11	
	299-W19-21	5.788	11.600	3.320	6	3	9	
	299-W23-13	5.459	10.500	7.250	2	2	4	
	299-W22-22	5.307	7.640	3.410	7	0	7	
	299-W26-6	4.808	6.560	4.410	3	1	4	
	699-25-70	4.230	4.880	2.470	6	0	6	
	299-W18-22	4.087	6.460	2.290	7	2	9	
	699-32-77	4.064	5.110	3.060	7	0	7	
	299-W23-8	3.780	3.780	3.780	1	0	1	
	299-W26-3	3.003	3.320	2.790	3	0	3	
	299-W26-10	2.360	4.650	2.760	2	3	5	
	699-29-78	2.360	4.750	1.930	5	3	8	
	299-W26-9	1.572	2.170	2.170	1	4	5	
Heptachlor								
	299-W19-18	1.700	1.700	1.700	1	0	1	
a Iodine-129	699-35-70	30.057	87.800	10.300	7	0	7	
	299-W22-9	23.900	23.900	23.900	1	0	1	
	299-W19-3	10.540	15.500	5.580	2	0	2	
	299-W19-2	7.100	7.100	7.100	1	0	1	
	699-35-66	5.257	7.720	1.490	3	0	3	
	299-W19-18	5.125	6.120	4.130	2	0	2	
	299-W22-12	3.870	3.870	3.870	1	0	1	
	299-W19-16	3.405	4.560	2.250	2	0	2	
	299-W21-1	3.370	3.370	3.370	1	0	1	
	699-32-70B	2.559	3.570	.856	3	0	3	
	299-W19-20	2.330	2.330	2.330	1	0	1	
	299-W19-25	2.220	2.220	2.220	1	0	1	
	299-W22-22	2.110	2.180	2.040	2	0	2	
	299-W19-15	1.985	2.680	1.290	2	0	2	
	699-38-65	1.808	3.510	.920	3	0	3	
	299-W19-19	1.770	1.770	1.770	1	0	1	
	299-W19-24	1.745	1.970	1.520	2	0	2	
	299-W22-7	1.630	1.630	1.630	1	0	1	
	699-38-70	1.545	2.450	.319	4	0	4	
	299-W19-9	1.540	1.540	1.540	1	0	1	
	299-W19-23	1.290	1.290	1.290	1	0	1	
	299-W22-20	1.146	2.020	.339	5	0	5	
	299-W19-28	.729	.889	.569	2	0	2	
	299-W23-9	.406	.406	.406	1	0	1	
	299-W27-1	.168	.336	.336	1	1	2	
	699-40-62	.140	.266	.266	1	1	2	
	699-32-62	.034	.058	.058	1	1	2	
	N-nitrosodimethylamine							
		299-W23-10	27.000	27.000	27.000	1	0	1
	a Nitrate	299-W19-19	1321666.667	1450000.000	1220000.000	18	0	18
		299-W19-26	1120000.000	1360000.000	850000.000	11	0	11

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
■ Nitrate							
	299-W19-20	1031666.667	1200000.000	827000.000	24	0	24
	299-W19-24	1024571.429	1270000.000	584000.000	21	0	21
	299-W19-30	1000000.000	1000000.000	1000000.000	1	0	1
	299-W19-25	805750.000	960000.000	588000.000	16	0	16
	299-W19-23	418941.176	586000.000	330000.000	17	0	17
	299-W19-29	395666.667	496000.000	301000.000	3	0	3
	299-W19-28	322673.600	620000.000	368.000	5	0	5
	299-W22-42	266000.000	340000.000	210000.000	5	0	5
	699-38-70	257615.385	330000.000	216000.000	13	0	13
	299-W19-2	250705.882	340000.000	101000.000	17	0	17
	299-W22-41	210000.000	300000.000	160000.000	5	0	5
	299-W23-10	113990.000	158000.000	87100.000	10	0	10
	699-38-65	101563.600	171000.000	150.000	15	0	15
	299-W19-18	98346.600	146000.000	25.200	22	0	22
	299-W22-20	90568.400	199000.000	122.000	15	0	15
	299-W19-15	88600.000	109000.000	68600.000	10	0	10
	299-W19-11	80720.000	93100.000	44800.000	5	0	5
	299-W23-9	78438.889	223000.000	1700.000	18	0	18
	299-W14-10	56470.000	101000.000	14300.000	4	1	5
	299-W19-16	46440.000	53600.000	39100.000	10	0	10
	699-40-62	44461.538	52000.000	11000.000	13	0	13
	299-W27-1	43100.000	96900.000	13000.000	14	0	14
	299-W19-3	41772.222	60300.000	21900.000	18	0	18
	299-W21-1	39700.000	40700.000	38700.000	2	0	2
	299-W23-2	30342.857	33000.000	27700.000	7	0	7
	699-32-62	26160.000	27100.000	25000.000	5	0	5
	299-W22-40	25500.000	26000.000	25000.000	6	0	6
	299-W19-9	22711.111	36000.000	16200.000	9	0	9
	299-W22-21	21900.000	35300.000	12700.000	3	0	3
	699-35-66	21718.583	28500.000	23.000	12	0	12
	699-35-70	19555.472	29200.000	23.200	18	0	18
	299-W19-13	18100.000	21000.000	15000.000	9	0	9
	699-36-61A	17917.038	22100.000	21.500	13	0	13
	299-W19-31	17375.000	19000.000	15500.000	4	0	4
	699-32-70B	17353.846	22000.000	4600.000	13	0	13
	299-W18-22	16555.556	19000.000	13800.000	9	0	9
	299-W22-39	14525.000	19000.000	4100.000	4	0	4
	299-W22-22	13750.000	24900.000	2810.000	9	1	10
	299-W23-3	13345.857	21500.000	11.000	7	1	7
	699-25-70	12350.000	13500.000	11700.000	6	1	6
	299-W22-26	12000.222	18700.000	1.110	5	0	5
	299-W19-12	11025.000	16700.000	7100.000	4	0	4
	699-36-61B	10703.333	26100.000	20.000	7	2	9
	299-W23-1	9912.857	58800.000	830.000	4	3	7
	299-W19-17	9807.500	10000.000	9660.000	4	0	4
	299-W23-13	8950.000	11000.000	7700.000	4	0	4
	299-W19-14	8838.000	11700.000	3540.000	5	0	5
	699-29-78	7684.000	8660.000	7200.000	10	0	10
	699-32-72	7335.556	10600.000	5970.000	8	1	9
	299-W22-1	6415.714	12400.000	3830.000	7	0	7
	299-W19-32	6366.667	7000.000	5500.000	3	0	3
	699-32-77	5113.624	6400.000	6.240	10	0	10

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Nitrate							
	299-W22-2	5078.571	7400.000	900.000	7	0	7
	299-W26-7	4985.714	6000.000	3500.000	7	0	7
	299-W23-4	4947.857	9730.000	900.000	13	1	14
	299-W26-9	4888.000	5800.000	2440.000	5	0	5
	299-W22-9	4056.000	12000.000	400.000	3	2	5
	299-W23-14	3720.000	4200.000	2800.000	5	0	5
	299-W26-6	2952.500	3850.000	3310.000	3	1	4
	299-W26-10	2700.000	3400.000	2400.000	5	0	5
	299-W22-10	2675.000	5100.000	5100.000	1	1	2
	299-W19-5	2500.000	4220.000	2100.000	3	1	4
	299-W22-12	1914.286	2770.000	1300.000	6	1	7
	699-26-89	1743.333	2730.000	2730.000	1	2	3
	299-W26-3	1433.333	1800.000	1800.000	1	2	3
	299-W26-8	1366.667	3850.000	800.000	6	0	6
	299-W18-15	1305.000	1570.000	1200.000	3	5	8
	299-W23-11	1267.143	1420.000	1200.000	2	5	7
	699-35-78A	1154.700	1800.000	500.000	4	6	10
	299-W19-27	1113.000	2580.000	600.000	7	3	10
	299-W26-12	730.000	1600.000	400.000	4	0	4
	299-W19-21	679.167	700.000	300.000	5	7	12
	299-W19-1	650.000	1300.000	400.000	3	1	4
	299-W22-18	5.090	5.090	5.090	1	0	1
Plutonium-238							
	299-W19-24	.024	.170	.170	1	6	7
	299-W19-26	.011	.070	.070	1	5	6
	299-W19-23	.007	.049	.049	1	6	7
	299-W19-25	.003	.021	.021	1	6	7
Potassium-40							
	299-W19-32	373.000	373.000	373.000	1	0	1
	299-W22-26	211.000	211.000	211.000	1	0	1
	299-W26-12	208.000	208.000	208.000	1	0	1
	299-W23-13	207.000	207.000	207.000	1	0	1
	299-W23-14	171.000	171.000	171.000	1	0	1
	299-W22-42	146.000	146.000	146.000	1	0	1
	299-W19-29	140.000	140.000	140.000	1	0	1
	299-W18-22	131.000	131.000	131.000	1	0	1
	299-W26-7	128.000	128.000	128.000	1	0	1
	299-W19-31	126.000	126.000	126.000	1	0	1
	299-W22-20	120.850	250.000	55.900	4	1	5
	699-32-72	111.000	111.000	111.000	1	0	1
	299-W19-30	97.800	97.800	97.800	1	0	1
	699-35-70	94.181	149.000	125.000	4	2	6
	699-38-70	74.500	74.500	74.500	1	0	1
	699-38-65	72.158	118.000	87.800	4	2	6
	299-W22-40	66.600	66.600	66.600	1	0	1
	299-W22-12	53.600	53.600	53.600	1	0	1
Selenium							
	299-W27-1	20.333	35.000	21.000	2	1	3
	299-W19-23	10.000	10.000	10.000	1	0	1
	299-W22-20	9.500	14.000	14.000	1	1	2
	299-W19-28	7.000	7.000	7.000	1	0	1
	299-W19-26	6.000	6.000	6.000	1	0	1

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Selenium	299-W19-20	4.250	6.000	6.000	1	1	2
Strontium-90	299-W22-10	21.950	29.800	13.100	6	0	6
	299-W22-1	7.588	8.040	6.910	4	0	4
	299-W19-2	4.865	8.240	2.020	6	0	6
	299-W19-24	1.944	4.310	1.430	5	1	6
	299-W22-2	1.344	1.890	1.100	5	0	5
	299-W19-18	1.225	2.150	2.150	1	1	2
	299-W19-3	1.107	3.460	1.330	2	3	5
	299-W19-26	.518	1.880	1.880	1	4	5
	299-W22-7	.433	.899	.899	1	1	2
	299-W19-19	.254	1.010	1.010	1	6	7
	299-W19-20	.239	1.200	1.200	1	5	6
	299-W27-1	.066	.883	.883	1	6	7
Technetium-99	299-W19-24	28262.500	41000.000	19100.000	16	0	16
	299-W19-25	20057.857	33000.000	8810.000	14	0	14
	299-W19-20	13947.059	25400.000	10600.000	17	0	17
	299-W19-19	13741.250	24600.000	8530.000	16	0	16
	299-W19-28	7315.000	8450.000	6180.000	2	0	2
	299-W19-29	5330.000	10000.000	2520.000	3	0	3
	299-W19-18	4279.922	9200.000	91.600	18	0	18
	699-38-70	3153.684	4230.000	1760.000	19	0	19
	299-W19-26	3077.778	7290.000	1040.000	9	0	9
	299-W19-30	2800.000	2800.000	2800.000	1	0	1
	299-W23-2	2760.824	5150.000	103.000	17	0	17
	299-W23-7	2203.778	7830.000	117.000	18	0	18
	299-W19-11	1768.333	2870.000	355.000	3	0	3
	299-W19-23	1270.267	1850.000	907.000	15	0	15
	299-W19-12	1117.667	2350.000	302.000	3	0	3
	299-W19-16	975.358	1720.000	105.000	5	1	6
	299-W19-3	927.796	1280.000	323.000	1	1	14
	299-W19-15	713.133	1030.000	36.800	6	0	6
	299-W22-21	637.000	637.000	637.000	1	0	1
	299-W19-9	511.000	1020.000	247.000	6	0	6
	299-W19-32	460.333	521.000	397.000	3	0	3
	299-W22-39	444.750	554.000	359.000	4	0	4
	299-W19-31	230.750	297.000	152.000	4	0	4
	699-32-708	172.775	210.000	93.100	4	0	4
	299-W19-17	139.620	178.000	76.100	5	0	5
	299-W22-42	125.650	151.000	89.600	4	0	4
	299-W22-20	121.481	184.000	124.000	3	1	4
	299-W19-13	110.000	110.000	110.000	1	0	1
	299-W19-5	94.950	117.000	72.900	2	0	2
	299-W22-41	91.750	117.000	75.600	4	0	4
	699-35-70	80.386	135.000	24.500	7	0	7
	299-W22-18	65.950	69.400	62.500	2	0	2
	299-W23-9	53.350	81.200	25.500	2	0	2
	699-32-72	51.850	86.400	15.000	4	0	4
	699-38-65	42.500	92.400	40.700	2	1	3
	299-W19-14	38.700	38.700	38.700	1	0	1
	299-W19-1	33.667	46.700	24.400	3	0	3

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Constituent	Well Number	Average of Reported Values (Detections and Nondetections)*	Maximum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Technetium-99							
	699-35-66	31.381	44.700	37.400	3	1	4
	299-W22-26	26.100	26.100	26.100	1	0	1
	299-W23-10	14.083	20.100	19.800	2	1	3
	299-W22-40	11.140	23.400	12.200	2	3	5
	299-W23-14	7.285	12.000	12.000	2	3	5
a Trichloroethylene							
	299-W22-20	32.200	41.000	25.000	5	0	5
	299-W19-29	4.733	6.200	5.500	2	1	3
	699-38-70	3.367	8.000	5.700	2	4	6
	299-W19-20	2.188	2.800	2.800	1	7	8
Uranium							
	299-W19-18	2257.466	3910.464	552.625	19	0	19
	299-W19-11	1908.924	2661.288	1030.000	4	0	4
	299-W19-3	1889.405	3496.335	737.000	15	0	15
	299-W19-29	1535.672	2206.425	282.422	3	0	3
	299-W19-9	912.894	1452.846	344.881	6	0	6
	299-W19-16	638.062	1045.506	435.175	6	0	6
	299-W19-19	539.275	1968.810	343.523	17	0	17
	299-W19-24	381.605	545.157	279.028	19	0	19
	299-W19-20	325.635	501.028	2.040	20	0	20
	299-W19-25	218.203	311.000	176.514	15	0	15
	299-W19-26	180.572	340.000	5.513	12	0	12
	299-W19-23	136.866	168.367	106.587	16	0	16
	299-W19-15	91.833	228.110	27.700	6	0	6
	299-W19-2	67.401	101.156	8.800	17	0	17
	299-W23-4	59.699	252.551	14.700	13	0	13
	299-W19-30	53.429	53.429	53.429	1	0	1
	699-38-70	42.752	63.749	28.310	18	0	18
	299-W18-15	38.181	42.906	31.773	5	0	5
	299-W19-28	35.050	53.300	27.224	5	0	5
	299-W23-10	31.402	41.820	19.500	6	0	6
	299-W23-9	24.389	49.763	13.374	17	0	17
	299-W22-21	20.503	20.503	20.503	1	0	1
	299-W19-17	18.772	33.809	12.220	4	0	4
	299-W19-21	16.054	20.900	9.912	9	0	9
	699-35-78A	15.468	19.077	11.406	6	0	6
	299-W23-11	13.684	19.484	10.184	7	0	7
	299-W26-8	13.454	18.534	9.912	6	0	6
	699-32-77	10.862	10.862	10.862	1	0	1
	299-W19-27	10.476	16.361	6.110	11	0	11
	299-W26-12	9.712	31.365	2.098	4	0	4
	299-W23-13	9.129	12.763	.604	4	0	4
	299-W23-14	8.864	10.659	6.029	5	0	5
	299-W19-5	7.020	7.340	6.700	2	0	2
	299-W27-1	6.839	9.505	4.474	8	0	8
	299-W19-13	6.473	6.993	6.069	5	0	5
	299-W22-20	6.469	8.418	3.870	2	0	9
	299-W23-1	5.850	6.280	5.420	2	0	2
	299-W23-2	5.505	5.970	4.760	4	0	4
	299-W22-39	5.377	6.633	3.591	4	0	4
	299-W22-2	5.097	6.250	4.470	3	0	3
	299-W22-9	4.775	5.360	4.190	2	0	2

Table B-1. Summary of LFI Constituent Detections for 200-UP-1 Groundwater Operable Unit Wells
(January 1988 - September 1992)

Page 12

Constituent	Well Number	Average of Reported Maximum of Values (Detections and Nondetections)*	Minimum of Detections	Minimum of Detections	Number of Detections in Well	Number < D.L. in Well	Total Number of Analyses
Uranium							
	299-W22-1	4.285	5.150	3.420	2	0	2
	299-W23-8	3.157	3.157	3.157	1	0	1
	299-W22-26	3.047	4.710	.530	3	0	3
	299-W19-14	2.718	3.116	2.172	5	0	5
	299-W19-31	2.677	2.919	2.403	4	0	4
	299-W19-12	2.400	2.539	2.261	2	0	2
	699-35-70	2.380	3.950	1.750	10	0	10
	299-W19-1	2.326	4.390	.944	3	0	3
	299-W22-40	2.180	2.607	1.541	6	0	6
	299-W27-42	2.128	2.471	1.853	5	0	5
	699-35-66	2.103	2.390	1.840	6	0	6
	299-W19-32	2.012	2.111	1.819	3	0	3
	699-38-65	1.700	2.180	1.460	6	0	6
	699-32-708	1.575	3.250	1.080	7	0	7
	299-W22-22	1.508	4.230	.508	5	0	5
	299-W22-41	1.481	1.867	1.331	5	0	5
	299-W21-1	1.465	1.470	1.460	2	0	2
	699-36-61A	1.329	1.399	1.260	2	0	2
	699-40-62	1.263	1.263	1.263	1	0	1
	299-W26-9	1.206	1.690	.842	5	0	5
	299-W26-10	1.192	1.677	.855	5	0	5
	299-W26-6	1.187	1.430	.944	2	0	2
	299-W22-7	1.106	1.480	.731	2	0	2
	299-W14-10	1.100	1.100	1.100	1	0	1
	299-W26-7	1.081	1.317	.896	7	0	7
	299-W26-3	1.080	1.080	1.080	1	0	1
	299-W22-12	.854	1.040	.749	3	0	3
	699-25-70	.767	.767	.767	1	0	1
	299-W18-22	.630	.875	.369	9	0	9
	699-32-72	.254	.419	.263	4	2	6

Note: D.L. Detection limit

Ⓐ Chemical data combined from two chemical constituent data codes or more than one analytical method.
Chemical constituent codes provided from Hanford Site Groundwater Chemical Database by WHC.

