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1. EDT № 141934

2. To: (Receiving Organization) DISTRIBUTION	3. From: (Originating Organization) GEOSCIENCES	4. Related EDT No.:
5. Proj./Prog./Dept./Div.: GEOSCIENCES	6. Cog. Engr.: KEVIN LINDSEY, VERNON JOHNSON	7. Purchase Order No.: E48599
8. Originator Remarks: Approval and release		9. Equip./Component No.: N/A
		10. System/Bldg./Facility: N/A
11. Receiver Remarks:		12. Major Assm. Dwg. No.: N/A
		13. Permit/Permit Application No.: N/A
		14. Required Response Date: 6 May 1993

MAY 1994 RECEIVED EPIC

9413276.1581

15. DATA TRANSMITTED

(A) Item No.	(B) Document/Drawing No.	(C) Sheet No.	(D) Rev. No.	(E) Title or Description of Data Transmitted	(F) Impact Level	(G) Reason for Transmittal	(H) Originator Disposition	(I) Receiver Disposition
1	WHC-SD-EN-AP-133		0	HYDROGEOLOGIC CHARACTERIZATION PLAN: I. PRINCIPAL RECHARGE ZONE FOR THE HANFORD SITE 200 AREAS WASTE STORAGE AND DISPOSAL SITES, COLD CREEK VALLEY AREA, WESTERN HANFORD SITE	3Q	1/2	1	

16. KEY

Impact Level (F)	Reason for Transmittal (G)	Disposition (H) & (I)
1, 2, 3, or 4 (see MRP 5.43)	1. Approval 2. Release 3. Information 4. Review 5. Post-Review 6. Dist. (Receipt Acknow. Required)	1. Approved 2. Approved w/comment 3. Disapproved w/comment 4. Reviewed no/comment 5. Reviewed w/comment 6. Receipt acknowledged

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1/2	1	Cog. Mgr. K.R. Fecht	[signature]	5/17/93	H6-06	F. Ruck, III	[signature]	11/3/93	H6-23	3	1
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ID Number (include revision, volume, etc.): WHC-SD-EN-AP-133, Rev. 0

List attachments: n/a

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Title: Hydrogeologic Characterization Plan: I. Principal Recharge Zone for the Hanford Site 200 Areas Waste Storage and Disposal Sites, Cold Creek Valley Area, Hanford Site

Unclassified Category: UC-

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RL Program/Project	[x] KAL	[x]	[redacted]		
Publication Services	[x]	[]	Gayle Crawford	Gayle Anne Crawford	5/10/93
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References Available to Intended Audience	[x]	[]
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SUPPORTING DOCUMENT

1. Total Pages 94

2. Title

HYDROGEOLOGIC CHARACTERIZATION PLAN: I. PRINCIPAL RECHARGE ZONE FOR THE HANFORD SITE 200 AREAS WASTE STORAGE AND DISPOSAL SITES, COLD CREEK VALLEY AREA, WESTERN HANFORD SITE

3. Number

WHC-SD-EN-AP-133,

4. Rev No.

0

5. Key Words

GEOLOGY, HYDROLOGY, HYDROCHEMISTRY, NATURAL BACKGROUND, COLD CREEK VALLEY

APPROVED FOR PUBLIC RELEASE.
5/10/93 D. Solis

6. Author

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7. Abstract

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I. PRINCIPAL RECHARGE ZONE FOR THE HANFORD SITE 200 AREAS WASTE STORAGE AND DISPOSAL SITES, COLD CREEK VALLEY AREA, WESTERN HANFORD SITE

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FOREWORD

Characterization plans are required to fully implement the *Hanford Site Groundwater Protection Management Program* plan (DOE/RL 1989) required by U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Program* (DOE 1988). This document is the first of a set of three plans that will be used to control the work required to meet this objective.

The hierarchy of programs, plans, and supporting documents that implement DOE Order 5400.1 is shown in Figure F-1. Supporting documents for the *Hanford Site Groundwater Protection Management Program* are shown as multiple plans in each of four categories. Three of the categories consist of either existing plans or work plans in progress for the *Resource Conservation and Recovery Act of 1976* (RCRA), *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) or Underground Storage Tank programs. The fourth category, Characterization and Development Plans, involves preparation of new work plans for implementing the Groundwater Protection Management Program (GPMP) described in Section III of DOE Order 5400.1. Implementation of one element of the GPMP involves acquisition of additional geohydrologic data to more fully characterize the "groundwater regime" beneath and adjacent to the Hanford Site. Three general geohydrologic systems that control groundwater movement in the vicinity of the Hanford Site are illustrated in Figure F-2 (Johnson 1993; DOE/RL 1989; DOE/RL 1993).

The Dry Creek and Cold Creek drainage and the Cold Creek syncline (Area I) will be addressed first because this is the primary recharge zone for the groundwater flow system beneath the 200 Areas Plateau of the Hanford Site. Subsequent plans will be developed for the other two major areas after (1) review of data emerging from the CERCLA Remedial Investigation studies in the 100 Areas and along the Hanford Reach of the Columbia River and (2) review of a U.S. Geological Survey report on the geohydrology of the agricultural land contiguous with the northern boundary of the Hanford Site.

REFERENCES

Johnson, V. G., 1993, *Westinghouse Hanford Company Groundwater Status Report, 1990-1992*, WHC-EP-0595, Westinghouse Hanford Company, Richland, Washington.

DOE, 1988, *Consultation Draft, Site Characterization Plan, Reference Repository Location, Hanford Site, Washington: Volume 1*, DOE/RW-0164, U.S. Department of Energy, Office of Civilian Waste Management, Washington, D.C.

DOE/RL, 1989, *Hanford Site Groundwater Protection Management Program*, DOE/RL-89-12, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE/RL, 1993, *Hanford Site Groundwater Protection Management Program*, DOE/RL 89-32, Rev 1, [draft], U.S. Department of Energy, Richland Field Office, Richland, Washington.

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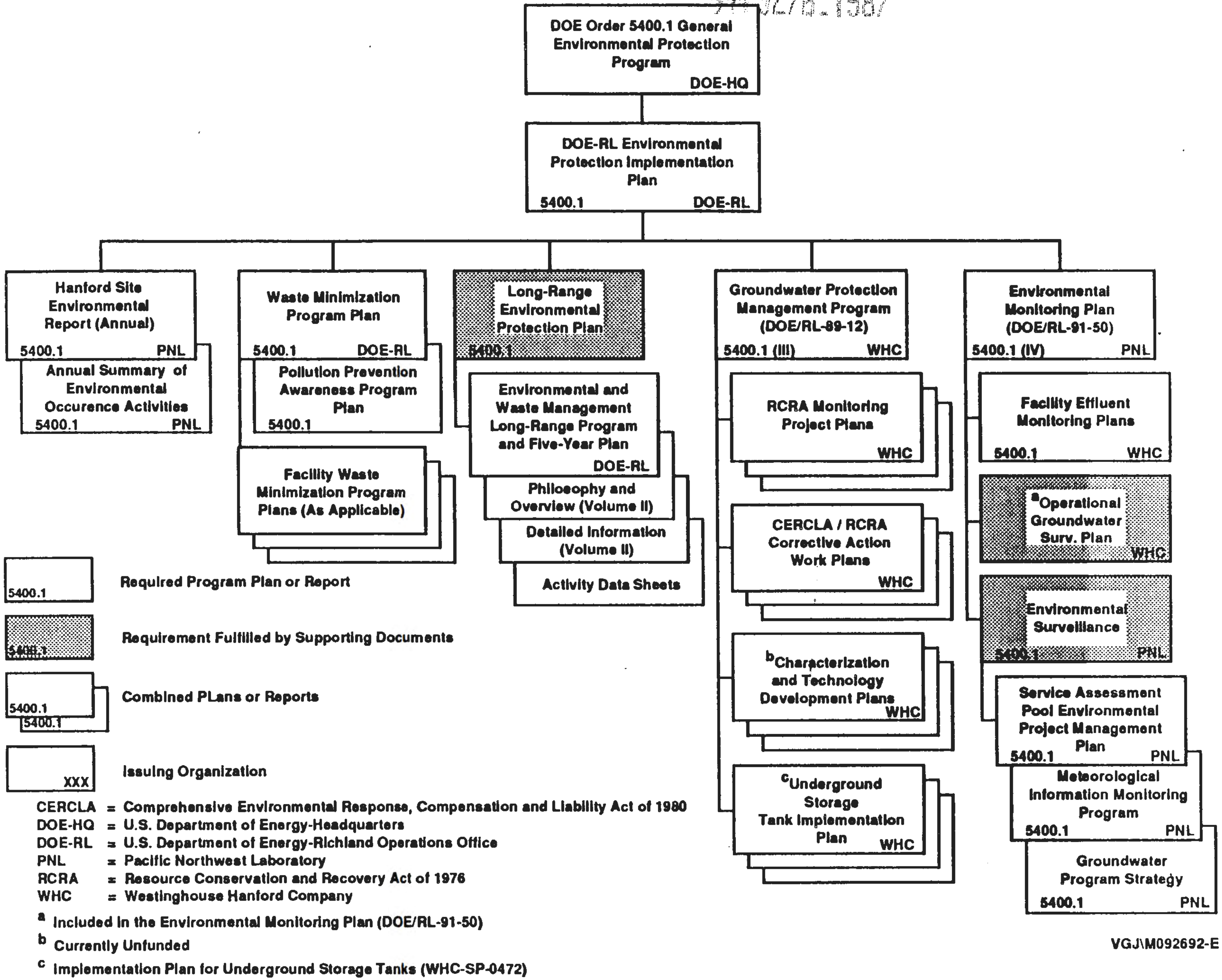

Figure F-1. Relationship Between the Groundwater Protection Management Program and other Environmental Protection Programs and Plans Required by U.S. Department of Energy Order 5400.1.

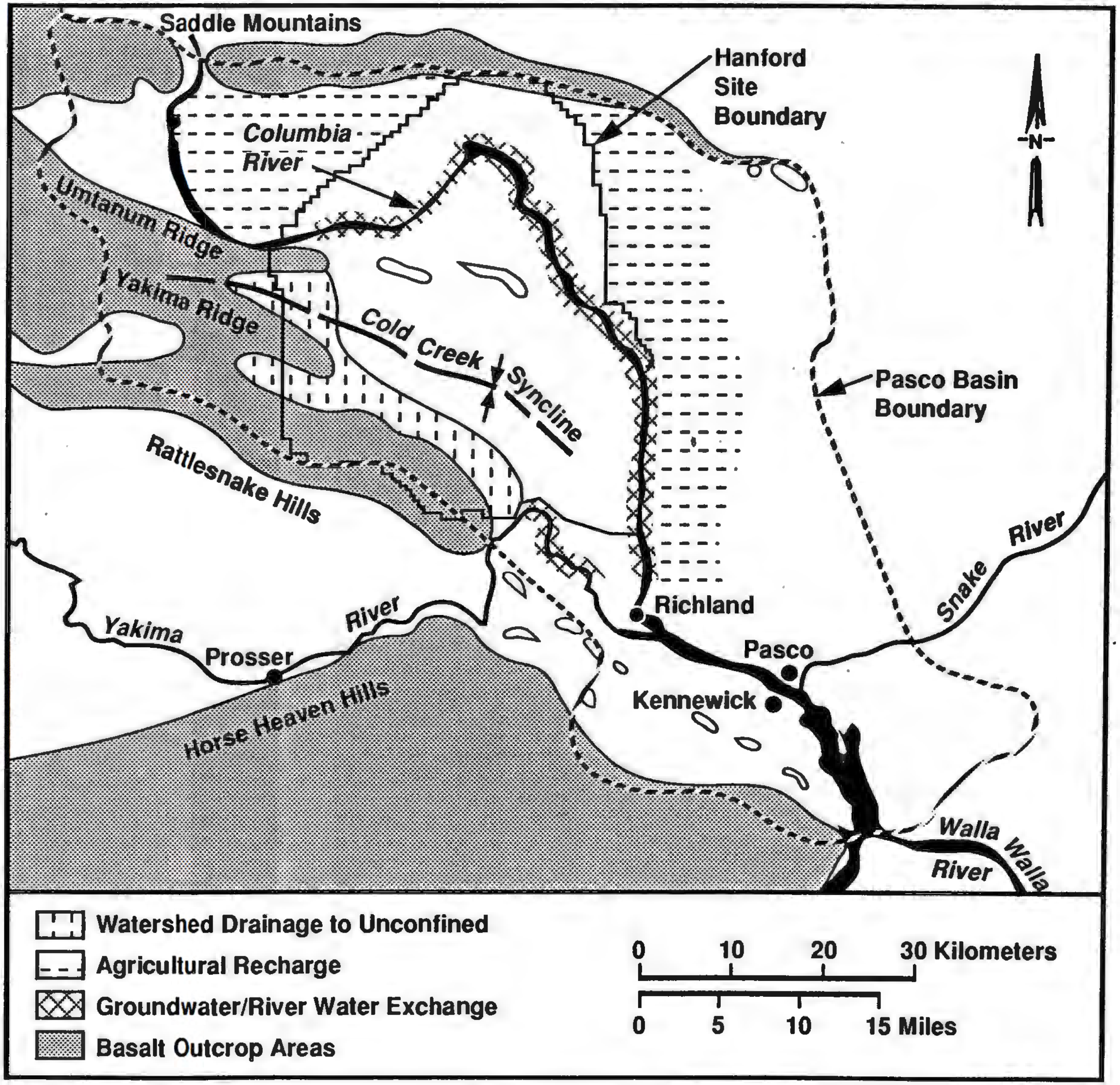

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Figure F-2. Natural and Artificial Sources of Water.

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1.0 INTRODUCTION

1.1 SCOPE AND PURPOSE

A more complete characterization of the geohydrologic regime in the vicinity of the Hanford Site is fundamental to groundwater protection and related environmental restoration activities. The types of information needed for this purpose include: (1) hydrostratigraphy, (2) hydrochemical characteristics, (3) water levels and hydraulic properties, (4) recharge-discharge boundaries and quantities, and (5) flow dynamics (Johnson 1993). Collectively, this type of information is used to refine conceptual flow models and to document the geohydrologic regime as required by U.S. Department of Energy (DOE) Order 5400.1 (DOE 1988b). As described in the *Hanford Site Groundwater Protection Management Program* (GPMP) (DOE/RL 1989) and the Hanford Site Five Year Plan (Activity Data Sheets), new boreholes are needed to supplement existing geohydrologic data for use in upgrading both conceptual and numerical models (see also DOE/RL 1991).

Characterization plans for the above data collection purposes are an important element of the implementation strategy for the GPMP (DOE/RL 1989). Responsible organizations and relationships to other environmental planning documents for the Hanford Site are discussed in the *U.S. DOE-RL Environmental Protection Implementation Plan* (EPIP) (DOE/RL 1990). The EPIP identifies the GPMP and supporting documents, such as "characterization plans," as Westinghouse Hanford Company (WHC) responsibilities (DOE/RL 1990, p. 1-5). The activities described herein constitute one of the characterization plans required as supporting documentation for the GPMP plan (DOE/RL 1993).

The characterization activities described in this document involve the proposed drilling of five new wells in a critical area of the hydrologic system that accounts for most of the natural component of groundwater flow beneath the 200 Areas waste management units. The target area for this characterization is in the Cold Creek valley (Figures 1, 2, and 3), the zone of primary "natural" recharge to the 200 Areas Plateau. The 200 Areas contains over 90 percent of the radioactive and hazardous wastes on the Hanford Site as well as the most widespread and significant groundwater contamination (Johnson 1993). In addition, estimates of the natural recharge component to this important area reveal major discrepancies between observed surface recharge and the predicted recharge required to account for inferred hydraulic gradients across Cold Creek valley. This is in part attributed to the lack of hydrologic data in the Cold Creek valley. A better understanding of the geohydrology in this critical area is clearly needed.

The primary purpose of the proposed drilling described in this plan is to provide the geohydrologic, hydrochemical, and natural groundwater background data as discussed in DOE/RL (1989, 1990, 1991, 1993) and Johnson (1993). This document provides the technical guidance and procedural controls for conducting initial drilling and sampling in accordance with applicable state and company requirements.

1.2 RELATED STUDIES

Several studies for various programs are underway that will benefit from the proposed well drilling program. Integration of the proposed GPMP drilling with these activities is essential to maximize information for all programs and to minimize costs. Major related studies and/or their relationship to the proposed boreholes in this plan are discussed below.

1.2.1 Groundwater Background Study

The need to characterize the natural background groundwater quality for the Hanford Site has long been recognized. Background wells were included in the original *Resource Conservation and Recovery Act of 1976* (RCRA) drilling program for the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology 1989a) that was signed in 1989. This need was formalized more recently in state and federal groundwater protection regulations (e.g., WAC 173-200) and in cleanup guidance documents (e.g., EPA/540; WAC 173-340-700). Existing Hanford Site data that might fulfill this need was reviewed and summarized in DOE/RL-92-23, *Hanford Site Groundwater Background* (1992). This review resulted in provisional background values for interim use. Application of this provisional data for on-going groundwater impact assessments at active waste disposal sites was discussed by Johnson (1993) and statistical methods were reviewed and applied to a background comparison test case by Chou (1993).

Review of existing data (DOE/RL 1992; Johnson 1993; Chou 1993) revealed deficiencies in the groundwater data base for background application purposes. Principal among these were: (1) inadequate spatial coverage of suitable monitoring wells, especially in the Cold Creek valley, (2) inadequate well construction materials, and (3) incomplete analysis of regulatory constituents. Also identified was the poorly known areal and vertical variation in "natural" background groundwater compositions with depth or hydrostratigraphic unit.

The well installations proposed in this plan will partially address the above deficiencies. Additional wells at other locations will be needed to establish an adequate data base for statistical testing and decision-making purposes (additional wells for this purpose are planned for the Background Study Program, TPA M-28). Likewise, future drilling plans for the Background Study may provide important supplemental information to meet the objectives for development or refinement of a geohydrologic conceptual model of the Hanford Site/Pasco Basin.

1.2.2 Microbial-Geochemical Characterization Borehole

A Pacific Northwest Laboratory (PNL) research borehole to investigate interaction of subsurface microbial, geochemical, and hydrologic processes is underway at a site located in the study area near the Yakima Barricade. Stratigraphic and water level data from this borehole will be used to supplement the information obtained from the present study. In addition, one of the deeper test zones (Rattlesnake Ridge interbed) planned for the present study will be sampled by PNL for the above program in order to extend the microbial/geochemical characterization to the uppermost confined aquifer. PNL scientists will conduct the special handling required for recovery of "uncontaminated" core samples in this test zone in coordination with the WHC Geosciences cognizant engineer, project engineer, field team coordinator, and project scientist. The additional geochemical sampling associated with this effort will also benefit the overall geohydrologic characterization of the uppermost confined aquifer in the study area.

1.2.3 U.S. Geological Survey Surface Recharge Studies

The U.S. Geological Survey (USGS) is currently studying recharge to the uppermost aquifer from surface runoff in the upper Dry Creek-Cold Creek drainage basins. This characterization plan complements the USGS study by focusing on subsurface recharge and groundwater flow in the lower part of this drainage basin.

1.2.4 Recharge from Springs

Studies related to the USGS study conducted by WHC Geosciences in collaboration with Northwest College/University Association for Science (NORCUS) and Columbia Basin College (CBC) include evaluation of structural controls and/or stratigraphy on spring-related recharge in and adjacent to the study area (Law et al. 1993).

1.2.5 Regulatory Requirements

State of Washington groundwater protection standards (WAC 173-200) and guidance for development of background-based cleanup standards (WAC 173-340-700) indicate the need to characterize groundwater quality upgradient of waste management or disposal activities. The study area and proposed well locations are upgradient (Figures 1 and 2) of known effects of past and present Hanford Site operations and meet this guidance. An important issue, however, is whether or not upgradient hydrochemical characteristics are representative of "natural" groundwater at locations further downgradient or in the vicinity of waste management areas. Other efforts are underway to address this and related issues (DOE/RL 1992). Data from the proposed wells described in this plan will contribute significantly to the resolution of this issue.

1.3 PROCESS OVERVIEW

Characterization will be accomplished through the following activities:

- Vadose and saturated zone sediment sampling and analysis
- Groundwater sampling and analysis
- Aquifer testing and hydrologic modeling.

Sediment samples from the vadose and saturated zones will be retrieved during drilling of the boreholes. Samples will be analyzed in the field for physical and mineralogic properties and archived for later geochemical analysis. Boreholes will be geologically and geophysically logged in order to describe and interpret geologic conditions between the landsurface and bottom of the borehole. This information will be incorporated into future hydrogeologic modeling efforts.

Five groundwater monitoring wells will be installed, four of which will be completed in the shallow unconfined aquifer and one of which will be completed in the upper confined aquifer. Water levels, flow rate measurements, and aquifer test results from each of these wells, coupled with similar data from other wells, will be used to refine estimates of the rate and direction of groundwater movement in the study area. Groundwater samples will be analyzed to determine background groundwater quality including pH, temperature, conductivity, major cations and anions, metals, and trace elements. Isotopic measurements may also be used to evaluate groundwater origin and relative age.

1.4 LOCATIONS OF BOREHOLES

The locations for the five boreholes are shown on Figure 1. The well numbers and approximate Hanford Site coordinates for each is listed below.

