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Interim Characterization Report for the 300 Area Process Trenches

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September 1988

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**Pacific Northwest Laboratory
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ABSTRACT

This document contains information on the results of the Hazardous Waste Ground-Water Monitoring Compliance Program characterization studies of wastes disposed of in the 300 Area process trenches. The characterization of the 300 Area process trenches has been conducted as part of an effort initiated in June 1985, when a facility-specific monitoring program was implemented. The characterization effort is part of a regulatory ground-water monitoring compliance program for hazardous chemicals on the Hanford Site. The characterization work described in this document represents an expanded ground-water monitoring compliance effort, and incorporates or refers to previous studies useful in characterizing the 300 Area. This document is primarily a compendium of technical information on the 300 Area; therefore, data interpretations are limited to the most obvious conclusions. Final conclusions will not be presented until the analysis of data is completed in September 1989.

EXECUTIVE SUMMARY

This document contains information on the results of the Hazardous Waste Ground Water Monitoring Compliance Program characterization studies of wastes disposed of in the 300 Area process trenches. This document is primarily a compendium of technical information on the 300 Area; therefore, data interpretations are limited to the most obvious conclusions. Final conclusions will not be presented until the analysis of data is completed in September 1989. The significance of these data, modeling results, and conclusions will be discussed in a final characterization report. The characterization of the 300 Area process trenches has been conducted as part of an effort initiated in June 1985, when a facility-specific monitoring program was implemented. The characterization effort is part of a regulatory ground-water monitoring compliance program for hazardous chemicals on the Hanford Site. The characterization work described here represents an expanded ground-water monitoring compliance effort, and incorporates or refers to previous studies useful in characterizing the 300 Area.

The sampling effort began in June 1985 and was expanded in the summer of 1986 to include characterization studies and installation of new wells. The plans for this expanded effort were based on two objectives: 1) to collect additional site-specific hydrogeologic information needed to more fully characterize the area and to support decisions concerning the monitoring network for the 300 Area process trenches, and 2) to conduct an expanded sampling and analysis effort designed to determine the potential for and rate of migration, if any, of contaminants. The overall goal is to achieve compliance with applicable monitoring requirements in the Resource Conservation and Recovery Act (RCRA), [U.S. Environmental Protection Agency (USEPA) 1984 (40 CFR 265.90)], and in Washington State's regulations [Washington State Department of Ecology 1986 (WAC 173-303-400)].

The well installation and hydrogeologic characterization work mentioned above was initiated in September 1986. Eighteen new wells were installed by February 12, 1987, thereby meeting a milestone in the Consent Agreement and Compliance Order dated October 1, 1986 (including the 6-week extension granted

because of technical difficulties during drilling). Data of various types pertinent to the characterization work were collected from the new wells during and following their installation. The initial evaluations based on these data and other characterization work conducted simultaneously are presented in this document. A brief summary of key findings is presented below, and further information is contained in the remainder of this document.

- Recent drilling and testing of 18 new monitoring wells (well 16D is not a monitoring well) (Figure S.1) in the 300 Area provided the following new hydrogeologic information: 1) the Hanford Formation is probably the most permeable portion of the unconfined aquifer; however, immediately underlying it are very permeable sands and gravels in the uppermost portion of the middle member of the Ringold Formation; 2) three members (middle, lower, and basal) of the Ringold Formation underlie the Hanford Formation in the 300 Area: a) the middle member, which consists primarily of 65 to 86 ft of permeable conglomerate with medium to fine sand filling the interstitial spaces, is continuous throughout the 300 Area; b) the lower member, which typically consists of 60 ft of nearly impermeable, blue and green silts and clays, is continuous but thins to 17 ft in the northern portion of the site; c) the basal member, which is chiefly characterized as a well-consolidated clayey sand to a gravelly sand with clay, varies in thickness from 2 to 17 ft; 3) the middle member of the Ringold Formation and the Hanford Formation comprise the unconfined aquifer in the 300 Area; 4) the lower member of the Ringold Formation forms a confining layer or aquitard; 5) the basal member of the Ringold Formation forms part of the uppermost confined aquifer; 6) underlying the basal member of the Ringold Formation are the uppermost basalt flows (the Martindale and the Goose Island flows) of the Ice Harbor member of the Saddle Mountains Basalt that are thought to contribute approximately half of the observed transmissivity of the uppermost confined aquifer; 7) although much knowledge has been gained about hydrologic properties of the various portions of the unconfined aquifer and the confined aquifer (Figure S.2), definitive

FIGURE S.2. Schematic of the Hydrogeology and Types of Monitoring Wells in the 300 Area

information is not available on the soil geochemistry and the depositional history is not completely understood, which precludes defining transport properties and continuity of primary hydrostratigraphic units.

- The results of monthly and continuous water level monitoring indicate that the primary natural influence on ground-water flow direction is

the Columbia River, and the most important artificial influence in the 300 Area is the process water disposed of in the process trenches. Ground water flows primarily to the east and southeast (Figure S.3), but reversals in ground-water flow direction do occur near the Columbia River when water levels in the river remain high for a few weeks. The results of recent transient simulations using a mathematical flow model indicated that a time step of one day is sufficient to account for changes in the ground-water levels in response to changing river stage. This determination of an appropriate time step was possible because continuous water level data were collected on several wells and the river. The level and gradient of the Columbia River adjacent to the 300 Area vary with actions taken at the upstream Priest Rapids and downstream McNary dams. The amount of change in gradient and its significance have not been determined. The confined aquifer in the 300 Area has hydraulic heads approximately 20 to 35 ft higher than the unconfined aquifer. Therefore, the potential for downward migration from the unconfined aquifer into the confined aquifer is considered minimal unless an artificial hydraulic interconnection is created between the two aquifers and the hydraulic head is reduced 20 or 30 ft in the confined aquifer. The presence and character of the sedimentary deposits of former river channels have been partially determined. The existence of a continuous natural levee separating the old channel deposits from the current Columbia River channel has not been confirmed. The aquifer test data and water level data do indicate some variability in sedimentary characteristics.

- Constituents present at levels well above background in soil from the process trenches and ponds have all, with the exception of Sb, been detected in the ground water since June 1985. Constituents in ground water that are found to be above the EPA Interim Primary Drinking Water Standards or the Maximum Contaminant Levels (MCLs) are gross alpha, gross beta, fluoride, trichloroethylene (TCE), and trans-1,2-dichloroethylene (trans-1,2-DCE). The highest concentrations of gross alpha and beta were found in the shallowest

FIGURE S.3. Map of Ground-Water Flow in the Shallow Portion of the Unconfined Aquifer in the 300 Area

portion of the unconfined aquifer in the vicinity of the process trenches. Most of the alpha probably represents uranium and radon from the process trenches. According to RCRA 40 CFR regulations, these two constituents are not to be included in the alpha count for determining whether the drinking water standard has been exceeded. Gross alpha levels in intermediate and deep wells remain below detection limits. Fluoride concentrations are below drinking water standards (DWS) in the shallow zone, but near or above DWS in intermediate and deep wells. This suggests that fluoride in the lower portions of the unconfined aquifer and the confined aquifer are attributable to a source other than the trenches. Both TCE and trans-1,2-DCE have been detected in the intermediate-depth wells that are downgradient of the process trenches and process ponds.

- In addition to the constituents and contaminants noted in the preceding paragraph, other constituents serve to differentiate between water in the upper portion of the unconfined aquifer and that from deeper zones. Also, some concentrations of several constituents are unique to the process water entering the ground-water system. These unique constituents can, in a few instances, serve as tracers and help delineate flow paths and the horizontal and vertical extent of water moving from the process trenches. By using chloroform and trans-1,2-DCE as tracers or index constituents, there is evidence that water from the process trenches has a very discrete areal extent. The configurations of constituent plumes from the process trenches are transient and are not completely defined spatially, particularly west of the process trenches. Also, the vertical distribution of these index constituents is limited to specific hydrostratigraphic units. Chemistry data from wells screened in different strata indicate there is mixing of background ground water with water from the process trenches in the middle portion of the unconfined aquifer.
- Based on water chemistry data for perchloroethylene (PCE) and methylene chloride, non-continuous (pulse type) releases of these or

similarly mobile constituents from the process trenches migrate rapidly (approximately 35 ft/day) through the shallow portion of the unconfined aquifer to the Columbia River.

The primary recommendation to be made is that the data collection efforts and evaluations should continue, but routine monitoring should be reduced so that efforts are directed toward achieving compliance with the assessment requirements.

The following are other recommendations:

- Determine the extent of contamination of all contaminants of concern in the 300 Area and whether they originate from the process trenches or some other source.
- Complete characterization of the hydrogeologic system, particularly the bottom of the unconfined aquifer.
- Complete studies of the relationship between ground-water movement and surface water to determine boundary conditions for simulation of flow and transport in the unconfined aquifer.
- Perform tracer tests to evaluate hydrologic properties within the study area and to enable calibration and validation of the transport model.
- Quantify the uncertainty of all the data in information used for input into models or used for interpretation.
- Prepare a detailed planning document to expedite efforts toward completing the assessment study phase.

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The value of this document as a reference and basis for guiding further study to characterize the 300 Area is a reflection of the project staff's technical competence, insight, and dedication to this effort. In particular, Richard Wallace for writing the chapter on regional setting; George Last and Steve Airhart for preparing much of the chapter on characterization of the 300 Area; Mark Freshley for his discussion on ground-water modeling; Rosanne Aaberg for her in-depth discussion of all aspects of water chemistry quality assurance and quality control; Elizabeth Westergard, Douglas Dennison, Jan Carlile, Douglas Sherwood, Rick Bates, and Richard Gilbert for their production of the soil and ground-water chemistry section, and Ronald Schalla for his contribution to several chapters and overall internal review and coordination of the document. The value of the document has been enhanced by the editorial review provided by Regina Brown and Linda Gentry, and the care in production executed and guided by Pat Young. In addition to those authors already mentioned, many other PNL staff members contributed to the production of the appendices including: Jody Cearlock, Charles Cline, Susanne Dudziak, Randall Hagen, Paula Heller, Eric Jensen, Susan Marshall, Khris Olsen, Richard Parkhurst, and JoAnn Rieger. Peer review was provided by Phil Oberlander and Jeffrey Serne. Accuracy and completeness of the document have been aided by contributions from Robert Hall and Marvin Zimmerman of Westinghouse Hanford Company, and Grant Brazil and his colleagues of Kaiser Engineers Hanford. The quality of the graphics is the result of the cooperative efforts of Daniel Foley and Gene Wattenberg's staff and Scotty Getschel of Boeing Computer Services.

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1.0 INTRODUCTION

This document consists of an interim report of continuing activities described in the revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches (Schalla et al, 1986). The activities reported represent a part of an effort initiated in June 1985 when a facility-specific monitoring program to characterize the 300 Area process trenches was implemented at the 300 Area process trenches. The characterization effort is part of a regulatory compliance program for hazardous chemicals on the Hanford Site. The monitoring program was based on the U.S. Environmental Protection Agency (USEPA) ground-water monitoring requirements for interim-status facilities, which are those facilities authorized to continue interim operations while engaged in the permitting process and which do not yet have final permits.

The program implemented for the 300 Area process trenches (trenches) was designed to be an assessment-level program, which is required when a facility is known or suspected to have contaminated the ground water in the uppermost aquifer, rather than a detection-level program. The plans for the program (DOE 1985a) called for monthly sampling of 14 of the 37 existing monitoring wells in the 300 Area plus the installation and sampling of two new wells. This effort, called the Resource Conservation and Recovery Act (RCRA) Compliance Ground-Water Monitoring Project for the 300 Area, was implemented in June 1985 by the U.S. Department of Energy's (DOE) Pacific Northwest Laboratory (PNL).

Results of the first year of ground-water monitoring were used to produce the revised ground-water monitoring plans requested by the USEPA and the Washington State Department of Ecology. The objective of the revised plans was to achieve compliance by: 1) collecting the additional site-specific hydrogeologic information needed to more fully characterize the area and to support decisions concerning the design and effectiveness of the monitoring well network for the 300 Area, and 2) conducting an expanded sampling and analysis effort to determine the extent of contamination originating from the trenches and the rate of contaminant movement.

Eighteen new wells have been constructed under the revised ground-water monitoring plans to expand the existing monitoring effort. The new well installations consist of three, three-well clusters, eight single wells and one deep well to create a four-well cluster. The locations, descriptions, well logs, and completion data for the new wells are included as part of this document. A water-level monitoring station has been established on the Columbia River to determine the effect of the river level on the ground-water flow system in the 300 Area. Aquifer pumping tests have been conducted on a number of the new wells for additional hydrologic information. Sampling pumps have been installed in the new wells.

The characterization effort has furnished data and new monitoring locations directed toward meeting the objectives of the revised ground-water monitoring plan mentioned above: to more fully characterize the hydrogeology of the trenches' area and to furnish an extended monitoring and sampling network for determining the extent and rate of movement of contaminants. Continued efforts will consist of analyzing and interpreting the data obtained, as well as collecting samples from the expanded network.

2.0 REGIONAL SETTING: THE PASCO BASIN

The Hanford Site is located in a semiarid region of southcentral Washington State (Figure 2.1). This portion of the state lies within the Columbia River Plateau and is defined generally by a thick accumulation of basaltic lava flows that extend laterally from central Washington eastward into Idaho and southward into Oregon (Tallman et al. 1979). Deformation of these lava flows has formed a number of broad structural and topographic basins. The Hanford Site lies within one of these basins, the Pasco Basin, near the confluence of the Yakima and Columbia rivers.

Three sides of the boundaries of the Pasco Basin are defined by anticlinal structures of basaltic rock. These structures are the Saddle Mountains to the north; the Umtanum Ridge, Yakima Ridge, and Rattlesnake Hills to the west; and the Rattlesnake Hills and a series of doubly plunging anticlines merging with the Horse Heaven Hills to the south. The terrain within the Pasco Basin and its eastern boundary is relatively flat. Its surface features were formed by catastrophic floods and have undergone little modification, with the exception of more recently formed sand dunes (DOE 1984).

Within the Pasco Basin, the basaltic lava flows of the Columbia River Basalt Group are covered by late Miocene- to Pleistocene-aged fluvial, lacustrine, and glaciofluvial sediments. During the late Miocene to mid-Pliocene, intercalated fluvial and lacustrine sediments, known as the Ringold Formation, partially filled the subsiding Pasco Basin (Myers and Price et al. 1979). Pleistocene-aged glaciofluvial sediments, informally known as the Hanford formation, overlie the Ringold Formation. The deposition of these coarser materials was a result of catastrophic postglacial flood events.

The Hanford Site itself occupies an area of about 560 mi² and is about 30 mi north to south and about 24 mi east to west. This land area, with restricted public access, provides a buffer for the smaller areas currently used for operations, waste storage, and waste disposal. Adjoining lands to the west, north, and east of the Site are principally range and agricultural land. The cities of Richland, Kennewick, and Pasco (collectively called the Tri-Cities) compose the nearest population center and are located southeast of the Site.

FIGURE 2.1. Location of the 300 Area and the Hanford Site

The terrain of the central and eastern parts of the Site is relatively flat (DOE 1984). The northern and western parts of the Site have moderate to steep topographic ridges composed of basalt and sediments. The central part of the Site, including the 200 Area Plateau, has undergone minimal erosion since formation by floodwaters about 13,000 years ago.

The Hanford Site overlies the structural low point of the Pasco Basin and is bounded to the southwest, west, and north by large ridges that trend eastwardly and southeastwardly from the Cascade Range, enter the Pasco Basin, and die out within the confines of the Pasco Basin. The Site is bounded to the north and east by the Columbia River and the steep bluffs of the Ringold Formation.

The elevations of the alluvial plain that covers much of the Site vary from 345 ft above mean sea level (MSL) in the southeast corner to 803 ft in the northwest. The 200 Area Plateau, in the central part of the Site, varies in elevation from 623 to 804 ft. The highest point is on Rattlesnake Mountain (3585 ft) at the southwestern border of the Site.

2.1 GEOLOGY

The following major geologic units of the Hanford Site are discussed in ascending order: basement rocks of unknown origin and composition, the Columbia River Basalt Group with intercalated sediments of the Ellensburg Formation, the Ringold Formation, the Plio-Pleistocene unit, and the Hanford formation (Figure 2.2). Locally, Pleistocene/Holocene sand, silt, and loess exist as surficial material.

The regional geology is dominated by the thick sequence of tholeiitic flood basalts designated the Columbia River Basalt Group. This layered sequence consists of more than 48,000 mi³ of basalt covering more than 59,900 mi² and is subdivided into five formations (Ledgerwood et al. 1978; Swanson et al. 1979). The upper three formations, the Grande Ronde Basalt, the Wanapum Basalt, and the Saddle Mountains Basalt, collectively constitute the Yakima Basalt Subgroup (Swanson et al. 1979). Beneath the 200 Area, near the center of the Site, this basalt sequence is at least 4,790 ft thick and may be

as much as 14,000 ft thick (Myers and Price et al. 1979). Approximately 100 basalt flows, including both Columbia River basalts and older lavas, have been identified from geophysical logs obtained from a 10,660-ft-deep borehole (RSH-1) located just west of the Hanford Site (Swanson et al. 1979). Flows of the Columbia River Basalt Group are interbedded with and overlain by Miocene-Pliocene epiclastic and volcanoclastic sediments of the Ellensburg Formation (Myers and Price et al. 1979). These sedimentary interbeds become thicker and more frequent in the Saddle Mountains Formation.

Deformation continued after the volcanic activity that formed the Columbia River Basalts had stopped, resulting in the further accumulation of sediments in the Pasco Basin. These sediments of the Ringold Formation were deposited between 3.7 and about 8.5 million years before present (mybp) in a fluvial/flood plain environment (Myers and Price et al. 1979) and accumulated to a thickness of over 1200 ft.

The Ringold Formation overlies the basalts and in the 300 Area it is delineated by increasing amounts of silt and some clay. The Ringold Formation is of the White Bluffs section-type along the east bank of the Columbia River and just north of the 300 Area.

The Ringold Formation has been divided into four textural units: 1) sand and gravel of the basal Ringold member; 2) clay, silt, and fine sand with minor gravel lenses of the lower Ringold member; 3) occasionally cemented sand and gravel of the middle Ringold member; and 4) silt and fine sand of the upper Ringold member (Brown 1959).

Most of the Ringold Formation is of Pliocene age [approximately 3 to 5 million years old (Gustafson 1978)] and, with the exception of a weakly consolidated conglomerate member (the middle Ringold), consists mainly of layered silts, clays, and fine sands deposited in a lacustrine/fluvial/flood plain environment. The conglomerate member is considered to have been deposited in a high-energy, fluvial environment. Sediments deposited in the 300 Area above the current Columbia River level, primarily the upper member, (to an altitude of 1000 ft) were removed by erosion before the deposition of the overlying Pasco gravels.

An old (Plio-Pleistocene) eolian silt and fine sand overlies the Ringold Formation in the western part of the Hanford Site (Brown 1960). This silty-fine sand to sandy silt was deposited when the wind reworked and redeposited Ringold sediments. Relatively high caliche contents are found in much of this unit.

The Hanford formation lies on the eroded surface of the Plio-Pleistocene unit, the Ringold Formation, and in a few areas, on the basalt bedrock. The Hanford formation consists of catastrophic flood sediments that were deposited when ice dams in western Montana and northern Idaho were breached and massive volumes of water spilled abruptly across eastern and central Washington. The floods scoured the land surface, locally eroding the Ringold Formation, the basalts, and sedimentary interbeds, leaving a network of buried channels crossing the Pasco Basin (Tallman et al. 1979). Thick sequences of sediments were deposited by several episodes of Pleistocene flooding with the last major flood sequence dated at about 13,000 years before present (Myers and Price et al. 1979). These sediments have locally been divided into two main facies, termed the "Pasco gravels" facies and the "Touchet beds" facies (Myers and Price et al. 1979).

The Pasco gravels facies is composed of poorly sorted, subrounded-to-angular clasts that commonly display forset bedding (Myers and Price et al. 1979). These sediments indicate high-energy depositional environments. The Touchet beds facies consist of rhythmically bedded sequences of graded silt, sand, and minor gravel units. These deposits are limited to areas where slack-water conditions occurred during the impoundment of flood waters behind the Wallula Gap constriction (Myers and Price et al. 1979; Tallman et al. 1979).

Eolian sediments consisting of loess and sand dunes (both active and inactive) locally veneer the surface of the Hanford Site.

2.2 HYDROLOGY

The Hanford Site occupies approximately one-third of the land area within the Pasco Basin. Ground-water flow under the Hanford Site is interrelated to the surface water bodies (e.g., rivers, ponds) within and adjacent to the site boundaries.

2.2.1 Surface Water

Primary surface-water features associated with the Hanford Site are the Columbia and Yakima rivers. Several surface ponds and ditches are present and are generally associated with fuel and waste processing activities.

Flow from approximately two-thirds of the Hanford Site is considered to drain directly into the Columbia River along the Hanford Reach, which extends from the headwaters of Lake Wallula to the Priest Rapids Dam. The flow has been inventoried and is described in detail by the U.S. Army Corps of Engineers (DOE 1984). Flow along this section of the Columbia is controlled by the Priest Rapids Dam. Several drains and intakes are also present along this reach, including irrigation outfalls from the Columbia Basin Irrigation Project and Hanford Site intakes for the onsite water export system.

Cold Creek and its tributary, Dry Creek, are ephemeral streams within the Yakima River drainage system along the southern boundary of the Hanford Site. Both streams drain areas to the west of the Hanford Site and cross the southwestern part of the Site toward the Yakima River. Surface flow, when it occurs, disappears into surface sediments in the western part of the Site. Rattlesnake Springs, located on the western part of the Site, forms a small surface stream that flows for about 1.8 mi before disappearing into the ground. Approximately one-third of the Hanford Site is drained by the Yakima River system.

The Yakima River, bordering the southern portion of the Hanford Site, has a lower annual flow rate compared to the Columbia River. For a period of 57 years of record, the average annual flow of the Yakima River is about $104 \text{ m}^3/\text{sec}$ with monthly maximum and minimum flows of $490 \text{ m}^3/\text{sec}$ and $4.6 \text{ m}^3/\text{sec}$, respectively. Recorded flow rates of the Columbia River have ranged from 4,500 to $18,000 \text{ m}^3/\text{sec}$ during the runoff in spring and early summer, to 1000 to $4500 \text{ m}^3/\text{sec}$ during the low flow period of late summer and winter (Jamison 1982). The average annual Columbia River flow in the Hanford Reach, based on

65 years of record, is about 3400 m³/sec (DOE 1987). Large Columbia River floods have occurred in the past but the likelihood of recurrence of large-scale flooding has been reduced by the construction of several flood control/water storage dams upstream of the Site. Normal river elevations within the Site range from 394 ft where the river enters the Site near Vernita to 341 ft where it leaves the Site near the 300 Area.

2.2.2 Ground Water

Ground water at the Site occurs under unconfined and confined conditions. The unconfined aquifer is contained within the glaciofluvial sands and gravels and within the Ringold Formation. It occurs most often in the middle member of the Ringold Formation, which consists of poorly sorted sands and gravels. The bottom of the unconfined aquifer is the basalt surface or, in some areas, the clay zones of the lower member of the Ringold Formation. The confined aquifers consist of sedimentary interbeds and/or interflow zones that occur between dense basalt flows in the Columbia River Basalt Group. The main waterbearing portions of the interflow zones occur within a network of interconnecting vesicles and fractures of the flow tops or flow bottoms.

Sources of natural recharge to the unconfined aquifer are rainfall and runoff from the higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Yakima and Columbia rivers. The movement of precipitation through the unsaturated (vadose) zone has been studied at several locations on the Hanford Site to define the movement of water there. Conclusions from these studies are varied depending on the location studied. Some investigators conclude that no downward percolation of precipitation occurs on the 200 Area Plateau where soil texture is varied and is layered with depth, and all moisture penetrating the soil is removed by evaporation. Others have observed downward water movement below the root zone in tests conducted near the 300 Area, where soils are coarse-textured and when precipitation was above normal (DOE 1987). From the recharge areas to the west, the ground water flows downgradient to the discharge areas, primarily along the Columbia River. This general west-to-east flow pattern is interrupted locally by the ground-water mounds in the 200 Areas. From the 200 Areas, there is also a component of ground-water flow

to the north, between Gable Mountain and Gable Butte. These flow directions represent present conditions; the aquifer is dynamic, and responds to changes in natural and artificial recharge.

2.3 METEOROLOGICAL CONDITIONS

The climate of the Hanford Site is mild and dry with occasional periods of high winds. Summers are hot and dry; winters are less dry and are relatively mild for the latitude. Average maximum temperatures occur in July, and average minimum temperatures occur in February. Average relative humidity is lowest in the summer and highest in the winter. Average annual precipitation is about 6.3 in. The 100-year maximum predicted rainfall event in a 24-hour period is 2 in. Potential evapotranspiration rates greatly exceed annual precipitation rates, but much of the precipitation occurs between November and February when evapotranspiration rates are lowest. The highest monthly average winds occur during the hot summer, creating high evaporative potentials.

Climatological data are available for the Hanford Meteorological Station, located between the 200 Areas, and are considered to be representative of the current general climatic conditions for the region. Data have been collected at this facility since 1945. Temperature and precipitation data are also available from nearby locations for the period 1912 through 1943. A summary of these data, through 1980, has been published by Stone et al. (1983).

Prevailing wind directions are from the northwest in all months of the year (DOE 1987). Secondary maxima occur for southwesterly winds. Summaries of wind direction data indicate that winds from the northwest quadrant occur most often during the months of December, January, and February and also during the months of June, July, and August. The frequency of southwesterly winds increases during the spring and fall. Monthly average wind speeds are lowest during the winter months, averaging 8.7 to 9.9 mi/hour on a monthly basis. Wind speeds that are well above average are usually associated with southwesterly winds. In the summer, high winds from the southwest are responsible for most of the dust storms experienced in the region.

Diurnal and monthly averages and extremes of temperature, dewpoint, and humidity are reported in Stone et al. (1983). For the period 1912 through

1980, the average monthly temperatures vary from a low of -1.5°C in January to a high of 24.7°C in July. During the winter, the highest monthly average temperature at the Hanford Meteorological Station was 6.9°C , and the record lowest was -5.9°C ; both of these temperatures occurred during February. During the summer the record maximum monthly average temperature was 27.7°C (in July), and the record lowest was 17.2°C (in June). The annual average relative humidity at the Hanford Meteorological Station is 54%, with maxima during the winter months averaging about 75% and minima during the summer averaging about 35%.

Average annual precipitation at the Hanford Meteorological Station is about 6.3 in. (Stone et al. 1983). Most of the precipitation occurs during the winter with nearly half of the annual amount occurring in the months of November through February. Days with greater than 0.5 in. precipitation occur less than 1% of the year. Rainfall intensities of 0.5 in./hour persisting for 1 hour are expected once every 10 years. Rainfall intensities of 1 in./hour for 1 hour are expected only once every 500 years. Winter monthly average snowfall ranges from 0.3 in. in March to 5.3 in. in January. The record snowfall during the reported period was (24.4 in. and occurred in February 1916 (Stone et al. 1983).

3.0 CHARACTERIZATION OF THE 300 AREA

The 300 Area is located about 1 mi north of the city of Richland, Washington, and is situated with its eastern boundary on the Columbia River. The area encompasses approximately 370 acres and is the site of many ongoing research and operational programs, including reactor fuel fabrication in facilities located inside a fenced security area. Administrative offices for Westinghouse Hanford Company (WHC) are also located in the 300 Area. Figure 3.1 is a map showing the main facilities and all the wells in the 300 Area, including abandoned wells.

The 300 Area process trenches are located in the northern portion of the 300 Area. The two trenches are each 1500 ft long, 10 ft wide at the bottom, and about 34 ft wide at the top. They are unlined trenches, excavated about 12 ft into the subsurface and separated by an earthen berm. The trench bottoms are about 20 ft above the water table. The northern end of the west trench opens into a natural depression. Figure 3.2 contains a schematic cross section showing the dimensions and relationship of the east and west trenches to the water table. The plan view of the area and location of the cross section is shown in Figure 3.2.

Beginning in 1975, the trenches were the main facility for disposal of most liquid wastes generated in the 300 Area. A variety of chemical wastes was included in the process wastes but no large quantities of any one of these chemical wastes were disposed of. The liquid wastes also contained hazardous constituents in low concentrations. Administrative controls to prevent disposal of dangerous wastes to the trenches were instituted by WHC on February 1, 1985.

The trenches continue to receive approximately 3 million gal of wastewater per day, consisting primarily of cooling water with small quantities of nonhazardous maintenance and process wastes. About one-third of the 3 million gal/day of water are cooling and rinse water used for fuel fabrication. The remaining two-thirds are derived from a wide variety of operations by WHC and

▽ Water Table

Elevations are in feet
above mean sea level

Not to Scale

FIGURE 3.2. Schematic Cross Section of the 300 Area Process Trenches

PNL. The trenches are used alternately for periods up to 8 months. The west trench generally receives discharge water for longer periods than the east trench.

3.1 PREVIOUS STUDIES

Several historical accounts of 300 Area activities and an evaluation of their impact are available. Other documents pertain to a variety of topics regarding the 300 Area hydrogeology. Brief synopses of several of the more important documents are provided in the following paragraphs.

3.1.1 Historical Data from Hanford Ground-Water Monitoring

A report by Clukey in 1954 tabulated the radioactive liquid-waste disposal facilities at Hanford including four in the 300 Area. One was known to have received solvents. Clukey also produced a document that same year that discussed the three liquid-waste streams containing low concentrations of radioactive material. The following three sources were discussed: 1) the process sewer stream from the Metal Preparations Facility (Building 3706), the 321 Building, and miscellaneous buildings; 2) the works laboratory area discharge to retention basins east of the 300 Area; and 3) the chemical and metallurgical laboratories. Disposal practices were also discussed. The location and disposal practices in burial grounds, the liquid-waste disposal trenches, the ash trench, the old pond (now called south pond) and the new pond (north pond) are particularly interesting. Disposal of solutions of sodium aluminate resulted in the formation of gelatinuous aluminum hydroxide that precipitated and plugged the pond bottoms. On October 25, 1948, the rising water burst the dike on the northwest corner, and the pond liquid flowed down a natural channel and into the Columbia River. Subsequently the percolation was improved every year or two by dredging through the crust on the bottom of the ponds with a dragline. Also mentioned was the elimination of an explosion hazard by disposing of 5 to 10 gal/week of immiscible organic solutions into a stainless steel pipe laid down along the dike on the north side of the south pond.

A report by Paas in 1955 summarizes underground radioactive waste and contamination in the 300 Area and miscellaneous areas. The report documents

the disposal sites and the locations and quantities of some hazardous wastes including hexone and solvents in containers and drums.

A report on the percentage of dilution of the uranium wastes from the 300 Area facilities that enter the Columbia River indicates that during normal river stage, the wastes dilute to less than 1/500th of the concentration in the ponds by the time the wastes reach the Hanford boundary (Haney 1957). This dilution reduced the uranium concentration to background or near-background levels. The report indicates that all of the dilution occurred in the Columbia River. The study shows that the removal of uranium by soil adsorption mechanism and dilution via the ground-water system is negligible (Haney 1957). Haney notes that during high river-stage (May and June), a westward ground-water gradient forces river water into the unconfined aquifer as evidenced by the reduction in uranium concentrations in wells near the river and by increases in concentrations in wells west of the ponds. Ground-water velocity in the 300 Area is estimated to be approximately 15 ft/day.

In 1960 Haney also prepared a report on the functions and methods of operation of the 300 Area waste systems, and the characterizations of the wastes with respect to their chemical and physical properties. The report discussed the disposal of radioactive liquid wastes from the 300 Area laboratory facilities and included recommendations for improvement.

In 1967 an investigation of effluent control standards and practices of the 300 Area was published (Loe 1967). This report described the frequency, quantity, and concentrations of chemicals discharged to the process ponds and sewers. The effluent sources and routes were illustrated in the publication.

A few foundation investigation reports have been prepared for the largest structures in the 300 Area. Two of the most detailed and complete reports were the foundation investigations for Building 331 (Bestwick and Meese 1967) and Building 337 (Schwantes and Sibley 1970). Both field and laboratory data on soil characteristics were provided in these reports. Most of the soil boring data pertained to the eolian and Hanford formation, but one boring apparently was drilled into the middle Ringold member. Some detailed information on the variability and continuity of Hanford formation deposits was provided.

In 1982, a plume of ground water containing elevated concentrations of $\text{NH}_3 + \text{NO}_3\text{-N}$, fluoride, and sulfate reportedly existed near the Fuel Fabrication Facility of Exxon Nuclear Company, Inc., of Richland, Washington. The ground-water analysis of May 1982 indicated the plume to be approximately 500 ft across and 1000 ft long. In May 1982, concentrations in the plume ranged from 10 to 70 mg/l for nitrate, 1 to 17 mg/l for fluoride, and 50 to 423 mg/l for sulfate. Maximum concentrations in the plume exceeded federal drinking water standards of 45, 2.4, and 250 mg/l, respectively.

This plume is traveling in a northeast direction toward the 300 Area. The precise ground-water velocities in this area southwest of the 300 Area are unknown. However, based on the geology of this area and the hydraulic gradient, the ground water probably flows at a rate of 0.2 to 2.0 ft/day and will increase to approximately 20 ft/day as it enters the 300 Area. If this is true, then the more mobile constituents of the plume will migrate into the 300 Area in as little time as several years (late 1980s) or possibly not for decades (middle of the 21st century).

The impact of this plume upon entering the 300 Area will probably be minimal and may be at concentrations below current detection limits. Additionally, the impact on the water quality of the Columbia River would be less because of the dilution of spring water when mixed with the much larger volumes in the Columbia River. However, from a data-interpretation perspective, it is important to be aware that concentrations of these constituents will eventually enter the 300 Area.

An historical account of the 300 Area process ponds is provided by Price in a 1982 publication. The document provides a review of documents including old Hanford Works^(a) reports and correspondence. Information was reviewed on the types and amounts of potentially hazardous materials sent to the ponds and the movement of materials away from the immediate environs of the ponds. The

(a) Hanford Works was one of the former names for what is now referred to as the Hanford Site.

results of this review showed that large quantities of radioactive wastes, primarily uranium, and nonradioactive wastes, such as sodium aluminate and copper-bearing solutions were sent to the ponds for disposal. The review also showed that, to some extent, the disposed material has moved away from the ponds. There were two major factors that caused the migration of the material from the ponds: a large quantity of water with variable pH was disposed of in the ponds and because of poor infiltration into the ponds caused by the accumulation of insoluble materials on the pond bottoms, the material was scraped from the bottom and deposited along the dike or used elsewhere as fill.

Reports soon to be released will include chemical and hydrogeological information on the 300 Area process trenches and the process ponds. The information will discuss the geology of the process trenches by R. E. Brown based on an interpretation of historical data and an investigation that included sediment samples, soil borings, and the installation of one monitoring well (1-19) between the process trenches.

Excluding the quarterly progress reports (PNL 1987a, 1987b, 1987c), one of the most comprehensive studies of the 300 Area is the geohydrology and ground-water quality report on the 300 Area (Lindberg and Bond 1979). These reports reference many of the documents previously cited.

A number of wells have been installed in and around the 300 Area since the 1940s. Drillers' logs exist for most of these wells and provide some useful information for describing the local hydrogeology. Information concerning the extent of radionuclide and chemical movement has been provided by past ground-water monitoring efforts in the 300 Area. A study in the late 1940s of the hydrogeology and radionuclide movement beneath the 300 Area, based on water levels, ground-water temperatures, and radionuclide concentrations, revealed that the ground-water system was being influenced by Columbia River fluctuations. Periods of high river stage during spring floods were found to be causing a reversed gradient, resulting in the westward (or inland) movement of ground water containing radionuclides (Haney 1957). The maximum detected westward penetration of the radionuclides was to wells 8-1 and 8-3 (Lindberg and Bond 1979), although significant head changes occurred up to 2 to 2.5 mi from the river. This study provided information on the nature and extent of

radionuclide movement; however, the chemical constituents being analyzed for the current RCRA compliance monitoring effort may behave differently in the ground water. Also, the construction of several dams, and the management practices at the dams along the Columbia River have changed since the 1940s and 50s, and high river-stage effects are minimized.

Further knowledge concerning the movement of dangerous waste constituents in the ground water in the 300 Area has been provided by special monitoring following two unplanned releases of PCE, a solvent used in equipment cleaning operations. Both releases resulted from the accidental discharge of PCE to the trenches. Following each release incident, samples were collected from nearby monitoring wells to track the movement of the PCE in the ground water.

After the two releases occurred, (one in 1982 and the other in 1984), sampling began in wells closest to the trenches after 4- and 5-day periods, respectively. As the PCE was transported away from the trenches, the sampling network was changed to track the plume's leading edge. Monitoring of the concentration of the solvent was continued for 4 months. In both incidents, the highest concentrations of PCE were found in the wells closest to the trenches and downgradient (in the direction of water movement) from them. Samples were collected from both the Columbia River and from a spring at the river's edge in the 300 Area. The samples showed that low levels of PCE had reached the spring and the river sampling sites approximately 35 days after a spill occurred. Movement of the peak concentration was estimated at 35 ft/day (Cline et al. 1985).

Results from monitoring the spill indicate that the ground water beneath the 300 Area has been affected by wastes discharged to the 300 Area process trenches. The extent of the area affected was approximately defined by the results from previous studies of uranium leaks and from the PCE spills. A full description of the area affected by hazardous wastes will be made when further monitoring and evaluation are completed.

3.1.2 Interim-Status Work

The DOE prepared plans for an interim-status ground-water monitoring program for the 300 Area process trenches in February 1985. This facility-specific effort was based on the ground-water monitoring requirements in USEPA 1984 (40 CFR 265.90) and those in Washington State's regulations [Washington State Department of Ecology 1986 (WAC 173-303-400)], as well as on the results of past monitoring conducted in the 300 Area. The program was designed to be an assessment-level ground-water monitoring program, which is required when the facility being monitored is known to have or is suspected to have contaminated the uppermost aquifer, as opposed to a detection-level program. This effort, named the RCRA Compliance Ground-Water Monitoring Project, which was initiated for the 300 Area process trenches, began in June 1985 and has continued to the present.

Initial plans for the RCRA Compliance Ground-Water Monitoring Project were presented by the DOE in a document entitled Hazardous Waste Ground-Water Monitoring Plan (DOE 1985b). Implementation of these plans occurred in June 1985, when monthly sampling of the 16-well network was initiated. In response to discussions with the Washington State Department of Ecology and USEPA Region 10, the assessment level ground-water monitoring program was expanded. A revised plan was developed and implemented in September 1986 (Schalla et al. 1986). Details of this expanded effort are presented in Section 4.0.

The 16-well network used for this project consists of 14 existing shallow wells in the 300 Area and two new wells (one a somewhat deeper well). Two of the wells in the network, 699-S19-E13 and 399-8-2, are included because they are upgradient of the trenches. The locations of these wells and the trenches are shown in Figure 3.3.

Most of the existing (pre-1986) wells used for monitoring are constructed of carbon steel and have perforations rather than screens. Some of the existing wells that were constructed in the last several years in the 300 Area have stainless steel screens, and one has a stainless steel casing. Recent work conducted on the Hanford Site under a special field investigation has shown that within the limitations of this study (i.e., for selected volatile organic chemicals at one field location), the different construction materials used in

FIGURE 3.3. Monitoring Well Network for Water Chemistry Data During 1985 and 1986

these wells did not, under field conditions, significantly affect the analytical results obtained for ground-water samples collected from them (Liikala et al. 1988).

Almost all wells, both old and new, were emplaced using a cable-tool drilling rig and most of them are either 6 or 8 in. in diameter. The monitoring wells have been maintained and repaired regularly to keep them as useful sampling structures. This maintenance consists of periodically swabbing or cleaning out the wells and visually inspecting them by means of a downhole television camera.

Six of the 16 wells have stainless steel screens and the other 10 have perforated casings. Most of the wells are open at the top of the aquifer; well 1-8 was drilled to the top of the first clay layer specifically to check for the possible presence of solvents or other dense materials at deeper levels. Fourteen of the 16 wells have completion intervals that are roughly equivalent, although the length of water columns and open intervals do vary. The remaining two wells are completed in a deeper interval. All 14 wells are open at the upper portion of the aquifer and are designed to accommodate the water table fluctuations that occur in the area.

For the interim-status monitoring program, each well has two pumps: a submersible pump used for purging the well and for collecting samples to be analyzed for constituents that are not affected by air stripping, and a Teflon® bladder pump used for collection of samples that will be analyzed for volatile organics. Both pumps are located near the top of the water column, except in the deep well, 1-8. Monitoring-well installation details and geologic logs for these wells are contained in Appendix A.

Some of the existing wells near the 300 Area process trenches have been used for the interim-status program because they were considered to be suitable sampling structures, and were in proper locations. New wells have been installed where needed for adequate monitoring.

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Water level measurements, in addition to those taken in the sampled wells, are made once every month from a network of selected wells located in and around the 300 Area. The data obtained from this effort are entered into the data base and are used to construct water table maps and to determine ground-water flow directions. They will also be used in modeling. These scheduled measurements were begun in February 1985. The 32 wells included in the original network were:

699-S19-E13	399-1-5	399-3-2	399-4-7
699-S27-E14	399-1-6	399-3-6	399-4-9
699-S29-E12	399-1-7	399-3-7	399-4-10
699-S30-E15A	399-1-8	399-3-9	399-5-1
399-1-1	399-2-1	399-3-10	399-8-1
399-1-2	399-2-2	399-3-11	399-8-2
399-1-3	399-2-3	399-3-12	399-8-3
399-1-4	399-3-1	399-4-1	399-8-4

The locations of these wells are shown in Figure 3.4. Information on sample treatment and analysis is contained in Section 4.1, "Description of the Sampling and Analysis Effort."

3.2 GEOLOGY OF THE 300 AREA

This section focuses on the principal lithologic units, distribution, and thicknesses of the geologic formations beneath the 300 Area, with emphasis on the area near the process trenches. Interpretation of the lithologic units is based on sediment sample descriptions from both new and existing wells. An accurate understanding of these units is necessary in defining ground-water movement and transport near the process trenches. Geologic information contained within this section is, therefore, preliminary and may need refinement pending laboratory analysis of recent drilling samples and further research of wells drilled before the RCRA ground-water monitoring project.

Three major stratigraphic formations were encountered during drilling operations at the 300 Area site. The three formations, in ascending order, are the Saddle Mountains Basalt Formation, Ringold Formation, and the Hanford formation (informal name). The geologic log for well 399-1-16C (Figure 3.5) is

FIGURE 3.4. Original Water Level Monitoring Network

FIGURE 3.5. Geologic Log for Well 399-1-16C

typical of wells penetrating these three formations. Quaternary eolian deposits form a thin veneer (0 to 15 ft thick) over most of the site. Two cross sections, A-A' and B-B', shown in Figure 3.6 illustrate the distribution and stratigraphic correlations between the principal geologic units. A location map for these cross sections is found in Figure 3.7.

A discussion of each stratigraphic formation follows. Further references to depth in this chapter are given in feet below land surface, with elevation given in feet above mean sea level (MSL). The study site, as mentioned in this section, refers to the area immediately surrounding the newly drilled 300 Area RCRA wells.

3.2.1 Saddle Mountains Formation

The Saddle Mountains Basalt is the uppermost formation of the Columbia River Basalt Group. This formation was encountered in wells 399-1-9, 399-1-16C, 399-1-16D, 399-1-17C at an average elevation of 207 ft above MSL. Geologic samples collected during drilling were characterized as dark gray to black basalt mixed with gray clay and caliche. At well 399-1-18C, basalt was encountered at a higher elevation (240 ft above MSL) and was characterized as being very dark gray and mixed with clay and caliche. Samples from both areas exhibited a scoriaceous texture with iron stains and sulfide mineralization on the surface of the basalt drill cuttings.

The x-ray fluorescence analysis of basalt cuttings from wells 399-1-9, 399-1-16C, and 399-1-17C indicates that the uppermost basalt flow underlying these localities is the Martindale flow of the Ice Harbor Member. The analysis of basalt cuttings taken from well 399-1-18C indicates the Goose Island flow is the uppermost basalt flow beneath the north portion of the study site. The Goose Island flow is also of the Ice Harbor Member and is stratigraphically younger than the Martindale flow. The presence of this younger flow explains why basalt was encountered at a shallow depth in well 399-1-18C. The presence of the Goose Island flow is consistent with Myers and Price (1981) who reported that the flow was at well DC-15 (north of the study site) but was missing at well DDH-3 located south of the study site. Apparently the Goose Island flow is controlled by the flow front of the older Martindale flow (Myers and Price

1981), and terminates somewhere north of the process trenches. Details of the x-ray fluorescence analysis are presented in Appendix B.

3.2.2 Ringold Formation

The Saddle Mountains Basalt is overlain by the Ringold Formation. The Ringold Formation was partially or fully penetrated in all 18 new wells. In this location, the Ringold is composed of the basal, lower, and middle units.

Newcomb et al. (1972) summarized the main distinctions between the Pasco gravels and the underlying Ringold Formation. The Pasco gravels are basaltic in both the sand and the gravel fractions; generally less compacted, less indurated, and more permeable than the Ringold Formation; and the gravels show no appreciable alteration. The Ringold Formation sands, however, are composed primarily of quartz; the gravels include such exotic rock types as granite, volcanic porphyry, and quartzite, and may show alteration rinds up to one-eighth in. thick. In general, the Ringold sediments contain more silt and clay, even in the gravels.

3.2.2.1 Basal Ringold

The basal Ringold was encountered in wells 399-1-9, 399-1-16C, 399-1-16D, 399-1-17C, and 399-1-18C and is chiefly characterized as a well-consolidated clayey sand to a gravelly sand that varies in thickness from 2 to 5 ft in the central and southern portion of the study site, to 17 ft in the northern section above the Goose Island basalt flow (see Figure 3.6). The clay fraction of this unit appears to be transitional from the overlying clay-dominated lower Ringold unit. The sand is primarily basaltic with some quartz and feldspar, and ranges from very fine to medium sized grains. The gravel fraction, only found in well 399-1-18C, is dominantly basaltic with some granitic, quartzitic, and other metamorphic clasts. Calcium carbonate in the form of caliche is found locally at the basal Ringold-basalt contact.

3.2.2.2 Lower Ringold

The overlying lower Ringold unit was partially or fully penetrated in eight of the new wells. Samples collected in this unit are characterized as bluish-green clay, which gradually changes to brown clay/silt with depth. Very fine grained sand and silt stringers were locally evident within the study site. The

FIGURE 3.6. Cross Sections A-A' and B-B-

FIGURE 3.7. Location Map of Cross Sections A-A' and B-B'

unit is 60 ft thick in the eastern portion of the site at well 399-1-16C and significantly thins to 17 ft above the Goose Island flow at well 399-1-18C.

3.2.2.3 Middle Ringold

The middle Ringold unit forms the top of the Ringold Formation beneath the 300 Area. This unit was partially or fully penetrated in all of the 18 new wells. This unit is characterized as moderately to well consolidated, brown-to-gray sandy gravel with local silt and sand lenses. The gravel fraction is represented by subangular-to-subrounded, pebble-to-cobble-sized clasts of basaltic, granitic, and metamorphic compositions. Although it appears to be a variable phenomena, a decrease in the percentage of basalt clasts is generally a useful tool in marking the contact between this unit and the overlying Hanford formation. Clast surfaces are moderately altered showing evidence of chloritization. The sand and silt are composed of quartz, feldspar, and mica with some basaltic and metamorphic rock fragments. The sand fraction is dominantly very fine to very coarse grained. This basaltic sedimentary unit is relatively consistent over the entire study site, differing only 21 ft from the thinnest section at well 399-1-9 (65 ft thick) to the thickest portion at well 399-1-16C (86 ft thick). The surface of the middle Ringold unit appears to be an irregularly shaped erosional surface. Wood fragments were found in the area immediately south and east of the process trenches in wells 399-1-9, the 399-1-16 well cluster, and the 399-1-17 well cluster. The elevation of the wood horizon in these locations ranges from 295 to 315 ft above MSL. Efforts are underway to correlate the wood horizon over the entire 300 Area.

3.2.3 Hanford Formation

Overlying the Ringold Formation is the unconsolidated, poorly sorted sediments of the Hanford formation. The composition of this formation is characterized as dark grayish-brown to dark olive-gray sandy gravel with some silt and local sand stringers. The upper portion of the unit generally exhibits a pebble-to-boulder gravel which grows finer with depth to a very fine-to-medium pebble gravel. The gravels of this unit are composed mainly of subangular-to-rounded basaltic clasts and also include a few quartz-rich and metamorphic clasts. The sands vary highly in composition but are predominantly basaltic. Calcium carbonate deposits were noted on clast surfaces especially in the upper

portion of the unit. Lenses of gravelly sand and pure sand were noted locally; however, no cross-borehole correlations were evident. The thickness of the unit is quite varied, ranging from 81 ft thick at well 399-4-11 in the southern-most portion of the study site to 21 ft thick at well 399-1-10 in the central portion. Carbon-14 age dating has been performed on wood samples from wells 399-1-16D and 399-1-17B. The contact with the middle Ringold unit is determined by using particle size and by evidencing a predominance of basaltic sediments.

Excavation in the 300 Area in 1958 disclosed the presence of a paleo-channel incised into the Ringold Formation beneath the 300 Area (Lindberg and Bond 1979). The channel is filled with glaciofluvial sediments and separated from the present channel by a levee of relatively less permeable Ringold sediments. The paleochannel has been confirmed by more recent drilling logs, samples, and aquifer tests, and this paleochannel merges with the Columbia River somewhere north of the 300 Area and exits near the south end of the 300 Area.

3.2.4 Eolian Deposits

Overlying the Hanford formation in most areas of the study site is a thin veneer of fine-to-coarse-grained, eolian (wind transported) sand deposits. The thickness of this deposit is quite varied over the study site, ranging from 0 to 2 ft in the 1-16 well cluster to nearly 15 ft in the 1-18 well cluster. The lack of these deposits at some well locations is a result of their removal from areas during construction activities at Hanford over the last several decades. The geologic contact between the eolian deposits and the underlying Hanford formation is quite distinct.

3.2.5 Structure of the 300 Area

The 300 Area lies above the axis of the northwest-southeast trending Pasco Syncline shown in Figure 3.8. The syncline plunges gently northwestward toward the structural low of the Pasco Basin about 10 mi to the northwest of the 300 Area. The basaltic bedrock surface along the synclinal axis beneath the 300 Area dips toward the northwest at a gradient of 25 ft/mi or about 0.25 degree.

FIGURE 3.8. Location Map of the Pasco Syncline

Part of this dip may be related to the thinning and pinching out of the basalt flows, and the true dip of the individual flows may be slightly less than 0.25 degree.

Ringold Formation sediments generally have dips similar to the underlying basalt; however, slightly lower dips prevail upward in the section. Gently dipping Ringold Formation strata are also apparent in the southern end of the White Bluffs. Beneath the 300 Area, less than a mile from the White Bluffs, the dips are even lower.

3.3 300 AREA HYDROLOGY

Both unconfined and confined aquifers are present beneath the 300 Area. The uppermost aquifer is unconfined; underlying aquifers are contained in the basal member of the Ringold Formation and the basalts, and are generally confined.

3.3.1 The Confined Aquifer

The confined aquifers in the basalts consist primarily of permeable zones at the contacts between basalt flows. The permeable zones, or interflow zones, are zones of fractured, jointed, brecciated vesicular basalt that occur at the upper and/or lower surfaces of the individual basalt flows and are the primary conduits for ground water. Sand or gravel interbeds may also be present in the interflow zones and serve as conduits for ground water. These aquifers are confined by the largely impermeable central or interior part of the basalt flows and by the low permeability siltstones and claystones of the interbedded sediments. The confined aquifer in the 300 Area referred to in this report is the sandy gravels of the basal member of the Ringold Formation that are probably hydraulically interconnected to the uppermost confined basalt aquifer.

Much of the area near the axis of the Pasco Syncline is considered to be a discharge area for the confined aquifers, with ground water flowing upward from the uppermost basalt aquifers into the overlying unconfined sedimentary aquifer (Gephart et al. 1979). Well 5-2, near the 300 Area in a confined basalt aquifer, illustrates this; the water level is less than 10 ft from the land surface, whereas, nearby wells in the unconfined aquifer typically have depths to

water of 40 to 45 ft. The potential for the trenches to affect the basalt-confined aquifers is believed to be negligible because of the upward vertical gradient from the basalt aquifers and because of the 17-to-60-ft-thick unit of low-permeability clay and silt of the lower Ringold member that separates the unconfined aquifer from the confined aquifer. Transmissivities of the basalt member vary from 1.6 ft²/day to 100 ft²/day.

3.3.2 The Unconfined Aquifer

In the 300 Area, the water table (the upper surface of the unconfined aquifer) is in the glaciofluvial sediments of the Hanford formation. The lower part of the unconfined aquifer is the middle member of the Ringold Formation and may be partially confined by thin interbeds of silt and clay. The water table is at a depth of about 40 ft below the land surface, and the top of the Ringold Formation is at a depth of 35 to 65 ft.

Based on drilling logs, the Hanford formation (glaciofluvial sediments) in the 300 Area consists of unsaturated sandy gravel with few cobbles and boulders in the upper half of the unit and saturated sandy gravel with more cobbles and boulders in the lower half. The glaciofluvial sediments, as reported in the drilling logs, vary from 30 to 85 ft in thickness, with a typical value for the trench area of from 32 to 50 ft. In the vicinity of and beneath the trenches, the saturated thickness varies from 0 to 15 ft. The transmissivity based on previous aquifer tests is consistently high, varying from 40,000 to 102,000 ft²/day. Most of the transmissivity in the unconfined aquifer in the 300 Area has been attributed to the glaciofluvial sediments; however, more recent tests indicate that the transmissivity attributable to the uppermost middle Ringold member is similar, varying from 10,000 to 200,000 ft²/day.

Transmissivities in the lowermost 10 to 15 ft of the middle Ringold member range from 8 to 30 ft²/day for partial penetrating test wells and 150 to 200 ft²/day for observation wells screened in the same interval.

Ringold Formation sediments, consisting of saturated silt, clay, sand, and gravel, are not well defined hydrogeologically in the existing drilling logs for the 300 Area. The sand and gravel layers usually contain some silt, which probably reduces the transmissivity of the coarser sediment, but there are no

measured transmissivities or hydraulic conductivities in the formation. The Ringold Formation is approximately 200 ft thick beneath the 300 Area.

The stratigraphy of the Ringold Formation and overlying units, based on drilling records, is shown in Figure 3.9. The upper portion of the middle Ringold member near the trenches contains only a thin, discontinuous silt layer approximately 0.5 to 10 ft thick. The limited data on hydraulic head indicate that the upper sandy gravel layer (even below the silt lens) has good hydraulic interconnection with the Hanford formation. The lower Ringold sandy gravel is believed to be semiconfined, beneath portions of the Hanford Site, by layers of silt and clay that act as aquitards.

Natural recharge of the unconfined aquifer beneath the Hanford Site occurs at the northwest margin of the Pasco Basin. An artificial recharge occurs at the 200 Area near the center of the Site. Ground water flows from these recharge areas toward the 300 Area in a general southeasterly direction. In the southeast corner of the Hanford Site, ground-water recharge is mainly from the Yakima River. The 300 Area is located approximately at the point where these two ground-water sources meet. As a result, ground water enters the 300 Area from the northwest, west, and southwest (Lindberg and Bond 1979).

Water level measurements collected on a monthly basis from a network of wells (49 wells as of March 1987, as shown in Figure 3.8) located in and around the 300 Area have been used to produce a series of recent (1985-86) water table maps with water level contours and arrows indicating approximate flow directions. Four maps, one each for 1985 and 1986, and two for 1987, are shown in Figures 3.10 through 3.13. All of the water level contour maps including these are presented in large sized (foldouts) in Appendix C. Tables summarizing all water level data are also presented in Appendix C.

Near the trenches, ground water generally flows toward the river to the southeast and east as shown in Figures 3.10 and 3.11. The exact direction of ground-water flow at any given time is determined by both natural and man-caused influences. The primary natural influence is the level of water in the Columbia River. Lindberg and Bond (1979) verified that when the river stage rises during spring run-off, bank storage occurs and causes a reversed water table gradient in the 300 Area. During these times, ground water tends to flow

Not to Scale

FIGURE 3.9. General Stratigraphy of the 300 Area

FIGURE 3.11. Water Level Contour Map of the Unconfined Aquifer, August 1986

FIGURE 3.12. Water Level Contour Map of the Unconfined Aquifer, April 1987

in a more southerly direction, roughly subparallel to the river as shown in Figure 3.12. When the river level drops, the natural gradient is restored and ground water flows more easterly in a direction nearly perpendicular to the river. Effects of river fluctuations are dampened with distance from the river as shown in the hydrographs of wells (see Figure 3.14).

Lindberg and Bond (1979) suggest that the former river channel (paleo-channel) discovered in 1958 is responsible for the rapid response of the ground-water levels and contaminant movement to changes in the hydraulic gradient, because the Pasco Gravels within the channel are more permeable than the surrounding Ringold Formation. The former channel extends north and south of the 300 Area, and a breach in the natural levee separating the old channel and the current Columbia River channel has been proposed to account for the higher flow rate between the trenches. Probably many breaches and few barriers separate the channels as evidenced by irregular water level contours along the river bank, shown in Figure 3.10 at lower water levels and Figure 3.12 at higher water levels.

The primary man-caused influence on ground-water levels and flow direction in the 300 Area is from the trenches, which receive approximately 3.0×10^6 gal of waste water per day. This large volume of process water percolates quickly to the ground water and creates a small ground-water mound on the water table surface under the trenches. The mound increases the water table gradient and produces divergent flow around the process trenches as was shown in Figure 3.13 during steep (2-ft) and rapid (24-hr) declines in river level. Lindberg and Bond (1979) stated that during the winter months, water standing in the process trenches becomes quite cold and cools the ground-water temperature to a few degrees (4°F) cooler than ground water elsewhere in the area. Only one trench is used at a time. An alternation of discharge between the east and west trench occurs every few months.

Before the current series of aquifer tests, some aquifer tests had been conducted in wells in the 300 Area, although none of the wells were pumped for more than 8 hours. Calculated transmissivities based on recovery data from these tests vary from 40,000 ft²/day at well 8-2 to 102,000 ft²/day at well 8-1. At well 1-4, transmissivity was calculated to be 65,400 ft²/day. Additional data on more recent aquifer tests can be found in Appendix D.

ELEVATIONS FOR APRIL

(START 3/27/87 0800)

3.33
ELEVATIONS

TIME IN DAYS

— 1-10

— 1-13

— 1-16A

— 1-17A

— RIVER

FIGURE 3.14. Hydrograph of Water Levels for the Columbia River and Four Wells During April 1987

4.0 ASSESSMENT INVESTIGATION

Routine sampling and analysis of the ground water has been conducted for this facility on a monthly basis since June 1985. Until the recent expansion, the monitoring network consisted of 16 wells (Figure 3.3). Two of the wells in this original network, 8-2 and S19-E13, are considered to be upgradient of the facility and the remaining 14 wells in the original monitoring network are downgradient of the trenches. Details of well construction and pump placement for these 16 wells are contained in Appendix A.

4.1 DESCRIPTION OF THE GROUND-WATER SAMPLING AND CHARACTERIZATION EFFORT

The expansion of the monitoring network through the installation of 18 new wells, as detailed in the Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches (Schalla et al. 1986), was initiated in September 1986 and completed in February 1987. The new monitoring network consists of 34 sampling wells. Locations of the 18 new monitoring wells, in addition to the 16 original wells, are shown in Figure 4.1. The 18 new monitoring wells and one observation well (1-16D) (shown in Figure 4.2) consist of nine single wells and three well clusters, with each cluster having three wells. Upon completion, each new well was developed, and sampling was delayed for a short time to allow geochemical equilibration. Piston-type sampling pumps were ordered for the wells as soon as completion depths were known and pump settings could be determined. Once the pumps were installed, tested, and functioning properly, they were added to the sampling network. One additional well (1-16D) was installed for the observation of aquifer tests only; monthly water levels and routine ground-water samples will not be collected from this well. The 16 original monitoring wells continue to be sampled with a combination of two dedicated pumps, a submersible pump, and a Teflon® bladder pump (Schalla et al. 1986). Table 4.1 summarizes information on each of the 18 new wells, including temporary well name, permanent well name, completion date, and month of first routine sampling. Summaries of well installation and field hydro-geologic characterization efforts are presented in Section 4.2. Additional details of well construction and pump placement can be found in Appendix A.

TABLE 4.1. New 300 Area Monitoring Wells for Process Trenches

<u>Temporary Well Name</u>	<u>Permanent Well Name</u>	<u>Completion Date</u>	<u>Month of First Sampling</u>	<u>Pump Intake Below Top of Casing (ft)</u>
S1	399-4-11	11-26-86	2-87	67
S2	399-1-9	2-12-87	3-87	62
S3	399-1-10	12-23-86	2-87	37
S4	399-1-11	11-20-86	2-87	42
S5	399-1-12	11-3-86	2-87	52
S6	399-1-13	11-5-86	2-87	52
S7	399-1-14	11-14-86	2-87	42
S8	399-1-15	11-7-86	2-87	42
C1A	399-1-16A	12-5-86	3-87	47
C1D	399-1-16B	2-10-87	3-87	62
C1B	399-1-16C	1-16-87	3-87	62
C2A	399-1-17A	11-13-86	2-87	42
C2B	399-1-17B	12-19-86	3-87	62
C2C	399-1-17C	1-16-87	3-87	62
C3A	399-1-18A	11-12-86	2-87	52
C3B	399-1-18B	1-23-87	3-87	62
C3C	399-1-18C	1-6-87	3-87	62
I-3	399-1-19	5-23-86	3-87	42
C1C	399-1-16D	1-29-87	(a)	None

(a) Observation well currently dedicated to water level measurements; not being routinely sampled at present time.

Sample collections were performed at all 34 wells on a monthly and bimonthly basis in FY 1987. Nine of the new wells were first included in the sampling network in February 1987 (see Table 4.1); the remaining nine new wells were first included in the sampling network during the March 1987 sampling period. Draft procedures were developed for use with the piston-type pumps, and sampling personnel were trained in their use; the procedures will be incorporated into the appropriate PNL procedures manual once they are finalized and approved. For all wells, samples were collected only after 1) removal of three borehole volumes of water from the well, and 2) observed stabilization of pH,

specific conductance, and temperature. Samples were preserved, as appropriate, upon collection. Chain-of-Custody procedures were followed on all samples collected. Additional details of sample collection techniques and chain-of-custody procedures can be found in a previously issued report (Schalla et al. 1986).

All analytical work continues to be performed at the local facility of the United States Testing Company, Inc. (UST). Most of the ground-water samples are analyzed monthly for a standard list of constituents developed for this project (Table 4.2). This list was compiled on the basis of 1) instructions given in USEPA guidance documents, and 2) information provided by the facility manager concerning the composition of the wastes. According to the USEPA guidance document regarding assessment-level programs (USEPA 1984), analyses must be conducted for the parameters in the Primary Drinking Water Standards and for the specific dangerous waste constituents known to have been discharged to the facility. This guidance was deemed applicable for the alternate ground-water monitoring program being conducted, and the list in Table 4.2 was compiled accordingly. Additional parameters, such as the contamination indicators that are required for a detection-level program (but not necessarily for an assessment-level program), have been added to provide consistency with other interim-status programs at Hanford. These additional parameters, however, are measured only once for each sample and are not replicated four times as they would be under a detection-level program.

On a quarterly basis, samples from two wells in the network are also analyzed for some additional parameters, including the dangerous waste constituents in WAC 173-303-9905 (Washington State Department of Ecology 1986). These extra analyses, listed in Table 4.3, provide information needed for the permitting process and further ensure that potential contaminants are not being overlooked. The two wells being analyzed for these additional parameters include one upgradient well (S19-E13) and one downgradient well (399-1-3). In order to determine if samples from any of the new wells may have unexpected contamination, the additional analyses (Table 4.3) will be conducted on samples from these wells once during one of the first few months of sampling. If concentrations of any of these additional constituents should be measured above detection levels, those constituents will be added to the standard list.

TABLE 4.2. Standard List of Analyses for the 300 Area Network

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
Barium			6
Cadmium			2
Chromium			10
Silver			10
Sodium			100
Nickel			10
Copper	P, HNO ₃ to pH<2	SW-846, #6010	10
Aluminum			150
Manganese			5
Iron			50
Calcium			50
Zinc			5
Arsenic	P, HNO ₃ to pH<2	SW-846, #7060	5
Mercury	P, HNO ₃ to pH<2	SW-846, #7470	0.1
Selenium	P, HNO ₃ to pH<2	SW-846, #7740	5
Lead	P, HNO ₃ to pH<2	SW-846, #7421	5
Nitrate			500
Sulfate	P, None	70-IC ^(e,f)	500
Fluoride			500
Chloride			500
Cyanide	P, NaOH to pH>12	SW-846, #9010	10
Sulfide	P, zinc acetate + NaOH to pH>9	SW-846, #9030	1000
Radium	P, HNO ₃ to pH<2	EPA Method #903.0	1 pCi/L

- (a) P = plastic, G = glass.
(b) All samples will be cooled to 4°C upon collection.
(c) Constituents grouped together within brackets are analyzed by the same method.
(d) Detection limit units except where indicated.
(e) In-house analytical method.
(f) IC = ion chromatography.
(g) Analyzed quarterly on selected wells.
(h) From UST Procedure Manual, UST-RD-PM-9-80 (Hembree et al. 1986).
(i) Analyzed on quarterly basis only.
(j) MPN = most probable number.
(k) DAI = direct aqueous injection.

TABLE 4.2. (contd)

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
Gross Alpha	P, HNO ₃ to pH<2	EPA Method 680/4-75-001	4 pCi/L
Gross Beta	P, HNO ₃ to pH<2	EPA Method 680/4-75-001	8 pCi/L
Natural Uranium ^(g)	P, HNO ₃ to pH<2	20-U-03 ^(h)	4 pCi/L
Strontium-90 ^(g)	P, HNO ₃ to pH<2	20-Sr-02 ^(h)	5 pCi/L
Gamma scan ^(g)	P, HNO ₃ to pH<2	30-GS & 40-07 ^(h)	20 pCi/L (Cs)
Total Organic Halogen	G, no headspace	SW-846, #9020	100
Total Organic Carbon	G, H ₂ SO ₄ to pH<2	Std. Methods #505	1000
Ammonium ion	G, H ₂ SO ₄ to pH<2	Std. Methods #417 A-E	50
Hydrazine	G, None	70-DAI ^(e,k)	3000
Endrin	G, None	SW-846, #8080 ⁽ⁱ⁾	1
Methoxychlor			1
Toxaphene			1
Lindane (4 isomers)			1
2,4-D	G, None	SW-846, #8150 ⁽ⁱ⁾	1
2,4,5-TP silvex			1

(a) P = plastic, G = glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together within brackets are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) In-house analytical method.

(f) IC = ion chromatography.

(g) Analyzed quarterly on selected wells.

(h) From UST Procedure Manual, UST-RD-PM-9-80 (Hembree et al. 1986).

(i) Analyzed on quarterly basis only.

(j) MPN = most probable number.

(k) DAI = direct aqueous injection.

TABLE 4.2. (contd)

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
1,1,1-trichloroethane	G, no headspace	SW-846, #8240	10
Perchloroethylene			10
Chloroform			10
Methylene chloride			10
1,1,2-trichloroethane			10
1,1,2-trichloroethylene			10
Methylethyl ketone			10
Coliform bacteria	P, None	Std. Methods #908A	2.2 MPN ^(j)
Temperature	Field measurement	See Appendix B	0.1°C
Specific conductance	Field measurement	See Appendix B	1 µmho
pH	Field measurement	See Appendix B	0.01 pH unit

(a) P = plastic, G = glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together within brackets are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) In-house analytical method.

(f) IC = ion chromatography.

(g) Analyzed quarterly on selected wells.

(h) From UST Procedure Manual, UST-RD-PM-9-80 (Hembree et al. 1986).

(i) Analyzed on quarterly basis only.

(j) MPN = most probable number.

(k) DAI = direct aqueous injection.

4.2 DESCRIPTION OF THE WELL INSTALLATION AND HYDROGEOLOGIC CHARACTERIZATION EFFORT

Plans for the recent well installation and hydrogeologic characterization effort formed the basis for the results described in the remaining chapters of this document, therefore, an updated description of the work that was conducted, including information on modifications made in the field, is provided below.

TABLE 4.3. Additional Analytical Parameters

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
Beryllium			5
Osmium	P, HNO ₃ to pH<2	SW-846, #6010	300
Strontium			300
Antimony			100
Vanadium			5
Potassium			100
Thallium	P, HNO ₃ to pH<2	SW-846, #7840	200
Thiourea			200
1-acetyl-2-thiourea			200
1-(o-chlorophenyl) thiourea	G, None	SW-846, #8330 (modified)	200
Diethylstilbesterol			200
Ethylenethiourea			200
1-naphthyl-2-thiourea			200
N-phenylthiourea			200
DDD			1
DDE			1
DDT			1
Heptachlor			1
Heptachlor epoxide	G, None	SW-846, #8180	1
Dieldrin			1
Aldrin			1
Chlordane			1
Endosulfan I			1
Endosulfan II			1
Chlorobenzilate			100
2,4,5-T	G, None	SW-846, #8150	1
Perchlorate	P, None	70-IC ^(e,f)	1000
Phosphate			1000

(a) P = plastic, G = glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together within brackets are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) In-house analytical method.

(f) IC = ion chromatography.

(g) DAI = direct aqueous injection.

(h) Listed in Table E.1 of Appendix E.

(i) Listed in Table E.2 of Appendix E.

(j) GC/FID = gas chromatography/flame ionization detector.

TABLE 4.3. (contd)

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
Carbophenothion	G, None	SW-846, #8140	2
Tetraethylpyrophosphate			100
Disolfoton			2
Dimethoate			5
Methyl parathion			2
Parathion			2
Citrus red #2	G, None	AOAC #34.015B	1000
Paraldehyde	G, None	DAI ^(e,y)	3000
Cyanogen bromide			3000
Cyanogen chloride			3000
Acrylamide			3000
Allyl alcohol			3000
Chloral			3000
Chloroacetaldehyde			3000
3-Chloropropionitrile			3000
Cyanogen			3000
Dichloropropanol			3000
Ethyl carbamate			3000
Ethyl cyanide			3000
Ethylene oxide			3000
Fluoroacetic acid			3000
Glycidylaldehyde			3000
Isobutyl alcohol			3000
Methyl hydrazine			3000
n-propylamine			3000
2-propyn-1-ol			3000
1,1-Dimethyl hydrazine			3000
1,2-Dimethyl hydrazine			3000
Acetonitrile			3000

(a) P = plastic, G = glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together within brackets are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) In-house analytical method.

(f) IC = ion chromatography.

(g) DAI = direct aqueous injection.

(h) Listed in Table E.1 of Appendix E.

(i) Listed in Table E.2 of Appendix E.

(j) GC/FID = gas chromatography/flame ionization detector.

TABLE 4.3. (contd)

Constituent	Collection ^(a) and Preservation ^(b)	Method ^(c)	Detection Limit, ppb ^(d)
Tetrachloromethane			10
Xylene-o,p			10
Xylene-m	G, None	SW-846, #8240	10
Formaldehyde			500
Additional volatiles ^(h)			10
Hexachlorophene			10
Naphthalene			10
Phenol			10
Kerosene			10 ppm
Hexachlorobenzene			10
Pentachlorobenzene			10
1,2-Dichlorobenzene	G, None	SW-846, #8270	10
1,3-Dichlorobenzene			10
1,4-Dichlorobenzene			10
1,2,3-Trichlorobenzene			10
1,2,4-Trichlorobenzene			10
1,3,5-Trichlorobenzene			10
1,2,3,4-Tetrachlorobenzene			10
1,2,3,5-Tetrachlorobenzene			10
1,2,4,5-Tetrachlorobenzene			10
Additional semi-volatiles ⁽ⁱ⁾			10
Ethylene glycol	G, None	GC/FID ^(e,j)	10 ppm

(a) P = plastic, G = glass.

(b) All samples will be cooled to 4°C upon collection.

(c) Constituents grouped together within brackets are analyzed by the same method.

(d) Detection limit units except where indicated.

(e) In-house analytical method.

(f) IC = ion chromatography.

(g) DAI = direct aqueous injection.

(h) Listed in Table E.1 of Appendix E.

(i) Listed in Table E.2 of Appendix E.

(j) GC/FID = gas chromatography/flame ionization detector.

4.2.1 Technical Approach

A phased approach was adopted for expansion of the monitoring program and installation of 18 new monitoring wells around the 300 Area process trenches. The work discussed in this document represents the initial phase of well construction and characterization. With this phased approach, information

obtained from the installation, testing, and sampling of the new wells installed in 1986 and 1987 will be used to construct plans for any needed follow-up work. The first wells drilled were the deep wells of each cluster. This approach allowed for the definition of significant hydrogeologic units and the anticipation of geologic conditions at the remaining well locations. Details of field and laboratory efforts are contained in the Appendices. A general summary of activities is presented in the following paragraphs.

4.2.2 Methods

The new wells were constructed and completed in accordance with the well designs discussed in Appendix A. The well designs and locations were made in response to the initial conceptual model.

4.2.3 Well Installation Protocol

The general well installation protocol was as follows. All of the new wells were drilled by the cable-tool method. As the wells were being drilled, geologic samples were collected. Each well was geophysically logged upon completion. Aquifer testing was performed on some of the wells. Each well was constructed with stainless steel materials and sealed to the surface. Upon completion a Hydrostar^(a) piston-type sampling pump was installed in each well. These steps are discussed below.

4.2.3.1 Geologic Sampling

Geologic samples were collected at 5-ft intervals and at changes in formation during drilling operations. Soil moisture samples were collected above the water table when drilling with a drive barrel. Each sample was characterized by the well-site geologist and recorded on a drilling log. The collection and documentation of these samples were performed in accordance with the written procedures described in Appendix A.

Selected lithologic samples are currently being analyzed for the following: 1) grain size distribution, 2) soil moisture content, 3) soil moisture retention, 4) bulk density, 5) bulk porosity, and 6) hydraulic conductivity.