* For constituents with analysis results below the analytical detection limit, averages were calculated using one-half of the detection limit value.

Units: All organic and inorganic compounds in micrograms per liter

All radionuclides in picocuries per liter

Maximum and minimum of detections are presented as they are reported in the database.

Average of the reported values were calculated from the database information and rounded to two decimal places.

For some constituents, varying analytical detection limits over time have been high enough to result in calculated average (including nondetections at one-half detection limit value) to exceed detected concentrations.

APPENDIX C
LFI CONSTITUENT CONCENTRATION TIME VARIABILITY PLOTS
FOR
SELECTED 200-UP-1 GROUNDWATER OPERABLE UNIT WELLS

Legend:

- + RESULT DETECT
- O RESULT NONDETECT

Figure C-1. Technetium-99 Time Variation Plot for Well 299-W19-18.

C-2

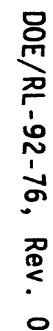


Figure C-2. Technetium-99 Time Variation Plot for Well 299-W19-26.

C-3

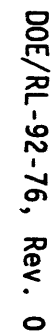


Figure C-3. Technetium-99 Time Variation Plot for Well 299-W23-2.

Uranium: Well 299-W19-2

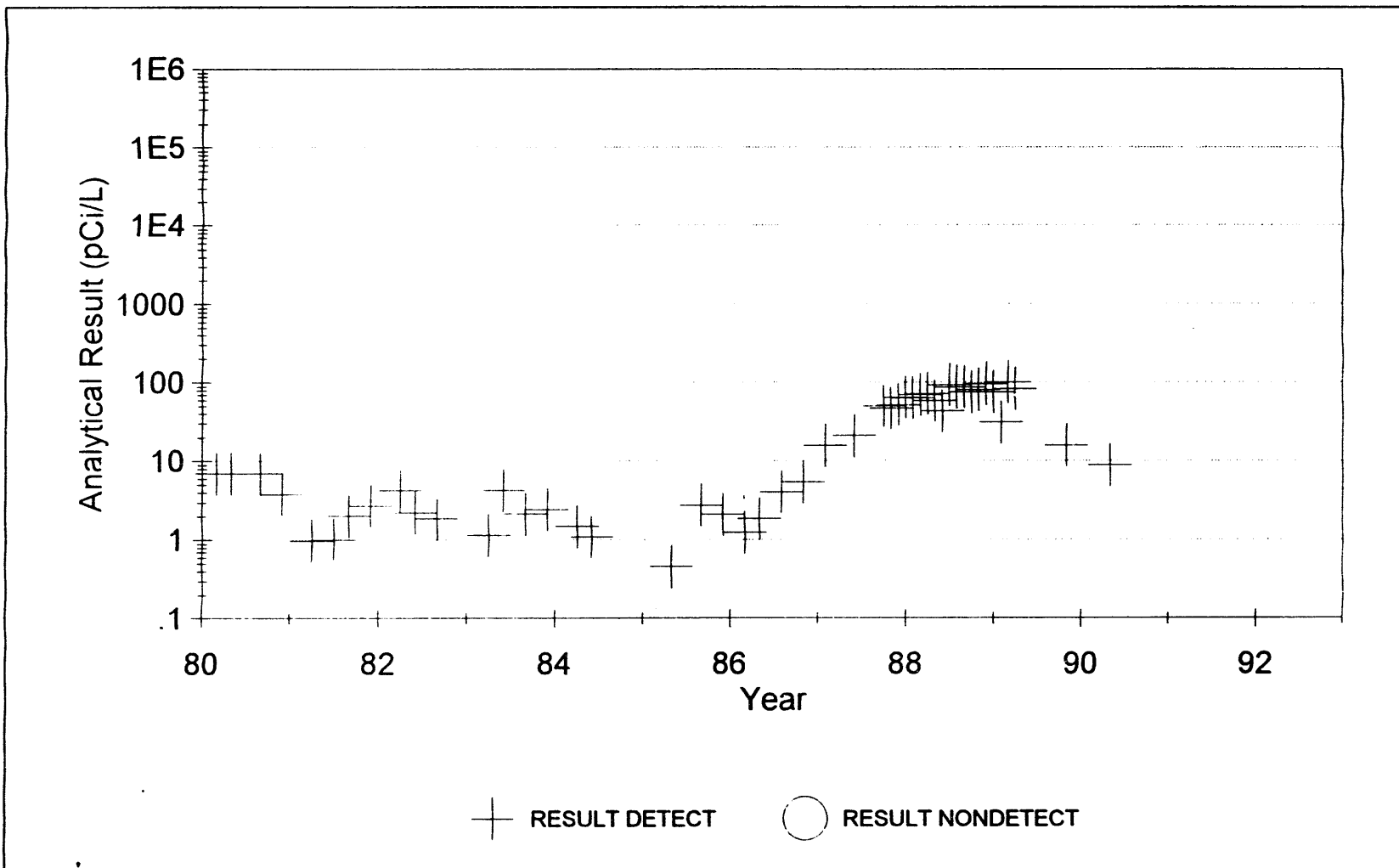


Figure C-4. Uranium Time Variation Plot for Well 299-W19-2.

Uranium: Well 299-W19-26

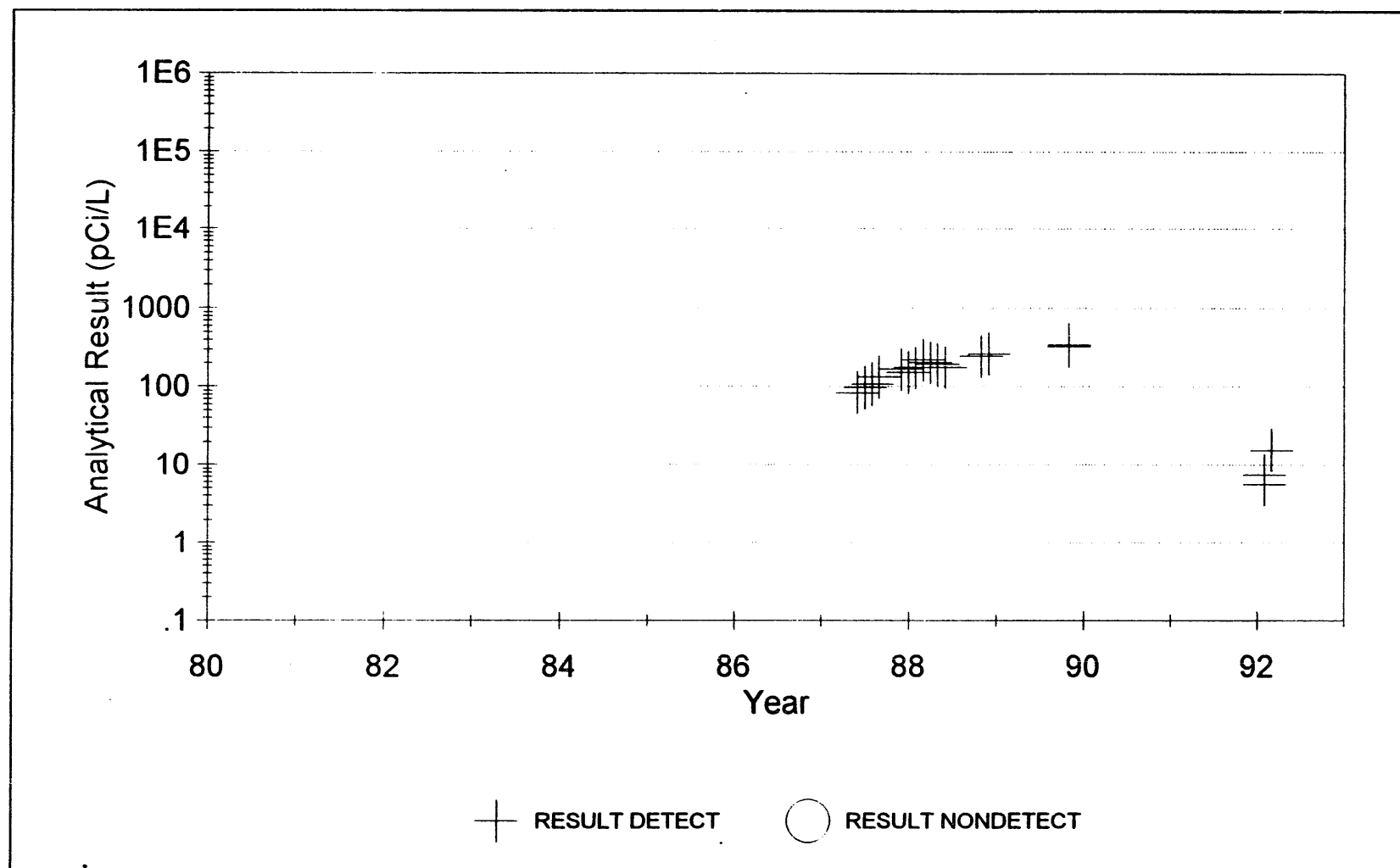


Figure C-5. Uranium Time Variation Plot for Well 299-W19-26.

Uranium: Well 299-W22-22

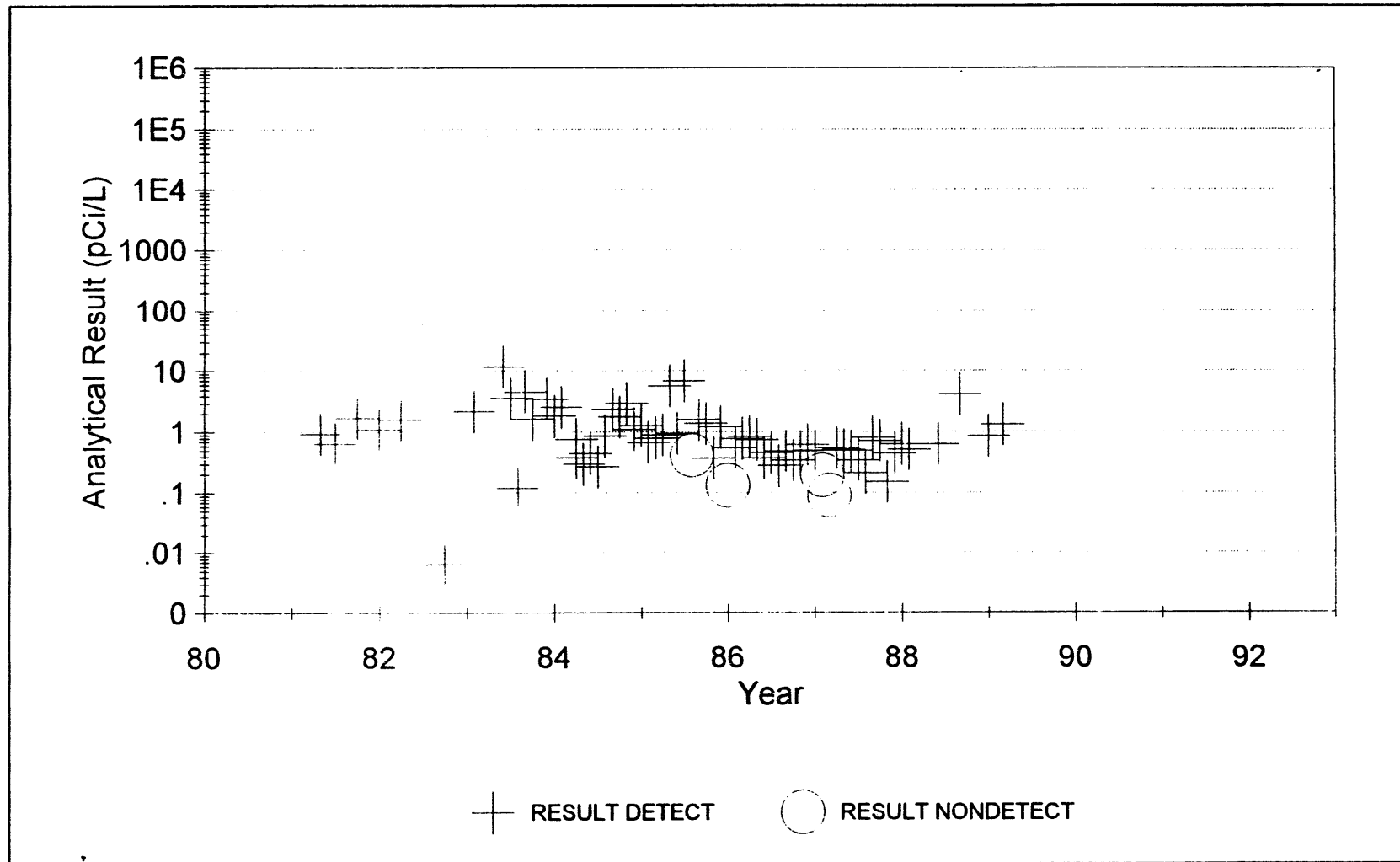


Figure C-6. Uranium Time Variation Plot for Well 299-W22-22.