- Well 1: 47000N, 92000W - 699-47-92B.
- Well 2: 40000N, 91000W - 699-39-91.
- Well 3: 28000N, 87000W - 699-28-87.
- Well 4: 34000N, 88000W - 699-34-88B.
- Well 5: 52000N, 95000W - 699-52-95.

1.5 CHARACTERIZATION PLAN ORGANIZATION

This plan consists of eight sections and accompanying attachments. Section 1.0 presents an introduction and the purpose of the work. Section 2.0 presents information about the expected site conditions based on the examination of available information in and around each site. Section 3.0 defines the data needs and provides an overview of the characterization methods. This section also identifies analyses and analytical methods where appropriate. Section 4.0 describes general activities and requirements of the characterization work. Section 5.0 describes the tasks necessary to conduct the characterization work. Health and safety, quality assurance (QA), and record control are discussed in Sections 6.0, 7.0, and 8.0 respectively.

Attachments to this plan include supporting documents that are necessary to conduct the project. These documents are:

- Attachment 1: Groundwater Sampling and Analysis Plan (SAP). The SAP addresses:
  - Sample collection procedures
  - Chain-of-custody procedures
  - QA/Quality Control.

- Attachment 2: Quality Assurance Project Plan (QAPP). The following areas are addressed in the QAPP:
  - Project organization and responsibilities
  - QA objectives
  - Well drilling procedures
  - Sampling procedures
  - Calibration procedures
  - Analytical procedures
  - Data reduction, validation, and reporting
  - Internal quality control
  - Performance and system audits
  - Preventive maintenance
  - Data assessment procedures
  - Corrective action
  - QA reports.

1.6 QUALITY ASSURANCE

The basic objective of the characterization plan and attachments is to ensure that the data and results or findings obtained are sufficiently accurate and reliable for use in hydrogeologic characterization activities. All work on the Hanford Site is subject to the requirements of DOE-RL Order 5700.6C, *Quality Assurance* (DOE/RL 1991b). WHC QA requirements are discussed in WHC-CM-4-2, *Quality Assurance Manual* and WHC (1990). All environmental investigation activities conducted on the Hanford Site are conducted in accoradnce with WHC-CM-7-7, *Environmental Investigation and Site Characterization Manual* and also to comply with the Tri-Party Agreement (Ecology et al. 1989a; as amended in 1990) QA program requirements.

2.0 GEOHYDROLOGIC AND ENVIRONMENTAL SETTING OF PROPOSED BOREHOLES

The borehole locations were chosen in an effort to complement existing monitoring wells to maximize hydrologic and hydrochemical characterization data upgradient of facilities located in the 200 Areas on the Hanford Site. The following sections summarize the hydrogeologic settings of each of the borehole sites. Air quality, biotic survey, and cultural resources are discussed in separate reports.

2.1 GEOLOGY

The topography, principal features, and structural geology of the western part of the Hanford Site (where the five borehole sites are located) are shown on Figures 1, 3, and 4. The geologic setting of the area will only be summarized here. More detailed information for each of the proposed well sites will be given in the following sections. However, because few boreholes are present in the areas of the five proposed well sites, these discussions are not detailed and geologic interpretations are speculative.

Several geologic units are present beneath the western Hanford Site (Figures 5, 6, 7, and 8). The uppermost unit is a discontinuous veneer of Holocene-aged alluvium and eolian silt and sand. These Holocene deposits overlie Pleistocene-aged (1.0 (?) Ma to 13 Ka) cataclysmic flood deposits of the Hanford formation. A thin sequence of eolian and alluvial deposits referred to collectively as the early Palouse/Plio-Pleistocene interval separate the Hanford formation from the fluvial-lacustrine deposits of the Miocene- to Pliocene-aged (<8.5 to >3.4 Ma) Ringold Formation. The Ringold Formation disconformably overlies the flood basalts of the Miocene-aged (17.5 to 6.5 Ma) Columbia River Basalt Group and intercalated sediments of the Ellensburg Formation. For detailed information about the major aspects of Hanford Site and regional geology refer to Fecht (1978), Myers et al. (1979), Reidel and Fecht (1981), Tallman et al. (1979, 1981), Fecht et al. (1987), DOE (1988a), Delaney et al. (1991), Lindsey (1991, 1992), Lindsey et al. (1992a, 1992b), and Reidel et al. (1992).

2.1.1 Site 1

At Site 1 (Figure 1), the stratigraphic units encountered are expected to be, from the top down: (1) Hanford formation, (2) early Palouse/Plio-Pleistocene interval, (3) Ringold Formation upper unit, and (4) Ringold Formation unit E (Figure 9). The Hanford formation is approximately 67 to 68.5 m (220 to 225 ft) thick at Site 1 and consists of a mix of sand-dominated and gravel-dominated facies. Generally, it displays an upper gravelly interval approximately 6 m (20 ft) thick overlying 9 to 12 m (30 to 40 ft) of sands, 12 to 15 m (40 to 50 ft) of gravel-dominated strata, 15 to 18 (50 to 60 ft) of sands, and a lower gravelly interval up to 18 m (60 ft) thick. The early Palouse/Plio-Pleistocene interval is approximately 7 m (25 ft) thick although no clear indication of early Palouse silty sediments are found in the few nearby wells. Upper Ringold strata, consisting of 9 to 10.5 m (30 to 35 ft) of sandy sediments, probably are present. The lowest unit that will be encountered at the site is fluvial gravel and intercalated fluvial sand of Ringold Formation unit E.

2.1.2 Site 2

Holocene topsoil and eolian silt and fine-grained sand up to 1.5 m (5 ft) thick lies at the surface at Site 2. This material overlies, from top down the following: (1) Hanford formation, (2) early Palouse/Plio-Pleistocene interval, (3) Ringold Formation upper unit, and (4) Ringold Formation unit E (Figure 9). The Hanford formation is expected to be approximately 30 to 32 m (100 to 105 ft) thick and consist of a silty to sandy upper half and a more gravel-rich to sandy lower half. The early Palouse and Plio-Pleistocene interval is approximately 9 to 10.5 m (30 to 35 ft) thick and appears to be dominated by gravelly carbonate-rich alluvium with the silts of the early Palouse apparently being absent. Approximately 6 m (20 ft) of sandy deposits comprising the Ringold Formation upper unit is the next unit encountered. The final unit to be encountered is the fluvial gravels and intercalated fluvial sands of Ringold Formation gravel unit E.

2.1.3 Site 3

The units encountered at this site are the same as those projected to be encountered at Site 2 (Figure 9). The uppermost horizon will be topsoil and eolian silt and sand and is approximately 3 m (10 ft) thick. This overlies the Hanford formation which is approximately 27 m (90 ft) thick and consists of an upper silty to sandy interval and a lower sandy interval with increasing gravel content with depth. The base at two boreholes to the north and south appears to be gravel-dominated. Like the locations discussed above the early Palouse and Plio-Pleistocene interval appears to lack clearly developed Palouse silts and be dominated by basaltic gravels containing variable amounts of pedogenic calcium carbonate. This interval is expected to be about 12 to 12.5 m (40 to 45 ft) thick. The Ringold Formation upper unit at this location is less than 3 m (10 ft) thick and probably dominated by fluvial sands. The final unit to be encountered is the fluvial gravel and intercalated fluvial sand of Ringold Formation gravel unit E.

2.1.4 Site 4

The entire suprabasalt stratigraphic section, in addition to the uppermost parts of the Saddle Mountain Basalt, will be encountered during drilling of this borehole (Figure 9). The Hanford formation is expected to consist of an upper more sandy interval and a lower more gravelly interval and to total approximately 27 to 29 m (90 to 95 ft) in thickness. The early Palouse/Plio-Pleistocene interval is expected to be about 4.5 m (15 ft) thick and dominated by alluvial sand and gravel containing pedogenic calcium carbonate. Upper Ringold sands approximately 13.5 m (45 ft) thick underlie these alluvial deposits. Approximately 85 m (280 ft) of fluvial gravel and lesser fluvial sand of Ringold unit E, 35 to 36 m (115 to 120 ft) of paleosol overbank, and lacustrine deposits of the Ringold Formation lower mud unit, and 33.5 m (110 ft) of fluvial gravel and fluvial sand of Ringold Formation gravel unit A comprise the remainder of the Ringold Formation at Site 4. The uppermost Saddle Mountains Basalt unit, the Elephant Mountain Member, is expected to be approximately 27 to 30 m (90 to 100 ft) thick. Paleosols, overbank deposits, tuffaceous sediments, and fluvial deposits are expected to comprise the 30 m (100 ft) thick Rattlesnake Ridge interbed of the Ellensburg Formation. The final unit encountered will be the top of the Pomona Member of the Saddle Mountains Basalt at approximately 257 m (850 ft) depth.

Site 4 is located east of the Cold Creek and Yakima Ridges faults. The Cold Creek fault has been interpreted to allow upward migration of deep groundwater (Johnson et al. 1993). The Yakima Ridge fault could also provide intercommunication between the Rattlesnake Ridge aquifer and deeper aquifers. The Yakima Ridge fault is a thrust fault that places much of the Saddle Mountains Basalt over the top of basalt in the Cold Creek syncline, which potentially could bring the Priest Rapids aquifer in communication with the Rattlesnake Ridge interbed in this area. If this is the case, groundwater chemical composition from the Rattlesnake Ridge interbed at Site 4 will be different than is seen elsewhere (see Section 2.4).

2.1.5 Site 5

The expected geology at Site 5 (Figure 9) will be similar to that predicted for Site 1. If eolian deposits are encountered they will be no more than 1.5 m (5 ft) thick. The Hanford formation is expected to be approximately 39 to 42 m (130 to 140 ft) thick and consist largely of gravel-dominated facies and lesser sand-dominated deposits. An interval consisting of the early Palouse and Plio-Pleistocene units plus the Ringold Formation upper unit is expected to be present. However, it is difficult to estimate with any certainty what the characteristics of this interval will be. If this interval is encountered it will probably be no more than 12 m (40 ft) thick. Unlike the other sites, fluvial gravels and intercalated fluvial sands of Ringold unit E will be the next stratigraphic unit encountered downsection. Unit E is expected to be approximately 85 m (280 ft) thick and be underlain by the Ringold Formation lower mud unit.

2.2 HYDROLOGY

The hydrogeology at each of the sites is characterized by a multiaquifer system that consists of four hydrogeologic units that correspond to the upper three formations of the Columbia River Basalt Group (Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt) and the suprabasalt sediments (see DOE (1988a) and Delaney et al. (1991) for more detailed discussion). For this section only the upper aquifer system in the suprabasalt sediments and the uppermost part of the Saddle Mountains Basalt aquifer will be discussed. Kasza et al. (1992) contains potentiometric maps for the suprabasalt aquifer in the study area. A potentiometric map for the Rattlesnake Ridge interbed is found in Jackson (1992) and shown in Figure 10.

2.2.1 Water Table

Four of the five proposed wells will be screened in the suprabasalt aquifer system. In the study area the suprabasalt aquifer will be entirely within the sediments of the Ringold Formation. Hanford Site groundwater maps indicate the unconfined water level will decrease from south to north (Kasza et al. 1992). The estimated depths to groundwater and water table elevations for the suprabasalt aquifer at each of the locations is summarized in Table 1.

Table 1. Predicted Depth and Elevation of Water in the Suprabasalt Aquifer System at the Five Proposed Sites.

Site Number	Depth (ft)	Depth (m)	Elevation* (ft)	Elevation* (m)
1	338	103	470	143
2	177	54	470	143
3	162	49	470	143
4	164	50	468	143
5	329	100	470	143

*above mean sea level.

At Sites 1, 2, 3, and 5 (the shallow wells), no significant perching or confining layers are suspected. These layers are inferred to be absent because the available data indicate that laterally extensive fine-grained horizons probably are absent. However, drilling experience in the 200 West Area indicates that localized fine-grained horizons and well-cemented zones that can generate locally confined, semi-confined, or perched conditions may be encountered. Perching also is not suspected because of the absence of significant surficial recharge (either natural or manmade) in the area.

Borehole 4 will be drilled to the top of the Pomona Member of the Saddle Mountains Basalt. The purpose of this borehole is to place a monitoring well in the Rattlesnake Ridge interbed aquifer. However, because of the lack of data from the Rattlesnake Ridge interbed in this area, the entire approximately 30 m (100 ft) interval will be drilled in order to determine the best interval in which to screen the well. Potentiometric mapping of the Rattlesnake Ridge interbed (Figure 10) (Jackson 1992) indicates water level will be at approximately 140 m (460 ft) above sea level at location 4. This level is approximately 2.5 m (8 ft) lower than the expected water level for the unconfined aquifer at this location.

2.2.2 Hydrologic Parameters

Hydrologic parameters and interpretations for the Hanford Site are presented in a number of reports. These parameters include hydraulic conductivity, transmissivity, storativity, effective porosity, groundwater flow paths, and groundwater travel times. The most recent collection of these types of data are found in Connelly et al. (1992a, 1992b). These reports discuss the hydrogeologic conditions of the 200 West and East Areas and the data presented is applicable to the proposed well sites.

2.3 VADOSE ZONE CONDITIONS

The proposed well sites are expected to be free of contaminants; this is based primarily on knowledge of operations at the Hanford Site and best available data for the western Hanford Site. Locations of known waste units are documented in the *Preliminary Operable Units Designation Project* (WHC 1989a). Vadose conditions are known for the general area based on drilling activity by the Basalt Waste Isolation Project (BWIP) (DOE 1988a). Present knowledge of the vadose zone conditions are summarized in DOE (1988a) and Connelly et al. (1992a, 1992b).

2.4 GROUNDWATER QUALITY AND HYDROCHEMICAL CHARACTERISTICS

Groundwater quality characteristics near the proposed well locations can be estimated from existing data collected for both past and present programs. For example, WHC conducts RCRA and operational groundwater quality monitoring programs in the 200 Areas, and PNL conducts the sitewide groundwater quality surveillance monitoring program (Johnson 1993). The hydrochemical data base for the BWIP (DOE/RL-92-23) includes results for both confined and unconfined aquifers in the vicinity of the study area.

Task 2 of the plan includes a review of existing data from the above sources for possible use in meeting the overall objectives of this characterization plan. The following summary and discussion addresses depth and areal variations in water quality and hydrochemical characteristics near the proposed borehole locations, as well as possible differences between the study area and other areas across the Hanford Site.

2.4.1 Contaminant Indicators

The most recent analytical results in the Hanford Site groundwater data base support the expectation that the proposed well locations will provide groundwater compositions that have not been influenced by past or present Hanford Site disposal activities. For example, the nearest existing wells for which recent data are available (Table 2) show no evidence of detectable tritium or other major 200 West Area contaminant indicators (carbon tetrachloride, gross alpha, and gross beta). Nitrate, however, may be slightly elevated in well 6-43-88 (7.5 ppm). This may be due to input from agricultural activities. Groundwater nitrate concentrations of several parts per million may also result from natural processes (Hodges and Johnson 1991). Furthermore, since the proposed boreholes in this area are located upgradient of well 6-43-88, the influence of contaminant plume from the 200 West Area disposal sites seems unlikely. Also, the direction of groundwater contaminant movement from U-Pond and the REDOX pond and cribs, the nearest sources to the proposed well locations, was to the south-southeast (Freshly and Thorne 1992). Groundwater transport to the west from the T-Pond and T-Tank Farms area reportedly occurred during the early history of operations. But with declining wastewater discharges to 200 West Area disposal facilities, and the shift of major wastewater discharges from T-Pond to U-Pond, residual contaminant levels from the early years have probably been carried back toward the east. Increased input of agricultural recharge water in upper Cold Creek valley during the last 10-15 years may also act to accelerate such a trend.

An anomalous hydrochemical occurrence for well 6-36-93, located west of the proposed location # 4, should also be noted. Tritium has been reported as nondetected in this well; however, a single analysis of major anions in 1992 indicated elevated nitrate, chloride, and sulfate. The area around the well is referred to as an alkali flat which frequently contains standing water during periods of high surface runoff. Since this is an old well (unsealed) it is possible that water with a modified chemical composition due to partial dissolution of evaporites migrates down the outside of the well. Thus, groundwater in the immediate vicinity of this well may not be representative of the aquifer. Further investigation of this anomalous occurrence is warranted in connection with the study of groundwater background for the Hanford Site.

2.4.2 Depth Variability

The general hydrochemical characteristics of the major hydrostratigraphic units in the vicinity of the study area are illustrated in Figure 11. The Stiff diagrams for the stratigraphic units near the study area (DB-14, 699-24-95, 699-19-88) suggest there is not much difference in major chemical composition between the uppermost unconfined aquifer and the Rattlesnake Ridge

Table 2. Data Listing for Monitoring Wells in the Vicinity of Proposed Well Locations. (2 sheets)

Well	Date	Constituent	Sample Number	Result	Error	LT
6-43-88	04-Jan-90	Tritium	JM3391	-35.6	215	<
6-43-88	04-Jan-90	Gross Beta	JM3391	1.87	2.15	<
6-43-88	04-Jan-90	Gross Alpha	JM3391	0.942	1.16	<
6-43-88	04-Jan-90	Nitrate	JM3391	7500	755	
6-43-88	12-Mar-92	Carbon Tetrachloride	B06484	5		U
6-43-88	12-Mar-92	Benzene	B06484	5		U
6-43-88	12-Mar-92	Methyl ethyl ketone	B06484	100		U
6-43-88	12-Mar-92	Toluene	B06484	5		U
6-43-88	12-Mar-92	1,1,1-TCA	B06484	5		U
6-43-88	12-Mar-92	1,1,2-TCA	B06484	5		U
6-43-88	12-Mar-92	TCE	B06484	5		U
6-43-88	12-Mar-92	PCE	B06484	5		U
6-43-88	12-Mar-92	Chloroform	B06484	5		U
6-43-88	12-Mar-92	1,1-DCA	B06484	5		U
6-43-88	12-Mar-92	1,2-DCA	B06484	5		U
6-43-88	12-Mar-92	trans-1,2-DCE	B06484	5		U
6-43-88	12-Mar-92	Methylene chloride	B06484	5		U
6-43-88	12-Mar-92	Vinyl Chloride	B06484	10		U
6-43-88	12-Mar-92	p-dichlorobenzene	B06484	5		U
6-43-88	12-Mar-92	Acetone	B06484	100		U
6-43-88	12-Mar-92	1-Butanol	B06484	1		U
6-43-88	12-Mar-92	Tetrahydrofuran	B06484	10		U
6-43-88	12-Mar-92	4-methyl-2-Pentanone	B06484	50		U
6-43-88	12-Mar-92	Xylenes (total)	B06484	5		U
6-34-88	04-Dec-90	Tritium	H0007077	-55	200.2	U
6-36-93	04-Dec-90	Tritium	H0007080	-54.1	200.3	U
6-36-93	17-Sep-91	Tritium	B00LY2	-38.5	280.4	U

Table 2. Data Listing for Monitoring Wells in Vicinity of Proposed Well Locations. (2 sheets)

Well	Date	Constituent	Sample Number	Result	Error	LT
6-36-93	01-May-92	Nitrate	B06J91	49000	27600	
6-36-93	01-May-92	Sulfate	B06J91	58000	56000	
6-36-93	01-May-92	Fluoride	B06J91	300	63.3	
6-36-93	01-May-92	Chloride	B06J91	27000	9090	
6-36-93	01-May-92	Phosphate	B06J91	400		U
6-36-93	01-May-92	Bromide	B06J91	500		U
6-36-93	01-May-92	Nitrite	B06J91	200		U

interbed. In contrast, the deeper confined system (Priest Rapids flow top) at DB-14 and the Mabton interbed at DB-7 show a major hydrochemical facies change. If significant vertical leakage of the deeper confined system occurs due to faults or other structural features as interpreted by Johnson et al. (1993) and Reidel and Johnson (1993), it should be easily identified as marked changes in relative concentrations of the major cations and anions. Evaluation of hydrochemical results from the stratigraphic units to be sampled in the study area will allow testing of the effects of vertical leakage from the deeper confined aquifer system into the shallow suprabasalt aquifer system in this portion of the geohydrologic regime beneath the Hanford Site.

The extent of natural variation in groundwater composition with depth in the study area will be evaluated using both new and existing data. The mix of intervals available for this purpose are listed together with the planned completion intervals in Table 3. In addition to the wells indicated in Table 3, six RCRA compliant wells have been completed at the base of Ringold unit E in the 200 West Area that appear to be contaminant free. Data from these wells will be compared to major cation and anion data from wells in the study area.

In addition to well completions in specific stratigraphic zones, modified drill and test sampling using probe techniques may be evaluated for use during the drilling of wells 4 and 5 in order to obtain better resolution of depth variation in chemistry through the suprabasalt aquifer. This information will be used for planning and decision-making concerning the need for multiple completions at various depths for the background study (DOE/RL 1992). Sampling will include major cation and anion composition and selected stable isotope measurements at three to four depth intervals in the suprabasalt sediments.

Table 3. Distribution of Available and Planned Hydrostratigraphic Test Intervals in the Study Area.

	Ringold E[1]	Ringold A[4]	Rattlesnake Ridge interbed	Mabton interbed
well 1	X			
well 2	X			
well 3	X			
well 4			X	
well 5	X			
6-43-91A		X[2]	X[2]	
6-43-91C				X[2]
6-43-88	X			
6-34-88	X			
DC-16B				X
DB-14			X[3]	

[1]Uppermost unconfined aquifer.
[2]Piezometers; major cation and anion sampling only.
[3]Well has been reclaimed, existing data only.
[4]Unit A is the lower, semi-confined portion of the suprabasalt aquifer.