(a) The Hydrostar Sampling Pump is a product of Instrumentation Northwest, Inc., Redmond, Washington.

Soil moisture tests were limited to analyses associated with obtaining hydraulic conductivity. Samples were selected for these tests as follows:

- grain size distribution
 - performed on all samples from several wells as noted in Appendix B
- bulk density
 - performed on six to eight samples from each of the three deep wells
- bulk porosity
 - calculated from the bulk density values
- hydraulic conductivity
 - performed on a total of three split-spoon samples from deep wells.

In addition, x-ray fluorospectroscopy as performed on basalt cuttings to determine constituents from all four deep wells, and carbon-14 dating was performed on samples from two wells to determine the contact between the Hanford and Ringold formations. Most of these analyses have been completed and the interpretations of the results are now in progress. The data and interpretations will be reported when they become available.

4.2.3.2 Geophysical Logging

Each new well was logged with geophysical probes following completion. All of the wells were logged with the natural gamma, neutron, and density probes. In addition, the uncased interval within each of the three deep wells was logged with the caliper probe. Procedures for use of these probes are included in Appendix G, and the logs are presented in figures included in Appendix A.

4.2.3.3 Aquifer Testing

Aquifer tests were performed on selected wells during installation. The methods used and results obtained are described in Appendix D. However, a summary is presented on the following pages.

Between November 5, 1986, and March 5, 1987, thirteen 300 Area wells were tested to determine aquifer properties. All but one well tested were drilled for the 300 Area RCRA project. All wells were pumped at a constant-discharge rate and water levels were observed during both the drawdown and the recovery portions of the tests.

No water levels were measured in observation wells during the pumping of wells 1-10, 1-13, 1-14, and 1-18A. Both well 1-13 and 1-14 were screened in the Hanford formation (glaciofluvial materials). Although wells 1-10 and 1-18A (the top of the Ringold Formation in these wells do not correlate with that in either the intermediate or the deep wells in this cluster), were considered shallow wells, they were screened in the upper part of the Ringold Formation and water levels never rose above the Hanford-Ringold contact. All four wells were pumped at approximately 600 gpm. Transmissivity values were calculated to be approximately 110,000 ft²/day from testing well 1-13 and 200,000 ft²/day from testing well 1-14. Transmissivity values were approximately 1×10^6 ft²/day and 100,000 ft²/day calculated from tests conducted on wells 1-18A and 1-10, respectively. Data collected from well 1-10 were affected by the Columbia River.

Tests were conducted in two other shallow wells in addition to those mentioned above. Well 1-16A, apparently, was screened in the upper part of the Ringold Formation and the static water level was over 6 ft deeper than the Ringold-Hanford contact. This well was pumped at 30 gpm for 180 min. Well 1-3 is an older well, drilled in 1950, and is perforated in both the Hanford and Ringold Formations, at 25 to 44 ft and 54 to 70 ft below land surface datum (lsd). This well was pumped at approximately 230 gpm for 24 hours. Although observation wells were monitored during both tests, the water levels were not affected by pumping or they were masked by river effects. A transmissivity of approximately 10,000 ft²/day could be calculated from pumping well 1-16A. No transmissivity could be determined from pumping 1-3 because of the fluctuation of the discharge rate and, consequently, the fluctuations of the observed water levels.

Seven more aquifer tests were conducted on wells drilled to intermediate depths (just above the confining clay layer of the Ringold Formation) and

deeper depths (between the clay layer and the underlying basalt). Eight-hour pumping tests were used to determine the aquifer characteristics of the intermediate wells 1-17B and 1-18B, and of the deep wells 1-16C, 1-17C, 1-18C, and 1-9. A 13-hour and a 5-hour pumping test were conducted on the intermediate well 1-16B.

Transmissivities calculated from the tests indicated values of approximately 30 ft²/day for well 1-17B, 8 ft²/day for 1-18B, 7 ft²/day for 1-16C, 100 ft²/day for 1-17C, 8 ft²/day for 1-18C, and 1.6 ft²/day for 1-9. Observation wells that were measured during these tests were drilled to different levels and showed only small effects from the pumping of 1-16B. However, both 1-18B and 1-18C showed very similar characteristics, including specific capacities, heads, and transmissivities. These wells were completed in very similar parts of the Ringold Formation where the clay layer is thin and may not prevent or retard vertical leakage as is the case in other wells tested in the 300 Area.

Well 1-16B was pumped for over 8 hours because well 1-16D was completed in the same zone and could be used as an observation well. The other wells in the cluster, although monitored for changes in head during pumping, never reacted to the pumping of 1-16B. Well 1-16D did react to pumping, and water levels were drawn down over 3.5 ft during the second aquifer test (pumped at 20 gpm). Transmissivity for well 1-16B was calculated to be 20 to 60 ft²/day. The transmissivity of the observation well 1-16D was 150 to 200 ft²/day, which may be more indicative of the aquifer because of the drawdown in the pumped well caused by partial penetration and borehole effects. The river was also a factor in the testing of this well because recharge effects were apparent later in the tests. A storativity value was calculated from the Theis curve match of both the first and the second tests, the result was a storativity of 0.008. This number is more indicative of a semiconfined aquifer, which is possible because of the quick reaction of well 1-16D, located 28 ft from the pumped well.

4.2.3.4 Sampling Pump Installation

Piston-type sampling pumps, with the water intake located at the bottom of the pump, were installed in all 18 of the new wells. Once the pumps were

installed, tested, and functioning properly, the new wells were added to the sampling network. The 16 original shallow monitoring wells continue to be sampled with a combination of two dedicated pumps: 1) a submersible pump for purging the well and for collecting samples to be analyzed for nonvolatile constituents such as anions and metals; and 2) a Teflon® bladder pump for collecting samples to be analyzed for volatile, semi-volatile, and organic chemicals. Recent studies, although limited in scope, have indicated that the two different sampling systems now in use for this effort (i.e., piston pump and the submersible/bladder combination) should provide comparable monitoring results (Schalla et al. 1988). Appendix A provides information on the pump intake settings and initial depth to water for each well.

4.2.4 Well Locations, Design, and Construction

Three new well clusters and eight single shallow wells were recently installed in the 300 Area. Each well cluster consists of three wells, shallow, intermediate-depth and deep, located approximately 25 ft apart in a triangular arrangement. The single and shallow cluster wells are completed in the upper portion of the unconfined aquifer, the intermediate-depth wells are completed at the base of the middle member of the Ringold Formation, and the deep wells are completed within the basal member of the Ringold Formation. The purpose of well clusters was to obtain 3-dimensional data on likely horizons of interest. Three clusters were created downgradient and one upgradient of the process trenches. Single and cluster well locations are shown in Figure 4.1. Distribution of the single wells served more than one purpose including: determining flow direction particularly near the process trench ground-water mound; determining the distribution, concentration, and maximum extent of process water and associated constituents; and determining the effects of river fluctuations on flow patterns in the 300 Area. As-built diagrams, inspection logs and drilling logs for these wells are contained in recent publications (PNL 1987a and b). Detailed completion information for each well is provided in Appendix A.

4.2.5 Method of Determining Rate and Extent of Contaminant Movement

At sites where contaminants are known to have entered the ground water, as with the 300 Area process trenches, the regulations specified in 40 CFR 265.90 (USEPA 1984) require that the rate and extent of contaminant movement be

determined. The methods to be applied to the trenches for determining the rate and extent of contaminant movement are described in the following section on planned ground-water flow and transport modeling.

5.0 PLANNED GROUND-WATER FLOW AND TRANSPORT MODELING

Ground-water flow and contaminant transport in the vicinity of the 300 Area process trenches are being modeled to support the monitoring effort. The specific objectives of modeling are to 1) evaluate data collected for characterization of the hydrogeology beneath the trenches, and 2) assist with determining the rate and extent of contaminant movement. The model will also provide a mechanism for storing and integrating the information gathered on the geology and hydrology beneath the trenches.

Lindberg and Bond (1979) conducted a 2-year monitoring and modeling study of ground water beneath the 300 Area. The major objective of the study was to gain a thorough understanding of ground-water flow and the location, extent, and movement of ground-water contamination in the 300 Area.

The model of ground-water flow beneath the 300 Area was developed by Lindberg and Bond (1979) and was based on the Variable Thickness Transient (VTT) code. The model was calibrated to existing data on hydraulic head and estimates of transmissivity and was compared to measured water levels with time. The model demonstrated that the 300 Area ground-water system is influenced by changes in elevation of the Columbia River (controlled by Priest Rapids Dam upstream and McNary Dam downstream) and the large quantities of process waste-water discharged to the trenches. The model was also applied to predict flow paths and travel times from locations in the 300 Area to the Columbia River.

A model for contaminant transport based on the Multicomponent Mass Transfer (MMT) code was developed, calibrated, and used to predict movement of contaminants for a test case. The model was used to predict the concentrations of radionuclides arriving at the Columbia River with time.

The steps for modeling ground-water flow and contaminant transport beneath the 300 Area process trenches are listed below:

- reviewing previous work by Lindberg and Bond (1979)
- evaluating data collected during hydrogeologic investigation and ground-water monitoring at the trenches

- establishing a conceptual model of ground-water flow and contaminant movement
- developing and calibrating a numerical model
- applying the model to test our understanding of the hydrologic system.

The existing ground-water flow model for the Hanford Site will be applied to provide boundary conditions for a more detailed model of the ground-water flow system beneath the 300 Area.

The first step in modeling ground-water flow and contaminant movement beneath the trenches is to review previous modeling by Lindberg and Bond (1979). The data collected in the hydrogeologic investigation for the trenches are being compiled and reviewed to develop a conceptual model for ground-water flow and contaminant transport. The data that will be used to develop a conceptual model include geologic logs, aquifer testing data, water level maps, information on liquid discharges to 300 Area facilities including the trenches, and ground-water monitoring data.

A cross-section model from the trenches to the Columbia River is being developed. The cross-section model is based on geologic logs from wells drilled for hydrogeologic characterization, results of aquifer testing, and water level measurements. The cross-section model will be applied to determine whether the numerical model of the trenches should be two- or three-dimensional.

The ground-water flow model of the 300 Area will be developed from the conceptual model. The numerical model will be based on the Coupled Fluid, Energy and Solute Transport (CFEST) code (Gupta et al. 1982). The finite-element grid for the model will be constructed to reflect boundary conditions, the estimated distribution of hydraulic properties, the location and shape of discharge facilities, and the greater detail required near the trenches. The model will be developed in two or three dimensions, depending on the data collected during hydrogeologic characterization and the results of cross section modeling. The submodel will be calibrated with the estimates of transmissivity

determined from aquifer testing. The predicted hydraulic heads will be compared with measured hydraulic heads and the transmissivities adjusted to calibrate the flow model.

Following calibration of the ground-water flow model, the transport model will be established and applied to simulate one or both of the unplanned releases of PCE to the trenches which occurred in November 1982 and July 1984. The data from ground-water samples taken over time to track movement of the spills will be evaluated for application in the transport model. By simulating these spills, it may be possible to estimate the longitudinal and transverse dispersities.

The model will be applied to simulate ground-water flow and contaminant transport in the vicinity of the trenches. The predicted distribution of hydraulic head will be compared with the measured distribution over time. The comparison will help determine how well the model is performing and will help to obtain a measure of the level of understanding that exists for the ground-water flow system near the trenches. A similar comparison will be made for contaminant data that are available to determine how well the transport model is performing.

Once a correct understanding of the flow system has been demonstrated and the model is performing satisfactorily, the model will be applied to predict ground-water flow beneath the trenches and the 300 Area. Information from application of the transport model to simulating the PCE spill will be used along with the results of geochemical experiments, to provide data for predicting the transport of other contaminants. The design of the monitoring system, interpretation of aquifer test data, and design of other field tests will benefit from the ground-water flow and contaminant transport modeling. Modeling the extent of contamination and the rate of contaminant movement will help determine if any additional monitoring wells are needed beyond those already planned. River-level measurements, discharges to the process trenches, and transmissivities estimated by aquifer testing will be used with the model to remove their influence for interpreting the aquifer test data.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance (QA) for this ground-water monitoring program is conducted in accordance with PNL's quality assurance procedures. The project QA plan which includes specific requirements for this project was included in the Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches (Schalla et al. 1986). The quality control (QC) program for the RCRA Compliance Ground-Water Monitoring Project was established to determine and document the quality of the analytical results being produced by UST and to institute corrective actions as needed. The QC program and its results as of September 1986 were described in the compliance plan for this facility (Schalla et al. 1986). The following discussion will briefly review the QC Program and provide updated information on quality control measures and results.

6.1 QC PROGRAM DESCRIPTION AND RESULTS

The QC program for the RCRA Compliance Ground-Water Monitoring Project features the submission of blind standards and blanks to UST, the primary analytical laboratory, as well as the investigation of problems and the follow-up of corrective actions. In addition, UST participates in interlaboratory comparisons and in EPA-sponsored performance studies, and also performs and reports results of routine QC procedures and corrective actions. Results for each of these QC program components are described in the following sections.

6.1.1 Blind Standards

Blind standards are samples spiked with a known concentration of constituents. They are used to estimate the bias of an analytical laboratory procedure, and to determine when the bias exceeds control limits. Constituents that are found regularly in well-water samples in the 300 Area include metals, anions (nitrate, sulfate, chloride), ammonium (a cation), and volatile organic compounds (primarily chloroform). Blind standards containing these and other constituents have been submitted on a quarterly basis. The metals found primarily include barium, sodium, potassium, magnesium, calcium, copper, iron, manganese, vanadium, and zinc. Rarely, very low levels of cadmium, chromium,

aluminum, and arsenic have been detected. Results on blind standards containing metals occasionally have varied. Recent samples have generally been good, with a few isolated cases of metals that are outside the target range, such as manganese and lead in October 1986, chromium in July 1986, and sodium in June 1986. No reason was found for the manganese results. Lead in blank water contributed to but did not explain the magnitude of the lead discrepancy. The chromium result (12 ppb vs. a true value of 9 ppb) is acceptable considering that the detection limit of this analysis is 10 ppb. The high sodium result was blamed on incidental contamination. Recent corrective actions concerning the use of the graphite furnace should improve results for lead, as well as for selenium and arsenic, which are done by the same method.

Performance on anion analyses has improved in the last two quarters. Nitrate analyses were acceptable in all four blind standards submitted in the last two quarters. The most recent fluoride analyses were within target range. In past analyses, fluoride results have been slightly outside the target range (at levels of 800 to 3800 ppb). As discussed in the section entitled "EPA-Sponsored Performance Evaluations," more accuracy may be obtained with alternate methods of analyses.

Recent analyses for ammonium ion have been within the target range based on USEPA regressions, whereas previous analytical results for blind ammonium samples have been above the target range. The effect of the preservative, which was checked in the most recent batch of QC samples, was found to be negligible.

Identification and quantification of volatile organic compounds is generally excellent.

Other constituents that have not been detected in 300 Area ground-water samples, but for which QC samples are submitted, include Acid/Base/Neutral organic compounds (A/B/Ns), herbicides, pesticides, and cyanide. Detection of A/B/Ns has been very good in recent samples. Previous low recoveries of acid compounds and phthalates were corrected by refinements to UST procedures. Performance on the analysis of herbicides and pesticides has been excellent, and results of cyanide analysis have been acceptable.

6.1.2 Blanks

Blanks are water samples that are treated with the same preservative and which have the same type of container as field samples, but contain distilled water. For every analysis conducted, one bottle blank is submitted each sampling period to evaluate contamination. Transport blanks for volatile organic analyses (VOA) are used to determine whether environmental conditions encountered during the collection and transportation of samples have affected the results obtained by the analyses. Up to September 1987, one transport blank was submitted with each volatile organic sample. Now only one VOA blank is submitted per sampling area.

Analyses of bottle blanks show that sodium (200 to 300 ppb) and calcium (50 to 100 ppb) have appeared several times. Incidental contamination of elements such as sodium and calcium is extremely difficult to avoid. Other constituents that have appeared in isolated cases include cadmium, total organic carbon (TOC), nitrate, and ammonia.

The VOA bottle blanks have shown only blank water (or container) contamination, which usually affects all blank samples in 1 month. Examples of this include methyl ethyl ketone and tetrahydrofuran (January 1986), chloroform (September 1986), and acetone (July 1986 and January 1987). Methylene chloride detected throughout 1985 and early in 1986 was traced to bottles used to transport blank water.

To date, the VOA transport blanks have indicated no problems with contamination from the collection of samples, but bottle blanks have indicated occasional contamination of blank water and/or containers.

6.1.3 Interlaboratory Comparisons

Interlaboratory comparisons are used to determine if results obtained by the primary laboratory are comparable to those obtained from other laboratories. Interlaboratory comparisons have been performed for anions and selected volatile organic compounds and metals. The results are generally in good agreement.

Five anions (nitrate, sulfate, chloride, fluoride, and phosphate) are routinely analyzed by UST, WHC, and the Hanford Environmental Health Foundation (HEHF). Nitrate, sulfate, and chloride were found in all samples. Fluoride

has been detected occasionally in the trenches, and phosphate has been found only once at a level above the detection limit.

Nitrate analyses are generally consistent among the three laboratories, but with an occasional outlier. Since the last quarter of 1986, values from UST appear to be higher than those reported by WHC. At that time three minor changes were made to UST procedures: analyses of the samples within 48 hours of receipt, use of an autosampler, and a change of personnel performing the analysis. These changes may account for the recent differences.

Comparisons of sulfate analyses are generally consistent among the labs, with only occasional outliers. Results of chloride analyses are usually in agreement. When fluoride is detected, it is usually right around the UST detection limit of 500 ppb. More accurate results, if needed, would require the use of a method (specific ion electrode) that is used by WHC.

Three volatile compounds (chloroform, 1,1,1 trichloroethane; and PCE have been analyzed by PNL for comparison with UST results. Usually only chloroform is found at levels above the UST contractual detection limit (10 ppb). Except for the first month (November/December 1985) of the comparisons, there has been excellent agreement between the labs. (An inconsistency in data from July through December 1986 was traced to an extra correction factor for density. When this factor was removed from the PNL data, results were consistent with UST.)

Six metals (barium, cadmium, chromium, copper, lead, and sodium) have been analyzed by HEHF for comparison with UST results. Of these, barium, chromium, and sodium are generally found in levels above the detection limit. Results for chromium are generally consistent between the labs. Consistent differences in the analyses of barium are suspected to have been caused by matrix interference in the method used by HEHF. Incidental contamination is assumed to have caused occasional discrepancies in the sodium analyses.

6.2 USEPA-SPONSORED PERFORMANCE EVALUATIONS

At the request of PNL, UST has participated in the EPA-administered Performance Evaluation Studies. The two latest studies for which results are

available, are Water Supply Study No. 18 (WS018) and Water Pollution Study No. 17 (WP017). United States Testing performed very well in both studies.

WS018 included analyses of eight metals, nitrate and fluoride, five pesticides and herbicides, 17 volatile organic compounds, and the minerals calcium and sodium. Results reported for all these analyses were acceptable, with the following exceptions.

Unacceptable results were obtained for four metals. A high value for cadmium was traced to incidental contamination of deionized water used to prepare the sample. As a result, deionized water that is to be used in the metals analysis will be analyzed prior to being used in sample preparations. The low recovery of selenium was traced to an ambiguity in the cookdown method, which has since been corrected.

A transcription error rather than an analytical error caused an unacceptable result for the pesticide endrin. No specific reason was found for an unacceptable result for the volatile organic compound 1,2 dichloropropane (at about 1 ppb). United States Testing erroneously reported the presence of two isomers of xylene (1,2 and 1,4) when in fact only one isomer was present. However, the difference between these two isomers cannot be distinguished by the method of analysis currently in use (Method 8240).

The following analyses were performed for WP017: 21 trace metals; minerals including calcium, magnesium, sodium, potassium, chloride, fluoride, and sulfate; nutrients including ammonia, nitrate, and orthophosphate; TOC; two polychlorinated biphenyls; eight pesticides; 14 volatile organic compounds (halocarbons and aromatics); and miscellaneous parameters including cyanide.

Acceptable results were reported for all analyses, with the following exceptions. Among the metals, arsenic and iron results were unacceptable. The results for arsenic appear to have been switched, but one sample was still too low. Since the analysis was done, analysis procedures have been improved, thus improving spike recoveries. A discrepant result for iron was most likely caused by incidental contamination during sample preparation.

One fluoride result near detection limit (DL) of 500 ppb was unacceptable. For greater accuracy at this level, an alternate method may have to be considered. A marginal result for chloride is most likely caused by a dilution error.

Unacceptable results for total cyanide at 219 ppb are under review. The unacceptable result for pH probably resulted from the improper treatment of the pH electrode, which is now immersed in a pH 4 buffer solution. No specific reason was found for the low result for total dissolved solids.

6.3 UST INTERNAL QC AND CORRECTIVE ACTIONS

The internal QC effort performed by UST includes general practices applicable to a wide range of analyses and also the specific procedures stipulated for particular analyses. The QC and QA programs at UST are documented in the Quality Control Manual (Hembree, Lardy, and Swoboda 1986) and in the Quality Assurance Manual (Hembree and Lardy 1986). A summary of methods and QC procedures is given in the Revised Ground-Water Monitoring Compliance Plan for the 300 Area Process Trenches (Schalla et al. 1986).

The performance of UST analyses continues to improve as refinements are made. A summary of QC information written for the Hazardous Substance Analysis (HSA) Lab at UST, which conducts the majority of analyses for this project, is given in a quarterly report (UST 1986, 1987). In the last two quarterly reports covering the period from July 1, 1986, through December 31, 1986, the following corrective action has been taken: a new calibration curve for total radium (which has shown a bias) was put into service in April 1986, and subsequent data are acceptable.

Matrix spike recoveries for calcium, magnesium, potassium, and sodium have varied considerably. Higher levels of spikes are now being used to reduce the effect of the sample concentration. New VOA standards are now placed in use monthly. (Significant bias in dichloroethane, the most volatile of the VOA standards, could be accounted for by evaporation from the calibration standard.)

Additional refinements have been made in the operation of the laboratory. As was alluded to in the discussion of WS018, blank water is now tested for metals by the inductively coupled plasma method being used in sample preparation. Deionized water is also collected at the same time PNL collects water for transport blanks, providing verification of the purity of the deionized water and allowing prompt corrective action when necessary. Improvements in digestion procedures (for metals analyzed by graphite furnace atomic absorption) and more frequent replacement of carbon electrodes on the graphite furnace have resulted in improved matrix spike recoveries and more stable instrument operation. Matrix spike recoveries for A/B/Ns were improved by the additional training of the extraction technicians. Previously, losses in recovery were occurring from over-drying the acid extracts.

7.0 SEDIMENT AND GROUND-WATER CHEMISTRY

Any evaluation of the sediment and ground-water chemistry of the 300 Area process trenches must also include the sediment and ground-water chemistries in and around the inactive north and south process ponds. Inventories of materials discharged to the trenches and ponds are similar (Tables 7.1 and 7.2), and it is difficult to separate contaminants that have originated primarily from the trenches from those originating from the ponds. A discussion of the most important aspects of sediment and ground-water chemistries is presented in the following sections. Detailed supporting data for sediment and ground-water chemistries are presented in Appendices E and F, respectively.

7.1 SEDIMENT CHEMISTRY

There are discussions of the chemistry of sediments in the north and south process ponds, and discussions on process trenches are located in Zimmerman and Kossik (1987). Summaries of the sediment analyses presented in those reports are shown in Tables 7.3 and 7.4.

Sediment samples from the process trenches were taken from the surface of each trench and at depths of 6 to 10 in. and 18 to 24 in. at 100-ft intervals along each trench. Based on the sediment data currently available, those constituents present at levels above background in sediments from the process trenches are silver (Ag), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), antimony (Sb), and zinc (Zn). Elevated concentrations of barium (Ba) and vanadium (V) were also measured in several samples, particularly those samples taken at shallow depths. Gross alpha and gross beta activities in many of the samples were also above background levels. Detailed radiochemical analyses of the sediments from the process trenches have not been performed. However, based on the process history of the trenches and on the results of radiochemical analyses of sediments from the process ponds discussed below, the primary radiological contaminant is believed to be uranium. With the exceptions of Ba and V, all of the above constituents are known to have been discharged to the trenches. The highest concentrations of most constituents were detected in sediments from either end of the trenches and

TABLE 7.1. An Estimate of Chemicals Discharged to the 300 Area Process Trenches Before February 1, 1985

Intermittent Discharges		Routine Discharges ^(a)	
Ammonium bifluoride	Benzene	Copper	30 kg/mo ^(b)
Antimony	Carbon tetrachloride	Detergents	30 kg/mo ^(b)
Arsenic	Chromium	Ethylene glycol	200 L/mo
Barium	Chlorinated benzenes	Hydrofluoric acid	100 kg/mo ^(b)
Cadmium	Degreasing solvents	Nitrates	2000 kg/mo
Dioxane	Formaldehyde	Nitric acid	300 L/mo
Dioxin(c)	Formic acid	Sodium hydroxide	300 L/mo
Hydrocyanic acid	Hexachlorophene	Paint solvents	100 L/mo
Pyridine	Kerosene	Photo chemicals	700 L/mo ^(b)
Selenium and compounds	Lead	Sodium chloride	75 ton/yr
Thiourea	Methyl ethyl ketone	Uranium	20 kg/mo ^(b)
Misc. laboratory chemicals	Mercury		
	Napthalene		
	Nickel		
	Phenol		
	Silver		
	Sulfuric acid		
	Tetrachloroethylene (perchloroethylene)		
	Toluene		
	Tributylphosphate (paraffin hydrocarbon solvents)		
	1,1,1-Trichloroethane (methyl chloroform)		
	Trichloroethylene		
	Xylene		
	Perchloroethylene		450 L ^(d)
	Heating oil		300 L ^(d)

(a) These discharges were relatively continuous.

(b) The materials are still discharged.

(c) Included only because of the potential for Dioxin to exist as a trace impurity in chlorinated benzenes.

(d) Known spills.

TABLE 7.2. Inventory of Chemicals and Radionuclides Disposed in the North and South Ponds (in kg, except ⁶⁰Co, which is in curies decayed through April 1, 1986)

<u>Chemicals and Radionuclides</u>	<u>South Pond</u>	<u>North Pond</u>
Nitrite	900,000	700,000
Mercury	60	40
Chromium (VI)	5,000	3,000
Cadmium (II)	80	60
Lead (II)	4,000	2,000
Fluoride	7,000	5,000
Trichloroethylene	100,000	100,000
Uranium	40,000	30,000
Sodium Aluminate	2,000,000	2,000,000
Nitrate	1,000,000	800,000
Sodium Silicate	100,000	90,000
Sodium	2,000,000	1,000,000
Sodium Hydroxide	1,000,000	800,000
Nickel (II)	10,000	8,000
Zinc (II)	5,000	3,000
Silver (I)	1,000	900
Beryllium	40	30
Copper (II)	60,000	50,000
Nitric Acid	1,000,000	900,000
Co-60	0.001	0.001

concentrations generally decreased with depth. Concentrations of many of the constituents approached background levels with depth, particularly near the midpoint of the trenches.

Many of the constituents (Ba, Cd, Cr, Cu, Mn, Ni, V) were found in concentrations above background in the sediments in the dike separating the trenches but at levels less than those within the trenches (Table 7.3). The contents of Ag, Hg, Pb, Sb, Zn, gross alpha, and gross beta in sediments from the dike

were near background levels. Sediment samples from the dike were taken at 5-ft intervals to depths of 40 ft. Systematic variations in concentrations of the constituents with depth were not evident.

A remedial investigation (RI) of the inactive 300 Area process ponds, being conducted as part of the implementation of the Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act (CERCLA/SARA) Program at Hanford, has provided information on the chemistry of sediments from the ponds. Sediment contaminants in the ponds are similar to those measured in the sediments from the trenches. Contaminated sediments in the ponds are typified by high gross alpha and gross beta activities and by elevated concentrations of Ag, Al, Cr, Cu, Ni, and Zn, relative to background levels (Table 7.4). Additionally, As, F, Hg, Pb, Sb, Sr, V, and nitrate were present in concentrations above background at several locations in both ponds. Most of these contaminants are known to have been discharged to the ponds. Radiochemical analyses of sediment samples indicated that uranium is the primary radiological contaminant in the pond sediments with lesser quantities of ^{60}Co and ^{137}Cs also detected in several samples.

Detailed characterization of the release rates and mobility of contaminants in sediments from the process trenches and ponds has not been completed. Zimmerman and Kossik (1987) reported the results of EP toxic leach tests on six sediment samples from the process trenches. The results of the tests were below the levels which define a dangerous waste in WAC 173-303-090 of Washington State's regulations (Washington State Department of Ecology 1986). Mineralogic characterization of sediments from the ponds was initiated under the CERCLA/SARA Program. The composition of the fine-grained (<2-mm) fraction of the background sediments is typical of the Pasco Gravels, which consist predominantly of quartz and feldspar with small amounts of clay and mica. Analyses of contaminated sediments from the ponds revealed the complex nature of these sediments but have not identified which mineral or minerals control the distribution of the contaminants.

TABLE 7.3. Summary of Sediment Analyses for the 300 Area Process Trenches and the Dike Separating the Trenches

Constituent(a)	Background(b)	Trenches			Dike		
		Range	Mean	s(c)	Range	Mean	s
Ag	<1.0	2-405	66.7	86.0	n.d.(d)	--	--
Ba	96.6 ± 26.0	53-491	138.1	98.2	57-110	85.7	13.3
Cd	0.5 ± 0.3	4-28	9.5	3.6	0.5-9	5.5	1.1
Cr	9.8 ± 1.2	5-551	92.8	129.7	4-10	6.5	1.5
Cu	18.4 ± 4.92	104-8470	1390	1804	8-42	18.1	6.8
Hg	<0.1	0.2-69	6.6	13.3	0.11	0.11	--
Mn	396.2 ± 63.5	121-6740	457.7	874.6	167-346	277.6	35.3
Ni	7.6 ± 1.0	15-4700	280.3	667.2	2-11	5.1	1.7
Pb	5.1 ± 0.88	2-486	63.2	102.7	2-6	3.3	1.0
Sb	<10.0	13-128	55.2	40.3	n.d.	--	--
V	60 ± 7.0	1-207	52.1	34.5	46-83	60.5	8.1
Zn	50.2 ± 8.2	49-1160	203.8	205.7	29-50	39.9	5.0
Gross alpha	6.4 ± 2.1	16-18700	1740	3440	<1-11	5.0	2.7
Gross beta	21.4 ± 2.4	75-20800	3280	5690	11-25	15.4	2.7

(a) Units are µg/g except for gross alpha and gross beta, which are in pCi/g.

(b) Average, plus or minus one standard deviation, of concentrations in five samples from a location outside the South Process Pond.

(c) s is one standard deviation.

(d) Not detected.

7.2 GROUND-WATER CHEMISTRY

Ground-water data from the 300 Area RCRA Compliance Ground-Water Monitoring Project were compared with soils data and waste inventories from the process trenches and ponds in an attempt to identify ground-water contaminants that may have originated from these sites. Because the materials that have been discharged to the trenches and ponds are similar, it is very difficult to distinguish contaminants that may have originated from one facility versus the other. However, by virtue of the large amounts of liquids currently being discharged to the process trenches, that facility is presumably primarily responsible for the mobility of many of the contaminants detected in the ground

TABLE 7.4. Results of Analyses of Contaminated Sediments in the North and South Process Ponds. Samples 316001A02 and 316001B02 are from the South Pond; 316002A02 and 331002B01 from the North Pond.

Constituent ^(a)	Background ^(b)	316001A02	316001B02	316002A02	316002B01
Ag	<1.0	12.0	6.0	153	45
Al	9910 ± 2060	19500	16800	31400	20700
As	3.04 ± 1.36	15.1	27.0	7.0	14
Ba	96.6 ± 26.0	121	140	135	135
Be	0.65 ± 0.05	1.0	0.7	1.0	1.0
Ca	7782 ± 3135	20100	12800	55100	16500
Cd	0.5 ± 0.3	1.5	0.2	<0.2	1.0
Cl	1.84 ± 0.41	<1.0	<1.0	32	1.0
Cr	9.8 ± 1.2	129	116	519	205
Cu	18.4 ± 4.92	7060	2090	65600	3550
F	2.44 ± 0.94	1.6	2.8	10	4.3
Fe	27620 ± 3985	40100	40900	16100	29900
Hg	<0.1	0.7	1.0	8.5	4.7
K	1620 ± 330	1470	1750	469	871
Mg	6188 ± 1106	10600	9460	12100	8830
Mn	396.2 ± 63.5	395	441	594	341
Na	315.6 ± 123.9	309	771	582	322
Ni	7.6 ± 1.0	199	87.0	1830	216
Os	<30.0	<30.0	<30.0	<30.0	<30.0
Pb	5.08 ± 0.88	22.8	21.2	191	20
Sb	<10.0	<10.0	<10.0	20	10
Se	<0.5	<0.5	<0.5	<0.5	0.5
Sr	31 ± 0.8	45.0	37.0	91	57
Tl	<1.0	<1.0	<1.0	<1.0	<1.0
V	60 ± 7.0	86.0	80.0	226	84
Zn	50.2 ± 8.2	116	77.0	11	132
Gross alpha	6.35 ± 2.08	333	200	1960	374
Gross beta	21.44 ± 2.38	314	149	2140	295
Nitrate	1.06	3.8	2.6	645	3.8
Phosphate	<2.0	<2.0	<2.0	<2.0	2.0
Sulfate	9.68 ± 4.88	4.2	3.8	502	10.3

- (a) Units are µg/g except for gross alpha and gross beta, which are in pCi/g.
 (b) Average, plus or minus one standard deviation, of concentrations in five samples from a location outside the South process pond.

water. In addition, other facilities, active and inactive, in and around the 300 Area cannot be ruled out as possible sources of contaminants. Additional discussion and details of water chemistry results are presented in Appendix E. Also, plots of many constituents for the last 2 years are presented in Appendix E.

The addition of new wells to the monitoring network in early 1988 will greatly enhance the interpretation of ground-water data. In particular, the addition of several wells that were completed in intermediate and deep portions of the unconfined aquifer will assist in the interpretation of contaminant transport vertically throughout the aquifer. As is discussed in more detail below, initial analytical results from these wells indicate separation of the upper interval of the aquifer from the lower intervals.

The ground-water distributions of the constituents being investigated are highly variable over time. The following discussion is based on empirical observations of the available data. It does not take into account changes in ground-water level, changes in stage of the Columbia River, changes in quantity or quality of fluids discharged to the process trenches, or other factors to which many of the variations can be attributed. These issues will be discussed in detail in the final characterization report.

Those constituents present at elevated levels in soil from the process trenches and ponds have all, with the exception of Sb, been detected in the ground water since initiation of the RCRA Compliance Monitoring Project in June 1985. Silver, Cd, Hg, Ni, and Pb have been detected in the ground water sporadically since monitoring began but are generally present in concentrations near or below detection. Analyses of Zn in ground water have only been reported for most of the wells since mid-1986. Based on this limited data, the concentrations of Zn in wells near and downgradient from the trenches are slightly greater than those detected in upgradient wells. Chromium was detected in several wells shortly after monitoring began but generally has declined to levels below detection, except in the recently completed intermediate and deep wells as discussed below.

Barium is commonly detected in all wells in the monitoring network. The concentrations of Ba, however, detected in shallow wells adjacent to and

immediately downgradient from the trenches, are similar to those detected in upgradient wells and wells distant from the trenches. Similarly, vanadium is often present in concentrations above detection in most wells in the network but its concentration in wells near and downgradient from the trenches is generally lower than in upgradient wells.

Gross alpha, gross beta, coliform, Cu, fluoride, and nitrate are the most ubiquitous contaminants detected in wells in the monitoring network. Gross alpha, gross beta, and Cu concentrations are generally higher in wells near and downgradient from the trenches than in upgradient wells. In March 1987, the Cu that was evident in well 1-5 in December 1986 and January 1987 is appearing in several of the immediate downgradient wells, such as 1-3 and 1-7. Also, all shallow monitoring wells adjacent to the trenches showed a relatively large increase in March 1987. Fluoride concentrations in shallow wells in the network have declined since monitoring began, but, as discussed below, fluoride has been reported at levels near or above Drinking Water Standards of 1400 ppb in all of the new intermediate and deep wells at 1-16, 1-17, and 1-18.

Nitrate levels in wells near and immediately downgradient from the trenches have declined over the past year and are generally lower than the concentrations detected in upgradient and distant downgradient wells. Based on analyses of the process water stream discharged to the trenches during the first half of 1986 (Table 7.5), a rough correlation exists between the concentration of nitrate in the process water stream and the nitrate concentration in wells near the trenches. Because data from analysis of the process water stream are not available for the period of time in which the nitrate concentrations in the wells declined, it is unclear whether the decline is in response to declining nitrate in the process water stream. Coliform is detected sporadically in wells throughout the network.

Several organic compounds have been detected in the ground water since monitoring was initiated. Detected organics include chloroform, methylene chloride, PCE, TCE, 1,1,1-trichloroethane, and trans-1,2-dichloroethylene.

TABLE 7.5. Concentrations (ppb) of Chloroform in Samples from the Monitoring Wells in the 300 Area

Well No.	Month and Year																						
	6/85	7/85	8/85	9/85	10/85	11/12/85	1/86	2/86	3/86	4/86	5/86	6/86	7/86	8/86	9/86	10/86	11/86	12/86	1/87	2/87	3/87	4/87	
1-1	30	28	33	23	17	13	11	11	--(c)	--	--	11	18	20	22	19	15	11	DL(a)	13	12	11	
1-2	15	27	16	23	18	12	12	11	DL	12	13	18	18	19	16	14	15	12	14	11	DL	DL	
1-3	42	--	25	23	19	12	13	12	DL	11	13	18	22	21	18	17	16	12	--	11	12	13	
1-4	30	32	--	25	18	11	11	10	11	11	13	19	27	20	16	15	11	13	13	11	12	14	
1-5	25	21	22	20	17	11	14	10	12	12	17	18	27	24	17	17	11	13	13	12	12	15	
1-6	38	--	25	21	14	--	--	10	DL	12	13	18	20	20	15	15	12	11	13	11	11	14	
1-7	--	--	--	22	13	12	12	11	DL	DL	12	19	23	20	20	15	13	DL	--	13	14	13	
1-8(b)	--	--	--	--	--	--	--	DL	DL	DL	DL	12	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	
1-9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	11	14	
1-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	14	16	
1-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	13	14	
1-13	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11	DL	12	
1-14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	DL	
1-15	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	DL	
1-16A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	13	
1-16B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-16C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-17A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11	14	13	
1-17B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-17C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-18A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-18-B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-18-C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	
1-19	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	15	14	
2-1	13	17	13	14	--	--	--	DL	DL	DL	DL	11	--	14	11	11	11	DL	DL	11	DL	DL	
3-7	--	--	27	--	--	--	--	--	DL	DL	--	--	18	19	11	DL	DL	DL	DL	DL	11	DL	
3-10	--	--	--	--	--	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	
4-1	--	--	--	--	--	--	--	--	DL	DL	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	
4-7	--	--	--	--	--	--	--	--	DL	DL	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	
4-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	DL	
8-2	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	
6-S19-E13	DL	DL	DL	DL	12	--	DL	--	--	DL	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	DL	
6-S30-E15A	--	--	--	--	--	--	--	--	--	--	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL	

(a) DL = At or below the detection limit, which is 10 ppb.

(b) Well 1-8 is an intermediate well with along screened interval.

(c) -- = not sampled.

Chloroform (Trichloromethane) is known to be ubiquitous in the environment (Callahan et al. 1979), and is particularly common in finished drinking water (Jolley 1984) and wastewater effluents. Concentrations of chloroform vary from summer highs of 42 ppb near the process trenches (Figure 7.1) to winter and spring lows of less than 20 ppb (Figure 7.2). Concentrations from June 1985 to April 1987 are shown in Table 7.5. Concentrations of chloroform are highest near the process trenches and form a persistent plume that varies in concentration. Based on the detection limit of 10 ppb, the minimum horizontal extent of the chloroform plume during 2 different months is shown in Figures 7.1 and 7.2. The concentrations of chloroform in intermediate and deep wells (Figure 7.3) are always below the detection limit. The concentration of chloroform in well 1-8, which is a shallow hybrid well, is consistently less than in the adjacent (i.e., within 25 ft) shallow wells 1-3 and 1-7, but it is not always below the detection limit. The shallow hybrid well is screened in an interval of the middle Ringold, which is above the intermediate depth wells and just below the shallow wells. Concentrations of chloroform decline with depth in the unconfined aquifer.

In the early months of sampling, June through August 1985, methylene chloride was sporadically detected in many of the wells in the original monitoring network. These levels were initially traced to residual contamination of the dedicated pumps that were being used. Subsequently, the pumps were removed and replaced with new ones in late October 1985. However, instead of solving the problem, results from the monitoring network after the new pumps were installed showed that every well in the network had a methylene chloride value greater than 100 ppb at least once over the following 5 months, with several values greater than 1000 ppb (see Table 7.6). Possible explanations for this anomalous increase are that the new pumps also had residual methylene chloride contamination or that some external (e.g. laboratory) source of contamination existed. This latter possibility is very real because methylene chloride levels near 400 ppb had been found in almost all transport blanks for the first 4 months of sampling. The transport blank problem was later traced to sample preparation activities and was corrected. Note that methylene chloride was not originally a constituent that was requested to be reported by UST. However, as part of their contract, UST reported at their discretion, constituents that

FIGURE 7.1. Concentration Contours in ppb for Chloroform for August 1986

FIGURE 7.2. Concentration Contours in ppb for Chloroform for April 1987

FIGURE 7.3. Examples of Monitoring Wells

were detected but not specifically requested. Therefore, much of the first year of data is very spotty, which precludes making any simple conclusions. However, once methylene chloride became part of the standard list of reportable constituents in August of 1986, it has been below the detection level of 10 ppb in all the wells except for a few readings in February and April of 1987. There is a possibility that these latter readings indicate an actual pulse-type plume of methylene chloride did migrate from the process trenches in late

TABLE 7.6. Concentrations (ppb) of Methylene Chloride in Samples from the Shallow Wells in the 300 Area

Well No.	6/85	Month and Year																						
		7/85	8/85	9/85	10/85	11/85	12/85	1/86	2/86	3/86	4/86	5/86	6/86	7/86	8/86	9/86	10/86	11/86	12/86	1/87	2/87	3/87	4/87	
1-1		13	n ^(d)	n	n		430	310	n	n		3	450	-- ^(c)	--	DL ^(a)	DL	DL	DL	DL	DL	DL	DL	DL
1-2		170	n	n	n	n		370	n	n		33	860	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL
1-3		n	n	n	n	n		280	n	n		9	--	--	--	DL	DL	DL	DL	DL	--	100	DL	DL
1-4		n	n	n	n	n		440	n	n		--	1400	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
1-5		0	32	0	1600	n		1200	DL	n		11	DL	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL
1-6		18	n	20	n	n		1150	n	n		740	960	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
1-7		--	17	n	n	71		n	n	n		370	1650	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
1-8 ^(b)		--	--	--	--	n		1500	n	n		130	--	--	1170	--	DL	DL	DL	DL	DL	DL	DL	DL
1-9		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	--	DL	DL
1-10		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
1-11		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
1-12		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
1-13		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
1-14		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	500	DL	DL
1-15		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	47	DL	DL
1-16A		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	--	DL	DL
1-17A		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
1-18A		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	--	DL	DL
1-19		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	--	DL	DL
2-1		n	n	n	n	n		750	n	n		14	690	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
3-7		n	n	n	n	n		13	n	n		100	--	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
3-10		n	n	n	n	460		n	n	140		240	240	--	--	DL	DL	DL	DL	DL	DL	DL	DL	300
4-1		n	n	n	n	n		960	n	n		350	80	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL
4-7		n	n	n	n	n		310	n	n		40	78	--	--	--	DL	DL	DL	DL	DL	DL	DL	DL
4-11		--	--	--	--	--		--	--	--		--	--	--	--	--	--	--	--	--	--	DL	DL	DL
8-2		n	n	n	n	340		n	n	n		820	470	--	--	16	DL	DL	DL	DL	DL	DL	DL	DL
6-S19-E13		DL	DL	DL	n	70		DL	n	n		27,500	DL	--	--	DL	DL	DL	DL	DL	DL	DL	DL	DL
6-S30-E15A		n	n	n	n	2000		n	n	n		35	1400	70	40	--	DL	DL	DL	DL	DL	DL	DL	DL

(a) Detection limit (DL), which is 10 ppb.

(b) Well 1-8 is not a true shallow well because it is screened primarily between the shallow and intermediate zones.

(c) -- = not sampled.

(d) n = not reported.

February 1987. Moderate concentrations of methylene chloride were detected in several wells near the trenches, but only in those wells sampled in the latter part of the month and not in those sampled in early February. Two months later, in April, 1987, 3000 and 300 ppb of methylene chloride were detected in downgradient wells 3-7 and 3-10, respectively. The arrival time and location of methylene chloride at wells 3-7 and 3-10 are consistent with the present understanding of ground-water movement in the 300 Area, although the failure to detect the original plume in more wells near the trenches makes this conclusion very speculative. Also, there are no known uses of methylene chloride in the 300 Area.

Perchloroethylene has been detected sporadically in a few wells since the 1982 and 1984 spills reported by Cline (1985), but not in significant amounts and rarely in more than one well during a sampling period. The sporadic occurrence may be caused by the release of residual PCE left over from the spill, or may be carried in the process water from the fuel rod assembly area or the chemistry or instrumentation laboratories where PCE and TCE are commonly used. Trichloroethylene is also sporadically present in the shallow portion of the unconfined aquifer, and more consistently present in the intermediate wells of the unconfined aquifer. For example, TCE in well 1-16B sampled in March was reported at 20 ppb, which is greater than the proposed maximum contaminant level (MCL) of 5 ppb in 40 CFR 141.50.

Of particular concern at the present are the high concentrations of trans-1,2-dichloroethylene (DCE) being detected in intermediate and deep wells downgradient from the trenches (i.e., wells 1-16B, 1-16C, 1-17B, and 1-17C). These wells were first sampled during March 1987, at which time trans-1,2-DCE was detected in concentrations near or above the USEPA maximum contaminant level (MCL) of 70 ppb. Subsequent analyses in April and June 1987 have confirmed the levels of trans-1,2-DCE detected in March. The results are summarized in Table 7.7. Trans 1,2-DCE is not used in any process in the 300 Area but is more likely a degradation product of the PCE and TCE (Wilson 1983). Field studies have also confirmed that the degradation process usually produces primarily cis 1,2-DCE rather than the trans-isomer, but the analytical method currently in use cannot distinguish between these isomers (Schalla

TABLE 7.7. Concentrations (ppb) of DCE in the Intermediate Wells and Adjacent Wells in Clusters During 1987

<u>Well No.</u>	<u>March</u>	<u>April</u>	<u>Early June</u>	<u>Late June</u>
1-8	D ^(a)	D	n ^(b)	-(c)
1-16A	n	n	D	D
1-16B	66	71	67	72
1-16C	n	n	20	D
1-17A	n	n	D	D
1-17B	28	31	27	28
1-17C	n	n	D	D
1-18A	n	n	-	-
1-18B	D	D	-	-
1-18C	n	n	-	-

(a) D = less than detection limit (10 ppb).

(b) - = not reported for constituent of interest.

(c) - = not sampled for constituent of interest.

et al. 1984; Schalla et al. 1985). From a regulatory stand point, there is no need to distinguish between these two isomers because both isomers have the same RMCL.

1,1,1-Trichloroethane has been detected rarely and in low concentrations. Most recently, 1,1,1-Trichloroethane was reported above detection in well 8-2 (83 ppb).

Based on the data currently available, the intermediate and deep portions of the unconfined aquifer have a different water chemistry than shallow portions and are generally uncontaminated or are affected only a small degree by the trenches. Gross alpha, gross beta, chloroform, copper, and nitrate, which are commonly detected in the shallow wells, are not detected in the intermediate and deep wells. The only contamination detected in the intermediate and deep wells is the presence of trans-1,2-DCE discussed above and fluoride. The intermediate and deep wells generally have concentrations of several

constituents (i.e., barium, fluoride, iron, manganese, potassium, sodium, and sulfate) that are significantly different from the shallow wells. Differences in the concentrations of these constituents presumably can be accounted for by differences in the portion of the aquifer being sampled. The high fluoride concentrations detected, for example, may be a manifestation of interaction with water from the confined basalt aquifer. Ground water from the basalt aquifer commonly has had high concentrations of fluoride in other areas (e.g., 33.4 ppm) (Jones 1982).

In addition to the constituents mentioned above Al, As, iron, and radium have been detected occasionally in wells in the 300 Area monitoring network. The presence of these constituents is generally isolated and varies considerably between samples.

A comparison of the gross alpha and uranium activities, for wells from which samples were analyzed for both constituents in FY 1987, shows that uranium in the ground water beneath the 300 Area accounts for the gross alpha activities detected (Table 7.8). With the exception of the results for three samples, the gross alpha and uranium activities shown in Table 7.8 are within the range of experimental error. The gross alpha activities reported for the February 23, 1987 sample from well 3-1-3 and the January 22, 1987 sample from well 3-4-7 are greater than the uranium activities. These discrepancies could be the result of an analytical error or the presence of an alpha particle emitting radionuclide other than uranium. In that there is close agreement between the gross alpha and uranium activities for samples from other 300 Area wells and for samples from wells 3-1-3 and 3-4-7 taken on other dates, it appears that the discrepancies most likely result from analytical errors. The reverse case, displayed by the October 22, 1986 sample from well 3-8-2, where the uranium activity reported is greater than the gross alpha activity reported, is unquestionably a result of an analytical error.

Samples from five 300 Area wells were analyzed for isotopic uranium in July 1987. The results of these analyses (Table 7.9) indicate that the activities of uranium isotopes in the samples analyzed are well below the DOE Derived Concentration Guides (DCG) for those isotopes. The DCGs for ^{234}U , ^{235}U , and ^{238}U are 500 pCi/L, 600 pCi/L, and 600 pCi/L, respectively. The percentage by

TABLE 7.8. Comparison of Gross Alpha and Uranium Activities for 300 Area Wells. (Results are in pCi/L plus or minus the counting error when an error was reported.)

<u>Well Number</u>	<u>Date</u>	<u>Uranium</u>	<u>Alpha</u>
3-1-1	10/21/86	21.0 ± 6.0	10.6 ± 2.35
	04/16/87	13.9	15.4 ± 2.80
3-1-2	10/13/86	5.5 ± 5.2	7.21 ± 1.96
	01/16/87	13.1	5.66 ± 1.77
	04/17/87	8.58	8.85 ± 2.06
3-1-3	10/28/86	<4.0 ± 5.0	15.6 ± 2.83
	02/23/87	9.0	29.9 ± 4.01
	04/17/87	25.5	34.7 ± 4.18
3-1-4	10/21/86	12.0 ± 3.7	5.26 ± 1.65
	01/16/87	36.0	24.9 ± 3.56
	04/17/87	23.2	27.1 ± 3.58
3-1-5	10/23/86	17.0 ± 5.8	12.3 ± 2.54
	01/23/87	29.4	24.8 ± 3.7
	04/30/87	58.2	55.5 ± 5.22
3-1-6	10/20/86	5.7 ± 5.1	4.89 ± 1.6
	01/19/87	15.0	9.91 ± 2.27
	04/15/87	14.6	14.8 ± 2.62
3-2-1	10/21/86	10.0 ± 3.4	6.99 ± 1.95
	01/19/87	12.0	7.38 ± 1.94
	04/21/87	5.53	7.86 ± 2.12
3-3-7	10/20/86	12.0 ± 3.7	8.28 ± 2.36
	01/19/87	10.3	7.74 ± 2.14
	04/28/87	7.36	7.22 ± 2.08
3-3-10	10/22/86	19.0 ± 4.2	14.2 ± 2.69
	01/22/87	27.3	17.9 ± 3.25
	04/14/87	13.9	13.0 ± 2.79
3-4-1	10/23/86	21.0 ± 4.3	11.9 ± 2.72
	02/23/87	16.1	10.8 ± 2.63
	04/21/87	11.4	10.7 ± 2.64
3-4-7	11/18/86	47.0 ± 7.4	33.9 ± 4.51
	01/22/87	3.25	23.1 ± 3.8
	04/21/87	31.4	30.8 ± 4.3
3-8-2	10/22/86	21.0 ± 6.0	1.78 ± 1.22
	01/16/87	4.49	1.34 ± 1.05
	04/15/87	2.97	1.88 ± 1.22

TABLE 7.9. Isotopic Uranium Composition of Ground-Water Samples from 300 Area Wells

Well Number	^{234}U (a)	^{235}U (a)	^{238}U (a)	% ^{235}U (b)
3-3-11	13.9 ± 0.333	0.508 ± 0.064	13.2 ± 0.325	0.595
3-3-12	14.1 ± 0.336	0.501 ± 0.063	13.1 ± 0.323	0.592
3-4-7	21.2 ± 0.418	0.843 ± 0.084	20.8 ± 0.414	0.627
3-4-9	15.8 ± 0.361	0.726 ± 0.077	15.7 ± 0.361	0.714
3-4-10	18.7 ± 0.391	0.740 ± 0.078	18.5 ± 0.389	0.619
Specific Activity	$6.2 \times 10^{-3}\text{Ci/g}$	$2.14 \times 10^{-6}\text{Ci/g}$	$3.33 \times 10^{-7}\text{Ci/g}$	

(a) Activity (pCi/L) plus or minus the counting error.

(b) Percentage by weight. For comparison, the percentage of ^{235}U in natural uranium is 0.711.

weight of ^{235}U in the samples is the same as that for naturally occurring uranium. It is not clear whether the isotopic compositions of these samples are typical of ground water beneath the 300 Area because very little uranium isotope data exists for the 300 Area wells. The samples analyzed were from wells relatively far from the process trenches and may not reflect the uranium isotopic composition of the ground water closer to the trenches. To determine the percentage of each uranium isotope in picograms/L, the activity value must be divided by the specific activity for each isotope.

Samples from all wells in the monitoring network were analyzed for uranium once in November. The results of these analyses ranged from less than the analytical detection limit ($0.7625 \mu\text{g/L}$) to $131 \mu\text{g/L}$ in the sample from well 399-1-19. Uranium concentrations were highest in wells immediately adjacent to the trenches (Figure 7.4). The data used to draw the concentration gradients in this figure are from the 300 Area RCRA project (Table 7.10) and the Hanford Site ground-water monitoring program (Table 7.11). Uranium concentrations in shallow wells screened in the top of the unconfined aquifer decrease downgradient, and concentrations in upgradient wells 399-1-18A, 399-8-1, 399-8-2, 399-8-3, and 699-S19-E13 were relatively low, ranging from $1.9 \mu\text{g/L}$ in well 699-S19-E13 to $5.2 \mu\text{g/L}$ in well 399-8-3. Uranium concentrations in intermediate-depth well 399-1-18B (i.e., bottom of the unconfined

FIGURE 7.4. Uranium Distribution in the Shallow Portion of the Unconfined Aquifer in 300 Area, October through November 1987

TABLE 7.10. Uranium Concentrations in 300 Area RCRA Wells in November 1987

<u>Well Name</u>	<u>Collection Date</u>	<u>U-Chem Ug/L (a) M</u>
3-1-1	11/10/87	17.400
3-1-2	11/09/87	16.800
3-1-4	11/12/87	36.100
3-1-6	11/20/87	13.800
3-1-7	11/13/87	37.700
3-1-8	11/13/87	24.800
3-1-10	11/19/87	11.400
3-1-11	11/06/87	35.000
3-1-12	11/11/87	48.100
3-1-13	11/18/87	13.100
3-1-14	11/18/87	18.100
3-1-15	11/16/87	7.870
3-1-16A	11/16/87	12.900
3-1-16B	11/16/87	4.120
3-1-16C	11/16/87	2.510
3-1-17A	11/05/87	47.300
3-1-17B	11/05/87	.
3-1-17C	11/06/87	.
3-1-18A	11/17/87	4.280
3-1-18B	11/17/87	*0.043
3-1-18C	11/17/87	*0.071
3-1-19	11/05/87	131.000
3-2-1	11/10/87	16.300
3-3-7	11/09/87	12.100
3-3-10	11/20/87	78.700
3-4-1	11/12/87	16.000
3-4-7	11/06/87	.
3-4-11	11/11/87	16.800
3-8-1	11/19/87	5.110
3-8-2	11/13/87	2.750
3-8-3	11/20/87	5.200
6-S19-E13	11/19/87	1.920
6-S30E15A	11/20/87	2.130

(a) To convert uranium concentrations from $\mu\text{g/L}$ to pCi/L , multiply by 0.69.

TABLE 7.11. Uranium Concentrations in 300 Area Hanford Wells in October 1987

<u>Well Name</u>	<u>Collection Date</u>	<u>U-Chem μg/L^(a) M</u>
3-1-3	10/20/87	27.300
3-1-5	10/13/87	22.900
3-2-2	10/20/87	17.900
3-2-3	10/20/87	15.000
3-3-1	10/15/87	8.410
3-3-2	10/20/87	7.250
3-3-3	10/20/87	8.480
3-3-6	10/20/87	9.980
3-3-7	10/20/87	10.700
3-3-9	10/19/87	17.400
3-3-11	10/20/87	22.100
3-3-12	10/19/87	29.200
3-4-10	10/19/87	38.300
3-5-1	10/20/87	3.600
3-6-1	10/20/87	5.870
3-8-4	10/19/87	1.960
V6-S29-E12	10/21/87	2.410

(a) To convert uranium concentrations from μg/L to pCi/L, multiply by 0.69.

aquifer) and deep well 399-1-18C (in the confined aquifer), both upgradient from the trenches, were less than the detection limit. Intermediate and deep wells (399-1-16B and 399-1-16C, respectively), downgradient from the trenches, had concentrations of 4.1 and 2.5 μg/L.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This chapter contains two main sections. The first section contains a compilation of key information including conclusions from the work completed to date. Based on this information, the second section provides recommendations and plans for further work.

8.1 CONCLUSIONS

The results of the last two years of field and characterization work, with emphasis on the last year, has revealed many new facts which have been discussed in detail within the preceding chapters. They are reiterated briefly and compiled under the following sections.

8.1.1 Hydrogeology

Recent drilling, aquifer testing, and continuous water-level monitoring have provided the following new information:

- The uppermost basalt flows of the Ice Harbor member of the Saddle Mountains Basalt underlying the sediments in the 300 Area are the Martindale and the Goose Island flows. The Goose Island flow is stratigraphically younger than the Martindale flow and only detected northwest of the process trenches. At the contact with the overlying Ringold Formation these units are thought to contribute approximately half of the observed transmissivity of the uppermost confined aquifer.
- The consolidated sediments underlying the 300 Area consist of three members of the Ringold Formation, the basal, lower, and middle members. The basal member is chiefly characterized as a well-consolidated clayey sand to a gravelly sand with clay that varies in thickness from 2 to 17 ft in thickness. Transmissivities of this member, including a few feet of the underlying basalt, vary from 1.6 ft²/day to 100 ft²/day. These two units form the portion of the confined aquifer monitored in the 300 Area. The lower member consists of bluish-green clay, which gradually changes to brown clayey

silt with depth, and varies from 17 to 60 ft in thickness. The lower member has very low hydraulic conductivity and is considered a confining layer. The middle member forms the top of the Ringold Formation beneath the 300 Area. This member consists of 65 to 85 ft of brown-to-gray sandy gravel with local silt and sand lenses. Transmissivities in the lowermost 10 to 15 ft of this member range from 8 to 30 ft²/day, whereas the transmissivities in the upper 10 to 15 ft are 3 to 4 orders of magnitude higher. This variation in transmissivity is primarily the result of differences in the silt content and degree of consolidation and cementation of the sandy gravels.

- The unconsolidated sediments that overlie the Ringold Formation in the 300 Area consist of the Hanford formation and eolian deposits. The Hanford formation is characterized as a dark-grayish-brown to dark-olive-gray sandy gravel with some silt and local sand stringers. The upper portion of the unit generally exhibits a pebble-to-boulder gravel which becomes finer with depth near the contact with the underlying Ringold Formation. The Hanford formation is typically 32 to 50 ft thick in the vicinity of the process trenches, but the saturated thickness varies from 0 to 15 ft. Historically most of the transmissivity in the unconfined aquifer in the 300 Area has been attributed to the Hanford formation; however, more recent tests indicate that the range of transmissivity (10,000 to 200,000 ft²/day) of the shallow portion of the unconfined aquifer is equally or in some areas primarily attributable to the uppermost portion of the middle member of the Ringold Formation. The eolian sediments consist of a thin (2- to 15-ft) veneer of fine-to-coarse grained, wind transported sand deposits. No definitive information is available on the soil geochemistry, and the continuity of sediments and their depositional history is not completely understood.
- The confined aquifer in the 300 Area has water level elevations that are approximately 20 to 35 ft higher than the unconfined aquifer. Therefore, the potential for downward migration from the unconfined

aquifer into the confined aquifer is nil unless an artificial hydraulic interconnection is created between the two aquifers.

- The results of monthly and continuous water-level monitoring indicate that the primary natural influence on ground-water flow direction is the Columbia River, and the most important man-caused influence in the 300 Area is the waste water disposed of in the process trenches. The results of recent transient simulations using a mathematical flow model indicated that a time step of one day is sufficient to account for changes in the ground-water levels in response to changing river stage. This determination of an appropriate time step was possible because continuous water level data was collected on several wells and the river. The gradient of the Columbia River adjacent to the 300 Area varies with actions at Priest Rapids and McNary dams. The amount change in gradient and the significance have not been determined.
- The character and presence of the sedimentary deposits of former river channels have been partially determined. The theory concerning the existence of a continuous natural levee separating the old channel deposits from the current Columbia River channel is not correct. The aquifer test data and water-level data do indicate some variability in sedimentary characteristics, but the levee, if present, appears to have only a minimal effect as a hydrologic barrier and would probably be discontinuous.

8.1.2 Geochemistry

As discussed below, the geochemical work recently performed has provided new information concerning 1) the characteristics of the waste, and 2) the transport of waste constituents in the ground water. The analytical results of soil and water chemistry obtained to date, particularly from the new wells,

have given a much more detailed and complete picture of the spatial distribution of various waste constituents in the ground water. These data indicate the following:

- Constituents present at elevated levels in soil from the process trenches and ponds have all, with the exception of Sb, been detected in the ground water since June 1985. Constituents found to be above the USEPA Interim Primary Drinking Water Standards or the MCLs are gross alpha, gross beta, fluoride, TCE, and trans 1,2-DCE. The highest concentrations of gross alpha and beta are found in the shallowest portion of the unconfined aquifer in the vicinity of the process trenches. The uranium concentrations and gross alpha activities reported for samples analyzed for both constituents are in close agreement, indicating that uranium is the primary alpha-emitting radionuclide in the samples. Uranium, which must be excluded from the alpha count to determine whether the drinking water standard has been exceeded, represents most of the alpha activity. Therefore, alpha activity does not exceed the drinking water standard for the 300 Area wells. Gross alpha levels in intermediate and deep wells remain below detection limits. Fluoride concentrations are very low in the shallow zone, but very high in intermediate and deep wells. This suggests that fluoride in the lower portions of the unconfined aquifer and the confined aquifer are attributable to a source other than the trenches. Both TCE and trans 1,2 DCE have been detected in the intermediate depth wells that are downgradient of the process trenches and process ponds. The source of these constituents may be residuals left over from the process ponds or previous releases to the process trenches.
- In addition to the constituents and contaminants noted in the preceding paragraph, other constituents serve to differentiate between water in the upper portion of the unconfined aquifer and deeper zones. Also, some concentrations of several constituents are unique

to the process water entering the groundwater system. These unique constituents in a few instances can serve as tracers and help delineate flow paths and the horizontal and vertical extent of water from the process trenches. Using chloroform and trans 1,2 DCE as tracers or index constituents, it is evident that water from the process trenches has a limited areal extent, but its vertical distribution does not extend significantly into the lowest portion of the unconfined aquifer. Also, the mixing of background ground water with process trench water occurs in the middle portion of the unconfined aquifer.

- Based on water chemistry data for PCE and methylene chloride, noncontinuous (pulse type) releases of these or similarly conservative constituents from the process trenches migrate rapidly through the shallow portion of the aquifer to the Columbia River. Collecting time equivalent water chemistry samples for interpretation requires sample collection of the wells of interest over a period of a few days at most. Sampling of process water before it is discharged into the trenches requires a much shorter time interval and more continuous sampling.

8.2 RECOMMENDATIONS

The primary recommendation to be made is that the data collection efforts and evaluations should continue, but routine monitoring should be reduced so that efforts are directed toward achieving compliance with the assessment requirements.

The following are other recommendations:

- Determine the extent of contamination of all contaminants of concern in the 300 Area and whether they originate from the process trenches or some other source.
- Complete characterization of the hydrogeologic system, particularly the bottom of the unconfined aquifer.

- Complete studies of the relationship between ground-water movement and surface water to determine boundary conditions for simulation of flow and transport in the unconfined aquifer.
- Perform tracer tests to evaluate hydrologic properties within the study area and to enable calibration and validation of the transport model.
- Quantify the uncertainty of all the data in information used for input into models or used for interpretation.
- Prepare a detailed planning document to expedite efforts toward completing the assessment study phase.

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APPENDIX A

MONITORING-WELL INSTALLATION DETAILS, SURVEY CONTROL, AND GEOLOGIC AND
GEOPHYSICAL LOGS

APPENDIX A

MONITORING-WELL INSTALLATION DETAILS, SURVEY CONTROL, AND GEOLOGIC AND GEOPHYSICAL LOGS

This appendix contains detailed information on construction of the new monitoring wells and many older wells. Included is a general description of how the wells were constructed, descriptions of individual monitoring-well construction (new wells only), diagrams of well construction correlated with geophysical logs, and horizontal and vertical survey control data.

MONITORING-WELL INSTALLATION DETAILS

From September 24, 1986, to February 12, 1987, a total of 18 wells were installed in the 300 Area. Seventeen wells (1-9 through 1-18C) were installed in the north half of the 300 Area, and one (well 4-11) in the south half. Seventeen were new monitoring wells and one (well 1-16D) was an observation well that was added to well cluster 1-16 to obtain hydrologic data only. Monitoring-well construction and hydrogeologic data collection activities are discussed in the following paragraphs.

The 17 monitoring wells consisted of seven shallow single wells, three 3-well clusters, and one deep well that added to an existing cluster of intermediate and shallow monitoring wells. Locations of these wells and a monitoring well (1-19) installed by WHC during 1986 are shown in Figure A.1. A summary of well completion information for new wells is presented in Table A.1, and Table A.2 contains older well data. Each well cluster was to consist of a shallow, an intermediate, and a deep monitoring well. Clusters 1-16 and 1-17 do have three wells screened in three distinct intervals, but cluster 1-18 contains two intermediate wells and one shallow well. Shallow wells (clusters and individual wells) are screened in the upper 10 ft of the unconfined alluvial aquifer, typically consisting almost entirely of the Hanford formation. Intermediate wells (1-16B, 1-17B, and 1-18B) are screened in the lower portion of the middle member of the Ringold Formation, which is just above the bottom of

the unconfined aquifer. The other intermediate well (1-18C) is screened in the sediments just above the Goose Island basalt flow which overlies the Martindale basalt flow. Water level and aquifer test data indicate that the sediments overlying the Goose Island flow are hydraulically connected to the unconfined aquifer, whereas the Martindale appears to be hydraulically interconnected with the confined sediments of the basal member of the Ringold Formation. Deep wells are screened in the sediments of the basal member, are hydraulically isolated from the unconfined aquifer, and are therefore considered part of the confined aquifer. The three deep wells (1-16C, 1-17C, and 1-9) were completed as deep wells screened in the basal member of the Ringold Formation.

Before drilling, well locations were staked and surveyed, then investigated to determine if underground utilities or other possible obstacles were present. The drilling contractor prepared each site so that the working area drained drilling debris away from the borehole. All drilling equipment and materials were decontaminated before and after use, by steam cleaning with water from the 300 Area Fire Station.

The shallow monitoring wells were drilled to approximately 50 ft, and the intermediate and deep wells were typically drilled to approximately 110 and 180 ft in depth, respectively, as shown in Figure A.2. One shallow-hybrid well (well 1-8) had been installed previously. All monitoring boreholes were drilled using a truck-mounted Bucyrus Eries cable-tool drilling rig. Before drilling most boreholes, the drill sites were excavated to approximately 15 ft, and a 20-ft section of 10- or 12-in.-diameter, schedule 40, steel casing with drive shoe was set vertically in the excavation. The excavation was backfilled around the casing with the native materials previously removed from the excavation. Boreholes were advanced by cable-tool methods using primarily a hard tool with continuously driven 10- or 12-in.-diameter, temporary, schedule 40, steel casing. To obtain intact samples of the Ringold Formation for laboratory analysis, a core (drive) barrel was used in a few of the deep and intermediate wells. Cores were obtained for a limited number of samples for various physical analyses presented in Appendix B. To advance the borehole to greater depths for intermediate and deep monitoring wells, a 10-in.-diameter, steel casing was set inside the 12-in.-diameter, temporary steel casing. The bottom

FIGURE A.1 Location Map of New 1987 Monitoring Wells

TABLE A.1. Summary of Completion Information for New Wells and Pumps Installed in the 300 Area June 1, 1986 Through June 1, 1987

Permanent Well Number	Former Designation	Completion Date (M-D-Y) (a)	Drilled Depth (b) (feet)	Present Depth to Bottom (b) (feet)	Initial Depth to Water (b) (feet)	Depth to Open Interval (c) (feet)	Depth to Pump Intake (b) (feet)	Casing Diameter (inches)	Casing Height Above Ground (feet)
399-1-9	S2	2-12-87	181	180	42.9	170-180	60	6.0c	1.6
399-1-10	S3	12-1-86	45	39.5	29	24.5-39.5	35	6.0ss	1.7
399-1-11	S4	11-20-86	47	47	37	27-47	40	6.0ss	1.6
399-1-12	S5	11-3-86	65	60	39.1	45-60	50	6.0ss	2.4
399-1-13	S6	11-5-86	56	53	43	38-53	49	6.0ss	2.8
399-1-14	S7	11-14-86	50	46	36.5	31-46	39	6.0ss	2.8
399-1-15	S8	11-7-86	48	44	33.3	29-44	40	6.0ss	1.8
399-1-16A	C1A	12-5-86	48	47.5	37.3	32.5-47.5	46	6.0ss	1.3
399-1-16B	C1D	2-10-87	118	115	37.9	105-115	61	6.0ss	1.1
399-1-16C	C1B	1-16-87	178	177.5	39	167.5-177.5	60	6.0ss	1.9
399-1-16D	C1C	1-29-87	180	116	40.5	106-177.5	None	6.0ss	1.3
399-1-17A	C2A	11-13-86	41	40	31.9	25-40	40	6.0ss	2.3
399-1-17B	C2B	12-19-86	115	110	32.9	100-110	60	6.0ss	2.4
399-1-17C	C2C	1-16-87	173	171	33	161-171	60	6.0ss	2.5
399-1-18A	C3A	11-12-86	63	54	44.2	39-54	49	6.0ss	3.0
399-1-18B	C3B	1-23-87	125	118	45.5	108-118	59	6.0ss	2.7
399-1-18C	C3C	1-6-87	153	140	42.8	130-140	59	6.0ss	2.7
399-1-19	T3	5-23-86	45	45	38.0	35-45	40	6.0ss	2.5
399-4-11	S1	11-26-86	95	70	59.9	55-70	65	6.0ss	1.7

(a) (M-D-Y) = Month, day, and year completed.

(b) All depths are given relative to land surface.

(c) Screened interval (stainless steel, wire wrap, type 304).

c Carbon steel casing, A53, grade B, SCH 40.

ss Stainless steel casing type 304 or 304L.