Nitrate: Well 299-W19-3

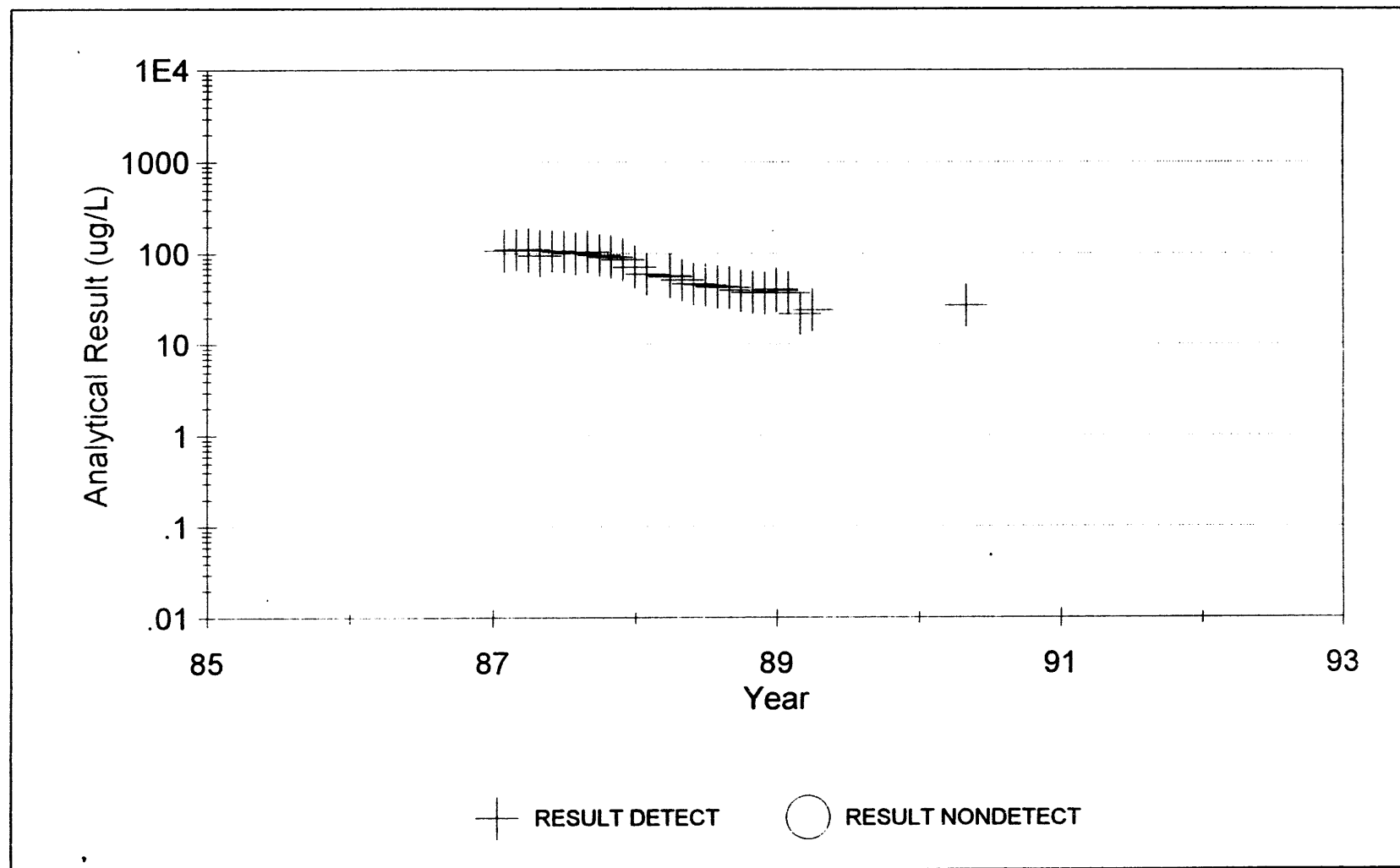


Figure C-7. Nitrate Time Variation Plot for Well 299-W19-3.

C-8

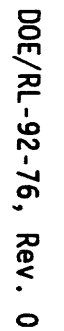


Figure C-8. Nitrate Time Variation Plot for Well 299-W23-3.

Nitrate: Well 299-W27-1

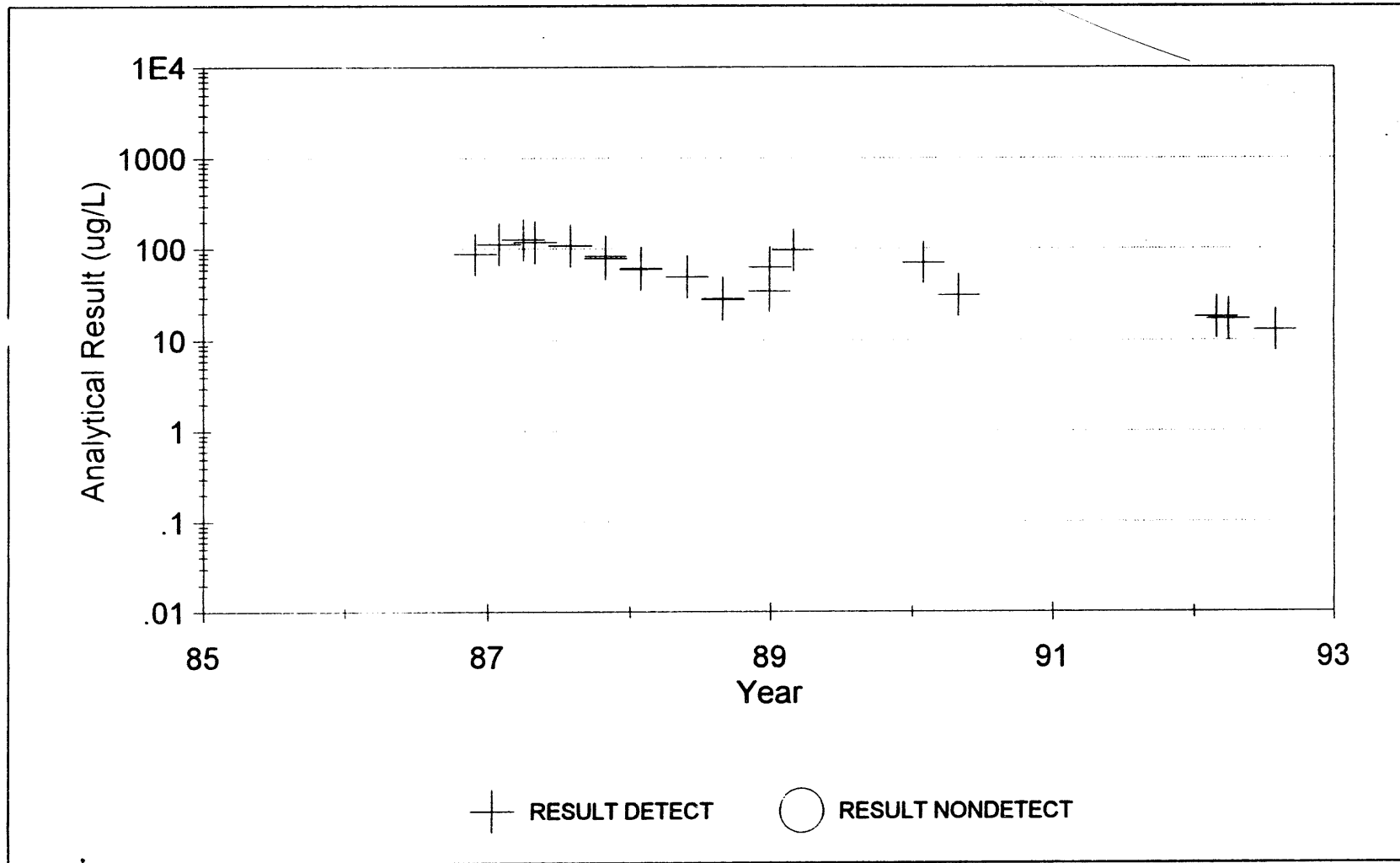


Figure C-9. Nitrate Time Variation Plot for Well 299-W27-1.

Carbon Tetrachloride: Well 299-W19-16

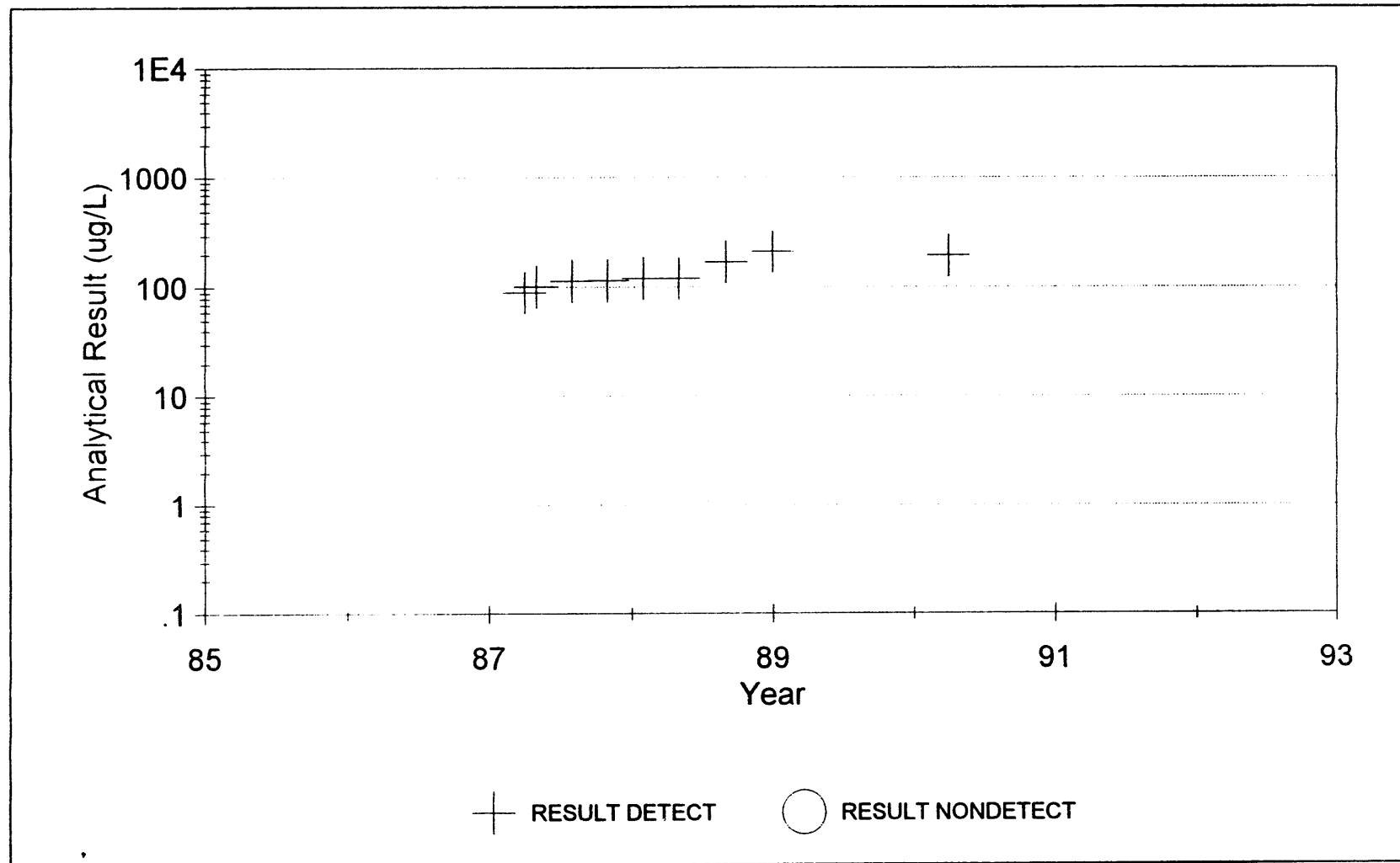


Figure C-10. Carbon Tetrachloride Time Variation Plot for Well 299-W19-16.

Trichloroethylene: Well 299-W22-20

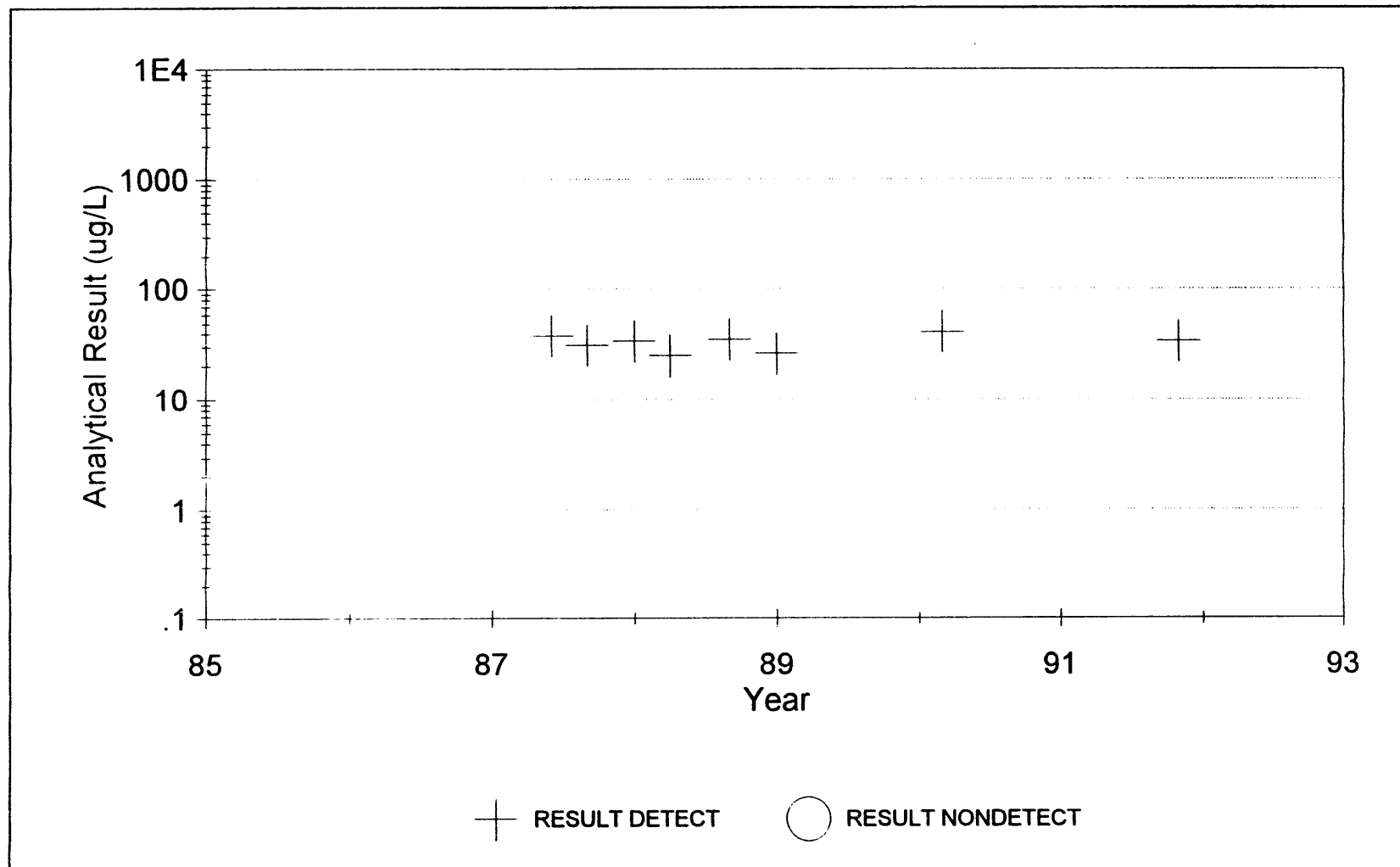


Figure C-11. Trichloroethylene Time Variation Plot for Well 299-W22-20.

Iodine-129: Well 699-35-70

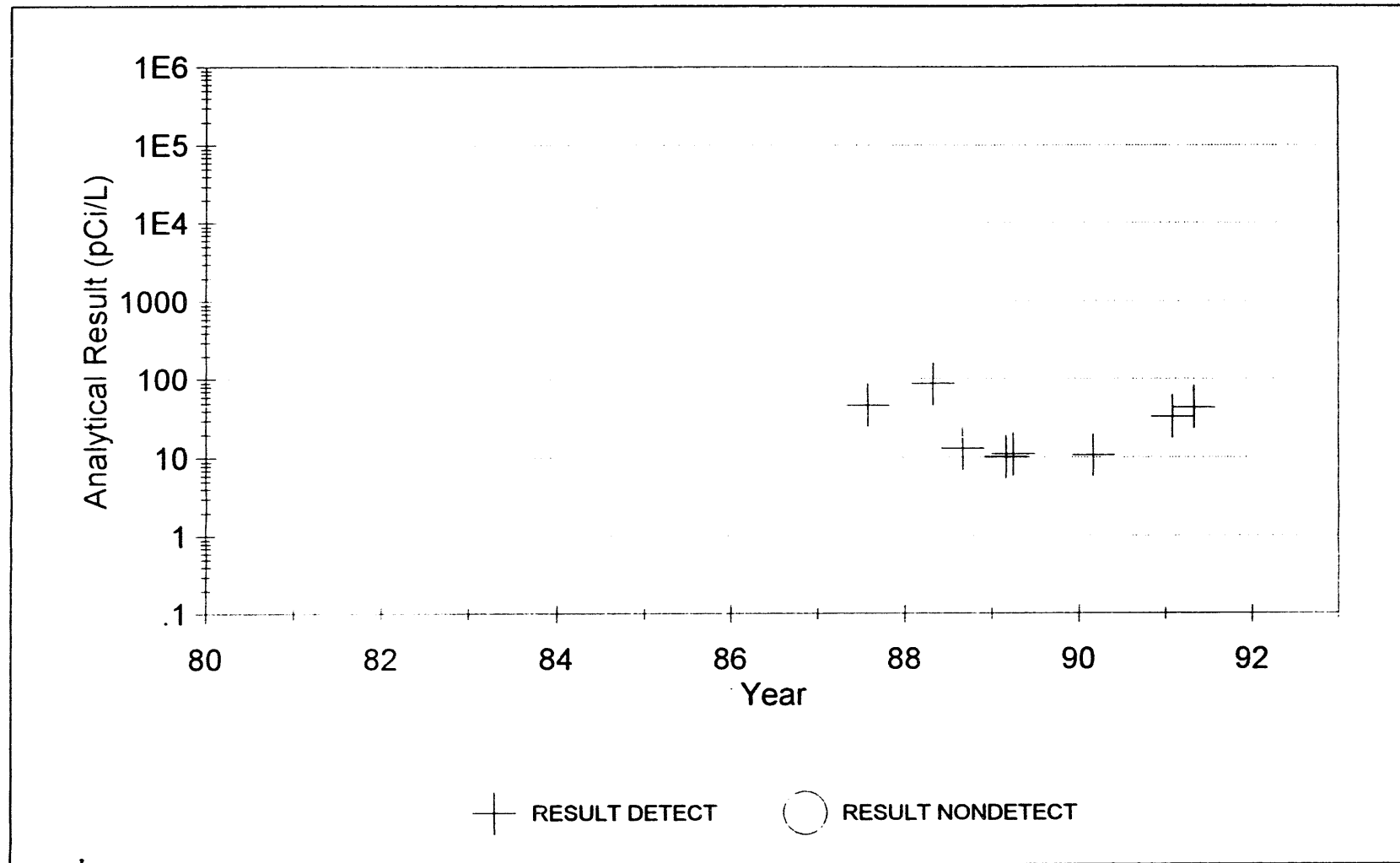


Figure C-12. Iodine Time Variation Plot for Well 699-35-70.