2.4.3 Areal Variation

The chemical composition of groundwater may vary with time and/or changes in lithology within specific hydrostratigraphic units. Such changes have been observed within the Priest Rapids confined aquifer in the upper Cold Creek syncline (see Figure 8) but involve residence times of 10 to 20 thousand years. For much shorter residence times, however, such as within the uppermost unconfined aquifer, changes in groundwater chemistry may be minor. In addition to residence time, the unconfined aquifer across the Hanford Site occurs in two different lithologic units: the Ringold Formation and Hanford formation. The possible influence of lithologic variations on groundwater chemical composition is unknown.

One working hypothesis to be tested in this characterization plan is that (1) the unconfined aquifer chemical composition is set early in its history near the zone of recharge and (2) chemical changes with time and distance during migration from the western side of the Pasco Basin to the Columbia River are minor. If the hypothesis is true, spatially distinct sample populations should not exhibit significant differences in chemical composition and/or in concentration ranges. An initial test of this working hypothesis was conducted and is summarized as follows.

The hypothesis that spatially distinct subsets or populations are identical within the upper unconfined aquifer was tested using a USGS data set acquired during 1979-1984. Statistical tests were conducted using the Kolmogorov-Smirnov two-sample test on subsets of major and trace constituents from well locations shown in Figure 12. These wells were selected from a data set consisting of approximately 100 wells located across the Hanford Site. Only data from those wells (42 wells) with tritium concentrations of less than 1000 pCi/L were selected for the comparisons. Three subsets were identified from the 42 chosen wells (Figure 12): (1) a Rattlesnake Ridge subset (10 wells), located along the western side of the Hanford Site; (2) Gable Mountain north subset (10 wells), representing an area far downgradient from the assumed recharge location in upper Cold Creek Valley; and (3) an area-wide subset consisting of all 42 wells, minus the Rattlesnake Ridge subset, for a total of 32 wells. Results of comparison of the Rattlesnake Ridge vs area-wide and Rattlesnake Ridge vs Gable Mountain North are summarized in Tables 4 and 5. The test results strongly suggest there is little, if any, difference between upgradient locations as represented by the Rattlesnake Ridge subset and downgradient locations. More specifically, the null hypothesis, that the spatially distinct populations tested are identical, cannot be rejected at the 5% level of significance.

It should be noted that adequate data for spatial variability testing is available only for the unconfined aquifer. Variations with time and distance in the confined aquifers was noted above for the Priest Rapids flow top (see Figure 8). Similar evolution in groundwater composition may exist for the Rattlesnake Ridge interbed across the Hanford Site. The upper portion of the unconfined aquifer, however, is the primary target aquifer for consideration in groundwater impact assessments and groundwater protection, and is the aquifer most likely impacted by past and present waste disposal practices. The representativeness of chemical composition from well 4, which will be completed in the Rattlesnake Ridge interbed, can be evaluated by comparison with other downgradient locations (e.g., 1-H4-2 in the 100 H Area) using contemporary sampling/analytical results.

Based on the above discussion and initial statistical test results, it appears that (1) major portions of the unconfined aquifer exhibit similar concentration ranges of major and selected trace constituents and (2) selected wells from across the Hanford Site can be used to supplement the very limited number of existing wells in the upgradient area. Variability with depth within the suprabasalt aquifer and upper confined, however, is relatively unexplored. The latter question will be addressed by the hydrostratigraphic characterization indicated in Table 3.

Table 4. Results of Kolmogorov-Smirnov Two-Sample Test for Selected Constituents in Hanford Site Groundwater: Rattlesnake Ridge Corridor vs Hanford Site.

Constituent	Kolmogorov-Smirnov Test[a] Test-Statistic	Critical Value (α = 0.05)	Result
Sodium	0.231	0.493	n.s.
Potassium	0.323	0.495	n.s.
Magnesium	0.406	0.495	n.s.
Calcium	0.322	0.495	n.s.
Barium	0.300	0.495	n.s.
Silica	0.306	0.493	n.s.
Lab Conductivity	0.248	0.515	n.s.
Lab pH	0.261	0.515	n.s.
Lab Alkalinity	0.476	0.594	n.s.
Sulfate	0.313	0.493	n.s.
Fluoride	0.256	0.493	n.s.
Chloride	0.356	0.493	n.s.
Nitrate	0.388	0.493	n.s.
Arsenic	0.175	0.493	n.s.
Gross Alpha	0.156	0.493	n.s.
Gross Beta	0.281	0.493	n.s.

NOTE: The above test comparison is based on 10 wells from the Rattlesnake Ridge Corridor subset vs 32 wells from all other subset locations (Gable Mountain North plus "other") shown on the well location map.

[a]The test is a two-tailed test. The null hypothesis (H_o) is that the distributions functions associated with the two populations (Rattlesnake Ridge Corridor and Hanford Site) are identical. The alternative hypothesis (H_a) is that they are different. Reject H_o when the test statistic is greater than the critical value.

n.s. = not significant at α = 0.05.

Table 5. Results of Kolmogorov-Smirnov Two-Sample Test for Selected Constituents in Hanford Site Groundwater: Rattlesnake Ridge Corridor vs Gable Mountain North Region.

Constituent	Kolmogorov-Smirnov Test[a] Test-Statistic	Critical Value (α = 0.05)	Result
Sodium	0.300	0.600	n.s.
Potassium	0.300	0.600	n.s.
Magnesium	0.400	0.600	n.s.
Calcium	0.500	0.600	n.s.
Barium	0.400	0.600	n.s.
Silica	0.300	0.600	n.s.
Lab Conductivity	0.278	0.578	n.s.
Lab pH	0.267	0.578	n.s.
Lab Alkalinity	0.571	0.714	n.s.
Sulfate	0.300	0.600	n.s.
Fluoride	0.300	0.600	n.s.
Chloride	0.400	0.600	n.s.
Nitrate	0.300	0.600	n.s.
Arsenic	0.300	0.600	n.s.
Gross Alpha	0.300	0.600	n.s.
Gross Beta	0.400	0.600	n.s.

NOTE: The above test comparison is based on 10 wells from the Rattlesnake Ridge Corridor subset vs 10 wells from Gable Mountain North subset shown on the well location map.

[a]The test is a two-tailed test. The null hypothesis (H_0) is that the distributions functions associated with the two populations (Rattlesnake Ridge Corridor and Gable Mountain North Region) are identical. The alternative hypothesis (H_a) is that they are different. Reject H_0 when the test statistic is greater than the critical value.

n.s. = not significant at α = 0.05.

2.5 AIR QUALITY

Ambient air sampling is conducted by WHC to determine baseline concentrations of radionuclides in the 200 Areas and to assess the impact of operations on the local environment. These measurements also provide an indication of the 200 Areas facility performance and are used to demonstrate compliance with environmental protection criteria. Meteorological conditions are continuously monitored by the PNL meteorological stations positioned around the Hanford Site (Elder et al. 1988). All analysis for contamination from the monitoring stations were below applicable DOE guidelines in 1991. The positions of the proposed well sites generally upwind of the 200 Areas indicate these areas should have little impact on the proposed well sites.

2.6 BIOTIC SURVEY

A biotic survey of the proposed well sites will be done by the WHC Environmental Technology Group.

2.7 CULTURAL RESOURCES REVIEW

A cultural resources review of the proposed well sites will be done by the PNL Hanford Cultural Resources Laboratory.

3.0 CHARACTERIZATION PLAN RATIONALE

This section defines the data needs for characterization activities; it also presents an overview of the characterization methods and a listing of analyses and analytical methods to be used. Existing data were compared with information needed for siting evaluation. From this comparison, the data needs and required quality that form the basis for characterization activities were identified. Descriptions of the characterization tasks are in Section 5.0. QA objectives are included in the QAPP.

3.1 DATA NEEDS

Existing data relevant to hydrogeologic conditions in the study is sparse. This section describes the rationale behind well site selection, data needed to characterize background conditions, and any additional data needed to support development of sub-basin hydrostratigraphic models.

3.1.1 Site Selection

The well sites were selected in an effort to: (1) obtain better definition of the cross-sectional profile and saturated thickness of the unconfined aquifer entering the Hanford Site from the Cold Creek valley and western Cold Creek syncline, (2) improve spatial well coverage for water table elevations and hydraulic parameters, and (3) acquire representative and intact samples of various stratigraphic intervals in the suprabasalt sediment aquifer as well as the uppermost confined basalt aquifer. Well placement was designed to best utilize and complement the already existing, but sparse, monitoring well network in the westernmost Hanford Site. The new wells, in combination with existing wells, will allow the construction of a representative profile of hydrogeologic and hydrochemical conditions across the Cold Creek valley for both the suprabasalt aquifer and the Rattlesnake Ridge aquifer.

Well Number 1: Well number 1 will be completed in the upper part of the unconfined suprabasalt aquifer. Data from this well will complement data from a soon-to-be-completed PNL Yakima Barricade borehole, an existing monitoring well to the southeast (699-43-88), and an existing monitoring well to the northeast (699-50-85). Wells 43-88 and 50-85 are screened in the uppermost unconfined aquifer. The PNL well is planned to be screened in the uppermost unconfined aquifer as well as at deeper intervals.

Well Number 2: The rationale for placement of well number 2 is the same as that for well number 1. Well number 2 will fill a gap between already existing wells to the north (699-43-88) and south (699-34-88). Well number 2 also will be completed in the uppermost unconfined aquifer.

Well Number 3: Well number 3 forms the southern end of the well line across the Cold Creek valley. Data from this well will complement data from a well to the northwest (699-34-88) and several wells located to the east (south of the 200 West Area). The placement of well number 3 at the south end of the line should enable sampling of the southernmost waters inferred to be recharging the Hanford Site and Pasco Basin from the Cold Creek valley. Well number 3 serves an additional purpose of aiding in the assessment of potential recharge of the western Hanford Site from Rattlesnake Springs and the Dry Creek valley areas.

Well Number 4: Well number 4 will be drilled into and completed within the Rattlesnake Ridge interbed of the Ellensburg Formation. The purpose of this well is to allow monitoring of the Rattlesnake Ridge interbed. Currently, there is only one well in the western Hanford Site that monitors the Rattlesnake Ridge interbed (Table 3) and well number 4 is necessary to more adequately monitor the interval. The addition of this well to the monitoring network will provide three-dimensional data that are needed but generally lacking.

Well Number 5: Well number 5 anchors the north end of the monitoring network and on the basis of predicted groundwater flow paths (Kasza et al. 1992) should be the northernmost point necessary to monitor waters entering the Cold Creek plateau area. This well complements an already existing well to the west (699-50-85) and the PNL Yakima Barricade borehole to the south.

3.2 CHARACTERIZATION METHODS

Data will be obtained during the drilling of boreholes and following installation of groundwater monitoring wells. Geologic units will be characterized from drill cuttings and cores. Intact sediment cores will be taken at intervals outlined in Section 5.0. Cores will be taken to provide samples for description and analysis of physical properties. Cores will be archived to provide a source of readily available and truly representative intact samples for future testing and analysis of physical and chemical parameters. Monitoring wells will then be installed and groundwater samples taken and analyzed. Following well installation, depth to groundwater will be established.

Data obtained from physical properties tests, logging of the boreholes, and geochemical analyses of sediments will be used to meet the following data needs:

- Refine the three-dimensional geologic model of the western Hanford Site and provide information for characterization of background upgradient hydrogeologic conditions
- Describe the physical properties of the sediments within the vadose and saturated zones
- Analyze the geochemical properties of sediments.

Groundwater chemical measurements and hydrologic tests will be used to evaluate the flow system characteristics. Sampling and analysis for appropriate regulatory constituents (see Table 5) will provide "natural" background data for regulatory and environmental restoration purposes.

3.3 LABORATORY ANALYSES AND FIELD TESTS

The general types of laboratory analyses and field testing to support the characterization effort are described as follows.

3.3.1 Soil/Sediment Samples

Sediment physical and chemical properties, including calcium carbonate, texture, petrology, moisture content and retention, saturated hydraulic conductivity, and major and trace elements, in both the vadose and saturated zone will be determined from core samples from all five boreholes. Subsamples for these purposes, collected either from the field or core storage facility, will be placed in the appropriate containers in accordance with WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual*. Additional special sample handling techniques will be defined by the project scientist as needed. Samples will be collected from selected core intervals over a depth from 0 to 9 m (0 to 30 ft) at each of the five sites to evaluate net infiltration rates using the chloride mass balance method. Duplicate sealed can moisture samples will be collected for this purpose from each core-depth interval selected by the project scientist. Water extractable chloride will be determined on the same sample as processed for moisture content (i.e., water extraction of the dried sample remaining from the gravimetric moisture determination).

3.3.2 Groundwater Quality and Hydrochemical Sampling

Groundwater will be collected and analyzed in accordance with standard procedures used in the RCRA groundwater monitoring program as described in Section 5.5.4 and Attachment 1. This will include both major and minor naturally occurring constituents as well as the regulatory constituents (see Table 5). Special analyses for aquifer hydrochemical characterization include stable isotopes of carbon, oxygen and hydrogen; carbon-14, alkalinity, dissolved oxygen, and redox potential. Sample collection for the latter parameters will be conducted under a separate sampling and analysis plan. The latter effort will follow the sampling noted above and after establishment of an interagency agreement with the USGS covering the isotopic analytical work.

3.3.3 Aquifer Testing

Aquifer properties will be determined using both single and multiple drawdown and recovery pumping test methods as described in EII 10.1, WHC-CM-7-7. Single well tests will be conducted in the four shallow wells. A two-well test will be conducted at the site of well number 4 using an existing adjacent well (699-34-38) completed in the upper unconfined aquifer as the observation well. At well number 4, drilling will be temporarily suspended upon reaching the depth determined by the project scientist for the pump test. Specific conditions for the pump tests will be defined by the project scientist or a designee and will be based on professional judgement appropriate to the site-specific conditions encountered. Appropriate temporary completion and pumping systems will be used. Because the test area is purposely chosen in a noncontaminated, upgradient portion of the flow system, purgewater will be discharged directly to the ground away from the well via an irrigation/ sprinkler system to prevent reinfiltration near the test wells. In addition to aquifer tests, velocity measurements also will be taken.

4.0 GENERAL ACTIVITIES AND REQUIREMENTS

Before commencing field activities, a Job Safety Analysis is required. Neither a Hazardous Waste Operating Permit (HWOP) or a Radiation Work Permit (RWP) should be required because the proposed well sites are not in waste units or known contaminated areas. Work authorizations for any subcontractors must be acquired and scheduling of activities must be coordinated with subcontractors. In addition, procurement of general equipment and supplies for anticipated activities will be necessary. Appropriate personnel will periodically monitor for health hazards if this is determined to be necessary.

4.1 PROJECT MANAGEMENT

Section 2.0 of the QAPP (Attachment 2) identifies the individuals and organizations necessary to support characterization activities. The purpose of this task is to provide the general project management necessary to stay within budget and on schedule, direct and document activities, and secure the generated data with acceptable technical performance.

4.2 RECORDS

Records maintained for the project will be established in accordance with WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual* (EII) procedures to include EII 5.8 for groundwater sampling, EII 6.7 for well drilling, EII 9.1 for geologic logging, EII 10.1 for aquifer testing, and EII 5.2 for sampling. Records will be documented on the Drilling Planning Form (A-6000-422). All records will be managed in accordance with EII 1.6, *Records Management*.

4.3 EQUIPMENT DECONTAMINATION

All drill rigs and equipment will be decontaminated before commencement of drilling activities and during demobilization in accordance with EII 5.4, *Field Decontamination of Drilling Equipment*. Decontamination of sampling equipment for chemical sampling also will be done according to EII 5.5.

4.4 DRILL CUTTINGS AND PURGEWATER

The five proposed well sites are anticipated to be free of chemical and radiological contamination. Consequently, drill cuttings and groundwater from the boreholes will be disposed of at the drill sites. Drill cuttings will be spread on the ground at the drill site. All groundwater recovered as a result of sampling, aquifer testing, and well development will be returned to the ground.

4.5 DATA EVALUATION AND REPORTING

Data will be evaluated to determine if they provide the information necessary to accurately characterize site conditions. Because much of the data will be descriptive in nature, the field personnel, project scientists, and project engineers will make this determination based on professional judgement. Analytical data will be evaluated using standard criteria such as precision and accuracy of analyses and consistency with other data sets. Data evaluation will identify data gaps and reveal whether sufficient information has been obtained to understand site conditions and provide a scientifically defensible conclusion.

A report will be prepared that addresses characterization information obtained. This report will incorporate data acquired from this project as well as any other data deemed useful from the surrounding area. Specific results of characterization activities that will be included in this report include:

- Depth to groundwater and hydrologic conditions
- Groundwater quality including pH, temperature, conductivity, major cations and anions, and trace elements and metals
- Description and interpretation of geologic conditions both in the vadose and saturated zone

- Description and interpretation of hydrochemical conditions

- Results of aquifer testing.

The final site evaluation report will incorporate conclusions and evaluations from the characterization work and provide the scientific basis for future decisions.

4.6 MODIFICATIONS TO THE CHARACTERIZATION PLAN

Under field conditions, optimal aspects of the plan are often not achievable. Due to unforeseen field conditions, modifications to this Characterization Plan may be necessary, as determined by the field team coordinator, project scientist, project engineer, and cognizant engineer. Necessary modifications will be recorded in the field activity report along with circumstances requiring the action. Ecology will be informed of changes to the Characterization Plan. Any deviation from EII will be done in accordance with EII 1.4, *Deviation from Environmental Investigations Instructions* (WHC-CM-7-7).

5.0 CHARACTERIZATION TASKS

This section describes tasks to be undertaken during borehole characterization activities at the proposed sites. The tasks are designed to provide data specific to the sites and address topics identified in Section 3.0.

The tasks identified and described for the characterization are as follows:

- Task 1: Project Management Organization
- Task 2: Evaluate Existing Data
- Task 3: Geologic Investigation
- Task 4: Core Storage
- Task 5: Groundwater Investigation.

A general schedule for implementation of these tasks is given in Figure 13.

5.1 TASK 1: PROJECT MANAGEMENT ORGANIZATION

Task 1 includes organizational activities necessary for conducting the work. The project management organization is presented in Section 2.0 of the QAPP (Attachment 2).

5.2 TASK 2: EVALUATE EXISTING DATA

Data from previous reports and projects in the areas of the proposed wells will be evaluated and incorporated into final reports for this project where applicable. Data evaluation will be undertaken in three main areas: (1) geology, (2) hydrology, and (3) hydrochemistry.

5.2.1 Geology

Some geologic data have been gathered in the areas of the proposed wells as a result of previous projects. The most accurate data was gathered during corehole drilling for the BWIP. The BWIP coreholes (usually prefixed with DC, DH, and RRL) are scattered throughout the area west of the 200 West Area, with the bulk of the locations situated along the Old Army Loop Road west of the 200 West Area and adjacent to the highway up to 1 mile east of the Yakima Gate. Sediment and basalt cores from these boreholes are stored in the WHC Environmental Division Geotechnical Library. Other geologic data collected from the study area largely consist of drill cuttings from a few groundwater monitoring wells.

Preliminary assessments of the geologic conditions at the proposed drill sites are based on these pre-existing boreholes. However, because of the wide and uneven spacing between these pre-existing wells the estimates of geologic conditions at the proposed well sites only are approximations. Analysis of physical and chemical properties data from core drilled at the new locations will be added to the limited data available from previously drilled core.

5.2.2 Hydrology

Existing groundwater conditions in the study area will be evaluated based on the most recently published water table maps and elevations and related studies. The results of this effort when combined with data from the proposed wells will permit considerably improved water table maps for the mid to upper Cold Creek valley area, estimates of flow velocities within the suprabasalt aquifer, and hydrogeologic conceptual model.

5.2.3 Hydrochemistry

Existing groundwater quality and hydrochemical data within or in the immediate vicinity of the study area are very limited. However, some existing data from selected RCRA compliant wells in the 200 West area may be suitable for evaluation where it can be shown there is little evidence of contamination from past practice operations. Existing RCRA compliant wells in the 200 Area will be screened for potential use as background data wells and/or to better define potential depth variation in hydrochemical composition within the suprabasalt aquifer in the vicinity of the study area.

5.3 TASK 3: GEOLOGIC INVESTIGATION

5.3.1 Purpose

The subsurface sediment sampling to be done under this plan is necessary because:

- Reliable and accurate subsurface stratigraphic information is required for understanding the origin and composition of natural groundwater in the Cold Creek valley portion of the Hanford Site.

- This stratigraphic information coupled with accurate physical property analysis is necessary to accurately interpret groundwater flow characteristics in the suprabasalt aquifer.

- Intact and representative sediment samples are necessary to accurately assess Hanford Site geologic conditions in the western Cold Creek valley. This information is directly applicable to site characterization activities across much of the Hanford Site.

5.3.2 Activities

The activities anticipated for this task include:

- Activity preparation
- Location and designation of boreholes
- Drilling and geologic material sampling
- Sample handling
- Analysis of samples
- Documentation
- Borehole geophysics
- Well completion.

5.3.3 Activity Preparation

Preparation activities necessary before beginning field work for Task 3 include the following:

- Coordinate with team members

- Coordinate with support services as addressed in the QAPP (Attachment 2)

- Evaluate drilling techniques

- Obtain support documentation

- Obtain monitoring and sampling equipment.