TABLE A.2. Summary of Completion Information for Wells and Pumps Installed Prior to 300 Area
RCRA Drilling in June 1986

Permanent Well Number	Former Designation	Completion Date (M-Y) ^(a)	Drilled Depth ^(b) (feet)	Present Depth to Bottom ^(b) (feet)	Initial Depth to Water ^(b) (feet)	Depth to Open Interval ^(b) (feet)	Depth to Pump Intake ^(b) (feet)	Casing Diameter (inches)	Casing Height Above Ground (feet)
399-1-1	303-3	11-48	77	74	42	20-75p	42	8.0c	2.3
399-1-2	303-4	4-50	101	100	45	25-75p	48	8.0c	1.3
399-1-3	303-6	4-50	102	77	37	25-70p	48	8.0c	1.7
399-1-4	303-7	5-50	101	78	42	23-70P	44	8.0c	1.5
399-1-5		2-75	45	45	35	23-45s	41	6.0ss	3.0
399-1-6		2-75	44	44	33	22-44s	36	6.0ss	3.0
399-1-7	T-1	3-85	75	75	37	25-75s	48	6.0c	2.8
399-1-8	T-2	8-85	118	105	39	85-105s	93	6.0ss	1.6
399-2-1	303-2	11-48	77	73	40	18-73p	41	8.0c	3.1
399-2-2		10-76	65	63	39	35-55s	41	8.0c	2.0
399-2-3		10-76	65	63	40	35-55s	41	8.0c	1.1
399-3-1	303-1	10-48	74	74	43	20-65p	46	8.0c	2.3
399-3-2	300-3	10-47	102	89	53	40-75p	45	10.0c	-3.4
	3905-3								
399-3-3	300-4	1-48	175	83	52	52-83p	50	10.0c	2.0
	3905-4								
399-3-4	330-3 T.H.	5-51	40	cr	cr	None	None	8.0c	None
399-3-5	300-4 T.H.	5-51	40	cr	cr	None	None	8.0c	None
399-3-6	300-DIW	8-43	85	85	48	42-55p	72	10.0c	2.1
	3905-1								
399-3-7	300-D2W	1-44	86	86	63	52-70p	68	12.0c	2.5
	3905-2								
399-3-8		3-70	48	48	43	28-48p	None	8.0c	2.0
399-3-9		8-76	70	65	45	45-55s	52	8.0c	2.0
399-3-10		9-76	67	63	40	34-49s	47	8.0c	2.7
399-3-11		9-76	72	70	47	47-70s	61	8.0c	2.0

TABLE A.2. (contd)

Permanent Well Number	Former Designation	Completion Date (M-Y) ^(a)	Drilled Depth ^(b) (feet)	Present Depth to Bottom ^(b) (feet)	Initial Depth to Water ^(b) (feet)	Depth to Open Interval ^(b) (feet)	Depth to Pump Intake ^(b) (feet)	Casing Diameter (inches)	Casing Height Above Ground (feet)
399-3-12		9-80	65	65	46	35-49p	50	6.0c	1.4
399-4-1	303-10	2-51	101	84	52	25-80p	58	8.0c	2.7
399-4-2	300-1 T.H.	5-51	42	cr	cr	None	None	8.0c	NA
399-4-3		4-58	100	cr	cr	None	None	8.0c	NA
399-4-4		5-58	40	cr	cr	None	None	6.0c	NA
399-4-5		8-58	200	196	50	110-195p	160	12.0c	NA
399-4-6		7-58	134	cr	cr	None	None	8.0c	NA
399-4-7		11-61	155	82	35	21-82p	42	8.0c	1.5
399-4-8		10-71	72	72	41	35-53p	NA	8.0c	2.0
399-4-9		9-76	65	59	32	38-58s	46	8.0c	2.3
399-4-10		9-76	60	55	33	37-50s	42	8.0c	1.9
399-5-1	303-11	2-51	102	90	52	23-100p	60	8.0c	2.6
399-5-2	303-13	7-54	424	417	40	192-412p	None	8.0c	2.0
399-5-3	300-2 T.H.	5-51	36	cr	cr	None	None	8.0c	NA
399-6-1	303-9	5-50	101	62	42	25-75p	50	8.0c	1.2
399-8-1	303-5	4-50	102	98	52	35-83p	62	8.0c	2.0
399-8-2	303-8	5-50	119	92	53	43-72p	64	8.0c	1.4
399-8-3	303-12	3-51	102	94	50	25-99p	60	8.0c	1.2
399-8-4		9-79	65	61	45	42-60p	57	8.0c	2.0
699-S30E15A	49-17A	10-71	80	78	58	58-78s	64	6.0c	2.5
699-S30E15B	49-17B	10-71	93	93	58	NA	None	6.0c	NA
699-S30E15C	DDH-3	8-62	219	211	56	45-160p	None	1.5c	NA
	3099-49-16								
699-S29-E12	50-15	11-71	80	79	40	37-79p	50	6.0c,ss	3.5
699-S27-E14	3000-7	4-48	165	105	58	60-150p	71	8.0c	0.9
699-S19-E13	4N	11-71	80	78	46	50-78p	53	6.0c	3.1

(a) (M-Y) = Month and year completed.

(b) All depths are given relative to land surface.

p Perforated interval (steel casing).

s Screened interval (stainless steel, wire wrap, type 304).

NA Information not available.

ss Stainless steel casing, type 304 or 304L.

c Carbon steel casing, which is commonly A53, grade B, SCH 40.

cr Casing removed.

FIGURE A.2. Types of Monitoring Wells

of the temporary steel casing was protected by drive shoes that had been machined and tapered to minimize friction when removing the casing during the pullback operation.

The ambient air above all exploratory wells and borehole cuttings was monitored with an HNU^(a) photoionizer to detect volatile organics and/or petroleum hydrocarbons potentially harmful to personnel or the environment. The results were negative. During drilling operations, drill cuttings from boreholes were monitored for radiation by radiation protection technicians. The drill cuttings were also monitored for discoloration and odor to detect contamination.

A qualified geologist was on site at each well to record the characteristics of the drill cuttings and soil cores as they were withdrawn. This, along with the following information, was included on the borehole logs presented in this appendix:

- well depths (recorded to the nearest 0.1 ft, where possible)
- sample descriptions including basic lithologic classification, Munsell color, and secondary geotechnical information
- lithologic boundaries
- depth-to-ground water and where encountered
- start-up and completion dates
- type of drilling equipment
- special problems encountered during drilling.

Upon completion of drilling, a straightness test was performed on each well. The test consisted of lowering a 20-ft section of pipe inside the temporary well casing. This 20-ft pipe was 2 in. smaller in diameter than the temporary casing. All of the wells passed the straightness test.

Next each well was geophysically logged with natural gamma, neutron, and gamma density probes. In addition, a few wells were logged with a caliper log

(a) HNU is a registered product of HNU Systems, Newton, Massachusetts.

to determine the integrity of the temporary casing before and during removal (pullback). Procedures for use of these probes are included in Appendix G, and the logs are presented in figures included in this appendix.

Shallow monitoring wells were completed with the screened interval in the saturated portion of the Hanford formation or the upper 10 ft of saturated sediment of the unconfined aquifer. A 10-ft section of 10-in.-diameter telescope sized, stainless-(type 304) steel wirewrap well screen was installed at the bottom of five of the 10 shallow wells. Wells with the telescoping screen installed are 1-10, 1-13, 1-14, 1-16A, and 1-18A. Originally a sixth well, 4-11, was to have a telescoping screen for aquifer testing, but a satisfactory disposal area for the discharged water could not be found within 1000 ft of the well. Because a high-volume and discharge-rate type aquifer test would not be performed, the 10-in.-diameter well screen was not installed in well 4-11. The 10-in. temporary casing was pulled back 9 to 10 ft, allowing the formation of a natural sand and gravel pack around the exposed 10-ft section of well screen.

Each well was then developed using a dart bailer followed by development using a test pump. Upon completion of the well development and a step drawdown test, an aquifer test was performed on 13 of the 17 wells installed. After completion of the aquifer test and removal of the test pump, each of these wells and all other shallow wells were completed by installing a 10- to 20-ft section of 6-in. (pipe-sized) wirewrap stainless-steel well screen. In five shallow wells, the 6-in. screen was set inside the 10-in. well screen; in all other wells, the 6-in screen was set in the 10-in. temporary casing. Then in either case the wells were developed and tested. The riser or blank pipe consisted of schedule 10, 6-in.-diameter stainless- (type 304L) steel with schedule 40 externally flush-threaded couplings with Viton o-rings.

Before placing the stainless-steel pipe and well screen inside the temporary casing, a base of 8-12 or 10-20 U.S. mesh-sized Colorado Silica Sand was poured into the cased borehole. The 0.040- or 0.020-in. continuous wirewrap, PVC well screen (manufactured by Johnson Union Oil Products, Inc.) was assembled with a bottom plate and then lowered into the cased borehole. The shallow wells in the unconfined aquifer were screened to 2 ft above the maximum water table surface; seasonal variations were taken into consideration. Successive

lengths of stainless-steel pipe were screwed together onto the well screen to create a continuous well casing from the top of the screen to approximately 2.0 ft above ground surface.

An artificial sand pack was placed between the 6-in. and 10-in. screen and/or pipe, extending upward to a maximum of 5 ft above the top of each 6-in. screen. Each well screen was sand packed with rounded sand that was manufactured (sieved, washed, and bagged) by Colorado Silica Sand, Colorado Springs, Colorado. This sand had a grain-sized distribution of 8-12 U.S. mesh size where a 0.040 in. slot size was used and of 10-20 U.S. mesh size where a 0.020 in. slot size was used. Both sizes of sand have a Hazen uniformity coefficient of 1.5 or less and a Powers roundness of 4 to 6 (round to very round). Perfectly uniform and rounded grains have a uniformity coefficient of 1.0 and a roundness of 6.0, whereas most river sands have a uniformity coefficient of 4 to 10 and an average roundness of 2.5 (subangular) (Folk 1968). Depth to the top of the sand and the depths of all subsequent completion materials were obtained using a weighted steel surveyor's tape.

A bentonite seal was placed above a sand pack extending to within 5 ft of ground surface. In shallow wells, this seal consisted of granular bentonite, which is made of crumbled sodium bentonite (the size of coarse sand) manufactured by American Colloid Company, Skokie, Illinois. In intermediate-depth wells, 0.25-in.-diameter, high-density, sodium bentonite pellets were used to the top of the water table; then the seal was completed with bentonite crumbles to within 5 ft of ground surface. Granulated bentonite pellets were tremied above the sand pack through tremie pipes and near ground surface through the annular space formed by the pipe and temporary casing. In the deep wells, bentonite pellets were rarely used, although a thin layer was sometimes tremied immediately above the sand pack or at least the attempt was made. Volclay grout was tremied by pipe to the water table surface and crumbles were added to fill the annulus to within 5 ft of ground surface after allowing at least 2 hours for the grout to set. Grout was mixed and placed in accordance with the manufacturer's specifications. The temporary casing was progressively pulled back as the sand pack and bentonite sealants were placed in the annulus to maintain a continuous annular pack or seal.

Bentonite crumbles were moistened with water before placing the Type I Portland Cement concrete plug to the ground surface. The stainless-steel riser was seated in a 4-ft by 4-ft square by 6-in.-thick concrete surface pad. The pad sloped away from the well casing. A lockable, stainless-steel slip-over cap was installed on the stainless-steel casing. Typical completions of shallow and intermediate or deep wells are presented in Figures A.3 and A.4. All wells needed additional protection from vehicular traffic, and two or more steel guard posts were also installed per well. Typically four guard posts (6 ft in length and recessed approximately 2 ft into the ground) were installed 2 ft radially from each corner of the concrete pad except for well clusters and wells near a structure where fewer posts were needed. The guard posts were painted safety yellow for visibility, and the well was clearly numbered on the brass marker set in the concrete pad. Locking lugs were provided for well casings and caps.

Each well was then developed and aquifer tested, except for the five shallow wells already tested. Aquifer test procedures and results are described in detail in Appendix D. A detailed discussion of the lithology and well construction of each well is contained on the following pages in this appendix. Diagrams of well construction and geology and geophysical logs are presented in Figures A.5b through A.68 with individual construction histories of each new well, and without narratives for older wells.

SURVEY CONTROL

Hydrologic studies require accurate knowledge of the location and elevation of monitoring wells and sampling points for interpolation of hydrologic and chemistry data. Each of the new monitoring-well locations (shown in Figure A.1) was horizontally and vertically surveyed or resurveyed in the spring of 1987 as noted in the last column of Table A.3. Older wells (i.e., wells constructed before January 1, 1986) were also resurveyed to resolve differences in historical surveys and to survey the wells to a common benchmark. The survey data for all older wells, excluding those that have been abandoned, are listed in Table A.4.

Not to Scale

FIGURE A.3. Schematic Diagram of a Typical Shallow Monitoring Well

Not to Scale

FIGURE A.4. Schematic Diagram of a Typical Intermediate or Deep Monitoring Well

TABLE A.3. Horizontal and Vertical Control Reference Data for 300 Area Wells Drilled After January 1, 1986

Well Number	EMA Number	Coordinates ^(a)		Casing (ft) Elevation ^(b)	Elevation ^(b,c) Brass Marker	Date of Most Recent Survey
		N	E			
399-1-9	4929	055766.5	015696.9	384.80	383.21	3-16-87
399-1-10	4930	057083.8	016018.6	373.65	371.94	3-16-87
399-1-11	4931	056853.7	015240.6	377.79	376.18	3-16-87
399-1-12	4932	056489.0	015005.0	384.45	382.04	3-16-87
399-1-13	4933	056526.5	014579.1	388.62	385.84	3-16-87
399-1-14	4934	057250.5	014560.9	383.23	380.40	3-16-87
399-1-15	4935	057857.0	014856.0	379.59	377.81	3-16-87
399-1-16A	4936	056035.6	015910.1	381.51	380.21	3-16-87
399-1-16B	4937	056026.9	015931.6	381.14	380.03	3-16-87
399-1-16C	4938	056023.6	015889.8	382.29	380.40	3-16-87
399-1-16D	None	056013.9	015906.7	382.05	380.72	3-16-87
399-1-17A	4939	056045.7	015236.2	377.47	375.13	3-16-87
399-1-17B	4940	056059.5	015210.3	377.87	375.48	3-16-87
399-1-17C	4941	056030.6	015209.0	378.13	375.59	3-16-87
399-1-18A	4942	058970.1	014483.3	390.83	387.77	3-16-87
399-1-18B	4943	058956.5	014470.8	389.94	387.24	3-16-87
399-1-18C	4944	058947.4	014491.7	388.05	385.34	3-16-87
399-1-19	4953	056214.9	015149.0	374.64	372.16	3-16-87
399-4-11	4928	053733.6	015121.3	404.53	402.82	3-16-87
SWS-1 ^(d)	None	053942.0	016746.7	None	350.25	3-16-87

(a) Coordinates are in the Richland coordinate system.

(b) Elevations are in feet above mean sea level according to the U.S. Coast and Geodetic Survey 1929 datum, which is 0.28 ft lower than the 300 Area Reference datum.

(c) Elevation of brass marker is typically 0.1 to 0.5 feet above adjacent ground surface.

(d) The 300 Area surface water monitoring station is next to the water intake structure.

TABLE A.4. Horizontal and Vertical Control Reference Data for 300 Area Wells Drilled Before January 1, 1986

Well Number	EMA Number	Coordinates ^(a)		Casing Elevation ^(b)	Elevation ^(b) of Ground Surface	Date of Most Recent Survey
		N	E			
399-1-1	4403	056608	016057	375.90	373.60	4-23-87
399-1-2	4404	055770	015133	384.52	383.27	4-23-87
399-1-3	4406	055781	015698	384.75	382.98	3-16-87
399-1-4	4407	056987	014949	380.83	379.25	4-18-77
399-1-5	4806	056499	015240	389.82	386.82	3-16-87
399-1-6	4837	057639	015358	373.81	370.86	4-23-87
399-1-7	4400	055780	015716	385.63	382.90 ^(c)	3-16-87
399-1-8	4896	055762	015708	384.91	383.05 ^(c)	3-16-87
399-2-1	4402	055068	016385	375.26	372.13	4-23-87
399-2-2	4633	055602	016126	375.53	373.58	4-23-87
399-2-3	4634	055398	016096	375.44	374.34	4-23-87
399-3-1	4401	054696	016426	384.43	382.13	4-23-87
399-3-2	3033	054051	014597	392.36	395.71	4-23-87
399-3-3	3034	054050	015000	397.50	395.50	4-23-87
399-3-4	None	054140	014800	402.00	cr	?
399-3-5	None	054250	014430	398.00	cr	?
399-3-6	3031	054514	014605	392.85	390.90	4-23-87
399-3-7	4839	054600	015000	394.22	391.75	4-23-87
399-3-8	4786	054449	015408	387.58	385.58	2-15-72
399-3-9	4626	054399	016498	387.31	385.31	4-23-87
399-3-10	4627	054117	016578	385.40	382.70	4-23-87
399-3-11	4628	054001	015851	395.55	393.55	4-23-87
399-3-12	4870	054508	015546	386.38	385.03	4-23-87
399-4-1	4410	053162	015724	395.00	392.30	4-23-87
399-4-2	None	053860	014900	402.00	cr	?
399-4-3	4615	053960	016700	372.00	cr	?
399-4-4	None	054021	016953	370.00	cr	?

TABLE A.4. (contd)

Well Number	EMA Number	Coordinates ^(a)		Casing Elevation ^(b)	Elevation ^(b) of Ground Surface	Date of Most Recent Survey
		N	E			
399-4-5	4482	053500	015250	402.00	400.0	?
399-4-6	None	No Record	No Record	390.00	cr	?
399-4-7	4568	052999	016802	376.99	375.49	4-23-87
399-4-8	4809	052123	017004	382.04	380.04	2-15-72
399-4-9	4629	053819	016599	381.40	379.15	4-23-87
399-4-10	4630	053537	016688	377.59	375.69	4-23-87
399-5-1	4411	053148	014006	395.60	393.05	4-23-87
399-5-2	4575	052961	010931	390.71	389.19	4-23-87
399-5-3	None	053930	014170	394.00	cr	?
399-6-1	4409	054083	013286	386.93	385.77	4-23-87
399-8-1	4405	055800	013657	394.88	392.88	4-23-87
399-8-2	4408	055717	012245	396.06	394.66	4-23-87
399-8-3	4412	056954	013653	393.11	391.91	4-23-87
399-8-4	4865	055718	011163	393.06	391.08	4-23-87
699-S19-E13	4802	059967	014384	394.51	391.39	4-23-87
699-S27-E14	4413	052104	015184	399.76	398.83	4-23-87
699-S29-E12	4803	050018	013551	387.95	384.42	4-23-87
699-S30-E15A	4804	049121	016311	400.14	397.69	4-23-87
699-S30-E15B	4805	049093	016301	399.33	397.03	4-23-87
699-S30-E15C	4582	048999	015927	401.39	399.39	4-23-87

(a) Coordinates are in the Richland coordinate system.

(b) Elevations are in feet above mean sea level according to the U.S. Coast and Geodetic 1929 survey datum, which is 0.28 ft lower than the 300 Area Reference datum.

(c) Elevation of Brass marker, which is typically 0.1 to 0.5 feet above adjacent ground surface.

(d) The 300 Area surface water monitoring station (SWS-1) is next to the water intake structure.

cr Casing removed.

The Hanford Site contains nine basic grid systems. Four of these pertain to specific areas at Hanford that do not include the 300 Area. Horizontal surveys performed in the 300 Area can be tied into the other five systems; however, on a practical basis only three are used, primarily because of the greater availability of benchmarks for control. These three are listed last in the following descriptions:

- Government Land Office: A grid composed of sections, townships, and ranges established in this particular area in the 1860s by the Government Land Office (GLO). The system uses approximately 1-mi-square sections with township lines every 6 mi in a northerly direction and range lines every 6 mi in an easterly direction, thereby designating 36 sections to the township. This grid is used primarily for the purpose of legal descriptions in property title transfers.
- Geographic: A global grid composed of latitude and longitude with latitude having a 0° basis at the equator and increasing going both north and south (Hanford is near N $46^\circ 30'$), and longitude having a 0° basis on the Greenwich meridian and progressing east and west to 180° (Hanford is near W $119^\circ 30'$).
- Washington Coordinate System: The official state plane coordinate system (also commonly referred to as the Lambert system) as defined by the Revised Code of Washington (RCW). The Hanford Site lies within the Washington coordinate system south zone. The system is converted to sea level datum and then to the plane itself for use and computations, then reconverted back to site datum for field use. This grid covers the entire site and uses X (Eastings) and Y (Northings) coordinates.
- Hanford Plant Grid: A local grid system with its initial point northeast of the 400 Area, but its control base is just north of the 200-East Area. It is rotated from north and is on a slightly different scale than Lambert. It covers 200-East, 200-West, 100-B, 100-D, 100-F, 100-H, and the 400 Area as well as general Site work such as wells and burial grounds. It uses all four quadrants.

- 300 Area: An extension of the old Richland Grid System covering the 300 Area and the original grid system for the City of Richland. This system with its origin southwest of Richland is rotated slightly from north and uses Northings and Eastings.

Horizontal surveys were tied to the Richland or 300 Area coordinate system (datum). Maps presented in this interim characterization report show this coordinate system in bold letters and many base maps have a grid on 1000-ft centers using this coordinate system as shown in Figure A.46. Also shown in Figure A.46 are the coordinates for the Lambert coordinate system. Like the 300 Area coordinate system, the Lambert system is given in northing and easting map coordinates and is shown above the Richland coordinate system on all maps. The Lambert system is indicated by tick marks along the edge of 300 Area maps used in this report.

For horizontal control, new wells were surveyed to the brass markers set in their concrete base, and old wells were surveyed to the centerline of the well casing using a Kern theodolite (Serial No. 93389) and an electronic distance measuring (EDM) system (Serial No. 93390). The horizontal coordinates of all wells are accurate (i.e., had closure) to within ± 0.4 ft. Horizontal control was tied to a common and accurate 300 Area monument (N 54,500 x E 16,330).

Vertical control was achieved by tying select 300 Area monuments to a common monument (B. M. No. M-323) of the National Geodetic Vertical Survey Datum (NGS) of 1929 (formerly the United States Coast and Geodetic Survey Datum, USC&GS). The 300 Area elevation datum is 0.28 ft higher than the NGS datum. The NGS elevations of the top of the steel well casing (marked with an "x") for all old and new wells were surveyed to within ± 0.04 ft and are presented in Tables A.3 and A.4. Closure on individual loops of 26 and 32 wells was a maximum of ± 0.02 ft. The wells were surveyed to the x's on top of the casing and, if present, to the brass survey markers in the concrete base using a Wild NA-2 Level (Serial No. WA-63324). All surveys were conducted by Kaiser Engineering of Hanford (KEH) and documented in KEH File No. WELL-109, request Numbers -871-043, -872-077, -872-084, and -872-085.

GEOLOGIC AND GEOPHYSICAL LOGS

The installation and other pertinent details of each of the new wells are described in the sections that follow.

Well number 399-1-9 (Temporary Well Number S2)

Coordinates: N 55,766.5

E 15,696.9

Casing Elevation: 384.80 ft

Brass Marker Elevation: 383.21 ft

Initial Depth to Water: 42.85 ft below land surface

Starting Date: 9-24-86

Completion Date: 2-12-87

Well 399-1-9 was drilled to a depth of 181 ft using a 72 Speedstar^(a) cable-tool rig with hard tools. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with 12-in. diameter casing to 45 ft and then reduced to 10-in. casing to total depth. The sediments encountered during drilling included unconsolidated sands and gravels of the Hanford Formation; semi-consolidated to well-consolidated gravels, sands, silts, and clay of the Ringold Formation; and the Ice Harbor Member/Martindale basalt flow. Positive identification of the Ice Harbor Member/Martindale flow was determined through chemical analysis of basalt drill cuttings from the 179- to 180-ft sample. Results from the analysis are shown in Table B.1 in Appendix B. Geophysical logging of the borehole was performed using natural gamma, density, and neutron probes. After logging the borehole, 6-in.-diameter, 0.040 in. continuous wire-wrap 40-slot stainless-steel screen was installed at a depth of 170 to 180 ft, which is just above the uppermost basalt flow beneath the confining clay layer of the Ringold Formation. Fifteen ft of 8-12 mesh (ASTM E11-61) Colorado silica sand was added around the screened interval. After several attempts to pull the 10-in. steel casing using the pull-head and casing-line method, it was decided to retrieve the stainless-steel casing to prevent its loss if in fact the 10-in. casing did not pull back. A high-pressure vacuum was created using an air compressor and a 1/2-in. galvanized tremie pipe. This method was successful in removing the sandpack, which enabled easy retrieval of the 6-in. casing.

On October 27, 1986, the cable-tool rig pulled off of the hole to begin drilling at another well site. On December 2, 1986, an Ingersoll Rand T4^(b) air-rotary rig was moved onto the hole to continue attempts at freeing the 10-in. casing. The casing was pulled approximately 2 ft; however, the rig's drive barrel was damaged. On December 8, 1986, the cable-tool rig along with hydraulic jacks were set up over the hole and 6 ft of 10-in. casing was pulled.

(a) Speedstar is a registered product of Speedstar-AMCA International, Enid, Oklahoma.

(b) Ingersoll Rand T4 is a registered trademark of Ingersoll Rand Company, Garland, Texas.

Once the temporary steel casing appeared to be free, the original stainless-steel casing and screen were reinserted at a depth of 180 ft. Sand-pack was added to 166 ft and the steel casing pulled back to 165 ft, where it locked up against boulders in the formation. Numerous attempts at pulling the casing using the cable-tool and the air-rotary rig continued unsuccessfully from December 10, 1986, until January 20, 1987, at which time the casing began to free up. While the casing was being pulled, Volclay^(a) grout was pumped through a tremie pipe into the annulus to produce an adequate seal. At 104 ft the casing again began tightening up, requiring alternate use of both the air-rotary and cable-tool rigs to attempt to free it. On February 2, 1987, the decision was made to drill a 6-in.-diameter relief well adjacent to the existing well by using air rotary. This attempt was interrupted by a major mechanical breakdown of the rotary's drill head. Once the air rotary was repaired, another attempt at drilling a 6-in. relief well began, this time closer to well 399-1-9. The initial relief hole that had only been drilled to 25 ft was sealed with granular bentonite. The new relief well was drilled to a depth of 125 ft with over 30 ft of open hole.

Final attempts at pulling the 10-in. steel casing began, using the cable-tool rig with hydraulic jacks. This attempt continued February 10 and 11, 1987, at which point the casing broke 16 ft below the ground surface with 85 ft remaining. The decision was made to grout the annulus to a level above the break in order to ensure a sufficient seal between the 10- and 12-in. casings. The 12-in. casing was pulled back with relative ease and the remaining annulus sealed with granular bentonite and a concrete surface seal. The relief well was completed with 8-12 mesh silica sand to 80 ft and the remaining annulus sealed with Volclay grout, granular bentonite, and a concrete surface seal. On February 27, 1987, well 399-1-9 was developed by pumping with a 5-hp submersible pump for 1 hour at 20 gpm and 4 hours at a discharge rate of 4 gpm. On March 2, 1987, the well was pumped for 8 hours at a constant discharge rate of approximately 2.7 gpm with a maximum drawdown of 80.64 ft. On March 9, 1987, the well was bailed using a 5-in.-diameter dart bailer to remove scum from the surface of the water. A slight sulfurous odor was detected while bailing. A Hydrostar^(b) sampling pump was installed on March 4, 1987 with the intake set at 62 ft below the top of the casing.

An explanation of lithologic symbols is shown in Figure A.5a. The well construction details and geologic and geophysical logs for well 399-1-9 are shown in Figure A.5b.

(a) Volclay is a registered trademark of American Colloid Company, Skokie, Illinois

(b) Hydrostar is a product of Instrumentation Northwest, Inc., Redmond, Washington.

FIGURE A.5a. Symbols Used for Lithologic Diagrams

FIGURE A.5b. Construction and Lithologic Diagram of Well 399-1-9

FIGURE A.5b. (contd)

A.25/A.26

Well number 399-1-10 (Temporary Well Number S3)

Coordinates: N 57,083.8

E 16,018.6

Casing Elevation: 373.65 ft

Brass Marker Elevation: 371.94 ft

Initial Depth to Water: 29 ft below land surface

Starting Date: 11-13-86

Completion Date: 12-1-86

The initial 18 ft of well 399-1-10 was dug with a backhoe and the surface casing was set. Drilling continued to a depth of 45 ft using a 22W Bucyrus Eries^(a) cable-tool rig with hard tools. Unconsolidated sands and gravels of the Hanford Formation were encountered during the course of drilling. The temporary 10-in. casing was pulled back allowing for natural back-fill to 40 ft. A 10-ft section of 10-in., stainless-steel telescoping screen was set at this level and the temporary casing was pulled back to expose the entire length of the screen. The borehole was geophysically logged using natural gamma, density, and neutron probes. The well was bailed using an 8-in.-diameter dart bailer for 1 hour. Additional development was performed by pumping at a rate of 600 gpm for 1 hour. On November 25, 1986, the well was pumped for 4 hours at a discharge rate of 630 gpm with a maximum drawdown of 2.4 ft. Upon completion of the aquifer testing, 6-in.-diameter, 40-slot stainless-steel screen was set in the upper portion of the unconfined aquifer between 24.5 and 39.5 ft. Colorado silica sand (8-12 mesh) was added around the screen to 18 ft and the remaining annular space was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was bailed for 2 hours using a 5-in.-diameter dart bailer to develop the sand pack. A Hydrostar sampling pump was installed on December 22, 1986, with the intake 37 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-10 are shown in Figure A.6.

(a) Unable to locate listing for Bucyrus Eries Company.

Well Number 399-1-11 (Temporary Well Number S4)
Coordinates: N 56,853.7
 E 15,240.6
Casing Elevation: 377.79 ft
Brass Marker Elevation: 376.18 ft
Initial Depth to Water: 37 ft below land surface
Starting Date: 11-17-86
Completion Date: 11-20-86

Well 399-1-11 was drilled to a depth of 47 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. Sediments encountered included unconsolidated sands and gravels of the Hanford Formation, and the uppermost semi-consolidated sands and gravels of the middle Ringold Formation. On completion of drilling, the borehole was geophysically logged using natural gamma, density, and neutron probes. Ten ft of 6-in.-diameter, 40-slot stainless-steel screen and 10 ft of 6-in.-diameter, 20-slot stainless-steel screen was installed in the upper portion of the unconfined aquifer between 27 and 47 ft. The additional screen was set to compensate for large water level fluctuations associated with the waste trench operations. Then 8-12 and 10-20 mesh Colorado silica sand was placed over the entire screened interval. The annulus was sealed using bentonite pellets, bentonite crumbles and a concrete surface seal. The well was developed for 30 min using a 5-in.-diameter dart bailer. The well's location inside a radiation zone prevented further development by pump and aquifer testing. A Hydrostar sampling pump was installed on December 30, 1986, with the intake set at 42 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-11 are shown in Figure A.7.

FIGURE A.6. Construction and Lithologic Diagram of Well 399-1-10

FIGURE A.6. (contd)

FIGURE A.7. Construction and Lithologic Diagram of Well 399-1-11

FIGURE A.7. (contd)

Well Number 399-1-12 (Temporary Well Number S5)

Coordinates: N 56,489.0

E 15,005.0

Casing Elevation: 384.45 ft

Brass Marker Elevation: 382.04 ft

Initial Depth to Water: 39.1 ft below land surface

Starting Date: 10-28-86

Completion Date: 11-3-86

The initial 17 ft of well 399-1-12 was dug by a backhoe and the 10-in.-diameter surface casing was set. Drilling continued to a depth of 65 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. Sediments encountered included surficial eolian sands; unconsolidated sands and gravels of the Hanford Formation; and semi-consolidated to well-consolidated gravels, sands, silt, and clay of the Ringold Formation. The borehole was geophysically logged using natural gamma, density, and neutron probes. The well was completed with 6-in.-diameter, 40-slot, stainless-steel screen in the uppermost portion of the unconfined aquifer between 45 and 60 ft. Twenty ft of Colorado silica sand (8-12 mesh) was added around the screen and the remaining annular space was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was bailed for approximately 1 hour using a 5-in.-diameter flat-bottomed bailer. A Hydrostar sampling pump was installed on December 12, 1986, with the intake set at a depth of 52 ft.

The well construction details and geologic and geophysical logs for well 399-1-12 are shown in Figure A.8.

Well Number 399-1-13 (Temporary Well Number S6)
Coordinates: N 56,526.5
 E 14,579.1
Casing Elevation: 388.62 ft
Brass Marker Elevation: 385.84 ft
Initial Depth to Water: 43 ft below land surface
Starting Date: 10-28-86
Completion Date: 11-5-86

The initial 16 ft of well 399-1-13 was dug using a backhoe and the 10-in.-diameter surface casing was set. Drilling continued to a depth of 56 ft using a 71 Speedstar cable-tool rig with hard tools. Unconsolidated sands and gravels of the Hanford Formation and semi-consolidated sands and gravels of the middle Ringold Formation were encountered during drilling. The borehole was geophysically logged using natural gamma, density, and neutron probes. A 10-ft section of 10-in.-diameter, 40-slot stainless-steel telescoping screen was set between 43 and 53 ft. The 10-in. steel casing was pulled back to expose the screened interval. The well was bailed for 4 hours using an 8-in.-diameter flat-bottomed bailer. Further development was performed using a 10-hp submersible pump at a discharge rate of 600 gpm for approximately 3.5 hours. On November 5, 1986, the well was pumped for 2 hours at a constant discharge rate of 660 gpm with a maximum drawdown of 0.98 ft. The test, originally planned for 8 hours, was aborted because of a problem in containing the large volume of discharge water. On completion of testing, the well was screened using 15 ft of 6-in.-diameter, 40-slot stainless-steel screen in the interval between 38 and 53 ft. Nineteen ft of 8-12 mesh Colorado silica sand were added around the screened interval. Bentonite pellets, bentonite crumbles, and a concrete surface seal were added to seal the remaining annulus. A Hydrostar sampling pump was installed on December 30, 1986, with the pump intake set at 52 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-13 are shown in Figure A.9.

FIGURE A.8. Construction and Lithologic Diagram of Well 399-1-12

2

FIGURE A.8. (contd)

FIGURE A.9. Construction and Lithologic Diagram of Well 399-1-13

FIGURE A.9. (contd)

Well Number 399-1-14 (Temporary Well Number S7)

Coordinates: N 57,250.5

E 14,560.9

Casing Elevation: 383.23 ft

Brass Marker Elevation: 380.40 ft

Initial Depth to Water: 36.5 ft below land surface

Starting Date: 11-6-86

Completion Date: 11-14-86

Well 399-1-14 was drilled to a depth of 50 ft using a 72 Speedstar cable-tool rig with hard tools. The sediments encountered during drilling included surficial eolian sands; unconsolidated sands and gravels of the Hanford Formation; and semi-consolidated sands and gravels of the middle Ringold Formation. Ten ft of 40-slot, 10-in.-diameter stainless-steel telescoping screen was set between 37 and 47 ft in the upper portion of the unconfined aquifer. The well was bailed for 3 hours using an 8-in.-diameter flat-bottomed bailer. The borehole was geophysically logged using natural gamma, density, and neutron probes. Further development was performed using a 10-hp submersible pump at a discharge rate of approximately 600 gpm for 1.5 hours. On November 12, 1986, a 7-hour aquifer test was performed at a discharge rate of 565 gpm with a maximum draw-down of 2.13 ft. On completion of testing, 15 ft of 6-in.-diameter, 40-slot stainless-steel screen was installed between 31 and 46 ft. Colorado silica sand was added around the screen to 26 ft and the remaining annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. A Hydrostar sampling pump was installed on December 30, 1986, with the pump intake set at 42 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-14 are shown in Figure A.10.

Well Number 399-1-15 (Temporary Well Number S8)
Coordinates: N 57,857.0
 E 14,856.0
Casing Elevation: 379.59 ft
Brass Marker Elevation: 377.81 ft
Initial Depth to Water: 33.3 ft below land surface
Starting Date: 11-4-86
Completion Date: 11-7-86

Well 399-1-15 was drilled to a depth of 48 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. The sediments encountered during drilling included the unconsolidated sands and gravels of the Hanford Formation and semi-consolidated sands and gravels of the middle Ringold Formation. The borehole was geophysically logged using natural gamma, density, and neutron probes. The well was completed in the upper portion of the unconfined aquifer between the depths of 29 and 44 ft using a 6-in.-diameter, 40-slot stainless-steel screen. A 21-ft sandpack using 8-12 mesh Colorado silica sand was added around the screened interval. The remaining annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. A Hydrostar sampling pump was installed on December 22, 1986, with the pump intake set at 42 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-15 are shown in Figure A.11.

FIGURE A.10. Construction and Lithologic Diagram of Well 399-1-14

FIGURE A.10. (contd)

1

FIGURE A.11. Construction and Lithologic Diagram of Well 399-1-15

FIGURE A.11. (contd)

Well Number 399-1-16A (Temporary Well Number C1A)
Coordinates: N 56,035.6
E 15,910.1
Casing Elevation: 381.51 ft
Brass Marker Elevation: 380.21 ft
Initial Depth to Water: 37.3 ft below land surface
Starting Date: 12-1-86
Completion Date: 12-5-86

Well 399-1-16A was drilled to a depth of 18 ft with a backhoe and drilling was continued to the total depth of 48 ft using a 71 Speedstar cable-tool rig with hard tools. Unconsolidated sands and gravels of the Hanford Formation and semi-consolidated sands and gravels of the middle Ringold Formation were encountered during drilling. The borehole was geophysically logged using natural gamma, density, and neutron probes. A 10-ft section of 40-slot, 10-in.-diameter, stainless-steel telescoping screen was set in the upper portion of the unconfined aquifer between the depths of 37.5 and 47.5 ft. The temporary carbon steel casing was pulled back to expose the screen. The well was developed using a 5-in.-diameter flat-bottomed sand bailer and a 7-in.-diameter dart bailer for 4.5 hours. A significant amount of fine sand and silt penetrated the screen during development. A 20-slot, 6-in.-diameter stainless-steel screen was installed between 32.5 and 47.5 ft. Then 10-20 mesh Colorado silica sand was added to 25 ft and the remaining annular space was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was bailed for 1.25 hours using a 5-in.-diameter flat-bottom bailer to sufficiently develop the sandpack. The well was further developed for 1 hour on February 25, 1987, using a 10-hp submersible pump. Because the 10-hp pump over-stressed the well, a 5-hp submersible pump was installed and the well was pumped for approximately 0.5 hours at 30 gpm. On February 26, 1987, the well was pumped for 3 hours at a constant discharge rate of 30 gpm with a maximum drawdown of 1.64 ft. A Hydrostar sampling pump was installed on March 4, 1987 with the intake set at 47 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-16A are shown in Figure A.12.

Well Number 399-1-16B (Temporary Well Number C1D)
Coordinates: N 56,026.9
 E 15,931.6
Casing Elevation: 381.14 ft
Brass Marker Elevation: 380.03 ft
Initial Depth to Water: 37.9 ft below land surface
Starting Date: 1-28-87 (surface casing set)
Completion Date: 2-10-87

Well 399-1-16B was drilled to provide an acceptable monitoring structure, within the 1-16 cluster wells, completed in the lower portion of the unconfined aquifer. The initial 7 ft was dug by a backhoe and the surface casing was set. Drilling continued to a depth of 118 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. Sediments encountered included the unconsolidated sands and gravels of the Hanford Formation and the semi-consolidated to well-consolidated gravels, sand, silt, and clay of the Ringold Formation. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with a 12-in.-diameter casing to 60 ft and then reduced to a 10-in. casing to total depth. On completion of drilling, the borehole was geophysically logged using natural gamma, neutron, and density probes. A 6-in.-diameter, 20-slot stainless-steel screen was installed between the depths of 105 and 115 ft. Then 10-20 mesh Colorado silica sand was added to 100 ft and the remainder of the annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. On completion, the well was developed for 1.75 hours using a 5-in.-diameter dart bailer. Additional development was performed for 1.1 hours using a 5-hp submersible pump at a discharge rate ranging from 2.1 to 15 gpm. On February 24, 1987, the well was pumped for 5 hours at a constant discharge rate of 20 gpm with a maximum drawdown of 28.18 ft. A Hydrostar sampling pump was installed on March 4, 1987 with the intake set at 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-16B are shown in Figure A.13.

FIGURE A.12. Construction and Lithologic Diagram of Well 399-1-16A

FIGURE A.12. (contd)

FIGURE A.13. Construction and Lithologic Diagram of Well 399-1-16B

FIGURE A.13. (contd)

A.57/39

Well Number 399-1-16C (Temporary Well Number C1B)
Coordinates: N 56,023.6
E 15,889.8
Casing Elevation: 382.29 ft
Brass Marker Elevation: 380.40 ft
Initial Depth to Water: 39 ft below land surface
Starting Date: 12-1-86 (surface casing set)
Completion Date: 1-16-87

Well 399-1-16C was originally intended to be completed in the lower portion of the unconfined aquifer (intermediate depth). It was decided to make it a deep well when the original deep well (399-1-16D) was rendered unsuitable for obtaining representative water-chemistry samples. The well was dug to 17 ft using a backhoe and drilling was continued to a total depth of 178 ft using a 71 Speedstar cable-tool rig with hard tools. The sediments encountered included the unconsolidated sands and gravels of the Hanford Formation; the semi-consolidated to well-consolidated gravels, sand, silt, and clay of the Ringold Formation; and the Ice Harbor Member/Martindale basalt flow. Positive identification of the Ice Harbor Member/Martindale flow was determined through chemical analysis of basalt drill cuttings from the 178-ft lithologic sample (see table xx). During the course of drilling, two split-tube samples were taken at the 123- to 125-ft and 163- to 165-ft depths at the upper clay and lower clay boundaries, respectively. The samples were taken to determine vertical permeability and other physical characteristics of the confining Ringold clay layer. Upon completion of drilling, the borehole was geophysically logged using natural gamma, density, and neutron probes. The well was completed in the 167.5- to 177.5-ft interval in the uppermost basalt layer beneath the confining clay layer of the lower Ringold Formation. A 20-slot, 6-in.-diameter stainless-steel screen was installed. Then 14 ft of the borehole annulus was filled with Colorado silica sand (10-20 mesh) and the remaining annular space was sealed using bentonite pellets, Volclay grout, granular bentonite, and a concrete surface seal. On completion, the well was developed using a 5-in.-diameter dart bailer. Additional development was performed using a 5-hp submersible pump for approximately 5 hours at a discharge rate of 3 to 5.7 gpm. On February 17, 1987, the well was pumped for 8 hours at a constant discharge rate of approximately 2.8 gpm with a maximum drawdown of 42.43 ft. A Hydrostar sampling pump was installed on March 5, 1987 with the pump intake set at 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-16C are shown in Figure A.14.

Well Number 399-1-16D (Temporary Well Number C1C)
Coordinates: N 56,013.9
 E 15,906.7
Casing Elevation: 382.05 ft
Brass Marker Elevation: 381.72 ft
Initial Depth to Water: 40.5 ft below land surface
Starting Date: 9-25-86
Completion Date: 1-29-87

Well 399-1-16D was drilled to a depth of 180 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with 12-in.-diameter casing to 43 ft and then reduced to 10-in.-diameter casing to total depth. The sediments encountered included the unconsolidated sands and gravels of the Hanford Formation; the semi-consolidated to well-consolidated gravels, sands, silt, and clay of the Ringold Formation; and the Ice Harbor Member/Martindale basalt flow (based upon chemical analysis of basalt drill cuttings in adjacent well 399-1-16C). Upon completion of drilling, the well was completed above the uppermost basalt flow beneath the confining Ringold clay layer. Ten ft of 20-slot stainless-steel screen was installed between 169 and 179 ft and 10-20 mesh Colorado silica sand was added around the screened interval to 161 ft. The lack of progress in pulling back the 10-in.-diameter steel casing prompted the use of hydraulic jacks. On October 17, 1986, the 10-in.-diameter casing broke during the pull-back process. Determining the break location required the use of a down-hole television camera or caliper probe. Numerous attempts at removing the slough and the sand-pack from around the stainless-steel casing failed. Finally on December 17, 1986, the slough and sandpack were blown out of the annulus by connecting a 1-in. tremie pipe to the air line of an Ingersoll Rand T4 air-rotary rig. The stainless-steel casing was removed. Inspection of the 10-in.-diameter casing by television camera proved unsuccessful because the water was turbid. The caliper, however, showed a distinct defect in the casing at 114 ft. Because the presumed break location was close to the upper boundary of the Ringold clay layer (118 ft), it was decided to perforate the casing below the break, pressure grout to 118 ft, and complete the well in the lower portion of the unconfined aquifer. The 10-in.-diameter casing was perforated with 4 perforations per round per ft from 179 to 114 ft. The perforated casing was then pressure-grouted to 128 ft. Bentonite pellets and Colorado silica sand were added to 116 ft to ensure a firm base for the stainless-steel screen and casing. Ten ft of 40-slot screen were inserted between 106 and 116 ft. Then 8-12 mesh Colorado silica sand was added to 103.5 ft. The true location of the break (92.5 ft) was discovered after pulling the 10-in.-diameter casing back 10 ft and then measuring 18 ft of slough. As the remaining casing was removed, the annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. On completion, the well was bailed for 1 hour using a 5-in.-diameter dart bailer.

The well construction details and geologic and geophysical logs for well 399-1-16D are shown in Figure A.15.

FIGURE A.14. Construction and Lithologic Diagram of Well 399-1-16C

FIGURE A.14. (contd)

FIGURE A.15. Construction and Lithologic Diagram of Well 399-1-16D

FIGURE A.15. (contd)

Well Number 399-1-17A (Temporary Well Number C2A)
Coordinates: N 56,045.7
 E 15,236.2
Casing Elevation: 377.47 ft
Brass Marker Elevation: 375.13 ft
Initial Depth to Water: 31.9 ft below land surface
Starting Date: 11-8-86
Completion Date: 11-13-86

Well 399-1-17A was drilled to a depth of 41 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. Unconsolidated sands and gravels of the Hanford Formation and semi-consolidated sands and gravels of the middle Ringold Formation were encountered during drilling. The borehole was geophysically logged using natural gamma, density, and neutron probes. On completion of logging, the hole was completed in the uppermost portion of the unconfined aquifer using a 40-slot, 6-in.-diameter stainless-steel screen between the depths of 25.2 and 40.2 ft. As the temporary casing was removed, 19 ft of 8-12 mesh Colorado silica sand was added and the remaining annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was bailed for approximately 1 hour using a 5-in.-diameter dart bailer. A Hydrostar sampling pump was installed on December 22, 1986, with the intake level set at 42 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-17A are shown in Figure A.16.

Well Number 399-1-17B (Temporary Well Number C2B)
Coordinates: N 56,045.7
E 15,236.2
Casing Elevation: 377.87 ft
Brass Marker Elevation: 375.48 ft
Initial Depth to Water: 32.9 ft below land surface
Starting Date: 12-1-86
Completion Date: 12-19-86

The initial 18.5 ft of well 399-1-17B was dug by a backhoe and the surface casing was set. Drilling continued to a depth of 115 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with 12-in.-diameter casing to 58.5 ft and then reduced to 10-in.-diameter casing to total depth. Unconsolidated sands and gravels and semi-consolidated to well-consolidated gravels, sand, silt, and clay of the Ringold Formation were encountered during drilling. The borehole was geophysically logged using natural gamma, density, and neutron probes. Then 8-12 mesh Colorado silica sand was added around the screened interval to 110 ft. The well was completed in the lower portion of the unconfined aquifer using a 40-slot, 6-in.-diameter stainless-steel screen between the depths of 99.6 and 110 ft. As the temporary steel casing was removed, additional sand-pack was added to 95 ft and the remaining annulus was sealed with bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was bailed for approximately 1 hour using a 5-in.-diameter dart bailer. Additional development was performed for 2.5 hours using a 5-hp submersible pump with discharge rates of 5, 10, 15, and 20 gpm. On February 9, 1987, the well was pumped for 5.25 hours at a constant discharge rate of 22.6 gpm with a maximum drawdown of 42.03 ft. A Hydrostar sampling pump was installed on February 24, 1987, with the intake level 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-17B are shown in Figure A.17.

FIGURE A.16. Construction and Lithologic Diagram of Well 399-1-17A

FIGURE A.16. (contd)

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FIGURE A.17. Construction and Lithologic Diagram of Well 399-1-17B

FIGURE A.17. (contd)

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Well Number 399-1-17C (Temporary Well Number C2C)
Coordinates: N 56,030.6
E 15,209.0
Casing Elevation: 378.41 ft
Brass Marker Elevation: 375.87 ft
Initial Depth to Water: 33 ft below land surface
Starting Date: 11-14-86 (surface casing set)
Completion Date: 1-16-87

The initial 17 ft of well 399-1-17C was dug by a backhoe and the surface casing was set. Drilling continued to a depth of 173 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with a 12-in.-diameter casing to 70.5 ft and then reduced to a 10-in.-diameter casing to total depth. The sediments encountered during drilling included surficial eolian sands; unconsolidated sands and gravels of the Hanford Formation; semi-consolidated to well-consolidated gravels, sands, silts, and clay of the Ringold Formation; and the Ice Harbor Member/Martindale basalt flow. Positive identification of the Ice Harbor Member/Martindale flow was determined through chemical analysis of basalt drill cuttings from the 170- to 173-ft sample. Results from the analysis are shown in Table B.7. During the course of drilling, two split-tube samples were taken at the 123- to 125-ft and 163- to 165-ft depths, at the upper clay and lower clay boundaries, respectively. The samples were taken to determine vertical permeability and other physical characteristics of the confining lower Ringold clay layer. On completion of drilling, the borehole was geophysically logged using natural gamma, density, and neutron probes. A 20-slot, 6-in.-diameter stainless-steel screen was set between the depths of 160.6 and 171 ft, above the uppermost basalt layer beneath the confining clay layer of the lower Ringold Formation. As the temporary steel casing was removed, 14.25 ft of Colorado silica sand was added and the remaining annular space was sealed using bentonite pellets, Volclay grout, granular bentonite, and a concrete surface seal. On completion, the well was developed for 1.5 hours using a 5-in.-diameter dart bailer. Additional development was performed for 2 hours using a 5-hp submersible pump at a discharge rate of 15 to 32.3 gpm. On February 11, 1987, the well was pumped for 6 hours at a constant discharge rate of approximately 32 gpm with a maximum drawdown of 20.51 ft. A Hydrostar sampling pump was installed February 24, 1987, with the pump intake set at 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-17C are shown in Figure A.18.

Well Number. 399-1-18A (Temporary Well Number C3A)
Coordinates: N 58,970.1
 E 14,483.3
Casing Elevation: 390.83 ft
Brass Marker Elevation: 387.77 ft
Initial Depth to Water: 44.2 ft below land surface
Starting Date: 11-6-86
Completion Date: 11-12-86

Well 399-1-18A was drilled to a depth of 63 ft using a 72 Speedstar cable-tool rig with hard tools. The sediments encountered included surficial eolian sands; the unconsolidated sands and gravels of the Hanford Formation; and the semi-consolidated sands and gravels of the middle Ringold Formation. The borehole was geophysically logged using natural gamma, density, and neutron probes. To achieve the desired completion interval, the borehole was back-filled using borehole cuttings. Ten ft of 40-slot, 10-in.-diameter stainless-steel telescoping screen was set between 44 and 54 ft in the upper portion of the unconfined aquifer. The 10-in.-diameter temporary steel casing was pulled back to expose the screened interval. The well was developed using an 8-in.-diameter flat-bottomed bailer. Further development was performed for 2 hours using a 10-hp submersible pump at a discharge rate of 705 gpm. On November 11, 1986, the well was pumped for 2 hours at a constant discharge rate of approximately 680 gpm with a maximum drawdown of 0.29 ft. Upon completion of the aquifer testing, the well was completed using a 40-slot, 6-in.-diameter stainless-steel casing between the depths of 38.2 and 54.0 ft. As the temporary steel casing was pulled back, 8-12 mesh Colorado silica sand was added to 34.4 ft and the remaining annulus was sealed using bentonite pellets, bentonite crumbles, and a concrete surface casing. On December 22, 1986, a Hydrostar sampling pump was installed with the intake set at 52 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-18A are shown in Figure A.19.

1944-1945

1946-1947

FIGURE A.18. Construction and Lithologic Diagram of Well 399-1-17C

FIGURE A.18. (contd)

FIGURE A.19. Construction and Lithologic Diagram of Well 399-1-18A

FIGURE A.19. (contd)

Well Number 399-1-18B (Temporary Well Number C3B)
Coordinates: N 58,956.5
E 14,470.8
Casing Elevation: 390.83 ft
Brass Marker Elevation: 387.77 ft
Initial Depth to Water: 45.5 ft below land surface
Starting Date: 11-13-86
Completion Date: 1-23-87

The initial 19 ft of well 399-1-18B was dug using a backhoe and the surface casing was set. Drilling continued to a total depth of 125 ft using a 72 Speedstar cable-tool rig with hard tools. The sediments encountered during drilling included surficial eolian sands; unconsolidated sands and gravels of the Hanford Formation; and semi-consolidated to well-consolidated gravels, sands, silts, and clay of the Ringold Formation. The borehole was geophysically logged using natural gamma, density, and neutron probes. The 10-in.-diameter steel casing was pulled back to 119 ft to form a natural backfill to the desired completion depth. Hydraulic jacks were required in pulling back the casing. The well was completed in the lower portion of the unconfined aquifer using 40-slot stainless-steel screen between 118.5 and 108.1 ft. As the casing was pulled back, 8-12 mesh Colorado silica sand was added to 105 ft and the remaining annulus was sealed with bentonite pellets, Volclay grout, bentonite crumbles, and a concrete seal. Midway through completion, the top seal in one of the hydraulic jacks ruptured, causing hydraulic fluid to accumulate around the steel casing. On January 26, 1987, the contaminated soil was dug up and disposed of in a waste drum. On completion, the well was bailed for 1.5 hours using a 5-in.-diameter dart bailer. Additional development was performed on January 28, 1987, using a 5-hp submersible pump with a discharge of approximately 12 gpm. On January 29, 1987, the well was pumped for 8 hours at a constant discharge of approximately 4.3 gpm with a maximum drawdown of 25.87 ft. A Hydrostar sampling pump was installed on February 24, 1987, with the pump intake set at 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-18B are shown in Figure A.20.

Well number 399-1-18C (Temporary Well Number C3C)
Coordinates: N 58,947.4
 E 14,491.7
Casing Elevation: 388.05 ft
Brass Marker Elevation: 385.34 ft
Initial Depth to Water: 42.78 ft below land surface
Starting Date: 10-28-86 (surface casing set)
Completion Date: 1-6-87

The initial 16 ft of well 399-1-18C was dug using a backhoe and the surface casing was set. Drilling continued to the total depth of 153 ft using a 72 Speedstar cable-tool rig with hard tools. To minimize problems in pulling back the temporary steel casing, the borehole was drilled with a 12-in.-diameter casing to 79 ft and then reduced to a 10-in.-diameter casing to total depth. The sediments encountered during drilling included surficial eolian sands; unconsolidated sands and gravels of the Hanford Formation; semiconsolidated to well-consolidated gravels, sands, silts, and clay of the Ringold Formation; and the Ice Harbor Member/Goose Island basalt flow. Positive identification of the Ice Harbor Member/Goose Island flow was determined through the chemical analysis of basalt drill cuttings from the 145- and 150-ft samples. Results from the analysis are shown in Table B.7. The borehole was geophysically logged using natural gamma, density, and neutron probes. The well was back-filled to the desired completion depth of 140 ft, using 8-12 mesh Colorado silica sand. The well was completed above the uppermost basalt layer beneath the confining clay layer of the lower Ringold Formation. A 6-in.-diameter, 20-slot stainless-steel screen was installed between depths of 129.6 and 140 ft. As the temporary steel casing was removed, 10-20 mesh silica sand was added to 124 ft and the remaining annulus was sealed using Volclay grout, bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was developed for approximately 1 hour using a 5-in.-diameter dart bailer. Further developing was performed for 1.5 hours using a 5-hp submersible pump at a discharge rate of approximately 4 gpm. On February 3, 1987, the well was pumped for 8 hours at a constant discharge rate of 4 gpm and a maximum drawdown of 33.96 ft. A Hydrostar sampling pump was installed February 24, 1987, with the intake set at 62 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-18C are shown in Figure A.21.

FIGURE A.20. Construction and Lithologic Diagram of Well 399-1-18B

FIGURE A.20. (contd)

FIGURE A.21. Construction and Lithologic Diagram of Well 399-1-18C

FIGURE A.21. (contd)

Well Number 399-1-19

Coordinates: N 56,215.0

E 15,149.0

Casing Elevation: 374.92 ft

Brass Marker Elevation: 372.44 ft

Initial Depth to Water: 33.0 ft below land surface.

Starting Date: 5-20-86

Completion Date: 5-23-86

Well 399-1-19 was drilled to a depth of 45 ft using a 22W Bucyrus Eries cable-tool rig with hard tools. The sediments encountered included the unconsolidated sands and gravels of the Hanford Formation and the semi-consolidated sands and gravels of the middle Ringold Formation. Ten ft of 20-slot, 6-in.-diameter stainless-steel screen was set between 35 and 45 ft in the upper portion of the unconfined aquifer. The well was developed using a 6-in.-diameter sand pump bailer. On completion of the development, the annulus was sealed with a cement bentonite grout mix as the 8-in.-diameter temporary steel casing was removed. A Hydrostar sampling pump was installed on March 16, 1987 with the intake set at 42 ft below the top of the casing.

The well construction detail and geologic log are shown in Figure A.22. Geophysical logs have not yet been completed for well 399-1-19.

FIGURE A.22. Construction and Lithologic Diagram of Well 399-1-19

Well Number 399-4-11 (Temporary well number S1)
Coordinates: N 53,733.6
E 15,121.3
Casing Elevation: 404.53 ft
Brass Marker Elevation: 402.82 ft
Initial Depth to Water: 59.9 ft below land surface.
Starting Date: 11-14-86
Completion Date: 11-26-86

The initial 17 ft of well 399-4-11 was dug by a backhoe and the 10-in.-diameter surface casing was set. Drilling continued to a depth of 95 ft using a 72 Speedstar cable-tool rig with hard tools. The sediments encountered included the unconsolidated sands and gravels of the Hanford Formation and semi-consolidated sands and gravels of the middle Ringold Formation. The Ringold Formation contact was at 87 ft and was determined on the basis of changes in degree of consolidation, color, clay content, and basalt content. The borehole was geophysically logged using natural gamma, density, and neutron probes. The temporary steel casing was pulled back to 71 ft, forming a natural backfill to that level. The well was completed in the upper portion of the unconfined aquifer between 55 and 70 ft using a 6-in.-diameter, 40-slot stainless-steel screen. Twenty ft of 8-12 mesh Colorado silica sand was added around the screen and the remaining annular space was sealed using bentonite pellets, bentonite crumbles, and a concrete surface seal. The well was developed for 1 hour using a 4-in.-diameter sand bailer. Pump development and aquifer testing were cancelled because an adequate discharge location could not be found. A Hydrostar sampling pump was first installed on December 30, 1986, and in February of 1987 the intake was reset at 67 ft below the top of the casing.

The well construction details and geologic and geophysical logs for well 399-1-11 are shown in Figure A.23.

The well construction details and geologic and geophysical logs for wells drilled before January 1, 1986, are found in Figures A.24 through A.46.

FIGURE A.23. Construction and Lithologic Diagram of Well 399-4-11

FIGURE A.23. (contd)

A.97/98

Well Number 399-1-2

FIGURE A.25. Construction and Lithologic Diagram of Well 399-1-2

Well Number 399-1-3

FIGURE A.26. Construction and Lithologic Diagram of Well 399-1-3

Well Number 399-1-4

FIGURE A.27. Construction and Lithologic Diagram of Well 399-1-4

FIGURE A.28. Construction and Lithologic Diagram of Well 399-1-5

FIGURE A.29. Construction and Lithologic Diagram of Well 399-1-6

Well Number 399-1-7

FIGURE A.30. Construction and Lithologic Diagram of Well 399-1-7

Well Number 399-1-8

FIGURE A.31. Construction and Lithologic Diagram of Well 399-1-8

Well Number 399-2-1

FIGURE A.32. Construction and Lithologic Diagram of Well 399-2-1

Well Number 399-2-2

FIGURE A.33. Construction and Lithologic Diagram of Well 399-2-2

Well Number 399-2-3

A.109

FIGURE A.34. Construction and Lithologic Diagram of Well 399-2-3

Well Number 399-3-1

A.110

FIGURE A.35. Construction and Lithologic Diagram of Well 399-3-1

Well Number 399-3-2

FIGURE A.36. Construction and Lithologic Diagram of Well 399-3-2

Well Number 399-3-3

FIGURE A.37. Construction and Lithologic Diagram of Well 399-3-3

Well Number 399-3-4

FIGURE A.38. Construction and Lithologic Diagram of Well 399-3-4

Well Number 399-3-5

FIGURE A.39. Construction and Lithologic Diagram of Well 399-3-5

Well Number 399-3-6

Construction Diagram

Lithologic Diagram

FIGURE A.40. Construction and Lithologic Diagram of Well 399-3-6

FIGURE A.41. Construction and Lithologic Diagram of Well 399-3-7

Well Number 399-3-8

FIGURE A.42. Construction and Lithologic Diagram of Well 399-3-8

Well Number 399-3-9

FIGURE A.43. Construction and Lithologic Diagram of Well 399-3-9

Well Number 399-3-10

FIGURE A.44. Construction and Lithologic Diagram of Well 399-3-10

Well Number 399-3-11

FIGURE A.45. Construction and Lithologic Diagram of Well 399-3-11

Well Number 399-3-12

FIGURE A.46. Construction and Lithologic Diagram of Well 399-3-12

FIGURE A.47. Construction and Lithologic Diagram of Well 399-4-1

Well Number 399-4-2

FIGURE A.48. Construction and Lithologic Diagram of Well 399-4-2

Well Number 399-4-3

FIGURE A.49. Construction and Lithologic Diagram of Well 399-4-3

Well Number 399-4-4

FIGURE A.50. Construction and Lithologic Diagram of Well 399-4-4

Well Number 399-4-5

FIGURE A.51. Construction and Lithologic Diagram of Well 399-4-5

Well Number 399-4-6

Construction Diagram

Lithologic Diagram

FIGURE A.52. Construction and Lithologic Diagram of Well 399-4-6

FIGURE A.53. Construction and Lithologic Diagram of Well 399-4-7

Well Number 399-4-8

FIGURE A.54. Construction and Lithologic Diagram of Well 399-4-8

Well Number 399-4-9

FIGURE A.55. Construction and Lithologic Diagram of Well 399-4-9

Well Number 399-4-10

FIGURE A.56. Construction and Lithologic Diagram of Well 399-4-10

Well Number 399-5-1

FIGURE A.57. Construction and Lithologic Diagram of Well 399-5-1

Well Number 399-5-2

FIGURE A.58. Construction and Lithologic Diagram of Well 399-5-2

Well Number 399-5-3

FIGURE A.59. Construction and Lithologic Diagram of Well 399-5-3

Well Number 399-6-1

A.135

FIGURE A.60. Construction and Lithologic Diagram of Well 399-6-1

Well Number 399-8-1

FIGURE A.61. Construction and Lithologic Diagram of Well 399-8-1

FIGURE A.62. Construction and Lithologic Diagram of Well 399-8-2

Well Number 399-8-3

FIGURE A.63. Construction and Lithologic Diagram of Well 399-8-3

Well Number 399-8-4

FIGURE A.64. Construction and Lithologic Diagram of Well 399-8-4

A.140

FIGURE A.65. Construction and Lithologic Diagram of Well 699-S19-E13

Well Number 699-S27-E14

FIGURE A.66. Construction and Lithologic Diagram of Well 699-S27-E14

Well Number 699-S29-E12

FIGURE A.67. Construction and Lithologic Diagram of Well 699-S27-E12

FIGURE A.68. Construction and Lithologic Diagram of Well 699-S30-E15A

APPENDIX B

ANALYSIS OF GEOLOGIC SAMPLES

APPENDIX B

ANALYSIS OF GEOLOGIC SAMPLES

ANALYSIS

This appendix contains information on physical and chemical analyses of geologic samples from monitoring wells in the 300 Area. The physical analyses section that immediately follows covers the results of field moisture and water retention values, particle-size analysis, and hydraulic conductivity. The chemical analyses section provides information on the basalt and sedimentary units in the 300 Area.

Physical Analyses

Samples, taken at 5-ft intervals, from five wells drilled in the 300 Area were delivered for study in March 1987. Nearly all of these samples were taken using a hard tool. Nine backhoe samples and four undisturbed core samples were also analyzed. Table B.1 lists the samples that were received.

TABLE B.1. Samples

<u>Borehole Samples</u>		<u>Backhoe Samples</u>	
<u>Well</u> <u>Number</u>	<u>Depth (ft)</u>	<u>Well</u> <u>Number</u>	<u>Depth (ft)</u>
S2	0 to 180	C1A	5 to 7
C1B	0 to 170	C1A	9 to 11
C1C	0 to 170	C1A	14 to 16
C2C	0 to 170	C1B	5 to 7
C3C	0 to 150	C1B	10 to 12
		C1B	14 to 16
		C2B	5 to 6
		C2B	10 to 11
		C2B	15 to 16
<u>Undisturbed Core Samples</u>			
C1B	123 to 125		
C1B	163.5 to 165.5		
C2C	116 to 118		
C2C	160 to 162		

All samples were analyzed for particle size. The undisturbed core samples and samples from the borehole group containing mostly fines were analyzed using the hydrometer method; the remaining samples were just sieved. Water retention characteristics on designated samples were measured at 0.1, 0.3, and 1.0 bar applied pressure. Bulk porosity and hydraulic conductivity were measured on the undisturbed samples. Field water contents were measured on the backhoe samples only.

METHODS

Field Moisture

Field moisture content was determined on the nine backhoe samples. In the field the samples were placed in air-tight containers, taped in, and placed in plastic bags. After the plastic bag was removed in the laboratory, the entire sample was weighed and dried to determine the water content (Table B.2) in accordance with ASTM procedure D 2216 (ASTM 1986).

TABLE B.2 Field Moisture and Water Retention Values

<u>Sample (ft)</u>	<u>Field Water Content (g/g)</u>	<u>0.1 bar (g/g)</u>	<u>0.3 bar (g/g)</u>	<u>1.0 bar (g/g)</u>
C1A 5 to 7	0.0355	0.0920	0.0876	0.0714
C1A 9 to 11	0.0366	0.1120	0.0800	0.0637
C1A 14 to 16	0.0358	0.0720	0.0633	0.0567
C1B 5 to 7	0.0244	0.1431	0.0892	0.0601
C1B 10 to 12	0.0224	0.0501	0.0468	0.0439
C1B 14 to 16	0.0198	0.0922	0.0851	0.0612
C2B 5 to 6	0.0257	0.0919	0.0510	0.0425
C2B 10 to 11	0.0327	0.0832	0.0527	0.0431
C2B 15 to 16	0.0499	0.0948	0.0481	0.0469

Water Retention

Water retention characteristics were measured at 0.1, 0.3, and 1.0 bars applied pressure (Table B.2) using a pressure plate extractor.^(a) Equilibrium water contents were obtained by packing samples in containing rings on a porous plate where they were saturated and pressure-drained in the extractor.

Both the samples and the porous plate were brought to saturation by allowing an excess of water to stand on the surface of the plate for 24 hours. On complete saturation, the plate was placed in the extractor vessel and the internal air pressure raised to the desired test level. Equilibrium was reached when drainage ceased. At the end of each pressure run, each sample was carefully weighed and oven-dried to determine the moisture content at that pressure level. This procedure was modified from that given by Klute (1986).

Particle-Size Analysis

Particle-size analysis was done using both sieving and sedimentation procedures. Sieve analysis was done on those samples that visually appeared to be sands or gravels to determine size distribution in the sand-sized particle range. Sieve sizes included 2.00 mm, 1.00 mm, 0.50 mm, 0.25 mm, 0.125 mm, and 0.063 mm (Table B.3). Because most samples were taken using a hard tool, the samples were first wet-sieved through a #230 sieve to break up the small aggregates caused by the drying of the samples. Those samples not taken using a hard tool were also wet-sieved for consistency in the data. This procedure is slightly modified from Ubelacker (1985).

By visual inspection of the samples, many appeared to be fine textured. A number of samples were also analyzed per instructions to distinguish the clay content between various soil layers. These samples were analyzed using a hydrometer method for a complete particle-size-distribution curve to determine the sand, silt, and clay contents (Table B.4) (Gee and Bauder 1986).

(a) This pressure plate extractor used to measure water retention characteristics is a product of Soilmoisture Equipment Corporation, Santa Barbara, California.

TABLE B.3. Sieve Analysis

Sample	Percent of Sample Passing					
	2.00 mm	1.00 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm
S2 4-5'	48.38	40.44	32.65	23.91	18.75	15.44
S2 9-10'	70.02	64.08	56.17	38.15	25.38	18.76
S2 15-16'	26.44	22.07	17.77	12.08	8.82	7.77
S2 19-20'	45.30	36.82	30.23	23.59	18.81	15.22
S2 24-25'	45.24	37.66	31.06	26.95	24.15	21.57
S2 29-30'	58.51	43.89	33.53	26.02	21.23	18.24
S2 34-35'	51.89	40.52	31.38	22.01	15.62	11.26
S2 39-40'	63.35	50.04	40.62	32.89	26.87	22.22
S2 44-45'	34.56	25.66	16.98	11.54	8.03	5.61
S2 49-50'	42.06	24.99	17.09	12.61	9.80	7.79
S2 54-55'	79.17	69.85	61.55	43.43	20.96	12.87
S2 59-60'	36.42	36.40	36.37	27.98	24.00	21.96
S2 64-65'	36.68	26.66	21.44	16.02	11.42	8.85
S2 69-70'	74.85	72.89	61.39	43.31	36.98	26.55
S2 74-75'	99.89	98.52	88.17	56.52	26.34	11.16
S2 79-80'	95.82	91.02	84.72	21.65	5.91	3.56
S2 84-85'	93.20	86.82	80.54	24.57	7.58	5.12
S2 89-90'	71.22	52.80	36.88	16.86	6.36	3.17
S2 94-95'	92.44	82.64	63.81	25.49	6.14	3.25
S2 99-100'	40.30	30.35	22.88	10.11	3.73	1.58
S2 104-105'	43.15	29.19	18.24	6.05	1.98	0.96
S2 109-110'	61.01	45.95	35.81	16.97	6.78	5.05
S2 114-115'	74.42	60.02	43.38	21.97	7.67	3.05
S2 119-120'	38.01	23.67	19.07	16.95	15.55	14.32
S2 154-155'	77.57	60.60	41.59	21.77	8.64	4.92
S2 179-180'	64.38	31.91	17.07	10.67	7.37	5.25
C1B 4-6'	27.98	26.72	22.06	13.00	8.24	5.42
C1B 10-12'	37.21	26.38	5.82	1.86	1.18	0.86
C1B 14-16'	17.06	13.18	6.20	2.48	1.55	1.22
C1B 19-20'	50.20	40.69	32.46	25.45	20.69	16.72
C1B 24-25'	66.84	54.41	44.51	36.26	30.29	25.32

TABLE B.3. (contd)

Sample	Percent of Sample Passing					
	2.00 mm	1.00 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm
C1B 29-30'	91.23	87.77	84.16	58.34	27.29	21.16
C1B 34-35'	95.79	94.73	93.52	65.87	24.54	17.15
C1B 39-40'	71.84	64.96	58.83	40.55	18.99	14.19
C1B 45'	95.47	74.65	35.35	16.88	9.89	7.40
C1B 49-50'	93.52	89.75	81.40	54.74	24.44	11.71
C1B 54-55'	70.34	51.57	34.78	23.95	17.75	14.45
C1B 59-60'	97.76	88.87	67.29	37.66	23.62	17.53
C1B 64-65'	85.69	78.44	66.71	34.95	31.33	28.67
C1B 69-70'	97.38	93.75	86.99	53.70	24.45	15.24
C1B 74-76'	94.22	81.43	70.00	44.62	17.47	7.73
C1B 80'	78.52	51.05	35.13	15.65	6.76	3.80
C1B 85'	78.30	67.42	60.93	40.99	18.48	12.58
C1B 90'	79.56	69.93	63.55	47.95	33.27	27.95
C1B 95'	71.33	56.22	40.86	20.01	11.50	7.56
C1B 99-100'	42.98	25.41	19.98	14.33	10.68	8.54
C1B 104-105'	85.67	75.26	68.38	51.62	36.73	22.72
C1B 109-110'	87.80	80.65	75.95	63.45	48.62	36.94
C1B 114-115'	99.22	98.95	96.79	51.36	18.48	8.72
C1B 119-120'	87.77	76.82	69.36	58.49	53.27	49.24
C1B 124-125'	96.37	83.39	65.29	41.88	33.87	29.50
C1B 159-160'	88.49	82.75	79.13	74.16	67.64	52.74
C1B 174-175'	64.27	44.14	36.86	32.57	29.36	26.31
C1C 4-6'	65.25	56.21	45.19	33.79	26.26	21.25
C1C 10-12'	76.74	66.38	57.61	45.66	36.86	30.03
C1C 13-15'	29.52	23.90	16.94	11.30	9.31	7.58

TABLE B.3. (contd)

Sample	Percent of Sample Passing					
	2.00 mm	1.00 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm
C1C 19-21'	32.93	22.67	17.14	13.56	11.52	9.74
C1C 24-26'	58.89	39.17	25.09	16.84	11.86	9.15
C1C 30'	92.18	79.79	69.37	55.40	39.58	33.15
C1C 34-36'	88.23	83.54	79.50	59.14	31.19	23.28
C1C 39-41'	98.46	96.92	95.14	69.57	28.43	19.31
C1C 44-46'	41.50	33.06	26.90	21.69	18.54	14.83
C1C 49-51'	73.53	57.66	46.65	38.33	32.33	26.92
C1C 54-56'	99.91	99.17	89.83	58.33	26.77	13.21
C1C 59-60'	60.46	35.56	20.31	13.02	10.11	7.31
C1C 61'	22.77	15.59	12.19	7.63	5.55	4.44
C1C 64-66'	70.19	62.98	58.10	37.76	17.12	10.45
C1C 69-71'	86.25	80.54	75.57	47.75	22.18	13.85
C1C 74-75'	74.19	58.08	48.37	28.38	16.16	10.39
C1C 79-81'	73.03	62.43	55.65	35.06	20.35	14.04
C1C 85'	16.05	11.42	4.65	7.13	6.03	5.17
C1C 89-90'	40.43	29.33	24.40	18.12	13.28	9.52
C1C 94-95'	46.20	28.37	20.83	13.24	9.30	6.62
C1C 99-100'	52.17	40.07	32.31	22.30	15.53	11.34
C1C 104-106'	56.30	33.12	24.59	13.54	7.40	5.12
C1C 114-116'	57.16	49.82	45.90	34.87	18.35	12.04
C1C 118-120'	82.71	74.70	70.04	62.85	57.61	53.58
C1C 164-165'	97.35	97.35	94.25	88.00	26.75	11.38
C1C 179-181'	83.30	65.23	44.95	35.66	32.93	30.09
C2C 5'	28.06	26.49	19.18	9.74	6.12	4.10
C2C 10'	36.17	23.21	9.94	4.75	3.55	3.02
C2C 15'	23.44	21.29	10.18	2.00	0.80	0.34
C2C 20'	42.65	27.21	19.41	14.93	12.19	10.23
C2C 25'	46.26	34.81	27.24	15.93	12.23	9.76
C2C 30'	68.20	59.95	49.79	29.09	20.39	15.45
C2C 35-36'	42.99	32.41	24.59	15.93	10.87	7.11

TABLE B.3. (contd)

Sample	Percent of Sample Passing					
	2.00 mm	1.00 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm
C2C 40-41'	45.46	35.71	28.81	22.07	17.60	14.79
C2C 44-45'	49.44	36.96	27.65	21.75	18.20	15.28
C2C 50'	63.48	52.42	44.08	31.52	24.25	20.06
C2C 60'	74.18	47.38	29.90	13.51	7.49	5.26
C2C 65'	52.94	39.19	29.86	18.19	15.82	12.74
C2C 69-70'	47.55	38.66	29.80	26.33	25.59	25.18
C2C 74-75'	47.20	31.98	25.12	16.61	11.96	9.64
C2C 80-81'	70.68	43.37	30.26	14.32	6.42	3.52
C2C 85-86'	45.53	22.40	14.57	8.55	5.60	3.92
C2C 90'	72.99	58.29	46.67	29.42	19.09	13.68
C2C 94-95'	77.15	64.65	55.63	41.14	32.06	26.81
C2C 99-100'	62.22	47.00	37.46	21.52	13.15	9.48
C2C 104-105'	67.79	52.73	41.70	28.35	18.75	14.00
C2C 109-110'	77.16	61.62	50.36	33.55	23.02	17.84
C2C 114-115'	89.78	80.89	74.37	62.17	54.69	50.09
C2C 118'	84.77	79.69	76.83	73.87	70.53	65.13
C2C 119-120'	95.86	93.29	91.21	88.41	86.03	80.85
C2C 124-125'	76.05	72.28	70.60	68.72	54.57	41.91
C2C 129-130'	83.29	79.08	77.27	74.95	72.28	65.84
C2C 134-135'	84.56	81.09	79.46	78.18	76.85	71.75
C2C 139-140'	54.38	43.57	43.32	42.47	41.57	34.58
C2C 144-145'	67.81	64.60	62.29	54.82	38.30	23.65
C2C 149-150'	78.81	70.50	66.19	60.38	53.70	44.76
C2C 159-160'	94.30	92.83	92.17	77.60	67.45	55.00
C2C 162'	37.21	29.02	22.37	14.07	8.72	4.12
C2C 164-165'	94.00	91.13	89.34	87.18	84.10	78.40

TABLE B.3. (contd)

Sample	Percent of Sample Passing					
	2.00 mm	1.00 mm	0.50 mm	0.25 mm	0.125 mm	0.063 mm
C2C 169-170'	99.12	96.38	82.04	45.61	14.55	5.46
C3C 4-6'	100.00	99.36	88.12	36.09	11.48	4.18
C3C 9-11'	76.48	75.67	66.29	28.87	10.41	3.23
C3C 14-15'	32.14	30.61	23.72	9.17	3.34	1.42
C3C 20-23'	89.89	87.10	74.97	38.27	22.39	16.10
C3C 24-25'	90.26	84.35	77.25	66.45	61.04	57.49
C3C 29-30'	61.95	52.42	43.80	34.34	28.20	27.97
C3C 34-35'	56.17	45.97	37.47	30.77	26.05	21.93
C3C 39-40'	45.33	36.29	30.60	24.87	20.41	16.57
C3C 44-46'	68.36	56.57	46.74	38.49	32.57	26.69
C3C 48-50'	63.11	47.94	36.18	25.51	18.23	11.68
C3C 54-55'	52.19	44.32	38.20	27.57	22.20	18.50
C3C 58-60'	40.18	29.45	23.33	14.58	10.22	8.13
C3C 64-65'	68.56	54.22	43.87	29.22	20.68	14.38
C3C 69-70'	56.44	44.03	34.19	21.88	15.67	10.71
C3C 74-75'	98.56	94.46	79.36	47.11	22.43	10.99
C3C 80-81'	48.01	31.84	21.20	11.53	7.12	4.44
C3C 84-85'	68.40	61.13	55.56	32.28	19.90	13.71
C3C 89-90'	46.47	36.97	28.89	12.59	6.87	4.73
C3C 94-95'	66.41	44.99	30.85	19.00	12.05	7.30
C3C 99-100'	99.00	97.94	92.54	75.32	53.86	33.48
C3C 104-105'	48.84	41.57	31.94	17.35	8.66	5.47
C3C 109-110'	83.05	69.61	58.76	40.00	21.72	14.13
C3C 114-115'	57.17	41.38	30.92	20.10	13.44	8.13
C3C 124-125'	91.41	78.72	69.89	45.01	28.02	22.68
C3C 129-130'	83.94	73.11	64.59	46.03	29.50	20.63
C3C 134-135'	92.82	78.16	65.30	43.87	29.42	22.37
C3C 139-140'	71.03	52.38	39.11	24.84	16.84	12.69
C3C 144-145'	93.38	77.07	62.00	46.29	36.86	29.21
C3C 149-150'	99.66	88.19	55.71	28.66	12.85	5.46

TABLE B.4. Percent Sand, Silt, and Clay

Sample	Percent Passing		
	% sand	% silt	% clay
S2 34-35'	49	44	7
S2 44-45'	79	16	5
S2 54-55'	59	31	10
S2 64-65'	80	16	4
S2 124-125'	16	64	20
S2 134-135'	13	66	21
S2 139-140'	20	62	19
S2 144-145'	16	62	22
S2 149-150'	18	54	28
S2 154-155'	14	54	32
S2 159-160'	16	40	44
S2 164-165'	27	43	30
S2 169-170'	17	52	31
S2 174-175'	24	18	48
C1B 34-35'	82	12	6
C1B 45'	92	1	7
C1B 49-50'	91	4	5
C1B 54-55'	87	10	3
C1B 64-65'	80	15	5
C1B 123-124'	15	61	24
C1B 123-125'	10	68	22
C1B 125'	8	67	25
C1B 129-130'	22	56	22
C1B 134-135'	15	61	24
C1B 139-140'	35	40	25
C1B 144-145'	13	63	24
C1B 149-150'	25	50	25
C1B 154-155'	18	51	31
C1B 163.5-165.5'	19	55	26
C1B 164'	14	58	28

TABLE B.4. (contd)

Sample	Percent Passing		
	% sand	% silt	% clay
C1B 165-5'	47	35	18
C1B 169-170'	14	40	46
C1C 109-111'	73	21	6
C1C 124-126'	30	47	23
C1C 129-130'	19	61	20
C1C 134-136'	10	61	29
C1C 139-141'	16	58	26
C1C 144-146'	14	60	26
C1C 149-151'	15	63	22
C1C 154-156'	41	45	14
C1C 159-160'	17	43	40
C1C 169-170'	63	20	17
C1C 174-176'	65	21	14
C2C 35-36'	87	8	5
C2C 44-45'	80	17	3
C2C 48-50'	62	28	10
C2C 55'	80	13	7
C2C 116-118'	10	65	25
C2C 124-125'	32	54	14
C2C 134-135'	19	74	7
C2C 139-140'	19	61	20
C2C 144-145'	25	48	27
C2C 149-150'	12	48	40
C2C 154-155'	28	41	31
C2C 159-160'	19	51	30
C2C 160-162'	6	19	75
C2C 162'	7	25	68
C3C 39-40'	16	68	16
C3C 39-40'	16	69	15
C3C 48-50'	65	25	10
C3C 119-120'	70	20	10

Hydraulic Conductivity

The hydraulic conductivity of each of four core samples was determined by using a falling head method of analysis (Klute and Dirksen 1986). In this method, the sample is placed in a container and enclosed with lids having an inflow valve at one end and an outflow valve at the other end. The inflow valve is connected to a standpipe of a known cross sectional area and height. The sample is saturated before any test runs are done by slowly wetting it from the bottom. After saturation an initial head in the standpipe is recorded and water is allowed to flow from the standpipe through the sample for a given length of time. The ending head level in the standpipe is recorded. Test runs are repeated five times and the values are averaged for the calculations. The hydraulic conductivity is determined using the following equation:

$$K = (al/At)\ln(H_1/H_2)$$

where a = cross-sectional area of the standpipe

l = length of the sample

A = cross-sectional area of the sample

t = time for the hydraulic head to decrease from H_1 to H_2 .