Strontium-90: Well 299-W19-2

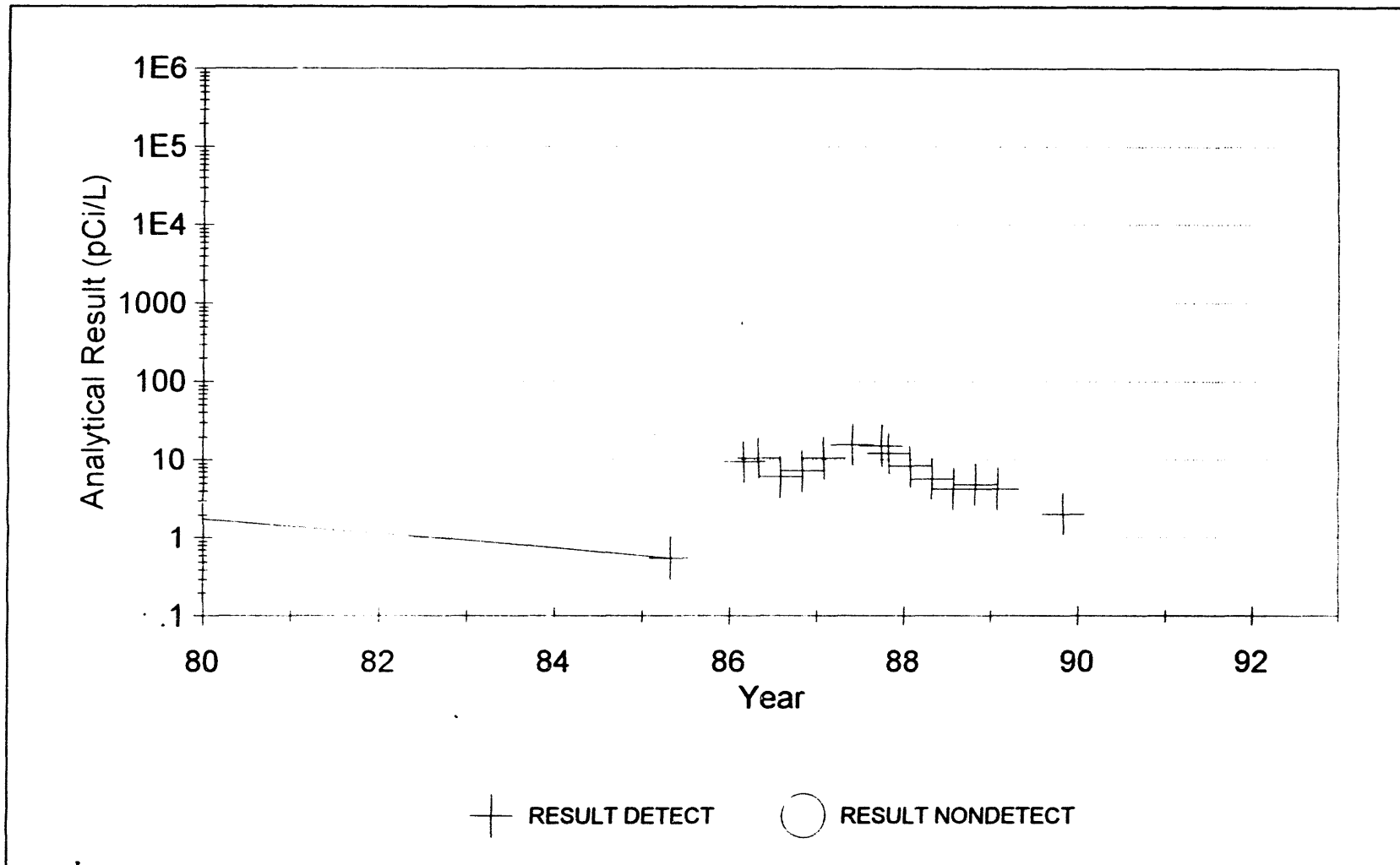


Figure C-13. Strontium-90 Time Variation Plot for Well 299-W19-2.

C-14

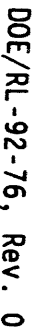


Figure C-14. Strontium-90 Time Variation Plot for Well 299-W22-1.

C-15

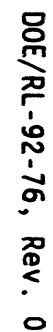


Figure C-15. Strontium-90 Time Variation Plot for Well 299-W22-10.

Gross alpha: Well 299-W19-3

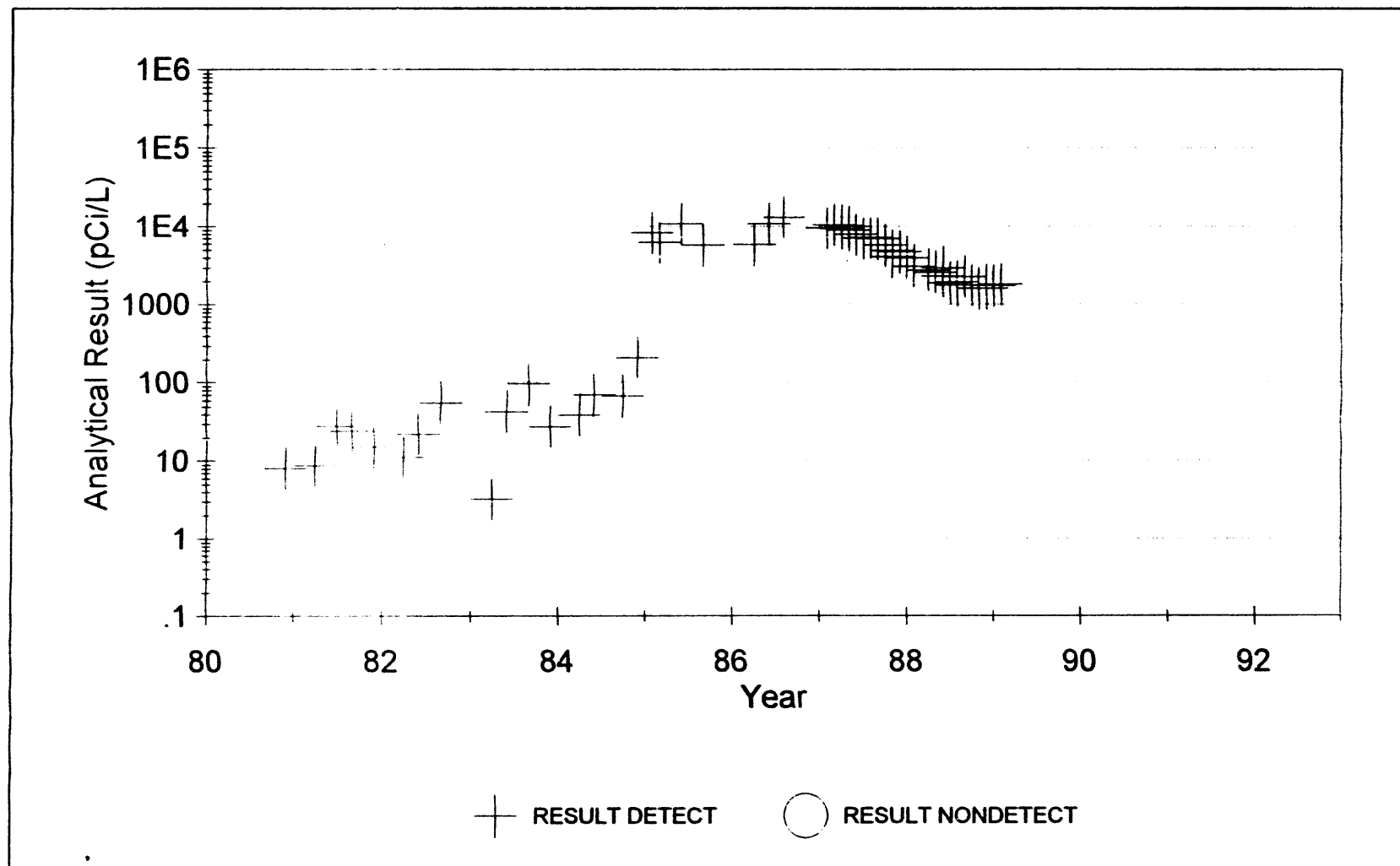


Figure C-16. Gross Alpha Time Variation Plot for Well 299-W19-3.

Fluoride: Well 299-W19-26

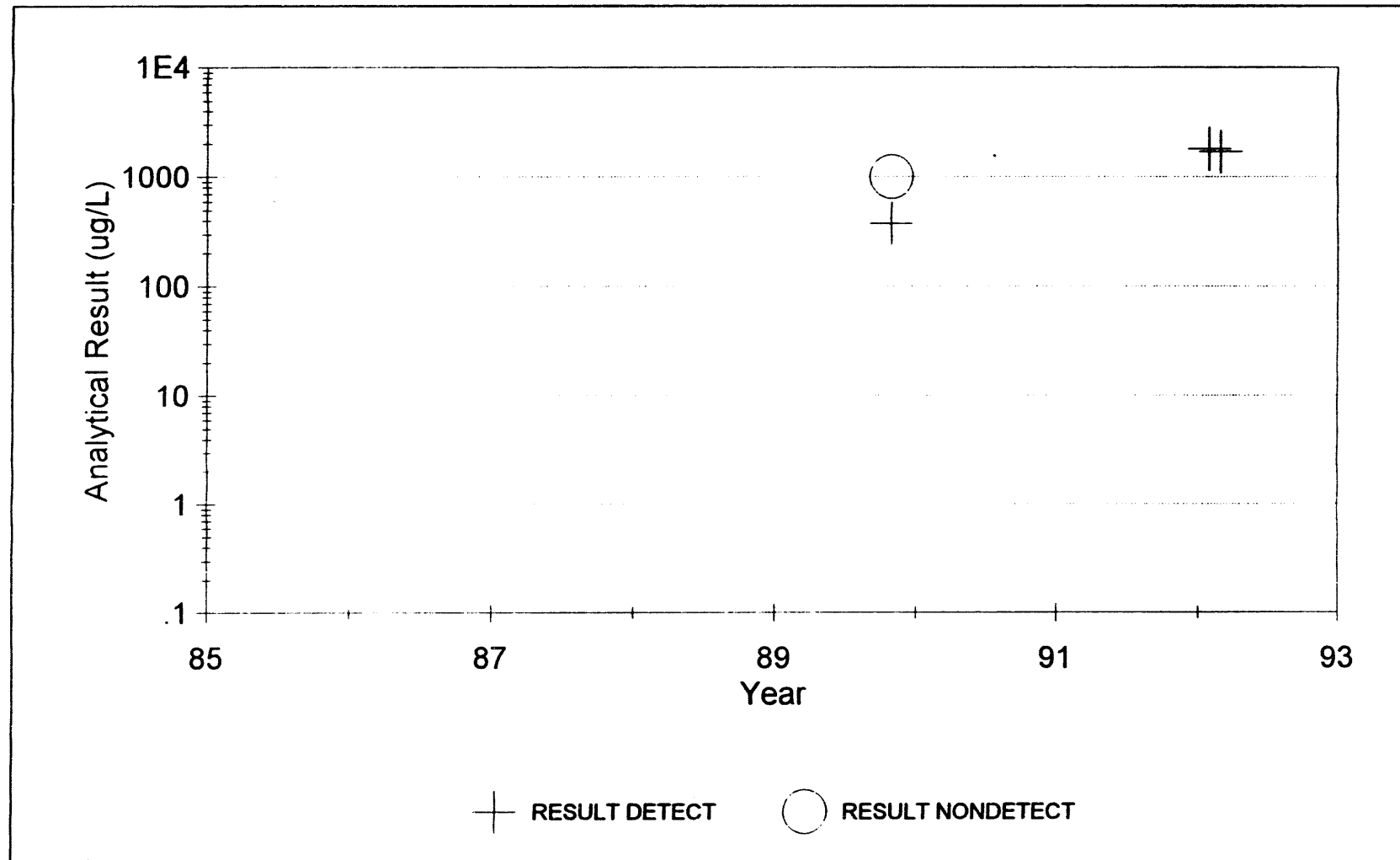


Figure C-17. Fluoride Time Variation Plot for Well 299-W19-26.

Fluoride: Well 299-W19-29

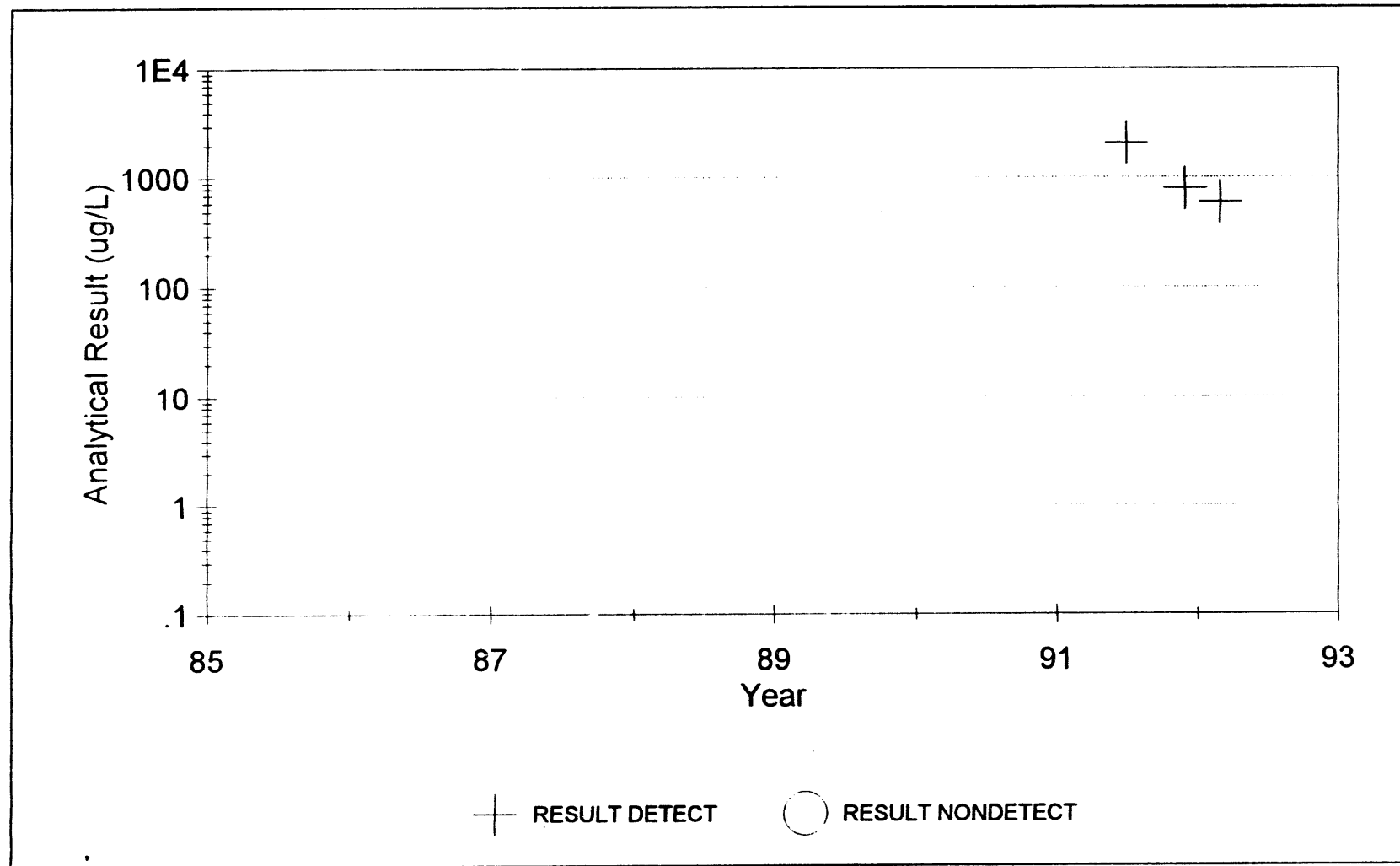


Figure C-18. Fluoride Time Variation Plot for Well 299-W19-29.