5.3.4 Location and Designation of Boreholes

The five boreholes are designed for a dual purpose: (1) characterization of the sediments in the vadose and saturated zones and (2) groundwater investigation (Task 5). Wells will be constructed in accordance with WHC-S-014, Rev. 7.

Boreholes 1, 2, and 3 (Figure 1) will be drilled into the uppermost 6 m (20 ft) of the unconfined aquifer to depths of approximately 111 m, 61 m, and 56 m (365 ft, 200 ft, and 183 ft) respectively. Borehole 4 (Figure 1) will be drilled through the Elephant Mountain Basalt and to the base of the Rattlesnake Ridge interbed, a depth of approximately 259 m (850 ft). Borehole 5 (Figure 1) will be drilled to the top of the Ringold Formation lower mud unit, a depth of approximately 146 m (480 ft). This borehole will then be backfilled and completed in the uppermost suprabasalt aquifer at a depth of approximately 113 m (370 ft).

5.3.5 Borehole and Sample Designation

Boreholes are given designations that relate to the area in which they are located. The permanent borehole numbers will be assigned once the wells are installed and surveyed. Borehole numbers will be as follows, 699 - North Coordinate - West Coordinate. The approximate 699 coordinates and well numbers for each well are listed in Section 1.4.

Cores will be retained in core boxes. The core boxes will be labeled with the borehole number and depth interval of the core. The top and bottom of each core interval will be labeled in the box. In addition, spacers with the correct footage will be placed in core boxes where convenient.

5.3.6 Sampling Equipment and Procedures

Rotary drilling techniques are planned for each well. Depending on borehole location and projected depth, a 6 m (20 ft) starter casing 30 to 51 cm (12 to 20 in.) in diameter will be used. Down sizing of well casing during drilling will be done at appropriate intervals depending on well conditions. Proposed casing as builts are shown in Figure 14.

Samples taken for examination and physical property analysis will be obtained from cored intervals. Drill cutting samples from uncored intervals will also be examined to determine gross lithologic trends.

Sampling activities will be administered in accordance with applicable EIIs in WHC-CM-7-7, *Environmental Investigations and Site Characterization Manual*.

5.3.7 Sampling Locations and Frequency

Cores will be taken from different intervals in each of the proposed boreholes for geologic logging, physical property tests, and chemical analyses. The specific cored intervals are outlined in Sections 5.3.7.1

through 5.3.7.5 and Figure 9. The site geologist, in consultation with the project scientist and cognizant engineer, may select additional cored intervals if horizons of interest that are not specifically planned for are encountered. For example, if a horizon that could form a perching or confining zone is encountered a representative core sample may be taken. If horizons are encountered from which cores are not retrievable, then the circumstances will be entered into the field activity report and drilling will proceed. Drill cuttings from uncored intervals will be logged in order to determine general geologic conditions between cored intervals. In addition, chip samples from basalt flows encountered in well number 4 will be analyzed by x-ray fluorescence to determine which basalt flows are present.

5.3.7.1 Well Number 1. From the surface to 67 m (220 ft), 3 m (10 ft) cores will be taken at approximately 6 m (20 ft) intervals or every casing break. These cores will be from a mix of sand-dominated and gravel-dominated Hanford formation lithologies. From approximately 67 m to 79 m (220 ft to 260 ft), continuous coring will be done to sample the early "Palouse" and Plio-Pleistocene interval and underlying upper Ringold Formation deposits. From approximately 79 m to total depth of approximately 111 m (260 ft to 365 ft), coring will again be done at 6 m (20 ft) intervals. The water table is expected to be encountered at a depth of approximately 103 m (338 ft).

5.3.7.2 Well Number 2. From the surface to 30 m (100 ft), 3 m (10 ft) cores will be taken at approximately 6 m (20 ft) intervals or every casing break. These cores will be from sand- and silt-dominated Hanford formation deposits. Lesser gravel-dominated intervals may also be encountered. At approximately 30 m to 43 m (100 ft to 140 ft), continuous coring will be done to sample the early "Palouse" and Plio-Pleistocene interval and underlying upper Ringold unit deposits. From approximately 43 m to total depth at approximately 61 m (140 ft to 200 ft), coring will again be done at 6 m (20 ft) intervals. The water table is expected to be at a depth of approximately 54 m (177 ft).

5.3.7.3 Well Number 3. From the surface to 21 m (70 ft), 3 m (10 ft) cores will be taken at approximately 6 m (20 ft) intervals or every casing break. These cores will be from sand- and silt-dominated Hanford formation deposits. At approximately 21 m to 37 m (70 ft to 120 ft) continuous coring will be done to sample the early "Palouse" and Plio-Pleistocene interval and underlying upper Ringold unit deposits. From 37 m to total depth at approximately 56 m (120 ft to 183 ft), coring will again be done at approximately 6 m (20 ft) intervals. The water table is expected to be at a depth of approximately 49 m (162 ft).

5.3.7.4 Well Number 4. The entire length of this borehole will be cored. This boring should encounter the Hanford formation (0 m to 28 m [0 to 93 ft]), early "Palouse" and Plio-Pleistocene interval (28 m to 33 m [93 to 108 ft]), upper Ringold unit (33 m to 47 m [108 to 153 ft]), Ringold gravel E (47 m to 132 m [153 to 433 ft]), Ringold lower mud unit (132 m to 167 m [433 to 549 ft]), Ringold gravel A (167 m to 201 m [549 to 660 ft]), Elephant Mountain Member (201 m to 229 m [660 to 750 ft]), Rattlesnake Ridge interbed (229 m to 259 m [750 to 850 ft]), and top of Pomona Member (259 m [850 ft]). Unconfined water level will be at approximately 50 m (164 ft). The Rattlesnake Ridge potentiometric surface will be at a depth of approximately 52 m (172 ft).

5.3.7.5 Well Number 5. From the surface to 43 m (140 ft), 3 m (10 ft) cores will be taken at approximately 6 m (20 ft) intervals or at casing breaks. These cores will be from gravel- to sand-dominated Hanford formation deposits. At approximately 43 m to 61 m (140 ft to 200 ft) continuous coring will be done to determine if the early Palouse/Plio-Pleistocene interval and the underlying upper Ringold unit are present. NOTE: Based on the limited data available in the area of this borehole, it is not clear if this sequence is present. If it is determined that these strata are absent before the end of this proposed core interval is reached, coring for this interval can be discontinued. From 43 m to 114 m (140 ft to 375 ft), coring will again be done at 6 m (20 ft) intervals. From 114 m to total depth at approximately 146 m (375 ft to 480 ft), no coring will be done. This drilling is to establish the top of the Ringold lower mud unit and little or no coring is anticipated. The water table is expected by be at a depth of approximately 100 m (329 ft).

5.3.8 Sample Handling

Samples and core will be transferred to a temporary handling/evaluation area at the job site where they will be geologically logged. Requirements for the type of analysis, the laboratory handling the analysis, or regulatory requirements may necessitate special handling requirements. These requirements will be specified on an as-need basisand documented in a letter to file from the Cognizant Engineer and Project Scientist.

5.3.9 Borehole Geophysics

The wells will be geophysically logged per EII 11.1 (WHC-CM-7-7). Two types of spectral gamma-ray logging systems, sodium-iodide and intrinsic germanium will be used in order to determine concentrations of naturally occurring potassium, uranium, and thorium. Only proven techniques with procedures adequate to control the quality of the data will be used.

Optimal conditions for logging require that no more than one thickness of casing be present. This will require logging to be done in stages before each additional casing is telescoped into place. The starter casing is exempt from this requirement unless the well-site geologist requests that it be logged.

The purpose of geophysical logging is to provide data comparison with cored derived data for stratigraphic interpretation and for the determination of naturally occurring potassium, uranium, and thorium.

5.3.10 Well Completion

The intent is to utilize all five of the boreholes as monitoring wells. Upon completion of drilling activities, if part of a borehole is to be abandoned, it will be done in accordance with EII 6.7, *Documentation of Well Drilling and Completion Operations*. All carbon steel casing will be removed and the hole will be grouted or otherwise sealed to the required depth in accordance with WAC 173-160 (Ecology 1989b).

5.4 TASK 4: CORE STORAGE

5.4.1 Purpose

The purpose of core storage is to have intact sediment samples available for description and interpretation of geologic conditions encountered during drilling and for the analysis of Hanford Site geologic and hydrogeologic background conditions. In addition, archived core will be used for verification of testing or analytical results, and for contingency tests or analyses.

5.4.2 Selection of Core

The cored intervals to be taken during drilling are detailed in Section 5.3.7. The sampling described in this characterization plan is designed to allow the acquisition of a large number of representative intact sediment cores. This scheme will result in 20 individual 3 m (10 ft) cores from borehole 1, 12 from borehole 2, 12 from borehole 3, and 21 from borehole 5. This is a total of 65 cores from these boreholes. The continuous coring from borehole 4 is not counted in this total but will result in a total of approximately 259 m (850 ft) of core.

5.4.3 Procedure

Once the cores are examined by the field geologist, they will be stored in 3 m (10 ft) core boxes. The core will then be transferred with a completed chain of custody form to the WHC Hanford Geotechnical Sample Library for storage.

5.5 TASK 5: GROUNDWATER INVESTIGATION

5.5.1 Purpose

The purpose of this task is to investigate groundwater characteristics and quality at each site. This will be accomplished by installing groundwater monitoring wells and analyzing groundwater samples from each site.

5.5.2 Well Locations

The well locations are outlined in Sections 1.4 and 5.2.3. Wells 1, 2, 3, and 5 will be constructed as monitoring wells for the shallow unconfined aquifer. Well number 4 will be constructed as a monitoring well for the Rattlesnake Ridge interbed, the uppermost sedimentary interbed within the CRBG in the western Pasco Basin.

5.5.3 Drilling and Well Installation

Each of the five wells will be drilled using air rotary techniques.

5.5.3.1 Well Construction. Well construction will be in accordance with specifications outlined in the latest revision of WHC-S-014, *Generic Well Specification for Groundwater Monitoring Wells*. These specifications provide requirements for construction of groundwater monitoring wells within the Hanford Site, including:

- Specifications for site preparation
- Drilling boreholes
- Collecting sediment samples
- Installation and removal of temporary well casing
- Disposition of purgewater
- Completion of final monitoring structure
- Development of monitoring intervals
- Installation of sampling pump
- Surveying the completed well for location and elevation.

Guidance for designing wells was obtained from WAC 173-160 (Ecology 1989b). Quality assurance requirements of the Tri-Party Agreement and WHC-SD-EN-QAPP-001 also apply.

5.5.3.2 Well Development. All wells will be developed after completion. Wells will be developed by the surge-and-bail technique, over pumping, or any other techniques deemed necessary until turbidity is less than 5 nephelometric turbidity units (NTU) and sediment content is less than 8 mg/L. If the water cannot be developed to a turbidity of less than 5 NTU, an explanation will be documented by a qualified hydrogeologist. Other hydrochemical indicators, such as total iron and drilling fluid tracers, may be monitored to assess the adequacy of development pumping for trace constituent sampling.

5.5.3.3 Surveying. After monitoring well installation is completed, the wells will be surveyed for location and elevation by qualified surveyors in accordance with WHC-S-014. The elevation of the top of the stainless steel protective casing and a brass marker in the concrete well head pad will be determined within 0.001 m (0.01 ft) using NGVD 1929 vertical datum. A mark will be placed on the casing to indicate the location that was surveyed. The areal location of the centerline of the well will be determined to the nearest 0.01 m (0.1 ft). All measurements will be referenced to a common datum and reported as Washington State Plane Coordinates (southzone) of the NAD 83 in meters. The survey results will be reviewed by a licensed surveyor.

5.5.4 Groundwater Sampling and Analysis

Sampling and analysis will involve collection of both routine and special samples in order to accommodate data quality objectives for all potential users. Routine sampling will involve use of the same procedures used in the RCRA groundwater monitoring program. This will maintain comparability of hydrochemical results from the new wells with results from the ongoing RCRA sampling and analysis program. Special samples will also be collected to meet data quality objectives of other programs (e.g., the Background Study). The latter will include stable isotopes of hydrogen, oxygen and carbon; carbon-14, oxidation-reduction potential, dissolved oxygen, low level tritium, field alkalinity/pH and natural radionuclides. Sampling plans for the special category will be prepared by the end user and data collection controlled under a separate sampling and analysis plan. The following description is for only the routine sampling as described above.

5.5.4.1 Sample Pumps. HydroStar* sampling pumps will be installed in the new wells as soon as possible after construction and well development are complete. The stainless steel and teflon components of this sample pump system will meet most of the sampling objectives of all potential users. At the present time, this is the standard configuration used in all contemporary monitoring well installations at the Hanford Site. However, some consideration is being given to substitution of other stainless steel sample pumps.

5.5.4.2 Sampling. The depth to water will be measured before the wells are purged. The wells will be purged and samples will be collected after at least three borehole volumes have been removed, when specific conductance and pH have stabilized, or (in the case of wells completed in very low permeability materials) after the well has recharged.

5.5.4.3 Analysis. Samples will be collected from all groundwater monitoring wells in conformance with 40 CFR 265.92 for analyses of the constituents listed in Table 4. Additional constituents may be added to this list after evaluation of the results. Analytical procedures and other analytes to be included are as indicated in Attachment 1.

Sampling, preservation, and chain-of-custody procedures are discussed in Attachment 1. The QA and quality control protocols, which are in addition to 40 CFR 265.92 requirements, are given in Attachment 2. The purpose of quality control activities is to determine and document the quality of analytical results and to institute corrective actions as necessary.

5.5.4.4 Sampling Schedule. The new wells will be sampled quarterly for at least the first year. Additional sampling will be considered after evaluation of the first full year of quarterly data. The data will be examined for evidence of autocorrelation effects for naturally occurring constituents and for evidence of variability introduced due to sampling and handling effects for the other constituents. Since these wells will be located upgradient of any Hanford Site operations, quarterly sample results will serve as a true "field equipment blank" for most of the RCRA constituents (i.e., usually distilled water passed through the same sample delivery tubing and related equipment is used to simulate the possible contributions to analytical results).

5.5.4.5 Data Analysis. Well-to-well difference tests will be conducted for the naturally occurring constituents to determine if spatial differences occur over the range of distances represented by the well locations (Table 6). Additionally, the results will be plotted together with the existing background data from both the sitewide data set and the Rattlesnake Ridge

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*Hydrostar is a tradename of Instrumentation Northwest, Inc.

Table 6. Groundwater Sampling Parameters[a], Maximum Level.

Interim primary drinking water standards	Maximum level[b]
Arsenic	0.05
Barium	1.0
Cadmium	.0.01
Chromium	0.04
Fluoride	1.4 to 2.4
Lead	0.05
Mercury	0.002
Nitrate (as NO_3)	45
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5-TP Silvex	0.01
Radium	5 pCi/L
Gross Alpha	15 pCi/L
Gross Beta	4 mrem/year
Turbidity (surface water only)	1 NTU
Coliform bacteria	1/100 Ml
Groundwater quality parameters	
Chloride	250
Iron	0.3
Manganese	0.05
Phenols	
Sodium	
Sulfate	250
Groundwater contamination indicator parameters	
pH	6.5-8.5
Specific conductance	700 (uS/cm)
Total organic carbon	
Total organic halogen	

[a]Regulatory requirements for sampling parameters are subject to change because of federal regulations.
[b]Unless otherwise noted, concentrations are in mg/L.

corridor set to determine if there are major spatial, well construction, and/or analytical effects. The Kolmogorov-Smirnov plots and standard difference testing will be used for this purpose as described in Chou (1993). Collectively, the four quarters of data can be compared with individual or multiple well results at other downgradient locations in the inferred flow field.

5.5.5 Evaluation of Recharge to the Suprabasalt Unconfined Aquifer

The purpose of this task is to investigate and refine the calculation of recharge from Cold Creek valley to the unconfined aquifer at the Hanford Site and to calculate the velocity field within this part of the aquifer. Subsurface recharge data gained here will complement surface water recharge studies conducted by the USGS under an Interagency Agreement with the DOE.

A Darcian approach will be used in the estimation of the groundwater flow from the Cold Creek valley into the Hanford Site unconfined aquifer. This approach requires information on the saturated thickness of the aquifer, the hydraulic gradient in the aquifer, and estimates of the hydraulic conductivity. Interpretation of existing data and that obtained from the new wells will be used to provided an initial interpretation of aquifer conditions and characteristics.

A second phase may be deemed appropriate at a later date to evaluate indirect recharge into the unconfined aquifer at the Hanford Site via the confined aquifer system. Any effort in this direction would be based on the results of this first investigation along with results obtained in the application of the sitewide groundwater flow model (which is being conducted separately from this task as part of DOE/RL 1991a). Two possible mechanisms for this indirect recharge could be through the Cold Creek valley fault or leakage through the confining basalt flows of the Saddle Mount Basalt Formation (see Figure 8).

As indicated in Section 1.0, knowledge of the recharge to the unconfined aquifer at the Hanford Site is basic to environmental restoration activities involving the Hanford Site groundwater system. Previously, qualitative statements have been made in the environmental impact statements prepared for Hanford Site operations stating that the recharge to the Hanford Site groundwater system is from the valleys in the northwestern Pasco Basin. Analysis of data from the proposed new wells will contribute significantly to improving our understanding of the influence of these recharge zones on present and future groundwater flow dynamics in the vicinity of Hanford Site waste storage and disposal sites.

6.0 HEALTH AND SAFETY

Kaiser Engineers Hanford will prepare a Job Safety Analysis to establish safety requirements associated with each location. An ALARA plan also will contribute to achieving a safe work environment.

7.0 QUALITY ASSURANCE

A QAPP will be prepared to address the following:

- Project organization and responsibility
- Objectives for measurement
- Sampling procedures
- Sample custody
- Calibration procedures
- Analytical procedures
- Data reduction, validation, and reporting
- Internal quality control
- Performance and system audits
- Preventative maintenance
- Data assessment procedures
- Corrective action
- QA reports.

8.0 RECORD CONTROL

The record requirements for the project will be in accordance with EII 6.1, *Activity Reports for Field Operations* and EII 6.7, *Groundwater Well and Borehole Drilling* (WHC-CM-7-7). The required records are:

- Geologic logs (when applicable)
- Health Physics Technician site radiological readings (if determined to be necessary)
- Field logbooks
- Remediation and Abandonment Field Activity Report
- Field Activity Report
- *Chain of Custody*, EII 5.1
- *Decontamination of Drilling Equipment*, EII 5.4
- *Geophysical Logging*, EII 11.1.

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Figure 1. Topographic Base Map of the Western Hanford Site and the Locations of the Five Proposed Boreholes. (See Figure 3 for general geographic setting of the Hanford Site.)

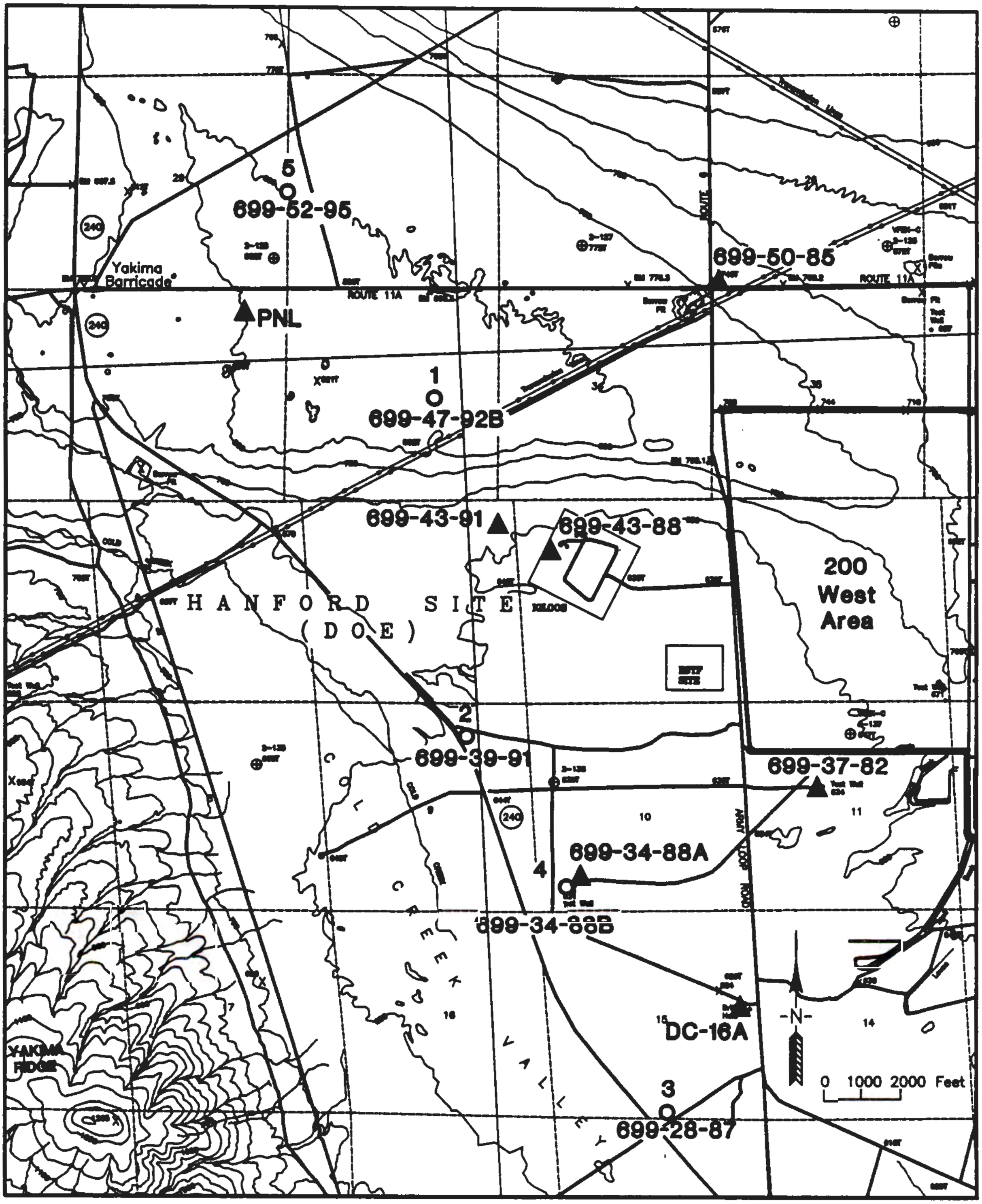

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Figure 2. Water Table Map of the Hanford Site Showing Inferred Flow Directions in the Uppermost "Unconfined" Aquifer (modified from Kasza et al. 1992).