The hydraulic conductivity values were determined on four undisturbed core samples cut to 10-cm lengths. Because the flow rates were extremely low, the samples were allowed to saturate over a period of several weeks and the measurements were made over several days. Table B.5 lists the hydraulic conductivity values, the density of each sample, and the porosity.

TABLE B.5. Hydraulic Conductivity, Density, and Porosity of the Undisturbed Cores

<u>Sample</u>	<u>Hydraulic Conductivity (cm/sec)</u>	<u>Density (g/cm³)</u>	<u>Porosity</u>
C1B 123-125 ft	2.12E-06	1.19	0.56
C1B 163.5-165.5 ft	3.19E-06	1.05	0.61
C2C 116-118 ft	4.40E-07	1.20	0.56
C2C 160-162 ft	5.28E-08	1.32	0.53

Chemical Analyses

Carbon-14 analyses were performed by Washington State University (WSU) on wood samples obtained during drilling of the new monitoring wells. The wood-chips, which were not from intact samples, would enable identification of the age of the formation from which they were obtained with some degree of certainty.

The results were not conclusive, because the sample interval was not certain. One sample is dated as modern in Table B.6. Considering the wells have common stratigraphic units, the inconsistency casts doubts on the usefulness of these age dates for stratigraphic interpretation.

X-ray fluorospectroscopy analyses were performed to determine the primary, secondary, and trace constituents of five basalt samples from four wells. The purpose of these analyses was to determine which basalt flow or flows are in contact and which flow or flows underlie the Ringold Formation in the 300 Area. The results of these analyses which were performed by Washington State University in February 1987, distinguished the flows as belonging to the Ice Harbor member of the Saddle Mountains Basalt. The two basalt flows identified were the Martindale flow and the Goose Island flow. The Goose Island flow was identified as the basalt unit in two samples, both from well 1-18C. In basalt samples from the other three deep-well boreholes in the 300 Area, the Martindale flow was identified using the chemistry data presented in Table B.7.

TABLE B.6. Results of August 12, 1987, Carbon 14 Age Dating of Wood Chips

<u>WSU Sample Number</u>	<u>PNL Sample Number</u>	<u>¹⁴C Age, Years B.P.</u>
3632	Well C2B 65-70'	25,830 ± 515
3633	Well C1B 65-70'	R%104.1 ± 0.70 (Modern)

Note: All analyses are based upon the Libby half-life (5570 ± 30 years) for radiocarbon. To convert ages to the half-life of 5730 years, multiply the age given above by 1.03. Zero age date is A.D. 1950.

TABLE B.7. Results of February 21, 1987, X-ray Fluorescence Determination of Basalt Flows in the Ice Harbor Member of the Saddle Mountains Basalt

Element/ Compound	Well Number, Basalt Depth Below Land Surface, and Flow Name				
	399-1-9 179-180'	399-1-16C 178'	399-1-17C 170-173'	399-1-18C 144-145'	399-1-18C 149-150'
	Martindale	Martindale	Martindale	Goose Island	Goose Island
SiO ₂	49.07	48.80	48.60	49.91	50.22
Al ₂ O ₃	13.47	13.23	13.07	12.45	12.73
TiO ₂	3.386	3.442	3.226	3.398	3.136
Fe ₂ O ₃	14.66	14.62	16.12	16.73	16.48
MnO	0.238	0.232	0.212	0.230	0.250
CaO	10.90	10.79	10.19	8.89	8.95
MgO	4.47	5.10	5.11	3.55	3.60
K ₂ O	0.65	0.69	0.50	1.01	1.02
Na ₂ O	2.07	2.07	2.04	2.10	2.15
P ₂ O ₅	0.858	0.812	0.736	1.500	1.254
Ni	0.0073	0.0042	0.0044	0.0021	0.0010
Cr	0.0209	0.0208	0.0145	0.0044	0.0039
Sc	0.0041	0.0044	0.0043	0.0038	0.0042
V	0.0387	0.0392	0.0363	0.0273	0.0282
Ba	0.0619	0.0630	0.0536	0.0773	0.0762
Rb	0.0012	0.0012	0.0010	0.0030	0.0031
Sr	0.0283	0.0264	0.0265	0.0279	0.0306
Zr	0.0246	0.0257	0.0243	0.0387	0.0334
Y	0.0057	0.0056	0.0054	0.0091	0.0078
Nb	0.0022	0.0025	0.0023	0.0037	0.0031
Ga	0.0018	0.0025	0.0022	0.0024	0.0023
Cu	0.0072	0.0014	0.0027	0.0058	0.0042
Zn	0.0172	0.0149	0.0145	0.0211	0.0191

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APPENDIX C

WATER LEVEL DATA

APPENDIX C

WATER LEVEL DATA

This appendix contains information on water levels in the ground water and Columbia River. Specifically, 19 water level contour maps shown in Figures C.1 to C.19 from November 1985 to May 1987 were constructed from monthly water level measurements of initially 32 wells (Figure C.20) and later in March 1987 expanded to the current network of 49 wells (Figure C.21). For comparison a contour map of the topographic surface is presented in Figure C.22. Only contour maps of the shallow wells are presented because only three intermediate and three deep wells have data that are considered sufficient for construction of meaningful contour maps. Water level measurements were measured to an accuracy of ± 0.03 ft using a steel tape or a factory calibrated electric sounder. The electric sounder (slope indicator, model no. 51453, serial no. 11034) was factory calibrated to ± 0.01 ft and field checked several times during each monthly set of water level measurements against the steel tape (100 ft steel tape by Keson, Inc., serial no. K100-01). Water levels in network wells were measured in a period of 4 hours or less to ensure time-equivalent results. During some months access to certain wells was limited, which delayed a few measurements. These potential sources of error caused by temporally nonequivalent measurements are noted in Tables C.1 through C.4. The importance of time-equivalent measurements is evident in the hydrographs of the SWS-1 river station and the four monitoring wells shown in Figures C.23 and C.24.

Several types of errors were addressed in constructing Tables C.1 through C.4. Errors detected and corrected included: the addition of 2.0 ft of casing to well 399-4-1 on July 31, 1986; transposition of numbers from original records; computation errors in addition and subtraction from original records; and non-time-equivalent data. Most of these errors were found during the construction of the contour maps because the errors created anomalous highs and lows in the water table surface. Other sources of error or apparent anomalies that were addressed by exclusion of data from use in interpretation

levels in an individual well by the technician, which produced a value inexplicably high or low, and errors in water levels caused by equipment malfunction or peculiar well conditions (e.g., shorting of the water level probe because of contact between the stainless steel of the well and pump). In Tables C.1 and C.4 some data were not used for constructing water level contour maps because of suspected errors by the technician or the malfunction of the technician's equipment. The well number, measurement dates, and the amount of error are listed below:

- The water level elevation in well 399-1-3 was reported to be about 2 ft lower than in surrounding wells on April 30, 1987.
- The water level elevation on April 30, 1987, in well 399-1-7 was reported to be about 8 ft higher than in other nearby shallow wells and 11 ft higher than in another shallow well, 399-1-3, which is located only 15 ft north.
- The water level elevation in well 399-1-13 was reported to be about 3 ft lower than in surrounding wells on March 31, 1987.
- The water level elevation in well 399-1-14 was reported to be about 22 ft lower than in surrounding wells on April 30, 1987.
- The water level elevation in well 399-5-1 was reported to be about 2 ft lower than in surrounding wells on July 23, 1986.

Other values were also not used for water level contouring because it is unknown if they were caused by measurement error or actual anomalous conditions in the stratigraphy of the aquifer are:

- Water level elevations in well 399-1-4 that were reported to be about a foot higher than in surrounding wells on April 8 and July 23, 1986.

Well 399-1-4 may be screened in an area of lower transmissivity that results in a delayed response during abrupt rises or declines in river stage.

Continuous water level data obtained for a few months from up to four monitoring wells and one stilling well (designated SWS-1) in the Columbia River near the water intake have given some insights into the probable shape and

continuity of the contours, particularly near the river. Knowledge of water levels read every half hour in wells and the river allows the interpreter to accurately interpolate between distant data points and even extrapolate contours with greater confidence. Response of wells are dampened and delayed in the shallow portion of the unconfined aquifer. The amount of delay in response and dampening of the amplitude of changes in river stage is roughly proportional to the distance from the river; that is, the greater the distance the greater the delay and dampening of the response in water levels. This axiom is demonstrated best by collecting 2 months of continuous water level data for the four wells in the 300 Area that are at various distances from the river and the SWS-1 river station. These hydrographs are presented in Figures C.22 and C.23. The hydrographs indicate that the 3,000,000 gal of liquid discharged each day into the process trenches has no significant influence on fluctuation of wells near the process trenches. The discharge of the process trenches creates a gentle ground-water mound, but the constant, sustained nature of the discharge has no apparent impact on the diurnal and longer-time-period fluctuations.

Continuous water level data are obtained using five Terra 8/D data loggers which were purchased in late 1986. These units are designed to fit inside the 6-in. wells and are battery operated for periods of up to 3 months. The system is contained in a stainless-steel watertight cylinder 3.5 in. O.D. x 28 in. long. The logger has a resident software program that allows wide variability in data collection. Data are recovered using a portable computer via an RS232C interface. Pressure sensors are stainless-steel cased, vented, pressure transducers with an output of 4 to 20 milliamps.

The data loggers are mounted inside the well casing and the well caps are locked to eliminate any chance of vandalism. The transducer is suspended from the logger to a minimum of 1 ft below the lowest water level expected. The depth to water is measured with a steel tape and used to calculate a correction factor that is entered in the program as a constant. This produces an output of actual water level elevations in feet. Measurements are taken at 30-min intervals. The output is compared to a steel tape measurement monthly.

The data logger for the Columbia River is mounted inside a 10-ft length of 4-in., stainless-steel well casing with 5 ft of stainless-steel well screen

underwater. The casing is mounted on the sheet piles next to the 300 Area intake structure. This data logger has been collecting data continuously since January 22, 1987. The remaining four data loggers were installed as follows: well 399-1-10, February 17, 1987; well 399-1-16A, March 8, 1987; well 399-1-17A, April 9, 1987; and well 399-1-13, April 21, 1987.

The data loggers are three-channel units, and additional sensors will be added to measure conductivity and temperature in addition to water elevation in at least three wells. These sensors should be received and installed in July 1987.

FIGURE C.1. Water Level Contour Map for the 300 Area for November 12, 1985

FIGURE C.2. Water Level Contour Map for the 300 Area for December 10, 1985

FIGURE C.3. Water Level Contour Map for the 300 Area for January 21, 1986

FIGURE C.4. Water Level Contour Map for the 300 Area for February 10, 1986

FIGURE C.5. Water Level Contour Map for the 300 Area for March 11, 1986

FIGURE C.6. Water Level Contour Map for the 300 Area for April 8, 1986

FIGURE C.7. Water Level Contour Map for the 300 Area for May 13, 1986

FIGURE C.8. Water Level Contour Map for the 300 Area for June 24, 1986

FIGURE C.9. Water Level Contour Map for the 300 Area for July 23, 1986

FIGURE C.11. Water Level Contour Map for the 300 Area for September 16, 1986

FIGURE C.12. Water Level Contour Map for the 300 Area for October 24, 1986

FIGURE C.14. Water Level Contour Map for the 300 Area for December 29, 1986

FIGURE C.16. Water Level Contour Map for the 300 Area for February 26, 1987

FIGURE C.17. Water Level Contour Map for the 300 Area for March 31, 1987

FIGURE C.22. Topographic Map of the 300 Area

ELEVATIONS FOR MAY

(START 4/28/87 0800)

FIGURE C.23. Hydrographs of Water Level Elevations in the Columbia River During May 1987

ELEVATIONS FOR JUNE

(START 5/27/87 0930)

C.28
ELEVATION

— 1-10 — 1-13 — 1-16A — 1-17A — RIVER

FIGURE C.24. Hydrographs of Water Level Elevations in Four Wells and the Columbia River During June 1987

TABLE C.1. 300 Area Water Level Elevations in Feet Above Mean Sea Level for
November 1985 and December 1985

Well No.	11/12	12/10	Interval Monitored
399-1-1	342.57	344.40	Shallow
399-1-2	341.42	343.86	Shallow
399-1-3	342.32	343.93	Shallow
399-1-4	343.58	344.83	Shallow
399-1-5	(a)	344.81(a)	Shallow
399-1-6	343.16	344.64	Shallow
399-1-7	342.27	344.91	Shallow
399-1-8	342.36	343.92	Shallow Hybrid
399-1-9	(b)		Deep
399-1-10			Shallow
399-1-11			Shallow
399-1-12			Shallow
399-1-13			Shallow
399-1-14			Shallow
399-1-15			Shallow
399-1-16A			Shallow
399-1-16B			Intermediate
399-1-16C			Deep
399-1-17A			Shallow
399-1-17B			Intermediate
399-1-17C			Deep
399-1-18A			Shallow
399-1-18B			Intermediate
399-1-18C			Intermediate
399-1-19			Shallow
399-2-1	341.96	343.86	Shallow
399-2-2	342.14	343.93	Shallow
399-2-3	342.10	343.91	Shallow
399-3-1	341.92	342.75	Shallow
399-3-2	342.23	343.59	Shallow
399-3-6	342.30	343.62	Shallow
399-3-7	342.26	343.64	Shallow
399-3-9	342.11	343.69	Shallow
399-3-10	341.93	343.52	Shallow
399-3-12	342.13	343.62	Shallow
399-4-1	341.92	343.46	Shallow
399-4-7	341.93	343.56	Shallow
399-4-9	342.04	343.63	Shallow
399-4-10	341.99	343.61	Shallow
399-4-11			Shallow
399-5-1	342.36	343.51	Shallow
399-6-1	342.72	343.76	Shallow
399-8-1	342.72	343.86	Shallow
399-8-2	343.10	344.03	Shallow
399-8-3	343.02	344.11	Shallow
399-8-4	344.32	344.84	Shallow
699-S19-E13	343.89	345.03	Shallow
699-S27-E14	341.87	343.37	Shallow
699-S29-E12	346.05	345.92	Shallow
699-S30-E15A	342.00	343.39	Shallow

(a) Measurement was not taken on the specified date.
(b) A blank space indicates the well did not exist.

TABLE C.2. 300 Area Water Level Elevations in Feet above Mean Sea Level for January 1986 through June 1986

Well No.	1/21	2/10	3/11	4/8	5/13	6/24
399-1-1	341.45	342.98	343.81	343.55	345.11	343.79
399-1-2	341.51	342.51	343.28	343.46	344.55	343.43
399-1-3	341.26	342.54	343.36	343.20	344.57	343.32
399-1-4	343.08	343.58	344.31	345.76	345.48	344.57
399-1-5	342.88(a)	343.69(a)	344.48(a)	344.38(a)	344.88(a)	344.30
399-1-6	341.31	343.31	344.05	344.38	345.42	344.32
399-1-7	341.24	342.49	343.33	343.15	344.53	343.28
399-1-8	341.34	342.55	343.36	342.26	344.59	343.32
399-1-10	(b)					
399-1-11						
399-1-12						
399-1-13						
399-1-14						
399-1-15						
399-1-16A						
399-1-16B						
399-1-16C						
399-1-17A						
399-1-17B						
399-1-17C						
399-1-18A						
399-1-18B						
399-1-18C						
399-1-19						
399-2-1	340.99	342.45	343.40	342.87	344.49	343.17
399-2-2	341.09	342.51	343.39	343.01	344.54	343.26
399-2-3	341.04	342.49	343.38	342.99	344.51	343.22
399-3-1	340.90	342.36	343.24	342.78	344.33	343.02
399-3-2	341.47(a)	342.30	343.06	343.36	344.28	343.01
399-3-6	341.58(a)	342.36	343.10	343.49	344.32	343.29
399-3-7	341.46(a)	342.30	343.09	343.35	345.33	343.21
399-3-9	340.99(a)	342.29	343.10	342.86	344.33	343.00
399-3-10	341.78(a)	342.13	342.94	342.65	344.14	342.82
399-3-12	341.18(a)	342.29	343.04	343.08	343.35	343.09
399-4-1	340.93(a)	342.15	342.90	(c)	(c)	342.85
399-4-7	340.66(a)	341.18	343.00	342.51	344.12	342.79
399-4-9	340.84(a)	342.25	343.07	342.72	344.24	342.90
399-4-10	340.69(a)	342.22	343.05	342.57	344.22	342.86
399-5-1	341.82(a)	342.29	343.07	343.69	344.24	343.42
399-6-1	342.11	342.50	343.31	343.99	344.54	343.68
399-8-1	342.16	342.63	343.40	344.06	344.66	343.79
399-8-2	342.98	342.91	343.72	344.62	344.98	344.51
399-8-3	342.59	342.92	343.67	344.41	344.93	344.16
399-8-4	344.49	344.29	344.68	345.40	345.73	345.66
699-S19-E13	343.42	343.93	344.56	345.17	345.93	345.24
6-990S27-E14	340.93(a)	342.10	342.74	(c)	(c)	342.81
699-S29-E12	345.48(a)	345.15	345.02	345.30	345.66	346.00
699-S30-E15A	341.01(a)	(c)	342.70	342.62	343.84	342.77

(a) Measurement was not taken on the specified date.

(b) A blank space indicates the well did not exist.

(c) Well was not measured.

TABLE C.3. 300 Area Water Level Elevations in Feet Above Mean Sea Level for July 1986 through December 1986

Well No.	7/23	8/19	9/16	10/24	12/1	12/29
399-1-1	344.58	342.65	341.93	342.07	342.03	342.59
399-1-2	344.12	342.42	341.42	341.77	(c)	342.25
399-1-3	344.15	342.32	341.39	341.75	341.94	342.26
399-1-4	345.20	343.70	342.74	342.83	343.52	343.41
399-1-5	344.06(a)	343.83(a)	342.91(a)	342.48(a)	(c)	(c)
399-1-6	344.92	343.26	342.45	342.56	342.81	343.04
399-1-7	344.11	342.28	341.38	341.71	341.88	342.08
399-1-8	344.16	342.36	341.43	341.77	342.02	342.28
399-1-10	(b)					342.57
399-1-11						
399-1-12						342.50
399-1-13						342.54
399-1-14						343.22
399-1-15						343.24
399-1-16A						
399-1-16B						
399-1-16C						
399-1-17A						342.22
399-1-17B						
399-1-17C						
399-1-18A						343.43
399-1-18B						
399-1-18C						
399-1-19	(c)	(c)	(c)	(c)	(c)	(c)
399-2-1	344.05	342.07	341.32	342.53	341.60	341.86
399-2-2	344.11	342.21	341.43	341.65	341.72	342.22
399-2-3	344.08	341.64	341.34	341.02	341.67	342.19
399-3-1	343.88	341.97	341.18	341.45	341.57	342.05
399-3-2	343.87	342.19	341.16	341.56	342.07	342.01
399-3-6	343.93	342.29	341.25	341.62	342.19	342.09
399-3-7	343.91	342.24	341.22	341.61	342.09	342.06
399-3-9	343.80	342.01	341.09	341.49	342.77	342.01
399-3-10	343.62	341.83	340.94	341.32	341.59	341.96
399-3-12	343.82	342.04	341.10	341.49	(c)	341.97
399-4-1	343.62	341.82	340.90	341.31	341.53	341.79
399-4-7	343.61	341.81	340.96	341.36	341.43	341.90
399-4-9	343.71	341.92	341.03	341.43	341.56	341.96
399-4-10	343.67	341.84	341.02	341.41	341.48	341.98
399-5-1	340.86(d)	342.44	341.40	341.70	342.38	342.18
399-6-1	344.05	342.85	341.81	341.95	342.63	342.47
399-8-1	344.22	342.86	341.83	342.02	342.72	342.53
399-8-2	344.32	343.72	342.78	342.57	343.25	343.16
399-8-3	344.48	343.28	342.22	342.33	342.92	342.87
399-8-4	345.20	345.07	344.56	344.24	344.63	(c)
699-S19-E13	345.39	344.39	343.45	343.36	343.88	343.91
699-S27-E14	343.58	341.81	340.85	341.27	341.58	341.75
699-S29-E12	346.21	346.42	346.42	346.12	346.07	345.97
699-S30-E15A	343.62	342.11	341.31	341.57	341.87	341.89

(a) Measurement was not taken on the specified date.

(b) A blank space indicates the well did not exist.

(c) Well was not measured.

(d) Datum considered an erroneous water level measurement.

TABLE C.4. 300 Area Water Level Elevations in Feet above Mean Sea Level for January 1987 through May 1987

Well No.	1/30	2/26	3/31	4/30	5/26
399-1-1	342.39	343.06	341.73	345.43	343.77
399-1-2	342.60	342.51	341.57	342.13	344.65
399-1-3	342.30	342.50	341.53	340.54(a)	343.38
399-1-4	343.97	343.59	342.91	343.53	342.99
399-1-5	344.43(b)	342.73(b)	341.43(b)	342.72	344.92(b)
399-1-6	343.31	343.31	342.51	343.55	344.46
399-1-7	342.26	342.62	339.72	351.36(a)	343.44
399-1-8	342.17(b)	342.62	341.40	342.21	341.56
399-1-9	(c)	374.46	373.08	374.35	374.07
399-1-10		343.27	341.80	343.50	344.88
399-1-11		343.42(b)	342.87(b)	343.44	345.37(b)
399-1-12		342.66	341.79	342.42	344.01
399-1-13		342.78	339.00(a)	342.49	344.29
399-1-14		343.41	342.77	320.72(a)	345.09
399-1-15		343.59	342.36	343.38	344.86
399-1-16A		342.32	341.41	342.30	343.24
399-1-16B		343.14	341.86	342.94	343.81
399-1-16C		359.00	351.82	349.01	344.01
399-1-17A		342.68	341.68	342.31	343.77
399-1-17B		342.76	339.81	342.43	343.82
399-1-17C		375.40	374.90	375.99	375.34
399-1-18A		343.80	342.94	343.62	345.14
399-1-18B		346.15	343.04	343.90	345.24
399-1-18C		342.05	343.42	344.19	345.67
399-1-19	(d)	(d)	342.09(b)	342.34	344.66(b)
399-2-1	341.84	342.66	341.22	342.39	343.26
399-2-2	342.07	342.53	341.31	342.23	343.22
399-2-3	341.99	342.58	341.31	342.40	343.27
399-3-1	341.77	342.42	341.12	342.21	343.01
399-3-2	342.46	342.31	341.40	341.81	343.50
399-3-6	342.62	342.46	341.64	342.00	343.77
399-3-7	342.50	342.33	341.43	341.84	343.49
399-3-9	341.97	342.27	341.31	342.13	343.09
399-3-10	341.74	342.27	341.13	342.65	342.93
399-3-12	342.19	342.30	(d)	341.98	352.28
399-4-1	341.92	342.10	341.15	341.75	342.81
399-4-7	340.55	342.20	341.02	342.04	342.76
399-4-9	341.79	342.24	341.08	341.97	342.86
399-4-10	341.60	342.25	341.05	342.03	342.72
399-4-11		342.17(b)	341.65(b)	341.88	343.17
399-5-1	342.84	342.34	341.66	341.22	343.36
399-6-1	343.18	342.56	342.02	342.03	344.32
399-8-1	343.25	342.69	342.03	342.25	344.38
399-8-2	343.01	343.09	342.72	342.76	345.06
399-8-3	343.63	342.97	342.43	342.52	344.73
699-S19-E13	344.71	344.09	343.42	343.94	345.43
699-S27-E14	341.94	342.08	341.04	341.66	342.80
699-S29-E12	346.01	345.77	345.39	345.18	347.51
699-S30-E15A	342.03	342.18	341.15	341.74	342.74

(a) Datum considered an erroneous water level measurement.

(b) Measurement was not taken on specified date.

(c) A blank space indicates the well did not exist.

(d) Well was not measured.

APPENDIX D

AQUIFER TESTING FOR THE 300 AREA PROCESS TRENCHES
RCRA PROGRAM NOVEMBER 1986 TO MARCH 1987

APPENDIX D

AQUIFER TESTING FOR THE 300 AREA PROCESS TRENCHES RCRA PROGRAM NOVEMBER 1986 TO MARCH 1987

INTRODUCTION

This appendix describes the hydrologic testing and characterization at wells 399-1-13 (S6); 399-1-18A,B, and C; 399-1-14 (S7); 399-1-10 (S3); 399-1-17B and C; 399-1-16A, B, and C; 399-1-9 (S2); and 399-1-3 in the 300 Area of the Hanford Site. The location of these wells is given in Figure D.1. While geologic and hydrogeologic information is included in each of the descriptions of the aquifer tests, basic information is given here as introductory material.

Aquifer tests impose an artificial stress on the ground-water system and measure the relative response. The natural system is almost always more complex than can be accounted for by the analytical techniques used in the interpretation of the data gathered during these tests. The results of the test must be understood and evaluated in the face of heterogeneous geologic conditions, rising and falling surface water and ground-water levels, delayed yield, casing storage effects, and partial penetration of the borehole. Where possible, these influencing conditions are considered quantitatively; however, this is not always possible, and the data must be interpreted qualitatively in the context which represents the most likely aquifer characteristics.

Aquifer testing and characterization are devised to collect data at discrete points to aid in the description of the site as a hydrologic unit. The testing and characterization allow us to accomplish four major objectives:

1. ascertain appropriate values of transmissivity and storativity to be used in analytical and numeric models for predicting ground-water flow and transport in the 300 Area
2. obtain additional information on the aquifer geometry, or boundaries, and characteristics so that the conceptual model of the aquifer can be refined and improved

FIGURE D.1. Location Map of Test Wells and nearby Monitoring Wells

3. provide additional information about the influence of the changing Columbia River stages on the 300 Area hydrology
4. determine where additional information will best improve site characterization and our understanding of the aquifer system.

The well testing at the 300 Area locations was conducted on four shallow wells before well construction was completed by setting a 10-in.-diameter stainless steel telescoping well screen inside the 10-in. temporary surface

casing at the test zone. The surface casing was then pulled back to expose the well screen and the well was tested. At the completion of the test, a 6-in. well screen was lowered inside the 10-in. screen, the annulus was then filled with clean silica sand, and the well was constructed according to methods described in Appendix A. This construction technique allowed a large pump to be set in the well for testing high-permeability aquifers without drilling and constructing a large-diameter well. This procedure was more cost-effective than drilling and constructing a larger diameter monitoring well. Wells 399-1-13 (S6), 399-1-18A (C3A), 399-1-14 (S7), and 399-1-10 (S3) were constructed and tested in this manner. Well 399-1-16A (C1A) was tested after construction was completed because of fine-grained formation sand flowing into the well and because of delays in the drilling and construction of nearby wells.

Geologic Setting

The formations present beneath the 300 Area include the following (in ascending order): the Columbia River Basalt Group, its various formations (the shallowest being the Saddle Mountains Basalt), and the interbedded sediments of the Ellensburg Formation; the Ringold Formation, including the basal Ringold consisting of silty sandy gravel, the lower Ringold member consisting of clays and silts, and the middle Ringold member consisting of sands and gravels; and the Hanford formation (informal name), containing gravels and coarse sands. The Ringold Formation is probably of Pliocene and Miocene ages and is about 130 ft thick beneath the 300 Area. The gravel deposits represent fluvial deposition, while the finer-grained materials may represent shallow lake or flood plain deposits (Lindberg and Bond 1979). The Hanford formation consists of glaciofluvial materials probably derived from catastrophic flooding during the Pleistocene ice age.

Hydrogeologic Setting

Ground water beneath the 300 Area occurs in confined aquifers within the basalt sequence and the basal member of the Ringold Formation, and in the unconfined aquifer within the lower and middle Ringold members and the Hanford formation. The boundary between the confined and the unconfined aquifers is the lower silt and clay member of the Ringold Formation. This boundary, where it occurs, allows little interchange of ground water between the confined and

unconfined aquifers. Evidence of this is the sharp contrast in hydraulic heads between the unconfined water table surface and the piezometric surface of the confined aquifer. The water table in this area is commonly 30 to 60 ft below land surface, whereas the confined piezometric (potentiometric) surface ranges from land surface to only 25 ft in depth. Table D.1 gives a typical range of the hydraulic properties of sediments located in the Hanford Site.

Confined aquifers within the basalts are predominantly located in the sedimentary interbeds or flow contacts where the basalt tends to be scoriaceous, brecciated, or highly jointed (Lindberg and Bond 1979). The basalt unit serves as the lower boundary for the characterization of the 300 Area.

Natural recharge occurs at the northwest margin of the Hanford Site and the ground water flows downgradient toward the Columbia River. The southeastern edge of the Hanford Site is recharged largely by the Yakima River and the ground water moves to the east and southeast toward the Columbia River. The 300 Area is located close to where the unconfined ground water flowing southeasterly from the central portion of the Hanford Site mixes with the ground water recharged by the Yakima River (Lindberg and Bond 1979).

The unconfined aquifer, which consists of the Hanford formation and middle Ringold member, is in hydraulic connection with the Columbia River. Based on recent continuous monitoring of the river and wells, river level fluctuations

TABLE D.1. Representative Hydraulic Conductivity Values of the Unconfined Aquifer within the Hanford Site (from Gephart et al. 1979)

<u>Geologic Unit</u>	<u>Hydraulic Conductivity (ft/day)</u>
Hanford formation	500 - 20,000
Undifferentiated Hanford - Middle Ringold	100 - 7,000
Middle Ringold Unit	20 - 600
Basal Ringold Unit	0.1 - 10

influence ground-water gradients and flow direction near the river. Previous studies of water levels in the 300 Area also disclosed that a reversed gradient was imposed on the ground water as the Columbia River level increased during spring floods (Haney 1957). The maximum detected westward penetration of uranium contamination (in the ground water from the 300 Area) caused by the reverse gradient was to wells 399-8-1 and 399-8-3 (Figure D.1), although water-level head changes occurred 2 to 2.5 miles from the river (Lindberg and Bond 1979). The reversed gradients at the present are not as extreme as those that occurred before the operation of the Priest Rapids Dam upstream and the McNary Dam downstream. The 300 Area is located at the northern edge of the McNary Dam pool, which dampens the more extreme river-stage fluctuations found upstream. The river-stage varied, at the most, 3 to 4 ft during the aquifer test period in February and March 1987, as may be seen in Figure D.2. Figure D.3

FIGURE D.2. Columbia River-Stage Recordings 2/5/87 to 3/25/87

FIGURE D.3. Well 399-1-10 Water Level Recordings 2/20/87 to 3/25/87

illustrates the water level fluctuations in well 399-1-10, located adjacent to the Columbia River in the 300 Area. The effects of the changes in river-stage are further dampened as may be seen in Figure D.3.

Summary of Aquifer Testing Results

The methods of analyses yielded one to three values of the formation parameters (i.e., transmissivity and hydraulic conductivity) for each aquifer test. By averaging and interpreting these values, they have been consolidated to a single, most-representative value for each parameter at each well location. These values are summarized in Table D.2. A detailed description of each aquifer test is given in the following individual aquifer test reports.

TABLE D.2. Summary of Aquifer Testing Results

Well Designation	Pumping Rate (gpm)	Maximum Drawdown (ft)	Transmissivity (ft ² /day)	Hydraulic Conductivity (ft/day)
399-1-13	660	0.98	110,000	11,000
399-1-18A	680	0.29	1,000,000	50,000
399-1-14	565	1.96	190,000	
399-1-10	630	2.37	200,000	
399-1-18B	4	25.87	100	1.9
3-1-18C(obs) (a)				
3-1-18A(obs)				
399-1-18C	4	33.96	90	6
3-1-18B(obs)				
3-1-18A(obs)				
399-1-17B	23	42.03	900	12
3-1-17C(obs)				
3-1-17A(obs)				
399-1-17C	28	20.68	1300	260
3-1-17B(obs)				
3-1-17A(obs)				
399-1-16C	2.8	43.03	90	9
3-1-16B(obs)				
3-1-16D(obs)				
3-1-16A(obs)				
399-1-16B(1) (b)	12	14.45	---	---
3-1-16D(obs)			130	2
3-1-16C(obs)				
3-1-16A(obs)				
399-1-16B(2)	20	28.18	---	---
3-1-16D(obs)			170	3
3-1-16C(obs)				
3-1-16A(obs)				
399-1-16A	30	1.64	10,000	500
3-1-16B(obs)				
3-1-16D(obs)				
3-1-16C(obs)				
399-1-9	2.7	80.64	60	6
3-1-3(obs)				
3-1-7(obs)				
3-1-8(obs)				
399-1-3	230	~10	----	----
3-1-7(obs)				
3-1-8(obs)				
3-1-9(obs)				
3-1-16A(obs)				
3-1-16B(obs)				
3-1-16C(obs)				
3-1-16D(obs)				

(a) obs indicates observation well.

(b) (1) indicates test #1, (2) indicates test #2.

AQUIFER TESTS

The aquifer tests are described in a series of testing reports. Each aquifer test report contains information on the conditions of the test, the method of interpretation, and the testing results. Information vital to the understanding of the method of analysis is repeated in the description of each of the aquifer tests.

Aquifer Test for Well 399-1-13 (S6)

Well 399-1-13 (previously labelled S6) in the 300 Area was constructed to characterize the geology and hydrogeology of the upper aquifer (Hanford formation) and to provide a means of sampling the water quality of that zone. The Hanford formation has a saturated thickness of approximately 10 ft at this location. The well was pumped at an average rate of 660 gpm for 132 min. Drawdown in the well demonstrated a specific capacity of approximately 670 gpm/ft, a Theis method transmissivity of 100,000 ft²/day, and a Cooper-Jacob method transmissivity of 108,000 ft²/day. The transmissivity was 120,000 ft²/day, as calculated from the recovery data. The hydraulic conductivity for the Hanford formation at well 399-1-13 is 11,000 ft/day. This value is typical of the Hanford Site as shown in Table D.1. No observation wells were measured during the testing of 399-1-13.

Well 399-1-13 has a total depth of 53 ft, a completed diameter of 6 in., and was set with a No. 40 slot, 6-in., stainless steel well screen from 38 to 53 ft. However, during aquifer testing, the well diameter was 10 in., with a 10-in. stainless steel telescoping screen set from 43 to 53 ft. Figure D.4 illustrates the site stratigraphy and well construction at well 399-1-13. A more detailed description of the site geology is included in Section 3 of the report.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent to produce a measurable drawdown within the well. The 300 Area process trenches are located between the Columbia River and well 399-1-13, approximately 600 ft to the east. The

Construction Diagram

Lithologic Diagram

FIGURE D.4. Well 399-1-13 Stratigraphy and Well Construction

Columbia River is approximately 1600 ft from well 399-1-13 (see Figure D.1). The river apparently did not affect the drawdown during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and determine the optimal discharge rate. The well was developed by bailing for 4 hours, at approximately 30 gpm, on October 31, 1986, and by pumping approximately 600 gpm for another 3 hours on November 4, 1986. Discharge was measured with a 55-gal drum during development. Water levels were measured by an electric sounding tape (E-tape) and recorded manually. The water was drawn down 0.5 ft and equilibrated very quickly. The static water level in well 399-1-13 was 43.1 ft below the land surface before development and was 43.14 ft below the land surface (342.98 ft above mean sea level) at the time of the constant-discharge test.

Description of the Aquifer Test

Flow rates were measured with either a 5-gal bucket calibrated to the 3.77-gal mark, a moderate-discharge (5- to 50-gpm) McCrometer® (#82-3-226) flow meter, or a higher discharge (100- to 1000-gpm) McCrometer® (#86-6-1161). The 5-gal test bucket was calibrated to an inside groove marked with ink. This mark was equivalent to a volume of 3.77 gal. The bucket was calibrated to this mark by filling and emptying it three times using a 2000-mL graduated cylinder with factory accuracies of ± 0.5 mL (0.000132 gal). Laboratory calibration was accurate to about 50 mL (0.0132 gal) because of multiple volumes from the graduated cylinder, and because visual perception of the thick line in the groove was difficult. Field measurements of discharge rate were subject to even greater error because of the poor lighting for visual inspection, difficulty in leveling the bucket for determining when the water level filled to the 3.77-gal calibration line, and slight distortions in the shape and hence the volume of the PVC bucket on an uneven surface. All of these factors may

®The McCrometer flow meter is a product of McCrometer, a Division of Ametek, Inc., Hemet, California.

increase the uncertainty of the volume discharged into the bucket to as much as ± 500 mL (0.132 gal), which would result in an uncertainty of discharge volume or rate of $\pm 3\%$.

The McCrometer® flow meters were factory calibrated to an accuracy of $\pm 2\%$ of the discharge rate within the operational range of the flow meter, which is slightly less than the range of the dial reading. It was not possible to perform field performance checks of the flow meters except when discharge rates were less than 30 gpm. The large 55-gal drum was not calibrated to any specific degree of accuracy and was difficult to use in measuring the volume during the higher discharge rates. Field checks with the 55-gal drum generally indicated if the discharge was within $\pm 10\%$. In many of the aquifer tests in the intermediate and deep zones, the discharge rates were just below the operational range of the moderate discharge flow meter and could not be measured accurately with the dial or totalizer on the meter. The bucket would substitute for the flow meter, and the rate at which water filled the bucket to the 3.77-gal or 5-gal mark was timed with a stop watch. When possible, the discharge rate was measured with both the flow meter and the calibrated bucket.

Depths to water were measured by E-tapes and data loggers with 10- and 15-psi transducers. The E-tapes have a factory delivered accuracy of ± 0.01 ft. Field precision varies with the user, but under the best conditions the accuracy of water level measurements is ± 0.01 ft. Water levels measured by electric sounders are dependent on E-tape or steel tape measurements for absolute depth to water measurements. Aquifer testing primarily requires data related to change in hydraulic head. Therefore, accuracy of the strain gauge transducer is not the issue; the issue is its ability to measure or resolve changes in hydraulic head. The precision for resolving these differences or resolution is ± 0.02 ft for the 10-psi transducer or 0.03 ft for the 15-psi transducer.

The pumping rate of the constant-discharge test averaged 660 gpm. Flow rates during this test were measured with a McCrometer® flow meter provided by the drilling contractor. The instantaneous rate was recorded on the field data collection sheets presented at the end of the test description. The total

quantity of water discharged during the test was 87,100 gal. The water from the test was discharged at the land surface about 1000 ft away in the direction of the Process Trenches.

Drawdown Test. The constant-discharge pumping test was conducted on November 5, 1986. Water levels were recorded manually by an E-tape and automatically by a pressure transducer and Terra 8/D® data logger. The pumping was terminated after 132 min because water being discharged was washing away an access road adjacent to the 300 Area process trenches. The maximum drawdown was 0.98 ft at the time pumping stopped. The specific capacity of the well was approximately 670 gpm/ft; however, drawdown was still occurring when the test was discontinued.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The observed water level in well 399-1-13 recovered in an erratic manner. It was suggested that the check valve for the pump may have been leaking; however, this has not been substantiated. The Columbia River apparently did not affect either the drawdown or the recovery water levels during this test.

Observation Wells. No observation wells were measured during the aquifer testing of well 399-1-13.

Analysis and Interpretation

The pumping rate measurements are considered accurate. Total discharge was 87,100 gal, which, when divided by the 132 min of pumping, gives a figure of 659.9 gpm. Instantaneous readings were predominantly 660 gpm.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount compared to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If the drawdown is considerable and equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob

®The Terra 8/D data logger is a product of Instrumentation Northwest, Inc., Redmond, Washington.

(1963) suggests that a correction factor be made to the drawdown data before analysis. In the case of borehole storage effects, the later data are selected for interpretation. Hantush (1964) suggests that partial penetration corrections be made if the well only penetrates a fraction of the aquifer thickness. Corrections are probably not required for data collected from well 399-1-13 because the well is apparently screened at the entire saturated thickness of the Hanford formation at this location. This assumption is only valid if the Hanford formation can be considered a hydrologic unit separate from the upper and middle units of the Ringold Formation. Data may be compared by analyzing both corrected and uncorrected water level measurements to determine if there is any difference. A comparison was not done because the thickness of the Ringold Formation is unknown at this location.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.5. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells. The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, no boundary was indicated by the plot, and data are selectively analyzed for the period from 10 to 132 min. Water level measurements taken earlier than 10 min into the test indicate pumping rate adjustments or formation heterogeneities. The transmissivity calculated using the Theis curve matching method is 100,000 ft^2/day .

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values, if certain conditions are met. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 10 min. However, for both the Theis and Cooper-Jacob methods, no storativity values can be calculated because there were no observation wells measured during aquifer testing of well 399-1-13. The transmissivity calculated from data collected manually, using the Cooper-Jacob method, is 106,000 ft^2/day . The transmissivity calculated from data collected

FIGURE D.5. Well 399-1-13 Observed Drawdown Using the Theis Analysis

automatically by transducer, and analyzed using the same method, is 110,000 ft²/day. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.6.

Transmissivity Calculations for the Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.7. The data that were used to calculate transmissivity appear to the left of a t/t' value of 14.2 [(132 + 10 min)/10 min]. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more reliable than pumping

RCRA Well 399-1-3 (S6)
Constant-Discharge Drawdown Test
11/5/86

FIGURE D.6. Well 399-1-13 Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

data, because they are not affected as much by changes in pumping rate as are the drawdown data. The calculated transmissivity from the recovery plot is 120,000 ft²/day.

The hydraulic conductivity of the Hanford formation at well 399-1-13 is 11,000 ft/day, based on an average of the transmissivities described above and an aquifer thickness of 10 ft. Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that the values determined for transmissivity are in approximate agreement. An aquifer testing and well construction summary are in Table D.3.

RCRA Well 399-1-13 (S6)
Constant-Discharge Recovery
11/5/86

FIGURE D.7. Well 399-1-13 Water Level Recovery Plot Using the Cooper-Jacob Analysis

The best values for aquifer characteristics that are determined by this test are a transmissivity of 110,000 ft²/day and a hydraulic conductivity of 11,000 ft/day. The Hanford formation aquifer thickness is 10 ft at this location.

Aquifer Test for Well 399-1-18A (C3A)

Well 399-1-18A (previously labelled C3A) in the 300 Area was constructed to characterize the geology and hydrogeology of the upper aquifer (combined Hanford formation and Ringold Formation) and to provide a means of sampling the water quality of that zone. The top of the upper or middle unit of the Ringold Formation lies above the water table in this well and has a saturated thickness of approximately 20 ft at this location. The well was pumped at an average rate of 680 gpm for 120 min. Drawdown in the well demonstrated a specific capacity of 2300 gpm/ft, a Theis method transmissivity of 625,000 ft²/day, and a Cooper-Jacob method transmissivity of 1,200,000 ft²/day. No transmissivity figure could be derived from the recovery data. The hydraulic conductivity for

TABLE D.3. Aquifer Testing and Well Construction Summary for Well 399-1-13

WELL: 399-1-13 (S6)

DATE OF TEST: 11/5/86

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 386.12
(brass cap)

STATIC WATER LEVEL (date of test): 43.14 ft below lsd

ELEVATION: 342.98 ft above msl

MAXIMUM PUMPING WATER LEVEL: 44.12 ft below lsd

ELEVATION: 342.0 ft above msl

MAXIMUM DRAWDOWN: .98 ft

PUMPING RATE: 660 gallons per minute (gpm)

PUMPING TIME: 132 minutes

TOTAL DISCHARGE: 87,100 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD: 52 ft below lsd

334.1 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: >10 ft (3.05 m)

TOP OF SCREEN: 38 ft below lsd

ELEVATION: 348.12 ft above msl

BOTTOM OF SCREEN: 53 ft below lsd

ELEVATION: 333.12 ft abv msl

OBSERVATION WELLS: NOT APPLICABLE

TABLE D.3. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		NA
Curve Match (Theis)	100,000 (9295)	
W(u) = 10		
1/u = 1,400		
s (ft) = 1		
t (min) = 10		
Q (gpm) = 660		
Straight-line Semilog Plot (Cooper-Jacob)	106,000 (9852.8)	NA
Transducer	110,000 (10,224.6)	NA
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	120,000 (11,154.1)	NA
PROBABLE VALUE ft ² /d (m ² /d)	110,000 (10,224.6)	
STORATIVITY:	-----	NA
CONDUCTIVITY: ft/d (m/d)	-----	NA

Aquifer Test Data

page 1 of

Data for Well S6

Pumping Well S6

Observation Wells None

Location 300 Area

Type of Aquifer Test Drawdown

How Q Measured Calibrated Flowmeter (Macrometer)

How W.L.'s Measured Electric tape and transducer

Depth of Pump/Airpipe

Rad./Dist. of/From Pumping Well 0

Pump On: date 11-5-86 time 0743

Meas. Point for W.L.'s top of steel casing

Pump Off: date 11-5-86 time 0955

Elevation of Meas. Point 23' above ground surface

Duration of Aquifer Test 2.2 hrs pumping

Time t = <u>132</u> at t' = 0					Water Level Data Static Water Level <u>45.44'</u>				Discharge		Recorded By	Comments
Day	Clock Time	min. t	t'	1/t'	ft. of Reading or Corrections	Conversions	Water Level	s or s'	Read- ing	Q		
	0743	0			4.9	0	45.44	0	0	0	RL	
		0.25			3.8	1.1	—				RL	
		0.50			3.7	1.2	—				RL	
		0.75			3.7	1.2	—				RL	
		1			3.7	1.2	46.02	.58			RL	
		2			3.7	1.2	—				RL	
		3			3.65	1.25	—				RL	
		5			3.65	1.25	46.08	.64			RL	
		7			3.6	1.3	46.12	.68			RL	
		10			3.6	1.3	46.14	.70	6,800	660	RL	
		12			3.6	1.3	46.15	.71	—	—	RL	
		15			3.6	1.3	46.18	.74	9,900	660	RL	
		20			3.55	1.35	46.21	.77	—	—	RL	
		25			3.5	1.4	46.23	.79	16,500	660	RL	
		30			3.5	1.4	—		19,800	660	RL	
		31			3.5	1.4	46.26	.82	—	—	RL	
		40			3.5	1.4	46.28	.84	26,500	670	RL	
		50			3.45	1.45	46.30	.86	33,100	660	RL	
		60			3.45	1.45	46.33	.89	39,600	650	RL	
		80			3.4	1.5	46.35	.91	52,800	660	RL	
		100			3.4	1.5	46.39	.95	66,000	660	RL	
		132	0		3.4	1.5	46.42	.98	87,100	660	RL	
	132	0.25	0.25	52.9			45.65	.21			RL	
		+0.50	0.75	26.5			45.47	.03			RL	
		+0.75	0.75	17.9			45.46	.01			RL	check valve
		133	1	133			45.63	.19			RL	may be
		134	2.5	63.8			45.59	.16			RL	leaking.
		135	3	45			45.68	.24			RL	
		136	4	34			45.59	.15			RL	
		137	5	23.4			45.40	-.04			RL	
		139	7	14.9			45.38	-.06			RL	
		140	8	13.5			45.37	-.07			RL	
		141	9	12.3			45.57	.13			RL	
		142	10	11.2	4.8		45.54	.12			RL	
		147	15	9.8	4.8		45.54	.10			RL	
		152	20	7.6	4.8		45.51	.07			RL	
		162	30	5.1	4.8		45.48	.04				

the upper portion of the Ringold Formation at well 399-1-13 is 50,000 ft/day. This value is greater than conductivities considered typical of either the Hanford formation or the undifferentiated Hanford and Ringold Formations at the Hanford Site, as shown in Table D.1. No observation wells were measured during the testing of 399-1-18A.

Well 399-1-18A was drilled to a total depth of 63 ft, but it was back-filled to 54 ft; it has a completed diameter of 6 in. and was set with a No. 40 slot, 6-in., stainless steel well screen from 39 to 54 ft. However, during aquifer testing, the well diameter was 10 in., with a 10-in., stainless steel, telescoping screen set from 44 to 54 ft. Figure D.8 illustrates the site stratigraphy and well construction at well 399-1-18A. A more detailed description of the site geology is included in Section 3 of the report.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area process trenches are located approximately 1400 ft to the southeast of well 399-1-18A, while the Columbia River is approximately 1400 ft to the east of well 399-1-18A (see Figure D.1). The river apparently did not affect the drawdown during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and determine the optimal discharge rate. The well was developed by bailing on November 11, 1986, and by pumping approximately 700 gpm for 2 hours on the same day. Discharge was measured with a McCrometer flow meter during development. Water levels were measured by an E-tape and recorded manually. The water was drawn down approximately 0.3 ft and equilibrated very quickly. The static water level in well 399-1-18A was 44.0 ft below land surface before development and was 44.25 ft below land surface (343.80 ft above msl) at the time of the constant-discharge test.

FIGURE D.8. Well 399-1-18A Stratigraphy and Well Construction

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 680 gpm. Flow rates during this test were measured with a McCrometer® flow meter provided by the drilling contractor. The instantaneous rate was recorded on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 81,500 gal. The water from the test was discharged at the land surface about 1000 ft away in the direction of the Columbia River.

Drawdown Test. The constant-discharge pumping test was conducted on November 11, 1986. Water levels were recorded manually by an E-tape and automatically by a pressure transducer and Terra 8/D® data logger. The pumping was terminated after 120 min because water levels had apparently achieved equilibrium. The maximum drawdown was 0.29 ft at the time pumping stopped. The specific capacity of the well was approximately 2300 gpm/ft.

Recovery Test. Recovery of the water level was observed for 40 min in well 399-1-18A, following termination of pumping. The observed water level recovered to static conditions within 6 min of the time the pumping was stopped. However, the recovery data were so poor that no interpretation or analysis could be made from this phase of testing.

Observation Wells. No observation wells were measured during the aquifer testing of well 399-1-18A.

Analysis and Interpretation

The pumping rate is considered accurate. Total discharge was 81,500 gal, which, when divided by the 120 min of pumping, gives a figure of 679.2 or approximately 680 gpm. Instantaneous readings ranged from 667 to 705 gpm.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be applied to the drawdown data

before analysis. Hantush (1964) suggests that corrections also be made for wells that partially penetrate the aquifer. In the case of borehole storage effects, the later data are selected for interpretation. Corrections are probably not required for data collected from well 399-1-18A, because the well penetrated 10 ft of the total aquifer thickness of 20 ft and drawdown was less than 0.3 ft. However, a preliminary calculation using drawdown values corrected by $s-s^2/2D_0$, where s is the observed drawdown and D_0 is the saturated thickness of the aquifer (Hantush 1964, p. 368), indicates little difference between corrected and observed drawdown data. If the aquifer is thicker than is assumed here, the difference between observed and corrected values would be even less.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.9. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells. The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, no boundary was indicated by the plot and data are selectively analyzed for the period from 10 to 120 min. Water level measurements taken earlier than 10 min into the test indicate pumping rate adjustments or heterogeneities. The transmissivity calculated using the Theis curve matching method is $\sim 625,000 \text{ ft}^2/\text{day}$.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximation of transmissivity and storativity values if certain conditions are met. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 10 min. However, for both the Theis and Cooper-Jacob methods, no storativity values can be calculated because there were no observation wells measured during aquifer testing of well 399-1-18A. The transmissivity calculated using the Cooper-Jacob method is $\sim 1,200,000 \text{ ft}^2/\text{day}$. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.10.

RCRA Well 399-1-18A (C3A)
Constant-Discharge Drawdown
11/11/86

FIGURE D.9. Well 399-1-18A Observed Drawdown Using the Theis Analysis

Transmissivity Calculations for the Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. No plot of the recovery data is presented for this test because the data were considered too noisy for interpretation. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. However, in this test, the data collected during the recovery after constant-discharge pumping may have been affected by a leaking pump valve that may have allowed water to flow back down the pump column and enter the well.

RCRA Well 399-1-18A (C3A)
Constant-Discharge Drawdown
11/11/86

FIGURE D.10. Well 399-1-18A Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

The hydraulic conductivity of the upper unit of the Ringold Formation at well 399-1-18A is 50,000 ft/day, based on a transmissivity of 1,000,000 ft²/day and an aquifer thickness of 20 ft.

The best values for aquifer characteristics determined by this test are a transmissivity of 1,000,000 ft²/day and a hydraulic conductivity of 50,000 ft/day. The aquifer thickness is approximately 20 ft at this location. Aquifer Test Data Sheets for well 399-1-18A follow.

TABLE D.4. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	625,000 (58,094)	N.A.
W(u) = 60		
1/u = 1.3E+7		
s (ft) = 1		
t (min) = 10		
Q (gpm) = 680		
Straight-line Semilog Plot (Cooper-Jacob)	1,200,000 (111,540.7)	N.A.
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	-----	N.A.
PROBABLE VALUE ft ² /d (m ² /d)	1E+6 (92,950.6)	N.A.
STORATIVITY:		
CONDUCTIVITY: ft/day (m/d)	50,000 (15,240)	N.A.

Aquifer Test Data

page 1 of 1
 Data for Well C3 - Shallow
 Pumping Well Same
 Observation Wells None

Location C3 - Shallow
 Type of Aquifer Test D
 How Q Measured Mc Gurometer
 How W.L.'s Measured Terra 80 data logger & Survey
 Rad./Dist. of/From Pumping Well 0
 Meas. Point for W.L.'s Top of (fine steel)
 Elevation of Meas. Point 1.2 ft above ground

Depth of Pump/Airpipe 49 ft.
 Pump On: date 11-11-86 time 1705 hrs
 Pump Off: date 11/11/86 time 1905 hrs
 Duration of Aquifer Test 2 hrs pumping

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>45.4 ft.</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
							<u>45.45</u>				RL	<u>147300</u>
	<u>5:05</u>											
	<u>5:30</u>						<u>45.7</u>	<u>.25</u>				
	<u>1:00</u>						<u>45.68</u>	<u>.23</u>				
	<u>1:30</u>						<u>45.71</u>	<u>.26</u>				
	<u>2:00</u>						<u>45.70</u>	<u>.25</u>				
	<u>2:30</u>						<u>45.70</u>	<u>.25</u>				
	<u>3:00</u>						<u>45.70</u>	<u>.25</u>				
	<u>3:30</u>						<u>45.71</u>	<u>.26</u>				<u>149700</u>
	<u>4:00</u>						<u>45.68</u>	<u>.23</u>				
	<u>4:00</u>						<u>45.52</u>	<u>(?) 05</u>				<u>151100</u>
	<u>6:30</u>						<u>45.70</u>	<u>.25</u>				
	<u>8:00</u>						<u>45.71</u>	<u>.26</u>				<u>152500</u>
	<u>10:00</u>				<u>70</u>		<u>45.71</u>	<u>.26</u>	<u>(15 min. 100 gal / 18.5 sec)</u>	<u>153800</u>		<u>765 gal/min</u>
	<u>20:00</u>						<u>45.71</u>	<u>.26</u>	<u>100 gal / 9.5 sec</u>	<u>160550</u>		<u>666 gal/min</u>
	<u>30:00</u>						<u>45.65</u>	<u>(?) .20</u>				<u>167300</u>
	<u>30:30</u>						<u>45.72</u>	<u>.27</u>	<u>100 gal / 9.3 sec</u>			
	<u>40:30</u>						<u>45.71</u>	<u>.26</u>				<u>174500</u>
	<u>50:00</u>						<u>45.72</u>	<u>.27</u>	<u>100 gal / 8.93 sec</u>	<u>187600</u>		
	<u>60:00</u>						<u>45.74</u>	<u>.29</u>	<u>100 gal / 8.9 sec</u>	<u>201100</u>		
	<u>70:00</u>						<u>45.74</u>	<u>.29</u>	<u>100 gal / 8.5 sec</u>	<u>214600</u>		
	<u>120:00</u>						<u>45.74</u>	<u>.29</u>				<u>228800</u>
	<u>1:00</u>						<u>45.20</u>					<u>81,500 gal. pumped</u>
	<u>1:30</u>						<u>45.48</u>					<u>~ 600 gpm</u>
	<u>1:45</u>						<u>45.47</u>					
	<u>1:58</u>						<u>45.47</u>					
	<u>1:20</u>						<u>45.48</u>					
	<u>1:45</u>						<u>45.52</u>					
	<u>2:30</u>						<u>45.44</u>					
	<u>3:00</u>						<u>45.41</u>					
	<u>3:30</u>						<u>45.47</u>					
	<u>4:00</u>						<u>45.48</u>					
	<u>6:00</u>						<u>45.47</u>					
	<u>8:00</u>						<u>45.45</u>					
	<u>10:00</u>						<u>45.45</u>					
	<u>20:00</u>						<u>45.45</u>					
	<u>40:00</u>						<u>45.45</u>					

Aquifer Test for Well 399-1-14 (S7)

Well 399-1-14 (previously labelled S7) in the 300 Area was constructed to characterize the geology and hydrogeology of the upper unconfined aquifer (Hanford formation) and to provide a means of sampling the water quality of that zone. The Hanford formation has a saturated thickness of 10 ft at this location. The well was pumped at an average rate of 565 gpm for a period of 420 min. Drawdown in the well demonstrated a specific capacity of approximately 280 gpm/ft. Drawdown observations could not be analyzed; however, recovery data indicated a transmissivity of approximately $190,000 \text{ ft}^2/\text{day}$. The hydraulic conductivity for the Hanford formation at well 399-1-14 is approximately 19,000 ft/day. This value is typical of the Hanford Site 300 Area as shown in Table D.1. No observation wells were measured during the testing of well 399-1-14. Well 399-1-14 has a total depth of 47 ft, a completed diameter of 6 in., and the well was set with a No. 40 slot, 6-in., stainless steel well screen from 31 to 46 ft. However, during aquifer testing, the well diameter was 10 in. with a 10-in., stainless steel, telescoping screen set from 37 to 47 ft. Figure D.11 illustrates the site stratigraphy and well construction at well 399-1-14. A more detailed description of the site geology is included in Section 3 of the report.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area process trenches are located approximately 600 ft to the east of well 399-1-14, between the Columbia River and well 399-1-14. The Columbia River is approximately 1500 ft from well 399-1-14 (see Figure D.1). The river apparently did not affect the drawdown during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On November 11, 1986, the well was developed by bailing for 2 hours using an 8-in.,

FIGURE D.11. Well 399-1-14 Stratigraphy and Well Construction

flat-bottomed bailer, and on November 12, 1986 was developed by pumping approximately 600 gpm for another 1.5 hours. Discharge was measured with a McCrometer® flow meter during development. Water levels were measured by an E-tape and recorded manually. The water level drew down 0.7 ft and equili

brated very quickly. The static water level in well 399-1-14 was 38.84 ft below the top of the 10-in. casing before development. The static water level was 38.79 ft below the top of the 10-in. casing at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 565 gpm. Flow rates during this test were measured with a McCrometer® flow meter provided by the drilling contractor. The instantaneous rate was recorded on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 237,300 gal. The water from the test was discharged at the land surface into a gravel pit about 1000 ft away to the northwest.

Drawdown Test. The constant-discharge pumping test was conducted on November 12, 1986. Water levels were recorded manually by an E-tape and automatically by a pressure transducer and Terra 8/D® data logger. The pumping was terminated after 420 min because water levels had apparently equilibrated. The maximum drawdown was 1.96 ft at the time pumping stopped. The specific capacity of the well was approximately 280 gpm/ft. The transducer data indicate a maximum drawdown of approximately 3.2 ft and a specific capacity of 180 gpm/ft. The discrepancy between the two methods of measurement may be caused by an erroneous conversion factor used with the transducer measurements.

Recovery Test. Recovery of the water level was observed in well 399-1-14 for 40 min following the termination of pumping. The observed water level in the pumped well recovered to within 0.04 ft of the initial static water level during the recovery phase of testing.

Observation Wells. No observation wells were measured during the aquifer testing of well 399-1-14.

Analysis and Interpretation

The pumping rate is considered accurate. Total discharge was 237,300 gal, which, when divided by the 420 min of pumping, gives a figure of 565 gpm.

Instantaneous readings indicated approximately 600 gpm. Cumulative flow monitored throughout the pumping period of the test indicated a range of 533 to 610 gpm. Drawdown data were very much affected by the variation in pumping rate, and no interpretable data could be collected during this phase of testing.

Transmissivity Calculations for the Drawdown Test. There are number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be applied to the drawdown data before analysis. Hantush (1964) suggests that corrections also be made for wells that partially penetrate the aquifer. In the case of borehole storage effects, the later data are selected for interpretation.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

None of the drawdown data collected during pumping could be used to calculate transmissivity values for well 399-1-14. Neither a Theis-type matching curve nor a Cooper-Jacob modified curve could be fitted to the drawdown data.

Transmissivity Calculations for the Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data as measured by E-tape is presented in Figure D.12. Figure D.13 shows recovery data as measured by a pressure transducer and recorded by a

RCRA Well 399-1-14 (S7)
Constant-Discharge Recovery (Transducer)
11/12/86 - 11/13/86

FIGURE D.12. Well 399-1-14 Recovery Data Using the Cooper-Jacob Method

Terra 8/D® 3-channel data logger. The data used to calculate transmissivity appear to the left of a t/t' value of 43.0 [i.e., $(420 + 10 \text{ min}) / 10 \text{ min}$]. The early-time data appear to the right on these plots.

The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in the pumping rate as are the drawdown data. The calculated transmissivity from the recovery plots are $180,000 \text{ ft}^2/\text{day}$ for the transducer data and $200,000 \text{ ft}^2/\text{day}$ for the hand-measured water levels.

The hydraulic conductivity of the Hanford formation at well 399-1-14 is $19,000 \text{ ft/day}$, based on the most-probable transmissivity described above and on an aquifer thickness of 10 ft.

RCRA Well 399-1-14 (S7)
Constant-Discharge Recovery
11/12/86 - 11/13/86

FIGURE D.13. Well 399-1-14 Recovery Data from Transducer

Analysis of selected portions of the two recovery plots generated from the aquifer test indicates that the values determined for transmissivity are in agreement. A summary of the aquifer testing results and well construction information is presented in Table D.5.

The best values for aquifer characteristics determined by this test are a transmissivity of 190,000 ft²/day and a hydraulic conductivity of 19,000 ft/day. The Hanford formation aquifer thickness is approximately 10 ft at this location. Aquifer Test Data Sheets for well 399-1-14 follow.

Aquifer Test for Well 399-1-10 (S3)

Well 399-1-10 (previously labelled S3) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined (combined Hanford formation and Ringold Formation) aquifer and to provide a means of sampling the water quality of that zone. The top of the Hanford formation lies above the water table in this well and the saturated thickness is unknown at this

TABLE D.5. Aquifer Testing and Well Construction Summary for Well 399-1-14

WELL: 399-1-14 (S7)

DATE OF TEST: 11/12/86 - 11/13/86

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 383.51 top
of 6-inch casing; 380.68 ft brass cap set in concrete pad

STATIC WATER LEVEL (date of test): 38.79 ft below top of 10" casing

ELEVATION: _____ ft above msl

MAXIMUM PUMPING WATER LEVEL: 40.75 ft below top of 10" casing

ELEVATION: _____ ft above msl

MAXIMUM DRAWDOWN: 1.96 ft

PUMPING RATE: 565 gallons per minute (gpm)

PUMPING TIME: 420 minutes

TOTAL DISCHARGE: 237,300 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD: 47 ft below lsd 333.7 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: > 10 ft (> 3.05 m)

TOP OF SCREEN 37 ft below lsd ELEVATION: 343.7 ft above msl

BOTTOM OF SCREEN 47 ft below lsd ELEVATION: 333.7 ft abv msl

OBSERVATION WELLS: N.A.

TABLE D.5. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	-----	N.A.
W(u) =		
1/u =		
s (ft) =		
t (min.) =		
Q (gpm) =		
Straight-line Semilog Plot (Cooper-Jacob)	-----	N.A.
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	200,000 (18,590)	N.A.
Transducer	180,000 (16,731)	N.A.
PROBABLE VALUE ft ² /d (m ² /d)	190,000 (17,660.6)	N.A.
STORATIVITY:	-----	
CONDUCTIVITY: ft/d (m/d)	< 19,000 (5,791)	N.A.