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6-49-85A



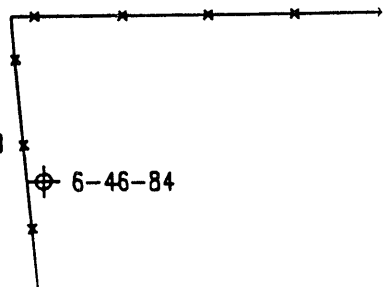
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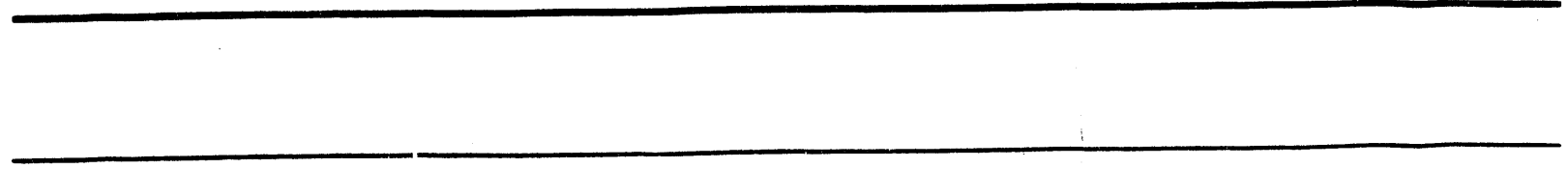
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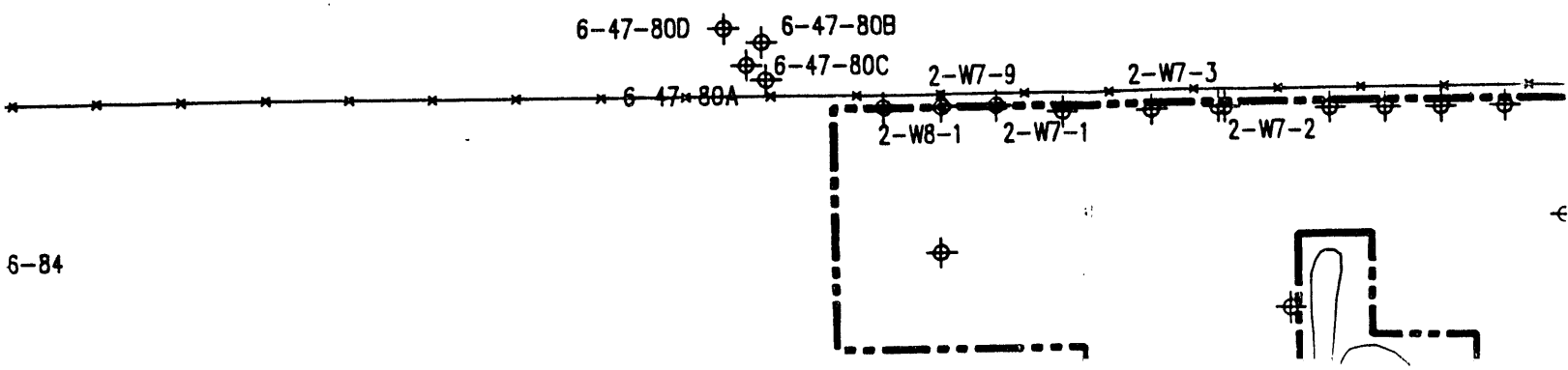
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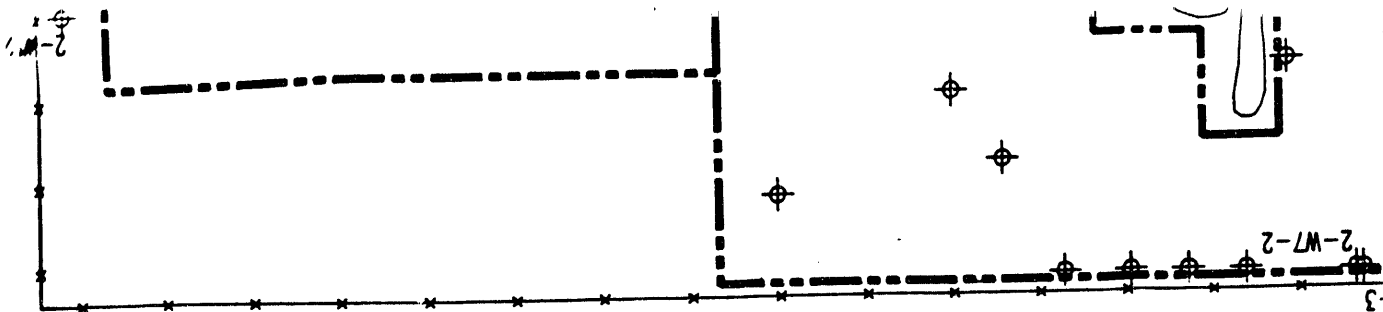




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⊕ 6-49-79





6 44-71

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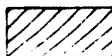
Φ 6-48-71

2-W12-1
4-1

200-UP-1 Groundwater
Operable Unit RI/FS Work Plan

PLATE 1b – Monitoring Wells

LEGEND

-  Approximate Operable Unit Boundary
-  Aggregate Area Boundary
-  Security Systems/Fences
-  Perimeter Boundary
-  Buildings

6-44-91
6-43-91D ~~⊕~~ ~~⊕~~ ~~⊕~~ 6-43-91B
6-43-91A,AP,AQ

~~⊕~~ 6-41-91

~~⊕~~ 6-37-92

~~⊕~~ 6-36-93 & 0-T

6-43-89

6-43-88

6-42-88

6-46-85A

6-46-85B

6-46-84

6-43-84

6-43-83

6-40-84

6-39-84B

6-38-84

6-39-84A

6-39-82

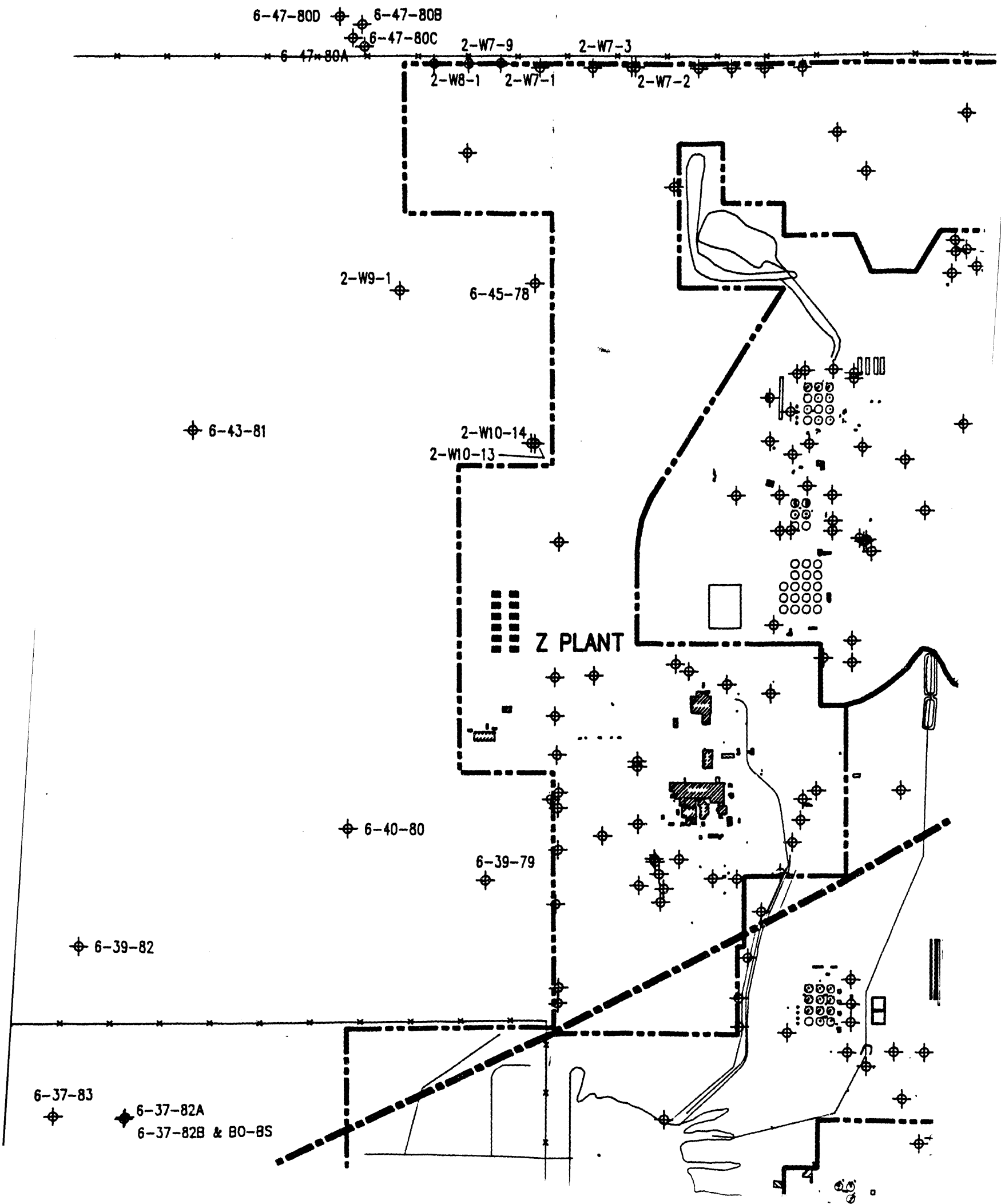
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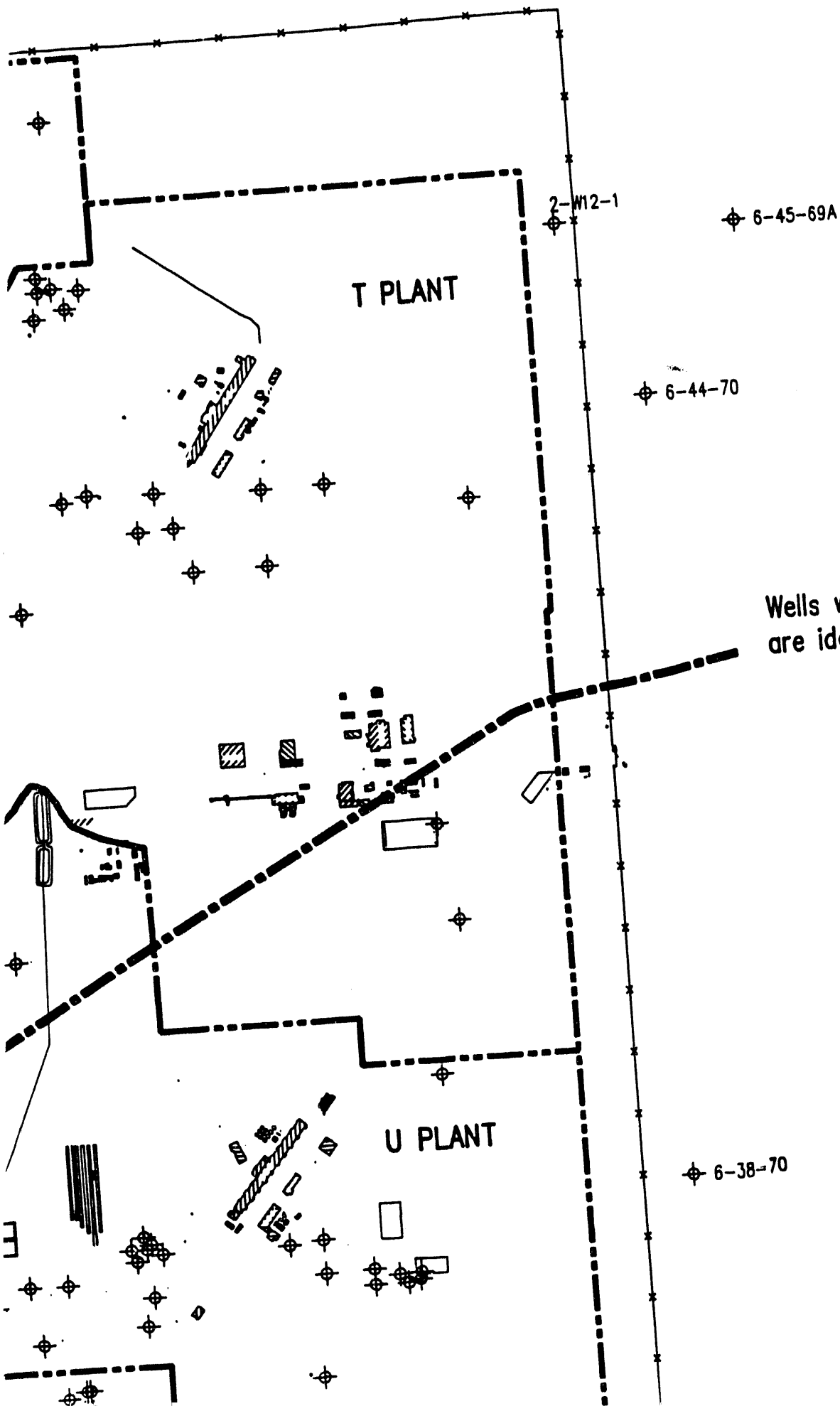
6-37-84

6-37-83

6-3
6-3

200-ZP-1
GROUNDWATER
OPERABLE UNIT





Wells within source aggregate are identified on Plate 1a

LEGEND



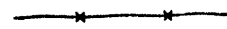
Approximate Open



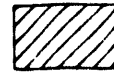
Aggregate Area



Security System



Perimeter Boundary



Buildings



Monitoring Wells

(Note: Well numbers have
first 3-digit number
complete number)

aggregate areas
Plate 1a

LEGEND



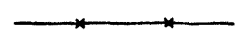
Approximate Operable Unit Boundary



Aggregate Area Boundary



Security Systems/Fences



Perimeter Boundary



Buildings



Monitoring Wells

(Note: Well numbers have been abbreviated by eliminating the "99" of the first 3-digit numbering code. For example, well "2-W26-2" has the complete number "299-W26-2".)