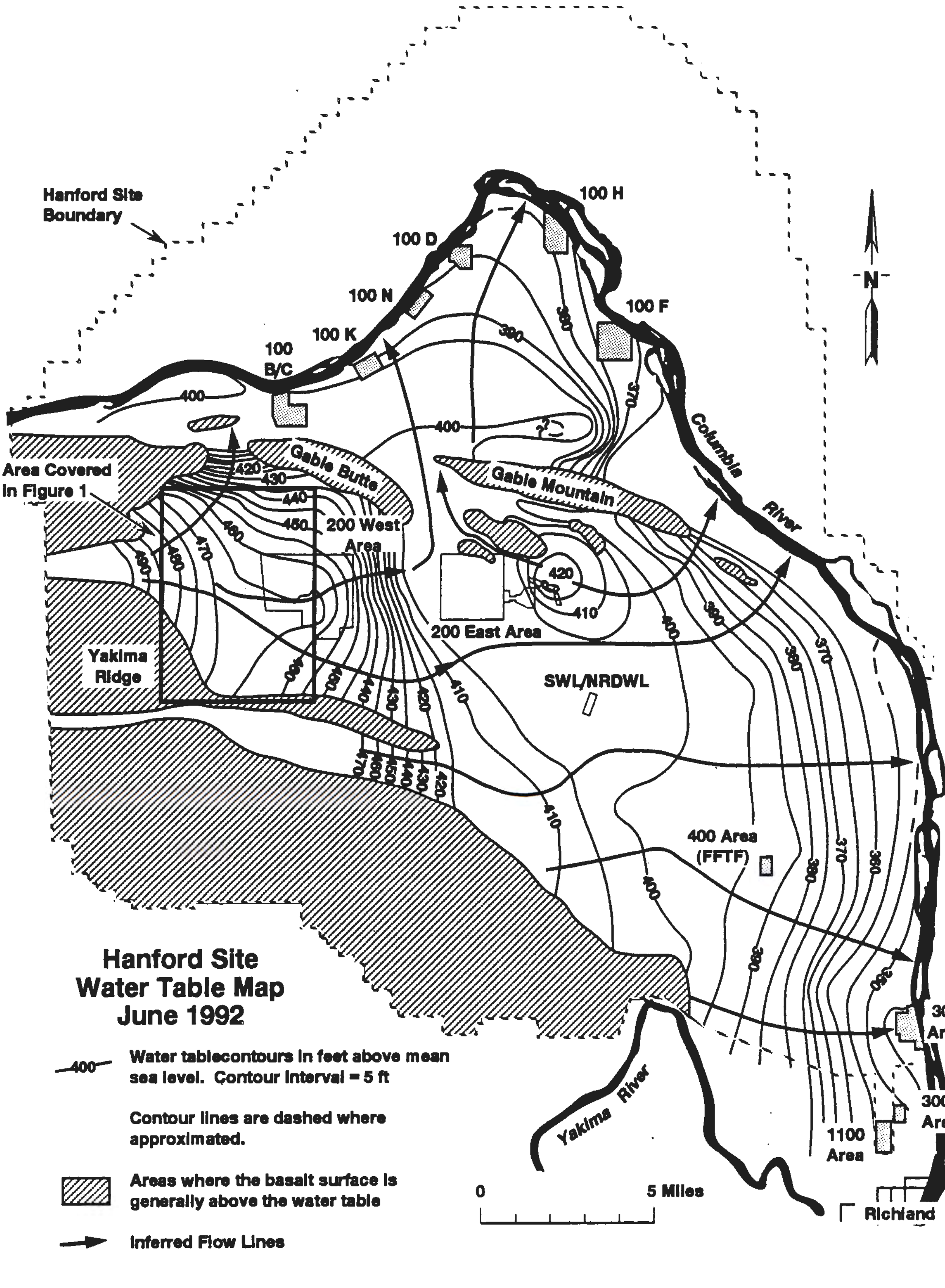
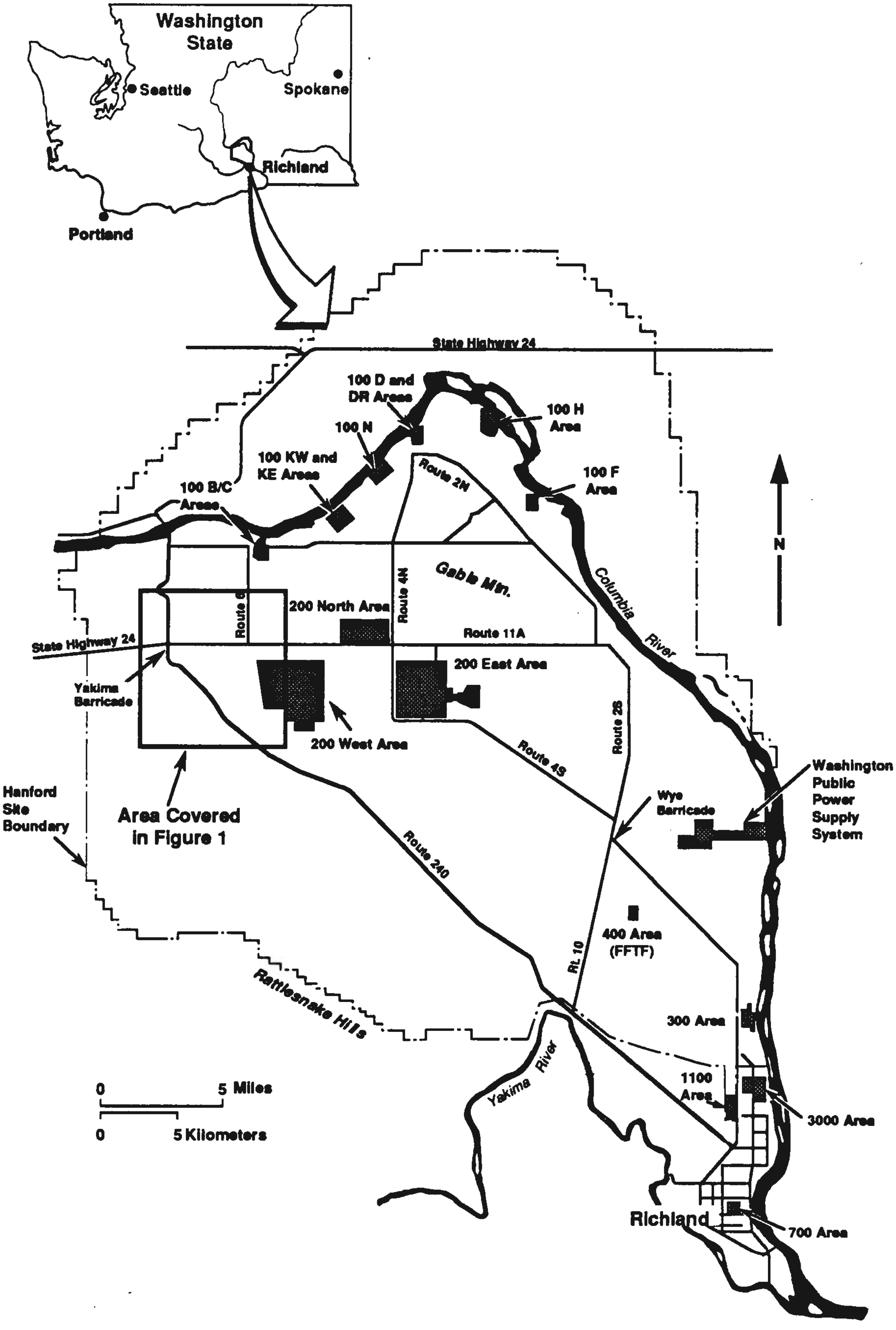


Figure 3. Geographic Setting of the Hanford Site.



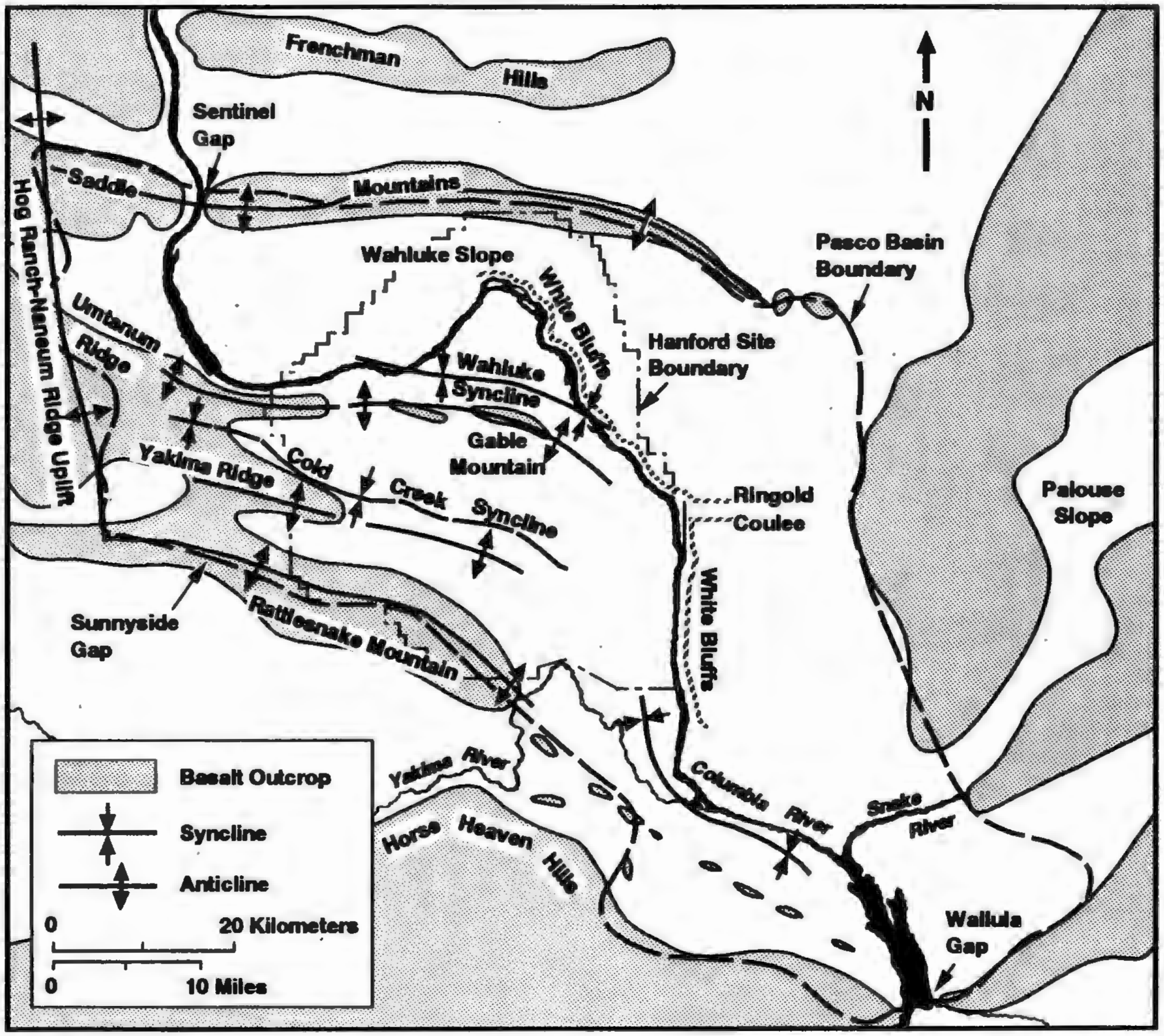
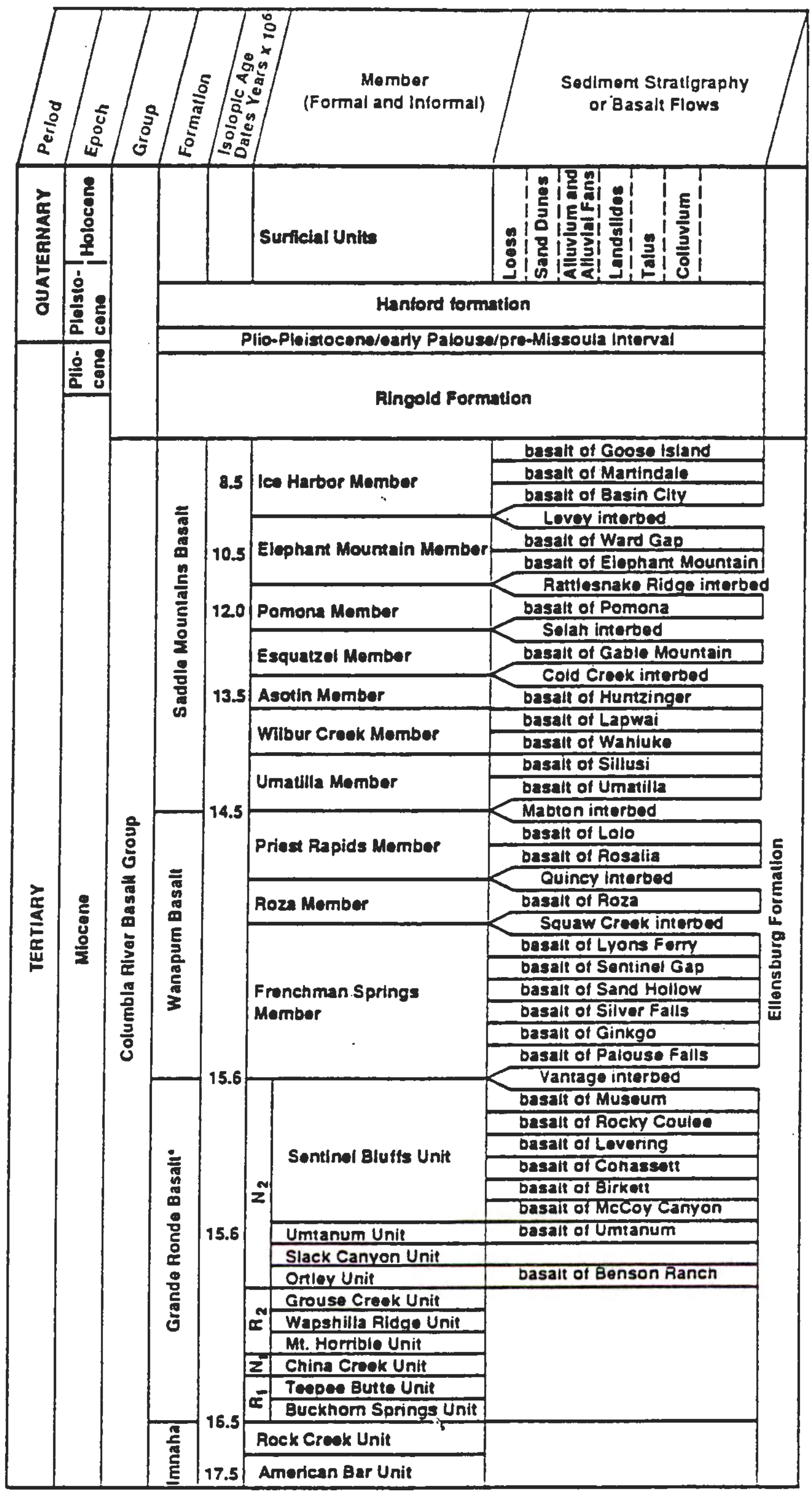


Figure 4. Structural Geologic Setting of the Pasco Basin and Hanford Site.

Figure 5. Stratigraphic Setting of the Hanford Site.



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

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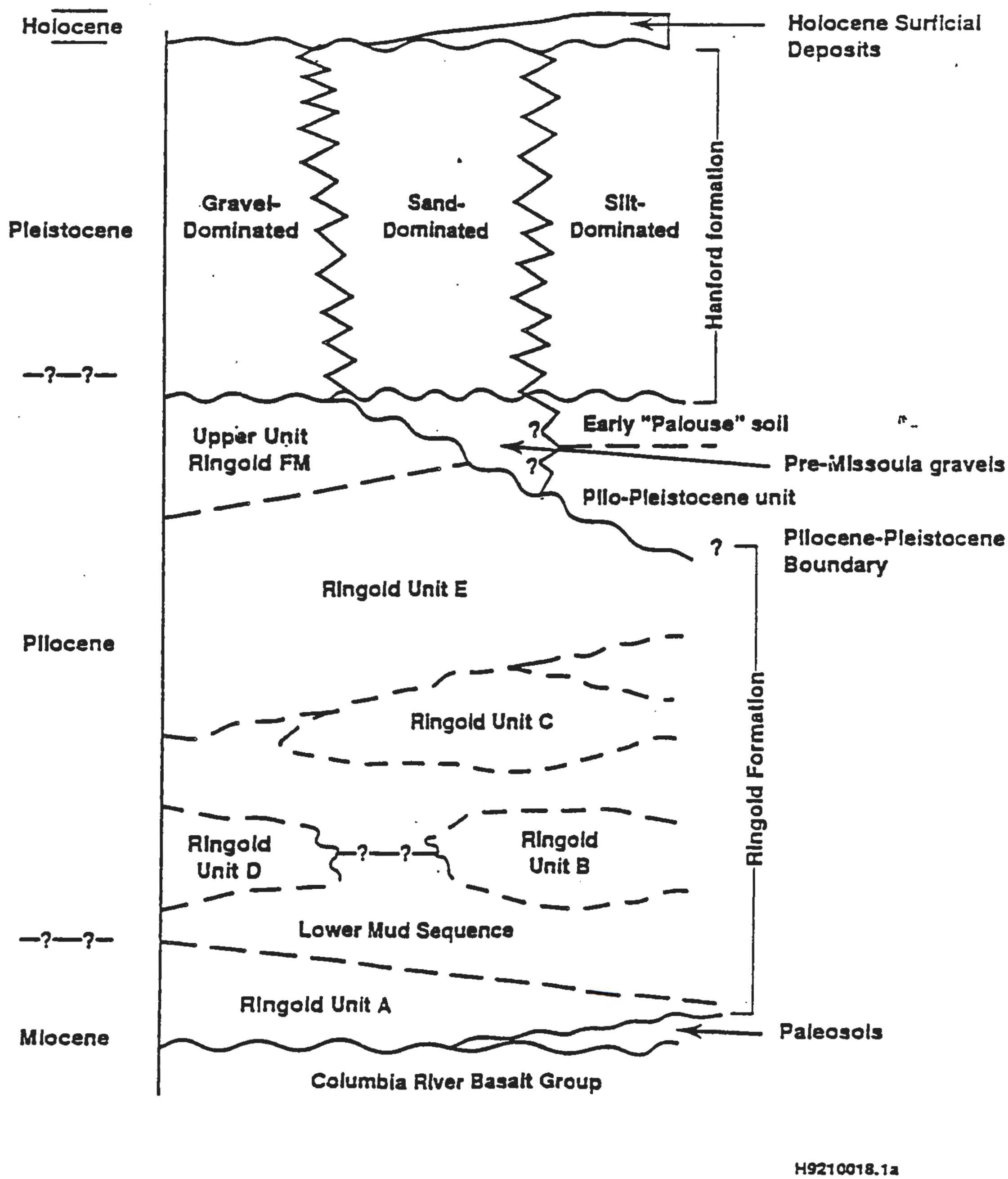
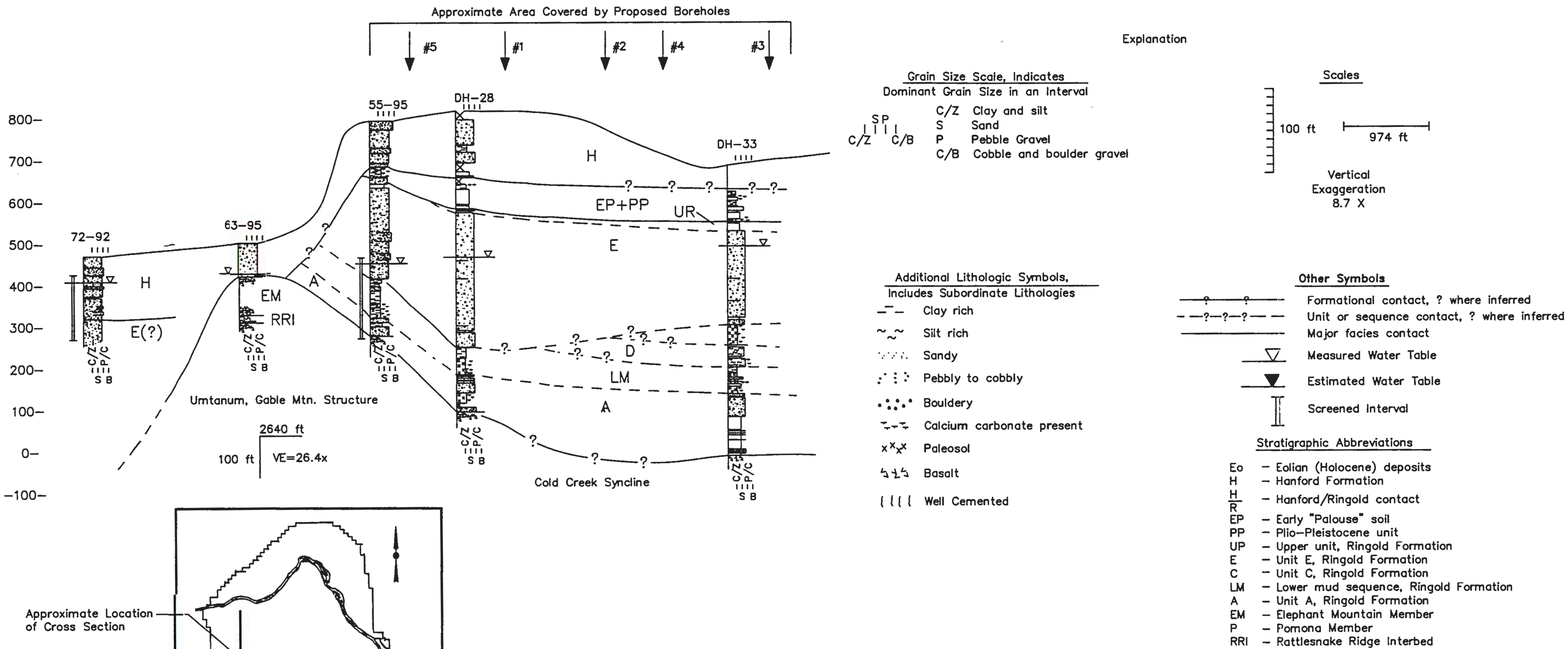
Figure 6. Generalized Stratigraphy of the Suprabasalt Sediments at the Hanford Site.