Aquifer Test Data

page 1 of 1

Data for Well 57

Pumping Well 57

Observation Wells -

Location 320 AREA

Type of Aquifer Test DRAWDOWN

How Q Measured CALIBRATED FLOW METER (MICROMETER)

How W.L.'s Measured E-TAPE, TRANSDUCER Depth of Pump/Airpipe ~ 35'-40'

Rad./Dist. of/From Pumping Well 0 Pump On: date 11/12/86 time 1610 hrs

Meas. Point for W.L.'s TOP OF 10" CASING Pump Off: date 11/12/86 time 2310 hrs

Elevation of Meas. Point - Duration of Aquifer Test 7 hrs DRAWDOWN

1 hr RECOVERY

Time t = <u>420</u> at t' = 0					Water Level Data Static Water Level <u>38.79</u>					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
11/12	1 min						40.79					JSN	BEGIN 285600
	1.5 min						40.77					JSN	
	2.0 min						40.77					JSN	
	2.5 min						40.76					JSN	
	3.0						40.76					JSN	
	3.5						40.67	?				JSN	
	4.0						40.75		600 GPM			JSN	
	6.0						40.76		600 GPM			JSN	289100
	8.0						40.71					JSN	
	10.75						40.76		600 GPM			JSN	292000
	20.00						40.76					SPA	
	42.00						40.76					SPA	309600
	60.00						40.78					SPA	320000
	80.00						40.77					SPA	
	110.00						40.92	?				SPA	349600
	140.00						40.78					SPA	365600
	170.00						40.66					SPA	382460
	200						40.80					SPA	
	204											SPA	401500
	240						40.76					SPA	422000
	300						40.78					SPA	455500
	360						40.76					SPA	489300
	420						40.75					SPA	522900
	20 sec	33	1274				39.12	.33	5'			SPA	
	40 sec	67	628				39.08	.29				SPA	565 gpm
	60 sec	101	421				39.06	.27				SPA	
	1.25 min	125	337	11:10 P.M.			39.03	.24	PUMP OFF			JSN	
	1.75 min	175	241				39.03	.24				JSN	
	2.50	25	169				38.99	.20				JSN	
	3.00	423	3	141			38.98	.19				JSN	
	3.50	35	121				38.97	.18				JSN	
	4.00	424	4	100			38.95	.16				JSN	
	4.50	45	99.3				38.94	.15				JSN	
	5.00	425	8	85			38.94	.15				JSN	
	5.50	55	77				38.94	.15				JSN	
	6.00	426	6	71			38.93	.14				JSN	
	12.00	422	12	36			38.88	.09				SPA	
	15.00	425	15	29			38.87	.08				SPA	
	20.00	440	20	22			38.84	.07				SPA	

25.00 445 25 18
30.00 450 30 15
40.00 460 40 11.5

38.84 .05
38.83 .04
38.83 .04

SPA
SPA
SPA

t' t t/t' = 8 5/8
480
60.00 38.82 SPA

" Terra8® Data Collection Report"

"Firmware Version 3.1/86"
 "Number of Bytes in Data Dump 6236"
 "User Supplied Comment
 "Time Header Block Loaded 11/12 15:09:56.80 "
 "Time Data File Dumped 11/26 09:09:29.60 "
 "Remaining Memory 18339"
 "Number of Logs 1947"
 "Type of Data Memory Main Memory"
 "Logs/Timestamp 50"
 "Power was OK During Data Collection Period"

" Terra8 Channel Setup:"

"Number of Declared Analog Channels = 1"

Ch#	Description	Units	Delay	M	B
1	WELL S7.....	FEET....	1000	2.310	-4.805

" Terra8 Channel Setup:"

"Number of Declared Digital Channels = 0"

Ch#	Description	Units	Delay	M	B
-----	-------------	-------	-------	---	---

"*Initial Scan at "11 12 15 9 55 30

"*Next Scan at "11 12 15 9 55 30

" Time "" Analog#01"

0.00	0.012
30.00	0.012
60.00	0.012
90.00	0.012
120.00	0.012
150.00	0.012
180.00	0.012
210.00	0.012
240.00	0.012
270.00	0.012
300.00	0.012
330.00	0.012
360.00	0.023
390.00	0.012
420.00	0.023
450.00	0.023
480.00	0.023
510.00	0.023
540.00	0.023

<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>
570.00	0.012	2190.50	0.023	3810.50	-2.841
600.00	0.023	2220.50	0.023	3840.50	-2.795
630.00	-0.023	2250.50	0.023	3870.50	-2.772
660.00	0.000	2280.50	0.023	3900.50	-2.807
690.00	0.012	2310.50	0.023	3930.50	-2.864
720.00	0.000	2340.50	0.023	3960.50	-2.841
750.00	0.012	2370.50	0.023	3990.50	-2.841
780.00	0.012	2400.50	0.023	4020.50	-2.795
810.00	0.012	2430.50	0.023	4050.50	-2.887
840.00	0.012	2460.50	0.023	4080.50	-2.911
870.00	0.012	2490.50	0.023	4110.50	-2.876
900.00	0.012	2520.50	0.023	4140.50	-2.853
930.00	0.012	2550.50	0.023	4170.50	-2.830
960.00	0.012	2580.50	0.023	4200.50	-2.922
990.00	0.012	2610.50	0.023	4230.50	-2.876
1020.00	0.012	2640.50	0.023	4260.50	-2.957
1050.00	0.012	2670.50	0.023	4290.50	-2.934
1080.00	0.012	2700.50	0.023	4320.50	-2.899
1110.00	0.012	2730.50	0.035	4350.50	-2.911
1140.00	0.012	2760.50	0.035	4380.50	-2.887
1170.00	0.012	2790.50	0.035	4410.50	-2.934
1200.00	0.023	2820.50	0.035	4440.50	-2.887
1230.00	0.000	2850.50	0.023	4470.50	-2.957
1260.00	0.012	2880.50	0.035	4500.50	-2.864
1290.00	0.012	2910.50	0.023	4530.50	-2.968
1320.00	0.012	2940.50	0.035	4560.50	-2.911
1350.00	0.012	2970.50	0.035	4590.50	-2.853
1380.00	0.012	3000.50	0.035	4620.50	-2.980
1410.00	0.012	3030.50	0.035	4650.50	-2.968
1440.00	0.012	3060.50	0.035	4680.50	-2.934
1470.00	0.012	3090.50	0.035	4710.50	-2.980
1500.50	0.012	3120.50	0.035	4740.50	-2.991
1530.50	0.012	3150.50	0.023	4770.50	-2.945
1560.50	0.023	3180.50	0.035	4800.50	-2.980
1590.50	0.012	3210.50	0.035	4830.50	-2.957
1620.50	0.012	3240.50	0.035	4860.50	-2.991
1650.50	0.023	3270.50	0.035	4890.50	-3.003
1680.50	0.012	3300.50	0.023	4920.50	-2.980
1710.50	0.023	3330.50	0.035	4950.50	-2.991
1740.50	0.023	3360.50	0.035	4980.50	-2.968
1770.50	0.012	3390.50	0.035	5010.50	-2.991
1800.50	0.023	3420.50	0.035	5040.50	-3.003
1830.50	0.023	3450.50	0.035	5070.50	-2.968
1860.50	0.023	3480.50	0.035	5100.50	-3.015
1890.50	0.023	3510.50	0.035	5130.50	-3.003
1920.50	0.023	3540.50	0.035	5160.50	-2.957
1950.50	0.023	3570.50	0.035	5190.50	-2.991
1980.50	0.023	3600.50	0.035	5220.50	-2.968
2010.50	0.023	3630.50	-2.460	5250.50	-2.980
2040.50	0.012	3660.50	-2.830	5280.50	-2.934
2070.50	0.023	3690.50	-2.633	5310.50	-2.991
2100.50	0.023	3720.50	-2.784	5340.50	-2.980
2130.50	0.023	3750.50	-2.703	5370.50	-2.968
2160.50	0.023	3780.50	-2.772	5400.50	-2.980

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
5430.50	-2.991	7050.50	-3.003	8670.50	-3.003
5460.50	-2.968	7080.50	-3.026	8700.50	-3.072
5490.50	-2.957	7110.50	-3.015	8730.50	-3.095
5520.50	-2.922	7140.50	-3.003	8760.50	-3.026
5550.50	-2.945	7170.50	-3.084	8790.50	-3.084
5580.50	-2.980	7200.50	-3.015	8820.50	-3.107
5610.50	-3.038	7230.50	-2.934	8850.50	-3.049
5640.50	-3.038	7260.50	-3.049	8880.50	-3.026
5670.50	-3.026	7290.50	-3.084	8910.50	-3.072
5700.50	-3.015	7320.50	-3.003	8940.50	-3.015
5730.50	-2.968	7350.50	-3.015	8970.50	-3.049
5760.50	-3.003	7380.50	-3.038	9000.50	-3.107
5790.50	-3.003	7410.50	-3.049	9030.50	-3.095
5820.50	-3.015	7440.50	-2.991	9060.50	-3.061
5850.50	-3.026	7470.50	-2.991	9090.50	-3.107
5880.50	-3.026	7500.50	-3.003	9120.50	-3.072
5910.50	-2.991	7530.50	-3.038	9150.50	-3.072
5940.50	-3.049	7560.50	-3.095	9180.50	-3.072
5970.50	-2.968	7590.50	-3.061	9210.50	-3.072
6000.50	-2.980	7620.50	-3.049	9240.50	-3.084
6030.50	-3.038	7650.50	-3.026	9270.50	-3.084
6060.50	-3.003	7680.50	-3.061	9300.50	-3.072
6090.50	-3.003	7710.50	-3.003	9330.50	-3.072
6120.50	-3.049	7740.50	-2.991	9360.50	-3.026
6150.50	-3.015	7770.50	-2.980	9390.50	-3.049
6180.50	-3.049	7800.50	-3.084	9420.50	-3.084
6210.50	-2.991	7830.50	-3.049	9450.50	-3.095
6240.50	-3.061	7860.50	-3.003	9480.50	-3.095
6270.50	-3.015	7890.50	-3.015	9510.50	-3.072
6300.50	-2.945	7920.50	-3.038	9540.50	-3.003
6330.50	-2.934	7950.50	-3.072	9570.50	-3.003
6360.50	-2.957	7980.50	-3.003	9600.50	-3.038
6390.50	-3.049	8010.50	-3.084	9630.50	-3.107
6420.50	-2.968	8040.50	-3.003	9660.50	-2.991
6450.50	-2.957	8070.50	-3.049	9690.50	-2.991
6480.50	-3.015	8100.50	-2.968	9720.50	-3.049
6510.50	-3.003	8130.50	-3.015	9750.50	-3.072
6540.50	-2.968	8160.50	-3.072	9780.50	-3.118
6570.50	-3.038	8190.50	-3.095	9810.50	-3.095
6600.50	-3.003	8220.50	-2.968	9840.50	-3.061
6630.50	-3.026	8250.50	-3.015	9870.50	-3.095
6660.50	-3.026	8280.50	-3.038	9900.50	-3.072
6690.50	-2.991	8310.50	-3.015	9930.50	-3.049
6720.50	-2.980	8340.50	-3.107	9960.50	-3.142
6750.50	-2.968	8370.50	-2.968	9990.50	-3.061
6780.50	-3.026	8400.50	-3.026	10020.50	-2.934
6810.50	-3.038	8430.50	-3.084	10050.50	-3.049
6840.50	-3.038	8460.50	-3.038	10080.50	-3.107
6870.50	-3.026	8490.50	-3.061	10110.50	-3.107
6900.50	-3.015	8520.50	-3.015	10140.50	-3.049
6930.50	-3.049	8550.50	-3.072	10170.50	-3.003
6960.50	-2.957	8580.50	-3.015	10200.50	-3.072
6990.50	-3.015	8610.50	-2.991	10230.50	-3.072
7020.50	-2.945	8640.50	-3.026	10260.50	-3.095

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
10290.50	-3.049	11910.50	-3.026	13530.50	-3.015
10320.50	-3.061	11940.50	-3.061	13560.50	-3.061
10350.50	-3.026	11970.50	-3.084	13590.50	-3.107
10380.50	-3.038	12000.50	-3.084	13620.50	-3.130
10410.50	-3.095	12030.50	-3.026	13650.50	-3.026
10440.50	-3.038	12060.50	-3.061	13680.50	-3.061
10470.50	-3.026	12090.50	-3.095	13710.50	-3.038
10500.50	-2.991	12120.50	-3.084	13740.50	-3.061
10530.50	-2.980	12150.50	-3.038	13770.50	-3.015
10560.50	-3.038	12180.50	-3.061	13800.50	-3.038
10590.50	-3.084	12210.50	-3.072	13830.50	-3.015
10620.50	-2.980	12240.50	-3.003	13860.50	-3.061
10650.50	-3.072	12270.50	-3.072	13890.50	-3.072
10680.50	-3.026	12300.50	-3.003	13920.50	-2.945
10710.50	-3.003	12330.50	-3.015	13950.50	-3.038
10740.50	-3.084	12360.50	-3.072	13980.50	-3.026
10770.50	-3.026	12390.50	-3.049	14010.50	-3.084
10800.50	-3.084	12420.50	-3.049	14040.50	-3.095
10830.50	-3.061	12450.50	-3.084	14070.50	-3.072
10860.50	-3.095	12480.50	-3.061	14100.50	-3.084
10890.50	-3.072	12510.50	-3.061	14130.50	-3.049
10920.50	-3.015	12540.50	-3.118	14160.50	-3.130
10950.50	-3.015	12570.50	-3.072	14190.50	-3.084
10980.50	-3.015	12600.50	-3.072	14220.50	-3.118
11010.50	-3.072	12630.50	-3.061	14250.50	-3.061
11040.50	-3.026	12660.50	-3.061	14280.50	-3.072
11070.50	-3.084	12690.50	-3.038	14310.50	-3.118
11100.50	-3.118	12720.50	-3.049	14340.50	-3.049
11130.50	-3.015	12750.50	-3.038	14370.50	-3.061
11160.50	-3.095	12780.50	-3.130	14400.50	-3.049
11190.50	-2.980	12810.50	-3.038	14430.50	-3.072
11220.50	-3.072	12840.50	-3.072	14460.50	-3.072
11250.50	-3.038	12870.50	-3.061	14490.50	-3.130
11280.50	-3.038	12900.50	-3.072	14520.50	-3.084
11310.50	-3.026	12930.50	-3.107	14550.50	-3.095
11340.50	-3.026	12960.50	-3.015	14580.50	-3.061
11370.50	-3.038	12990.50	-3.130	14610.50	-3.026
11400.50	-3.107	13020.50	-3.084	14640.50	-3.026
11430.50	-3.061	13050.50	-3.038	14670.50	-3.084
11460.50	-3.118	13080.50	-3.003	14700.50	-3.142
11490.50	-3.061	13110.50	-3.084	14730.50	-3.118
11520.50	-3.003	13140.50	-3.049	14760.50	-2.991
11550.50	-3.026	13170.50	-3.084	14790.50	-3.107
11580.50	-3.107	13200.50	-3.153	14820.50	-3.015
11610.50	-3.072	13230.50	-3.095	14850.50	-3.176
11640.50	-3.072	13260.50	-3.084	14880.50	-3.084
11670.50	-3.015	13290.50	-3.107	14910.50	-3.095
11700.50	-2.934	13320.50	-3.026	14940.50	-3.084
11730.50	-3.003	13350.50	-3.026	14970.50	-3.142
11760.50	-3.038	13380.50	-3.072	15000.50	-3.003
11790.50	-2.991	13410.50	-3.084	15030.50	-3.084
11820.50	-3.015	13440.50	-3.015	15060.50	-3.072
11850.50	-3.015	13470.50	-3.095	15090.50	-3.003
11880.50	-3.061	13500.50	-3.084	15120.50	-3.084

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
15150.50	-3.142	16770.50	-3.095	18390.50	-3.072
15180.50	-3.049	16800.50	-3.072	18420.50	-3.107
15210.50	-2.991	16830.50	-3.015	18450.50	-3.072
15240.50	-3.026	16860.50	-3.072	18480.50	-3.038
15270.50	-3.049	16890.50	-3.084	18510.50	-3.130
15300.50	-3.049	16920.50	-3.049	18540.50	-3.084
15330.50	-3.072	16950.50	-3.061	18570.50	-3.061
15360.50	-3.003	16980.50	-3.118	18600.50	-3.061
15390.50	-3.038	17010.50	-3.049	18630.50	-3.084
15420.50	-3.072	17040.50	-3.038	18660.50	-3.095
15450.50	-3.072	17070.50	-3.072	18690.50	-3.107
15480.50	-3.061	17100.50	-3.095	18720.50	-3.095
15510.50	-3.049	17130.50	-3.084	18750.50	-3.049
15540.50	-3.049	17160.50	-3.061	18780.50	-3.095
15570.50	-3.026	17190.50	-3.026	18810.50	-3.038
15600.50	-3.072	17220.50	-3.026	18840.50	-3.107
15630.50	-3.095	17250.50	-3.095	18870.50	-3.026
15660.50	-2.980	17280.50	-3.049	18900.50	-3.015
15690.50	-3.061	17310.50	-3.084	18930.50	-3.061
15720.50	-3.084	17340.50	-3.049	18960.50	-3.026
15750.50	-3.061	17370.50	-3.061	18990.50	-3.095
15780.50	-3.026	17400.50	-3.107	19020.50	-3.061
15810.50	-3.084	17430.50	-3.049	19050.50	-3.072
15840.50	-3.095	17460.50	-3.049	19080.50	-3.084
15870.50	-3.061	17490.50	-3.107	19110.50	-3.072
15900.50	-3.095	17520.50	-3.095	19140.50	-3.026
15930.50	-3.142	17550.50	-3.072	19170.50	-3.061
15960.50	-2.980	17580.50	-3.095	19200.50	-3.118
15990.50	-3.015	17610.50	-3.130	19230.50	-2.968
16020.50	-3.084	17640.50	-3.072	19260.50	-3.095
16050.50	-3.084	17670.50	-3.084	19290.50	-3.026
16080.50	-3.072	17700.50	-3.084	19320.50	-3.118
16110.50	-3.061	17730.50	-3.038	19350.50	-3.084
16140.50	-3.095	17760.50	-3.015	19380.50	-3.118
16170.50	-3.015	17790.50	-3.118	19410.50	-3.072
16200.50	-3.142	17820.50	-3.118	19440.50	-3.084
16230.50	-3.061	17850.50	-3.015	19470.50	-3.084
16260.50	-3.072	17880.50	-3.072	19500.50	-3.061
16290.50	-3.026	17910.50	-3.107	19530.50	-3.061
16320.50	-3.095	17940.50	-3.038	19560.50	-3.095
16350.50	-3.084	17970.50	-3.026	19590.50	-3.107
16380.50	-3.095	18000.50	-3.049	19620.50	-3.142
16410.50	-3.084	18030.50	-3.049	19650.50	-3.118
16440.50	-3.118	18060.50	-3.095	19680.50	-3.095
16470.50	-3.118	18090.50	-3.061	19710.50	-3.026
16500.50	-3.084	18120.50	-3.142	19740.50	-3.084
16530.50	-3.038	18150.50	-3.130	19770.50	-3.026
16560.50	-3.038	18180.50	-3.049	19800.50	-3.003
16590.50	-3.118	18210.50	-3.072	19830.50	-3.084
16620.50	-3.084	18240.50	-3.038	19860.50	-3.072
16650.50	-3.049	18270.50	-3.003	19890.50	-3.118
16680.50	-3.015	18300.50	-3.061	19920.50	-3.072
16710.50	-3.049	18330.50	-3.049	19950.50	-3.084
16740.50	-3.049	18360.50	-3.049	19980.50	-3.153

<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>
20010.50	-3.142	21630.50	-3.095	23250.50	-3.118
20040.50	-3.118	21660.50	-3.095	23280.50	-3.107
20070.50	-3.026	21690.50	-3.142	23310.50	-3.084
20100.50	-3.118	21720.50	-3.130	23340.50	-3.084
20130.50	-3.072	21750.50	-3.095	23370.50	-3.049
20160.50	-3.107	21780.50	-3.061	23400.50	-3.095
20190.50	-3.061	21810.50	-3.072	23430.50	-3.084
20220.50	-3.107	21840.50	-3.107	23460.50	-3.142
20250.50	-3.061	21870.50	-3.061	23490.50	-3.188
20280.50	-3.026	21900.50	-3.026	23520.50	-3.015
20310.50	-3.107	21930.50	-3.072	23550.50	-3.107
20340.50	-3.118	21960.50	-3.142	23580.50	-3.095
20370.50	-3.049	21990.50	-3.153	23610.50	-3.118
20400.50	-3.049	22020.50	-3.061	23640.50	-3.095
20430.50	-3.130	22050.50	-3.095	23670.50	-3.061
20460.50	-3.118	22080.50	-3.061	23700.50	-3.165
20490.50	-3.130	22110.50	-3.165	23730.50	-3.061
20520.50	-3.130	22140.50	-3.130	23760.50	-3.107
20550.50	-3.118	22170.50	-3.118	23790.50	-3.084
20580.50	-3.084	22200.50	-3.107	23820.50	-3.095
20610.50	-3.049	22230.50	-3.199	23850.50	-3.095
20640.50	-3.118	22260.50	-3.095	23880.50	-3.107
20670.50	-3.049	22290.50	-3.095	23910.50	-3.107
20700.50	-3.130	22320.50	-3.026	23940.50	-3.072
20730.50	-3.107	22350.50	-3.084	23970.50	-3.049
20760.50	-3.049	22380.50	-3.026	24000.50	-3.176
20790.50	-3.118	22410.50	-3.061	24030.50	-2.991
20820.50	-3.061	22440.50	-3.049	24060.50	-3.107
20850.50	-3.038	22470.50	-3.107	24090.50	-3.072
20880.50	-3.049	22500.50	-3.118	24120.50	-3.038
20910.50	-3.049	22530.50	-3.084	24150.50	-3.038
20940.50	-3.061	22560.50	-3.049	24180.50	-3.222
20970.50	-3.003	22590.50	-3.118	24210.50	-3.015
21000.50	-3.072	22620.50	-3.038	24240.50	-3.038
21030.50	-3.026	22650.50	-3.199	24270.50	-3.142
21060.50	-3.084	22680.50	-3.130	24300.50	-3.107
21090.50	-3.072	22710.50	-3.153	24330.50	-3.072
21120.50	-3.015	22740.50	-3.095	24360.50	-3.095
21150.50	-3.118	22770.50	-3.049	24390.50	-3.095
21180.50	-3.072	22800.50	-3.061	24420.50	-3.107
21210.50	-3.130	22830.50	-3.026	24450.50	-3.061
21240.50	-3.153	22860.50	-3.084	24480.50	-3.084
21270.50	-3.015	22890.50	-3.130	24510.50	-3.107
21300.50	-3.038	22920.50	-3.084	24540.50	-3.095
21330.50	-3.049	22950.50	-3.188	24570.50	-3.095
21360.50	-3.107	22980.50	-3.072	24600.50	-3.107
21390.50	-3.026	23010.50	-3.061	24630.50	-3.072
21420.50	-3.107	23040.50	-3.049	24660.50	-3.072
21450.50	-3.049	23070.50	-3.038	24690.50	-3.165
21480.50	-3.130	23100.50	-3.061	24720.50	-3.153
21510.50	-3.142	23130.50	-3.118	24750.50	-3.130
21540.50	-3.142	23160.50	-3.107	24780.50	-3.130
21570.50	-3.084	23190.50	-3.038	24810.50	-3.095
21600.50	-3.107	23220.50	-3.049	24840.50	-3.130

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
24870.50	-3.118	26490.50	-3.153	28110.50	-3.095
24900.50	-3.095	26520.50	-3.107	28140.50	-3.095
24930.50	-3.038	26550.50	-3.061	28170.50	-3.199
24960.50	-3.118	26580.50	-3.130	28200.50	-3.061
24990.50	-3.084	26610.50	-3.072	28230.50	-3.095
25020.50	-3.142	26640.50	-3.072	28260.50	-3.084
25050.50	-3.026	26670.50	-3.049	28290.50	-3.107
25080.50	-3.049	26700.50	-3.142	28320.50	-3.142
25110.50	-3.118	26730.50	-3.118	28350.50	-3.188
25140.50	-3.142	26760.50	-3.038	28380.50	-3.084
25170.50	-3.118	26790.50	-3.072	28410.50	-3.084
25200.50	-3.130	26820.50	-3.107	28440.50	-3.142
25230.50	-3.153	26850.50	-3.107	28470.50	-3.049
25260.50	-3.061	26880.50	-3.026	28500.50	-3.072
25290.50	-3.049	26910.50	-3.130	28530.50	-3.165
25320.50	-3.072	26940.50	-3.142	28560.50	-3.049
25350.50	-3.118	26970.50	-3.107	28590.50	-3.107
25380.50	-3.107	27000.50	-3.118	28620.50	-3.049
25410.50	-3.061	27030.50	-3.165	28650.50	-3.084
25440.50	-3.142	27060.50	-3.107	28680.50	-3.049
25470.50	-3.072	27090.50	-3.130	28710.50	-3.118
25500.50	-3.118	27120.50	-3.107	28740.50	-3.118
25530.50	-3.153	27150.50	-3.107	28770.50	-3.107
25560.50	-3.095	27180.50	-3.107	28800.50	-3.211
25590.50	-3.107	27210.50	-3.095	28830.50	-0.393
25620.50	-3.130	27240.50	-3.107	28860.50	-0.312
25650.50	-3.095	27270.50	-3.038	28890.50	-0.277
25680.50	-3.130	27300.50	-3.072	28920.50	-0.254
25710.50	-3.130	27330.50	-3.095	28950.50	-0.231
25740.50	-3.142	27360.50	-3.118	28980.50	-0.219
25770.50	-3.038	27390.50	-3.003	29010.50	-0.196
25800.50	-3.072	27420.50	-3.049	29040.50	-0.185
25830.50	-3.142	27450.50	-3.072	29070.50	-0.185
25860.50	-3.107	27480.50	-3.130	29100.50	-0.173
25890.50	-3.153	27510.50	-3.118	29130.50	-0.162
25920.50	-3.049	27540.50	-3.130	29160.50	-0.162
25950.50	-3.165	27570.50	-3.118	29190.50	-0.150
25980.50	-3.107	27600.50	-3.142	29220.50	-0.150
26010.50	-3.130	27630.50	-3.095	29250.50	-0.139
26040.50	-3.072	27660.50	-3.095	29280.50	-0.139
26070.50	-3.142	27690.50	-3.107	29310.50	-0.139
26100.50	-3.130	27720.50	-3.095	29340.50	-0.139
26130.50	-3.049	27750.50	-3.118	29370.50	-0.139
26160.50	-3.049	27780.50	-3.118	29400.50	-0.127
26190.50	-3.095	27810.50	-3.072	29430.50	-0.127
26220.50	-3.084	27840.50	-3.165	29460.50	-0.127
26250.50	-3.026	27870.50	-3.188	29490.50	-0.127
26280.50	-3.107	27900.50	-3.130	29520.50	-0.115
26310.50	-3.072	27930.50	-3.084	29550.50	-0.115
26340.50	-3.130	27960.50	-3.130	29580.50	-0.115
26370.50	-3.072	27990.50	-3.153	29610.50	-0.115
26400.50	-3.095	28020.50	-3.095	29640.50	-0.115
26430.50	-3.107	28050.50	-3.095	29670.50	-0.115
26460.50	-3.176	28080.50	-3.142	29700.50	-0.104

<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>	<u>" Time</u>	<u>"" Analog#01 "</u>
29730.50	-0.104	31350.50	-0.069	32970.50	-0.058
29760.50	-0.104	31380.50	-0.069	33000.50	-0.058
29790.50	-0.104	31410.50	-0.069	33030.50	-0.058
29820.50	-0.104	31440.50	-0.069	33060.50	-0.058
29850.50	-0.104	31470.50	-0.069	33090.50	-0.046
29880.50	-0.104	31500.50	-0.058	33120.50	-0.046
29910.50	-0.104	31530.50	-0.069	33150.50	-0.046
29940.50	-0.092	31560.50	-0.069	33180.50	-0.058
29970.50	-0.092	31590.50	-0.069	33210.50	-0.046
30000.50	-0.092	31620.50	-0.069	33240.50	-0.046
30030.50	-0.092	31650.50	-0.058	33270.50	-0.046
30060.50	-0.092	31680.50	-0.058	33300.50	-0.046
30090.50	-0.092	31710.50	-0.058	33330.50	-0.046
30120.50	-0.092	31740.50	-0.069	33360.50	-0.046
30150.50	-0.092	31770.50	-0.069	33390.50	-0.046
30180.50	-0.092	31800.50	-0.058	33420.50	-0.046
30210.50	-0.092	31830.50	-0.058	33450.50	-0.046
30240.50	-0.092	31860.50	-0.058	33480.50	-0.046
30270.50	-0.081	31890.50	-0.058	33510.50	-0.046
30300.50	-0.081	31920.50	-0.058	33540.50	-0.046
30330.50	-0.081	31950.50	-0.058	33570.50	-0.046
30360.50	-0.081	31980.50	-0.058	33600.50	-0.046
30390.50	-0.081	32010.50	-0.058	33630.50	-0.046
30420.50	-0.081	32040.50	-0.058	33660.50	-0.046
30450.50	-0.081	32070.50	-0.069	33690.50	-0.046
30480.50	-0.081	32100.50	-0.058	33720.50	-0.046
30510.50	-0.081	32130.50	-0.058	33750.50	-0.046
30540.50	-0.081	32160.50	-0.058	33780.50	-0.046
30570.50	-0.081	32190.50	-0.058	33810.50	-0.046
30600.50	-0.081	32220.50	-0.058	33840.50	-0.046
30630.50	-0.081	32250.50	-0.058	33870.50	-0.046
30660.50	-0.081	32280.50	-0.058	33900.50	-0.046
30690.50	-0.081	32310.50	-0.058	33930.50	-0.046
30720.50	-0.081	32340.50	-0.058	33960.50	-0.046
30750.50	-0.081	32370.50	-0.058	33990.50	-0.046
30780.50	-0.081	32400.50	-0.058	34020.50	-0.046
30810.50	-0.069	32430.50	-0.058	34050.50	-0.046
30840.50	-0.069	32460.50	-0.058	34080.50	-0.046
30870.50	-0.081	32490.50	-0.058	34110.50	-0.046
30900.50	-0.069	32520.50	-0.058	34140.50	-0.046
30930.50	-0.069	32550.50	-0.058	34170.50	-0.046
30960.50	-0.069	32580.50	-0.058	34200.50	-0.046
30990.50	-0.069	32610.50	-0.058	34230.50	-0.046
31020.50	-0.069	32640.50	-0.058	34260.50	-0.046
31050.50	-0.069	32670.50	-0.058	34290.50	-0.046
31080.50	-0.069	32700.50	-0.046	34320.50	-0.046
31110.50	-0.069	32730.50	-0.058	34350.50	-0.046
31140.50	-0.069	32760.50	-0.058	34380.50	-0.046
31170.50	-0.069	32790.50	-0.058	34410.50	-0.046
31200.50	-0.069	32820.50	-0.058	34440.50	-0.046
31230.50	-0.069	32850.50	-0.058	34470.50	-0.046
31260.50	-0.069	32880.50	-0.046	34500.50	-0.046
31290.50	-0.069	32910.50	-0.058	34530.50	-0.046
31320.50	-0.069	32940.50	-0.058	34560.50	-0.046

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
34590.50	-0.046	36210.50	-0.046	37830.50	-0.035
34620.50	-0.046	36240.50	-0.035	37860.50	-0.035
34650.50	-0.046	36270.50	-0.035	37890.50	-0.035
34680.50	-0.046	36300.50	-0.035	37920.50	-0.035
34710.50	-0.046	36330.50	-0.035	37950.50	-0.035
34740.50	-0.046	36360.50	-0.046	37980.50	-0.035
34770.50	-0.046	36390.50	-0.035	38010.50	-0.035
34800.50	-0.046	36420.50	-0.046	38040.50	-0.035
34830.50	-0.046	36450.50	-0.035	38070.50	-0.035
34860.50	-0.046	36480.50	-0.035	38100.50	-0.035
34890.50	-0.035	36510.50	-0.046	38130.50	-0.035
34920.50	-0.046	36540.50	-0.035	38160.50	-0.035
34950.50	-0.046	36570.50	-0.046	38190.50	-0.035
34980.50	-0.046	36600.50	-0.035	38220.50	-0.035
35010.50	-0.035	36630.50	-0.035	38250.50	-0.035
35040.50	-0.046	36660.50	-0.035	38280.50	-0.035
35070.50	-0.046	36690.50	-0.035	38310.50	-0.035
35100.50	-0.046	36720.50	-0.035	38340.50	-0.035
35130.50	-0.035	36750.50	-0.035	38370.50	-0.035
35160.50	-0.046	36780.50	-0.046	38400.50	-0.035
35190.50	-0.046	36810.50	-0.035	38430.50	-0.035
35220.50	-0.046	36840.50	-0.035	38460.50	-0.035
35250.50	-0.046	36870.50	-0.035	38490.50	-0.035
35280.50	-0.046	36900.50	-0.035	38520.50	-0.035
35310.50	-0.035	36930.50	-0.035	38550.50	-0.035
35340.50	-0.046	36960.50	-0.035	38580.50	-0.035
35370.50	-0.035	36990.50	-0.035	38610.50	-0.035
35400.50	-0.035	37020.50	-0.035	38640.50	-0.035
35430.50	-0.035	37050.50	-0.035	38670.50	-0.035
35460.50	-0.046	37080.50	-0.035	38700.50	-0.035
35490.50	-0.046	37110.50	-0.035	38730.50	-0.035
35520.50	-0.046	37140.50	-0.035	38760.50	-0.035
35550.50	-0.035	37170.50	-0.035	38790.50	-0.035
35580.50	-0.046	37200.50	-0.035	38820.50	-0.035
35610.50	-0.046	37230.50	-0.035	38850.50	-0.035
35640.50	-0.046	37260.50	-0.035	38880.50	-0.035
35670.50	-0.035	37290.50	-0.035	38910.50	-0.035
35700.50	-0.035	37320.50	-0.035	38940.50	-0.035
35730.50	-0.035	37350.50	-0.035	38970.50	-0.035
35760.50	-0.046	37380.50	-0.035	39000.50	-0.035
35790.50	-0.035	37410.50	-0.035	39030.50	-0.035
35820.50	-0.035	37440.50	-0.035	39060.50	-0.035
35850.50	-0.035	37470.50	-0.035	39090.50	-0.035
35880.50	-0.035	37500.50	-0.035	39120.50	-0.035
35910.50	-0.035	37530.50	-0.035	39150.50	-0.035
35940.50	-0.046	37560.50	-0.046	39180.50	-0.035
35970.50	-0.035	37590.50	-0.035	39210.50	-0.035
36000.50	-0.035	37620.50	-0.035	39240.50	-0.035
36030.50	-0.035	37650.50	-0.046	39270.50	-0.035
36060.50	-0.035	37680.50	-0.035	39300.50	-0.035
36090.50	-0.046	37710.50	-0.046	39330.50	-0.035
36120.50	-0.035	37740.50	-0.035	39360.50	-0.035
36150.50	-0.035	37770.50	-0.035	39390.50	-0.035
36180.50	-0.035	37800.50	-0.035	39420.50	-0.035

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
39450.50	-0.035	41070.50	-0.035	42690.50	-0.035
39480.50	-0.035	41100.50	-0.035	42720.50	-0.035
39510.50	-0.035	41130.50	-0.035	42750.50	-0.035
39540.50	-0.035	41160.50	-0.035	42780.50	-0.035
39570.50	-0.035	41190.50	-0.035	42810.50	-0.035
39600.50	-0.035	41220.50	-0.035	42840.50	-0.035
39630.50	-0.035	41250.50	-0.035	42870.50	-0.035
39660.50	-0.035	41280.50	-0.035	42900.50	-0.035
39690.50	-0.035	41310.50	-0.035	42930.50	-0.035
39720.50	-0.035	41340.50	-0.035	42960.50	-0.035
39750.50	-0.035	41370.50	-0.035	42990.50	-0.035
39780.50	-0.035	41400.50	-0.035	43020.50	-0.035
39810.50	-0.035	41430.50	-0.035	43050.50	-0.035
39840.50	-0.035	41460.50	-0.035	43080.50	-0.035
39870.50	-0.035	41490.50	-0.035	43110.50	-0.035
39900.50	-0.035	41520.50	-0.035	43140.50	-0.035
39930.50	-0.035	41550.50	-0.035	43170.50	-0.035
39960.50	-0.035	41580.50	-0.035	43200.50	-0.035
39990.50	-0.035	41610.50	-0.035	43230.50	-0.035
40020.50	-0.035	41640.50	-0.035	43260.50	-0.035
40050.50	-0.035	41670.50	-0.035	43290.50	-0.035
40080.50	-0.035	41700.50	-0.035	43320.50	-0.035
40110.50	-0.035	41730.50	-0.035	43350.50	-0.035
40140.50	-0.035	41760.50	-0.035	43380.50	-0.035
40170.50	-0.035	41790.50	-0.035	43410.50	-0.035
40200.50	-0.035	41820.50	-0.035	43440.50	-0.035
40230.50	-0.035	41850.50	-0.035	43470.50	-0.035
40260.50	-0.035	41880.50	-0.035	43500.50	-0.035
40290.50	-0.035	41910.50	-0.035	43530.50	-0.035
40320.50	-0.035	41940.50	-0.035	43560.50	-0.035
40350.50	-0.035	41970.50	-0.035	43590.50	-0.035
40380.50	-0.035	42000.50	-0.035	43620.50	-0.035
40410.50	-0.035	42030.50	-0.035	43650.50	-0.035
40440.50	-0.035	42060.50	-0.035	43680.50	-0.035
40470.50	-0.035	42090.50	-0.035	43710.50	-0.035
40500.50	-0.035	42120.50	-0.035	43740.50	-0.035
40530.50	-0.035	42150.50	-0.035	43770.50	-0.035
40560.50	-0.035	42180.50	-0.035	43800.50	-0.035
40590.50	-0.035	42210.50	-0.035	43830.50	-0.035
40620.50	-0.035	42240.50	-0.035	43860.50	-0.035
40650.50	-0.035	42270.50	-0.035	43890.50	-0.035
40680.50	-0.035	42300.50	-0.035	43920.50	-0.035
40710.50	-0.035	42330.50	-0.035	43950.50	-0.035
40740.50	-0.035	42360.50	-0.035	43980.50	-0.035
40770.50	-0.035	42390.50	-0.035	44010.50	-0.035
40800.50	-0.035	42420.50	-0.035	44040.50	-0.035
40830.50	-0.035	42450.50	-0.035	44070.50	-0.035
40860.50	-0.035	42480.50	-0.035	44100.50	-0.035
40890.50	-0.035	42510.50	-0.035	44130.50	-0.035
40920.50	-0.035	42540.50	-0.035	44160.50	-0.035
40950.50	-0.035	42570.50	-0.035	44190.50	-0.035
40980.50	-0.035	42600.50	-0.035	44220.50	-0.035
41010.50	-0.035	42630.50	-0.035	44250.50	-0.035
41040.50	-0.035	42660.50	-0.035	44280.50	-0.035

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
44310.50	-0.035	45930.50	-0.035	47550.50	-0.035
44340.50	-0.035	45960.50	-0.035	47580.50	-0.035
44370.50	-0.035	45990.50	-0.035	47610.50	-0.035
44400.50	-0.035	46020.50	-0.035	47640.50	-0.035
44430.50	-0.035	46050.50	-0.035	47670.50	-0.046
44460.50	-0.035	46080.50	-0.035	47700.50	-0.035
44490.50	-0.035	46110.50	-0.035	47730.50	-0.035
44520.50	-0.035	46140.50	-0.035	47760.50	-0.046
44550.50	-0.035	46170.50	-0.035	47790.50	-0.035
44580.50	-0.035	46200.50	-0.035	47820.50	-0.046
44610.50	-0.035	46230.50	-0.035	47850.50	-0.035
44640.50	-0.035	46260.50	-0.035	47880.50	-0.035
44670.50	-0.035	46290.50	-0.035	47910.50	-0.035
44700.50	-0.035	46320.50	-0.035	47940.50	-0.035
44730.50	-0.035	46350.50	-0.035	47970.50	-0.035
44760.50	-0.035	46380.50	-0.035	48000.50	-0.035
44790.50	-0.035	46410.50	-0.035	48030.50	-0.035
44820.50	-0.035	46440.50	-0.035	48060.50	-0.035
44850.50	-0.035	46470.50	-0.035	48090.50	-0.046
44880.50	-0.035	46500.50	-0.035	48120.50	-0.035
44910.50	-0.035	46530.50	-0.035	48150.50	-0.035
44940.50	-0.035	46560.50	-0.035	48180.50	-0.035
44970.50	-0.035	46590.50	-0.035	48210.50	-0.035
45000.50	-0.035	46620.50	-0.035	48240.50	-0.035
45030.50	-0.035	46650.50	-0.035	48270.50	-0.046
45060.50	-0.035	46680.50	-0.035	48300.50	-0.035
45090.50	-0.035	46710.50	-0.035	48330.50	-0.035
45120.50	-0.035	46740.50	-0.035	48360.50	-0.035
45150.50	-0.035	46770.50	-0.035	48390.50	-0.035
45180.50	-0.035	46800.50	-0.035	48420.50	-0.035
45210.50	-0.035	46830.50	-0.035	48450.50	-0.046
45240.50	-0.035	46860.50	-0.035	48480.50	-0.046
45270.50	-0.035	46890.50	-0.035	48510.50	-0.035
45300.50	-0.035	46920.50	-0.035	48540.50	-0.035
45330.50	-0.035	46950.50	-0.035	48570.50	-0.046
45360.50	-0.035	46980.50	-0.046	48600.50	-0.035
45390.50	-0.035	47010.50	-0.035	48630.50	-0.046
45420.50	-0.035	47040.50	-0.035	48660.50	-0.046
45450.50	-0.035	47070.50	-0.035	48690.50	-0.035
45480.50	-0.035	47100.50	-0.035	48720.50	-0.035
45510.50	-0.035	47130.50	-0.035	48750.50	-0.035
45540.50	-0.035	47160.50	-0.035	48780.50	-0.035
45570.50	-0.035	47190.50	-0.035	48810.50	-0.035
45600.50	-0.035	47220.50	-0.035	48840.50	-0.035
45630.50	-0.035	47250.50	-0.035	48870.50	-0.035
45660.50	-0.035	47280.50	-0.035	48900.50	-0.035
45690.50	-0.035	47310.50	-0.035	48930.50	-0.046
45720.50	-0.035	47340.50	-0.035	48960.50	-0.046
45750.50	-0.035	47370.50	-0.035	48990.50	-0.046
45780.50	-0.035	47400.50	-0.035	49020.50	-0.046
45810.50	-0.035	47430.50	-0.035	49050.50	-0.035
45840.50	-0.035	47460.50	-0.035	49080.50	-0.035
45870.50	-0.035	47490.50	-0.035	49110.50	-0.035
45900.50	-0.035	47520.50	-0.035	49140.50	-0.035

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
49170.50	-0.035	50790.50	-0.035	52410.50	-0.046
49200.50	-0.035	50820.50	-0.035	52440.50	-0.046
49230.50	-0.035	50850.50	-0.046	52470.50	-0.046
49260.50	-0.046	50880.50	-0.035	52500.50	-0.046
49290.50	-0.035	50910.50	-0.046	52530.50	-0.046
49320.50	-0.035	50940.50	-0.035	52560.50	-0.046
49350.50	-0.035	50970.50	-0.035	52590.50	-0.046
49380.50	-0.035	51000.50	-0.035	52620.50	-0.046
49410.50	-0.035	51030.50	-0.046	52650.50	-0.046
49440.50	-0.035	51060.50	-0.035	52680.50	-0.046
49470.50	-0.035	51090.50	-0.035	52710.50	-0.046
49500.50	-0.035	51120.50	-0.035	52740.50	-0.046
49530.50	-0.035	51150.50	-0.035	52770.50	-0.046
49560.50	-0.046	51180.50	-0.035	52800.50	-0.046
49590.50	-0.035	51210.50	-0.035	52830.50	-0.046
49620.50	-0.035	51240.50	-0.035	52860.50	-0.046
49650.50	-0.046	51270.50	-0.035	52890.50	-0.046
49680.50	-0.035	51300.50	-0.046	52920.50	-0.046
49710.50	-0.035	51330.50	-0.046	52950.50	-0.046
49740.50	-0.035	51360.50	-0.046	52980.50	-0.046
49770.50	-0.035	51390.50	-0.046	53010.50	-0.046
49800.50	-0.035	51420.50	-0.046	53040.50	-0.046
49830.50	-0.046	51450.50	-0.035	53070.50	-0.046
49860.50	-0.046	51480.50	-0.046	53100.50	-0.046
49890.50	-0.035	51510.50	-0.035	53130.50	-0.046
49920.50	-0.035	51540.50	-0.035	53160.50	-0.046
49950.50	-0.035	51570.50	-0.035	53190.50	-0.046
49980.50	-0.046	51600.50	-0.046	53220.50	-0.046
50010.50	-0.046	51630.50	-0.046	53250.50	-0.046
50040.50	-0.035	51660.50	-0.035	53280.50	-0.046
50070.50	-0.035	51690.50	-0.035	53310.50	-0.046
50100.50	-0.035	51720.50	-0.035	53340.50	-0.035
50130.50	-0.035	51750.50	-0.046	53370.50	-0.046
50160.50	-0.046	51780.50	-0.046	53400.50	-0.046
50190.50	-0.046	51810.50	-0.046	53430.50	-0.046
50220.50	-0.046	51840.50	-0.046	53460.50	-0.046
50250.50	-0.035	51870.50	-0.046	53490.50	-0.046
50280.50	-0.035	51900.50	-0.046	53520.50	-0.046
50310.50	-0.046	51930.50	-0.046	53550.50	-0.046
50340.50	-0.035	51960.50	-0.046	53580.50	-0.046
50370.50	-0.035	51990.50	-0.035	53610.50	-0.046
50400.50	-0.046	52020.50	-0.046	53640.50	-0.046
50430.50	-0.035	52050.50	-0.046	53670.50	-0.046
50460.50	-0.046	52080.50	-0.046	53700.50	-0.046
50490.50	-0.046	52110.50	-0.035	53730.50	-0.046
50520.50	-0.035	52140.50	-0.046	53760.50	-0.046
50550.50	-0.046	52170.50	-0.046	53790.50	-0.046
50580.50	-0.035	52200.50	-0.046	53820.50	-0.046
50610.50	-0.035	52230.50	-0.046	53850.50	-0.046
50640.50	-0.046	52260.50	-0.046	53880.50	-0.046
50670.50	-0.046	52290.50	-0.046	53910.50	-0.046
50700.50	-0.035	52320.50	-0.046	53940.50	-0.046
50730.50	-0.046	52350.50	-0.046	53970.50	-0.046
50760.50	-0.046	52380.50	-0.046	54000.50	-0.046

<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>	<u>" Time</u>	<u>" " Analog#01 "</u>
54030.50	-0.046	55650.50	-0.046	57270.50	-4.805
54060.50	-0.046	55680.50	-0.046	57300.50	-4.805
54090.50	-0.046	55710.50	-0.046	57330.50	-4.805
54120.50	-0.046	55740.50	-0.046	57360.50	-4.805
54150.50	-0.046	55770.50	-0.046	57390.50	-4.805
54180.50	-0.046	55800.50	-0.046	57420.50	-4.805
54210.50	-0.046	55830.50	-0.046	57450.50	-4.805
54240.50	-0.046	55860.50	-0.046	57480.50	-4.805
54270.50	-0.046	55890.50	-0.046	57510.50	-4.805
54300.50	-0.046	55920.50	-0.046	57540.50	-4.805
54330.50	-0.046	55950.50	-0.046	57570.50	-4.805
54360.50	-0.046	55980.50	-0.046	57600.50	-4.805
54390.50	-0.046	56010.50	-0.046	57630.50	-4.805
54420.50	-0.046	56040.50	-0.046	57660.50	-4.805
54450.50	-0.046	56070.50	-0.046	57690.50	-4.805
54480.50	-0.046	56100.50	-0.046	57720.50	-4.805
54510.50	-0.046	56130.50	-0.046	57750.50	-4.805
54540.50	-0.046	56160.50	-0.046	57780.50	-4.805
54570.50	-0.046	56190.50	-0.046	57810.50	-4.805
54600.50	-0.046	56220.50	-0.046	57840.50	-4.805
54630.50	-0.046	56250.50	-0.046	57870.50	-4.805
54660.50	-0.046	56280.50	-0.046	57900.50	-4.805
54690.50	-0.046	56310.50	-0.046	57930.50	-4.805
54720.50	-0.046	56340.50	-0.046	57960.50	-4.805
54750.50	-0.046	56370.50	-0.046	57990.50	-4.805
54780.50	-0.046	56400.50	-0.046	58020.50	-4.805
54810.50	-0.046	56430.50	-0.046	58050.50	-4.805
54840.50	-0.046	56460.50	-0.046	58080.50	-4.805
54870.50	-0.046	56490.50	-0.046	58110.50	-4.805
54900.50	-0.046	56520.50	-0.046	58140.50	-4.805
54930.50	-0.046	56550.50	-0.046	58170.50	-4.805
54960.50	-0.046	56580.50	-0.046	58200.50	-4.805
54990.50	-0.046	56610.50	-0.046	58230.50	-4.805
55020.50	-0.046	56640.50	-0.046	58260.50	-4.805
55050.50	-0.046	56670.50	-0.046	58290.50	-4.805
55080.50	-0.046	56700.50	-0.046	58320.50	-4.805
55110.50	-0.046	56730.50	-0.046	58350.50	-4.805
55140.50	-0.046	56760.50	-0.046	58380.50	-4.805
55170.50	-0.046	56790.50	-0.046	**Last Scan at "11 13 7 22 55 80	
55200.50	-0.046	56820.50	-0.046		
55230.50	-0.046	56850.50	-0.046		
55260.50	-0.046	56880.50	-0.046		
55290.50	-0.046	56910.50	-0.046		
55320.50	-0.046	56940.50	-0.046		
55350.50	-0.046	56970.50	-0.046		
55380.50	-0.046	57000.50	-0.046		
55410.50	-0.046	57030.50	-4.805		
55440.50	-0.046	57060.50	-4.805		
55470.50	-0.046	57090.50	-4.805		
55500.50	-0.046	57120.50	-4.805		
55530.50	-0.046	57150.50	-4.805		
55560.50	-0.046	57180.50	-4.805		
55590.50	-0.046	57210.50	-4.805		
55620.50	-0.046	57240.50	-4.805		

location. The well was pumped at an average rate of 630 gpm for a period of 240 min. Drawdown in the well demonstrated an apparent specific capacity of 270 gpm/ft, a Theis method transmissivity of 87,000 ft²/day, and a Cooper-Jacob method transmissivity of 110,000 ft²/day. The recovery demonstrated a transmissivity of 260,000 ft²/day. The hydraulic conductivity for the upper Ringold Formation at well 399-1-10 could not be derived because the thickness of the saturated sediments was unknown. No observation wells were measured during the testing of well 399-1-10.

Well 399-1-10 has a total depth of 40 ft, a completed diameter of 6 in., and was set with a No. 40 slot, 6 in., stainless steel well screen from 24 to 39 ft. However, during aquifer testing, the well diameter was 10 in. with a 10-in., stainless steel, telescoping screen set from 30 to 40 ft. The static water level was approximately 29 ft below land surface at the time of testing, but fluctuated with the changes in the Columbia River stage. Figure D.14 illustrates the site stratigraphy and well construction at well 399-1-10. A more detailed description of the site geology is included in Section 3 of the report.

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. Certain limitations were encountered in this test because of the short distance between the static water level and the bottom of the borehole. The submersible pump could be placed only to approximately 35 ft below the pump column stickup or just over 33 ft below land surface. The limitations will become apparent later. The 300 Area Process Trenches are located approximately 800 ft to the west of well 399-1-10. The Columbia River is approximately 150 ft to the east of well 399-1-10 (see Figure D.1). The river apparently did influence water levels during aquifer testing; however, this influence was limited by the short period of pumping and recovery measurements, and the constancy of the river level during the test. No river-stage data were available for this aquifer test because the 300 Area Columbia River monitoring station was not established until late January, 1987.

FIGURE D.14. Well 399-1-10 Stratigraphy and Well Construction

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and determine the optimal discharge rate. The well was developed by bailing for 1 hour on November 24, 1986, and by pumping approximately 615 gpm for another hour on the same day. Discharge was measured with a

McCrometer® flow meter (#86-6-1161) during development. Water levels were measured by an E-tape and recorded manually. The water level drew down approximately 2 ft to the pump intake, and the discharge rate had to be cut back to prevent cavitation or the "sucking of air." The water levels recovered very quickly after the pump was shut off. The static water level in well 399-1-10 was 29.14 ft below land surface (31.41 ft from the top of the 10-in. casing) before development. The static water level was 28.90 ft below land surface (343.32 ft above msl) at the time of the constant-discharge test on November 25, 1986.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 630 gpm. Flow rates during this test were measured with a McCrometer® flow meter (#86-6-1161) provided by the drilling contractor. The instantaneous rate was recorded on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 152,160 gal. The water from the test was discharged at the land surface about 1000 ft north of the well.

Drawdown Test. The constant-discharge pumping test was conducted on November 25, 1986. Water levels were recorded manually by an E-tape. The pumping was terminated after 240 min because water levels had apparently equilibrated or were affected by the limitations of the pump placement. The maximum drawdown was 2.37 ft at the time pumping stopped. The apparent specific capacity of the well was approximately 270 gpm/ft.

Recovery Test. Recovery of the water level was observed in well 399-1-10 for 120 min following termination of pumping. The observed water level in this well recovered .07 ft beyond the initial static water level, indicating influence from the Columbia River.

Observation Wells. No observation wells were measured during the aquifer testing of well 399-1-10.

Analysis and Interpretation

The pumping rate is considered accurate. Total discharge was 152,160 gal, which, when divided by the 240 min of pumping, gives a figure of 634 gpm. Instantaneous readings ranged from 650 to 750 gpm. The fluctuations in discharge rate may be indicative of the depth at which the submersible pump was set. Because of the short distance between static water level and the pump intake, the pump may have been cavitating or "sucking air." The Cooper-Jacob drawdown curve may substantiate this phenomenon; as the water level is drawn down to the pump intake, cavitation would cause a sudden drop in the discharge rate and a subsequent rise in water levels. The sudden rise and fall of water levels on the straight-line curve indicates just such a situation.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be applied to the drawdown data before analysis. Hantush (1964) suggests that corrections also be made for wells that partially penetrate the aquifer. In the case of borehole storage effects, the later data are selected for interpretation. Although the well probably penetrates only a fraction of the total saturated thickness of the unconfined aquifer, no corrections could be applied because the total saturated thickness is unknown at this location.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.15. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells. The data

RCRA Well 399-1-14 (S7)
Constant-Discharge Recovery (Transducer)
11/2/86 - 11/13/86

FIGURE D.15. Well 399-1-10 Observed Drawdown Using the Theis Analysis

considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, no boundary was indicated by the plot; however, because of the proximity to the Columbia River and the influence of changing river levels, data are selectively analyzed for the period from 2 to 100 min. Water level measurements taken earlier than 2 min into the test indicate pumping rate adjustments or heterogeneities. The transmissivity calculated using the Theis curve matching method is 87,000 ft²/day.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values, if certain conditions are met. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 2 min. However, for both the Theis and Cooper-Jacob methods, no storativity values could be calculated because there were no

observation wells measured during aquifer testing of well 399-1-10. The transmissivity calculated using the Cooper-Jacob method is 110,000 ft²/day. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.16.

Transmissivity Calculations for the Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.17. The data that were used to calculate transmissivity appear to the left of a t/t' value of 121 [i.e., $(240 + 2 \text{ min})/2 \text{ min}$]. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more

FIGURE D.16. Well 399-1-10 Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

RCRA Well 399-1-10 (S3)
Constant-Discharge Recovery
11/25/86

FIGURE D.17. Well 399-1-10 Water Level Recovery Plot Using the Cooper-Jacob Analysis

reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. The calculated transmissivity from the recovery plot is 260,000 ft²/day.

The hydraulic conductivity of the Hanford formation at well 399-1-10 cannot be calculated because the thickness of the saturated portion of the Ringold Formation is unknown at this location.

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that the values determined for transmissivity are not in agreement. River effects and the limitations of the pump placement may have influenced the drawdown and recovery segments of the aquifer test. A most probable value is selected and is included in the aquifer testing and well construction summary shown in Table D.6.

TABLE D.6. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	87,000 (8086.7)	N.A.
W(u) = 90		
1/u = 5E+8		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 630		
Straight-line Semilog Plot (Cooper-Jacob)	110,000 (10,224.6)	N.A.
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	260,000 (24,167)	N.A.
PROBABLE VALUE ft ² /d (m ² /d)	200,000 (18,590)	N.A.
STORATIVITY:	-----	N.A.
CONDUCTIVITY: ft/d (m/d)	-----	N.A.

Aquifer Test Data

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Data for Well 300 Area S3

Pumping Well 1

Observation Wells NONE

Location 300 Area RCRA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER MCKONETER-45

How W.L.'s Measured E-TAPE #10178

Rad./Dist. of/From Pumping Well: _____

Meas. Point for W.L.'s TOP OF 10" CASING

Elevation of Meas. Point .61' ABV LSD

Depth of Pump/Airpipe _____

Pump On: date 11/25/86 time 0715 hrs

Pump Off: date 11/25/86 time 1115 hrs

Duration of Aquifer Test 4 hrs pumping

Time			Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0			Static Water Level <u>29.51</u>				Reading	Q		
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		
11/25	0710	0			29.51		0		CSC	MEASURED by GVL
	0715	0			29.51		0		CSC	
		15 sec			30.12		0.61		CSC	
		30			30.30		0.79		CSC	
		45			31.39		1.88		CSC	
		1			30.68		1.17		CSC	
		1:15			31.43		1.92		CSC	
		1.5			31.45		1.94		CSC	
		1.75			31.46		1.95		CSC	
		2			31.47		1.96		CSC	
		2.5								
		3			31.52		2.01		CSC	
		3.5			31.22		1.71		CSC	
		4			31.53		2.02		CSC	
		5			31.57		2.06		CSC	
		6			31.58		2.07		CSC	~ 600 gpm
		7			31.59		2.08		CSC	
		8			31.60		2.09		CSC	~ 600 gpm
		9			31.65		2.14		CSC	
		10								
		11			31.64		2.13		CSC	
		13			31.53		2.02		CSC	
		15			31.66		2.15	750	CSC	~ 750 gpm
		20			31.53		2.02	700	CSC	~ 700 gpm
		25			31.48		1.97	670	CSC	~ 670 gpm
		30			31.58		2.07	670	CSC	~ 670 gpm
		40			31.70		2.19	650	CSC	~ 650 gpm
		50			31.87		2.36			
		60								USED OTHER E-TAPE
		70			31.82					MODE-150 ACTAT COMP. OLYMPIC W/ KILL PROBE
		80								OTHER E-TAPE HUNG UP
0815	60						2.31			
	70				31.82		1.84			
0845	90									
	100									
	105				31.35		1.84	~ 670		NEW TAPE ACTAT
	110				31.25		1.74			
0915	120				31.84		2.33	670		
	130				31.87		2.36	670		
	140				31.87		2.36	670		

Aquifer Test Data

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Data for Well 300 S3Pumping Well 11

Observation Wells N/A

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER, MACROMETER # 86-6-1161

How W.L.'s Measured E-TAPE ACTUAL 44 Depth of Pump/Airpipe

Rad./Dist. of/From Pumping Well

Pump On: date 11/25/86 time 0715

Meas. Point for W.L.'s I/c

Pump Off: date 1/29/01 time 11:00

Elevation of Meas. Point 161' ABV L.S.D.

Duration of Aquifer Test _____

Time					Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>29.51</u>							
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read-ing	Q		
<u>11/6/50</u>	<u>0945</u>	<u>150 min</u>			<u>31.88</u>			<u>2.37</u>		<u>670</u>	<u>CSC</u>	
	<u>1015</u>	<u>180</u>			<u>31.87</u>			<u>2.36</u>		<u>670</u>	<u>CSC</u>	
	<u>1045</u>	<u>210</u>			<u>31.88</u>			<u>2.37</u>		<u>670</u>	<u>CSC</u>	
	<u>1115</u>	<u>240</u>							<u>722900</u>			<u>722900 gals.</u>
												<u>Avg. discharge</u> <u>(634 gpm) ~</u> <u>722900 - 566300</u> <u>2+7 min.</u>
												<u>240 min const D</u> <u>test + Friction</u> <u>development</u>

630
gpm

240 min. const. Ditch
test + 7 min.
development

page 1 of 1

Data for Well 300 S 3

Pumping Well _____

Observation Wells NONE

Location 300 AREA RERA

Type of Aquifer Test RECOVERY

How Q Measured

How W.L.'s Measured E-TAP 0 ACTAT OLYMPIC P²00 Depth of Pump/Airpipe _____

Rad./Dist. of/From Pumping Well _____

Pump On: date 11/25/86 time 0715

Meas. Point for W.L.'s T/C

Pump Off: date 11/25/86 time

Elevation of Meas. Point 161' AGU LSD

Duration of Aquifer Test _____

INITIAL WL = 29.51

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>29.51</u>					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q			
11/29		240	0	-	31.89'			2.38				SPA	
		243	18"	801	29.58'			.07				SPA	
		241	59"	241	29.581			.07				SPA	
		241.5	1' 30"	161	29.58'			.07				SPA	
		242.12	5"	1153	29.57'			.06				SPA	
		242.42	35"	933	29.56'			.05				SPA	
		244	460"	61	29.55'			.04				SPA	
		245	500"	49	29.54'			.03				SPA	
		246	500"	41	29.53'			.02				SPA	
		247	700"	35.3	29.53'			.02				SPA	
		249	900"	27.7	29.52'			.01				SPA	
		251	11	22.8	29.52'			.01				SPA	
		253	13	19.5	29.51'			0				SPA	
		255	15	17	29.50'			+ .01				SPA	
		261	21	12.4	29.49'			+ .02				SPA	
		265	25	10.6	29.47'			+ .04				SPA	
		270	30	9	29.48'			+ .03				SPA	
		280	40	7	29.46'			+ .05				SPA	
		290	50	5.8	29.46'			+ .05				SPA	
		300	60	5	29.44'			+ .07				SPA	
		330	90	3.7	29.45'			+ .06				SPA	
		360	120	3	29.47'			+ .04				SPA	

The most probable transmissivity determined by this test is 200,000 ft²/day. The aquifer thickness is unknown at this location.

Aquifer Test for Well 399-1-18B (C3B)

Well 399-1-18B (previously labelled C3B) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer, including the Hanford formation and that portion above the base of the uppermost sand and gravel layer of the Ringold Formation, and to provide a means of sampling the water quality of that zone. The aquifer has a saturated thickness of approximately 75 ft at this location; however, the aquifer thickness will be considered to be approximately 53 ft and will include only the more consolidated and less transmissive portion of the Ringold Formation immediately above the underlying clays. The well was pumped at an average rate of 4 gpm for a period of 480 min. Drawdown in the well demonstrated a specific capacity of 0.15 gpm/ft, a Theis method transmissivity of 60 ft²/day, and a Cooper-Jacob method transmissivity of 140 ft²/day. No transmissivity could be calculated from recovery data. The hydraulic conductivity for the unconfined aquifer at well 399-1-18B is 0.15 ft/day (1.9 ft/day corrected for water-table conditions). This value is more typical of the basal unit of the Ringold Formation at the Hanford Site as shown in Table D.1. Water levels in wells 399-1-18A and 399-1-18C were measured during the testing of 399-1-18B. Well 399-1-18A is located 20.7 ft from 399-1-18B and did not show any interpretable drawdown or recovery response. Observation well 399-1-18C, 22.4 ft from the pumped well, did respond to pumping. Water levels in well 399-1-18C drew down 0.4 ft and recovered to within 0.08 ft of static conditions 558 min after pumping was discontinued.

Well 399-1-18B has a total depth of 119 ft, a completed diameter of 6 in., and was set with a No. 40 slot, 6-in., stainless steel well screen from 109 to 119 ft. Figure D.18 illustrates the site stratigraphy and well construction at well 399-1-18B. A more detailed description of the site geology is included in Section 3 of the report.

Well 399-1-18A and well 399-1-18C were incorporated as observation wells during the pumping of 399-1-18B. Well 399-1-18A was completed with 15 ft of

FIGURE D.18. Well 399-1-18B Stratigraphy and Well Constructions

No. 40 slot, 6-in., stainless steel screen set from 39 to 54 ft, as documented in Figure D.9 above. The deep well, 399-1-18C, was completed in the uppermost basalt layer (considered to be the Ice Harbor-Goose Island basalt flow) beneath the confining clay layer of the Ringold Formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 130 and 140 ft. The site stratigraphy and well construction at well 399-1-18C are illustrated in a figure under its aquifer test.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 1400 ft to the southeast of well 399-1-18B. The Columbia River is located approximately 1400 ft to the east of well 399-1-18B (see Figure D.1). The river may have affected the drawdown and recovery during the period of aquifer testing. Figure D.19 shows the changes in river-stage at the time of testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On January 24, 1987, the well was developed by bailing for 1.5 hours with a 5-in. dart bailer at approximately 15 gpm. The well was further developed by pumping approximately 4 gpm for another hour on January 28, 1987. The pump intake was set at 105.1 ft below the land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal.

Water levels were measured by an E-tape and recorded manually. Measurements were made through a stilling pipe (pvc tube) installed in the well bore. The stilling pipe extended almost to the bottom of the well, which reduced water level fluctuations resulting from turbulence near the pump intake and protected the E-tape cable from hanging up in the hole or being crushed between the pump column and the 6-in. casing.

FIGURE D.19. Water Level Elevation in the Columbia River
During the Testing of Well 399-1-18B

The static water level in well 399-1-18B was 43.16 ft below the land surface before development. The water was drawn down nearly 60 ft and equilibrated slowly after pumping was terminated. The static water level was 41.97 ft below land surface at the time of the constant-discharge test. Static water levels in wells 399-1-18A and 399-1-18C were 43.58 and 40.67 ft below land surface, respectively, at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 4.2 gpm. Flow rates during this test were measured with a calibrated 5-gal bucket. The discharge rate was too low to be measured accurately with the flow meter and flow measurements were recorded by timing the rate at which water filled the bucket. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water

discharged during the test was 2035 gal. The water from the test was discharged at the land surface about 1000 ft to the northeast.

Drawdown Test. The constant-discharge pumping test was conducted on January 29, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells. The pumping was terminated after 480 min, as planned. The maximum drawdown in the well was 25.87 ft, 180 min before pumping stopped. The specific capacity of the well was approximately 0.15 gpm/ft.

The observation wells measured during the aquifer testing of well 399-1-18B provided some possibly useful data for calculating aquifer coefficients. Well 399-1-18A apparently was not affected by pumping 399-1-18B. Well 399-1-18C, however, did show a drop in water level beginning 20 min into the pumping period.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The observed water level recovered beyond the static water level within 50 min of the start of recovery. Figure D.19 shows the river stage at the time pumping began and ended; the figure, however, does not show the lag-time for these effects to reach the wells being tested. Water levels within the aquifer were probably dropping at the time of drawdown testing and were rising during the early part of the recovery test. After 2.5 hours of recovery, water levels began to drop again.

The recovery was monitored in the observation wells with the result that only well 399-1-18C showed any changes in water level because of the recovery from constant-discharge pumping. The observed water level in well 399-1-18C recovered to within 0.08 ft of the initial static level 558 min after the pump was turned off.

Analysis and Interpretation

The pumping rate was measured with a calibrated 5-gal bucket and measurements are considered accurate. Total discharge was 2035 gal, which, when divided by the 480 min of pumping, gives a figure of 4.2 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. Pumping rates varied from 3.9 to 4.55 gpm.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that this correction also be made for wells that partially penetrate the aquifer. Corrections were applied to the data collected from well 399-1-18B because the drawdown was almost 26 ft of the aquifer thickness of 53 ft. The formula used was that recommended by Jacob (1963):

$$s_c = s - s^2 \times (2 \times m)^{-1} \quad (1)$$

where s_c = the corrected drawdown, in ft

s = the observed drawdown, in ft

m = the original saturated thickness of the aquifer, in ft.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the corrected drawdown data is presented in Figure D.20. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells, if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to aquifers:

- 1) that are entirely homogeneous, 2) that are of infinite areal extent,
- 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and
- 5) where the pumped well has an infinitesimal diameter.

In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter

Well 399-1-18B (C3B)
Corrected Drawdown Data
1/29/87

FIGURE D.20. Well 399-1-18B Observed Drawdown Using the Theis Analysis

portion of the test, unless some hydraulic boundary is encountered. For this test, partial penetration and casing storage effects were encountered, and data were selectively analyzed for the period from 160 to 480 min. Water level data that are plotted earlier than 160 min into the test indicate pumping rate adjustments and casing storage effects.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests the following equation:

$$t_c = 360,000 \times r_c^2 \times T^{-1} \quad (2)$$

where t_c = the time of pumping to dissipate borehole storage effects, in min
 r_c = the radius of the well casing in the interval over the water level declines, in ft
 T = the transmissivity of the aquifer, in ft^2/day .

Using the Hargis equation, it would require 160 min of pumping to dissipate the well storage effects if the transmissivity of the aquifer is 140 ft²/day.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses the following equation:

$$t_c = 0.6 \times (d_c^2 - d_p^2) \times (Q/s)^{-1} \quad (3)$$

where d_c = the inside diameter of the well casing, in in.

d_p = the outside diameter of the pump column pipe, in in.

Q/s = the specific capacity of the well, in gpm/ft of drawdown at time t_c .

If Equation (3) is used, it would require 90 min of pumping to dissipate the well storage effects. In this particular test situation the more conservative figure was selected.

The transmissivity calculated using the Theis curve matching method is 60 ft²/day.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 10 min for the pumped well. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing. Because well 399-1-18C is completed at a different elevation than is well 399-1-18B, only the pumped well is used to calculate the aquifer coefficients. The transmissivity calculated using the Cooper-Jacob method is 140 ft²/day. The Cooper-Jacob semi-logarithmic plot of the corrected drawdown data is presented in Figure D.21.

Transmissivity Calculations for the Recovery Test. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. Recovery data or, more precisely, residual drawdown data are

FIGURE D.21. Well 399-1-18B Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the corrected recovery data is presented in Figure D.22. The late-time data that would have been used to calculate transmissivity appear to the left of a t/t' value of 4 [i.e., $(480 + 160 \text{ min})/160 \text{ min}$]. The early-time data appear to the right on this plot. The transmissivity could not be calculated from the early-time data because of borehole storage effects or from the late-time data because of the influence of the changes in the Columbia River stage.

The pertinent information of the well construction and aquifer test results are summarized in Table D.7.

FIGURE D.22. Well 399-1-18B Water Level Recovery Plot Using the Cooper-Jacob Analysis

The most probable transmissivity determined by this test is $100 \text{ ft}^2/\text{day}$. The hydraulic conductivity is 1.9 ft/day if the aquifer thickness is 53 ft at this location. Aquifer Test Data Sheets for well 399-1-18B follow.

Aquifer Test for Well 399-1-18C (C3C)

Well 399-1-18C (previously labelled C3C) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer and the confined or semiconfined aquifer underlying the clay or silt layer of the lower unit of the Ringold Formation, and to provide a means of sampling the water quality of that zone. The aquifer has a thickness of 15 ft at this location. The well was pumped at an average rate of 4 gpm for a period of 480 min . Draw-down in the well demonstrated a specific capacity of 0.12 gpm/ft , a Theis method transmissivity of $40 \text{ ft}^2/\text{day}$, and a Cooper-Jacob method transmissivity of $140 \text{ ft}^2/\text{day}$. The transmissivity determined from the recovery data was

TABLE D.7. (contd)

AQUIFER TEST DATA SUMMARY:

PARAMETER	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft^2/d (m^2/d)		
Curve Match (Theis)	60 (5.6)	399-1-18A, 399-1-18C screened at different depths; could not determine aquifer characteristics
$W(u) = 10$		
$1/u = 7\text{E}+6$		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 4		
Straight-line Semilog Plot (Cooper-Jacob)	140 (13)	399-1-18A, 399-1-18C screened at different depths; could not determine aquifer characteristics
RECOVERY		
TRANSMISSIVITY: ft^2/d (m^2/d)	could not be determined; river effects	399-1-18A, 399-1-18C screened at different depths; could not determine aquifer characteristics
PROBABLE VALUE ft^2/d (m^2/d)	100 (9.3)	399-1-18A, 399-1-18C screened at different depths; could not determine aquifer characteristics
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	1.9 (.58)	-----

Aquifer Test Data

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Data for Well C3B

Pumping Well C3E

Observation Wells C3A, C3C

Location 300 AREA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FLOWMETER / 5 gal. bucket

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well -

Meas. Point for W.L.'s AIRBORNE 4.4' ABV LSD

Elevation of Meas. Point 1.30' ABV T/C = 390.22'

Depth of Pump/Airpipe Intake 105.1' below 1st

Pump On: date 1/29/87 time 1445

Pump Off: date 1/29/87 time 2245

Duration of Aquifer Test B hr. pumping

LSD = brass cap = 387.52' m.s.s.

Time			Water Level Data			Discharge		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Static Water Level	Reading	gpm		
					46.37 MP				
1/29	1427	0			46.43		1272.4	OSC	Mc Crometer
	1436	0			46.37			ASC	# B2-3-226
	1445	0			46.37			ASC	RANGE 0-250 gpm
	1:30							ASC	indicates 124W5
	1				50.68	4.28	4.11	ASC	gpm Totalizer
	1:30				52.11	5.74	5.43	ASC	at about 2 gpm.
	2				53.15	6.38	6.35	ASC	
	2:30				53.91	7.54	7.00	ASC	
	3				55.19	8.82	8.09	ASC	4.5 gpm by one
	3:30				55.90	9.53	8.63	ASC	minute bucket
	4				56.76	10.39	9.37	ASC	reading.
	4:30				57.5	11.13	9.96	ASC	
	5				58.30	11.93	10.59	ASC	
	6				59.72	13.35	11.67	ASC	bucket calibrated
	7				60.68	14.31	12.38	ASC	to 377 gallons at
	8				61.61	15.24	13.05	ASC	black mark
	9				62.53	16.16	13.80	ASC	
	10				63.36	16.99	14.27	ASC	
	11				63.97	17.60	14.68	ASC	
	12				64.6	18.29	15.13	ASC	
	13				65.24	18.87	15.51	ASC	
	14				65.73	19.36	15.82	ASC	
	15				66.21	19.84	16.13	ASC	
	20				68.01	21.64	17.24	ASC	
	25				68.84	22.47	17.71	ASC	meter
	30				69.36	23.09	18.00	ASC	1349 37.0 min.
	35				69.40	23.03	18.03	ASC	
	40				69.79	22.92	17.96	ASC	
	45				69.23	22.86	17.93	ASC	
	50				69.19	22.82	17.91	ASC	
	60				69.06	22.69	17.83	ASC	
	70				68.93	22.56	17.76	ASC	4.55
	80				68.96	22.59	17.78	ASC	4.37/1108
	90				68.94	22.57	17.76	ASC	
	100				68.89	22.32	17.62	ASC	4.75/1110
	120				68.77	21.80	17.32	ASC	
128	130				69.92	23.55	18.32		OPENED VALVE TO
143	180				71.06	24.69	18.94		4.55
150	210				71.16	24.79	18.99	ASC	4.45

Aquifer Test Data

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Data for Well C3B

Pumping Well C3B

Observation Wells _____

Location 300 AREA RCR

Type of Aquifer Test constant-discharge

How Q Measured 5 gal. bucket - cal. bucket

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s AIRHOSE 4.4' ABV. L&B

Elevation of Meas. Point _____

Depth of Pump/Airpipe 105.1'

Pump On: date 1/29/87 time 1445

Pump Off: date 1/29/87 time 2245

Duration of Aquifer Test 8 hr. pumping

L&B = brass cap = 387.52' msd

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					41.97' L&B Static Water Level <u>46.37'</u>								
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Partial Flooded	Reading	gpm Q		
1/29		160					71.49	25.12	19.17		4.33	CSC	VALVE ADJUSTED
"		180									4.3	CSC	CALIBRATED BUCK
"		190									4.3	CSC	
"		210					71.04	24.67	18.93			CSC	
	6:45	240					70.87	24.5	18.84		4.0	PL	Valveadjusted
		250					—				4.1	PL	Valveadjusted
		260					70.02	23.65	18.37	1835	4.4	PL	
		265					71.03	24.66	18.92		4.35	PL	
	7:23	280					72.08	25.71	19.47	1925	4.33	PL	
		300					72.24	25.87	19.56		4.35	CSC	
		360					71.60	25.23	19.22			CSC	390 min. took pump adj. f
		420					71.43	25.06	19.14			CSC	
	9:55	480								2501	4.2		
		480					71.21	24.84	19.02			CSC	~ 2035 g.p.m. ≈ 4.2 gal/min
		480					71.21	24.84	19.02			CSC	PUMP OFF
		485	30	961			68.32	21.95	17.40			CSC	RECOVERY
		481	1	481			—					CSC	
		485	11:30	321			65.62	19.25	15.74			CSC	
		482	2	241			64.31	17.97	14.90			CSC	
		482	2:30										
		3											
		485	3:30	130			61.6	15.23	13.04			CSC	
		4											
		4:30											
		485	5	97			59.55	13.18	11.54			CSC	
		486	6	91			58.18	11.81	10.49			CSC	
		487	7	84			57.05	10.68	9.60			CSC	
		488	8	61			56.00	9.63	8.74			CSC	
		489	9	54.3			55.01	8.64	7.94			CSC	
		490	10	49			54.10	7.73	7.17			CSC	
		491	11	44.6			53.11	6.74	6.31			CSC	
		492	12	41			52.49	6.12	5.77			CSC	
		493	13	37.9			51.83	5.46	5.18			CSC	
		494	14	35.3			51.32	4.95	4.72			CSC	
		495	15	33			50.84	4.47	4.28			CSC	
		500	20	25			48.97	2.60	2.54			CSC	
		505	25	20.2			47.76	1.39	1.37			CSC	
		510	30	17			47.11	.74	.73			CSC	

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Data for Well C9B

Pumping Well C3B

Observation Wells _____

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE RECOVERY

How Q Measured Flow Meter / 5 gal. calibrated Bucket

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well

Meas. Point for W.L.'s AIRLINE 44' ABJ LSP

Elevation of Meas. Point

Depth of Pump/Airpipe 105.1 BLW LSD

Pump On: date 1/29/87 time 1445 hrs

Pump Off: date 1/29/87 time 2245 hrs

Duration of Aquifer Test

$$LSD = \text{brass cap} = 387.52 \text{ m s}^2$$
[illegible]

Aquifer Test Data

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Data for Well C3A

Pumping Well C3B

Observation Wells C3A, C3C

Location 300 AREA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FLOWMETER / 5 gal. bucket

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well 20.7'

Meas. Point for W.L.'s T/K 3.06' AW L90

Elevation of Meas. Point 391.11' msl

Depth of Pump/Airpipe intake 105.1 below 1st

Pump On: date 1/29/87 time 1445 hrs.