⊕ 6-37-92

⊕ 6-36-93 & 0-T

⊕ 6-35-95

⊕ 6-37-89

⊕ 6-37-84

⊕ 6-37-92

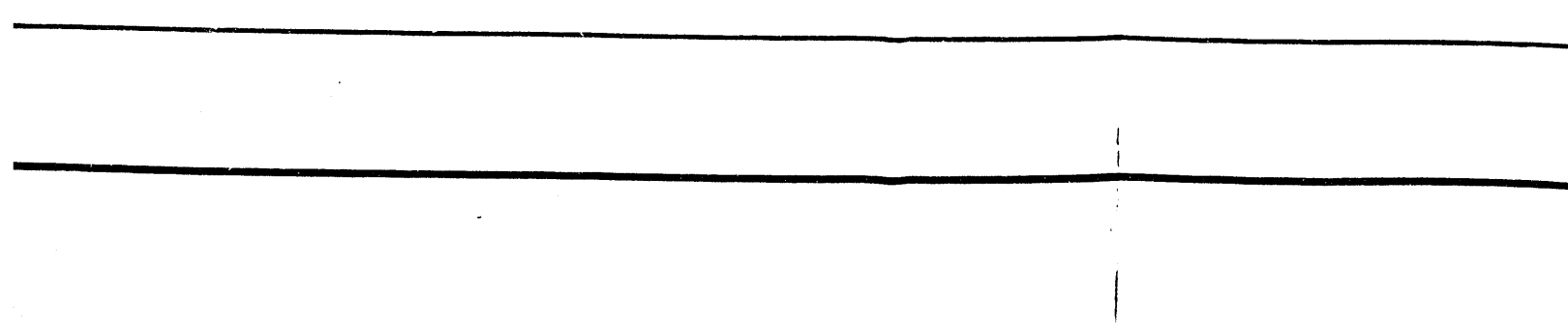
200-ZP-
GROUNDV
OPERABL

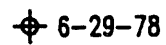
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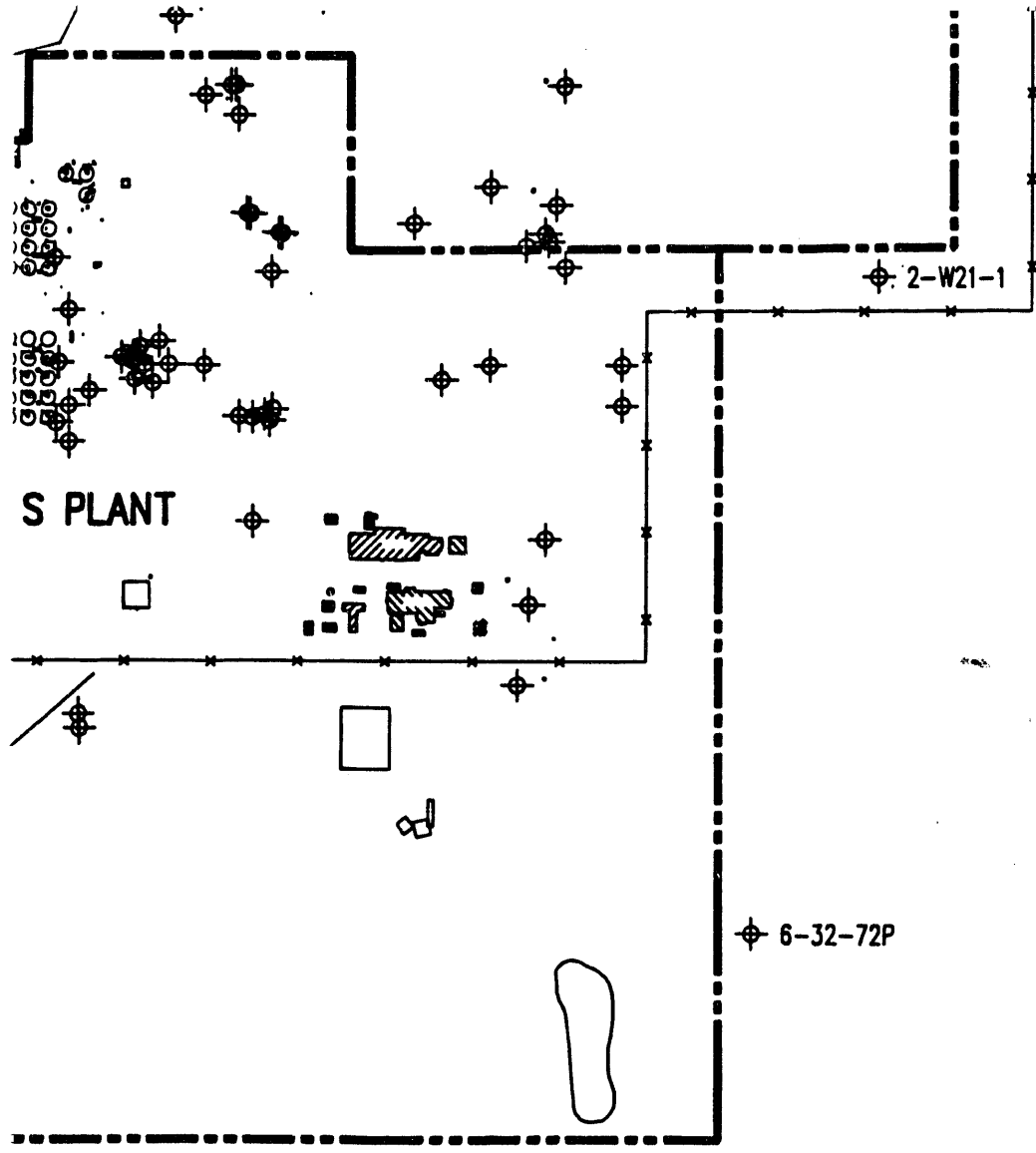
⊕ 6-34-89A
⊕ 6-34-89B

6-31-84C ⊕

⊕ 6-
6-







S PLANT

2-W21-1

6-35-70

6-32-72P

6-32-70B
6-32-70A

6-29-70C & CP-CU
6-29-70DP
6-29-70A,AP,AQ

⊕ 6-38-65P

⊕ 6-35-66

⊕ 6-31-65 & O-R

200

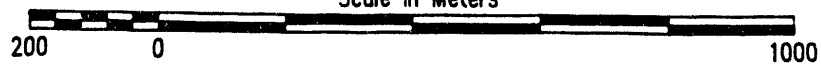
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P-CU

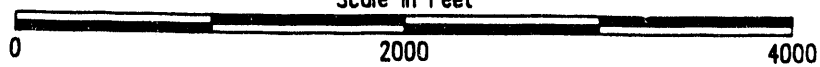
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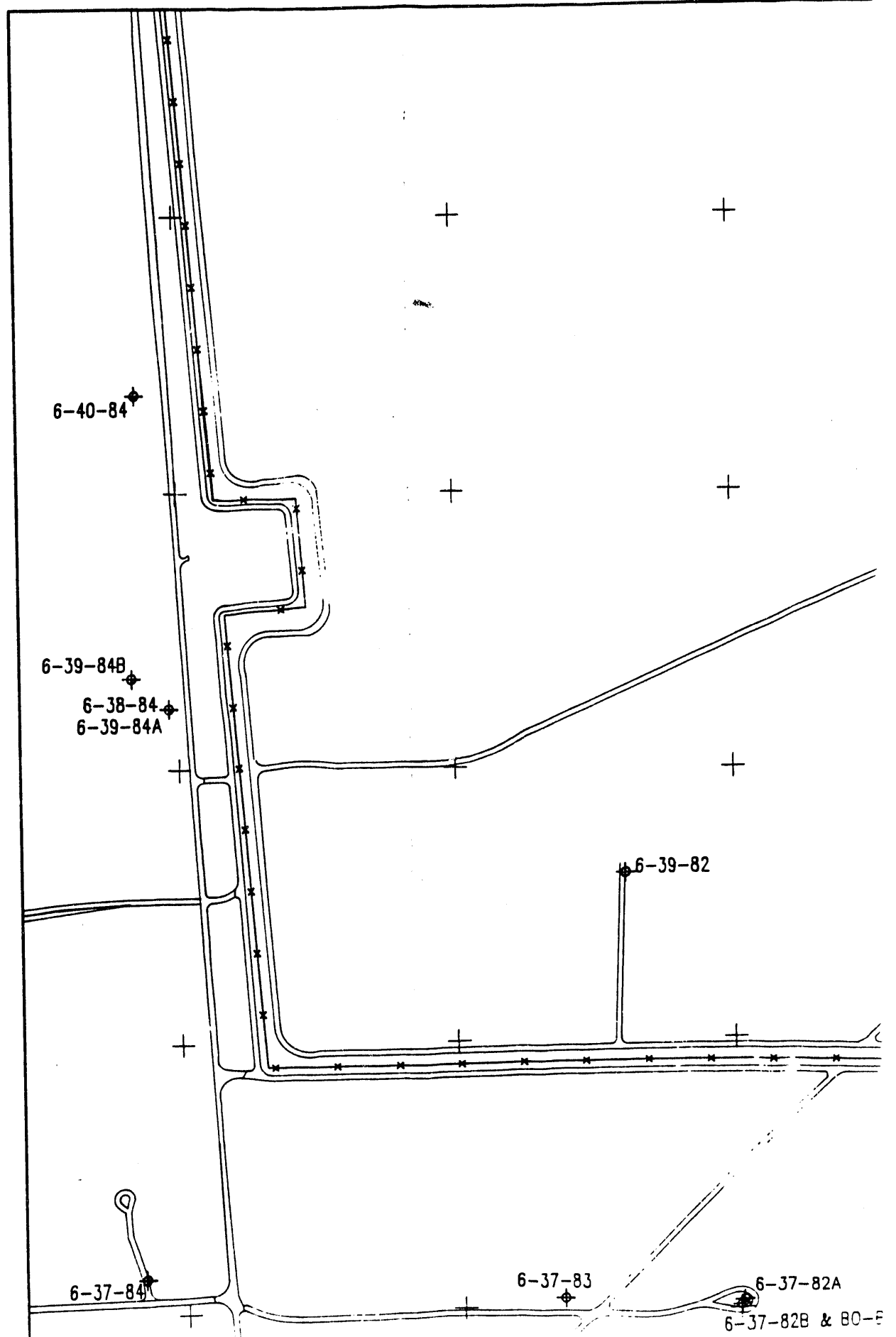


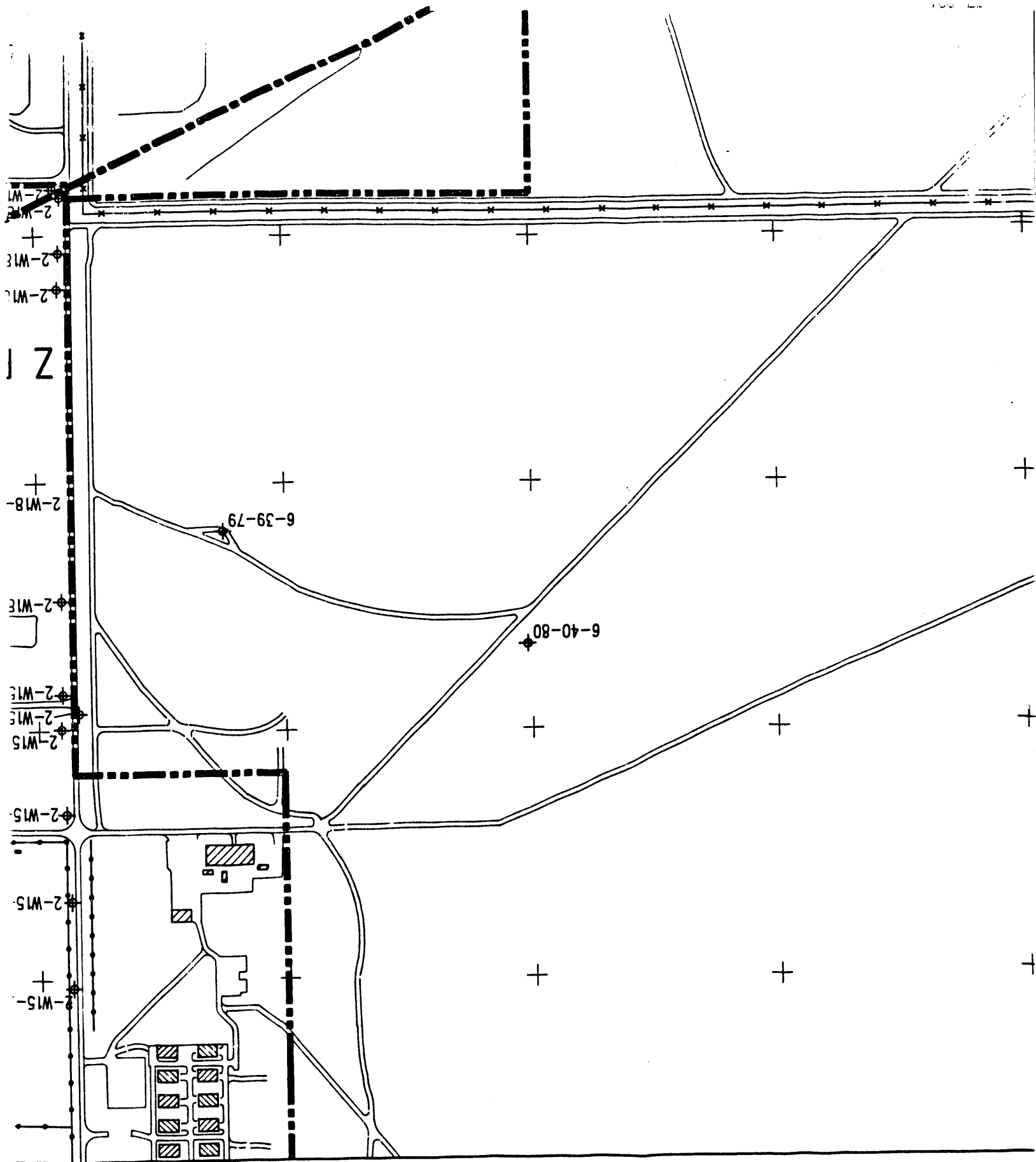
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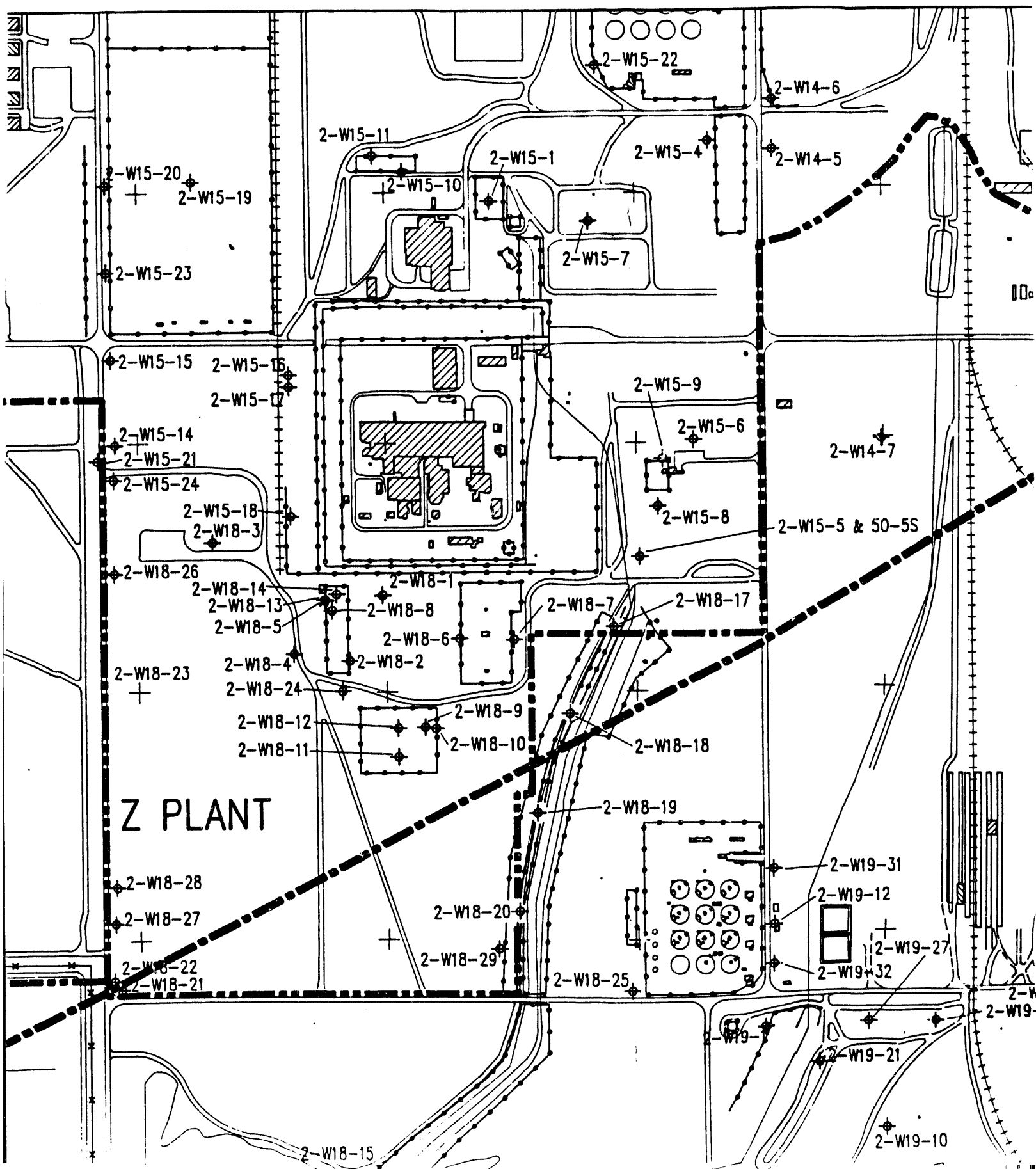