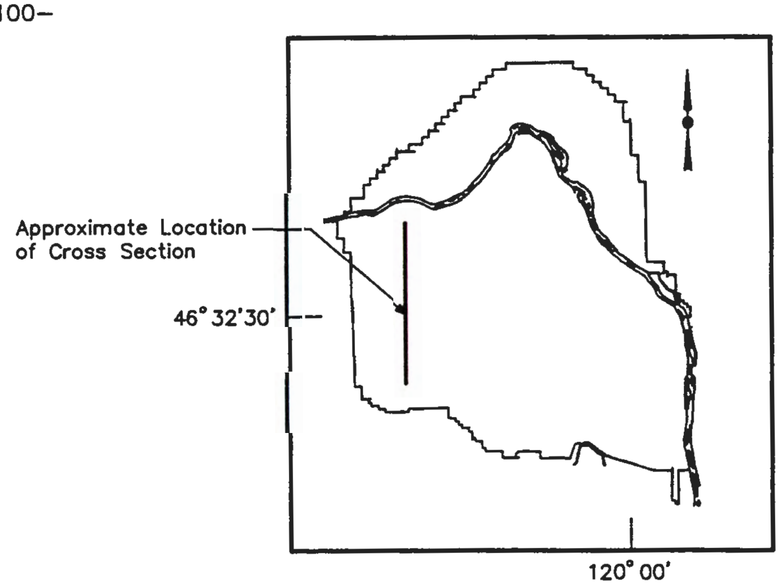


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Figure 7A. North-South Geologic Cross-Section Showing the Stratigraphic Relationships within the Suprabasalt Sediments in the Western Cold Creek Syncline. The General Area of the Five Proposed Boreholes is Situated between Boreholes 55-95 and DH-33.

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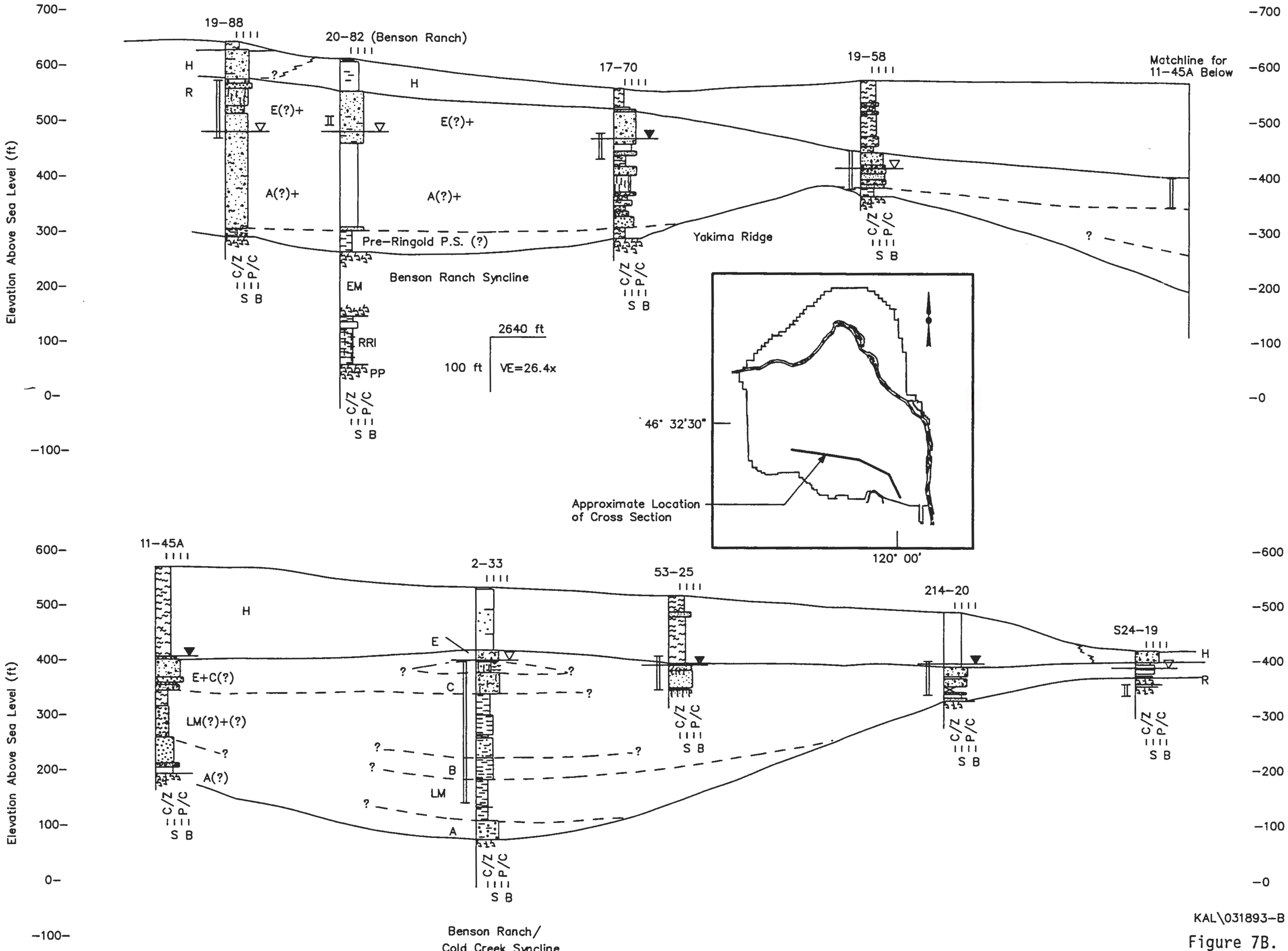

Figure 7B. East-West Geologic Cross-Section Showing the Stratigraphic Relationships within the Suprabasalt Sediments in the Cold Creek Syncline.

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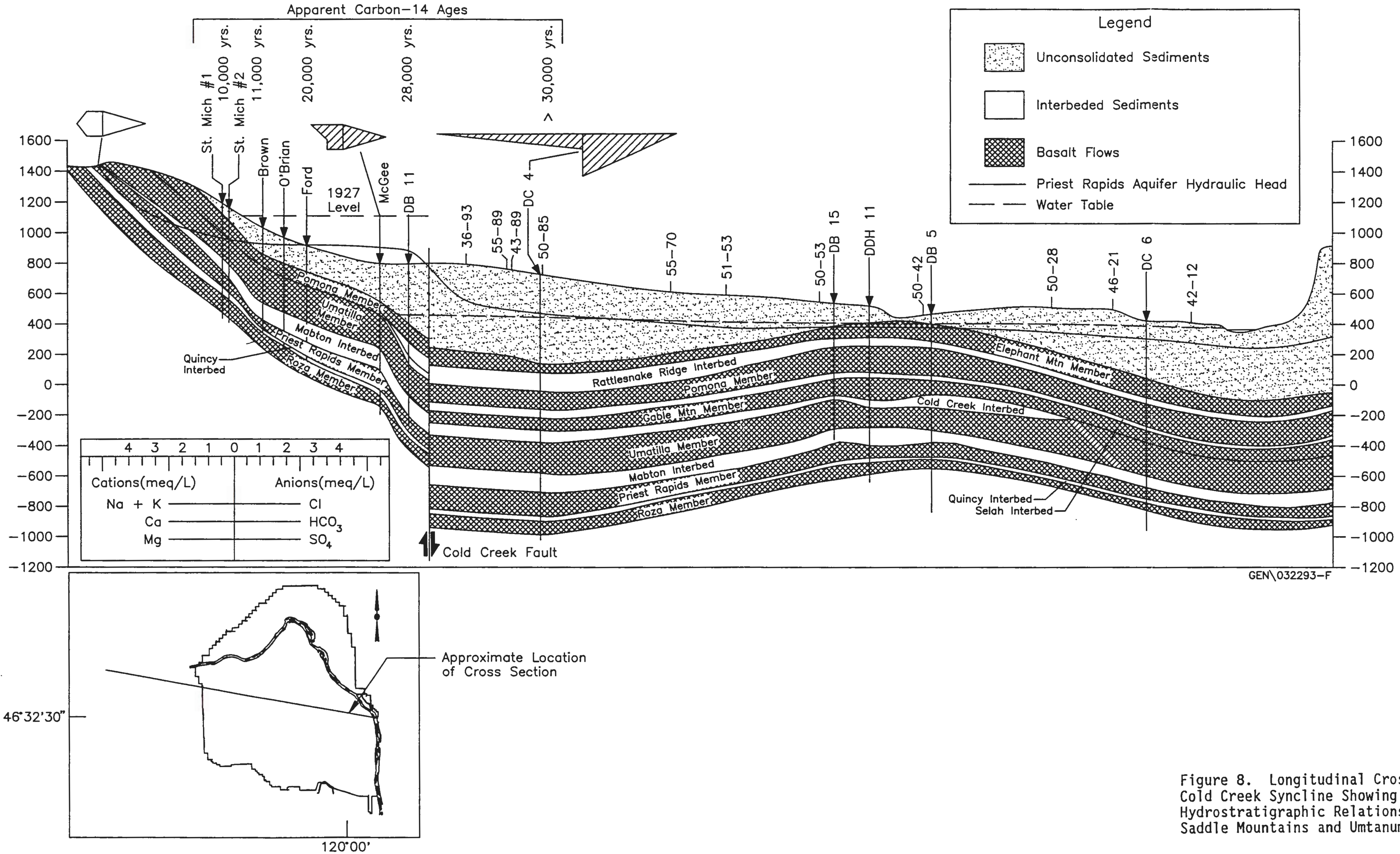

Figure 8. Longitudinal Cross-Section of the Cold Creek Syncline Showing Structural and Hydrostratigraphic Relationships within the Saddle Mountains and Umtanum Basalts.

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Figure 9. Inferred Geology and Planned Coring Intervals for the Five Proposed Wells.

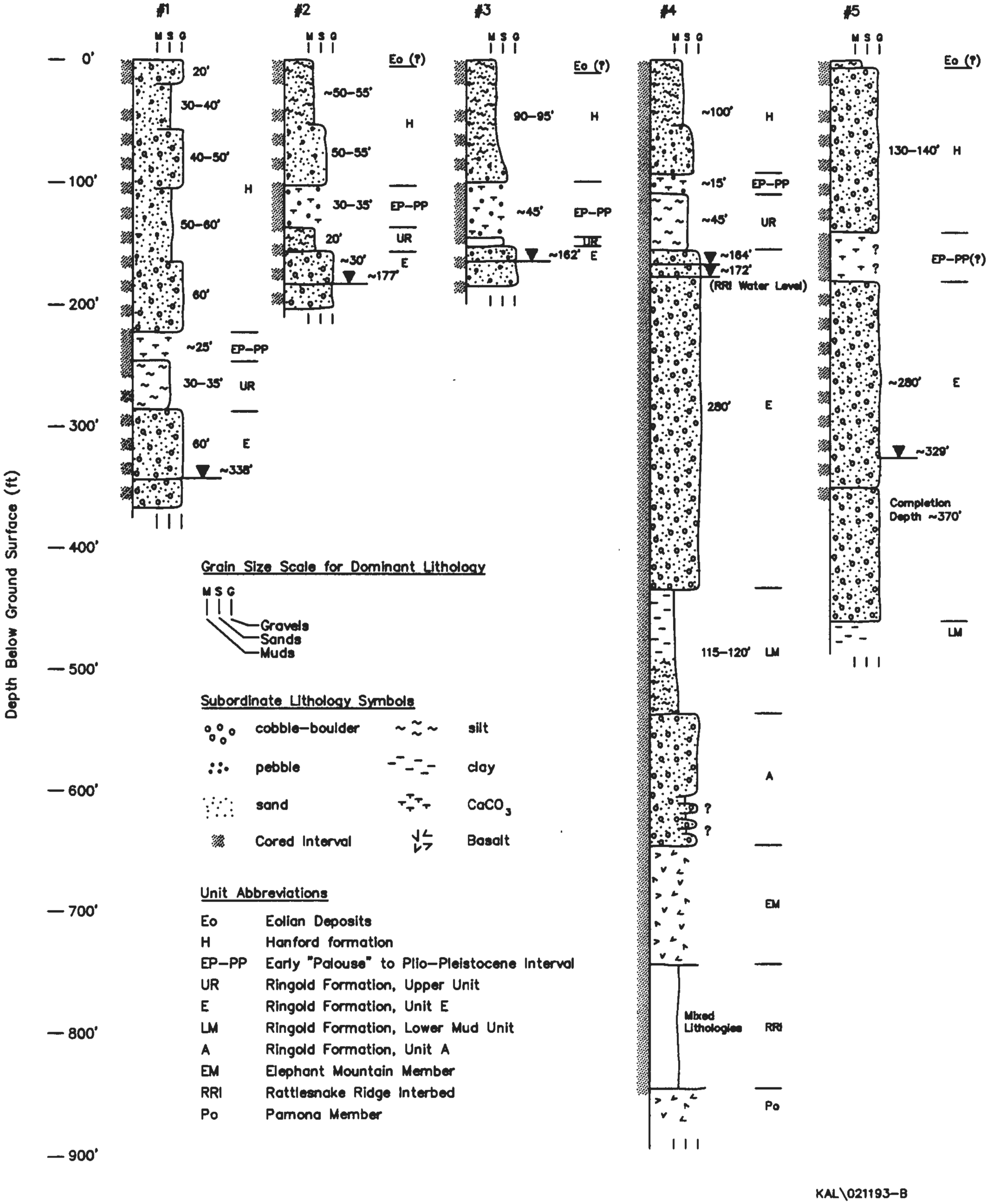

Figure 10. Potentiometric Map for the Rattlesnake Ridge Interbed (from Jackson 1992).

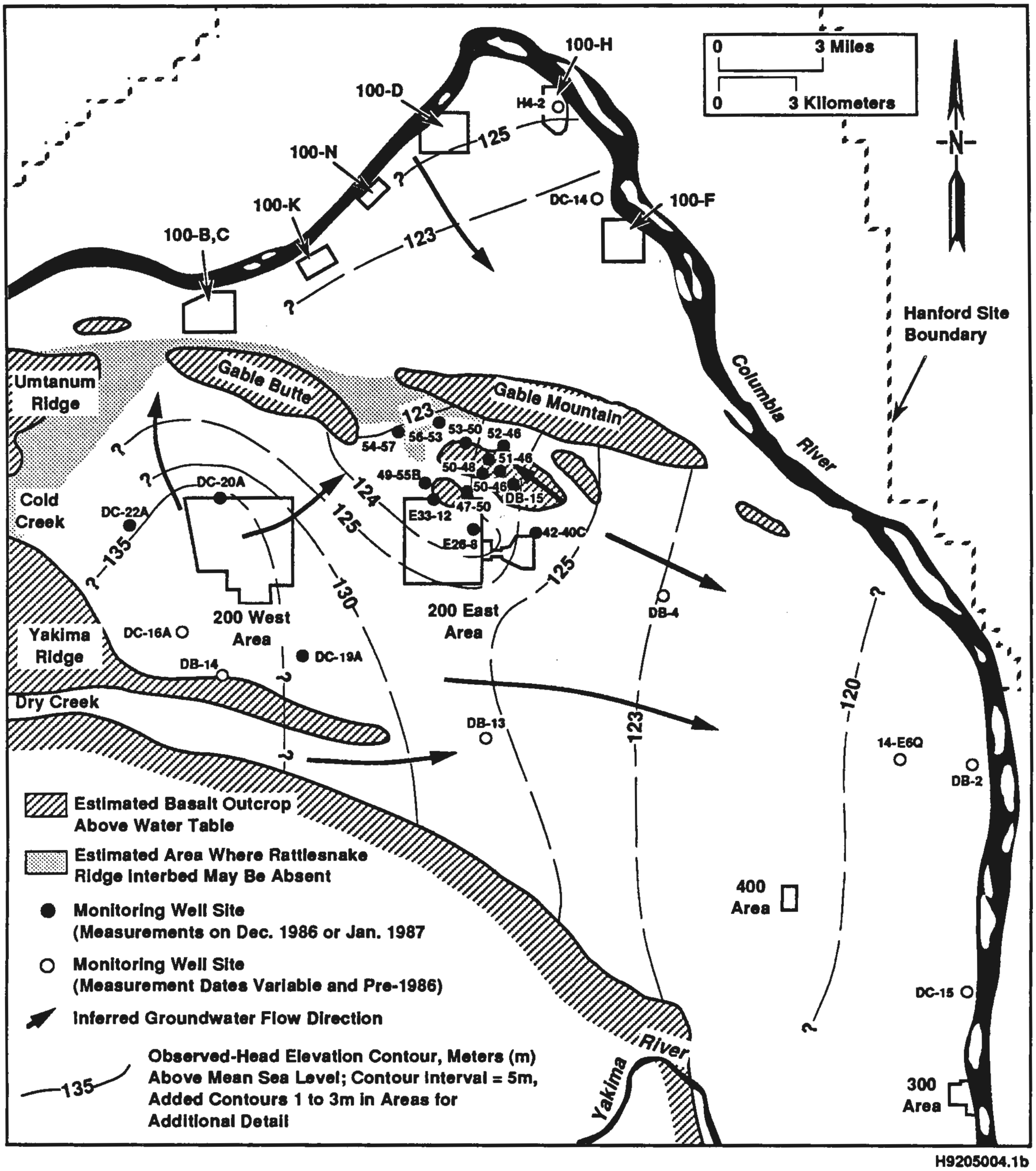

Figure 11. Chemical Composition and Apparent Carbon-14 Ages of Selected Aquifers in the Western and Southern Hanford Site.