Pump Off: date _____ time _____

Duration of Aquifer Test _____

DISTANCE BETWEEN C3A-C3C = 23.6' L90 = 388.05 brass cq.

Time t = _____ at t' = 0				Water Level Data Static Water Level <u>46.64</u>				Pumping Discharge		Recorded By	Comments
Day	Clock Time	Min. t	t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	gpm Q		
1/29	1430					46.64		0		PL	
	1445	0				46.64		0		PL	
		.5				46.64				PL	
		1				46.64				PL	
		2				46.63				PL	
		3				46.63		4.7		PL	
		4				46.64		4.8		PL	
		5				46.64		4.8		PL	
		6				—				PL	
		7				—				PL	
		8				—		4.7		PL	
		9				—				PL	
		10				46.64				PL	
		11				—		4.75		PL	
		12				—		4.75		PL	
		15				46.64		4.6		PL	
		17				46.64				PL	
		22				46.64				PL	
		25				—		4.5		PL	
		28				46.64		4.8		PL	
		35				46.64				PL	
		40				46.64		4.5		PL	at 45 minutes 4:32pm
		50				46.64		4.3		PL	
		60				46.64		4.1		PL	
		70				46.62 → 46.64 by RS				CSC	
		80				46.62				CSC	
		90				46.62				CSC	
		100									
		135				46.63				CSC	
		180						4.3		PL	calibrated bucket
		190				46.66		4.3		PL	
		265				46.67		4.4		PL	
		300				46.67		4.35		CSC	adjust valve
		390				46.67		4.3		CSC	
		435				46.67		4.3		CSC	
		452				46.67				PL	
		465				46.68		4.2		PL	
		470				46.68				PL	
		479				46.68				PL	

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Data for Well C 3 A

Pumping Well C 3 B

Observation Wells C3C,
C3A Also dataloggers
in S6 + S3.

Location 300 Area

Type of Aquifer Test Constant Discharge

How Q Measured Flammear, Spol bucket

How W.L.'s Measured E-TAPE / 8

Rad./Dist. of/From Pumping Well 20.7'

Meas. Point for W.L.'s Top of SS casing

Elevation of Meas. Point 391.11' msl

Depth of Pump/Airpipe _____

Pump On: date 1/29/87 time 1445 hrs

Pump Off: date 1/24/97 time 2245h

Duration of Aquifer Test 6 hours

$u_{3D} = \text{brass cap} = 388.05 \text{ m/s}$

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Aquifer Test Data

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Data for Well C3C

Pumping Well C3C

Observation Wells C3C, C3A

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER / 5 GAL. BUCKET

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe INTAKE 105.1' BELOW LAND SURFACE

Rad./Dist. of/From Pumping Well 22.4'

Pump On: date 1-29-87 time 1445

Meas. Point for W.L.'s T/C 2.71' above brass cap

Pump Off: date 1-29-87 time 2245

Elevation of Meas. Point 388.33' msl

Duration of Aquifer Test 8 hr pumping

23.6' BETWEEN C3C & C3A

LSD = brass cap = 385.62' msl

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>43.38</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
1/29	1435						43.38				SPA	
	1445	0	52.4				43.38	0			SPA	
		30					43.38	0			SPA	
		60					43.38	0			SPA	
		90					43.38	0			SPA	
		120					43.38	0			SPA	
		150					43.38	0			SPA	
		180					43.38	0			SPA	
		210					43.38	0			SPA	
		240					43.39	.01			SPA	
		270					43.37	-.01			SPA	
		300					43.37	-.01			SPA	
		6 min					43.39	.01			SPA	
		7 min					43.38	0			SPA	
		8 min					43.38	0			SPA	
		9 min					43.39	.01			SPA	
		10					43.39	.01			SPA	
		11					43.39	.01			SPA	
		12					43.40	.02			SPA	
		13					43.40	.02			SPA	
		14					43.41	.03			SPA	
		15					43.40	.02			SPA	
		20					43.41	.03			SPA	
		25					43.43	.05			SPA	
		30					43.45	.07			SPA	
		35					43.46	.08			SPA	
		40					43.48	.10			SPA	
		45					43.48	.10			SPA	
		50					43.49	.11			SPA	
		60					43.51	.13			SPA	
		70					43.52	.14			CSC	
		80					43.52	.14			CSC	
		90					43.53	.15			CSC	
		100					43.53	.15			CSC	
		120					43.55	.17			CSC	
		130					43.56	.18			CSC	OPENED VALVE
		150					43.59	.21			CSC	to bring up to 4.75 gpm
		164					43.59	.21			CSC	
		210					43.63	.25			CSC	
		240					43.63	.25			CSC	

Aquifer Test Data

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Data for Well C 30

Pumping Well C 38

Observation Wells C 30 + C 3A

Location 300 Area

Type of Aquifer Test Constant Discharge
Flow Meter = 1.5 gpm bucket

How Q Measured Flow Meter

How W.L.'s Measured ESTAPC

Rad./Dist. of/From Pumping Well 22.4'

Meas. Point for W.L.'s T/C

Elevation of Meas. Point 388.33' ms.l

23.6' BETWEEN C30 + C3A

Depth of Pump/Airpipe Intake 105.1' Below 1st

Pump On: date 1/29/87 time 1445 hrs

Pump Off: date 1/29/87 time 2245 hrs

Duration of Aquifer Test 8 hrs pumping C38

LSB = brass cap = 385.62' ms.l

Time					Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>43.38'</u>							
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
1/29		265					43.64	.26			OSC	See pump shut off
"		300					43.67	.29			OSC	
"		320					43.70	.32			OSC	
"		410					43.72	.34			OSC	
"		455					43.75	.37			RL	
"		467					43.76	.38			RL	
"		475					43.77	.39	4.2?		RL	
"	2245	480	0				43.78	.40	0		RL	Pump shut off
"		481	1	481			43.76	.38			RL	
		482	2	241			43.75	.37			RL	
		483	3	161			43.745	.37			RL	
		485	5	97			43.74	.36			RL	
		487	7	68.6			43.735	.36			RL	
		490	10	49			43.72	.34			RL	
		495	15	33			43.71	.33			RL	
		500	20	25			43.70	.32			RL	
		505	25	22.2			43.69	.31			RL	
		510	30	17			43.68	.30			RL	
		520	40	13			43.66	.28			RL	
1/29	2345	540	60	9			43.62	.24			RL	
1/30	2405	560	80	7			43.57	.19			RL	
1/30		580	100	5.8			43.55	.17			RL	
	0045	600	120	5			43.53	.15			RL	
		630	150	4.2			43.51	.13			RL	
	0145	660	180	3.7			43.50	.12			RL	
1/30	0725	1000	520	1.92			43.47	.09			SPA	
	0823	1028	558	1.86			43.46	.08			GA/L	
	0928	1123	643	1.7			43.48	.10			SPA	
										</		

Recovery

94 ft²/day. The hydraulic conductivity for the unconfined aquifer at well 399-1-18C is 6 ft/day. This value is typical for the basal unit of the Ringold Formation at the Hanford Site as shown in Table D.1. Water levels in wells 399-1-18A and 399-1-18B were measured during the testing of 399-1-18C. Well 399-1-18A is located 23.6 ft from 399-1-18C and did not show any interpretable drawdown or recovery response. Observation well 399-1-18B, 22.4 ft from the pumped well, did respond to pumping. Water levels in well 399-1-18B drew down 0.32 ft and recovered to within 0.08 ft of static conditions 625 min after pumping was discontinued.

Well 399-1-18C has a total depth of 140 ft, a completed diameter of 6 in., and was set with a No. 20 slot, 6-in., stainless steel well screen from 130 to 140 ft. This well was completed in the uppermost basalt layer (considered to be the Ice Harbor-Goose Island basalt flow) beneath the confining clay or silt layer of the Ringold Formation. Figure D.23 illustrates the site stratigraphy and well construction at well 399-1-18C. A more detailed description of the site geology is included in Section 3 of the report.

Well 399-1-18A and well 399-1-18B were incorporated as observation wells during the pumping of 399-1-18C. Well 399-1-18A was completed with 15 ft of No. 40 slot, 6-in., stainless steel screen set from 39 to 54 ft, as documented in Figure D.9 above. The intermediate well, 399-1-18B, was completed in the confining or semiconfining clay or silt layer of the lower Ringold Formation. A No. 40 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 109 and 119 ft. Figure D.18 illustrates the site stratigraphy and well construction at well 399-1-18B.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area process trenches are located approximately 1400 ft to the southeast of well 399-1-18c. The Columbia River is located approximately 1400 ft to the east of well 399-1-18C (see Figure D.1).

FIGURE D.23. Well 399-1-18C Stratigraphy and Well Construction

The river apparently did affect the drawdown during the period of aquifer testing. Figure D.24 shows the fluctuations in river-stage during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On January 13, 1987, the well was developed by bailing for 1 hour with a 5-in. dart bailer. On February 2, 1987, the well was further developed by pumping approximately 4 gpm for another hour. The pump intake was set at 126.9 ft below land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal.

FIGURE D.24. Water Level Elevations in the Columbia River During the Testing of Well 399-1-18C

Water levels were measured by an E-tape and recorded manually. Measurements were made through a stilling pipe (pvc tube) installed in the well bore. The stilling pipe extended almost to the bottom of the well, reduced the water level fluctuations resulting from turbulence near the pump intake, and protected the E-tape cable from hanging up in the hole and from being crushed between the pump column and the 6-in. casing.

The static water level in well 399-1-18C was 41.19 ft below the land surface before development. The water was drawn down over 31 ft and equilibrated slowly after pumping was terminated. The static water level was 41.38 ft below land surface at the time of the constant-discharge test. Static water levels in wells 399-1-18A and 399-1-18B were 43.94 and 42.62 ft below land surface, respectively, at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 4 gpm. Flow rates during this test were measured with a calibrated 5-gal bucket. The discharge rate was too low to be measured accurately with the flow meter, therefore, flow measurements were recorded by timing the rate at which water filled the bucket. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 1904 gal. The water from the test was discharged at the land surface about 1000 ft to the northeast.

Drawdown Test. The constant-discharge pumping test was conducted on February 3, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells. The pumping was terminated after 480 min, as planned. The maximum drawdown was 33.96 ft at 60 min into the test, which was the result of opening the valve too much to adjust the discharge rate. The specific capacity of the well was approximately 0.12 gpm/ft. The drawdown measurements in the observation wells provided some information that could be useful for calculating aquifer coefficients.

Recovery Test. Recovery of the water level was observed for 662 min in the pumping well following termination of pumping. The water level in well 399-1-18B was measured for 665 min following testing and recovered to within

0.08 ft of initial static water level in that period of time. The pumped well recovered beyond the initial water level by nearly 0.5 ft, indicating possible extraneous influences such as the Columbia River.

Analysis and Interpretation

The pumping rate was measured with a calibrated 5-gal bucket and measurements are considered accurate. Total discharge was 1904 gal, which, when divided by the 480 min of pumping, gives a figure of 4 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. Pumping rates varied from 3.8 to 4.5 gpm.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. A correction factor for these effects must be applied to the drawdown data before interpretation of the results may be made. In the case of borehole storage effects, the later data are selected for interpretation. Corrections were not required for data collected from well 399-1-18, because this well is considered to have penetrated most of the total aquifer thickness of 15 ft. Although it is presumed that this well did tap the confined or semiconfined aquifer below the clay or silt layer of the Ringold Formation, hydrologic data indicate that the unconfined aquifer may be more continuous than anticipated at this location. There appears to be little clay to retard vertical movement of water; therefore, at this location the unconfined aquifer may extend to the underlying basalt flows. If this is the case, the aquifer thickness would be more extensive and data corrections would be required.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.25. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells, if certain

RCRA Well 399-1-18C (C3C)
Constant-Discharge Drawdown Test
2/3/87

FIGURE D.25. Well 399-1-18C Observed Drawdown Using the Theis Analysis

assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to aquifers: 1) that are entirely homogeneous, 2) that are of infinite areal extent, 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and 5) where the pumped well has an infinitesimal diameter. In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, boundary conditions were encountered, and data were selectively analyzed for the period from 250 to 480 minutes. Water level data plotted earlier than 250 minutes into the test indicate pumping rate adjustments and casing storage effects.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2). By using Equation (2) calculations, it would require 250 min of pumping to dissipate the well storage effects if the transmissivity of the aquifer is $90 \text{ ft}^2/\text{day}$.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses Equation (3). By using Equation (3) calculations, it would require 150 min of pumping to dissipate the well storage effects. In this particular test situation the more conservative figure was selected.

The transmissivity calculated using the Theis curve matching method is $40 \text{ ft}^2/\text{day}$.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 10 min for the pumped well. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing. The transmissivity calculated using the Cooper-Jacob method is $140 \text{ ft}^2/\text{day}$ if the data that was obtained after 250 minutes of pumping is used in the calculation. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.26.

Transmissivity Calculations for the Recovery Test. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.27. The data used to calculate transmissivity appear to the left of a t/t' value of 3 [i.e., $(480 + 250 \text{ min})/250 \text{ min}$]. early-time data appear to the right on this plot. The early-time data are influenced by borehole storage effects, while the late-time data

RCRA Well 399-1-18C (C3C)
Constant-Discharge Drawdown Test
2/3/87

FIGURE D.26. Well 399-1-18C Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

are influenced by the changes in the Columbia River stage. The late-time data were still used in the calculation of transmissivity and averaged into the results from the drawdown testing. The calculated transmissivity from the recovery plot is $94 \text{ ft}^2/\text{day}$.

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that the values determined for transmissivity vary, probably as a result of the influence of the Columbia River. The results of well construction and the aquifer testing are summarized in Table D.8.

The most probable values for aquifer characteristics determined by this test are a transmissivity of $90 \text{ ft}^2/\text{day}$, determined by averaging the results of the various analytical methods and a hydraulic conductivity of 6 ft/day . The aquifer thickness is estimated to be 15 ft at this location. Aquifer Test Data Sheets for well 399-1-18C follow.

RCRA Well 399-1-18C (C3C)
Constant-Discharge Recovery
2/3/87 - 2/4/87

FIGURE D.27. Well 399-1-18C Water Level Recovery Plot Using the Cooper-Jacob Analysis

Aquifer Test for Well 399-1-17B (C2B)

Well 399-1-17B (previously labelled C2B) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer, including the Hanford formation and that portion above the base of the uppermost sand and gravel layer of the Ringold Formation, and to provide a means of sampling the water quality of that zone. The unconfined aquifer has a saturated thickness of approximately 77 ft at this location. The well was pumped at an average rate of 23 gpm for a period of 315 min. Drawdown in the well demonstrated a specific capacity of 0.55 gpm/ft, a Theis method transmissivity of 250 ft²/day, and a Cooper-Jacob method transmissivity of 1350 ft²/day. The recovery data indicated a transmissivity of 1000 ft²/day. The hydraulic conductivity for the unconfined aquifer at well 399-1-17B is probably 12 ft/day. This value is less than the typical conductivity found in the middle Ringold

TABLE D.8. Aquifer Testing and Well Construction Summary for Well 399-1-18C

WELL: 399-1-18C (C3C)

DATE OF TEST: 2/3/87

LAND SURFACE DATUM (1sd) ELEVATION (ft above msl): 385.62
(brass cap)

STATIC WATER LEVEL (date of test): 41.38 ft below 1sd

ELEVATION: 344.24 ft above msl

MAXIMUM PUMPING WATER LEVEL: 75.34 ft below 1sd

ELEVATION: 310.28 ft above msl

MAXIMUM DRAWDOWN: 33.96 ft

PUMPING RATE: 4 gallons per minute (gpm)

PUMPING TIME: 480 minutes

TOTAL DISCHARGE: 1,904 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD: 48 ft below 1sd 337.62 ft abv msl

TOP OF CLAY: 118 ft below 1sd 267.62 ft abv msl

TOP OF BASALT: 142 ft below 1sd 243.62 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 15 ft (4.6 m) or 78 ft (23.8 m)

TOP OF SCREEN 130 ft below 1sd ELEVATION: 255.62 ft above msl

BOTTOM OF SCREEN 140 ft below 1sd ELEVATION: 245.62 ft abv msl

OBSERVATION WELLS:

#1 WELL 399-1-18A (C3A)

TOP OF SCREEN: 39 ft

BOTTOM OF SCREEN: 54 ft

DISTANCE FROM PUMPED WELL: 23.6 ft

#2 WELL 399-1-18B (C3B)

TOP OF SCREEN: 109 ft

BOTTOM OF SCREEN: 119 ft

DISTANCE FROM PUMPED WELL: 22.4 ft

TABLE D.8. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	40 (3.7)	-----
W(u) = 6		
1/u = 3E+7		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 4		
Straight-line Semilog Plot (Cooper-Jacob)	140 (13)	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	94 (8.7)	-----
	-----	-----
PROBABLE VALUE ft ² /d (m ² /d)	90 (8.4)	-----
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	6 (1.8)	-----

Aquifer Test Data

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Data for Well C3C

Pumping Well C3C

Observation Wells C3A, C3B

Location 300 AREA

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured FLOWMETER / CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe 136 9' LSD

Rad./Dist. of From Pumping Well —

Pump On: date 2/3/87 time 0745

Meas. Point for W.L.'s 1/2 2.5' Abv LSD

Pump Off: date 2/3/87 time 1045

Elevation of Meas. Point 3.90' from Top pipe elevator

Duration of Aquifer Test 0 hr pumping

Time			Water Level Data				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or y	Reading	gpm Q
2/3	0745	0					43.84			
	0815	0					44.34		28820	
	1:30						50.63	6.29	CSC	
	1:00						52.83	8.49	CSC	
	1:30						53.64	9.3	CSC	
	2						54.97	10.63	CSC	
	2:30								CSC	
	3						56.75	12.41	4.0	76
	3:30						57.75	13.41	CSC	
	4						58.28	13.94	CSC	
	4:30						59.2	14.86	CSC	
	5						59.88	15.54	CSC	
	6						60.93	16.63	CSC	
	7						61.84	17.53	CSC	
	8:30						63.15	18.91	CSC	
	9						63.61	19.17	CSC	
	10						64.15	19.81	CSC	
	12						65.57	21.23	CSC	
	14						66.55	22.2	3.8	76
	16						67.45	23.11	CSC	
	18						68.12	23.78	CSC	
	20						69.26	24.52	4.0	76
	25						70.67	26.33	CSC	
	30						71.61	27.25	3.9	CSC
	35						72.03	27.68	3.8	CSC
	40						72.41	28.07		
	45								4.0	76
	50						75.64	31.32		
	60						78.34	33.96	4.5	CSC
	70						78.2	33.86	3.9	CSC
	80						76.9	32.54	4.0	CSC
	90						76.33	31.99	3.9	CSC
	100						76.24	31.92	4.0	CSC
	110						76.5	32.16	4.0	CSC
	120						76.63	32.29	4.0	CSC
	150						76.3	31.96	3.8	CSC
	180						76.65	32.31	4.0	CSC
	210						77.16	33.12	4.0	
	240						77.85	33.01	4.0	

2-18 min.

4147.5
4112.5

CSC

Aquifer Test Data

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Data for Well C-2-C

Pumping Well C-2-C

Observation Wells C-1-A, C-1-B

Location 300 AREA
Type of Aquifer Test CONSTANT DISCHARGE / RECOVERY

How Q Measured FLOWMETER / CALCULATED / METER

How W.L.'s Measured POTENTIAL

Depth of Pump/Airpipe 126.9' 1.272

Rad./Dist. of/From Pumping Well ---

Pump On: date 2/3/57 time 11:10

Meas. Point for W.L.'s TOP OF PIPE ELEVATION 2.16'

Pump Off: date 2/3/57 time 16:45

Elevation of Meas. Point ---

Duration of Aquifer Test 8 hr 35 min

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>44.3-1</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
		7:10					77.20	30.91		4.0	CSC	
		7:20					77.20	32.06		4.0	CSC	
		7:30					77.20	32.06		4.0	CSC	
		7:40					76.48	32.44		3.9	CSC	4.0 @ 240 min
2/3	16:45	480	0	<			75.87	21.48	5'	32.00	CSC	TOTAL 1670.3 gallons AVG. = 3.98 gpm
		120	96				77.45	28.11			CSC	RECOVERY
		1	481				70.30	25.86			CSC	
		1.30	321				67.71	24.37			CSC	use 3.9 gpm for 420 min → 480 min
		2	241				67.67	23.53			CSC	TOTAL 1904.3 gallons AVG. = 3.97 gpm
		2.50	161				66.38	22.04			CSC	
		3	128				65.52	21.18			CSC	
		4	96				64.65	20.31			CSC	
		5	72				63.79	18.45			CSC	
		6	61				62.97	17.56			CSC	
		7	48				62.35	16.01			CSC	
		8	36				61.72	14.86			CSC	
		9	24				61.05	13.81			CSC	
		10	18				60.47	12.75			CSC	
		11	14				59.81	11.87			CSC	
		12	11				59.18	10.74			CSC	
		14	8.5				58.54	9.20			CSC	
		16	6.3				57.91	7.79			CSC	
		18	4.7				57.29	6.67			CSC	
		20	3.6				56.67	5.76			CSC	
		25	2.4				55.01	3.81			CSC	
		30	1.7				54.35	2.61			CSC	
		35	1.4				53.69	1.78			CSC	
		40	1.3				53.01	1.17			CSC	
		45	1.1				52.31	.84			CSC	
		50	1.0				51.61	.57			CSC	
	17:45	540	60	4			50.91	.28			CSC	
		70	7.9				49.21	.21			CSC	
		80	7				48.51	.11			CSC	
		90	6.3				47.81	.11			CSC	
		100	5.8				47.17	.03			CSC	
		110	5.4				46.53				CSC	
	18:00	120	5				45.89	.04			CSC	

Aquifer Test Data

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Data for Well C-3-B

Pumping Well C-3-C

Observation Wells C-3-B, C-3-A

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER / CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe 126.9

Rad./Dist. of/From Pumping Well 22.4'

Pump On: date 2/3/87 time 0845

Meas. Point for W.L.'s T/C 3.38' ABV LSD

Pump Off: date 2/3/87 time 1645

Elevation of Meas. Point 112.62

Duration of Aquifer Test 8 hrs pumping

Time t = _____ at t' = 0					Water Level Data				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Static Water Level	Conversions or Corrections	Water Level	s or f	Reading	Q		
2/3	0821	0					47.0			40	PL	
	0845	0					46.00	0			PL	
		1					46.01	.01			PL	
		2					46.02	.02			PL	
		3					46.02	.02			PL	
		4					46.02	.02			PL	
		5					46.02	.02			PL	
		7					46.03	.03			PL	
		10					46.03	.03			PL	
		15					46.04	.04			PL	
		20					46.06	.06			PL	
		25					46.07	.07			PL	
		30					46.08	.08			PL	
		40					46.11	.11			PL	
		50					46.13	.13			PL	
		60					46.15	.15			CSC	
		70					46.16	.16			CSC	
		80					46.17	.17			CSC	
		90					46.18	.18			CSC	
		100					46.19	.19			CSC	
		110					46.20	.20			CSC	
		120					46.21	.21			CSC	
		150					46.22	.22			CSC	PL = Round School
		180					46.23	.23			CSC	
		210					46.24	.24			CSC	
		240					46.25	.25			CSC	
		270					46.26	.26			CSC	
		300					46.28	.28			CSC	
		360					46.30	.30			CSC	
		420					46.31	.31			CSC	
		480	0				46.32	.32			PL	
		5:30	46.1				46.32	.32			PL	
		1	48.1				46.32	.32			PL	
		1:30	32.1				46.32	.32			PL	
		2	24.1				46.32	.32			PL	
		2:30	19.1				46.32	.32			PL	
		3	16.1				46.32	.32			PL	
		3:30	138.1				46.32	.32			PL	
		4	12.1								PL	

Aquifer Test Data

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Data for Well C3B

Pumping Well C3B

Observation Wells C3A, C3B

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE 2D/RECOVERY

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well 22.4'

Meas. Point for W.L.'s T/C 338' ABV LSD

Elevation of Meas. Point _____

Depth of Pump/Airpipe 126.9' LSD

Pump On: date 2/3/87 time 0845

Pump Off: date 2/2/87 time _____

Duration of Aquifer Test _____

Time t = _____ at t' = 0					Water Level Data <u>E-TAPE</u> Static Water Level <u>46.0'</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	γ or s'	Read- ing	Q		
		4845	4:30	11.77			46.32	.32		0	PL	= R. Schalla
			5	97			46.32	.32			PL	
			6	81			46.32	.32			PL	
			7	69.6			46.31	.32			PL	
			8	61			46.31	.31			PL	
			9	54.3			46.31	.31			PL	
			10	49			46.31	.31			PL	
			11	44.6			46.31	.31			PL	
			12	41			46.31	.31			PL	
			14	35.3			46.30	.30			PL	
			16	31			46.30	.30			PL	
			18	27.7			46.29	.29			PL	
			20	25			46.29	.29			PL	
			25	20.2			46.28	.28			PL	
			30	17			46.27	.27			PL	
			35	14.7			46.26	.26			PL	
			40	13			46.25	.25			PL	
			45	11.7			46.25	.24			PL	
			50	10.6			46.23	.23			PL	
			60	9			46.21	.21			PL	
			70	7.9			46.19	.19			CSC	
			80	7			46.18	.19			CSC	
			90	6.3			46.17	.17			CSC	
			100	5.8			46.15	.15			CSC	
			110	5.4								
			120	5			46.15	.15			CSC	
			150	4.2			46.11	.11			CSC	
			180	3.7			46.13	.13			CSC	
			210	3.3			46.13	.13			CSC	
			240	3			46.12	.12			CSC	
			270									
			300									
			360									
			420									
			480									
2/4	0710	1105	625	1.8			46.08	.08			SPA	
	0750	1145	665	1.7			46.08	.08			SPA	

Aquifer Test Data

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Data for Well C3A

Pumping Well C3C

Observation Wells C3A, C3B

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOWMETER / CALIBRATED BUCKET

How W.L.'s Measured V-TAPE

Rad./Dist. of/From Pumping Well 236'

Meas. Point for W.L.'s T/C 3.06' Abv LSD

Elevation of Meas. Point _____

Depth of Pump/Airpipe 126.9' LSD

Pump On: date 2/3/87 time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

Time t = _____ at t' = 0					Water Level Data Static Water Level _____				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
2/3	0809	0			47.05		47.02'				RL	
"	0822	0			47.03		47.03				RL	
	0845	0					47.03				RL	
	0858	13					47.04				RL	
		26					47.03				RL	
		39					47.03				RL	
		52					47.03				CSC	
		65					47.03				CSC	
		78					47.03				CSC	
		91					47.03				CSC	
		104					47.03				CSC	
		117					47.03				CSC	
		130					47.03				CSC	
		143					47.03				CSC	
		156					47.03				CSC	
		169					47.03				CSC	
		182					47.03				CSC	
		195					47.03				CSC	
		208					47.03				CSC	
		221					47.03				CSC	
		234					47.03				CSC	
		247					47.03				CSC	
		260					47.03				CSC	
		273					47.03				CSC	
		286					47.03				CSC	
		299					47.03				CSC	
		312					47.03				CSC	
		325					47.03				CSC	
		338					47.03				CSC	
		351					47.03				CSC	
		364					47.03				CSC	
		377					47.03				CSC	
		390					47.03				CSC	
		403					47.03				CSC	
		416					47.03				CSC	
		429					47.03				CSC	
		442					47.03				CSC	
		455					47.03				CSC	
		468					47.03				CSC	
		481					47.03				CSC	
		494					47.03				CSC	
		507					47.03				CSC	
		520					47.03				CSC	
		533					47.03				CSC	
		546					47.03				CSC	
		559					47.03				CSC	
		572					47.03				CSC	
		585					47.03				CSC	
		598					47.03				CSC	
		611					47.03				CSC	
		624					47.03				CSC	
		637					47.03				CSC	
		650					47.03				CSC	
		663					47.03				CSC	
		676					47.03				CSC	
		689					47.03				CSC	
		702					47.03				CSC	
		715					47.03				CSC	
		728					47.03				CSC	
		741					47.03				CSC	
		754					47.03				CSC	
		767					47.03				CSC	
		780					47.03				CSC	
		793					47.03				CSC	
		806					47.03				CSC	
		819					47.03				CSC	
		832					47.03				CSC	
		845					47.03				CSC	
		858					47.03				CSC	
		871					47.03				CSC	
		884					47.03				CSC	
		897					47.03				CSC	
		910					47.03				CSC	
		923					47.03				CSC	
		936					47.03				CSC	
		949					47.03				CSC	
		962					47.03				CSC	
		975					47.03				CSC	
		988					47.03				CSC	
		1001					47.03				CSC	
		1014					47.03				CSC	
		1027					47.03				CSC	
		1040					47.03				CSC	
		1053					47.03				CSC	
		1066					47.03				CSC	
		1079					47.03				CSC	
		1092					47.03				CSC	
		1105					47.03				CSC	
		1118					47.03				CSC	
		1131					47.03				CSC	
		1144					47.03				CSC	
		1157					47.03				CSC	
		1170					47.03				CSC	
		1183					47.03				CSC	
		1196					47.03				CSC	
		1209					47.03				CSC	
		1222					47.03				CSC	
		1235					47.03				CSC	
		1248					47.03				CSC	
		1261					47.03				CSC	
		1274					47.03				CSC	
		1287					47.03				CSC	
		1300					47.03				CSC	
		1313					47.03				CSC	
		1326					47.03				CSC	
		1339					47.03				CSC	
		1352					47.03				CSC	
		1365					47.03				CSC	
		1378					47.03				CSC	
		1391					47.03				CSC	
		1404					47.03				CSC	
		1417					47.03				CSC	
		1430					47.03				CSC	
		1443					47.03				CSC	
		1456					47.03				CSC	
		1469					47.03				CSC	
		1482					47.03				CSC	
		1495					47.03				CSC	
		1508					47.03				CSC	
		1521					47.03				CSC	
		1534					47.03				CSC	
		1547					47.03				CSC	
		1560					47.03				CSC	
		1573					47.03				CSC	
		1586					47.03				CSC	
		1599					47.03				CSC	
		1612					47.03				CSC	
		1625					47.03				CSC	
		1638					47.03				CSC	
		1651					47.03				CSC	
		1664					47.03				CSC	
		1677					47.03				CSC	
		1690					47.03				CSC	
		1703					47.03				CSC	
		1716					47.03				CSC	
		1729					47.03				CSC	
		1742					47.03				CSC	
		1755					47.03				CSC	
		1768					47.03				CSC	
		1781					47.03				CSC	
		1794					47.03				CSC	
		1807					47.03				CSC	
		1820					47.03				CSC	
		1833					47.03				CSC	
		1846					47.03				CSC	
		1859					47.03				CSC	
		1872					47.03				CSC	
		1885					47.03				CSC	
		1898					47.03				CSC	
		1911					47.03				CSC	
		1924					47.03				CSC	
		1937					47.03				CSC	
		1950					47.03				CSC	
		1963					47.03				CSC	
		1976					47.03				CSC	
		1989					47.03				CSC	
		2002					47.03				CSC	
		2015					47.03				CSC	
		2028					47.03				CSC	
		2041					47.03					

Formation at the Hanford Site, as shown in Table D.1. Water levels in wells 399-1-17A and 399-1-17C were measured during the testing of 399-1-17B. Neither well 399-1-17A, located 29.5 ft from 399-1-17B, nor well 399-1-17C, located 28.0 ft from the pumped well, showed any interpretable response to pumping.

Well 399-1-17B has a total depth of 110 ft, a completed diameter of 6 in., and was set with a No. 40 slot, 6-in., stainless steel well screen from 100 to 110 ft. Figure D.28 illustrates the site stratigraphy and well construction at well 399-1-17B. A more detailed description of the site geology is included in Section 3 of the report.

Well 399-1-17A and well 399-1-17C were incorporated as observation wells during the pumping of 399-1-17B. Well 399-1-17A was completed with 15 ft of No. 40 slot, 6-in., stainless steel screen set from 25 to 40 ft, as documented in Figure D.28. The deep well, 399-1-17C, was completed in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow) beneath the confining clay layer of the Ringold Formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 161 and 171 ft. The site stratigraphy and well construction at well 399-1-17C are illustrated in the well's aquifer test description.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 100 ft to the north of well 399-1-17B. The Columbia River is located approximately 1100 ft to the east of well 399-1-17B (see Figure D.1). Both the river and the trenches may have affected the drawdown and recovery of water levels during aquifer testing. Figure D.29 shows the Columbia River stage fluctuations during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On December

FIGURE D.28. Well 399-1-17B Stratigraphy and Well Construction

300 Area Columbia River Monitoring Station
0015 hrs 2/9/87 - 0245 hrs 2/10/87

FIGURE D.29. Water Level Elevations in the Columbia River
During the Testing of Well 399-1-17B

19, 1986, the well was developed by bailing for 1 hour, and on February 6, 1987, the well was further developed by pumping from 5 to 20 gpm for another 2.5 hours. The pump intake was set at 85 ft below land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal. Water levels were measured by an E-tape and recorded manually. Measurements were made from the top surface of the elevator supporting the pump, which was 2.67 ft above land surface.

The static water level in well 399-1-17B was 35.8 ft below land surface before development. The water was drawn down over 37 ft and equilibrated slowly after pumping was terminated. The static water level was 33.58 ft below land surface (342.18 ft above msl) at the time of the constant-discharge test. Static water levels in wells 399-1-17A and 399-1-17C were 33.37 (342.04 ft above msl) and 0.78 ft below land surface (375.09 ft above msl), respectively, at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 23 gpm. Flow rates during this test were measured with a 5-gal bucket calibrated to 3.77 gal. The discharge rate was just below the range of the available flow meter to be measured accurately, and so flow measurements were recorded by timing the rate at which water filled the bucket to the 3.77-gal mark. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 7120 gal. The water from the test was discharged at the land surface about 1000 ft to the northwest.

Drawdown Test. The constant-discharge pumping test was conducted on February 9, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells. The pumping was terminated after 315 min. The maximum drawdown was 42.03 ft at the time pumping stopped. The specific capacity of the well was approximately 0.55 gpm/ft. The observation wells measured during the aquifer testing of well 399-1-17B did not provide data useful for calculating aquifer coefficients. Well 399-1-17A apparently was not affected by pumping 399-1-17B. Well 399-1-17C, however, did show a drop in water level beginning 14 min into the pumping period. Total drawdown in this well was approximately 0.07 ft. This effect could not be correlated to the pumping of well 399-1-17B, because the Columbia River water levels were dropping before the start of the test and began rising at approximately 1300 hours or 105 min after pumping began.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; only well 399-1-17C showed any changes in water level. The observed water level in this well recovered beyond the static level by 0.16 ft, indicating possible extraneous influences such as river effects, recharge by the trenches, possible atmospheric pressure changes, or a combination of all of these.

Analysis and Interpretation

The pumping rate was measured with a calibrated 5-gal bucket and measurements are considered accurate. Total discharge was 7120 gal which, when divided by the 315 min of pumping, gives a figure of 22.6 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. The pumping rate apparently did not vary during the test.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that this correction also be made for wells that partially penetrate the aquifer. Corrections were applied to the data collected from well 399-1-17B because the drawdown was almost 42 ft of the aquifer thickness of approximately 77 ft (if the unconfined aquifer is considered to range from the static water table to the top of the confining clay layer). The formula used was that recommended by Jacob (1963) in Equation (1).

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the corrected drawdown data is presented in Figure D.30. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to those aquifers:

- 1) that are entirely homogeneous, 2) that are of infinite areal extent,
- 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and
- 5) where the pumped well has an infinitesimal diameter.

In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged

RCRA Well 399-1-17B (C2B)
Corrected Drawdown Data
2/9/87

FIGURE D.30. Well 399-1-17B Observation Drawdown Using the Theis Analysis

instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, a recharge boundary and casing storage effects were encountered, and data were selectively analyzed for the period from 25 to 100 min. Water level data plotted earlier than 25 min into the test indicate pumping rate adjustments and casing storage effects.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2). By using Equation (2) calculations, it would require 25 min of pumping to dissipate the well storage effects if the transmissivity of the aquifer is 900 ft²/day.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses Equation (3). By using Equation (3) calculations, it would require 25 min of pumping to dissipate the well storage effects. In this particular test situation, both methods agree.

The transmissivity calculated using the Theis curve matching method is 250 ft²/day.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values, if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 5 min (if the radius of influence is considered to be within 1 ft of the pumped well). For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing. The transmissivity calculated using the Cooper-Jacob method is 1350 ft²/day. The Cooper-Jacob semi-logarithmic plot of the corrected drawdown data is presented in Figure D.31.

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the corrected recovery data is presented in Figure D.32. The data that were used to calculate transmissivity appear to the left of a t/t' value of 14, [i.e., (315 + 25 min)/25 min]. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. However, only a small number of data points could be analyzed between the end of the borehole effects and the start of the recharge boundary effects. The limitations on the recovery data make the resulting transmissivity evaluation questionable. Regardless, the recovery results were used to calculate the overall transmissivity for the tested interval. The calculated transmissivity from the recovery plot is 1000 ft²/day.

RCRA Well 399-1-17B (C2B)
Corrected Drawdown Data
2/9/87

FIGURE D.31. Well 399-1-17B Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that the values determined for transmissivity are not in complete agreement. The average of the three transmissivity values gives a most probable value of 900 ft²/day. The results of the aquifer test and the well construction are summarized in Table D.9.

The best values for aquifer characteristics determined by this test are a transmissivity of 900 ft²/day and a hydraulic conductivity of 12 ft/day. The aquifer thickness is 77 ft at this location. Aquifer Test Data Sheets for well 399-1-17B follow.

Aquifer Test for Well 399-1-17C (C2C)

Well 399-1-17C (previously labelled C2C) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer and the confined or semiconfined aquifer underlying the clay or silt layer of the lower

RCRA Well 399-1-17B (C2B)
Corrected Recovery Data
2/9/8 - 2/10/87

FIGURE D.32. Well 399-1-17B Water Level Recovery Plot Using the Cooper-Jacob Analysis

Ringold Formation and to provide a means of sampling the water quality of that zone. The confined aquifer has a thickness of approximately 5 ft at this location (5 ft of basalt aquifer). The well was pumped at an average rate of 28 gpm for a period of 360 min. Drawdown in the well demonstrated a specific capacity of 1.35 gpm/ft, a Theis method transmissivity of 430 ft²/day, and a Cooper-Jacob method transmissivity of 1100 ft²/day. The recovery data indicated a transmissivity of 2000 ft²/day. The hydraulic conductivity for the confined aquifer at well 399-1-17C is 260 ft/day (if the aquifer thickness is assumed to be 5 ft and the average transmissivity is 1300 ft²/day). This value is probably indicative of the basalt aquifer, not the basal Ringold Formation, and is not included in Table D.1. Water levels in wells 399-1-17A and 399-1-17B were measured during the testing of 399-1-17C. Neither well 399-1-17A, located 31.9 ft from 399-1-17C, nor well 399-1-17B, located 28.0 ft from the pumped well, showed any interpretable response to pumping.

TABLE D.9. Aquifer Testing and Well Construction Summary for Well 399-1-17B

WELL: 399-1-17B (C2B) DATE OF TEST: 2/9/87

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 375.76
(brass cap)

STATIC WATER LEVEL (date of test): 33.58 ft below lsd

ELEVATION: 342.18 ft above msl

MAXIMUM PUMPING WATER LEVEL: 75.61 ft below lsd

ELEVATION: 300.15 ft above msl

MAXIMUM DRAWDOWN: 42.03 ft

PUMPING RATE: 23 gallons per minute (gpm)

PUMPING TIME: 315 minutes TOTAL DISCHARGE: 7,120 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD:	38 ft below lsd	337.76 ft abv msl
TOP OF CLAY:	108 ft below lsd	267.76 ft abv msl
TOP OF BASALT:	166 ft below lsd	209.9 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 50 ft (15.2 m)

TOP OF SCREEN 100 ft below lsd ELEVATION: 275.76 ft above msl

BOTTOM OF SCREEN 110 ft below lsd ELEVATION: 265.76 ft abv msl

OBSERVATION WELLS:

#1 WELL 399-1-17A (C2A)	TOP OF SCREEN:	25 ft
	BOTTOM OF SCREEN:	40 ft
	DISTANCE FROM PUMPED WELL:	29.5 ft
#2 WELL 399-1-17C (C2C)	TOP OF SCREEN:	161 ft
	BOTTOM OF SCREEN:	171 ft
	DISTANCE FROM PUMPED WELL:	28.0 ft

TABLE D.9. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	250 (23.2)	-----
W(u) = 7		
1/u = 3.4E+8		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 23		
Straight-line Semilog Plot (Cooper-Jacob)	1350 (125.5)	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	1000 (93)	-----
PROBABLE VALUE ft ² /d (m ² /d)	900 (83.7)	-----
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	12 (3.7)	-----

Aquifer Test Data

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Data for Well C2B
Pumping Well C2B
Observation Wells C2A, C2C

Location 300 AREA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured CALIBRATED FLOWMETER

How W.L.'s Measured T-TAP

Rad./Dist. of/From Pumping Well —

Meas. Point for W.L.'s 32' FROM C2B

Elevation of Meas. Point 378.43

Depth of Pump/Airpipe 88' - 2.92' = 85.08' Isd

Pump On: date 2/9/87 time 1115

Pump Off: date 2/9/87 time 1630

Duration of Aquifer Test 315 minutes

Time t = _____ at t' = 0			Water Level Data Elev. <u>342.18</u> Static Water Level <u>36.25'</u> <u>MP</u>				Discharge				Recorded By	Comments	
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or f	Recovery	Q			
2/9	1115	0					36.25	0	<u>5.57</u> <u>MP</u> <u>37'</u>		CSC		
		.30					45.1	8.85	8.07	8.84	ASC		
		1					50.15	13.9	11.97	12.65	22.6	CSC	3.77 gal/10 sec.
		2					58.2	21.95	17.13	18.82	ASC		
		3					62.8	26.55	19.50	21.97	ASC		WHC working
		4					66.25	30.0	21.0	24.16	ASC		Trencher circled
		5					68.95	32.7	22.01	25.76	CSC		to work on
		6					71.1	34.85	22.70	26.96	CSC		gates
		7					72.6	36.95	23.14	27.77	CSC		
		8											
		9					74.8	38.55	23.69	28.90	CSC		
		10					75.3	39.0	23.81	29.17	22.6	CSC	3.77 gal/10 sec.
		12					76.2	39.5	23.99	29.59	CSC		
		14					76.5	40.25	24.05	29.73	CSC		
	17	16					77.0	40.75	24.14	29.78	CSC		
		18											
		20					77.3	41.05	24.20	30.11	CSC		
		25					77.7	41.02	24.19	30.09	22.6	CSC	3.77 gal/10 sec.
		30					77.40	41.15	24.22	30.15	CSC		
		35					77.47	41.22	24.23	30.19	CSC		
		40					77.53	41.28	24.24	30.21	CSC		
		45					77.57	41.32	24.25	30.23	22.6	CSC	3.77 gal/10 sec.
		50					77.59	41.34	24.25	30.24	CSC		
		60					77.72	41.47	24.27	30.30	22.6	CSC	3.77 gal/10 sec.
		70					77.79	41.54	24.28	30.34	CSC		
		80					77.83	41.58	24.29	30.35	22.6	CSC	3.77 gal/10 sec.
		90					77.87	41.62	24.30	30.37	CSC		
		100					77.89	41.64	24.30	30.38	CSC		
		110					77.90	41.65	24.30	30.39	22.6	CSC	3.77 gal/10 sec.
		120					77.93	41.68	24.31	30.40	CSC		
		150					77.97	41.62	24.30	30.37	22.6	CSC	3.77 gal/10 sec.
		180					77.91	41.66	24.30	30.39	22.6	CSC	3.77 gal/10 sec.
		210					78.02	41.77	24.32	30.44	CSC		WHC refilling
		240					78.20	41.95	24.35	30.52	CSC		trencher
		270					78.25	42.0	24.36	30.55	22.6	CSC	3.77 gal/10 sec.
		300					78.28	42.03	24.36	30.56	22.6	CSC	3.77 gal/10 sec.
		315											7120 gal. total

Aquifer Test Data

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Data for Well C 2 B

Pumping Well C 2 E

Observation Wells C 2 A, C 2 C

Location 300 AREA

Type of Aquifer Test RECOVERY - CONSTANT DISCHARGE

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well 2.67' ISD

Meas. Point for W.L.'s TOP ELEVATION

Elevation of Meas. Point 2.67' ISD

Depth of Pump/Airpipe 95.08' Below G.C.

Pump On: date 2/9/87 time 11:15

Pump Off: date 2/9/87 time 16:30

Duration of Aquifer Test 5 hr 15 min.

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>36.25'</u>					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	g.p.s.	Corrected Reading	Q			
2/9	10:30	0	0	1			36.25	400	30.56			CSC	RECOVERY
	3:55	0	0	1			65	28.75	23.38			CSC	
	10:51	1	3:16	0.316			52.42	23.17	19.68			CSC	
			1:30										
	11:52	2	3:17	0.317			53.30	17.05	15.16			CSC	
			2:30				48.28						
		3	3:18	0.318			53.30	12.07	11.09			CSC	
			3:30										
	16:54	4	3:19	0.319			44.32	-8.07	7.65			CSC	
			4:30										
		5	3:20	0.320			42.17	-5.87	5.64			CSC	
		6	3:21	0.321			40.33	-4.08	3.97			CSC	
		7	3:22	0.322			39.39	-3.14	3.08			CSC	
		8	3:23	0.323			38.26	-2.01	1.98			CSC	
		9	3:24	0.324			37.60	-1.35	1.34			CSC	
		10	3:25	0.325			37.25	-1.00	.99			CSC	
		11	3:26	0.326			37.02	-.77	.77			CSC	
		12	3:27	0.327			36.80	-.55	.55			CSC	
	3:30	15	3:28	0.328			36.41	-.16	.16			CSC	
	3:32	17	3:29	0.329			36.32	-.07	.07			CSC	
		18	3:33	0.330			36.27	-.02	.02			CSC	
		20	3:35	0.335			36.24	-.01	-.01			CSC	
		25	3:40	0.340			36.18	-.07	-.07			CSC	
		30	3:45	0.350			36.16	-.09	-.09			CSC	
		35	3:50	0.355			36.15	-.10	-.10			CSC	
		40	3:55	0.360			36.11	-.14	-.14			CSC	
		45	4:00	0.365			36.12	-.13	-.13			CSC	
		50	4:05	0.370			36.27	-.02	.02			CSC	
	17:30	60	4:15	0.375			36.27	-.02	.02			CSC	
		70	4:25	0.385			36.24	-.01	-.01			CSC	
		80	4:35	0.395			36.27	-.02	.02			CSC	
	18:00	90	4:45	0.405			36.23	-.02	-.02			CSC	
	7:15	1190	8:55	1.4			36.23	-.02	-.02			SPA	
	8:03	1248	9:33	1.3			36.25	.0	0			SPA	
	9:15	1320	10:05	1.3			36.06	-.19	-.19			SPA	

Aquifer Test Data

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Data for Well C20

Pumping Well C20

Observation Wells C21, C22

Location 300 AREA

Type of Aquifer Test CONSTANT-RATE PUMP

How Q Measured CALIBRATED "ROCKET"

How W.L.'s Measured STAFF

Rad./Dist. of/From Pumping Well 30'

Meas. Point for W.L.'s 30.25" T/C to L.S.

Elevation of Meas. Point 2.52' → 375.37' msl

Depth of Pump/Airpipe 28-35' = 85'

Pump On: date 2/4/87 time 11:15 hrs

Pump Off: date 2/4/87 time 16:30 hrs

Duration of Aquifer Test 5.25 hrs

Time					Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level _____ Msp							
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q	
	11:15	0					3.30	0				
		:30					3.30	0				EL
		1										
		1:30										
		2										
		2:30					3.30	0				EL
		3										
		3:30										
		4					3.30	0				EL
		4:30										
		5					3.30	0				EL
		6										
		7										
		8										
		9										
		10										
		11					3.30	0				EL
		12										
		14					3.33	.03				EL
		16					3.34	.04				CSC
		18										
		20					3.33	.03				EL
		25										
		30					3.33	.03				EL
		35										EL
		40					3.33	.03				EL
		45					3.33	.03				EL
		50					3.33	.03				EL
	12:15	60					3.33	.03				EL
		70										
		80					3.34	.04				EL
		90										
		100					3.34	.04				EL
		110										
	13:15	120					3.36	.06				EL
		150					3.36	.06				CSC
	14:15	180					3.37	.07				EL
		210					3.37	.07				EL
	15:15	240					3.36	.06				CSC
		270					3.36	.06				
	16:15	300					3.36	.06				EL
CSC Steel Tank 3.35												

CSC STEEL T/R 3.35'
EL

Aquifer Test Data

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Data for Well C2C

Pumping Well C2B

Observation Wells _____

Location 300 AREA

Type of Aquifer Test RECOVERY-CONSTANT DISCHARGE

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured R-TAPE

Rad./Dist. of/From Pumping Well 12'

Meas. Point for W.L.'s 2.52' T/c to LSP

Elevation of Meas. Point _____

Depth of Pump/Airpipe 85.08' BW LSP

Pump On: date 2/9/87 time 11:15 hrs

Pump Off: date 2/9/87 time 16:30 hrs

Duration of Aquifer Test 5.25 hrs

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>3.30' E-TAPE</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t' min	t/t'	Reading	Conversions or Corrections	Water Level	✓ or ✗	Read- ing	Q		
2/9		3:15	0				336	.06			SPA	RECOVERY
		3:15.5	.5	631			336	.06				
		3:16	1	316			336	.06				
		3:16.5	1.5				336	.06				
		3:17	2	158.5			336	.06				
		3:17.5	2.5				336	.06				
		3:18	3	106			336	.06				
		3:18.5	3.5				336	.06				
		3:19	4	79.8			336	.06				
		3:19.5	4.5				336	.06				
		3:20	5	64			336	.06				
		3:21	6	53.5			336	.06				
		7 min	7	46			336	.06				
		8	8	40.4			336	.06				
		9	9	36			336	.06				
		10	10	32.5			336	.06				
		12	12	27.3			336	.06				
		14	14	23.5			336	.06				
		16	16	20.7			336	.06				
		18	18	18.5			336	.06				
		20	20	16.8			336	.06				
		25	25	13.6			336	.06				
		30	30	11.5			336	.06				
		35	35	10			336	.06				
		40	40	8.9			334	.04				
		45	45	8			334	.04				
		50	50	7.3			334	.04				
		55	55	6.7			333	.03				
		60	60	6.25			332	.02				
		70	70	5.5			332	.02			CSC	
		80	80	4.9			332	.02			CSC	
		119.5	880	1.4			331	.01			CSC	
		124.9	934	1.34			323	-.07			SPA	
		132.2	1007	1.3			322	-.08			SPA	
							314	-.16			SPA	

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Data for Well C 2 APumping Well C 2 A

Observation Wells 124422

Location 300 AREA

Type of Aquifer Test CONSTANT-DECHARGE

How Q Measured CALIBRATED TROUGH

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well 29.5'

Meas. Point for W.L.'s 28.5" 7/c to

Elevation of Meas. Point 2.38' 377.79

Depth of Pump/Airpipe 88' - 3.5"

Pump On: date 2/9/82 time 1115

Pump Off: date 2/9/87 time 16:30

Duration of Aquifer Test 315 min.

$$\text{elevation of brace cap} = 375.41 - 33.37 = 342.04$$

Recovery trenches
have been
filled with the
after working on
them

Well 399-1-17C has a total depth of 171 ft, a completed diameter of 6 in., and was set with a No. 20 slot, 6-in., stainless steel well screen from 161 to 171 ft in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow). Figure D.33 illustrates the site stratigraphy and well construction at well 399-1-17C. A more detailed description of the site geology is included in Section 3 of the report.

Well 399-1-17A and well 399-1-17B were incorporated as observation wells during the pumping of 399-1-17C. Well 399-1-17A was completed with 15 ft of No. 40 slot, 6-in., stainless steel screen set from 25 to 40 ft, as documented in Figure D.28. The intermediate well, 399-1-17B, was completed in the lower portion of the unconfined aquifer above the confining or semiconfining clay layer of the Ringold Formation. A No. 40 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 100 and 110 ft. Figure D.28 illustrates the site stratigraphy and well construction at well 399-1-17B.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 100 ft to the north of well 399-1-17C. The Columbia River is located approximately 1100 ft to the east of well 399-1-17C (see Figure D.1). The river, trenches, or atmospheric conditions may have affected the drawdown and recovery of water levels during aquifer testing. Figure D.34 shows the changes in river stage during the period of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On February 10, 1987, the well was developed by bailing for 1.5 hours, using a 5-in. dart bailer, and was further developed by pumping from 15 to 32 gpm for another 2.0 hours. The pump intake was set at 85 ft below land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal and a McCrometer® flow meter (#82-3-226). Water levels were measured by an E-tape and recorded manually.

FIGURE D.33. Well 399-1-17C Stratigraphy and Well Construction

300 Area Columbia River Monitoring Station
0015 hrs 2/11/87 - 0246 hrs 2/12/87

FIGURE D.34. Water Level Elevations in the Columbia River During the Testing of Well 399-1-17C

Measurements were made from the top surface of the elevator supporting the pump, which was 2.79 ft above the land surface.

The static water level in well 399-1-17C was 0.90 ft below land surface before development. The water was drawn down over 19.5 ft and equilibrated slowly after pumping was terminated. The static water level was 0.80 ft below land surface (375.07 ft above msl) at the time of the constant-discharge test. Static water levels in wells 399-1-17A and 399-1-17B were 33.06 (342.35 ft above msl) and 33.31 ft below land surface (342.45 ft above msl), respectively, at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 28 gpm. Flow rates during this test were measured with a 5-gal bucket calibrated to 3.77 gal and a McCrometer® flow meter. The discharge rate was measured by timing the

rate at which water filled the bucket to the 3.77-gal mark and by corroborating these measurements with those from the flow meter by subtracting accumulated flow at the beginning of a timed interval from that recorded at the end of the interval. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 10,085 gal. The water from the test was discharged at land surface about 1000 ft to the northwest.

Drawdown Test. The constant-discharge pumping test was conducted on February 11, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells. The pumping was terminated after 360 min. The maximum drawdown was 20.68 ft at the time pumping stopped. The specific capacity of the well was approximately 1.35 gpm/ft. The observation wells measured during the aquifer testing of well 399-1-17C did not provide data useful for calculating aquifer coefficients. Both well 399-1-17A and well 399-1-17B apparently were not affected by pumping 399-1-17C.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; neither well showed any interpretable changes in water level. The observed water level in the pumped well recovered beyond the static level by 0.45 ft, indicating possible extraneous influences such as river effects, recharge by the trenches, possible atmospheric pressure changes, or a combination of all of these. Figure D.34 shows the changes in river-stage but does not indicate the possible delay that may occur between these changes and the eventual effect in well 399-1-17C.

Analysis and Interpretation

The pumping rate was measured with both a calibrated 5-gal bucket and a McCrometer® flow meter. The flow meter measurements are considered more accurate than those obtained by the calibrated bucket because the discharge rate was great enough to fill the bucket in a very short period of time, thus, creating a greater potential for error. Total discharge was 10,085 gal, which, when divided by the 360 min of pumping, gives a figure of 28.01 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. The pumping rate apparently did not vary more than 1 gpm during the test.

Transmissivity Calculations for the Drawdown Test. There may be a number of reasons why water levels are drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Corrections were not required for data collected from well 399-1-17C because the aquifer in which this well is screened is confined, and the total thickness is probably represented by the brecciated materials of the basalt and the sediments below the bottom of the Ringold clay layer.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.35. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells, if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to those aquifers: 1) that are entirely homogeneous, 2) that are of infinite areal extent, 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and 5) where the pumped well has an infinitesimal diameter. In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, since confined conditions pertain, most of the assumptions may be considered reasonable and the data represented during the latter portion of testing are probably accurate. Data are selectively analyzed for the period from 23 to 100 min. Water level data plotted earlier than 17 min into the test indicate

RCRA Well 399-1-17C (C2C)
Constant-Discharge Drawdown
2/11/87

FIGURE D.35. Well 399-1-17C Observed Drawdown Using the Theis Analysis

pumping rate adjustments and possible casing storage effects. The data collected after 100 min of pumping are probably affected by changes in river stage.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2). Using this equation, it would require 17 min of pumping to dissipate the well storage effects, if the transmissivity of the aquifer is 1300 ft²/day.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses Equation (3). Using this equation, it would require 13 min of pumping to dissipate the well storage effects. In this particular test situation, both methods are in close agreement; however, the more conservative Hargis value is used as the end of borehole storage.

The transmissivity calculated using the Theis curve matching method is 430 ft²/day.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximation of transmissivity and storativity values, if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 5 min, since only the pumped well is used to calculate a transmissivity value. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing, if the observation wells are in the same aquifer. The transmissivity calculated using the Cooper-Jacob method is 1100 ft²/day. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.36.

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob

FIGURE D.36. Well 399-1-17C Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.37. The data that were used to calculate transmissivity appear to the left of a t/t' value of 22 [i.e., $(360 + 17 \text{ min})/17 \text{ min}$]. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. The calculated transmissivity from the recovery plot is $2000 \text{ ft}^2/\text{day}$.

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that the values determined for transmissivity are not in complete agreement. The changes in the Columbia River stage during the period of testing may be the reason for the differences between the recovery and the drawdown data, but these changes do not explain

FIGURE D.37. Well 399-1-17C Water Level Recovery Plot Using the Cooper-Jacob Analysis

the discrepancy between the Theis-type curve results and those obtained by the modified Theis method. The most likely transmissivity was obtained by averaging the results. The aquifer test and well construction data are summarized in Table D.10.

The best values for aquifer characteristics determined by this test are a transmissivity of $1300 \text{ ft}^2/\text{day}$ and a hydraulic conductivity of $260 \text{ ft}/\text{day}$. The confined aquifer thickness is approximately 5 ft at this location. Aquifer Test Data Sheets for well 399-1-17C follow.

Aquifer Test for Well 399-1-16C (C1B)

Well 399-1-16C (previously labelled C1B) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer and the confined or semiconfined aquifer underlying the clay or silt layer of the lower Ringold Formation and to provide a means of sampling the water quality of the confined zone. The confined aquifer has a thickness of approximately 5 to 10 ft at this location (this includes the basalt layer). The well was pumped at an average rate of 2.8 gpm for a period of 480 min. Drawdown in the well demonstrated a specific capacity of 0.07 gpm/ft, a Theis method transmissivity of $15 \text{ ft}^2/\text{day}$, and a Cooper-Jacob method transmissivity of $10 \text{ ft}^2/\text{day}$. The recovery data indicated a transmissivity value of $90 \text{ ft}^2/\text{day}$. The hydraulic conductivity for the unconfined aquifer at well 399-1-16C is approximately 9 ft/day. This value is within the range of the typical conductivity for the basal unit of the Ringold Formation at the Hanford Site as shown in Table D.1. Water levels in wells 399-1-16A, 399-1-17B, and 399-1-16D were measured during the testing of 399-1-16C. Neither well 399-1-16A, located 23.6 ft from 399-1-16C, well 399-1-16B, located 41.9 ft from the pumped well, nor well 399-1-16D, located 19.3 ft from the pumped well, showed any interpretable response to pumping.

Well 399-1-16C has a total depth of 177.5 ft, a completed diameter of 6 in., and was set with a No. 20 slot, 6-in., stainless steel well screen from 167 to 177.5 ft in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow). Figure D.38 illustrates the site stratigraphy and well construction at well 399-1-16C. A more detailed description of the site geology is included in Section 3 of the report.

TABLE D.10. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	430 (40)	-----
W(u) = 10		
1/u = 7E+7		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 28		
Straight-line Semilog Plot (Cooper-Jacob)	1100 (102.2)	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	2000 (185.9)	-----
PROBABLE VALUE ft ² /d (m ² /d)	1300 (120.8)	-----
STORATIVITY:	-----	
CONDUCTIVITY: ft/d (m/d)	260 (79.2)	-----

Aquifer Test Data

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Data for Well C2C

Pumping Well C2C

Observation Wells C2A, C2E

Location 200 ARFL PCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FLOW METER / CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe RS' - 2.92 = 85.00' LSL

Rad./Dist. of From Pumping Well _____

Pump On: date 2/11/87 time 1135

Meas. Point for W.L.'s ELIADA 2.79' LSP

Pump Off: date 2/11/87 time 1735

Elevation of Meas. Point _____

Duration of Aquifer Test 6 hr.

Time t = _____ at t' = 0					3.57' Water Level Data E-TAPE Static Water Level 3.59'				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or y	Reading	Q		
	1135	0					3.59	0	4690		CSC	McGrometer #
		:30									CSC	82-3-226
		1					14.60	11.01			CSC	
		1:30									CSC	Wife working on
		2					18.70	15.17			CSC	Process traches
		2:30									CSC	
		3					20.67	17.08			CSC	
		3:30									CSC	
		4					21.63	18.04			CSC	
		4:30							6480		CSC	
		5					22.08	18.49				
		6					22.37	18.78	32.3		CSC	3.77 gal / 7 sec
		7					22.51	18.92			CSC	
		8					22.51	18.92			CSC	
		9					22.60	19.01			CSC	
		10					22.69	19.10			CSC	65000 11 min.
		12					22.77	19.18			CSC	65050 13 min.
		14					22.82	19.23			CSC	65100 14.75 min.
		16					22.86	19.27	32.3		CSC	65160 17 min. 3.77/4 sec
		18					22.86	19.27			CSC	65210 18.75 min.
		20					22.91	19.32			CSC	65300 22 min.
		25					22.97	19.38			CSC	65340 23.5
		30					23.04	19.45			CSC	65410 25 min. } 28 min
		35					23.10	19.51			CSC	65470 28.25
		40					23.13	19.59			CSC	65610 33.25
		45					23.15	19.56			CSC	65810 40.50 min. } 27.6
		50					23.20	19.61	3.77/4 sec. 32		CSC	66100 51.0 min. } 28.6
	1235	60					23.27	19.68			CSC	66180 54.0
		72					23.32	19.73			CSC	66400 62.0 min. } 27.5
		80					23.35	19.76	3.77/4 sec. 32		CSC	66540 67.0 min. } 28
		90					23.52	19.93			CSC	66870 79.0 min.
		100					23.50	19.93			CSC	67150 89.0 min.
		110					23.57	19.98			CSC	67430 99.0 min. } 28
	1335	120					23.55	19.96			CSC	67820 113.0
		150					23.77	20.18	3.77/4 sec.		CSC	68710 144.75 } 28
	1435	180					23.88	20.29			CSC	69570 175.50 } 28
		210					23.95	20.36	3.77/4 sec. 32		CSC	70380 204.25 } 28
	1535	240					24.04	20.45			CSC	70830 220.25 } 28
		270					24.10	20.51	3.77/4 sec.		CSC	71500 244.0 } 25.2

Aquifer Test Data

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Data for Well C2C

Pumping Well C2C

Observation Wells C2A, C2B

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FLOW METER / CALIBRATED BUCKET

How W.L.'s Measured F-TAPE

Rad./Dist. of From Pumping Well —

Meas. Point for W.L.'s ELEVATOR 279' L&D

Elevation of Meas. Point —

Depth of Pump/Airpipe 25.08' L&D

Pump On: date 2/11/87 time 1135

Pump Off: date 2/11/87 time 1735

Duration of Aquifer Test 6 hr

RECORDED

Time				Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0				Static Water Level _____ E-Tape							
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or f'	Reading	Q	
2/11	1635	300					24.17	20.58		(28.1)	
	1735	360					24.27	20.68	3.77		
		420	30	7.21			13.7	5.10.11			
		480	1	361			9.16	5.57	74775		
		540	1:30								
		600	2	181			5.17	1.58			
		660	3	121			4.12	.53			
		720	4	91			4.03	.44			
		780	5	73			4.02	.43			
		840	6	61			3.99	.40			
		900	7	52.4			4.01	.42			
		960	8	46			4.00	.41			
		1020	9	41			3.98	.39			
		1080	10	37			3.99	.40			
		1140	12	31			3.99	.40			
		1200	14	26.7			3.97	.38			
		1260	16	23.5			3.92	.38			
		1320	18	21			3.89	.30			
		1380	20	19			3.94	.35			
		1440	25	15.4			3.96	.37			
		1500	30	13			3.95	.36			
		1560	35	11.3			3.93	.34			
		1620	40	10			3.92	.33			
		1680	45	9			3.92	.33			
		1740	50	8.2			3.91	.32			
1835		1800	60	7			3.88	.29			
		1830	70	6.1			3.87	.28			
		1840	80	5.5			3.86	.27			
		1850	90	5			3.84	.25			
		1900	100	4.6			3.82	.23			
		1910	110	4.3			3.81	.22			
1935		1930	120	4			3.80	.21			
2000		5:10	150	3.4			3.76	.17		SPA	
2025		5:20	180	2.9			3.73	.14		SPA	
2105		5:30	210	2.7			3.72	.13		SPA	
2135		5:42	240	2.5			3.68	.09		SPA	

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Data for Well C-20

Pumping Well C2C

Observation Wells _____

Location 300 AREA 100A

Type of Aquifer Test Gravelly - Y - constant Vol. 104-80.

How Q Measured FLOWSHEET/CALIBRATED TUCKER

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe 85' L2D

Rad./Dist. of/From Pumping Well _____

Pump On: date 2/4/87 time 1135

Meas. Point for W.L.'s _____

Pump Off: date 2/11/87 time 1735

Elevation of Meas. Point _____

Duration of Aquifer Test 10 hr

[illegible]

Aquifer Test Data

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Data for Well C26

Pumping Well C26

Observation Wells C24, C25

Location 300 AREA PERA

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured FLOW METER / CALCULATED BUCKET

How W.L.'s Measured E-TAPE

Depth of Pump/Airpipe

Rad./Dist. of/From Pumping Well

Pump On: date 2/11/87 time 14:35

Meas. Point for W.L.'s T/2 ELEV = 878.15

Pump Off: date time

Elevation of Meas. Point

Duration of Aquifer Test

Time t = _____ at t' = 0				Water Level Data STEEL TAPE Static Water Level <u>35.70</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
2/11	11:35	0				35.70				CSC	E-TAPE
		9				35.75				EL	
		19				35.76				EL	
		36				35.72				CSC	
		48				35.72				CSC	
		59				35.71				CSC	
		65				35.71				EL	
		82				35.72				CSC	
		94				35.74				CSC	
		110				35.76				EL	
		124				35.74				CSC	
		148				35.74				CSC	
		172				35.72				CSC	
		212				35.72				CSC	
		238				35.72				CSC	
		267				35.74				CSC	
		295				35.73				CSC	
		348				35.72				CSC	
		357				35.75				CSC	
1735	9	0									
1748	16	13				35.76				CSC	Recovery
		27				35.67				CSC	
		37				35.72				CSC	
		47				35.80				CSC	
		63				35.82				CSC	
		71				35.80				CSC	
1908	93					35.50				CSC	
	104					35.72				CSC	
	128					35.82				CSC	
20:06						35.82				SPA	
20:44						35.98				SPA	
21:03						35.68				SPA	
21:37						35.82				SPA	
22:10						35.89				SPA	
22:40						35.89				SPA	
23:35						35.81				SPA	
01:38						35.80				SPA	
06:09						35.65				GVL	

Aquifer Test Data

page 1 of 1

Data for Well C.2-A

Pumping Well C.2-C

Observation Wells C.2-A, C.2-B

Location 300 AREA

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured FLOWMETER / CALCULATED BUCKET

How W.L.'s Measured F-TAPE

Depth of Pump/Airpipe

Rad./Dist. of From Pumping Well

Pump On: date 2/11/87 time

Meas. Point for W.L.'s T/C

Pump Off: date 2/11/87 time

Elevation of Meas. Point

Duration of Aquifer Test

12 15 45-
42-
40-
38-
36-

Time t = <u> </u> at t' = 0					25.44' Water Level Data Static Water Level				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
		8			35.46'		35.52'				FL	
		9					35.52'				FL	
		19					35.52"				EL	
		38					35.52"				EL	
		64					35.5 1/2"				CSC	
		95					35.5 1/2"				FL	
		110					35.5 1/2"				FL	
		125					35.5 1/2"				EL	
		149					35.5 1/2"				CSC	
		174					35.5 1/2"				CSC	
		214			35.48'		35.5 1/2"				CSC	
		242			35.48'		35.5 1/4"				CSC	
		268			35.48'		35.5 1/4"				CSC	
		296			35.48'		35.5 1/4"				EL	
		348			35.50		35.6"				FL	
	1735											
	1750	15			35.50'		35.6"				CSC	Recovery
		28			35.50'		35.6"				CSC	
		48			35.50		35.6"				CSC	
		65			35.50		35.6"				CSC	
		73			35.50		35.6"				CSC	
	1910	95			35.50		35.6"				CSC	
		116			35.52		35.6 1/4"				CSC	
		131			35.52		35.6 1/4"					
	20:08				35.50		35.6"				SPA	
	20:45				35.49		35.5 3/8"				GPA	
	21:07				35.49		35.5 3/8"				SPA	
	21:38				35.51		35.6 1/8"				SPA	
	22:12				35.47		35.5 3/8"				SPA	
	22:42				35.52		35.6 1/4"				SPA	
	23:38				35.52		35.6 1/4"				SPA	
	0:33				35.52		35.6 1/4"				SPA	
	06:05				35.41		35.4 3/4"				GA

FIGURE D.38. Well 399-1-16C Stratigraphy and Well Construction

Wells 399-1-16A, 399-1-16B, and 399-1-16D were incorporated as observation wells during the pumping of well 399-1-16C. Well 399-1-16A was completed with 15 ft of No. 40 slot, 6-in., stainless steel screen set from 32 to 47 ft, as documented in its aquifer test description. The two intermediate wells, 399-1-16B and 399-1-16D, were completed in the lower portion of the unconfined aquifer above the confining or semiconfining clay layer of the Ringold Formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 105 and 115 ft and a No. 40 slot, 6-in.-diameter, stainless steel screen was installed between 106 and 116 ft to complete wells 399-1-16B and 399-1-16D, respectively. The site stratigraphy and well construction at wells 399-1-16B and 399-1-16D are illustrated in their aquifer test descriptions.

Test Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 700 ft to the west of well 399-1-16C. The Columbia River is located approximately 400 ft to the east of well 399-1-16C (see Figure D.1). The river or atmospheric conditions may have affected the drawdown and recovery of water levels during aquifer testing. Figure D.39 shows the changes in river stage at the 300 Area Columbia River surface-monitoring station during the time of aquifer testing.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and determine the optimal discharge rate. Besides developing the well by bailing after completion, the well was further developed by pumping from 3 to 5.7 gpm for approximately 3 hours on February 13, 1987. The pump intake was set at 127 ft below the land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal. Water levels were measured by an E-tape and recorded manually. Measurements during development were made from the top surface of the elevator supporting the pump, which was 2.16 ft above the land surface. Measurements made during the constant-discharge test were made through a stilling hose standing 2.42 ft above the land surface.

300 Area Columbia River Monitoring Station
0016 hrs 2/17/87 - 0248 hrs 2/18/87

FIGURE D.39. Water Level Elevations in the Columbia River During the Testing of Well 399-1-17C

The static water level in well 399-1-16C was 25.84 ft below land surface before development. The water was drawn down over 98 ft and equilibrated slowly after pumping was terminated. The static water level was 26.77 ft below land surface (353.91 ft above msl) at the time of the constant-discharge test. Static water levels in wells 399-1-16A, 399-1-16B, and 399-1-16D were 39.05 ft below land surface (341.44 ft above msl), 38.30 ft below land surface (342.01 ft above msl), and 36.76 ft below land surface (344.24 ft above msl), respectively, at the time of the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 2.8 gpm. Flow rates during this test were measured with a 5-gal bucket calibrated to 3.77 gal. The flow meter was not used because of the low discharge rate. The discharge rate was measured by timing the rate at which water filled the bucket

to the 3.77-gal mark. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 1344 gal. The water from the test was discharged at the land surface about 500 ft to the northeast.

Drawdown Test. The constant-discharge pumping test was started at 1040 hours on February 17, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells. The pumping was terminated after 480 min, as planned. The maximum drawdown was 43.03 ft at the time pumping stopped. The specific capacity of the well was approximately 0.07 gpm/ft. The observation wells measured during the aquifer testing of well 399-1-16C did not provide data useful for calculating aquifer coefficients. The observation wells, apparently, were not affected by pumping 399-1-16C.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; none of the wells showed any interpretable changes in water level. The observed water level in the pumped well recovered to 1.01 ft of the static level 480 min after pumping stopped. However, by 1045 hours on February 18, 1987, the water level had recovered to 25.01 ft of land surface datum, 1.76 ft beyond the original starting level, indicating possible influence by the Columbia River. Figure D.39 shows the river fluctuations during the period of drawdown testing and the first 8 hours of recovery.