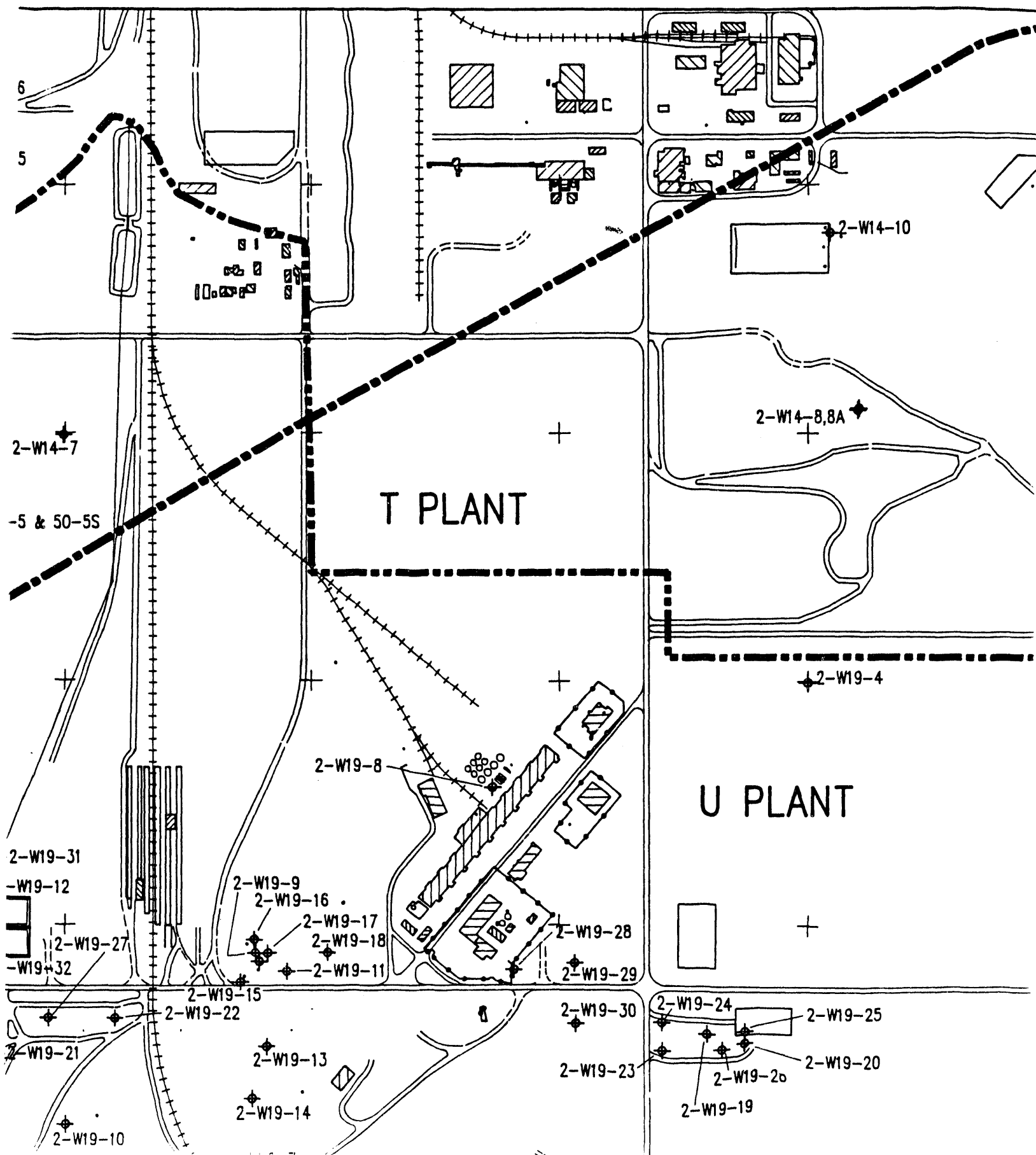
Scale in Feet

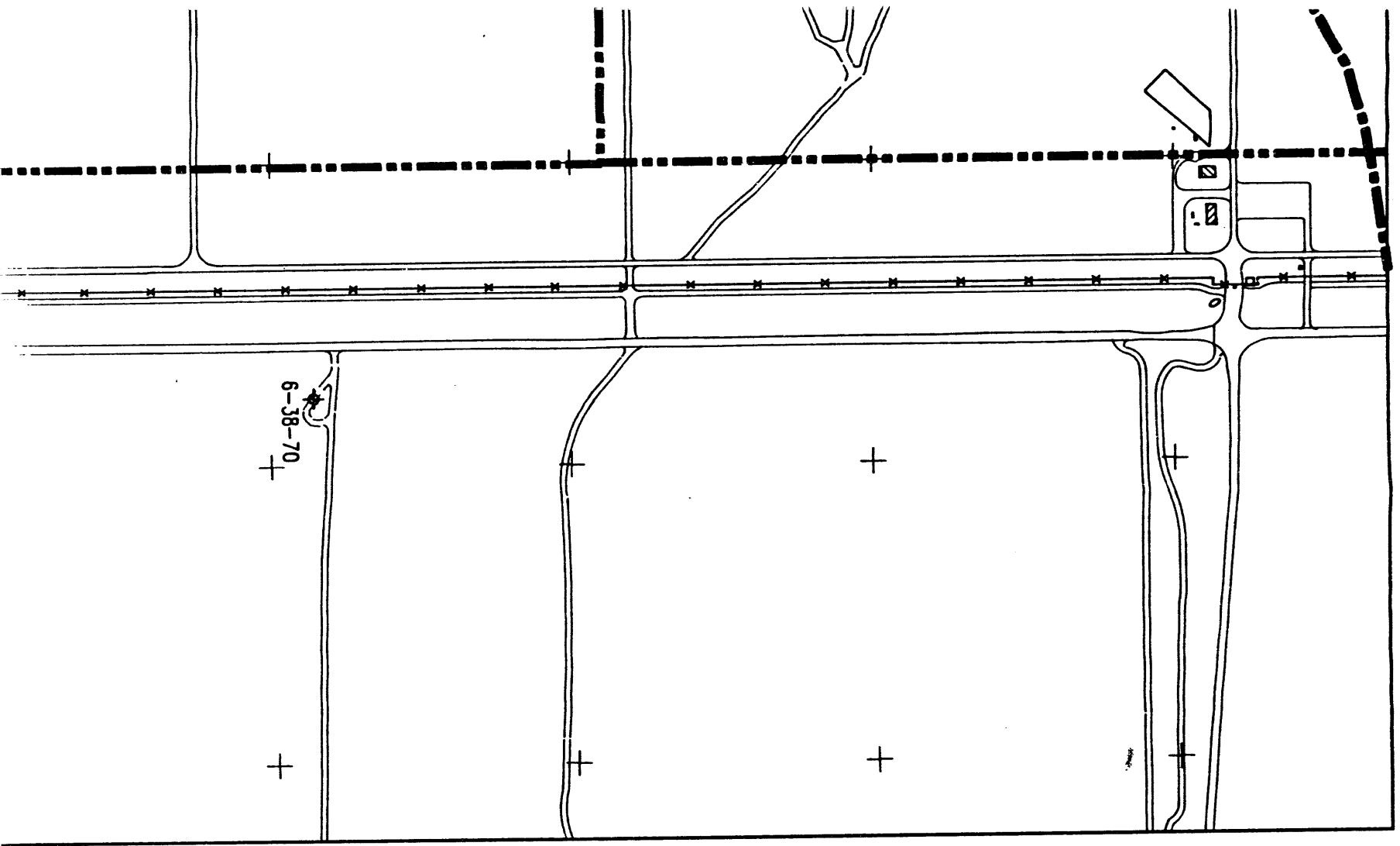












LEGEND

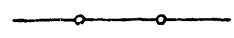
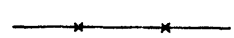
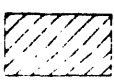
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200-UP-1 C
Operable Uni
PLATE 1a -

200-UP-1 Groundwater
Operable Unit RI/FS Work Plan

PLATE 1a - Monitoring Wells

LEGEND

-  Approximate Operable Unit Boundary
-  Aggregate Area Boundary
-  Security Systems/Fences
-  Perimeter Boundary
-  Buildings

200-ZP-1
GROUNDWATER
OPERABLE UNIT

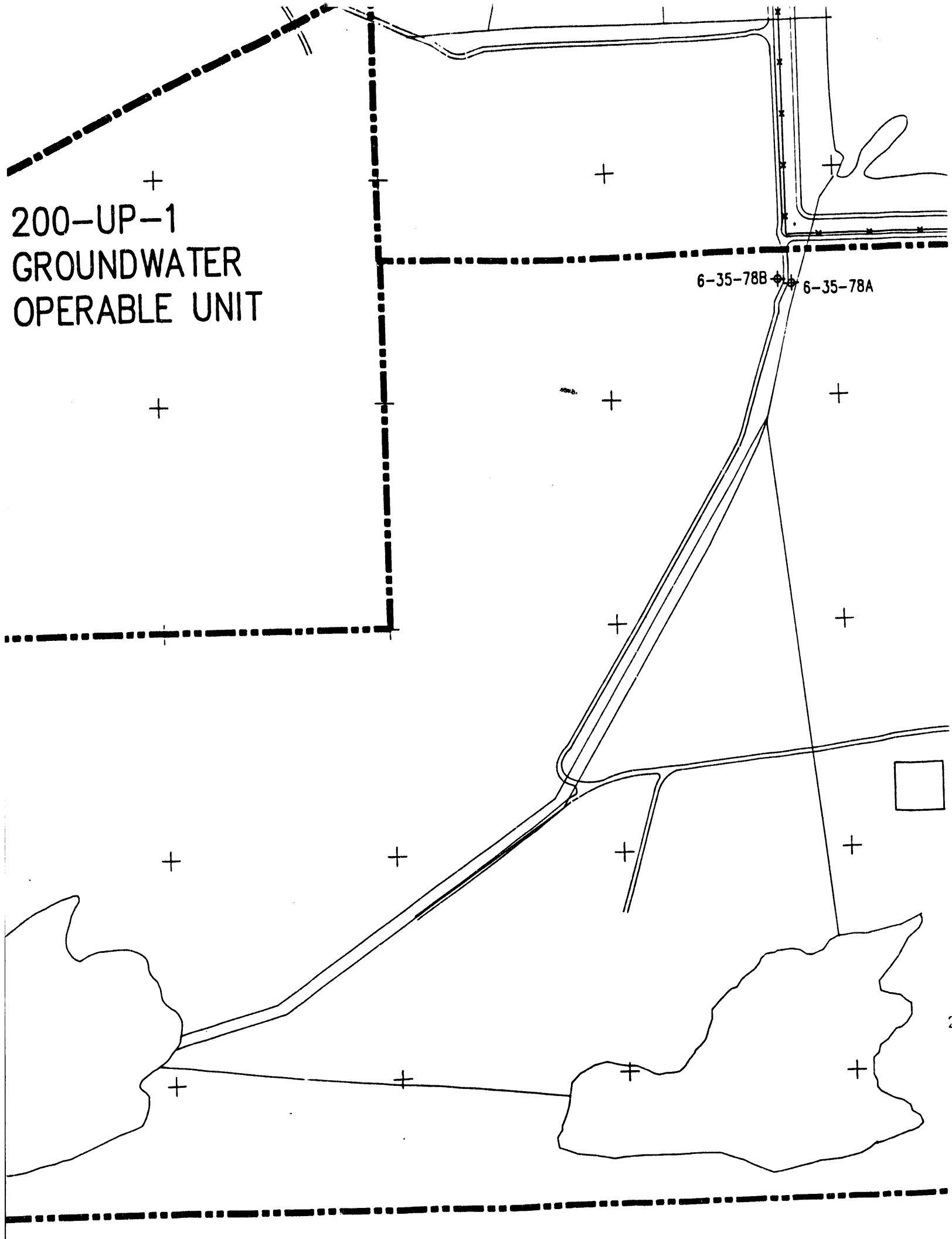
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GRG
OPE

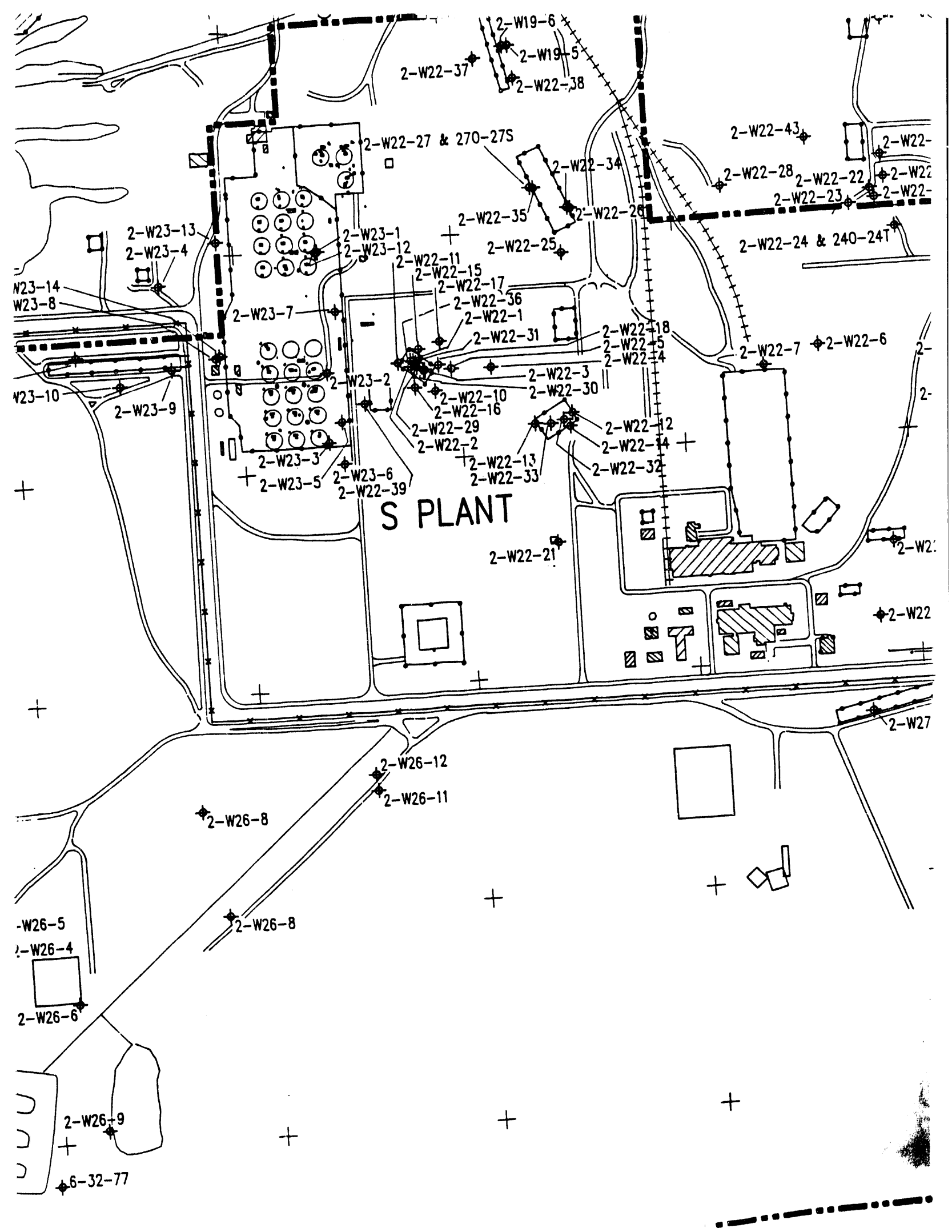
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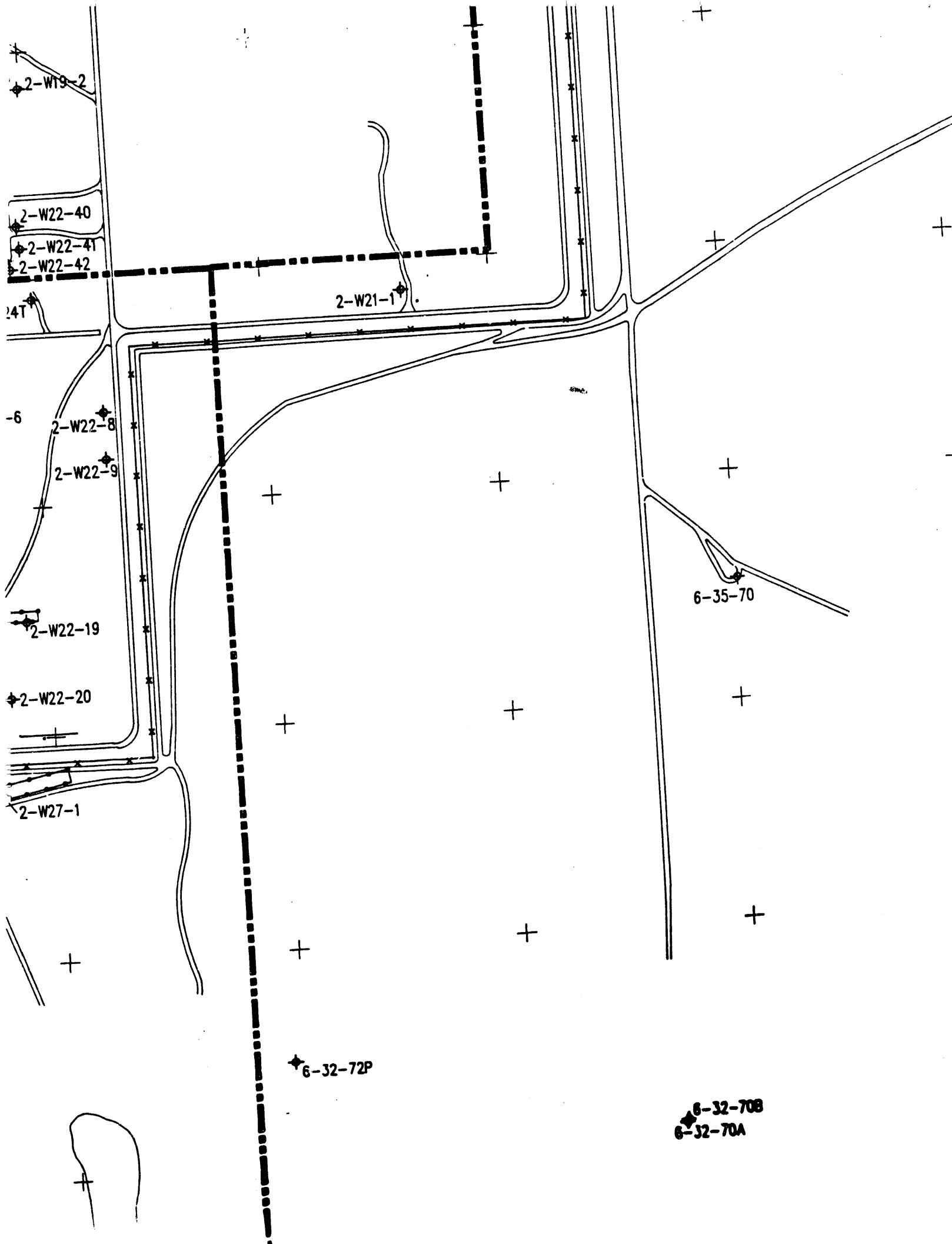
◆ 6-31-84A