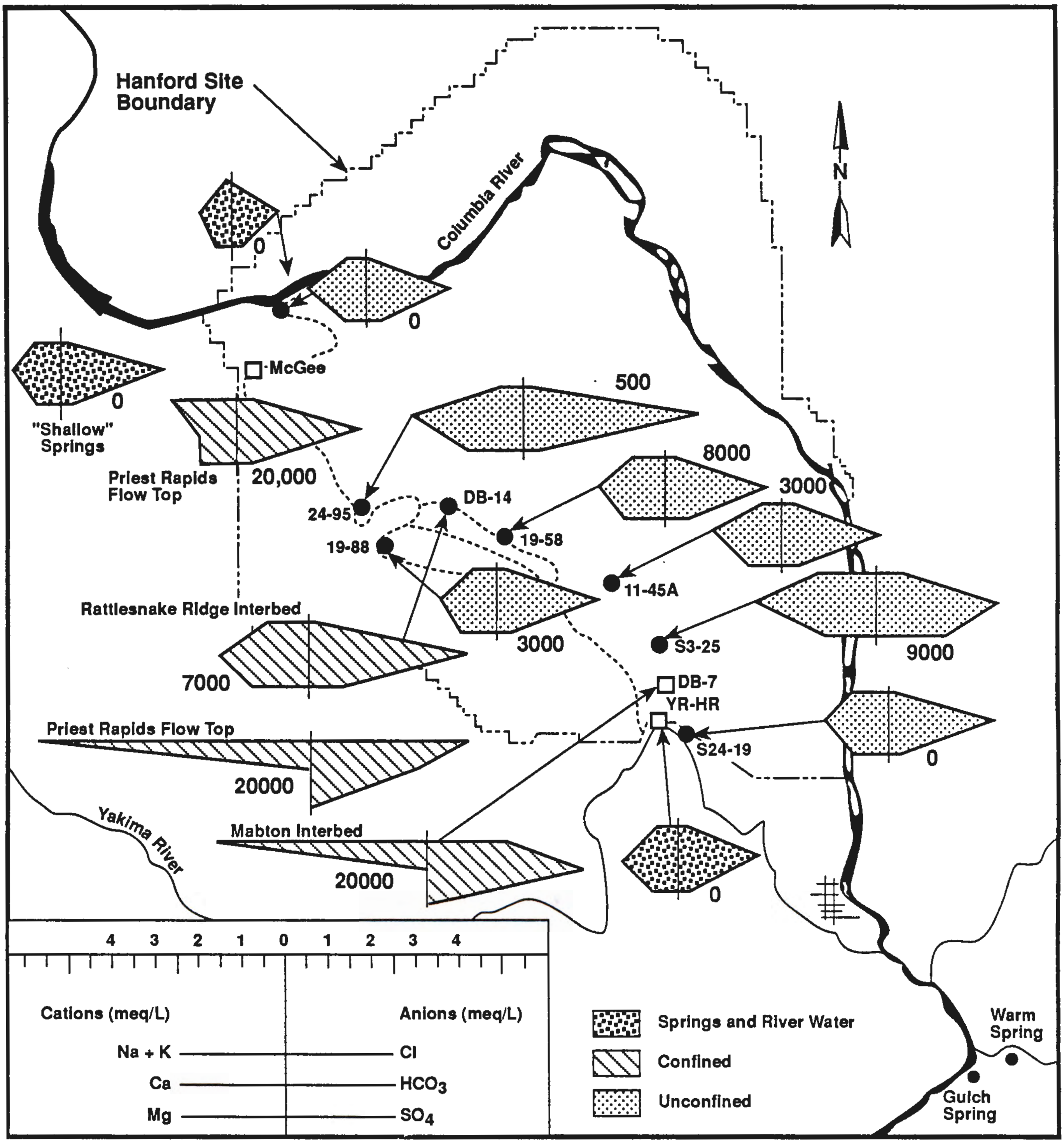

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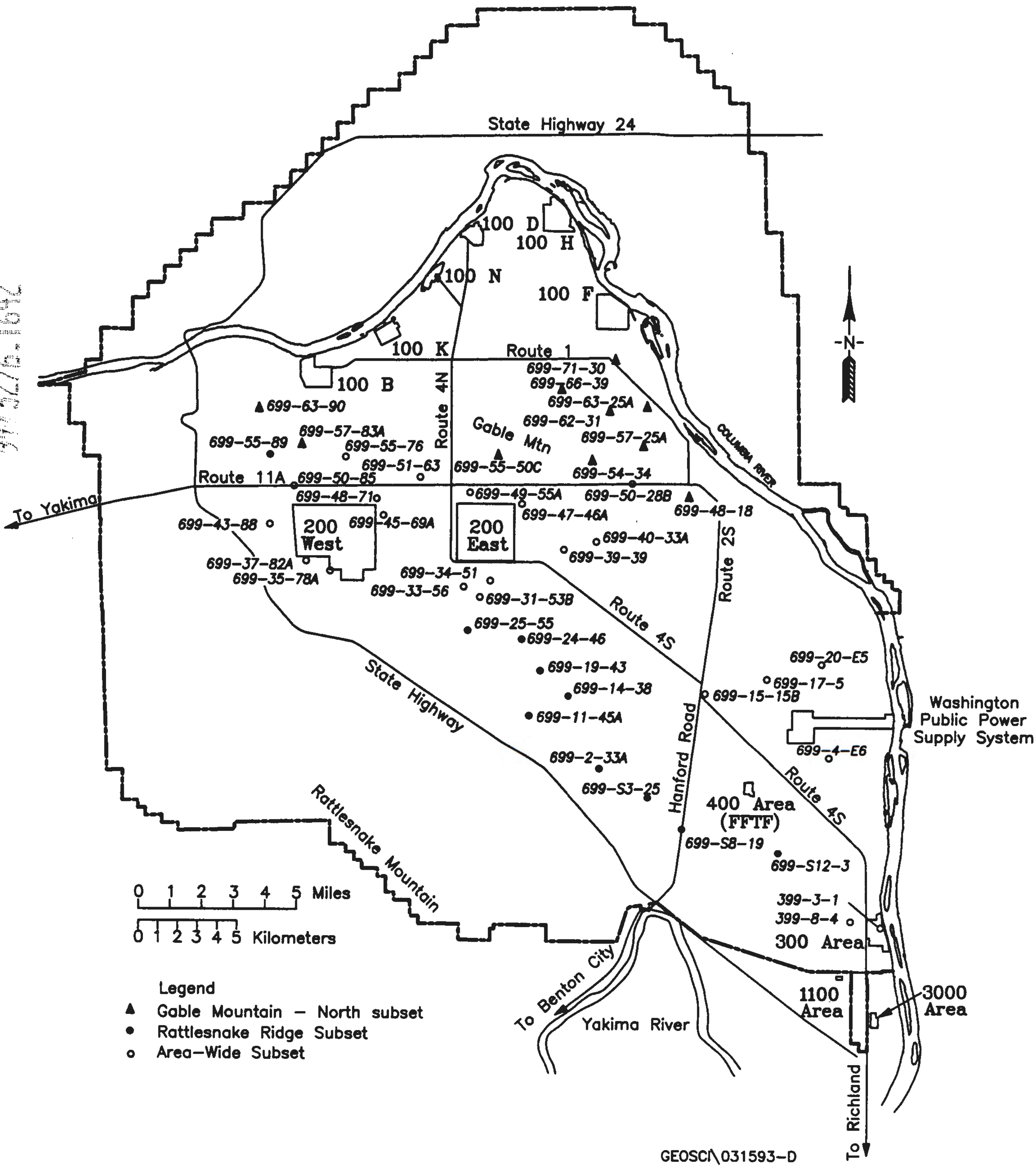
Figure 12. Monitoring Well Locations Outside of Known Contaminant Plume Areas Used for Background Application Test, USGS Data, 1979 to 1984.



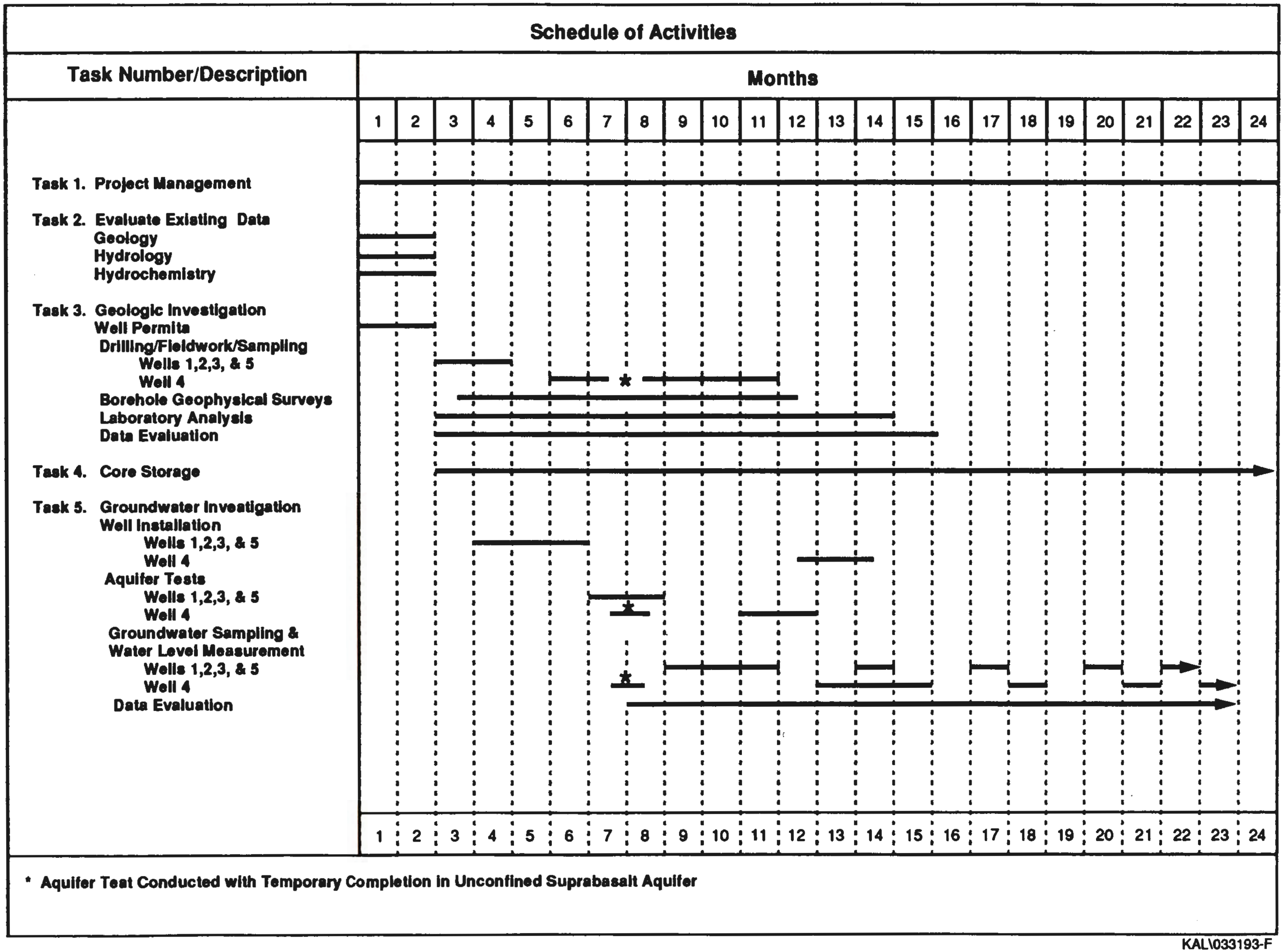
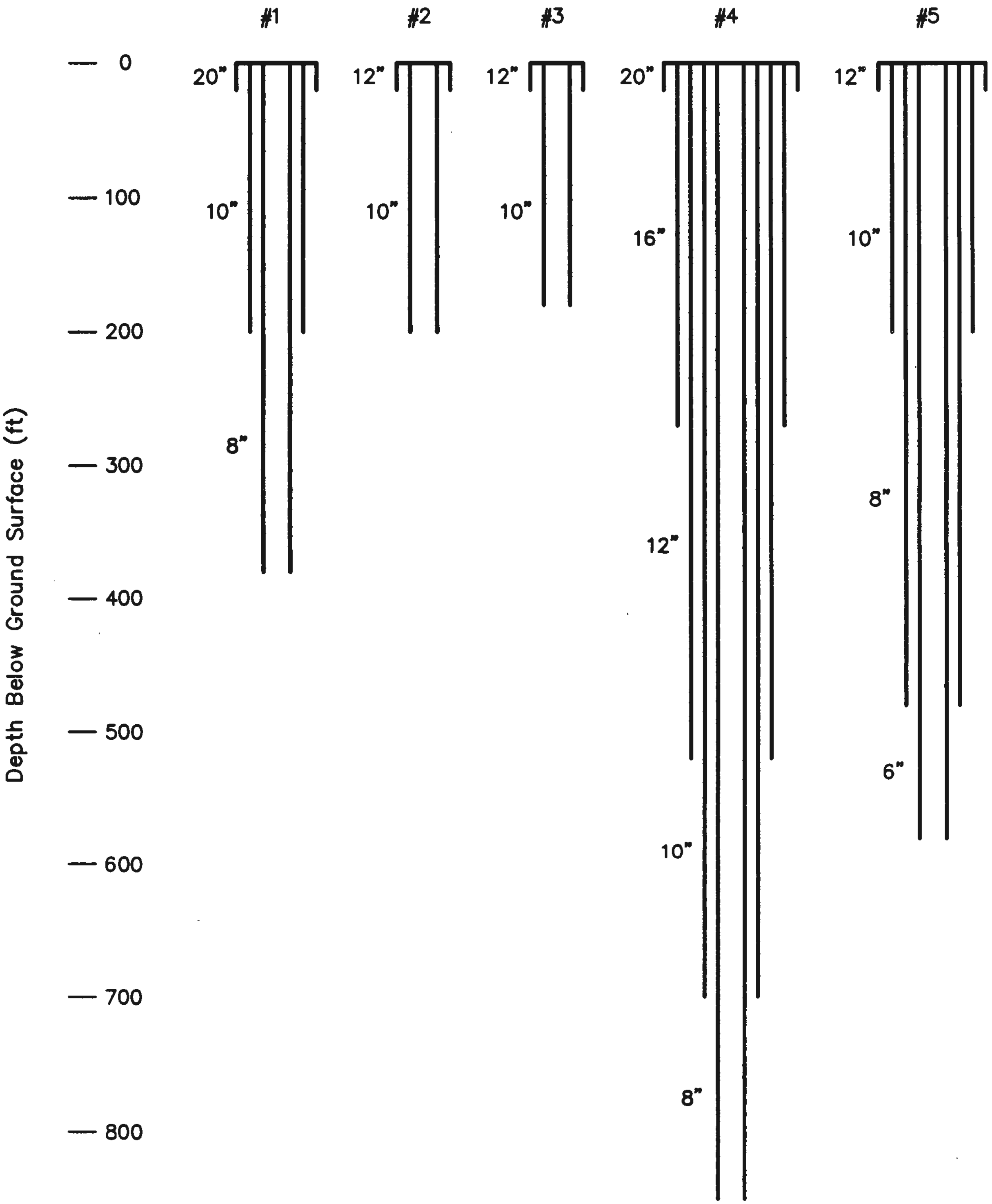


Figure 13. Generalized Schedule for Implementation of Characterization Tasks Discussed in this Work Plan.

Figure 14. Projected Casing As-Builts for the Five Proposed Wells.



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ATTACHMENT 1

SAMPLING AND ANALYSIS PLAN

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CONTENTS

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1.0 INTRODUCTION

This attachment introduces procedures for sample collection, chain of custody, sample preservation, shipment, chemical analysis, quality assurance and quality control.

2.0 SAMPLE COLLECTION PROCEDURES

Procedures from WHC-CM-7-7 for sample collection and field measurements are listed as follows:

- EII 5.1, *Chain of Custody*
- EII 5.2, *Soil and Sediment Sampling*
- EII 5.8, *Groundwater Sampling*
- EII 9.1, *Geologic Logging*
- EII 10.1, *Aquifer Testing*
- EII 10.2, *Measurement of Groundwater Levels*
- EII 10.3, *Purgewater Management*
- EII 11.1, *Geophysical Logging*

Analytical methods and sample preservation techniques are listed in Tables 1 through 8.

Table 1. Metals by Inductively Coupled Plasma Spectrometry Using Method 6010 of EPA (1986).

Constituent	CRQL* (ppb)
Antimony	200
Barium	20
Beryllium	3
Cadmium	10
Calcium	100
Chromium	20
Cobalt	20
Copper	20
Iron	20
Magnesium	100
Manganese	10
Nickel	30
Potassium	300
Silver	20
Sodium	300
Tin	100
Vanadium	30
Zinc	10

*Contract required quantitation limit.

Table 2. Metals by Atomic Absorption.

Constituent	CRQL (ppb)	Method
Arsenic	5	7060 (SW-846)
Lead	5	7421 (SW-846)
Mercury	0.2	7470 (SW-846)
Selenium	10	7740 (SW-846)
Thallium	5	7841 (SW-846)

Table 3. Anions by Ion Chromatography Using Either Method 300.0 of EPA (1984), Mar. 1984 or ASTM Method D4327-84 (ASTM 1986).

Constituent	CRQL (ppb)
Chloride[a]	2000
Nitrate[a]	2000
Phosphate[a]	4000
Chloride[b]	200
Nitrate[b]	200
Phosphate[b]	400
Bromide[c]	500
Chloride[c]	200
Fluoride[c]	100
Phosphate[c]	400
Sulfate[c]	500

[a]Preserved sample, diluted ten fold; chloride may be analyzed from a preserved sample.
[b]Preserved sample, undiluted.
[c]Unpreserved, undiluted sample.

Table 4. Miscellaneous Parameters and Bacteriological Tests.

Constituent	CRQL	Method
Turbidity	0.1*	APHA #214A
Coliform (fermentation)	2.2**	9131 (SW-846)
Coliform (filter)	1***	9132 (SW-846)

*Nephelometric Turbidity Units.
**Most Probable Number.
***Minimum Colony Count.

Table 5. Volatile Organics to be Analyzed for by Method 8010/8020 of EPA (1986).

Constituent	CRQL(ppb)
Benzene	2
Carbon Tetrachloride	1
Chloroform	0.5
p-Dichlorobenzene	2
1,1-Dichloroethane	1
1,2-Dichloroethane	0.5
cis-1,2-Dichloroethylene	1
trans-1,2-Dichloroethylene	1
Ethylbenzene	2
Methylene Chloride	5
Tetrachloroethylene	0.5
Toluene	2
1,1,1-Trichloroethane	0.5
1,1,2-Trichloroethane	0.2
Trichloroethylene	1
Vinyl Chloride	2
Xylene (total)	5
1-Butanol	1000

Table 6. Phenols by Gas Chromatography Using Method 8040 of EPA (1986).

Constituent	CRQL (ppb)
Phenol	20

Table 7. Radiological Parameters.

Constituent	CRQL (Pci/L)	Method
Radium	1	SW-846, #9315*
Gross Alpha	4	SW-846, #9310
Gross Beta	8	SW-846, #9310
Tritium	500	ASTM D2476-81

*The method also references ASTM (1988) and Krieger and Whittaker (1980).

Table 8. Indicator Parameters.

Constituent	CRQL (ppb)	Method
Conductivity	N/A	ASTM D1125-A
pH	±0.05*	ASTM D1293
Total organic carbon (TOC)	1000	Method 9060 (SW-846)
Total organic halides (TOX)	10	Method 9020 (SW-846)

*pH units.

3.0 CHAIN-OF-CUSTODY PROCEDURES

Chain-of-custody procedures are contained in EII 5.1, *Chain of Custody*. The history of the custody of each sample will be documented according to this procedure.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

4.1 QUALITY ASSURANCE

Quality assurance (QA) is a system of *management* activities (e.g., written procedures) designed to assure that data are adequate to fulfill the objectives of the groundwater monitoring project. The QA will be conducted in accordance with the *Quality Assurance Project Plan for RCRA Groundwater Monitoring Activities* (WHC 1992), which is supported by the *Westinghouse Hanford Environmental Investigations and Site Characterization Manual* (WHC 1989).

4.2 QUALITY CONTROL

Quality control (QC) is a system of *technical* activities designed to demonstrate that data are adequate to fulfill the objectives of the groundwater monitoring project. For analysis of groundwater chemistry, QC methods monitor for errors that may be introduced during sample bottle preparation, sample collection, transport, or in the laboratory. The QC program has two main components: (1) routine internal checks performed by the laboratory and (2) external checks conducted by PNL to evaluate laboratory performance. The scope of these efforts is described in the following sections.

4.2.1 Internal Quality Control

Internal quality control at the analitical laboratory will include general practices applicable to a wide range of analyses, as well as specific procedures stipulated for particular analyses. The quality control and quality assurance programs will be documented in a quality control manual and a quality assurance manual. The laboratory will provide a quarterly quality control report.

Minimum requirements for laboratory QC checks are described below, and are described more fully in WHC (1990). The frequencies of QC checks are listed in Table 9.

- **Matrix and matrix spike duplicate.** A known quantity of a representative analyte of interest is added to a sample as a measure of recovery percentage. The spike and spike duplicate shall be created from replicates of a field sample (separate aliquots removed from the same sample container in the laboratory).

- **Quality control reference sample.** A sample is prepared from an independent standard at a concentration other than that used for calibration but within the calibration range. Reference samples provide an independent check on analytical technique and methodology.

4.2.2 External Quality Control

Interlaboratory comparisons, replicate, blank, and blind samples to evaluate the accuracy of results from the subcontracted laboratory will be used. The purpose and scope of each of these is described below.

- **Field Duplicate Sample (replicate analyses).** Duplicate samples are collected from the same well using the same equipment and sampling technique. These samples help establish how much variability might be expected in the laboratory measurements performed on nearly identical samples and provide a check for gross errors.

Table 9. Summary of Quality Control Samples Required for Groundwater Monitoring Program.

Type of quality control sample	Frequency
Contract Laboratory External Quality Control Samples	
Field duplicate	At least one per 20 samples <u>or</u> 5% of the total number of samples, <u>or</u> one per sampling event, whichever is greater.
Split sample	At the discretion of Geosciences group manager
Blind sample	At the discretion of Geosciences group manager
Field transfer blank	Same frequency as field duplicates.
Equipment blank	Same frequency as field duplicates.
Trip blank	At least one per day of sampling
Full trip blank	At least one per 20 samples or one per sampling batch
Contract Laboratory Internal Quality Control Samples	
Matrix and matrix spike duplicates	At least one per analytical batch or one per 20 samples analyzed
Quality control reference samples	At least one per analytical batch or one per 20 samples analyzed

- **Split Sample (interlaboratory duplicates).** Some of the field or field duplicate samples will be split (i.e., placed into separate containers) in the field and sent to separate laboratories to audit the performance of the primary laboratory.