Analysis and Interpretation

The pumping rate was measured with both a calibrated 5-gal bucket and a McCrometer® flow meter. The flow meter measurements are considered inaccurate because of the low discharge rate. The discharge could be measured much more accurately using the calibrated bucket, because the time it took to fill the container to the 3.77-gal mark was approximately 80 s. Total discharge was 1344 gal, which, when divided by the 480 min of pumping, gives a rate of 2.8 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. The pumping rate apparently did not vary more than 0.5 gpm, after the valve had been adjusted properly.

Transmissivity Calculations for the Drawdown Test. There may be a number of reasons why water levels are drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that this correction also be made for wells that partially penetrate the aquifer. Corrections were not required for data collected from well 399-1-16C because the aquifer in which this well is screened is confined, and the total thickness is probably represented by the sediments below the bottom of the Ringold clay layer and by the brecciated materials of the basalt, a total thickness of probably 10 ft.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.40. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to those aquifers:

- 1) that are entirely homogeneous, 2) that are of infinite areal extent, 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and 5) where the pumped well has an infinitesimal diameter. In addition, the Theis method only applies to unconfined water bodies in which the water in the volume of sediments through which the water table has fallen is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, because confined conditions pertain, most of the assumptions may be considered reasonable and the data represented during the latter portion of testing are probably

FIGURE D.40. Well 399-1-16C Observed Drawdown Using the Theis Analysis

accurate. Data are selectively analyzed for the period from 280 to 480 min. Water level data plotted earlier than 280 min into the test indicate pumping rate adjustments and possible casing storage effects.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2). Using this equation, it would require 250 min of pumping to dissipate the well storage effects if the transmissivity of the aquifer is $90 \text{ ft}^2/\text{day}$.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses Equation (3). Using this equation, it would require 280 min of pumping to dissipate the well storage effects. In this particular test situation, both methods agree to some extent; however, the more conservative Schafer value is used as the end of borehole storage.

The transmissivity calculated using the Theis curve matching method is $15 \text{ ft}^2/\text{day}$.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 4 min because the pumped well is used to analyze the aquifer data. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing, if the observation wells are in the same aquifer. The transmissivity calculated using the Cooper-Jacob method is 10 ft²/day, based on data analyzed after 280 min of pumping (only four data points). The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.41.

FIGURE D.41. Well 399-1-16C Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.42. The data that were used to calculate transmissivity appear to the left of a t/t' value of 2.7 [i.e., $(480 + 280 \text{ min})/280 \text{ min}$]. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more reliable than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. The calculated transmissivity from the recovery plot is $90 \text{ ft}^2/\text{day}$.

Analysis of selected portions of the constant-discharge, drawdown, and recovery sections of the aquifer test indicates that the values determined for transmissivity are not in complete agreement. The extended period of borehole

FIGURE D.42. Well 399-1-16C Water Level Recovery Plot Using the Cooper-Jacob Analysis

storage effects necessitated using only a few data points in the transmissivity calculations. The drawdown values are suspect, because the discharge rate fluctuated considerably over the period of drawdown testing. For these reasons, the most reliable data probably were obtained during the recovery test, and the recovery transmissivity will be considered the most probable transmissivity for the confined aquifer at this location. The results of the aquifer testing and well construction are summarized in Table D.11.

The best values for aquifer characteristics determined by this test are a transmissivity of $90 \text{ ft}^2/\text{day}$ and a hydraulic conductivity of 9 ft/day . The aquifer thickness is 10 ft at this location. Aquifer Test Data Sheets for well 399-1-16C follow.

Aquifer Test for Well 399-1-16B (C1D)

Well 399-1-16B (previously labelled C1D) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer, including the Hanford formation and that portion above the base of the uppermost sand and gravel layer of the Ringold Formation, and to provide a means of sampling the water quality of this lower zone. The aquifer has a saturated thickness of approximately 80 ft at this location. The well was tested twice, the first time at an average pumping rate of 12 gpm for 800 min, and the second time at an average rate of 20 gpm for 300 min. Drawdown in the well demonstrated a specific capacity of 0.83 gpm/ft during the first test and a specific capacity of 0.71 gpm/ft during the second pumping period. No transmissivity or conductivity values could be calculated from data collected from the pumped well because of borehole (casing) storage effects and river boundary conditions. Water levels in wells 399-1-16A, 399-1-16C, and 399-1-16D were measured during the testing of well 399-1-16B. Neither well 399-1-16A, located 23.1 ft from 399-1-16B, nor well 399-1-16C, located 41.9 ft from the pumped well, showed any interpretable response to pumping. Water levels in observation well 399-1-16D, located 28.1 ft from the pumped well, dropped 3.46 ft during the first test and 3.59 ft during the second constant-discharge test. An average transmissivity value of $170 \text{ ft}^2/\text{day}$, a conductivity value of 2 ft/day , and a storativity of 0.001 were determined from data collected from this observation well. The hydraulic conductivity is low compared to the typical conductivity for the middle Ringold at the Hanford Site as shown in Table D.1.

TABLE D.11. Aquifer Testing and Well Construction Summary for Well 399-1-16C

WELL: 399-1-16C (C1B) DATE OF TEST: 2/17/87

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 380.68

STATIC WATER LEVEL (date of test): 26.77 ft below lsd
ELEVATION: 353.91 ft above msl

MAXIMUM PUMPING WATER LEVEL: 69.80 ft below lsd
ELEVATION: 310.88 ft above msl

MAXIMUM DRAWDOWN: 42.03 ft

PUMPING RATE: 2.8 gallons per minute (gpm)

PUMPING TIME: 480 minutes TOTAL DISCHARGE: 1,344 gallons

ESTIMATED DEPTH TO:
TOP OF RINGOLD: 32 ft below lsd 348.7 ft abv msl
TOP OF CLAY: 118 ft below lsd 262.7 ft abv msl
TOP OF BASALT: 172 ft below lsd 208.7 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 54 ft (16.46 m)

TOP OF SCREEN 167 ft below lsd ELEVATION: 213.7 ft above msl

BOTTOM OF SCREEN 177.5 ft below lsd ELEVATION: 203.2 ft abv msl

OBSERVATION WELLS:

#1 WELL 399-1-16A (C1A)	TOP OF SCREEN:	32 ft
	BOTTOM OF SCREEN:	47 ft
	DISTANCE FROM PUMPED WELL:	23.6 ft
#2 WELL 399-1-16B (C1D)	TOP OF SCREEN:	105 ft
	BOTTOM OF SCREEN:	115 ft
	DISTANCE FROM PUMPED WELL:	41.9 ft
#3 WELL 399-1-16D (C1C)	TOP OF SCREEN:	106 ft
	BOTTOM OF SCREEN:	116 ft
	DISTANCE FROM PUMPED WELL:	19.3 ft

TABLE D.11. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	15 (1.4)	-----
W(u) = 3.5		
1/u = 50,000		
s (ft) = 10		
t (min) = 10		
Q (gpm) = 2.8		
Straight-line Semilog Plot (Cooper-Jacob)	10 (0.9)	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	90 (8.4)	-----
PROBABLE VALUE ft ² /d (m ² /d)	90 (8.4)	-----
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	9 (2.7)	-----

Aquifer Test Data

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Data for Well C1B (deep)
Pumping Well C1B (deep)
Observation Wells C1A, C1C

Location 300 AREA RCRA
Type of Aquifer Test CONSTANT-DISCHARGE-DB
How Q Measured CALIBRATED BUCKET
How W.L.'s Measured F-TAPE
Rad./Dist. of From Pumping Well —
Meas. Point for W.L.'s 242' ABV
Elevation of Meas. Point 2.16

Depth of Pump/Airpipe 127.60
Pump On: date 2/17/87 time 1040 hrs
Pump Off: date 2/17/87 time 1840 hrs
Duration of Aquifer Test 8 hr pumping

Time			Water Level Data				Discharge		Recorded BY	Comments
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or f	Reading	Q
2/17/87		0					27.14	0	31210	
	30					36.18	32.42	6.99	CSC	discharge rate will
	1						32.41		CSC	be for 11:00
	1:30						29.7	9.51	CSC	good readings
	2									
	3						34.13	9.93	CSC	
	4									Tronco adjusting
	5									Discharge
	6						43.24	14.37	CSC	
	7									
	8						43.2	18.11	CSC	
	9								CSC	Cent bank
	10						54.15	19.96	CSC	
	12						49.48	20.27	2.26 CSC	
	14									
	16						49.54	20.35	CSC	
	18						49.2	20.01	1.9 CSC	open up
	20						50.2	21.01	2.5 CSC	
	22						52.4	23.23	2.8 CSC	Sat. level
	24						54.14	24.95	2.8 CSC	
	26						54.91	25.72	2.8 CSC	
	28						55.52	26.63	2.8 CSC	
	30						56.5	27.33	2.6 CSC	2.7
	32						57.2	28.01	2.7 CSC	↑
	34						57.1	29.84	2.8 CSC	2.77/25
	36						58.17	31.98	2.9 CSC	2.77/25
	38						59.1	33.53	2.9 CSC	2.77/25
	40						59.7	34.53	2.9 CSC	2.77/25
	42						60.61	35.02	2.9 CSC	2.77/25
	44						61.5	35.35	2.9 CSC	2.77/25
	46						62.5	35.57	2.8 CSC	2.77/25
	48						63.91	34.72	2.7 CSC	3.77/25
	50						67.66	38.47	2.9 CSC	increased by 1.5 gpm
	52						66.72	37.53	2.5 CSC	3.77/25
	54						67.12	37.93	2.7 CSC	↑ 2.9 gpm / 2.7/25
	56						67.25	38.16	2.7 CSC	3.77/25
	58						68.64	39.47	2.9 CSC	2.7
	60						69.51	40.32	2.9 CSC	
	62						69.97	40.64	2.8 CSC	

1840 4:30

Q ≈ 2.8 gpm average

Aquifer Test Data

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Data for Well C1B (deep)
Pumping Well C1B (deeper)
Observation Wells _____

Location 300 AREA RCRA
Type of Aquifer Test RECOVERY - CONSTANT DISCHARGE
How Q Measured CALIBRATED METER
How W.L.'s Measured E-TAPE
Rad./Dist. of From Pumping Well _____
Meas. Point for W.L.'s 242' ABV L.S.
Elevation of Meas. Point _____

Depth of Pump/Airpipe 127.1
Pump On: date 2/17/87 time 1040
Pump Off: date 2/17/87 time 1840
Duration of Aquifer Test 8 hrs pumping

Time t = _____ at t' = 0					26.77' L.S.D. Water Level Data Static Water Level <u>24.19'</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	ft or s	Read- ing	Q		
2/14	1240	480	0		70.22	21.84	48.38	43.02			CSC	Recovery
		480	730	961			70.67	38.49			CSC	
		481	1	161								
		481.5	1:30	321			65.70	36.51			CSC	
		482	2	241			64.94	28.75			CSC	
		483	3	161			63.47	34.29			CSC	
		484	4	121			61.71	32.52			CSC	
		485	5	97			60.48	31.29			CSC	
		486	6	81			59.10	29.91			CSC	
		487	7	69.4			57.81	28.62			CSC	
		488	8	61			56.27	27.08			CSC	
		489	9	54.3			55.05	25.86			CSC	
		490	10	49			53.70	24.51			CSC	
		492	12	41			51.48	22.29			CSC	
		494	14	35.3			49.22	20.02			CSC	
		496	16	31			47.17	17.98			CSC	
		498	18	27.7			45.20	16.01			CSC	
		500	20	25			43.58	14.31			CSC	
	1405	505	25	20.2			40.14	10.95			KRO	
		510	30	17			37.82	8.63			KRO	
		515	35	14.7			34.14	7.05			KRO	
		520	40	13			35.11	5.92			KRO	
		525	45	11.7			34.15	4.99			KRO	
	1930	530	50	10.6			33.43	4.28			KRO	
	1940	540	60	9			33.11	3.73			KRO	
		550	70	7.9			31.83	2.64			KRO	
		560	80	7			31.41	2.22			KRO	
		570	90	6.3			31.11	1.92			KRO	
		580	100	5.8			30.91	1.72			KRO	
		590	110	5.4			30.77	1.58			KRO	
	2040	600	120	5			30.71	1.52			KRO	
		630	150	4.2			30.58	1.39			KRO	
	2140	660	180	3.7			30.49	1.30			KRO	
		690	210	3.3			30.42	1.23			KRO	
	2240	720	240	3			30.38	1.19			KRO	
		750	270	2.8			30.37	1.18			KRO	
	2340	780	300	2.6			30.34	1.15			KRO	
	0040	840	360	2.3			30.29	1.09			KRO	
	0140	900	420	2.1			30.23	1.04			KRO	
	0240	960	480	2.0			30.20	1.01			KRO	

2/18/87 1045

26.97 STEEL 26.91 E-TAPE - CSC T1 1.9' ABV L.S.

2

page 2 of

Data for Well C12

Pumping Well CLB / doo.

Observation Wells C1A, C1C, C1D

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured F-TAPE

Rad./Dist. of/From Pumping Well 19.3'

Meas. Point for W.L.'s 1/c 1.27' ABV 6.57

Elevation of Meas. Point _____

Depth of Pump/Airpipe 127.6

Pump On: date 2/17/96 time _____

Pump Off: date time

Duration of Aquifer Test _____

ELEV. LSD = 381.00 AT BRASS CAP

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>38.12</u> " = <u>38.13</u>								
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
4/2		0					38' 1.5"	" =	38.13'			CSC	399-1-143 C13 = 31.46'
		41					38' 2.1"		38.14'			CSC	STEEL TAPE MP
		51					38' 2.2"		38.17'			CSC	MP 1.110' ABV LSW
		54					38' 2.2"		38.21'			CSC	LSW ELEV. = 380.31
		57					38' 2.5"		38.25'				
									</				

page 1 of 1

Data for Well (1.) A

Pumping Well C1E (deep)

Observation Wells CIA, C1C

Depth of Pump/Airpipe 127.6' LCP

Pump On: date 2/2/82 time

Pump Off: date 11/1/88 time 11:00

Duration of Aquifer Test _____

D.145

Well 399-1-16B has a total depth of 115 ft, a completed diameter of 6 in., and was set with a No. 20 slot, 6 in., stainless steel well screen from 105 to 115 ft. Figure D.43 illustrates the site stratigraphy and well construction at well 399-1-16B. A more detailed description of the site geology is included in Section 3 of the report.

Wells 399-1-16A, 399-1-16C, and 399-1-16D were incorporated as observation wells during the pumping of well 399-1-16B. Well 399-1-16A was completed with 15 ft of No. 20 slot, 6-in., stainless steel screen set from 32 to 47 ft, as documented in its aquifer test description. The deep well, 399-1-16C, was completed in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow) beneath the confining clay layer of the Ringold Formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 167 and 177.5 ft. Figure D.39 illustrates the site stratigraphy and well construction at well 399-1-16C. An intermediate-depth well, 399-1-16D, was originally to be constructed as a deep well; however, construction problems required that this well be completed at 116 ft. A No. 40 slot, 6-in.-diameter, stainless steel screen was set from 106 to 116 ft. Figure D.44 shows the site stratigraphy and well construction at both well 399-1-16D and well 399-1-16B. A more detailed description is included in Section 3 of the report.

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 16 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 700 ft to the west of well 399-1-16B. The Columbia River is located approximately 400 ft to the east of well 399-1-16B (see Figure D.1). The river apparently affected the drawdown and recovery of water levels during aquifer testing. Figures D.44 and D.45 show the fluctuation of the river stage at the 300 Area Columbia River monitoring station during the first and second aquifer tests, respectively.

FIGURE D.43. Well 399-1-16B Stratigraphy and Well Construction

FIGURE D.44. Water Level Elevations in the Columbia River
During the First Test of Well 399-1-16B

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On February 11, 1987, the well was developed by bailing for 1.75 hours, using a 5-in. dart bailer, and on February 18, 1987 the well was further developed by pumping from 2.1 to 15 gpm for another 1.1 hours. The pump intake was set at 106 ft below the land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal. Water levels were measured by an E-tape and recorded manually. Measurements were made from the top of a stilling hose suspended in the well with a stick-up of 2.63 ft above the land surface. The static water level in well 399-1-16B was 38.4 ft below the land surface before development. The water was drawn down nearly 18.7 ft. Recovery was not monitored after the development pumping had been terminated. The static water level was 37.86 ft

FIGURE D.45. Water Level Elevations in the Columbia River
During the Second Test of Well 399-1-16B

below the land surface (342.45 ft above msl) at the time of the first constant-discharge test, on February 19, 1987. The static water level was 37.48 ft below the land surface (342.83 ft above msl) at the time of the second constant-discharge test, on February 24, 1987. Static water levels were 24.74 ft (355.94 ft above msl) and 36.17 ft below the land surface (344.83 ft above msl) in wells 399-1-16C and 399-1-16D, respectively, before the first constant-discharge test. (No water level was recorded before the first test for well 399-1-16A.) Before the second constant-discharge test, static levels were 38.16 ft (342.33 ft above msl), 23.39 ft (357.29 ft above msl), and 35.82 ft below the land surface (345.18 ft above msl) in wells 399-1-16A, 399-1-16C, and 399-1-16D, respectively.

Description of the Aquifer Test

The pumping rate of the first constant-discharge test averaged 12 gpm; that of the second test averaged 20 gpm. Flow rates during both tests were measured with a 5-gal bucket calibrated to 3.77 gal and a McCrometer® (#82-3-226) flow meter. The discharge rate was just below the range of the flow meter and could not be measured accurately in the first test; flow measurements were recorded instead, by timing the rate at which water filled the bucket to the 3.77-gal mark. The discharge rate was sufficient to be measured with both the flow meter and the calibrated bucket during the second test. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the first test was 9482 gal; 6000 gal were discharged during the second test. The water from each test was discharged at the land surface about 500 ft to the northeast.

Drawdown Test. Constant-discharge pumping tests were conducted on February 19 and 24, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and each of the observation wells and were recorded automatically by transducers set in each of the observation wells and recorded by data logger during the first test. The first test had to be repeated because some water level changes were missed by the automatic system. The pumping was terminated after 800 min into the first test and 300 min into the second test. The maximum drawdown was 14.45 ft in the first test and 28.18 ft in the second test at the time pumping stopped. The specific capacity of well 399-1-16B was approximately 0.83 gpm/ft and 0.70 gpm/ft during the first and second tests, respectively. The differences in specific capacity may be the results of turbulence outside the well screen caused by pumping at the increased rate during the second test. Wells 399-1-16A and 399-1-16C did not provide data useful for calculating aquifer coefficients. Well 399-1-16A and well 399-1-16C, apparently, were not affected by pumping 399-1-16B. Well 399-1-16D, however, did show a drop in water level beginning almost immediately after pumping started. Total drawdown in this well was approximately 3.4 ft during the first test and 3.59 ft during the second test. Both observation well 399-1-16D and pumping well 399-1-16B were completed and screened at

approximately the same depths, and although the Columbia River does definitely affect the water levels in both wells, there is no doubt that the pumping did influence the water levels in this observation well.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. Recovery was measured for 35 min following the first pumping period on February 19, 1987. In that time, the water level recovered 0.09 ft beyond the original static water level. The water level recovered to within 0.05 ft of static in the 60 min following the second pumping test, on February 24, 1987.

The recovery was monitored in the observation wells; only well 399-1-16D showed any changes in water level caused by the recovery from the constant-discharge pumping. During the second aquifer test, the observed water level in this well recovered beyond the static level by 0.03 ft within 60 min after pumping. No water level measurements were obtained during the early part of the recovery period for the first test because the transducer data could not be recovered. However, the water level was 0.36 ft above original static level 592 min after the pump had been stopped. Figures D.44 and D.45 show the changes in the river stage during the early portion of the recovery period.

Analysis and Interpretation

The pumping rate was measured with a calibrated 5-gal bucket in both constant-discharge tests, and measurements are considered accurate. The pumping rate was also measured using a McCrometer® flow meter during the second test, and the results from this means of measurement corroborate the results obtained using the calibrated bucket. The total discharge in the first test was 9482 gal, which, when divided by the 800 min of pumping, gives a figure of 11.9 gpm. The total discharge in the second test was 6000 gal, which, when divided by 300 min, indicates a pumping rate of 20 gpm. The discharge rate was monitored throughout the pumping phase of each aquifer test. The pumping rate apparently did not vary during the second test. During the first test a constant flow was not established until nearly 12 min into the test; thus, data collected before this time would be considered questionable.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable and equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that this correction also be made for wells that partially penetrate the aquifer. Corrections were required for data collected from well 399-1-16B because the drawdown was over 14 ft in the first test and over 28 ft in the second test, of the total saturated thickness of approximately 75 to 80 ft (if the unconfined aquifer is considered to range from the static water table to the top of the confining clay layer). The data with and without corrections were compared for the second test to determine if there were any differences. The results showed very little difference between the analyses using corrected and uncorrected data. Figure D.46 shows the Cooper-Jacob straight-line plot using the corrected drawdown data from the second test. Figure D.47 shows the drawdown plot constructed from the uncorrected data.

The Jacob (1963) equation, Equation (1), was used to correct the data:

$$s_c = s - s^2 \times (2 \times m)^{-1} \quad (1)$$

where s_c = the corrected drawdown, in ft

s = the observed drawdown, in ft

m = the original saturated thickness of the aquifer in ft.

There were, however, influences on the pumping test data other than partial penetration and unconfined/confined aquifer conditions to consider. Borehole or casing storage influenced the data collected during the early portions of the pumping periods for both tests, and the recharge and fluctuation of the Columbia River stage influenced data collected during the later period of pumping.

RCRA Well 399-1-16B (C1D)
Corrected Drawdown Test #2
2/24/87

FIGURE D.46. Well 399-1-16B Observed Drawdown Test No. 2 Using the Corrected Data for the Cooper-Jacob Straight-Line Analysis

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells, if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation assumes that: 1) aquifers are entirely homogeneous, 2) aquifers are of infinite areal extent, 3) the well fully penetrates the aquifer, 4) the transmissivity is uniform in all directions, and 5) the pumped well has an infinitesimal diameter. In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935).

RCRA Well 399-1-16B (C1D)
Constant-Discharge Drawdown #2
2/24/87

FIGURE D.47. Well 399-1-16B Observed Drawdown Test No. 2 Using the Cooper-Jacob Straight-Line Analysis

The Cooper-Jacob straight-line method of analysis is a valid approximation of transmissivity and storativity values, if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 141 min, if the storativity is 0.001 and the transmissivity is 200 ft²/day. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing.

The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For the tests conducted on February 19 and 24, 1987, data cannot be selectively analyzed for the pumped well. Water level data plotted earlier than 20 min

into the tests indicate pumping rate adjustments and possible casing storage effects. Data plotted after 20 min indicate possible recharge boundary effects and are not used to evaluate aquifer coefficients.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2)

$$t_c = 360,000 \times r_c^2 \times T^{-1} \quad (2)$$

where t_c = the time of pumping to dissipate borehole storage effects, in min
 r_c = the radius of the well casing in the interval over which the water level declines, in ft
 T = the transmissivity of the aquifer, in ft^2/day .

Using this equation, it would require approximately 110 min of pumping to dissipate the well storage effects, if the transmissivity of the aquifer is $200 \text{ ft}^2/\text{day}$.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses Equation (3)

$$t_c = 0.6 \times (d_c^2 - d_p^2) \times (Q/s)^{-1} \quad (3)$$

where d_c = the inside diameter of the well casing, in in.
 d_p = the outside diameter of the pump column pipe, in in.
 Q/s = the specific capacity of the well, in gpm/ft of drawdown at time t_c .

Using this equation, it would require 20 min of pumping to dissipate the well storage effects in the first test and 26 min of pumping to dissipate the well storage effects in the second test. In this particular test situation, the Hargis and Schafer methods do not agree. However, because the observation well 399-1-16D reacted so quickly when pumping began and demonstrated approximately the same curves as did the pumped well for both tests, the shorter period of borehole storage is probably more appropriate in this instance. Figures D.48

FIGURE D.48. Well 399-1-16D Observed Drawdown Test No. 1 Using the Cooper-Jacob Straight-Line Analysis

and D.49 show the data plots for the observation well 399-1-16D and the pumped well 399-1-16B, respectively, generated from the drawdown data collected during the first test. Figure D.50 shows the plot of the drawdown curve for the observation well during the second test. Figure D.50 can be compared with Figure D.49 to illustrate the similarities in curve shapes.

Figures D.51 and D.52 show the Theis-type curves plotted from data collected from the observation well 399-1-16D during the first and second drawdown tests, respectively. The transmissivity calculated using the Theis curve matching method averaged $150 \text{ ft}^2/\text{day}$ for the two tests. No storage coefficient could be calculated using either the Cooper-Jacob method or the Theis-type curve.

The transmissivity calculated using the Cooper-Jacob method averaged $180 \text{ ft}^2/\text{day}$ for the two tests. These transmissivities were analyzed from data

RCRA Well 399-1-16B (C1D)
Constant-Discharge Drawdown Test #1
2/19/87

FIGURE D.49. Well 399-1-16B Observed Drawdown Test No. 1 Using the Cooper-Jacob Straight-Line Method Analysis

collected before 141 min of pumping had elapsed. The results analyzed using the Cooper-Jacob method are comparable to those obtained using the Theis curve matching method. These results were obtained over a period of time when the pumped well was still discharging from borehole storage. The drawdown in the observation well would be influenced by the fact that the aquifer was not completely contributing to the discharge from the pumped well during the period of analysis. The drawdown within the observation well would have been greater during the period of borehole storage, and the transmissivity value would be less than that actually recorded. However, considering the number of influences affecting the pumping test, the transmissivity value is probably a good approximation.

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob

RCRA Observation Well 399-1-16D (C1C)
Constant-Discharge Drawdown #2
2/24/87

FIGURE D.50. Well 399-1-16D Observed Drawdown During Test No. 2 of Well 399-1-16B

method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data for observation well 399-1-16D is presented in Figure D.53. The data used to calculate transmissivity appear to the left of a t/t' value of 100 [i.e., $(300 + 3 \text{ min})/3 \text{ min}$] in the plot of data from the second test. The early-time data appear to the right on this plot. After a value of 25 units the curve was not used for analysis because of possible Columbia River boundary effects. The calculated transmissivity from the recovery plot is $200 \text{ ft}^2/\text{day}$ (Figure D.53).

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicate that the values determined for transmissivity are in agreement. The aquifer testing data and well construction data for well 399-1-16B are summarized in Table D.12.

FIGURE D.51. Well 399-1-16D Observed Drawdown for Test No. 1 of Well 399-1-16B Using the Theis Analysis

The most probable values for aquifer characteristics determined by this test are a transmissivity of $170 \text{ ft}^2/\text{day}$, a hydraulic conductivity of $2 \text{ ft}/\text{day}$, and a storativity of 0.001 . The aquifer thickness is 75 to 80 ft at this location. Aquifer Test Data Sheets for well 399-1-16B follow.

Aquifer Test for Well 399-1-16A (C1A)

Well 399-1-16A (previously labelled C1A) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer, including the Hanford formation and the upper portion of the Ringold Formation, and to provide a means of sampling the water quality of that zone. The aquifer has a saturated thickness of approximately 80 ft at this location. The well was tested at an average pumping rate of 30 gpm for 180 min . Drawdown in the well demonstrated a specific capacity of $18.3 \text{ gpm}/\text{ft}$. An average Theis method transmissivity of $6000 \text{ ft}^2/\text{day}$ and a Cooper-Jacob method transmissivity of

FIGURE D.52. Well 399-1-16D Observed Drawdown for Test No. 2 of Well 399-1-16B Using the Theis Analysis

15,000 ft²/day were calculated for the aquifer penetrated by this well. The recovery data indicated a transmissivity of 7000 ft²/day. The hydraulic conductivity for the unconfined aquifer at well 399-1-16A is 125 ft/day. This value is typical of the Hanford Site as shown in Table D.1. Water levels in wells 399-1-16B, 399-1-16C, and 399-1-16D were measured during the testing of 399-1-16A. Neither well 399-1-16B, located 23.1 ft from 399-1-16A; well 399-1-16C, located 23.6 ft from the pumped well; nor well 399-1-16D, located approximately 21 ft from the pumped well, showed any interpretable response to pumping.

Well 399-1-16A has a total depth of 47 ft and a completed diameter of 6 in. and was set with a No. 20 slot, 6 in., stainless steel well screen from 32 to 47 ft. Figure D.54 illustrates the site stratigraphy and well construction at well 399-1-16A. A more detailed description of the site geology is included in Section 3 of the report.

RCRA Observation Well 399-1-16D (C1C)
Constant-Discharge Recovery #2
2/24/87

FIGURE D.53. Well 399-1-16D Water Level Recovery Plot Using the Cooper-Jacob Analysis for Test No. 2

Wells 399-1-16B, 399-1-16C, and 399-1-16D were incorporated as observation wells during the pumping of well 399-1-16A. Well 399-1-16B was completed with 10 ft of No. 20 slot, 6-in., stainless steel screen set from 105 to 115 ft, as documented in its aquifer test description. The deep well, 399-1-16C, was completed in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow) beneath the confining clay layer of the Ringold formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 167 and 177.5 ft. The site stratigraphy and well construction are illustrated in the aquifer test section for well 399-1-16C. An intermediate-depth well, 399-1-16D, was originally to be constructed as a deep well; however, construction problems required that this well be completed at 116 ft. A No. 40 slot, 6-in.-diameter, stainless steel screen was set from 106 to 116 ft. Figure D.43 shows the site stratigraphy and well construction at both well 399-1-16D and well 399-1-16B.

DATE OF TEST #2: 2/24/87

TABLE D.12. (contd)

#3 WELL 399-1-16D (C1C) TOP OF SCREEN: 106 ft
 BOTTOM OF SCREEN: 116 ft
 DISTANCE FROM PUMPED WELL: 28.1 ft

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
<u>TEST #1</u>		399-1-16D
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	-----	150 (13.9)
		W(u) = 8 1/u = 7.5 s (ft) = 10 t (min) = 10 Q (gpm) = 12
Straight-line Semilog Plot (Cooper-Jacob)	-----	120 (11.2)
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	-----	-----
<u>TEST #2</u>		
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)		150 (13.9)
		W(u) = 5 1/u = 7 s (ft) = 10 t (min) = 10 Q (gpm) = 20

TABLE D.12. (contd)

Straight-line Semilog Plot (Cooper-Jacob)	-----	200 (18.6)
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)		200 (18.6)
PROBABLE VALUE ft ² /d (m ² /d)		170 (15.8)
STORATIVITY:	-----	0.001
CONDUCTIVITY: ft/d (m/d)	-----	2 (.61)

Test Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 24 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 700 ft to the west of well 399-1-16A. The Columbia River is located approximately 400 ft to the east of well 399-1-16A (see Figure D.1). The river affected the drawdown and recovery of water levels during aquifer testing. Because of the influence of the Columbia River, the actual pumping period lasted for only 3 hours.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On February 3 and 4, 1987, the well was developed by bailing for 4.5 hours, using a 5-in., flat-bottomed sand bailer and a 7-in. dart bailer. At the time of development, the well was cased with a temporary 10-in. casing and completed with a 10-in. stainless steel telescoping screen from 37.5 to 47.5 ft. The well was further developed by bailing for 1.25 hours using a 5-in., flat-bottomed bailer after the 6-in. casing and screen had been installed. Additional development

Time	Analog#01	Analog#02	Analog#03	Analog#04	Digital#01
02/19 13:59:35.00	5.498	15.385	28.760	6.826	
02/19 14:09:35.00 C	5.498	15.385	28.760	6.861	
02/19 14:04:32.20	5.498	15.385	28.760	6.826	
02/19 14:11:30.30	5.521	15.419	28.760	6.895	
02/19 14:14:37.90	5.521	15.419	28.794	6.861	
02/19 14:24:37.90 C	5.544	15.454	28.794	6.791	
02/19 14:34:37.90 C	5.544	15.419	28.794	6.826	
02/19 14:44:37.90 C	5.521	15.454	28.794	6.826	
02/19 14:54:37.90 C	5.521	15.419	28.794	6.791	
02/19 15:04:37.90 C	5.521	15.419	28.794	6.791	
02/19 15:14:37.90 C	5.521	15.419	28.794	6.722	
02/19 15:24:37.90 C	5.521	15.419	28.794	6.757	
02/19 15:34:37.90 C	5.521	15.419	28.794	6.791	
02/19 15:44:37.90 C	5.521	15.419	28.794	6.722	
02/19 15:54:37.90 C	5.521	15.419	28.794	6.757	
02/19 16:04:37.90 C	5.521	15.419	28.794	6.687	
02/19 16:14:37.90 C	5.544	15.419	28.794	6.722	
02/19 16:24:37.90 C	5.544	15.419	28.794	6.722	
02/19 16:34:37.90 C	5.544	15.419	28.794	6.722	
02/19 16:44:37.90 C	5.544	15.454	28.829	6.653	
02/19 16:48:11.90	5.521	15.419	28.794	6.653	
02/19 16:56:44.80	5.521	15.419	28.794	6.653	
02/19 17:02:12.80	5.613				0.000
02/19 17:02:23.80	5.613				0.000
02/19 22:16:46.70	5.683	15.696	29.071	6.514	
02/19 22:17:31.50	5.683	15.696	29.106	6.480	
02/19 22:27:26.90	5.683	15.696	29.106	6.480	
02/19 22:30:15.50	5.683	15.696	29.106	6.514	
02/19 22:32:32.30	5.683	15.731	29.106	6.480	
02/19 22:40:02.80	5.683	15.731	29.106	6.514	
02/19 22:42:39.40	5.683	15.731	29.106	6.514	
02/19 22:43:20.70	5.683	15.731	29.106	6.514	
02/19 22:57:35.80	5.683	15.766	29.141	6.514	
02/19 23:28:28.60	5.729	18.919	29.210	20.998	
02/20 08:38:18.30	5.844	19.369	29.314	21.275	
02/20 08:56:28.10	5.844	19.369	29.314	21.275	
02/20 08:57:28.80	5.844	19.369	29.314	21.275	
02/20 08:58:47.80	5.844	19.369	29.279	21.275	
02/20 08:59:48.80	5.844	19.369	29.314	21.275	
02/20 09:00:48.80	5.844	19.369	29.314	21.275	
02/20 09:01:48.80	5.844	19.369	29.314	21.275	
02/20 09:02:55.50	5.844	19.335	29.314	21.240	
02/20 09:05:02.50	5.844	19.335	29.279	21.240	
02/20 09:05:08.30	5.821	19.335	29.279	21.240	
02/20 09:05:14.10	5.821	19.335	29.279	21.240	
02/20 09:05:19.90	5.821	19.335	29.279	21.240	

Aquifer Test Data

TEST # 2

page 1 of

Data for Well C1D

Pumping Well C1D

Observation Wells C1A, C, B

Location 300 Area

Type of Aquifer Test Continuous Drawdown

How Q Measured calibrated bucket

How W.L.'s Measured electric tape

Rad./Dist. of/From Pumping Well

Meas. Point for W.L.'s top of riser pipe 2.63' AWL

Elevation of Meas. Point

Depth of Pump/Airpipe 106 feet

Pump On: date 2-24-87 time 0845 hrs

Pump Off: date 2/24/87 time 1345 hrs

Duration of Aquifer Test 5 hrs

TOP OF
STILLING WARE

Time t = at t' = 0					Water Level Data					2-24-87		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Static Water Level	Conversions or Corrections	Water Level ft.	s or s'	Discharge	Read- ing	Q		
2/24					40.0		40.11						
87													
	0846	1			46.93'			6.82	6.53		20	TL	
	0848	3			51.91'			11.80	10.93			TL	
	0850	5			57.29'			17.18	15.34			TL	
	0852	7			62.32'			22.21	19.15			TL	
	0853	8			65.30'			25.19	21.22		20	TL	
	0854	9			66.19'			26.08	21.83			TL	
	0855	10			66.46'			26.84	22.34		20	TL	
	0856	11			67.75'			27.64	22.87			TL	
	0857	12			67.77'			27.68	22.89			TL	Handle Fall off of valve
	0858	13			67.60'			27.49	22.77			TL	
	0859	14			67.60'			27.49	22.77			TL	
	0900	15			67.54'			27.43	22.73			TL	
	0902	17			67.52'			27.41	22.71			TL	
	0904	19			67.49'			27.38	22.69		20	TL	
	0906	20			67.25'			27.14	22.54		20	TL	
	0907	22			67.27'			27.16	22.55		20	TL	
	0909	24			67.28'			27.17	22.56		20	TL	
	0911	26			67.32'			27.21	22.58		20	TL	
	0913	28			67.36'			27.25	22.61		20	TL	
	0915	30			67.46'			27.34	22.67		20	TL	
	0920	35			67.46'			27.35	22.67		20	TL	
	0925	40			67.51'			27.40	22.71		20	TL	
	0935	50			67.55'			27.44	22.73		20	TL	
	0945	60			67.55'			27.44	22.73		20	TL	5 gal Bucket = 15 sec
	1005	80			67.57'			27.46	22.75		20	TL	
	1025	102			67.64'			27.53	22.79		20	TL	5 gal Bucket = 15 sec
	1045	120			67.74'			27.63	22.86		20	TL	5 gal Bucket = 15 sec
	1105	140			67.86'			27.75	22.94		20	TL	
	1125	160			67.87'			27.76	22.94		20	TL	
	1145	180			68.06'			27.95	23.07		20	TL	
	1205	200			67.70'			27.79	22.96		20	TL	5 gal Bucket = 15 sec
	1225	220			68.04'			27.93	23.05		20	TL	
	1245	240			68.12'			28.01	23.11		20	TL	
	1305	260			68.18'			28.07	23.15		20	TL	5 gal Bucket = 15 sec
	1325	280			68.22'			28.11	23.17		20	TL	
	1344	299			68.29'			28.18	23.22		20	TL	

Aquifer Test Data

page 2 of

Data for Well C1D

Pumping Well C1D

Observation Wells C1A, C1C, C1B

Location 300 AREA RCRA

Type of Aquifer Test Recovery

How Q Measured BY CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well

Meas. Point for W.L.'s

Elevation of Meas. Point

Depth of Pump/Airpipe 106'

Pump On: date 2/24/87 time 0845

Pump Off: date 2-24-87 time 1345 hrs

Duration of Aquifer Test 5 hrs pumping

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>40.11'</u>								
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s' or s	corrected	Reading	Q		
	13:43:30	300	30	10			61.56	2.45	18.52			TW/es	F.L. F.S.
	13:46	301	1	301			55.88	15.77	14.22				PUMP TURNED OFF
	13:47	302	2	151			50.26	10.05	9.51				AT 13:45:00
	13:48	303	3	101			46.68	6.57	6.30				
	13:49	304	4	76			44.53	4.42	4.30				
	13:50	305	5	61			43.04	2.93	2.88				
	13:51	306	6	51			42.15	2.04	2.01				
	13:52	307	7	43.9			41.53	1.42	1.41				
	13:53	308	8	38.5			41.13	1.02	1.01				
	13:54	309	9	34.2			40.98	.87	.87				
	13:55	310	10	31			40.80	.69	.69				
	13:56	311	11	28.2			40.66	.55	.55				
	13:57	312	12	26			40.53	.42	.42				
	1400	315	15	21			40.43	.32	.32			TW	
	1405	320	20	16			40.32	.21	.21			TW	
	1410	325	25	13			40.27	.16	.16			TW	
	1415	330	30	11			40.24	.13	.13			TW	
	1420	335	35	9.6			40.20	.09	.09			RL	
	1425	340	40	8.5			40.17	.06	.06			TW	
	1430	345	45	7.7			40.17	.06	.06			TW	
	1435	350	50	7			40.16	.05	.05			TW	
	1440	355	55	6.5			40.16	.05	.05			TW	
	1445	360	60	6			40.16	.05	.05			TW	

12 min
15 min

Aquifer Test Data

page 1 of 1

Data for Well C1A

Pumping Well C1D

Observation Wells _____

Location 300A.

Type of Aquifer Test _____

How Q Measured _____

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well 22.6 feet

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 2-24-87 time _____

Pump Off: date _____ time _____

Duration of Aquifer Test _____

Time t = _____ at t' = 0					Water Level Data <u>516-12</u> Static Water Level <u>39.49</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
<u>24</u>	<u>1345</u>	<u>0</u>			<u>X</u>	<u>X</u>	<u>39.46</u>				<u>TL</u>	
<u>87</u>		<u>13</u>			<u>X</u>	<u>Y</u>	<u>39.46</u>				<u>TL</u>	
		<u>21</u>					<u>39.46</u>				<u>TL</u>	
		<u>48</u>					<u>39.42</u>				<u>TL</u>	
		<u>53</u>					<u>39.43</u>				<u>TL</u>	
		<u>62</u>					<u>39.43</u>				<u>ES.</u>	
		<u>82</u>					<u>39.43</u>				<u>TL</u>	
		<u>102</u>					<u>39.47</u>				<u>TL</u>	
		<u>123</u>					<u>39.44</u>				<u>TL</u>	
		<u>143</u>					<u>39.44</u>				<u>TL</u>	
		<u>163</u>					<u>39.43</u>				<u>TL</u>	
		<u>185</u>					<u>39.44</u>				<u>TL</u>	
		<u>205</u>					<u>39.44</u>				<u>TL</u>	
		<u>226</u>					<u>39.44</u>				<u>TL</u>	
		<u>244</u>					<u>39.46</u>				<u>TL</u>	
		<u>261</u>					<u>39.44</u>				<u>TL</u>	
		<u>282</u>					<u>39.50</u>				<u>TL</u>	
		<u>301</u>	<u>14</u>				<u>39.50</u>				<u>TL</u>	
		<u>357</u>	<u>57</u>				<u>39.50</u>				<u>TL</u>	

Aquifer Test Data

page 1 of 1

Data for Well C1B (deep)

Pumping Well C1D

Observation Wells _____

Location 300 Area

Type of Aquifer Test Continuous Drawdown

How Q Measured _____

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well 41.4 Feet

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 2-24-87 time 8:45 a.m.

Pump Off: date 2-24-87 time 1:45 p.m.

Duration of Aquifer Test 5 hrs.

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>26.26</u>					Read-	Q		
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		ing			
2/24	0846	0					25.13					RL	
		11					25.13					RL	
		14					25.14					RL	
		19					25.31					RL	
		27					25.40					RL	
		33					25.36					ES	
		43					25.33					ES	
		54					25.34					ES	
		1:01					25.36					ES	
		1:02					25.26					ES	
		1:06					23.61					TL	Sample Pump Set in Well
		1:13					24.44					TL	
		1:20					24.32					TL	
		1:24					24.24					TL	
		1:29					24.24					TL	
		1:35					24.20					TL	
		1:43					24.18					TL	
		1:45					24.20					ES	PUMP TURNED OFF
		1:46	16				24.16					ES	AT 1:45
		1:45	45				24.10					ES	

16 min

What's
2nd

Aquifer Test Data

page 1 of 1

Data for Well CIC

Pumping Well CID

Observation Wells _____

Location 300 Area

Type of Aquifer Test Drawdown continuous

How Q Measured calibrated bucket

How W.L.'s Measured electronic tape

Rad./Dist. of/From Pumping Well 28.1

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe 106

Pump On: date 2-24-87 time 0845

Pump Off: date 2-24-87 time 1345

Duration of Aquifer Test Shallow

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>37.16</u>					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Read- ing	gpm Q		
2/24	8:45	0			X	X	37.16	0		11	20	PL	
		1					37.40	.24		11	20	PL	
		2					37.90	.74				PL	
		3					38.38	1.22				PL	
		4					38.85	1.69				PL	
		5					39.20	2.04				PL	
		6					39.57	2.41				PL	
		8					39.86	2.70		11	20	PL	
		10					40.16	3.00				PL	
		12					40.36	3.20				PL	
		17					40.62	3.46				PL	
		20					40.64	3.48		11	20	PL	
		25					40.67	3.51				PL	
		30					40.52	3.36				PL	
		35					40.68	3.52				PL	
		40					40.75	3.57				PL	
		50					40.54	3.58				PL	
	0945	60					40.68	3.52				PL	
		80					40.73	3.57				PL	
		100					40.72	3.56				PL	
	1047	122					40.72	3.56				PL	
		142					40.73	3.57				PL	
		161					40.72	3.56				PL	
	1146	181					40.72	3.56				PL	
		202					40.73	3.57				PL	
		222					40.73	3.57				PL	
	1247	242					40.73	3.57				PL	
		262					40.72	3.56				PL	
		281					40.75	3.59				PL	
		299					40.75	3.59				PL	
	1345	300					40.75	3.59				PL	
		301	1	301			40.36	3.20		0	0	PL	RECOVERY
		302	2	151			40.27	3.11				PL	
		303	3	101			39.88	2.72				PL	
		304	4	76			39.48	2.32				PL	
		305	5	61			39.05	1.89				PL	
		306	6	51			38.80	1.64				PL	
		307	7	43.9			38.54	1.38				PL	
		308	8	28.5			38.32	1.16				PL	

Aquifer Test Data

page _____ of _____

Data for Well C/C internal

Pumping Well C1D

Observation Wells _____

Location 300 AREA RCRA

Type of Aquifer Test _____

How Q Measured _____

How W.L.'s Measured 28.1

Rad./Dist. of/From Pumping Well 27.6 feet

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 2/24/87 time 0845

Pump Off: date 2/24/87 time 1345

Duration of Aquifer Test 5 hr. pumping

Time			Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0			Static Water Level _____							
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s' or s''	Reading	Q
		309	9	34.3			38.13	.97		
		310	10	31			37.98	.82		
		311	11	28.3			37.88	.72		
		312	12	26			37.72	.56		
		315	15	21			37.56	.40		
		320	20	16			37.26	.10		
		328	28	11.7			37.35	.19		
		330	30	11			37.27	.11		
		335	35	9.6			37.26	.10		
		340	40	8.5			37.24	.08		
		345	45	7.7			37.16	0		
		350	50	7			37.16	0		
		355	55	6.5			37.14	-.02		
		360	60	6			37.13	-.03		
		365	65	5.6			37.14	-.02		

Aquifer Test Data

TRANSDUCERS
OIL OTHER
HOSES

page 1 of 2

Data for Well C1D

Pumping Well C1D

Observation Wells C1A

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured CALIBRATED BUCKET / FLOW METER

How W.L.'s Measured EC-TAPE

Depth of Pump/Airpipe 105.6' LSD

Rad./Dist. of/From Pumping Well

Pump On: date 2/19/87 time 0940

Meas. Point for W.L.'s TOP OF HOSE 2.63' ABV LSD

Pump Off: date 2/19/87 time 2300

Elevation of Meas. Point

Duration of Aquifer Test

TOP OF ELEVATOR 1.40' ABV LSD

Time				Water Level Data				Discharge		Recorded By	Comments
t = _____ at t' = 0				Static Water Level 40.49							
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q	
2/19	0940	0					40.49	0	10470		CSC McCrometer
		130					42.72	3.49			CSC 82-2-226
		1					45.1	4.63			CSC
		2					47.4	5.21			CSC
		3					49.7	5.33	5.7		CSC 277/410
		4					46.0	5.51			CSC
		5					46.2	5.71			CSC
		6					46.62	6.13			CSC ADJUSTED VALUE
		7					46.72	6.44			CSC
		8					47.0	6.51	8.1		CSC 3.77/25 sec
		9					47.2	6.71			CSC ADJUSTED VALUE
		10									
		12					49.2	8.71	11.9		CSC 3.77/17 sec
		16					51.42	10.93			CSC
		18					51.4	11.41	11.9		CSC 3.77/17 sec
		19							13830		CSC
	1000	20					52.2	11.78			CSC
		25					52.6	12.2	11.9		CSC 3.77/17 sec
		30					52.8	12.4			CSC
		35					53.0	12.59	11.9		CSC 3.77/19 sec
	210	40							79170		CSC
		45					53.19	12.7			CSC
		50					53.31	12.92	11.9		CSC 3.77/19 sec
		55					53.4	12.87			CSC
		60					53.57	13.08	11.9		CSC 3.77/19 sec
		70					53.56	13.07			CSC
	1100	80					53.8	13.31	11.9		CSC 3.77/19 sec
		90					53.45				CSC 100200 at 86.75 min
		100					53.79	13.39	11.9		CSC 3.77/19 sec
		110					53.8	13.32	11.9		CSC 3.77/19 sec
		120					53.88	13.39	11.9		CSC 100820 117 min
	1210	150					54.13	13.64	11.9		CSC 3.77/19 sec
		180					54.22	13.74	11.9		CSC 3.77/19 sec
		210					54.30	13.81	11.9		CSC 3.77/19 sec
		240					54.35	13.86	11.9		CSC 3.77/19 sec
	275	270					54.42	13.95	11.9		CSC 103420 243 min
		300					54.50	14.01	11.9		CSC Transducer
		360					54.61	14.12	11.9		CSC placed in Well
		120					54.69	14.11	11.9		CSC 60' from Top of
	180						54.60	14.11	11.9		CSC ELEVATOR 1.40'
	540						54.75	14.25	11.9		CSC ABV 1.40'

Aquifer Test Data

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Data for Well C1D

Pumping Well C1D

Observation Wells C1A, C1C, C1B

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured CALIBRATED BUCKET/FLOWMETER

How W.L.'s Measured E-TAPE/TRANSLOGER Depth of Pump/Airpipe 105.6

Rad./Dist. of/From Pumping Well Pump On: date 2/17/87 time 0940

Meas. Point for W.L.'s TRANSLOGER HOSE 2.63' ABV LSD Pump Off: date 2/17/87 time 1100 (2300 hrs)

Elevation of Meas. Point Duration of Aquifer Test 13.33 hrs pumping

Time t = _____ at t' = 0				Water Level Data				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
2/17		660				54.8	14.36		11.9	CSC	
		720				54.9	14.45		11.9		
	2340	720				54.8	14.40		11.9		
	2350							1150	5		TOTAL 9482 gallons
2/17	2350	800	17								pumped
		800.5	3			47.4	7.24				11.85 gpm
		801	1			47.5	7.86				~12 gpm
		802	2			47.5	33.31				
		803	3			47.5	2.08				
		804	4			47.6	1.16				
		805	5			47.6	.91				
		806	6			47.6	.58				
		807	7			47.6	.39				
		808	8			47.6	.31				
		809	9			47.6	3.34				
		810	10			47.6	2.23				
		812	12			47.6	1.12				
		814	14			47.6	.03				
		816	16			47.6	7.01				
		818	18			47.6	50.01				
		820	20			47.6	1.02				
		825	25								
		830	30								
		835	35			47.6	1.09				

Location 300 AREA PCRA

Type of Aquifer Test Constant Discharge

How Q Measured FLOW METER / CALIBRATED BUCKETS

How W.L.'s Measured K-TAFF

Rad./Dist. of/From Pumping Well 4.9'

Meas. Point for W.L.'s T/C 1.92' Above LSP

Elevation of Meas. Point _____

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Data for Well C13Pumping Well C10

Observation Wells C1B, C1A

Q. 12

Depth of Pump/Airpipe 105.6

Pump On: date 3/19/03 time

Pump Off: date 6/11/16 time 11:00

Duration of Aquifer Test _____

D.174

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Pumping Well C.15

Observation Wells C15, C16,

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured CALIBRATION TUCKER / FLOWMETER 82-3-274

How W.L.'s Measured False

Depth of Pump/Airpipe 105.6'

Rad./Dist. of/From Pumping Well 241

Pump On: date 2/19/94 time

Meas. Point for W.L.'s T/C 1.34' A&U 2 L

Pump Off: date 7/7 time 11:00

Elevation of Meas. Point

Duration of Aquifer Test

D.175

FIGURE D.54. Well 399-1-16A Stratigraphy and Well Construction

occurred for 1 hour on February 25, 1987, using a 10-hp submersible pump. The 10-hp pump over-stressed the well and was replaced with a 5-hp submersible pump, and the well was pumped for approximately 0.5 hour at 30 gpm. The pump intake was set at approximately 45 ft below the land surface. Discharge was measured with a McCrometer® flow meter and corroborated with a 5-gal bucket calibrated to 5.0 gal. Water levels were measured by an E-tape and recorded manually. Measurements were made from the top of a stilling hose suspended in the well. The static water level in well 399-1-16A was 38.42 ft below land surface (342.07 ft above msl) at the time of the constant-discharge test, on February 26, 1987. Static water levels were 36.89 ft (343.42 ft above msl), 21.4 ft (359.28 ft above msl), and 35.37 ft below the land surface (345.63 ft above msl) in wells 399-1-16B, 399-1-16C, and 399-1-16D, respectively, before the constant-discharge test.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 30 gpm. Flow rates during the test were measured with a 5-gal bucket calibrated to 5.0 gal, and the McCrometer® (#82-3-226) flow meter. Flow measurements were recorded primarily using the flow meter and the measurements were corroborated by timing the rate at which water filled the bucket to the 5.0-gal mark. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 5400 gal. The water from the test was discharged into the 300 Area sanitary trenches about 1000 ft to the south.

Drawdown Test. The constant-discharge pumping test was conducted on February 26, 1987. Water levels were measured manually using E-tapes dedicated to the pumped well and each of the observation wells and were measured automatically by transducers set in the pumping well and in observation wells 399-1-16B and 399-1-16D, and recorded on a Terra 8/D® data logger. The pumping was terminated after 180 min because water levels had apparently equilibrated in the pumped well. The maximum drawdown was 1.64 ft at the time pumping stopped. The specific capacity of well 399-1-16A was approximately 18.3 gpm/ft. Wells 399-1-16B, 399-1-16C, and 399-1-16D did not provide data useful for calculating aquifer coefficients. The Columbia River appears to affect the water levels in

all of the wells in this cluster. Figure D.55 shows the water-level fluctuations in well 399-1-10 and the Columbia River at the river monitoring station in the 300 Area during the aquifer test. The locations of well 399-1-10 and the Columbia River monitoring station are shown in Figure D.1.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; none of the wells showed any changes in water level because of the recovery from the constant-discharge pumping. The observed water level in the pumped well recovered beyond the static level by 0.06 ft within 15 s of the start of recovery measurements and by 0.09 ft within 40 min of the start of recovery measurements. Figure D.55 shows the changes in the Columbia River stage and the water level fluctuations in well 399-1-10 during the recovery period.

FIGURE D.55. Water Level Elevations in Well 399-1-10 and the Columbia River During Testing of Well 399-1-16A

Analysis and Interpretation

The pumping rate was measured with a McCrometer® flow meter and a calibrated 5-gal bucket, and measurements are considered accurate. The total discharge in the test was 5400 gal, which, when divided by the 180 min of pumping, gives a figure of 30 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. The pumping rate apparently did not vary during the test.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that corrections also be made for wells that partially penetrate the aquifer. Although the drawdown in well 399-1-16A was only 1.64 ft, corrections are probably required for data collected from this well because the well only partially penetrated the aquifer's total saturated thickness of approximately 70 to 80 ft (if the unconfined aquifer is considered to range from the static water table to the top of the confining clay layer, and the depth of this layer can be correlated from the other three wells of this well cluster). However, by examining the data and applying Jacob's equation (1963) as presented in previous tests, the maximum drawdown of 1.64 ft would be corrected to 1.62 ft, suggesting very little difference between corrected and uncorrected water levels.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.56. The method is valid for determining transmissivity at pumping wells and for determining both storativity and transmissivity in observation wells, if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation assumes that 1) aquifers are

RCRA Well 399-1-16A (C1A)
Constant-Discharge Drawdown
2/26/87

FIGURE D.56. Well 399-1-16A Observed Drawdown Using the Theis Analysis

homogeneous, 2) aquifers are of infinite areal extent, 3) the well fully penetrates the aquifer, 4) the transmissivity is uniform in all directions, and 5) the pumped well has an infinitesimal diameter. In addition, the Theis method only applies to unconfined water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. For this test, a recharge boundary was encountered and data are selectively analyzed for the period from 2 to 20 min. Water level data plotted earlier than 2 min into the test indicate pumping rate adjustments or borehole storage effects. Data plotted after 20 min indicate possible recharge boundary effects and are not used to evaluate aquifer coefficients. The data plotted from the drawdown-vs-time curve fall on the flattened portion of the Theis-type curve, which makes it difficult to interpret the results. A unique fit is not possible under

these circumstances; however, an attempt was made to determine the transmissivity from this method of analysis. The transmissivity calculated using the Theis curve matching method is 6000 ft²/day.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values, if pumping time is included with those conditions mentioned above for the Theis equation. Because only the pumping well data are used to determine aquifer characteristics, these theoretical conditions are satisfied for this aquifer test for pumping times greater than 1 min. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated from the observation well data measured during aquifer testing. The transmissivity calculated using the Cooper-Jacob method is 15,000-ft²/day. The Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.57.

FIGURE D.57. Well 399-1-16A Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

Transmissivity Calculations for the Recovery Test. Recovery data, or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the residual drawdown is included in this appendix as Figure D.58; however, the recovery data were greatly influenced by the Columbia River, as were the drawdown data. No straight-line analysis was done using this data. The water level in the well recovered within 15 s after the pump was shut-off. The Columbia River water stage was apparently rising during both the drawdown and recovery portions of the aquifer test, as is indicated in Figure D.56.

FIGURE D.58. Well 399-1-16A Water Level Recovery Plot Using the t/t' Analysis

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicate that the values determined for transmissivity are influenced by the Columbia River. The aquifer testing data and the construction data for well 399-1-16A are summarized in Table D.13.

The most probable values for aquifer characteristics determined by this test are a transmissivity of $10,000 \text{ ft}^2/\text{day}$ and a hydraulic conductivity of $125 \text{ ft}/\text{day}$. The aquifer thickness is 70 to 80 ft at this location. Aquifer Test Data Sheets for well 399-1-16A follow.

Aquifer Test for Well 399-1-9 (S2)

Well 399-1-9 (previously labelled S2) in the 300 Area was constructed to characterize the geology and hydrogeology of the unconfined aquifer and the confined or semiconfined aquifer underlying the silt or clay layer of the lower Ringold Formation, and to provide a means of sampling the water quality of that zone. The confined aquifer has a thickness of approximately 10 ft at this location. The well was tested at an average pumping rate of 2.7 gpm for 480 min. Drawdown in the well demonstrated a specific capacity of 0.03 gpm/ft during the test. An average Theis method transmissivity and a Cooper-Jacob method transmissivity could not be obtained for the aquifer penetrated by this well, because the borehole or casing storage effects were calculated to last longer than 375 min. A questionable transmissivity value of $60 \text{ ft}^2/\text{day}$ was determined from a few recovery data points. The hydraulic conductivity for the confined aquifer would be 6 ft/day, based on the recovery transmissivity and an aquifer thickness of 10 ft. This conductivity is typical for the basal Ringold Formation at the Hanford Site, as shown in Table D.1.

Water levels in wells 399-1-3, 399-1-7, and 399-1-8 were measured during the testing of 399-1-9. Neither well 399-1-3, located 13 ft from 399-1-9; well 399-1-7, located 24 ft from the pumped well; nor well 399-1-8, located 12 ft from the pumped well, showed any interpretable response to pumping. Water levels in all of these observation wells dropped during the test; however, coincidentally, the Columbia River stage dropped during the pumping portion of the test and rose during the recovery period of testing. The rise and fall of water levels in the observation wells are attributed to fluctuations of the Columbia River.

TABLE D.13. Aquifer Testing and Well Construction Summary for Well 399-1-16A

WELL: 399-1-16A (C1A) DATE OF TEST: 2/26/87

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 380.49
(brass cap)

STATIC WATER LEVEL (date of test): 38.42 ft below lsd
ELEVATION: (test) 342.07 ft above msl

MAXIMUM PUMPING WATER LEVEL: 40.06 ft below lsd
ELEVATION: 340.43 ft above msl

MAXIMUM DRAWDOWN: 1.64 ft

PUMPING RATE: 30 gallons per minute (gpm)

PUMPING TIME: 180 min. TOTAL DISCHARGE: 5,400 gal.

ESTIMATED DEPTH TO:

TOP OF RINGOLD:	32 ft below lsd	348.5 ft abv msl
TOP OF CLAY:	117 ft below lsd	263.5 ft abv msl
TOP OF BASALT:	172 ft below lsd	208.5 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 20 ft (6.1 m)

TOP OF SCREEN 32 ft below lsd ELEVATION: 348.5 ft above msl

BOTTOM OF SCREEN 47 ft below lsd ELEVATION: 333.6 ft abv msl

OBSERVATION WELLS:

#1 WELL 399-1-16B (C1D)	TOP OF SCREEN:	105 ft
	BOTTOM OF SCREEN:	115 ft
	DISTANCE FROM PUMPED WELL:	23.1 ft
#2 WELL 399-1-16C (C1B)	TOP OF SCREEN:	167 ft
	BOTTOM OF SCREEN:	177.5 ft
	DISTANCE FROM PUMPED WELL:	23.6 ft
#3 WELL 399-1-16D (C1C)	TOP OF SCREEN:	106 ft
	BOTTOM OF SCREEN:	116 ft
	DISTANCE FROM PUMPED WELL:	21 ft

TABLE D.13. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u> 399-1-16D
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	6000 (557.7)	-----
W(u) = 8		
1/u = 7.5		
s (ft) = 10		
t (min.) = 10		
Q (gpm) = 12		
Straight-line Semilog Plot (Cooper-Jacob)	15,100 (1403.6)	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	7,000 (650.7)	-----
PROBABLE VALUE ft ² /d (m ² /d)	10,000 (929.5)	-----
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	500 (152.4)	-----

Figure D.59 shows the fluctuations of the water table in well 399-1-10 and the changes in river stage during the testing of well 399-1-9.

Well 399-1-9 has a total depth of 180 ft and a completed diameter of 6 in. and was set with a No. 40 slot, 6-in., stainless steel well screen from 170 to 180 ft. This well was completed in the uppermost basalt flow (considered to be the Ice Harbor-Martindale basalt flow) beneath the confining clay layer of the

Aquifer Test Data

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 Data for Well CIA
 Pumping Well CIA
 Observation Wells _____

Location 300 Area Constant Discharge
 Type of Aquifer Test Constant Discharge
 How Q Measured Flow meter - performance check to +1 gpm at 30 gpm,
 How W.L.'s Measured Electric probe and transducer Depth of Pump/Airpipe 47.5 ft
 Rad./Dist. of/From Pumping Well _____ Pump On: date 2-26-87 time 1050 hrs
 Meas. Point for W.L.'s top of riser stilling well Pump Off: date 2-26-87 time 1350 hrs
 Elevation of Meas. Point 381.79 + .27 = 382.06' msl Duration of Aquifer Test 3 hrs
 Elev. LSD = 380.49' T/C DE BRASS CAP T/C = 381.79 ft $\therefore$ riser d.f. = 0.27

Time				Water Level Data				Discharge		Recorded By	Comments	
t = _____ at t' = 0				Static Water Level <u>39.99</u>								
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
2/26	1050	0					39.99	0		30	PL	Meter
		1					41.54	1.55		30	PL	
		2					41.56	1.57		30	PL	
		3					41.57	1.58		30	PL	
		4					41.58	1.59		30	PL	Discharge at
		5					41.59	1.60		30	PL	out let 30 gpm
		6					41.59	1.60		30	PL	10 Secs for 5
		7					41.60	1.61		30	PL	gallon bucket.
		10					41.61	1.62				(river level
		20					41.63	1.64				may be rising
		30					41.63	1.64				here.)
		40					41.63	1.64				
		50					41.63	1.64				
		60					41.63	1.64				
		80					41.63	1.64				
		100					41.63	1.64				
		120					41.63	1.64				
		140					41.63	1.64		30	PL	
		160					41.63	1.64		30	PL	
		180					41.63	1.64				
		0					41.63	1.64		0	PL	River level
		25 37					39.93	-.06			PL	probably falling
		5 36					39.93	-.06			PL	
		75 24									PL	
		1 0 18									PL	
		1 5 12									PL	
		2 9 1					39.95	-.04			PL	
		3 6 1					39.95	-.04			PL	
		4 4 2					39.95	-.04			PL	
		5 3 7					39.95	-.04			PL	
		7 2 7					39.95	-.04			PL	
		9 2 1					39.94	-.05			PL	
		10 1 9					39.95	-.04			PL	
		15 1 3					39.94	-.05			PL	
		20 1 0					39.94	-.05			PL	
		25 8 2					39.93	-.06			PL	
		30 7					39.92	-.07			PL	
		40 5 5					39.90	-.09			PL	

Aquifer Test Data

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Data for Well C10

Pumping Well C1A

Observation Wells _____

Location 300 Area

Type of Aquifer Test Continuous Drawdown

How Q Measured Calibrated Flow meter

How W.L.'s Measured P. Tape + Transducer

Rad./Dist. of/From Pumping Well 23.1'

Meas. Point for W.L.'s T/C

Elevation of Meas. Point 381.42

W.L. Elev. = 380.21' brass cap

Depth of Pump/Airpipe 47.5'

Pump On: date 2-26-87 time 10:50

Pump Off: date 2-26-87 time 13:50 hrs

Duration of Aquifer Test 3 hrs

ELEV. T/C 381.42

Time t = _____ at t' = 0					Water Level Data Static Water Level <u>38.00</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	gpm Q		
2/26	10:45	0					38.00			30	PL	Elev. = 381.42 - 38.00'
	10:48	0					38.00			300	PL	= 343.42'
	10:50	0					38.00			30	PL	
	10:51	145					38.15			30	PL	
	10:52	230					38.14			30	PL	
		345					38.14			30	PL	
		4					38.02			"	PL	
		5					38.17			"	PL	
		6					—			"	PL	
		7					—			"	PL	
		145					38.07			"	PL	
		20					38.06					
							38.16					
							38.14					
							38.14					
							38.14					
							38.12					
							38.10					
							38.10					
	13:49						38.05				TL	Switched to Sinec E-Tape

page _____ of _____

Data for Well 2152

Pumping Well C-1A

Observation Wells _____

Location 300 Area

Type of Aquifer Test RECOVERY

How Q Measured FLOW METER

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s _____

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date _____ time _____

Pump Off: date 2-26-87 time 1351 hrs

Duration of Aquifer Test _____

[illegible]

Aquifer Test Data

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Data for Well C1R

Pumping Well CIA

Observation Wells _____

Location 300 Area

Type of Aquifer Test Continuous drawdown

How Q Measured calibrated flowmeter

How W.L.'s Measured _____

Depth of Pump/Airpipe _____

Rad./Dist. of/From Pumping Well 23.6

Pump On: date 2-26-87 time _____

Meas. Point for W.L.'s top of casing

Pump Off: date 2-26-87 time

Elevation of Meas. Point top of casing

Duration of Aquifer Test _____

LSD FILE# : 320.123 barrel cap

T/C ELEV = 382.57' msl

[illegible]

Aquifer Test Data

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Data for Well C1C

Pumping Well C1A

Observation Wells _____

Location 300 Area

Type of Aquifer Test Constant rate drawdown

How Q Measured Calibrated flow meter

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well 19.3'

Meas. Point for W.L.'s top of casing

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 2-26-87 time _____

Pump Off: date 2-26-87 time _____

Duration of Aquifer Test _____

LSD Elev. = 381.00' brass cap

T/C elev. = 382.33' msl

Time t = <u>10:50</u> at t' = 0				Water Level Data Static Water Level <u>36.70</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
2/1	10:45	0		36.70				Static = 1.1101			Elev. = 382.33 - 36.70'
2/1	10:51			36.69							= 345.63 msl
	10:52			36.68							
	10:54			36.68							
	10:59			36.68							
	11:02			36.68							
	11:12			36.69							
	20			36.67							
	30			36.66							
	40			36.63							
	50			36.63							
				36.63							
				36.66							
				36.65							
				36.64							
				36.62							
	13:47			36.62							
	13:50	0	0								Pump turned off
	13:51	1		36.59						ES	1:50:00
		2		36.58						ES	
		3		36.59						ES	
		4		36.60						ES	
		7		36.60							
		10		36.60							
		12.5		36.60							
		15.0		36.60							
		20.25		36.60							
		30		36.60							
		35		36.60							
				24.87 42							

300 Area River Monitoring Stations
Well 399-1-10 and Columbia River Station
0001 hrs 3/2/87 - 0220 hrs 3/3/87

FIGURE D.59. Water Level Elevations in Well 399-1-10 and the Columbia River During Testing of Well 399-1-9

Ringold Formation. Figure D.60 illustrates the site stratigraphy and well construction at well 399-1-9. A more detailed description of the site geology is included in Section 3 of the report.

Wells 399-1-3, 399-1-7, and 399-1-8 were incorporated as observation wells during the pumping of well 399-1-9. Well 399-1-3 was drilled and completed in April 1950. This well is perforated from 25 to 44 ft and from 54 to 70 ft with 5 holes per ft for a total of 175 holes. In 1977, a cement plug was placed at 75 ft in this hole. Well 399-1-7 was completed with 50 ft of No. 15 slot, 6-in.-diameter, stainless steel screen set from 25 to 75 ft. Well 399-1-8 was completed with 20 ft of No. 25 slot, 6-in.-diameter, stainless steel screen set from 85 to 105 ft. A more detailed description may be found in Appendix A.

FIGURE D.60. Well 399-1-9 Stratigraphy and Well Construction

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 8 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 600 ft to the northwest of well 399-1-9. The Columbia River is located approximately 600 ft to the east of well 399-1-9 (see Figure D.1). The Columbia River probably did not affect the drawdown and recovery in well 399-1-9, as it did in the observation wells.

Pre-Test Measurements

The aquifer test was preceded by bailing development and a pumping period to develop the well and to determine the optimal discharge rate. On February 27, 1987, the well was developed by pumping with a submersible pump for 4 hours at discharge rates of 20 and 5 gpm. The pump intake was set at approximately 105 ft below the land surface. Discharge was measured with a 5-gal bucket calibrated to 3.77 gal. Water levels were measured by an E-tape and recorded manually. During the 8-hour aquifer test conducted on March 2, 1987, water levels were monitored using E-tapes and transducers connected to a Terra 8D® 3-channel data logger. Measurements were made from the top of an elevator riser supporting the pump column, 1.86 ft above the land surface.

The static water level was 10.82 ft below land surface (372.67 ft above msl) at the time of the constant-discharge test on March 2, 1987. Static water levels were 41.2 ft (344.71 ft above msl) and 41.25 ft below land surface (343.94 ft above msl) in wells 399-1-7 and 399-1-8, respectively, before the constant-discharge test. (No water level was recorded before the test for well 399-1-3.)

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 2.7 gpm. Flow rates during the test were measured with a 5-gal bucket calibrated to 3.77 gal. The discharge rate was insufficient to be measured by the flow meter, and so flow measurements were recorded by timing the rate at which water filled the bucket to the 3.77-gal mark. The discharge data are documented on the field

data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 1309 gallons. The water from the test was discharged at the land surface about 500 ft to the southeast, in the direction of the sanitary waste leaching trenches.

Drawdown Test. The constant-discharge pumping test was conducted on March 2, 1987. Water levels were recorded manually by E-tapes dedicated to the pumped well and, initially, to each of the observation wells. Water levels were also measured automatically by transducers set in each of the observation wells and recorded by a Terra 8/D® 3-channel data logger. Data were not recorded at a critical period of the aquifer test (from 1536 to 2007 hours on March 3, 1987) because of a malfunction in the automatic system. The pumping was terminated after 480 min. The maximum drawdown was 80.64 ft, 2 hours before pumping stopped. The specific capacity of well 399-1-9 was approximately 0.03 gpm/ft. Wells 399-1-3, 399-1-7, and 399-1-8 did not provide data useful for calculating aquifer coefficients. These wells apparently were not affected by pumping 399-1-9. All three wells, however, did show a drop in water level beginning approximately 2 hours after pumping started and a recovery after the pumping was terminated. The drawdown and recovery are attributed to the effects of the Columbia River. The total drawdown in all three wells was about 0.15 ft. Wells 399-1-3 and 399-1-7 are screened (or perforated) over the same interval, approximately 25 to 75 ft, while well 399-1-8 is screened between 85 and 105 ft, as described above.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; all three wells showed changes in water levels, probably because of the effects of the Columbia River. The observed water level in all three wells recovered beyond the static level by over 0.2 ft.

Analysis and Interpretation

The pumping rate was measured with a calibrated 5-gal bucket in the constant-discharge test, and measurements are considered accurate. Total discharge was 1309 gal, which, when divided by the 480 min of pumping, gives a figure of 2.73 gpm. The discharge rate was monitored throughout the pumping

phase of the aquifer test. The pumping rate varied during the test from 1.7 to 3.6 gpm, but was held within a 0.4-gpm variation during the last 400 min of the test.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, a tight or low transmissive interval, or a combination of these. If drawdown is considerable, and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Well 399-1-9 is screened in a confined or semiconfined aquifer and these corrections are not applicable, although partial penetration may be a factor since the aquifer could be nearly 50 ft thick. Hantush (1964) suggests that corrections be applied to account for partial penetration effects in both confined and unconfined conditions. The data from observation well 399-1-9 may require correction, but the data with and without corrections can be compared to determine if there are any differences.

The classic Theis and Cooper-Jacob (modified Theis) methods are used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986).

The Theis plot of the drawdown data is presented in Figure D.61. The method is valid for determining transmissivity at pumping wells and both storage and transmissivity in observation wells, if certain assumptions can be made (a number of which may have been violated in this instance). Theoretically, the Theis equation applies to those aquifers: 1) that are entirely homogeneous, 2) that are of infinite areal extent, 3) where the well penetrates the entire thickness of the aquifer, 4) where the coefficient of transmissivity is constant at all times and in all places, and 5) where the pumped well has an infinitesimal diameter. In addition, the Theis method only applies in unconfined situations to water bodies in which the water, in the volume of sediments through which the water table has fallen, is discharged instantaneously with the fall of the water table (Theis 1935). The data considered most

RCRA Well 399-1-9
Constant-Discharge Drawdown
3/2/87

FIGURE D.61. Well 399-1-9 Observed Drawdown Using the Theis Analysis

representative of the aquifer are taken during the latter portion of the test, unless some hydraulic boundary is encountered. This pumping test was not run long enough to eliminate the full effects of borehole storage. It was determined that the test would require at least 375 min of pumping to eliminate these effects. Water level data plotted earlier than 375 min into the test indicate pumping rate adjustments and casing storage effects.