200-UP-1
GROUNDWATER
OPERABLE UNIT

6-35-78B 6-35-78A





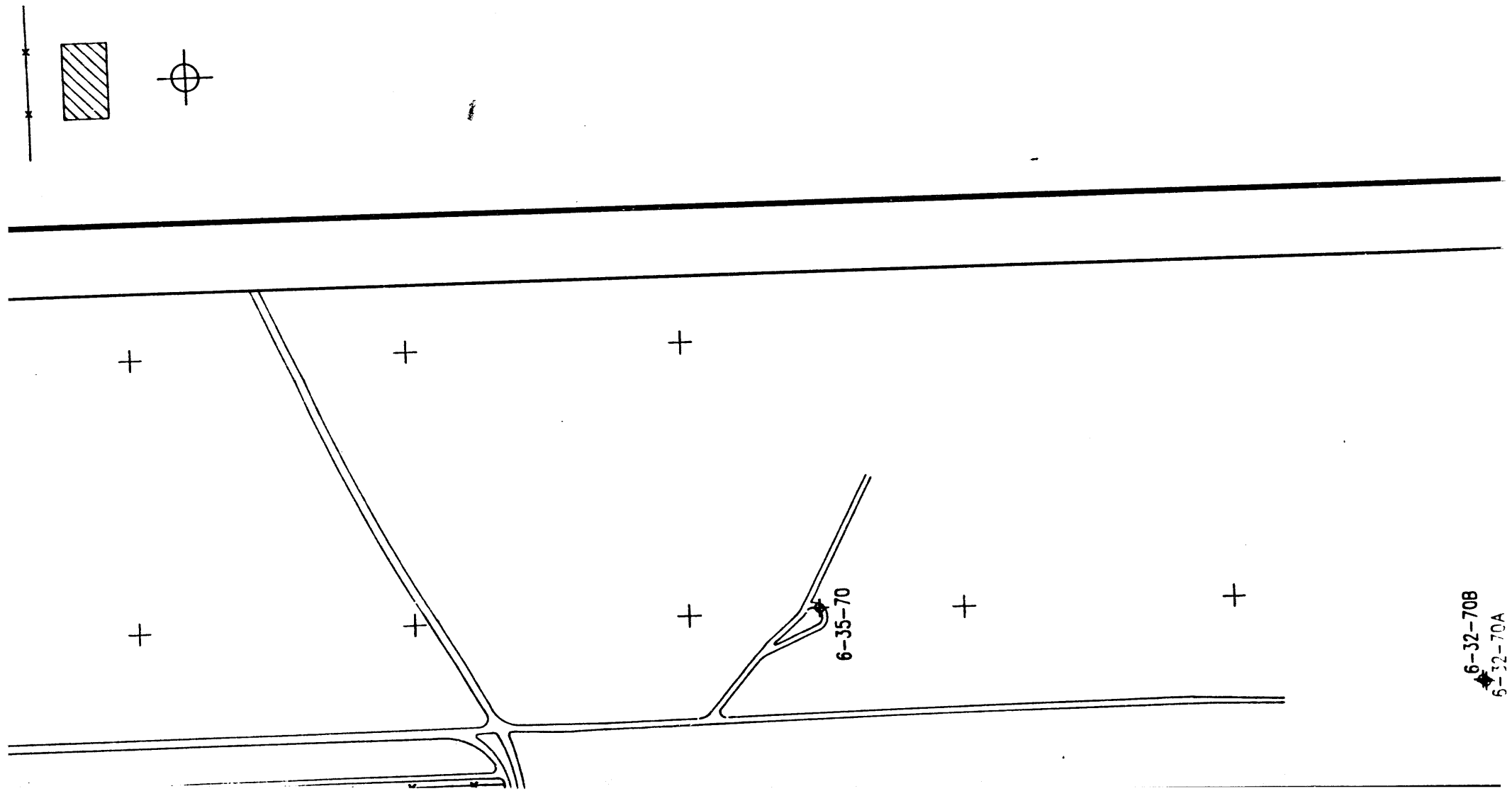


Perimeter Boundary

Buildings

Monitoring Wells

(Note: Well numbers have been
first 3-digit numbering c
complete number "299-V



6-32-70B
6-32-70A



Aggregate Area Boundary



Security Systems/Fences



Perimeter Boundary



Buildings



Monitoring Wells

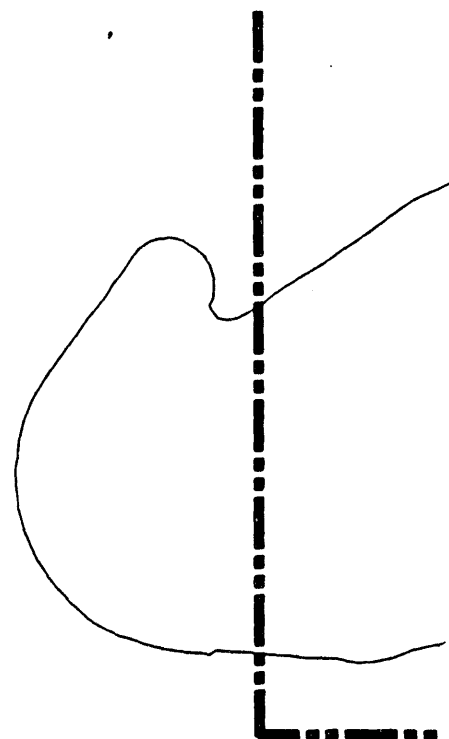
(Note: Well numbers have been abbreviated by eliminating the "99" of the first 3-digit numbering code. For example, well "2-W26-2" has the complete number "299-W26-2".)

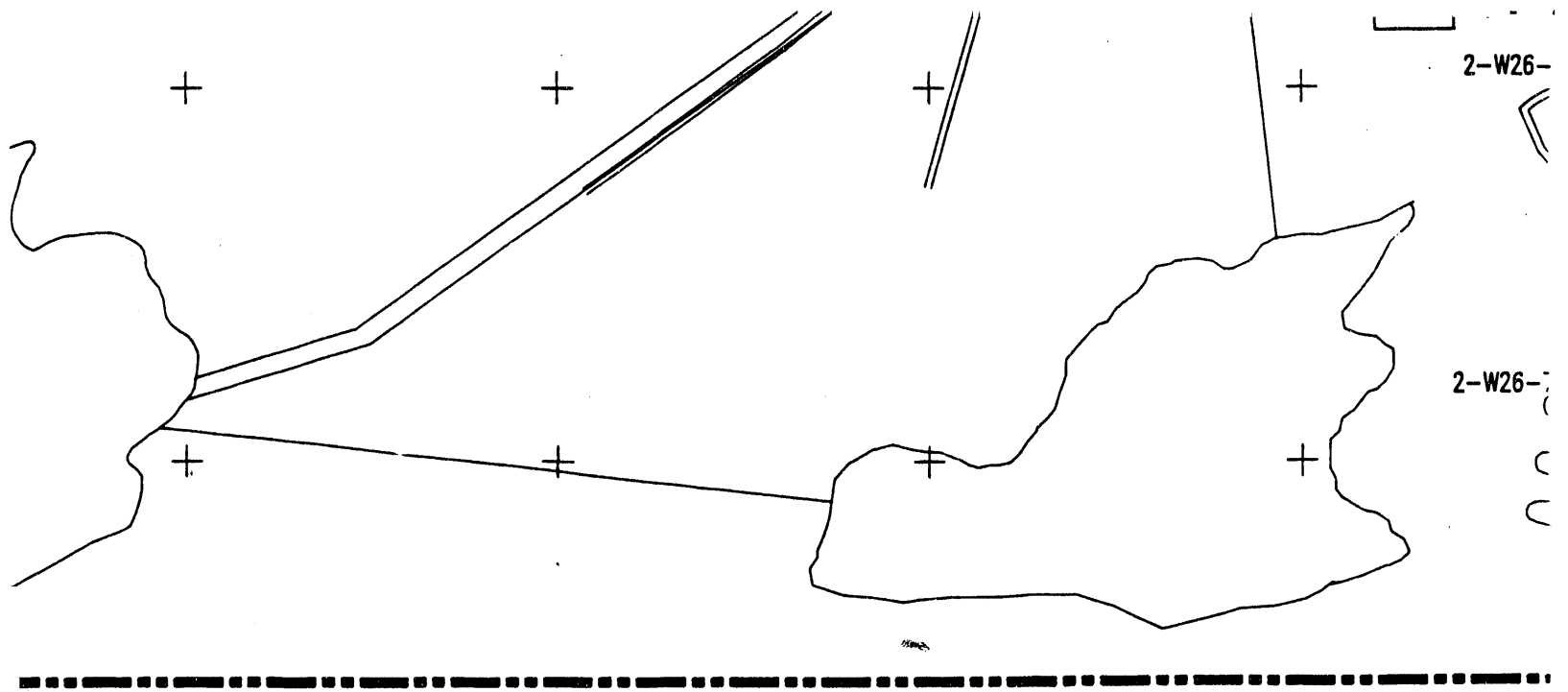
◆ 6-31-84C

◆ 6-31-84A
◆ 6-31-84B

◆ 6-32-83

◆ 6-29-83





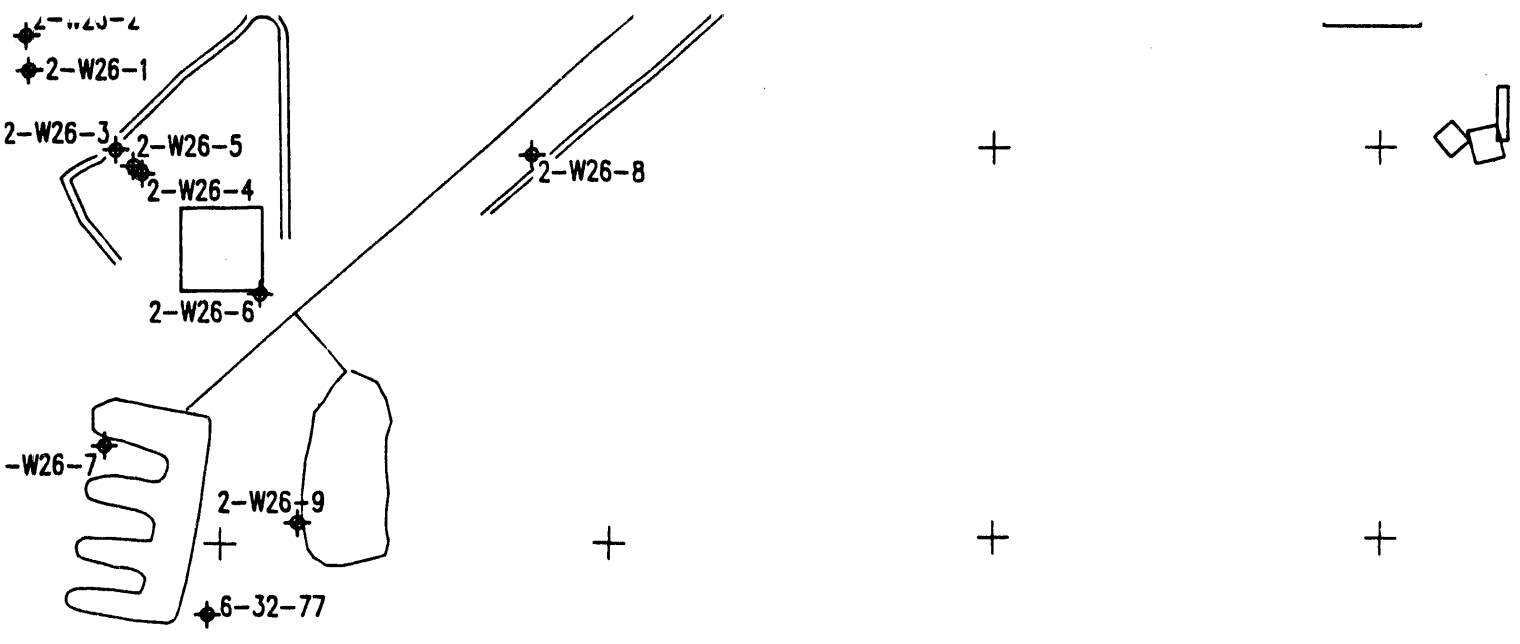
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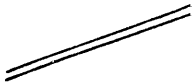
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◆ 6-29-78



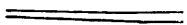


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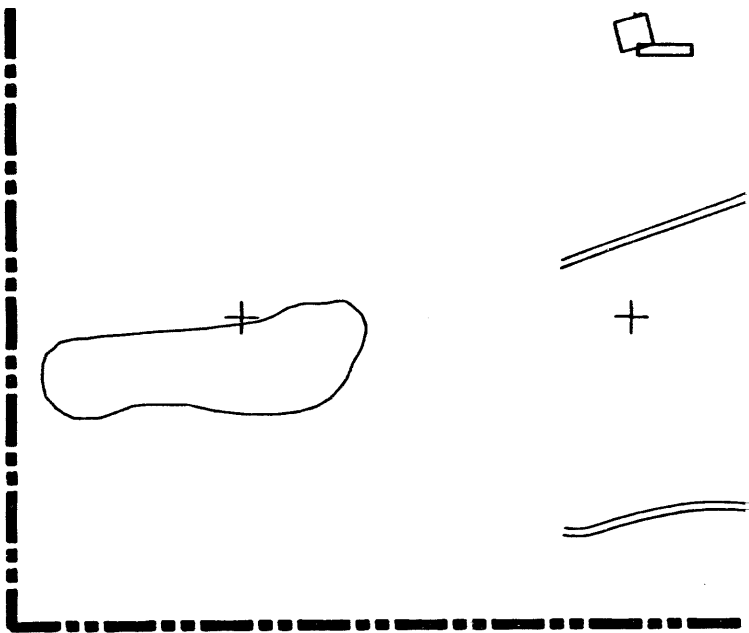
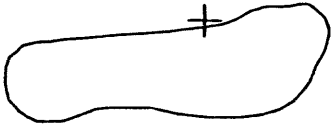
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✦ 6-32-72P

✦ 6-32-70B
6-32-70A



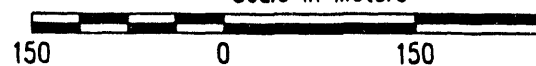
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-32-70B
2-70A

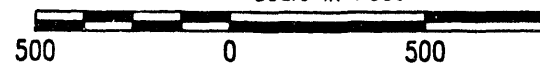
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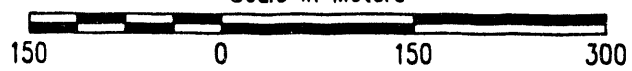
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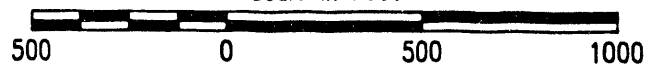
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Scale In Meters



Scale In Feet



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