- **Blind Sample.** A solution containing known quantities of various analytes is sent to the laboratory to estimate the bias of analytical laboratory procedures and to determine when this bias exceeds control limits. Most blind samples are now prepared with materials supplied by the U.S. Environmental Protection Agency (EPA), including metals, anions, herbicides, pesticides, volatile organic compounds, ammonium ion, cyanide, semivolatile compounds, and PCBs. Blind samples are part of the overall RCRA sampling and analysis program at the Hanford Site.

- **Field Transfer Blank.** Pure, deionized, distilled water is transferred into a sample container in the field and preserved with the reagent specified for the analyte of interest. Field blanks are used to check for contamination of the reagent or the sampling environment (e.g., air or dust).

- **Equipment Blank.** Pure, deionized, distilled water is washed through decontaminated sampling equipment and placed in regular sampling containers. Equipment blanks are used to verify equipment decontamination.

- **Trip Blank.** A sample container is filled with pure, deionized, distilled water in the laboratory, transported with the other sample containers in the field, and is returned unopened to the laboratory. Trip blanks check for possible contamination from container preparation, shipment, handling, storage, or site conditions. These blanks are analyzed for volatile organic constituents only.

- **Full Trip Blank.** A full trip blank is similar to a trip blank but is analyzed for all constituents of concern for a specific project. The sample bottles are filled in the laboratory with pure, deionized, distilled water and preservative is added if required for a specific method.

5.0 REFERENCES

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EPA, 1986, *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, 3rd ed, EPA SW-846, U.S. Environmental Protection Agency, Washington, D.C.

Krieger, H. L., and E. L. Whittaker, 1980, *Prescribed Procedures for Measurement of Radioactivity in Drinking Water*, EPA-600/4-80-032, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

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ATTACHMENT 2

QUALITY ASSURANCE PROJECT PLAN
UPGRADIENT BOREHOLES

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CONTENTS

CONTENTS (cont)

1.0 PROJECT DESCRIPTION

1.1 BACKGROUND INFORMATION

The sites that are addressed in this plan were selected to aid in the characterization of upgradient Hanford Site hydrogeologic conditions. This Quality Assurance Project Plan (QAPP) is intended to be used in conjunction with other associated project plans (i.e., Work Plan, Field Sampling and Analysis Plan, and Job Safety Analysis).

1.2 QUALITY ASSURANCE PROJECT PLAN APPLICABILITY AND RELATIONSHIP TO WHC QUALITY ASSURANCE PROGRAM

This Quality Assurance Project Plan (QAPP) applies specifically to drilling activities performed for upgradient groundwater monitoring wells discussed in the plan. The QAPP is an element of the Work Plan prepared specifically for this investigation and is prepared to be consistent with other environmental work (EPA 1988a) and the overall quality program requirements of the Westinghouse Hanford Company (WHC). It is also designed to be in compliance with the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement). Distribution and revision control of the QAPP will be performed in compliance with standard WHC procedures (WHC-CM-4-2).

1.3 SCHEDULE OF ACTIVITIES

Individual task scopes are described in the Characterization Plan. Procedures applicable to those tasks are discussed in Section 4.0.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 TECHNICAL LEAD RESPONSIBILITIES

The Geosciences Function of WHC has primary responsibilities for conducting this characterization.

2.2 ANALYTICAL SYSTEMS LABORATORIES

Samples will be routed to the appropriate onsite building for physical properties testing and to as unyet specified laboratories for chemical analyses and mineral analyses. All analyses shall be performed in compliance with WHC approved laboratory quality assurance (QA) plans and analytical procedures.

2.3 HEALTH PHYSICS

Because the proposed drill sites are not in or near contaminated areas a Radiation Work Permit and Health Physics support will not be necessary.

2.4 TRANSPORTATION LOGISTICS

Transportation Logistics shall provide guidance and instruction for the transport of samples. This shall include direction concerning proper shipping paperwork, marking, labeling, and packaging requirements. No samples are expected to be hazardous or radioactive. However, in the event of encountering hazardous and radioactive soil contamination, Transportation Logistics shall provide guidance on a daily basis, if necessary.

2.5 EXTERNAL CONTRACTOR LABORATORIES

External participant contractors or subcontractors will perform certain portions of task activities at the direction of the technical lead. A Quality Assurance Project Plan (QAPP), that is acceptable by WHC, shall be prepared by any contractor laboratory that identifies the analytical procedures that will be used. All analyses will be subject to standard internal and external quality auditing and surveillance controls.

2.6 KAISER HANFORD ENGINEERS

Kaiser Hanford Engineers Company (KEH) will conduct the drilling activities under the direction of WHC in accordance with Kaiser Engineers Hanford Generic QAPP for Drilling Construction Activities No. 27. KEH shall provide services in accordance with applicable Letter of Instruction (LOI).

2.7 OTHER SUPPORT CONTRACTORS

Procurement of any other contracted field activities shall be in compliance with applicable procedure requirements. All work shall be performed in compliance with WHC approved QA plans and/or procedures, subject to standard internal and external quality auditing and surveillance controls. Applicable quality requirements shall be invoked as part of the approved procurement documentation or work order.

3.0 OBJECTIVES FOR MEASUREMENTS

This project is a characterization activity and as such, Data Quality Objectives are to obtain data that is representative of the sites being investigated. This section summarizes the data quality requirements to meet the intended use and objectives discussed in the main body of this plan. The requirements are discussed in the following subsections.

3.1 GEOLOGIC INVESTIGATION (TASK 3)

Intact and representative core samples are necessary for accurate characterization of subsurface geologic conditions. Accurate interpretations of subsurface geology in turn form the framework for geochemical and hydrologic modeling of the subsurface. Cores provide the only means by which the geologic conditions in the borehole can be directly observed and analyzed. In addition, comparisons of core to analogous rocks in adjacent boreholes and exposed at the earth's surface are fundamental to the accurate interpretation of geologic conditions throughout the study area.

The proposed coring program will accommodate sample collection for stratigraphic interpretation and analysis of physical and chemical properties. Geologic logging of intact cores are the fundamental prerequisites for the stratigraphic interpretations that are necessary to support geochemical and hydrologic conceptual modeling. Consequently, the objective of the geologic logging is to describe the observable geologic features found in the core. Procedures for geologic logging are described in EII 9.1, REV 3, *Geologic Logging* (WHC 1989). Additional geologic logging requirements are described in the characterization plan and this QAPP.

Physical and chemical properties are necessary for the interpretations and modeling that are central to the attached characterization plan. Specific sample intervals for physical and chemical property tests will be determined by the project scientist prior to coring runs. Physical properties that can be directly obtained from intact cores include particle size distribution, hydraulic conductivity, specific gravity, soil moisture, moisture retention, and calcium carbonate. Sampling requirements and procedures for these physical analyses are described in the *Geotechnical Engineering and Procedure Manual*, WHC-IP-0635. Specific procedures for the analysis of particle size distribution, hydraulic conductivity, specific gravity, soil moisture, moisture retention, and calcium carbonate are GEL-07, GEL-09, GEL-10, GEL-14, GEL-17, and GEL-19, respectively.

Samples will be taken for analysis of heavy metals that are of regulatory interest for the Soil Background Study. Sufficient sample will be saved for mineralogic and grain size determinations from the same subsample used for regulatory constituent analyses. Care will be taken to avoid introduction of foreign material into samples used for regulatory constituent analyses.

3.2 GROUNDWATER INVESTIGATION

Data quality requirements for this task include measurements associated with both hydrologic testing and sampling and analysis for chemical constituents.

3.2.1 Hydrologic Testing

Hydrologic test data will be used to improve estimates of the rate and direction of groundwater movement upgradient of the 200 Areas Plateau. The intended end use is to be a refined estimate of the ambient upgradient "velocity field." This parameter is required as an input boundary condition in numerical models used to evaluate remediation scenarios for the RI/FS process.

The velocity field for the upgradient portion of the flow system is a fundamental boundary condition. This information is either derived from hydraulic conductivity data and gradient (water table elevations) or by direct measurement of borehole flow velocities. Both approaches are included in this investigation.

3.2.1.1 Water Table Elevation. This parameter is obtained by subtraction of the depth to groundwater from the well casing elevation in feet above mean sea level. The accuracy of well casing elevations are required to be surveyed within +/- 0.1 ft. Depth to water measurement equipment standards and calibration requirements are contained within EII 10.2, *Measurement of Groundwater Levels*.

3.2.1.2 Hydraulic Conductivity. Hydraulic conductivity (or transmissivity) will be estimated from slug tests and constant discharge tests (both single well and multiple well). The accuracy of hydraulic conductivity estimates are constrained by such items as natural hydrogeologic variations (anisotropic and non-homogeneous conditions), partial penetration of the well screen, lack of observation wells, hydrogeologic boundaries, and other such hydrogeologic phenomenon. For these reasons, the data quality objective (DQO) is to provide order-of-magnitude estimates for hydraulic conductivity.

Hydrogeologic conditions cannot be manipulated to meet the data quality objective of order-of-magnitude accuracy. In fact, the accuracy of the estimated hydraulic conductivity is not really known because the true value cannot be determined. Only indirect methods can be used to satisfy the DQO for hydraulic conductivity. These indirect methods will include calibrating or standardizing the measurement equipment to the tolerances set in EII 10.1, *Aquifer Testing*, conducting the tests using approved procedures, and using industry accepted analysis methods to interpret the test data. Acceptable industry analysis methods include at least Cooper-Jacob (Cooper and Jacob 1946), Neuman (Neuman 1975), Bouwer (Bouwer 1989), and Cooper-Bredehoeft-Papadopulos (Cooper et al. 1967).

In addition, a description of work or test plan will be written to direct aquifer testing. The test plan will provide technical guidance for performing the constant discharge tests and the slug tests.

3.2.1.3 Borehole Velocity. This parameter involves in situ measurement of horizontal flow velocity within the screened interval. Required measurements associated with each set of velocity readings in a well include: (1) depth to water (+/- 0.1 ft) from top-of-casing elevation, (2) depth of velocity sensor relative to top-of-casing (+/- 0.1 ft), (3) compass orientation (+/-5 degrees), and (4) observed flow velocity (+/- 0.1 ft/s).

The direct velocity measurements will be made in all available wells of suitable construction in the study area as well as in the newly completed wells. Quarterly readings are required to assess seasonal effects (e.g., onset of irrigation in upper Cold Creek valley). Multiple readings of vertical intervals of 5 ft within the saturated portion of the screened interval are required to establish a resultant vector for groundwater movement.

3.2.2 Chemical and Regulatory Constituents

A primary intended use of the new wells to be completed under this plan is to provide upgradient background groundwater quality data for constituents of regulatory interest. The geochemical characteristics of the hydrologic regime in the study area is also of interest for predicting the long-term behavior of contaminants introduced into the flow regime from current and past practice waste disposal activities. The analytes and associated analytical requirements for these two basic categories are as follows.

3.2.2.1 Regulatory Constituents. The regulatory constituents of interest include the primary and secondary contaminants and radionuclides listed in Table 1 of WAC 173-200. The data from this effort will be used in groundwater impact assessments of operating waste disposal facilities and for establishing background based cleanup standards as defined in WAC 173-340-700.

The general analytical requirement for the above uses is that the limit of quantitation (LOQ) must be less than the regulatory standard. Current contract required quantitation limits (CRQLs) for the constituents of regulatory interest for this plan are listed in Attachment 1, Tables 1 through 8. In some cases, lower CRQLs than shown in the referenced tables will be required. These include arsenic and cadmium for which LOQs of 1 ppb will be needed. The latter changes will be included in the statement of work for the sampling and analysis. The adequacy of all LOQs and CRQLs will be reviewed prior to issuance of the analytical contract in order to ensure that appropriate detection limits are used.

Validation of the analytical results will be required for the regulatory constituents described above prior to entry in the HEIS data base.

3.2.2.2 Geochemical Parameters. In addition to the regulatory constituents described above, other chemical and isotopic analytes are required to fully characterize the geohydrologic regime. These include: (1) the stable isotopes of carbon, oxygen and hydrogen; carbon-14, (2) alkalinity, dissolved oxygen, redox potential and dissolved gases, and (3) trace elements (by ICP-MS).

Specialized sampling and analytical methods are required for the above purposes and will thus be conducted under a separate sampling and analysis plan. Quarterly sampling will not be required for these constituents but sampling will be coordinated to coincide with one or more of quarterly sampling events for regulatory constituents described above.

4.0 SAMPLING PROCEDURES

4.1 PROCEDURE APPROVALS AND CONTROL

All procedures required for sampling activities shall be approved and in compliance with applicable WHC procedures. Where WHC Environmental Investigation Instructions (EIIs) are referenced (WHC 1989), they shall be the latest approved versions. Where WHC analytical laboratory procedures are referenced, they shall be the latest approved version defined within procedures manuals for the applicable facilities that have been reviewed and approved in compliance with standard procedures. Where physical properties are determined by the WHC Environmental Technology Development Laboratory, they shall be the latest approved versions Manual WHC-IP-0635.

4.2 SAMPLING PROCEDURES

4.2.1 Geologic Sampling

All geologic sampling shall be performed in accordance with EII 5.2, *Soil and Sediment Sampling*. All boreholes shall be logged in compliance with EII 9.1, *Geologic Logging*, except when otherwise directed by the project scientist who may direct that geologic logging be done following the facies and facies association criteria described in Lindsey (1991), Delaney et al. (1991), Lindsey et al. (1992a, 1992b), and Reidel et al. (1992). Sample numbers, types, location, and other site-specific considerations are defined in the characterization plan. Documentation requirements are contained within individual EIIs. Sampling of existing core shall be in accordance with EII 5.7a, *Hanford Geotechnical Sample Library Control*. Sample container selection shall be in accordance with EII 5.2, *Soil and Sediment Sampling*.

4.2.2 Hydrochemical Sampling

Groundwater sampling for regulatory constituents will be conducted as described in the Sampling and Analysis Plan (Attachment 1).

4.3 OTHER PROCEDURES

Other procedures that will be required that are not already identified in this QAPP will be identified in the task. Documentation requirements shall be addressed within individual procedures.

4.4 PROCEDURE CHANGES

Should deviations from established EIIs be required to accommodate unforseen field situations, they may be authorized by the field team coordinator in accordance with the requirements of EII 1.4, "Deviation from Environmental Investigations Instructions." Documentation, review, and disposition of instruction change authorization forms are defined within EII 1.4. Other types of procedure change requests shall be documented as required by WHC procedures governing their preparation.

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," from the point of origin to the analytical laboratory. Laboratory chain-of-custody procedures shall be reviewed and approved as required by WHC procurement control procedures and shall ensure the maintenance of sample integrity and identification throughout the analytical process. Chain-of-custody forms shall be initiated for returned residual samples. Results of analyses shall be traceable to original samples through the unique code or identifier specified in the FSP. All results of analyses shall be controlled as permanent project quality records as required by standard WHC procedures.

6.0 CALIBRATION PROCEDURES

Calibration of all WHC measuring and test equipment, whether in existing inventory or purchased for this investigation, shall be controlled as required by WHC calibration programs in compliance with the requirements of applicable WHC procedures. Equipment that requires user calibration or field adjustment shall be calibrated as required by standard procedures for user calibration.

All calibration of WHC or contractor laboratory measuring and test equipment shall meet the minimum requirements of Section II of *Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses* (EPA 1988b) and Section III of *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses* (EPA 1988c, 1986). Such requirements shall be invoked through WHC procurement control procedures. Laboratory QA Plans for both PNL and WHC shall address laboratory equipment to be calibrated and the calibration schedules.

7.0 ANALYTICAL PROCEDURES

Analytical methods are identified in the Characterization Plan. All analytical procedures approved for use in this investigation shall require the use of standard reporting techniques and units wherever possible to facilitate the comparability of data sets in terms of precision and accuracy (see appendix for definition of terms). All approved procedures shall be retained in the project QA records and shall be available for review upon request by the direction of the WHC technical lead.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Analytical data from sampling activities will be used primarily to determine the presence and amounts of analytes of interest in the sampled locations or intervals. Analytical laboratories shall be responsible for the examination and validation of analytical results to the extent appropriate. The requirements discussed in this section shall be invoked, as appropriate, in procurement documentation prepared in compliance with standard WHC procedures. Results from all analyses shall be summarized in a validation report and supported by recovery percentages, quality control checks, equipment calibration data, chromatograms, spectrograms, or other validation data.

All validation reports and supporting data shall be subjected to a detailed technical review by a qualified reviewer designated by the WHC technical lead. All validation reports, technical reviews, and supporting data shall be retained as permanent project QA records in compliance with referenced procedures.

9.0 INTERNAL QUALITY CONTROL

The quality of analytical samples shall be subject to in-process quality control checks in the field and the laboratory; minimum requirements are defined as follows.

Unless otherwise specified in the FSP, minimum field quality control checks for sample activities shall include the following.

- Duplicate samples--a minimum of 10 percent of the total collected samples shall be duplicated.

- Method (equipment) blank samples--the minimum number of blank samples shall be equivalent to 5 percent of the total number of collected samples. Blank sampling shall be evenly distributed throughout the entire sampling period.

Internal quality control checks performed by the analytical laboratories shall be in compliance with approved analytical procedure requirements.

10.0 PERFORMANCE AND SYSTEM AUDITS

Acceptable performance for this project is defined as compliance with the requirements of this QAPP, its implementing procedures and appendices, and associated plans such as the FSP, and other applicable WHC quality assurance program plans. All activities addressed by this QAPP are subject to surveillances of project performance and systems adequacy. Surveillances shall be conducted in accordance with appropriate WHC procedures and shall be scheduled at the discretion of the quality coordinator or technical lead.

11.0 PREVENTIVE MAINTENANCE

All measurement and testing equipment used in the field and laboratory that directly affects the quality of the analytical data shall be subject to preventive maintenance measures that ensure minimization of measurement system downtime. For this investigation, such measures are confined to laboratory equipment because all field measurements are related either to the measurement of the sample interval or to the determination of radiological or other health and safety hazards. 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 methods or in laboratory QA plans, subject to WHC review and approval.

12.0 DATA ASSESSMENT PROCEDURES

As discussed in Section 8.0, a data validation report shall be prepared by the analytical laboratory summarizing the precision, accuracy, and completeness of the analysis. The report shall compare actual analytical results with the objectives stated in that laboratory's analysis plan. If the stated objectives for a particular parameter are not met, the situation shall be analyzed, and limitations or restrictions on the uses of such data shall be established. The validation report shall be reviewed and approved by the technical lead, who may direct additional sampling activities if data quality objectives have not been met. The approved report shall be routed to the project quality records and included within the reports that will be prepared for submittal to the regulatory agencies at the completion of activities.

13.0 CORRECTIVE ACTION

Corrective action requests required as a result of surveillance reports shall be documented and dispositioned as required by standard WHC corrective action procedures. Primary responsibilities for corrective action resolution are assigned to the technical lead.

Other measurement systems, procedures, or plan corrections that may be required as a result of routine review processes shall be resolved as required by governing procedures or shall be referred to the technical lead for resolution. Copies of all surveillance documentation shall be routed to the project QA records upon completion or closure.

14.0 QUALITY ASSURANCE REPORTS

As previously stated in Sections 10.0 and 13.0, project performance shall be assessed by the surveillance process. Surveillance documentation shall be routed to the project records upon completion or closure of the activity. A report summarizing surveillance activity, as well as any associated corrective actions, shall be prepared by the QA organization overseeing drilling activities.

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16.0 GLOSSARY

Accuracy: For environmental investigations, accuracy may be interpreted as the measure of the bias in a system. Accuracy is the degree of agreement of a measurement (or the average of a set of measurements with identical parameters) with an accepted reference or true value. Accuracy may be expressed as (1) the difference between the measurement (X) with the reference value (T) (i.e., X-T) or (2) the difference between the two values as a percentage of the reference value (i.e., 100(X-T)/T) or simply as the ratio X/T.

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

Completeness: For environmental investigations, completeness may be interpreted as a measure of the amount of data actually obtained from a measurement system against the amount that would be expected under correct normal conditions.

Deviation: For environmental investigations, deviation refers to a planned 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.

Nonconformance: A nonconformance is a deficiency in 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. However, if the nature of the condition is such that it cannot be immediately and satisfactorily corrected, it shall be documented in compliance with approved procedures and brought to the attention of management for disposition and appropriate corrective action.

Precision: For environmental investigations, precision may be interpreted as a measure of relative agreement between individual measurements made with a common set of parameters or conditions. Precision is normally expressed in terms of the standard deviation.

Quality assurance: For environmental investigations, quality assurance 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 meet all end user requirements.

Quality Assurance Project Plan: The Quality Assurance Project Plan 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 environmental investigations, quality control refers to the routine application of procedures and defined methods to the performance of sampling, measurement, and analytical processes.

Representativeness: For environmental investigations, representativeness may be interpreted as the degree to which data accurately and precisely express the actual characteristics of the environmental conditions at the sampled interval.

Validation: For environmental investigations, validation refers to a systematic process of reviewing a body of 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 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, surveillances, or technical review.

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