The time after which borehole storage effects should no longer be a factor was determined by two different methods. Hargis (1979) suggests Equation (2)

$$t_c = 360,000 \times r_c^2 \times T^{-1} \quad (2)$$

where t_c = the time of pumping to dissipate borehole storage effects, in min
 r_c = the radius of the well casing in the interval over which the water level declines, in ft
 T = the transmissivity of the aquifer, in ft^2/day .

Using this equation, it would require approximately 375 min of pumping to dissipate the well storage effects, if the transmissivity of the aquifer is $60 \text{ ft}^2/\text{day}$.

Schafer (1978) does not require a transmissivity to calculate t_c . The Schafer method uses the following Equation (3):

$$t_c = 0.6 \times (d_c^2 - d_p^2) \times (Q/s)^{-1} \quad (3)$$

where d_c = the inside diameter of the well casing, in in.
 d_p = the outside diameter of the pump column pipe, in in.
 Q/s = the specific capacity of the well, in gpm/ft of drawdown at time t_c .

Using this equation, it would require 575 min of pumping to dissipate the well storage effects. In this particular test situation, the Hargis and Schafer methods do not agree. The difference is the transmissivity that must be plugged into the Hargis equation; $60 \text{ ft}^2/\text{day}$ would probably be a high value for the aquifer, determined by the last several data points plotted on the recovery curve. The borehole storage effects would probably dissipate over the range of 375 to 575 min of pumping.

The transmissivity calculated using the Theis curve matching method is not representative of the aquifer and the results are not reported.

The Cooper-Jacob (modified Theis) method of analysis is a valid approximator of transmissivity and storativity values, if pumping time is included with those conditions mentioned above for the Theis equation. These theoretical conditions are satisfied for this aquifer test for pumping times greater than 1 min, since only the data from the pumped well is used for analysis. For both the Theis and Cooper-Jacob methods, storativity values cannot be calculated from the data obtained from the pumped well but can only be calculated

from the observation well data measured during aquifer testing. The transmissivity calculated using the Cooper-Jacob method is not representative of the aquifer and the results are not reported; however, the Cooper-Jacob semi-logarithmic plot of the drawdown data is presented in Figure D.62.

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data, are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. A plot of the recovery data is presented in Figure D.63. The data that were used to calculate transmissivity appear to the left of a t/t' value of 2.3 [i.e., $(480 + 375 \text{ min})/375 \text{ min}$] in the plot of data from the test. The early-time data appear to the right on this plot. The recovery measurements from pumped wells are usually considered more reliable

FIGURE D.62. Well 399-1-9 Observed Drawdown Using the Cooper-Jacob (Theis Modified Equation) Analysis

FIGURE D.63. Well 399-1-9 Water Level Recovery Plot Using the Cooper-Jacob Analysis

than pumping data because they are not affected as much by changes in pumping rate as are the drawdown data. The calculated transmissivity from the recovery plot is 60 ft²/day, based on the final two data points on the plot, a very questionable procedure.

Analysis of selected portions of the constant-discharge drawdown and recovery sections of the aquifer test indicates that only the values determined from the recovery data can be considered as representative of aquifer conditions and these are on the borderline of acceptability. The aquifer testing and well construction data for well 399-1-9 are summarized in Table D.14.

The best values for aquifer characteristics determined by this test are a transmissivity of 60 ft²/day and a hydraulic conductivity of 6 ft/day. The aquifer thickness is approximately 10 ft at this location. Aquifer Test Data Sheets for well 399-1-9 follow.

TABLE D.14. Aquifer Testing and Well Construction Summary for Well 399-1-9

WELL: 399-1-9 (S2) DATE OF TEST: 3/2/87 - 3/3/87

LAND SURFACE DATUM (1sd) ELEVATION (ft above msl): 383.49
(brass cap)

STATIC WATER LEVEL (date of test): 10.82 ft below 1sd

ELEVATION: 372.67 ft above msl

MAXIMUM PUMPING WATER LEVEL: 91.46 ft below 1sd

ELEVATION: 292.03 ft above msl

MAXIMUM DRAWDOWN: 80.64 ft

PUMPING RATE: 2.7 gallons per minute (gpm)

PUMPING TIME: 480 minutes TOTAL DISCHARGE: 1309 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD: 52 ft below 1sd 331.5 ft abv msl

TOP OF CLAY: 117 ft below 1sd 266.5 ft abv msl

TOP OF BASALT: 175 ft below 1sd 208.5 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 20 ft (6.1 m)

TOP OF SCREEN 170 ft below 1sd ELEVATION: 213.5 ft above msl

BOTTOM OF SCREEN 180 ft below 1sd ELEVATION: 203.5 ft abv msl

OBSERVATION WELLS:

#1 WELL 399-1-3 PERFORATIONS: 25-44 ft & 54-70 ft
DISTANCE FROM PUMPED WELL: 13 ft

#2 WELL 399-1-7 TOP OF SCREEN: 25 ft
BOTTOM OF SCREEN: 75 ft
DISTANCE FROM PUMPED WELL: 24 ft

#3 WELL 399-1-8 TOP OF SCREEN: 85 ft
BOTTOM OF SCREEN: 105 ft
DISTANCE FROM PUMPED WELL: 12 ft

TABLE D.14. (contd)

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY: ft ² /d (m ² /d)		
Curve Match (Theis)	-----	-----
Straight-line Semilog Plot (Cooper-Jacob)	-----	-----
RECOVERY		
TRANSMISSIVITY: ft ² /d (m ² /d)	60 (5.6)	-----
	-----	-----
PROBABLE VALUE ft ² /d (m ² /d)	60 (5.6)	-----
STORATIVITY:	-----	-----
CONDUCTIVITY: ft/d (m/d)	6 (1.83)	-----

Aquifer Test Data

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Data for Well S-2 (397-1-9)

Pumping Well S-2

Observation Wells 3-1-3, 3-1-7, 3-1-8

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT-DISCHARGE RECOVERY

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well —

Meas. Point for W.L.'s TOP OF EXHAUST 1.86' ABV LSD

Elevation of Meas. Point —

Depth of Pump/Airpipe INTAKE 107' T/C

Pump On: date 3/2/87 time 0915

Pump Off: date 3/2/87 time 1715

Duration of Aquifer Test 8 hr pumping

Time					12.68' ^{Static} Water Level Data				Discharge		Recorded By	Comments	
t = _____ at t' = 0					Static Water Level 12.69' E-TAPE				Reading				
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	or s'		Reading	Q		
3/2	1715	480	0	-			58.89	77.16				CSC	RECOVERY
		480.5	.5	96.8			82.24	73.55				CSC	
		481	1	48.1									
		482	2	24.1			82.54	69.85				CSC	
		483	3	16.1			81.00	68.31				CSC	
		484	4	12.1			79.34	66.65				CSC	
		485	5	9.7			77.50	64.81				CSC	
		486	6	8.1			76.03	63.33				CSC	
		487	7	6.9			74.94	62.25				CSC	
		488	8	6.1			73.65	60.96				CSC	
		489	9	5.4			72.24	59.55				CSC	
		490	10	4.9			70.90	58.21				CSC	
		492	12	4.1			68.39	55.60				CSC	
		494	14	3.5			65.80	53.11				CSC	
		496	16	3.1			63.42	50.73				CSC	
		498	18	2.7			61.02	48.33				CSC	
		500	20	2.5			58.72	46.03				CSC	
		505	25	2.0			53.58	40.89				CSC	
		510	30	1.7			49.06	36.37				CSC	
		515	35	1.4			44.91	32.22				CSC	
		520	40	1.3			41.17	28.48				CSC	
		525	45	1.1			37.88	25.19				CSC	
		530	50	1.0			34.92	22.23				CSC	
		540	60	.9			29.87	17.18				CSC	
		550	70	.7			25.91	13.22				CSC	
		560	80	.7			22.73	10.04				CSC	
		570	90	.6			20.32	7.63				CSC	
		580	100	.5			18.70	6.01				CSC	
		590	110	.5			17.65	4.96				CSC	
		600	120	.5			16.69	4.00				CSC	
		630	150	.4			14.64	1.95				GVL	
		660	180	.3			13.96	1.27				GVL	
		690	210	.3			13.68	0.99				GVL	
		720	240	.3			13.50	0.81				GVL	
		750	270	.2			13.47	0.78				GVL	
		780	300	.2			13.49	0.80				GVL	CHECKED 3 TIMES
3/2	2315	810	360	.2			13.52	0.83				GVL	CHECKED TWICE - WIND STOPPED
3/3	0015	900	420	.2			13.46	0.77				GVL	CHECKED TWICE
		480											

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Pumping Well 5-2 (3-1-9)

Observation Wells 3-2-7, 3-1-3

3-1-8

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured E-TAPE / TRANSFER Depth of Pump/Airpipe 104 T/C

Rad./Dist. of/From Pumping Well _____ Pump On: date 3/2/87 time 09:15

Meas. Point for W.L.'s T/C 2.76' ABV UD Pump Off: date 1/1/80 time 1:00

Elevation of Meas. Point _____ Duration of Aquifer Test _____

TRANSDUCER in well
E. TAPE

Aquifer Test Data

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FOOD CALIBRATED BUCKET

How W.L.'s Measured E-TAPE - TRANSDUCER

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/C 1.9' ABOVE

Elevation of Meas. Point _____

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Data for Well 3-1-8

Pumping Well S-2 (3-1-9)

Observation Wells 3-1-8, 3-1-7, 3-1-3

Depth of Pump/Airpipe 107' 109' T/C _____

Pump On: date 3/2/82 time 0915

Pump Off: date _____ time _____

Duration of Aquifer Test _____

Data for Well 3-1-8

Pumping Well S-2 (3-1-9)

Observation Wells 3-1-8, 3-1-7,
3-1-3

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FOOD CALIBRATED BUCKET

How W.L.'s Measured E-TAP - TRANSVER Depth of Pump/Airpipe 109' T/c

Rad./Dist. of/From Pumping Well _____ Pump On: date 3/2/82 time 0916

Meas. Point for W.L.'s T/C 1.9' ABOVE SD Pump Off: date 7/1 time

Elevation of Meas. Point _____ Duration of Aquifer Test _____

[illegible]

10
20
25

Aquifer Test for Well 399-1-3

Well 399-1-3 in the 300 Area was constructed in April 1950 to characterize the geology and hydrogeology of the unconfined aquifer, including the Hanford formation and the upper portion of the Ringold Formation, and to provide a means of sampling the water of these zones. The aquifer has a saturated thickness of approximately 70 ft at this location. The well was tested at an average pumping rate of 230 gpm for 1440 min (24 hours). Drawdown in the well demonstrated a specific capacity of 23 gpm/ft. No transmissivity could be calculated for the aquifer penetrated by this well because of the large fluctuations in the pumping rate and the subsequent variation in drawdown during pumping. Water levels in wells 399-1-7, 399-1-8, and 399-1-9, and also wells 399-1-16A, B, C, and D were measured during the testing of 399-1-3. Neither well 399-1-16A, located 333 ft from 399-1-3; well 399-1-16B, located 341 ft from the pumped well; well 399-1-16C, located approximately 311 ft from the pumped well; nor well 399-1-16D, located 314 ft from the pumped well, showed any interpretable response to pumping. Well 399-1-9, located 13 ft from the pumped well, showed no interpretable response to the pumping of well 399-1-3. Wells 399-1-7, located 19.3 ft from the pumped well, and 399-1-8, located 20.7 ft from the pumped well, showed response to pumping and recovery; however, these effects were sufficiently masked by the influence of the Columbia River as to prevent any quantitative analysis of the data and calculation of aquifer coefficients. Both of these wells were influenced by pumping and by the river to the same extent, despite being screened at different intervals.

Well 399-1-3 has a total depth of 75 ft and a completed diameter of 8 in. and was perforated from 25 to 44 ft and from 54 to 70 ft. This well was drilled and completed in April 1950. Figure D.64 illustrates the site stratigraphy and well construction at well 399-1-3. A more detailed description of the site geology is included in Section 3 of the report.

Wells 399-1-7, 399-1-8, and 399-1-9, and wells 399-1-16A, B, C, and D were incorporated as observation wells during the pumping of well 399-1-3. These wells have been discussed in earlier sections of this appendix. Wells in the 399-1-16 cluster were not affected by pumping well 399-1-3. Wells 399-1-7, 399-1-8, and 399-1-9 deserve a little more discussion, however.

FIGURE D.64. Well 399-1-3 Stratigraphy and Well Construction

Well 399-1-7 was drilled as part of the Hazardous Materials Monitoring (HMM) program in February and March 1985. This well was completed with 50 ft of No. 15 slot, 6-in.-diameter, stainless steel screen set from 25 to 75 ft, as documented in Figure D.65. Well 399-1-8 was also drilled as part of the HMM program, in July and August 1985. This well was completed with 20 ft of No. 25 slot, 6-in.-diameter, stainless steel screen set from 85 to 105 ft. Figure D.66 shows the site stratigraphy and well construction at well 399-1-8. The deep well, 399-1-9, was completed in the uppermost basalt layer (considered to be the Ice Harbor-Martindale basalt flow) beneath the confining clay layer of the Ringold Formation. A No. 20 slot, 6-in.-diameter, stainless steel screen was installed between the depths of 170 and 180 ft. Figure D.60 illustrates the site stratigraphy and well construction at well 399-1-9. A more detailed description is included in Section 3 of the report.

FIGURE D.65. Construction and Lithologic Diagram of Well 399-1-7

FIGURE D.66. Construction and Lithologic Diagram of Well 399-1-8

Design of the Aquifer Test

The test was designed to pump the well at the highest constant-discharge rate possible for a period of 24 hours. The maximum pumping rate was intended to stress the aquifer system to the greatest extent for producing a measurable drawdown within the well. The 300 Area Process Trenches are located approximately 600 ft to the northwest of well 399-1-3. The Columbia River is located approximately 600 ft to the east of well 399-1-3 (see Figure D.1). The river affected the drawdown and recovery of water levels during aquifer testing. Figure D.67 shows the changes in Columbia River stage and the fluctuations of the water levels in well 399-1-10 during the aquifer testing of well 399-1-3.

Pre-Test Measurements

The aquifer test was preceded by a pumping period to develop the well and to determine the optimal discharge rate. On March 3, 1987, the well was developed by pumping for more than 30 min, using a 10-hp submersible pump. This

300 Area River Monitoring Stations
Well 399-1-10 and Columbia River Station
0001 hrs 3/4/87 - 0130 hrs 3/6/87

FIGURE D.67. Water Level Elevations in Well 399-1-10 and the Columbia River During Testing of Well 399-1-3

pumping period was primarily to determine a maximum pumping rate and the subsequent drawdown that might occur. The pump intake was set at approximately 67 ft below the land surface. Discharge was measured with a McCrometer® flow meter (#86-6-1161) and corroborated with a 5-gal bucket calibrated to 5.0 gal. However, the discharge rate was too great to be measured accurately with a 5-gal bucket. Water levels were measured by an E-tape and recorded manually. Measurements were made 2.45 ft above the land surface, at the top of a stilling hose suspended in the well.

The static water level in well 399-1-9 was 8.82 ft below the land surface (374.67 ft above msl) at the time of the constant-discharge test, on March 4, 1987. Static water levels were not obtained for wells 399-1-7 and 399-1-8 before the constant-discharge test.

Wells 399-1-16A, B, C, and D had initial water levels of 38.28, 37.57, 21.9, and 35.81 ft below the land surface, respectively, before the constant-discharge testing. These water levels equate to elevations of 342.21, 342.74, 358.78, and 345.19 ft above msl, respectively.

Description of the Aquifer Test

The pumping rate of the constant-discharge test averaged 230 gpm. Flow rates during the test were measured with a McCrometer® flow meter, but could not be corroborated with the 5-gal bucket calibrated to 5.0 gal, because of the large rate of discharge. The discharge data fluctuated considerably, ranging from 200 to 250 gpm. This fluctuation was a reflection of the water surging into the well from the dewatered upper perforated zone. Water levels rose and fell with the fluctuating discharge. The discharge data are documented on the field data collection sheets presented at the end of the test description. The total quantity of water discharged during the test was 327,750 gal. The water from the test was discharged into the 300 Area Process Trenches about 1000 ft to the northwest.

Drawdown Measurements. The constant-discharge pumping test was conducted on March 4 through 5, 1987. Water levels were measured manually using E-tapes dedicated to the pumped well and to each of the observation wells and were measured automatically by transducers set in the pumping well and observation wells 399-1-7 and 399-1-8, and recorded on a Terra 8/D® data logger. The pumping was terminated after 1440 min, as planned. The maximum drawdown was approximately 10 ft, but fluctuated considerably during the pumping period. The specific capacity of well 399-1-3 was approximately 23 gpm/ft. Wells 399-1-16A, 399-1-16B, 399-1-16C, and 399-1-16D were not affected by pumping. Wells 399-1-7, 399-1-8, and 399-1-9 did not provide data useful for calculating aquifer coefficients because of the influence of the Columbia River on the changing water levels. The Columbia River does appear to affect the water levels in all of the wells measured during this test.

Recovery Test. Recovery of the water level was observed in the pumping well immediately following termination of pumping. The recovery was monitored in the observation wells; only wells 399-1-7 and 399-1-8 showed any changes in water level because of the recovery from the constant-discharge pumping. The

observed water level in the pumped well did not recover to the initial static level because during the entire test the Columbia River stage was dropping and so were the water levels in all of the wells monitored. Therefore, there was no initial static water level in any of the wells, but rather an initial transient water level.

Analysis and Interpretation

The pumping rate was measured with a McCrometer® flow meter and measurements are considered accurate only to 10% or 20% because of the surging discharge conditions. Total discharge in the test was 327,750 gal, which, when divided by the 1440 minutes of pumping, gives a rate of approximately 230 gpm. The discharge rate was monitored throughout the pumping phase of the aquifer test. The pumping rate varied considerably during the test.

Transmissivity Calculations for the Drawdown Test. There are a number of reasons why water levels may be drawn down a significant amount in relation to the thickness of the aquifer. It may be because of a limited aquifer thickness, borehole or casing storage, partial penetration of the wellbore, or a combination of these. If drawdown is considerable and if equations applicable to confined aquifer conditions are applied to unconfined aquifer conditions, Jacob (1963) suggests that a correction factor be made to the drawdown data before analysis. Hantush (1964) suggests that corrections also be made for wells that partially penetrate the aquifer. Corrections are probably not required for data collected from this well because the well penetrated the entire saturated thickness of the aquifer (if the unconfined aquifer is considered to range from the static water table to the top of the confining clay layer). Data from the drawdown portion of this test could not be analyzed, however, because of the large fluctuation in drawdown measurements and pumping rate.

The classic Theis and Cooper-Jacob (modified Theis) methods are ordinarily used to analyze portions of the drawdown data. These methods are described in Lohman (1972), Bear (1979), and Driscoll (1986). Because of the fluctuations in pumping rate and drawdown measurements, and the influence of the Columbia River on the water levels, these data could not be analyzed with either the Theis-type plot or the Cooper-Jacob method.

Transmissivity Calculations for the Recovery Test. Recovery data or, more precisely, residual drawdown data are typically analyzed by the Cooper-Jacob method where the time-from-the-start-of-pumping is divided by the time-from-the-start-of-recovery (t/t') and plotted against residual drawdown (s') on semi-logarithmic paper. The recovery data were greatly influenced by the Columbia River, as were the drawdown data, and no transmissivity value could be derived. The water level in the well did not recover to the initial static level because the Columbia River water stage was falling during both the drawdown and recovery portions of the aquifer test, as is indicated in Figure D.66. Although both wells 399-1-7 and 399-1-8 showed indications of recovery following the termination of pumping, the influence of the river was too great and water levels began falling again 3 hours later. Water levels recovered less than 0.1 ft in both wells before they started to fall. Drawdown was approximately 0.3 ft in both wells at the time pumping was terminated. Table D.15 includes the summary of the well construction and aquifer testing data for well 399-1-3.

TABLE D.15. Aquifer Characteristics Determined in Testing Well 399-1-3

WELL: 399-1-3

DATE OF TEST: 3/4/87 - 3/5/87

LAND SURFACE DATUM (lsd) ELEVATION (ft above msl): 383.01
(top of casing 385.01-2.00 ft = 383.01)

STATIC WATER LEVEL (date of test): 40.81 ft below lsd

ELEVATION: 342.20 ft above msl

MAXIMUM PUMPING WATER LEVEL: 50.81 ft below lsd

ELEVATION: 332.20 ft above msl

MAXIMUM DRAWDOWN: approximately 10 ft

PUMPING RATE: 230 gallons per minute (gpm)

PUMPING TIME: 1440 minutes

TOTAL DISCHARGE: 327,750 gallons

ESTIMATED DEPTH TO:

TOP OF RINGOLD: 50 ft below lsd 333 ft abv msl

TOP OF CLAY: 102 ft below lsd 281 ft abv msl

TOP OF BASALT: 117 ft below lsd 208 ft abv msl

ESTIMATED THICKNESS OF AQUIFER: 10 ft (3.05 m) of Hanford fm
27 ft (8.23 m) upper Ringold fm

UPPER PERFORATIONS 25-44 ft below lsd ELEVATION: 358-339 ft
above msl

BOTTOM PERFORATIONS 54-70 ft below lsd ELEVATION: 329-313 ft
abv msl

OBSERVATION WELLS:

#1 WELL 399-1-7

TOP OF SCREEN: 25 ft
BOTTOM OF SCREEN: 75 ft
DISTANCE FROM PUMPED WELL: 19.3 ft

#2 WELL 399-1-8

TOP OF SCREEN: 85 ft
BOTTOM OF SCREEN: 105 ft
DISTANCE FROM PUMPED WELL: 20.7 ft

#3 WELL 399-1-9 (S2)

TOP OF SCREEN: 170 ft
BOTTOM OF SCREEN: 180 ft
DISTANCE FROM PUMPED WELL: 13 ft

TABLE D.15. (contd)

#4 WELL 399-1-16A (C1A)	TOP OF SCREEN:	32 ft
	BOTTOM OF SCREEN:	47 ft
	DISTANCE FROM PUMPED WELL:	333 ft
#5 WELL 399-1-16B (C1D)	TOP OF SCREEN:	105 ft
	BOTTOM OF SCREEN:	115 ft
	DISTANCE FROM PUMPED WELL:	341 ft
#6 WELL 399-1-16C (C1B)	TOP OF SCREEN:	167 ft
	BOTTOM OF SCREEN:	177.5 ft
	DISTANCE FROM PUMPED WELL:	311 ft
#7 WELL 399-1-16D (C1C)	TOP OF SCREEN:	106 ft
	BOTTOM OF SCREEN:	116 ft
	DISTANCE FROM PUMPED WELL:	314 ft

AQUIFER TEST DATA SUMMARY:

<u>PARAMETER</u>	<u>PUMPED WELL</u>	<u>OBSERVATION WELL</u>
DRAWDOWN		
TRANSMISSIVITY:		
ft ² /d (m ² /d)		
Curve Match	-----	-----
(Theis)		
W(u) =		
1/u =		
s (ft) =		
t (min) =		
Q (gpm) =		
Straight-line		
Semilog Plot	-----	-----
(Cooper-Jacob)		
RECOVERY		
TRANSMISSIVITY :	-----	-----
ft ² /d (m ² /d)		
	-----	-----
PROBABLE VALUE	-----	-----
ft ² /d (m ² /d)		
STORATIVITY:	-----	-----
CONDUCTIVITY:	-----	-----
ft/d (m/d)		

Aquifer Test Data

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Data for Well 399-1-3

Pumping Well 3-1-3

Observation Wells 3-1-7,
3-1-8, 3-1-9, 3-1-16A & B

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT - DISCHARGE

How Q Measured FLOW METER

How W.L.'s Measured E-TAPE / Steel TAPE / Transducer Depth of Pump/Airpipe 67'

Rad./Dist. of/From Pumping Well — Pump On: date 3/4/87 time 0945

Meas. Point for W.L.'s 2.45' Abv L&D Pump Off: date 3/5/87 time 0945

Elevation of Meas. Point — Duration of Aquifer Test 24 hr. pumping

Time t = _____ at t' = 0				Water Level Data Static Water Level <u>43.26' E-TAPE</u>				Discharge		Recorded By	Comments	
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or f	Reading			Q
3/4	0945	0					43.26	0	69900		CSC	McCrometer #
		1					45.04	1.78			CSC	86-6-1161
		2					50.50	7.24			CSC	Transducers in use
		3					51.63	8.33			CSC	3-1-8, 3-1-7, 3-1-3
		4					49.50	6.24	~ 200		CSC	fluctuating
		5					48.23	4.97			CSC	180-220
		6					52.2	8.99			CSC	
		7									CSC	
		8					47.4	4.04			CSC	
		9					50.74	7.28			CSC	
		10					52.4	9.14			CSC	
		12					52.9	9.14	220		CSC	fluctuating
		14					50.7	7.44			CSC	between 200-250
		16					50.6	7.34	240		CSC	100 gal / 25 sec
		18					51.76	8.50			CSC	totalizer
		20					51.25	7.99	74800 (245)		CSC	
		25					50.33	7.07			CSC	
		30					51.04	7.78	77200 (240)		CSC	
		35					47.50	4.24			CSC	
		40					48.34	5.08	~ 79580 (238)		CSC	
		45					58.73	7.47			CSC	
		50					49.47	6.21	81980 (240)		CSC	
10/45	60						49.23	5.97	84320 (234)		CSC	
	70											
	80						52.14	8.88	89100 (239)		CSC	
	90						49.25	5.99	91400 (230)		CSC	
	100						49.50	6.24	93800 (240)		CSC	
	110						50.53	7.27	96150 (235)		CSC	
11/45	120						49.89	6.59	98500 (235)		CSC	
	150						52.70	9.49	105550 (235)		CSC	Q averaged over 30 min
12/45	180						53.01	9.83	112500 (232)		CSC	Q averaged over 30 min
	210						49.86	6.60			CSC	
13/45	240						51.28	8.02	126400 (231)		CSC	120400 @ 214 min
	270						51.43	8.17	133400 (238)		CSC	
14/45	300						49.26	6.07	140300 (232)		CSC	
15/45	330						51.83	8.57	154160 (231)		CSC	
16/45	360						50.68	7.42	168000 (231)		CSC	
17/45	420						52.87	9.61	181700 (228)		KRD	
18/45	540						51.19	7.93	195350 (227.5)		KRD	

Aquifer Test Data

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Data for Well 399-1-3

Pumping Well 3-1-3

Observation Wells 3-1-7, 3-1-8,

3-1-9, 3-1-16 ABCD

Location 300 AREA PCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured FLOWMETER

How W.L.'s Measured E-TAPE/STEEL TAPE/TRANSOM Depth of Pump/Airpipe 67'

Rad./Dist. of/From Pumping Well _____ Pump On: date 3/4/87 time 0945

Meas. Point for W.L.'s TOP OF NOSE 2.45' ABOVE LSP Pump Off: date 3/5/87 time 0945

Elevation of Meas. Point _____ Duration of Aquifer Test 24 hr

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level <u>43.26 E-TAPE</u>					Reading	Q		
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or f					
3/4	1945	600					52.42	9.16		209000	(227.5)	KRD	
	2045	660					50.63	7.37		222300	(223.3)	KRD	
	2145	720					53.38	10.12		236300	(226.6)	KRD	
	2245	780					50.81	7.55		249900	(226.6)	KRD	
	2345	840					47.45	6.19		263500	(226.6)	KRD	
3/5	0045	900					47.83	4.57		277200	(228.3)	JRC	
	0145	960	20				50.03	6.77		290600	(223.3)	JRC	
	0245	1020					49.22	5.96		304100	(225.0)	JRC	
	0345	1080					50.60	7.34		317500	(223.3)	JRC	
	0445	1140					52.15	8.89		331000	(225.6)	JRC	
	0545	1200					52.51	9.28		344400	(223.3)	JRC	
	0645	1260					50.57	7.31		357800	(223.3)	JRC	
	0745	1320					50.09	6.83		371100	(221.7)	JRC	
	0845	1380					50.78	7.52		384350	(220)	CSC	
	0945	1440	0				5'			397600	(221)	CSC	average = 227.6 over test
			.5	2880			42.20	-0.06				CSC	Recovery
	1441	1	1441				43.72	.46				CSC	
		2	721				42.38	.32				CSC	WIND BLOWING IN
		3	481				43.60	.34				CSC	
		4	361				43.60	.34				CSC	
	1445	5	289				43.58	.32				CSC	
		6	241				43.58	.32				CSC	
		7	206				43.57	.31				CSC	
		8	181				43.57	.31				CSC	
		9	161				43.56	.30				CSC	
	1450	10	145				43.56	.30				CSC	
		12	121				43.56	.30				CSC	
		14	102.9				43.55	.29				CSC	
		16	91				43.55	.29				CSC	
		18	81				43.55	.29				CSC	
	1460	20	73				43.54	.28				CSC	
		25	38.4				43.54	.30				CSC	
	1470	30	49				43.54	.28				CSC	
		25	42.1				43.55	.29				CSC	
	1480	40	37				43.54	.28				CSC	
	1490	50	29.8				43.57	.31				CSC	
	1500	60	25				43.54	.28				CSC	WIND DIED
	510	70	21.6				43.54	.28				CSC	
	1520	80	17				43.54	.28				CSC	WIND INCREASING

Aquifer Test Data

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Data for Well 399-1-3

Pumping Well 3-1-2

Observation Wells 3-1-7, 3-1-8,
3-1-9, 3-1-14 A B C D

Location 300 AREA RCRA
Type of Aquifer Test CONSTANT-DISCH. RECOVERY

How Q Measured Flow Meters

How W.L.'s Measured F-TAPE - TRANSDUCER

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L. s 2.451 Above L.S.D

Elevation of Meas. Point _____

Depth of Pump/Airpipe ^{INTAKE} 67'

Pump On: date 3/5/83 time 0945

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hr.

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level _____								
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'		Reading	Q		
3/5	11:15	1530	90	17			43.53	.27				CSC	RECOVERY (cont.)
		1540	100	15.4			43.55	.29				CSC	FRONT MOVING THRU
		1550	110	14.1			43.54	.28				CSC	WIND INCREASED
		1600	120	13			43.57	.31				CSC	
		1610	150	10.6			43.56	.30				CSC	
		1620	180	9			43.60	.34				CSC	
		1650	210	7.9			43.61	.35				CSC	
		1650	240	7			43.63	.37				CSC	
		1710	270	6.3			43.63	.37				CSC	
		1740	300	5.8			43.65	.39				CSC	
		1800	360	5			43.66	.40				CSC	
		1800	420	4.4			43.69	.43				CSC	
		1920	480	4			43.72	.46				CSC	

Aquifer Test Data

page 1 of 3
 Data for Well 3-1-9 (S2)
 Pumping Well 3-1-3
 Observation Wells 3

Location 300 AFPA DCPA
 Type of Aquifer Test CONCEPT DISCHARGE
 How Q Measured FLOWMETER
 How W.L.'s Measured E-TAPE, STEEL PIPE
 Rad./Dist. of/From Pumping Well _____
 Meas. Point for W.L.'s TC-1.64 above LSP
 Elevation of Meas. Point _____

Depth of Pump/Airpipe 67'
 Pump On: date 3-4-87 time 0945
 Pump Off: date _____ time _____
 Duration of Aquifer Test _____

Time t = _____ at t' = 0					10.46' STEEL PIPE Water Level Data Static Water Level <u>10.46' E-TAPE</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or s'	Reading	Q		
	09:16	0					10.46				CSC	0945 started
		.5										Pumping 3-1-3
		1										
		2										
		3										
		4										
		5										
		6										
		7										
		8										
		9										
		10										
		12										
		14										
		16										
		18										
		20	23				10.50 .04				CSC	
		25	28				10.50 .04				CSC	
		30	33				10.50 .04		240		CSC	
		35	38				10.52 .06				CSC	
		40	43				10.52 .06				CSC	
		45	48				10.52 .06		240		CSC	
		50	53				10.53 .07				CSC	
		60	63				10.53 .07		234		CSC	
		75					10.53					
		85					10.53 .07		239		CSC	
		95					10.52 .06		230		CSC	
		105					10.52 .06		240		CSC	
		115					10.53 .07		235		CSC	
		125					10.53 .07		235		CSC	
		150					10.51 .05		235		CSC	
		180					10.50 .04		232		CSC	
		220					10.51 .05		232		CSC	
		240					10.52 .06		231		CSC	
		270					10.52 .06		233		CSC	
		300					10.52 .06		230		CSC	
		360					10.53 .07		231		CSC	
		420					10.53 .07		231		CSC	
		480					10.46 0		228		KRO	

Aquifer Test Data

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 Data for Well 3-1-7 (S-2)
 Pumping Well 3-1-3
 Observation Wells 3-1-7, 3-1-7,
3-1-8, 3-1-14 A & B

Location 300 AREA RCRA
 Type of Aquifer Test CONSTANT-DISCHARGE
 How Q Measured FLOWMETER
 How W.L.'s Measured E-TAPE STEEL TAPE / T
 Rad./Dist. of/From Pumping Well _____
 Meas. Point for W.L.'s T/C 1.64' A.W. 1.52
 Elevation of Meas. Point _____

Depth of Pump/Airpipe 67'
 Pump On: date 3/4/87 time 0945
 Pump Off: date _____ time _____
 Duration of Aquifer Test _____

Time t = _____ at t' = 0				Water Level Data Static Water Level <u>10.46'</u>				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	Q		
3/4	540					10.43'	-.03		227.5	KRD	
	600					10.40'	-.06		227.5	KRD	
	660					10.37'	-.09		228.3	KRD	WARM TEMP.
	720					10.36'	-.10		226.6	KRD	AMBIENT A.P.
	780					10.36'	-.10		226.6	KRD	avg 50.60°F
	840					10.42'	-.04		226.6	KRD	
	900					10.44'	-.02		229.3	JRC	
	960					10.46'	0		223.3	JRC	
	1020					10.48'	.02		225.0	JRC	
	1080					10.53'	.07		223.3	JRC	
	1140					10.47'	.01		215.0	JRC	
	1200					10.42'	-.04		223.3	JRC	
	1260					10.48'	.02		223.3	JRC	
	1320					10.52'	.06		221.7	JRC	
	1380					10.45'	-.01			CSC	WIND BLOWING
	1440	0				10.51'	.05			CSC	
1441	1500	1	1441			10.50				CSC	Recovery
	1442	2	721			10.50	.04			CSC	
	1443	3	481			10.50	.04			CSC	
		4	364			10.50	.04			CSC	
	1445	5	289			10.50	.04			CSC	
		6	241			10.50	.04			CSC	
		7	206.7			10.50	.04			CSC	
		8	181			10.50	.04			CSC	
		9	161			10.50	.04			CSC	
	1450	10	145			10.51	.04			CSC	
		12	121			10.51	.05			CSC	
		16	71			10.50	.04			CSC	
	1460	20	33			10.50	.04			CSC	
		25	59.6			10.50	.04			CSC	
	1470	30	49			10.50	.04			CSC	
		35	49.1			10.50	.04			CSC	
	1480	40	37			10.51	.05			CSC	
	1490	50	27.8			10.52	.06			CSC	
	1500	60	25			10.53	.07			CSC	
		70	20.6			10.53	.07			CSC	
		80	19			10.53	.07			CSC	
		90	17			10.53	.07			CSC	
	1540	100	154			10.54	.08			CSC	

Aquifer Test Data

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Data for Well 3-1-9 (S-2)

Pumping Well 3-1-2

Observation Wells 3-1-9, 3-1-8,
3-1-7, C-1 AREA (3-1-15 AREA)

Location 300 AREA 2CRA

Type of Aquifer Test CONSTANT - DISCHARGE - RECOVERY

How Q Measured Flowmeter

How W.L.'s Measured E-TAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/C 1.64' ABV L3D

Elevation of Meas. Point _____

Depth of Pump/^{INTAKE}Airpipe 67'

Pump On: date 3/4/97 time 0945

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hr.[illegible]

Aquifer Test Data

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Data for Well 3-1-16C

Pumping Well 3-1-3

Observation Wells 3-1-16A, B, C, D

1-3-7, 1-3-8

Location 300 AREA RCR

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER

How W.L.'s Measured E-TAPE, STEELTAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/C 1.90' above LSO

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 3-4-87 time 0945

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hr. pumping

Time		t = _____ at t' = 0		Water Level Data		Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or f	Reading	Q
3/4		10:15	30	23.82			.02	ES	INITIAL MEASUREMENT
	10:17	32		23.84			.04	ES	MADE FROM BOTTOM
	10:20	35		23.85			.05	ES	OF MARK N.03'
	10:30	45		23.88			.08	ES	DIFFERENCE TO MIDDLE
	10:40	55		23.88			.08	ES	MARK C3C
	10:50	65		23.87			.07	ES	E-TAPE KEEPS
	11:15	90		23.85			.05	ES	SHORTING OUT
	11:35	110		23.88			.08	ES	
	11:56	131		23.78			-.02	ES	CHANGED MEASUREMENT
	12:55	190		23.78			-.02	ES	PLACED TYPON R3603
	1:15	210		23.78			-.02	ES	1.5' ON PROBE AT
	2:10	265		23.72			.12	ES	SOLVED "SHORTING-OUT" PROBLEM
	2:30	285		23.72			.12	ES	
	2:45	300		23.74			.14	ES	
	3:11	326		23.75			.15	ES	
	4:11	386		23.77			.17	ES	
	5:11	446		23.77			.17	ES	
	6:06	501		23.75			.15	KRO	
	6:59	554		23.74			.14	KRO	
	7:59	614		23.93			.13	KRO	
	8:56	671		23.93			.13	KRO	
	9:55	730		23.92			.12	KRO	
	10:54	789		23.94			.14	KRO	
	11:59	854		23.96			.16	KRO	
	1:00	915		24.00			.20	JRC	
	1:58	973		24.06			.26	JRC	
	2:56	1031		24.01			.21	JRC	
	3:57	1092		24.02			.22	JRC	
	5:00	1155		24.03			.23	JRC	
	5:54	1209		24.03			.23	JRC	
	6:55	1270		24.03			.23	JRC	
	7:53	1328		24.02			.22	JRC	
		1396		24.06			.26	JRC	
3/5	9:51	1446	16	24.10			.30	RL	
	9:59	1454	14	24.12			.30	RL	
	10:16	1471	31	24.10			.30	RL	
	10:35	1490	50	24.11			.31	RL	
	10:51	1506	66	24.12			.32	RL	
	11:00	1515	75	24.12			.32	RL	

* Chuck time took static water level readings. Measurements used left side of tape value as datum

* E.S. used middle of tape value for datum. E-TAPE HAS 1-FT increments

Location 300 Area RCRA
Type of Aquifer Test Constant Discharge
How Q Measured Flow meter + bucket
How W.L.'s Measured _____
Rad./Dist. of/From Pumping Well _____
Meas. Point for W.L.'s T/c 1.90' above LSL
Elevation of Meas. Point _____

Observation Wells _____

Duration of Aquifer Test _____

D.222

Aquifer Test Data

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Data for Well 3-1-16 A

Pumping Well 3-1-3

Observation Wells 3-1-16 A,

3-1-16 B, 3-1-16 D, 3-1-7, 7-1-8

Location 200 AREA DATA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured Flowmeter

How W.L.'s Measured E-TAPE / DIRECT TAP

Rad./Dist. of/From Pumping Well

Meas. Point for W.L.'s 16

Elevation of Meas. Point

Depth of Pump/Airline Intake 67'

Pump On: date 3/4/87 time 9:45

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hr. pumping

Time			Water Level Data		Discharge		Recorded By	Comments
Day	Clock Time	t	at t' = 0	Static Water Level	Reading	Q		
	9:47	0		39.58' STEEL TAP	39.50		ES	anomalous for reading.
		.5					ES	E-TAPE probably started
	1:48	1			39.61	.01	ES	
	1:49	2			39.58	.02	ES	INITIAL MEASUREMENTS
	50	3			39.60	0	ES	MADE AT LOWER END
	51	4			39.59	-.01	ES	OF MARK - ACTUAL
	52	5			39.60	0	ES	M.P. should be
	53	6			39.60	0	ES	CENTER OF MARK
	54	7			39.60	0	ES	ON THIS TAP - the
	55	8			39.60	0	ES	DIFFERENCE ~.03'
	56	9			39.60	0	ES	CSC
	57	10			39.60	0	ES	∴ INITIAL MEAS ~
	10:28				39.63	.03	ES	39.63' M.P.
	10:38				39.64	.04	ES	
	10:48				39.65	.05	ES	
	11:08				39.67	.07	ES	
	11:33				39.68	.08	ES	
	12:11				39.69	.09	ES	
	1:06				39.58		ES	Anomalous Reading
	1:26				39.68	.08	ES	HAD DIFFICULTY WITH
	2:07				40.16	.56	ES	E-TAPE SHORTING OUT
	2:27				40.18	.58	ES	PLACED TUBING AROUND
	2:43				40.17	.57	ES	ON PROBE AT 1:55.
	3:09				40.18	.58	ES	SOLVED PROBLEM.
	4:09				40.22	.62	ES	
	5:09				40.25	.65	ES	
	6:04				40.28	.68	KRO	
	7:07				40.38	.68	KRO	
	7:57				40.38	.68	KRO	
	8:54				40.38	.68	KRO	
	9:53				40.28	.68	KRO	
	10:53				40.27	.67	KRO	
	11:54				40.30	.70	KRO	
	12:51				40.29	.69	JRC	
	1:56				39.99	.39	JRC	
	2:54				40.02	.42	JRC	
	2:56				39.93	.33	JRC	
	5:10				40.38	.78	JRC	
	5:52				39.97	.37	JRC	

* STATIC WATER LEVEL MEASUREMENTS BY CHUCK CLINE. MEASUREMENTS MADE WITH DATUM TO THE LEFT OF TAP VALUE

+ MEASUREMENTS BY E.S. USED CENTER OF VALUE AS DATUM. E-TAPE HAS 1'-FT INCREMENTS.

Aquifer Test Data

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Data for Well 3-1-16A

Pumping Well 3-1-3

Observation Wells 3-1-16A,

3-1-16B, 3-1-16D, 3-1-7, 3-1-9

Location 300 Acres RCRA

Type of Aquifer Test Constant-Discharge

How Q Measured Flowmeter

How W.L.'s Measured E-TAPE / STEELTAPE

Rad./Dist. of /From Pumping Well _____

Meas. Point for W.L.'s T/C 1.3' Above L.S.D

Elevation of Meas. Point _____

Depth of Pump/Airpipe _____

Pump On: date 3/4/87 time 9:45 a.m.

Pump Off: date 3/5/87 time 9:45 a.m.

Duration of Aquifer Test 1440 min. (24 hrs.)

Time t = _____ at t' = 0					Water Level Data Static Water Level _____					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s or f		Reading	Q		
3-5	6:55				40.00'			.40				JRC	PF
	7:52				40.00'			.40				JRC	
Recovery	09:05	1400	8		40.41'			.81				CSC	Adjusted Tygon tube
		1408	5		40.46'			.86				PL	ground probe got
		1445	5	28.9	40.45			.85				PL	better reading
	10:00	1455	15	9.7	40.43			.83				PL	
	10:05	1460	20	7.3	40.42			.82				PL	
	10:15	1470	30	4.9	40.42			.82				PL	
	10:33	1487	47	31.6	40.42			.82				PL	
	10:50	1505	65	23.2	40.43			.83				PL	
	11:02	1517	77	19.7	40.44			.84				PL	
	11:26	1541	101	15.3	40.44			.84				PL	
	11:36	1551	111	14	40.45			.85				PL	
		1600	160	10	40.45			.85				CSC	
		1625	185	8.8	40.45			.85				CSC	
		1657	217	7.6	40.46			.86				CSC	
		1690	250	6.8	40.47			.88				CSC	
		1715	275	6.2	40.51			.90				CSC	
		1751	311	5.6	40.51			.91				CSC	
		1807	367	4.9	40.52			.92				CSC	
		1833	413	4.3	40.55			.95				CSC	
		1936	476	3.9	40.56			.96				CSC	

Aquifer Test Data

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Data for Well 3-1-16B

Pumping Well 3-1-3

Observation Wells 3-1-16B, A, D, 3-1-7, 3-1-8

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT DISCHARGE

How Q Measured FLOW METER

How W.L.'s Measured E-TAPE, STEELTAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/C

Elevation of Meas. Point _____

Depth of Pump/ E-TAPE 67'

Pump On: date 3/4/87 time 0945

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hr. Pumping

Time 9:06			38.74' STEEL Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0			Static Water Level 38.75'-E-TAPE								
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or f	Reading	Q	
3/4							38.75	0			
	10:06	21			38.87			-.41			
	10:08	23			38.69			-.09			
	10:10	25			38.69			-.09			
	10:25	40			38.70			-.08			
	10:35	50			38.68			-.10			
	10:45	60			38.68			-.10			
	11:05	80			38.78			0			
	11:27	102			38.71			-.07			
	12:02	127			38.71			-.07			
	12:10	145			38.65			-.13			
	12:21	156			38.63			-.15			
	12:43	178			38.72			-.06			
	1:03	198			38.72			-.06			
	1:23	218			38.72			-.06			
	2:00	255			38.83			-.05			
	2:20	275			38.83			-.05			
	2:40	295			38.85			-.07			
	3:07	322			38.86			-.08			
	4:07	382			38.89			-.11			
	5:07	442			38.91			-.13			
	5:59	494			38.91			-.13			
	6:55	550			38.92			-.14			
	7:55	610			38.92			-.14			
	8:55	667			38.93			-.15			
	9:52	723			38.92			-.14			
	10:51	784			38.94			-.16			
	11:55	850			38.95			-.17			
	12:56	911			38.96			-.20			
	1:52	968			39.00			-.22			
	2:53	1028			39.04			-.26			
	3:54	1089			39.02			-.24			
	4:59	1154			39.02			-.24			
	5:51	1206			39.01			-.23			
	6:51	1264			39.02			-.24			
	7:52	1323			39.05			-.27			
		1392			39.09			-.31			
		1438			39.09			-.31			

* Static water level measurements by Chuck Cline, measurements made with datum to the left of tape value + measurements by E.S. used center of value as datum. E-TAPE HAS 1-FT INCREMENTS

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Data for Well 3-1-16B

Pumping Well 3-1-2

Observation Wells B-16A, F, D

Location San Jose, Costa Rica

Type of Aquifer Test Constant Head

How Q Measured (1000) / 276.8

How W.L.'s Measured 5 TAPS / 1050 TAPS Depth of Pump/Airpipe _____

Rad./Dist. of/From Pumping Well _____ Pump On: date _____ time _____

Meas. Point for W.L.'s 7/c 1.17' Above L.D Pump Off: date _____ time _____

Elevation of Meas. Point _____ Duration of Aquifer Test _____

Time t = _____ at t' = 0					Water Level Data Static Water Level _____					Discharge		Recorded By	Comments
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	s' or s'	Read- ing	Q			
3-5	9:45	1440	0				39.09	.31			RL		
		1448	2	72.1			39.06	.28			RL		
	9:55	1450	10	145			39.08	.30			RL		
	10:03	1458	18	8.1			39.09	.31			RL		
	10:14	1469	29	50.7			39.09	.31			RL		
	10:29	1484	44	23.7			39.09	.31			RL		
	10:40	1495	55	27.2			39.09	.31			RL		
	10:49	1504	64	23.9			39.10	.32			RL		
	11:08	1523	83	12.3			39.11	.33			RL		
	11:24	1539	99	15.5			39.12	.34			RL		
	11:34	1549	109	14.2			39.13	.35			RL		
		1505	155	10.3			39.08	.30			CSC		
		1629	189	8.6		39.14	39.18	.36			CSC		
		1653	213	7.8			39.15	.37			CSC		
		1687	247	6.8			39.17	.39			CSC		
		1719	279	6.2			39.18	.40			CSC		
		1747	307	5.7			39.19	.41			CSC		
		1806	366	4.9			39.21	.43			CSC		
		1869	429	4.4			39.24	.46			CSC		
		1932	492	3.9			39.26	.48			CSC		
												</	

Aquifer Test Data

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Data for Well 1-16P

Pumping Well 3-1-3

Observation Wells 1-16A, 1-16B,

3-1-16C, 3-1-7 3-1-9

Location 300 AN-11 RCH

Type of Aquifer Test CONSERVATIVE DISCHARGE

How Q Measured CLC 10012

How W.L.'s Measured E-TAPE, STEEL TAPE

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/C 1.4' ABOVE LSL

Elevation of Meas. Point _____

Depth of Pump/Airpipe 67' T/C

Pump On: date 3/4/87 time 0745

Pump Off: date 3/5/87 time 0945

Duration of Aquifer Test 24 hrs pumping

Time t = _____ at t' = 0				37.21' Water Level Data E-TAPE Static Water Level				Discharge		Recorded By	Comments
Day	Clock Time	t	t'	Reading	Conversions or Corrections	Water Level	s or f	* Read- ing	Q		
	10:00	15		37.21			-.02	37.23		ES	INITIAL READING
	10:02	17		37.23			0			ES	MADE AT BOTTOM
	10:04	19		37.20			-.03			ES	OF THE MARK
	10:22	37		37.24			.01			ES	should be bottom of
	10:32	47		37.22			-.01			ES	sample ~ .03' d.c. of
	10:42	57		37.25			.02			ES	initial 10.0
11:02	10:42	57		37.27			.04			ES	= 37.23'
	11:20	15		37.25			.02			ES	
	11:50	125		37.21			-.02			ES	E-TAPE KEEPS
	11:59	134		37.22			-.01			ES	SHORTING OUT -
	12:30	165		37.22			-.01			ES	
	11:02	192		37.27			.04			ES	
	11:22	212		37.27			.04			ES	
	1:58	252		37.29			.06			Placed on	Tygon R3603 tubing
	2:18	272		37.31			.08			Probe at 1:55	
	2:38	293		37.31			.08			ES	SOLVED PROBLEM
	3:04	319		37.32			.09			ES	
	4:04	379		37.35			.12			ES	
	5:04	439		37.37			.14			ES	
	5:57	492		37.36			.13			KRC	
	6:57	548		37.37			.14			KRC	
	7:57	608		37.37			.16			KRC	
	8:50	665		37.38			.15			KRC	
	9:50	725		37.38			.15			KRC	
	10:47	784		37.37			.16			KRC	
	11:57	843		37.41			.18			KRC	
	12:54	909		37.43			.20			JRC	
	1:51	966		37.47			.24			JRC	
	2:51	1026		37.47			.24			JRC	
	3:50	1085		37.52			.29			JRC	
	4:57	1152		37.57			.29			JRC	
	5:57	1205		37.51			.31			JRC	
	6:53	1268		37.59			.36			JRC	
	7:50	1325		37.60			.37			JRC	
		1390		37.52			.29			CSC	
		1438		37.54			.31			PL	

* CHUCK CLINE took static water level readings. Measurements used left side of tape value as datum

+ E.S. used middle of tape value for datum. E-tape has 1-foot increments.

Aquifer Test Data

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Data for Well 3-1-16D

Pumping Well 3-1-3

Observation Wells 3-1-16A B C D

3-1-7, 3-1-8, 3-1-9

Location 300 Area

Type of Aquifer Test Constant Discharge

How Q Measured _____

How W.L.'s Measured _____

Rad./Dist. of/From Pumping Well _____

Meas. Point for W.L.'s T/c 1.35' above

Elevation of Meas. Point _____

Depth of Pump/Airpipe 67' T/c

Pump On: date 3-4-87 time 0945

Pump Off: date 3-5-87 time 0945

Duration of Aquifer Test 24 hr. pumping

Time					Water Level Data					Discharge		Recorded By	Comments
t = _____ at t' = 0					Static Water Level _____					_____			
Day	Clock Time	t	t'	t/t'	Reading	Conversions or Corrections	Water Level	ft or s'		Reading	Q		
3-5	9:45	1440	0				37.54	.31				RL	
		1441	1	1441			37.54	.31				RL	
		1444	4	361			37.53	.30				RL	
		1448	8	181			37.54	.31				RL	
	9:57	1452	12	121			37.54	.31				RL	
	10:02	1457	17	85.3			37.54	.31				RL	
	10:13	1468	28	51.4			37.54	.31				RL	
	10:28	1483	43	34.5			37.54	.31				RL	WIND INCREASE
	10:39	1494	54	27.3			37.54	.31				RL	FRONT MOVING T
	10:48	1503	63	23.9			37.55	.32				RL	
	11:07	1522	82	18.6			37.56	.33				RL	
	11:25	1540	100	15.4			37.56	.33				RL	
	11:35	1550	110	14.1			37.57	.34				RL	
		1558	118	10.1			37.57	.34				CSC	
		1627	147	8.7			37.58	.35				CSC	
		1655	215	7.7			37.60	.37				CSC	WIND DIED
		1685	245	6.9			37.62	.39				CSC	WARM WEATH
		1720	280	6.1			37.64	.41				CSC	
		1746	306	5.7			37.64	.41				CSC	
		1805	365	4.9			37.66	.43				CSC	
		1821	431	4.3			37.69	.46				CSC	
		1930	490	3.9			37.67	.46				CSC	

Aquifer Test Data

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Data for Well S-2 (399-1-9)

Pumping Well S-2

Observation Wells 3-1-3,

3-1-7, 3-1-8

Location 300 AREA RCRA

Type of Aquifer Test CONSTANT-DISCHARGE

How Q Measured CALIBRATED BUCKET

How W.L.'s Measured E-TAPE TRANSDUCER Depth of Pump/Airpipe 107' T/C 109'

Rad./Dist. of From Pumping Well _____ Pump On: date 3/2/87 time 0915

Meas. Point for W.L.'s 1.86' ABW L5D Pump Off: date 3/2/87 time 1715

Elevation of Meas. Point _____ Duration of Aquifer Test 8 hr. pumping

Elev. Top Brasscap = 383.49 Elev. T/C = 385.08

Time				Water Level Data STEEL TAP				Discharge		Recorded By	Comments
t = _____ at t' = 0				Static Water Level 12.68' M9							
Day	Clock Time	t	t'	1/t'	Reading	Conversions or Corrections	Water Level	s or s'	Read- ing	gpm	
3/2	0915	0					12.69	0			
		.5					15.60	2.91			
		1					17.11	4.42			
		2					19.18	6.49			
		3					20.52	7.83			
		4					21.77	9.08			
		5					22.91	10.22			
		6					23.75	11.06	82	2.75	
		7					25.02	12.33			
		8					25.95	13.26			
		9					26.77	14.09			
		10					27.37	14.68	1.5	0.50	
		12					29.13	16.44			
		14					30.26	17.57			
		16					31.38	18.61			
		18					31.44	18.75			
		20					33.20	20.51			
		25					35.21	22.52			
		30					36.42	23.73	1.7	0.50	
		35					42.16	29.47			
		40					46.33	33.64	3.2	0.50	
		45					47.35	34.66	2.7	0.50	
		50					52.27	39.58	2.7	0.50	
		55					55.00	42.31	2.7	0.50	
		60					56.95	44.26	2.5	0.50	
		70					58.73	46.04	2.1	0.50	
		80					61.76	49.07	3.6	0.50	
		90					69.17	56.49	2.7	0.50	
		100					71.30	58.61			
		110					72.17	60.50	2.8	0.50	
		120					75.17	62.48	2.7	0.50	
		130					76.78	64.09	2.5	0.50	
		140					80.64	67.95	2.7	0.50	
		150					82.17	70.38	2.8	0.50	
		210					84.86	72.17	2.8	0.50	
		240					88.00	75.31	2.9	0.50	
		270					90.04	77.35	2.9	0.50	
		300					93.33	80.64	2.7	0.50	
		360					91.03	78.34	2.7	0.50	
		420									

480

89.85 77.16

TOTAL 1308.5 gal
Avg. = 2.7 gpm

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APPENDIX E

GROUND-WATER CHEMISTRY DATA

APPENDIX E

GROUND-WATER CHEMISTRY DATA

This appendix gives results of the chemical constituent analyses of the ground water for the 300 Area Process Trenches monitoring effort. Initial sampling began on a 16-well network in June 1985 and samples have been basically taken at monthly intervals since that time. Three or four field replicates were taken for selected subsets of wells and constituents for the first three months. Also, most of the first two months of data were analyzed at UST-Hoboken, while the remainder have been analyzed at UST-Richland. In October 1985, certain samples were split, with one subsample going to UST-Richland and one going to UST-Hoboken to cross-validate results from the two laboratories. Starting in September 1986, filtered samples for metal analyses were added to the regular metal analyses. In addition, as part of an expanded monitoring network, 18 new wells were added. Nine of these were initially sampled in February 1987, and the remaining new wells were first sampled in March 1987.

Sampling Schedule

At the 300 Area Process Trenches, the wells have been sampled according to the schedule given in Table E.1. To agree with standard Hanford Wells designation, all wells in the 300 Area would normally have a "399-" prefix except for S19E13 and S30E15A, which would have a "699-" prefix.

TABLE E.1. Sampling Schedule for the 300 Area Process Trenches

Sample Period	Dates Sampled	Wells							
		1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8
1-Jun85	17 Jun-02 Jul	4S	4S	S	S	L	S	.	.
2-Jul85	22 Jul-02 Aug	4S	4S	S	S	3L	S	S	.
3-Aug85	19 Aug-27 Aug	4S	4S	S	S	3L	S	S	.
4-Sep85	23 Sep-30 Sep	S	S	S	S	L	S	S	.
5-Oct85	23 Oct-01 Nov	xS	xS	S	S	xS	S	S	S
6-NovDec85	21 Nov-11 Dec	S	S	S	S	S	S	S	S
7-Jan86	13 Jan-20 Jan	S	S	S	S	L	S	S	S
8-Feb86	12 Feb-21 Feb	S	S	S	S	S	S	S	S
9-Mar86	13 Mar-21 Mar	S	S	S	S	S	S	S	S
10-Apr86	17 Apr-23 Apr	S	S	S	S	L	S	S	S
11-May86	19 May-27 May	S	S	S	S	S	S	S	S
12-Jun86	18 Jun-26 Jun	S	S	S	S	S	S	S	S
13-Jul86	15 Jul-22 Jul	S	S	S	S	L	S	S	S
14-Aug86	15 Aug-29 Aug	S	S	S	S	S	S	S	S
15-Sep86	17 Sep-23 Sep	S	S	S	S	S	S	S	S
16-Oct86	13 Oct-28 Oct	S	S	S	S	L	S	S	S
17-Nov86	10 Nov-17 Nov	S	S	S	S	S	S	S	S
18-Dec86	04 Dec-10 Dec	S	S	S	S	S	S	S	S
19-Jan87	15 Jan-23 Jan	S	S	.	S	L	S	.	S
20-Feb87	03 Feb-27 Feb	S	S	S	S	S	S	S	S
21-Mar87	13 Mar-02 Apr	S	S	S	S	S	S	S	S
22-Apr87	14 Apr-30 Apr	S	S	S	S	L	S	S	S

Sample Period	Dates Sampled	Wells							
		2-1	3-10	3-7	4-1	4-7	8-2	S19-E13	S30E15A
1-Jun85	17 Jun-02 Jul	S	4S	S	S	4S	S	L	S
2-Jul85	22 Jul-02 Aug	S	4S	S	S	4S	S	L	S
3-Aug85	19 Aug-27 Aug	S	4S	S	S	4S	S	L	S
4-Sep85	23 Sep-30 Sep	S	S	S	S	S	S	L	S
5-Oct85	23 Oct-01 Nov	S	xS	S	S	xS	S	S	S
6-NovDec85	21 Nov-11 Dec	S	S	S	S	S	S	S	S
7-Jan86	12 Jan-20 Jan	S	S	S	S	S	S	L	S
8-Feb86	12 Feb-21 Feb	S	S	S	S	S	S	S	S
9-Mar86	13 Mar-21 Mar	S	S	S	S	S	S	S	S
10-Apr86	17 Apr-23 Apr	S	S	S	S	S	S	L	S
11-May86	19 May-27 May	S	S	S	S	S	S	S	S
12-Jun86	18 Jun-26 Jun	S	S	S	S	S	S	S	S
13-Jul86	15 Jul-22 Jul	S	S	S	S	S	S	L	S
14-Aug86	15 Aug-29 Aug	S	S	S	S	S	S	S	S
15-Sep86	17 Sep-23 Sep	S	S	S	S	S	S	S	S
16-Oct86	13 Oct-28 Oct	S	S	S	S	S	S	L	S
17-Nov86	10 Nov-17 Nov	S	S	S	S	S	S	S	S
18-Dec86	04 Dec-10 Dec	S	S	S	S	S	S	S	S
19-Jan87	15 Jan-23 Jan	S	S	S	S	S	S	L	S
20-Feb87	03 Feb-27 Feb	S	S	S	S	S	S	S	S
21-Mar87	13 Mar-02 Apr	S	S	S	S	S	S	S	S
22-Apr87	14 Apr-30 Apr	S	S	S	S	S	S	L	S

TABLE E.1. (contd)

Sample Period	Dates Sampled	Wells									
		1-9	1-10	1-11	1-12	1-13	1-14	1-15	1-16A	1-16B	
20-Feb87	03 Feb-27 Feb	.	S	S	S	S	S	S	.	.	
21-Mar87	13 Mar-02 Apr	S	S	S	S	S	S	S	S	S	
22-Apr87	14 Apr-30 Apr	S	S	S	S	S	S	S	S	S	

Sample Period	Dated Sampled	Wells								
		1-16C	1-17A	1-17B	1-17C	1-18A	1-18B	1-18C	1-19	4-11
20-Feb87	03 Feb-27 Feb	.	S	.	.	S	.	.	.	S
21-Mar87	13 Mar-02 Apr	S	S	S	S	S	S	S	S	S
22-Apr87	14 Apr-30 Apr	S	S	S	S	S	S	S	S	S

S = Standard List of Constituents

L = Long List of Constituents (includes S and the 9905 requirements)

Number indicates amount of replicate sampling

x indicates samples split and sent to UST-Hoboken and UST-Richland

. indicates wells were not sampled at this time

Constituent Lists

The standard list of constituents is composed of those constituents that are regularly analyzed for all wells in the monitoring network. Several changes have occurred in the standard list over time, as original constituents that were never detected were removed from the list, and as constituents that were found to be regularly above the detection limit were added. The currently defined standard list consists of the following constituents:

- Indicators of Ground-Water Contamination - 40 CFR 265, Subpart F, 92 (b) (3)
- Interim Drinking Water Standards - Interim Primary Drinking Water Standards, 40 CFR 265, Subpart F, 92 (b) (1) and Appendix III
- Ground-Water Quality Characteristics - 40 CFR 265, Subpart F, 92 (b) (2)

- Site-Specific Constituents -

Constituents specific to this site based on historical information and detailed in the Monitoring Plan. Note: Some constituents in the above subsets are also of site specific interest. These are marked by an 'x' in the following lists.

- Tag-along Constituents -

Constituents that are analyzed because they are members of a group analysis that contains one of the constituents listed above.

Indicators of Ground-Water Contamination

pH
Specific Conductance
TOC - Total Organic Carbon
TOX - Total Organic Halogen

Interim Drinking Water Standards

Arsenic
Barium
Cadmium
Chromium
Lead
Mercury
x Selenium
Silver
x Fluoride
x Nitrate
Endrin^(a)
Lindane (a,b,g,d-BHC)^(a)
Methoxychlor^(a)

Ground-Water Quality Characteristics

x Chloride
Iron
Manganese

(a) Constituents that were on the standard list for the first year. They were never detected and are currently being sampled at all wells on a quarterly basis instead of monthly.

Phenols(a)
x Sodium
x Sulfate

Toxaphene(a)
2,4 D(a)
2,4,5 TP Silvex(a)
Radium
Gross Alpha
Gross Beta
Coliform Bacteria

Site-Specific Constituents

Zinc
Calcium
Nickel
Copper
Aluminum
Magnesium
Cyanide
Sulfide
Ammonium

Tetrachloromethane
Methyl ethyl ketone
1,1,1-trichloroethane
1,1,2-trichloroethane
Trichloroethylene
Perchloroethylene
Xylene-o,p
Xylene-m

Tag-along Constituents

Vanadium
Potassium
Phosphate

Chloroform
Methylene chloride

A well sampled for the long list of constituents would be analyzed for the standard list specified above plus constituents from WAC 173-303-9905 for which analytical methods were available and for any additional tag-along constituents that might occur. Occasionally, results were reported by the laboratory that were not specifically requested. These are listed with the 9905 data in all tables and graphs.

(a) Constituents that were on the standard list for the first year. They were never detected and are currently being sampled at all wells on a quarterly basis instead of monthly.

Constituents Detected

General guidelines used to prepare the data summaries presented here were taken from the "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document," September 1986, 6.10 - Procedures for Evaluating Assessment Monitoring Data.

The first summary, given in Table E.2, presents a list of all the constituents sampled to date along with the following information:

- Database constituent code
- Database abbreviated constituent name
- Analysis units: MPN = most probable number
pCi/L = picoCuries per liter
μmho = micro-mhos
ppb = parts per billion
- Laboratory's contractual detection limit
- Number of samples analyzed to date
- Number of samples below detection limit
- Indication (***) that ALL samples were below detection limits. Note that no further data summaries will be given for these
- Regulatory limits (. indicates no limit at present)
- Regulating agency for limit
EPA = Interim Primary Drinking Water Standards
EPAP = Proposed Maximum Contaminant Levels
- Indication (xxx) that one or more results have exceeded a regulatory limit
- Full name for constituent

The main uses of Table E.2 are to

- Summarize the scope of the sampling efforts at the 300 Area Process Trenches
- Organize the data by specific subsets of constituents

- Give a full description of the computerized information for each constituent
- Easily identify those constituents that were never detected
- Easily identify those constituents that have exceeded regulatory limits.

A review of Table E.2 shows that the herbicides and pesticides on the Interim Primary Drinking Water Standards list were never reported above detection limit. Phenols in the list of Water Quality Characteristics were not above the original detection limit of 10 ppb, but are detected in a new analytical procedure that has a detection limit of 1 ppb (Table E.3). Contamination indicators are shown in Table E.4. Several of the constituents in the site-specific list in Table E.5 have yet to be detected after an extensive sampling effort, and almost none of the additional constituents sampled as part of the WAC 173-303-9905 list effort have been detected, as shown in Table E.6. Several other constituents have only been reported above detection limit sporadically. Among those constituents that are regularly reported as being above the detection limit are gross alpha, gross beta, barium, nitrate, fluoride, sodium, iron, sulfate, chloride, zinc, calcium, copper, magnesium, ammonium, vanadium, potassium, and chloroform. Some of these are tag-along constituents shown in Table E.7.

For those constituents that have exceeded regulatory limits, coliform bacteria has sporadically given positive results, gross beta has exceeded the screening limit on five occasions, one chromium and two selenium results exceeded the limits very early in the sampling, and several mercury results were above the limits one month but have been near the detection limit the rest of the time. Fluoride has been reported above the limit, but this is mostly due to what appear to be natural levels of fluoride in the new intermediate and deep wells. The only constituent for the Drinking Water standards that has regularly exceeded the limit is gross alpha, which exceeds the screening limit of 15 pCi/L in several wells. Although, proposed maximum contaminant levels for trichloroethylene have seldom been exceeded, they have been exceeded once in the new wells located in the intermediate and deep zones.

Constituent Concentrations

Table E.8 presents the simplest data description for those constituents that had at least one value reported above detection limits for the 300 Area Process Trenches. The following information is included in Table E.8:

- database constituent code, constituent name, and analysis units
- number of samples analyzed to date
- laboratory detection limit
- number of samples below detection limit
- maximum permissible limit
- simple arithmetic mean of all the values
- median, or ordered middle, of all the values
- standard deviation of all the values
- coefficient of variation for all the values
- minimum reported value
- maximum reported value.

The mean, standard deviation, and coefficient of variation statistics were calculated as though the values met the assumptions of simple random sampling. Estimation problems posed by replicates, values below detection limits, and spatial and temporal variability have not been addressed at this stage.

Two measures of central tendency have been provided to alert the reviewer that a few extreme values for a particular constituent may be making the mean larger than appropriate. The more discrepancy there is between the mean and the median, the more likely it is that one or a few extreme values are in the data and heavily influencing the estimate of the mean. This effect is evident for TOX, coliforms, mercury, iron, copper, and methyl chloride. The coefficient of variation, which is 100 times the ratio of the standard deviation to its mean, serves as a flag for constituents that have very different reported values over the sampling conditions measured in the 300 Area Process Trenches monitoring network. This variability may be due to a few discrepant values, seasonal or temporal cycles or changes, or the fact that different wells in the network will generally give distinct ranges of values. The minimum and maximum are used as a quick summary of the range of values that were reported over all sampling conditions.

Graphs of the Data

The data collected through April 1987 at the 300 Area Process Trenches monitoring network are graphically presented in this appendix for those constituents that had at least one value reported above the detection limit. These plots present time-lines for each well, with the well denoted on the graph by an abbreviation of its name. The data for each constituent is separated into four plots to minimize overplotting while keeping the number of plots to a minimum. The four plots are

1. Adjacent to the Trenches - Those wells that are immediately adjacent to the trenches
2. Immediately Downgradient - Those wells that are expected to be immediately downgradient of the trenches
3. Generally to the North - Other wells that are generally to the north of the trenches
4. Generally to the South - Other wells that are generally to the south of the trenches

The plotting symbols are the third part of the well name for all wells starting with "3-1", the second and third part of the well name for others that start with "3-", and a short abbreviation for the 699 wells, as follows:

Adjacent	Downgradient	North	South
3-1-4 => 4	3-1-1 => 1	3-1-6 => 6	3-2-1 => 21
3-1-5 => 5	3-1-2 => 2	3-1-10 => 10	3-3-7 => 37
3-1-11 => 11	3-1-3 => 3	3-1-13 => 13	3-3-10 => 310
3-1-12 => 12	3-1-7 => 7	3-1-14 => 14	3-4-1 => 41
3-1-17A => 17A	3-1-8 => 8	3-1-15 => 15	3-4-7 => 47
3-1-17B => 17B	3-1-9 => 9	3-1-18A => 18A	3-4-11 => 411
3-1-17C => 17C	3-1-16A => 16A	3-1-18B => 18B	3-8-2 => 82
3-1-19 => 19	3-1-16B => 16B	3-1-18C => 18C	6-S30E15A => S30
	3-1-16C => 16C	6-S19-E13 => S19	

The locations of these four groups are shown in Figure E.1. Figures E.2 through E.43 show these four groups for 42 constituents. Each figure contains a graph for each of the four groups, labeled a through d.

TABLE E.2. Sample Summary for Constituent List of Drinking Water Standards June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits	Full name
						Limit Agency Exceeded	
109	COLIFRM	MPN	2.2	430	382	1 EPA	xxx Coliform bacteria
111	BETA	PCI/L	8	414	4	50 EPA	xxx Gross beta
181	RADIUM	PCI/L	1	429	383	5 EPA	Radium
212	LOALPHA	PCI/L	4	429	20	15 EPA	xxx Gross alpha
A06	BARIUM	PPB	6	435	0	1000 EPA	Barium
A07	CADMIUM	PPB	2	435	416	10 EPA	Cadmium
A08	CHROMIUM	PPB	10	435	401	50 EPA	xxx Chromium
A10	SILVER	PPB	10	435	434	50 EPA	Silver
A20	ARSENIC	PPB	5	435	411	50 EPA	Arsenic
A21	MERCURY	PPB	1	435	415	2 EPA	xxx Mercury
A22	SELENIUM	PPB	5	435	431	10 EPA	xxx Selenium
A33	ENDRIN	PPB	1	293	293 ***	.2 EPA	Endrin
A34	METHLOR	PPB	1	293	293 ***	100 EPA	Methoxychlor
A35	TOXAENE	PPB	1	293	293 ***	5 EPA	Toxaphene
A36	a-BHC	PPB	1	293	293 ***	4 EPA	Alpha-BHC
A37	b-BHC	PPB	1	293	293 ***	4 EPA	Beta-BHC
A38	g-BHC	PPB	1	293	293 ***	4 EPA	Gamma-BHC
A39	d-BHC	PPB	1	293	293 ***	4 EPA	Delta-BHC
A51	LEADGF	PPB	5	435	399	50 EPA	Lead (graphite furnace)
C72	NITRATE	PPB	500	429	12	45000 EPA	Nitrate
C74	FLUORID	PPB	500	429	318	1400 EPA	xxx Fluoride
H13	2,4-D	PPB	1	291	291 ***	100 EPA	2,4-D
H14	2,4,5TP	PPB	1	291	291 ***	10 EPA	2,4,5-TP silvex
H20	FBARIUM	PPB	6	167	0	1000 EPA	Barium, filtered
H21	FCADMIUM	PPB	2	167	166	10 EPA	Cadmium, filtered
H22	FCHROMIUM	PPB	10	167	165	50 EPA	Chromium, filtered
H23	FSILVER	PPB	10	167	167 ***	50 EPA	Silver, filtered
H37	FARSENIC	PPB	5	167	158	50 EPA	Arsenic, filtered
H38	FMERCURY	PPB	1	166	166 ***	2 EPA	Mercury, filtered
H39	FSELENIUM	PPB	5	167	167 ***	10 EPA	Selenium, filtered
H41	FLEAD	PPB	5	167	161	50 EPA	Lead, filtered

TABLE E.3. Sample Summary for Constituent List of Quality Characteristics June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits	Full name
						Limit Agency Exceeded	
A11	SODIUM	PPB	100	435	0	.	Sodium
A17	MANGESE	PPB	5	435	359	.	Manganese
A19	IRON	PPB	50	435	173	.	Iron
C67	PHENOL	PPB	10	240	240 ***	.	Phenol
C73	SULFATE	PPB	500	429	3	.	Sulfate
C75	CHLORID	PPB	500	429	1	.	Chloride
H24	FSODIUM	PPB	100	167	0	.	Sodium, filtered
H29	FMANGAN	PPB	5	167	134	.	Manganese, filtered
H31	FIRON	PPB	50	167	140	.	Iron, filtered
H57	LPHENOL	PPB	1	39	30	.	Phenol, low DL

TABLE E.4. Sample Summary for Constituent List of Contamination Indicators June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
191	CONDUCT	UMHO	1	394	0	.	Specific conductance
199	PH		1	393	0	.	pH
C88	TOX	PPB	100	406	371	.	Total organic halogen
C89	TOC	PPB	1000	406	311	.	Total organic carbon

TABLE E.5. Sample Summary for Constituent List of Site Specifics June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
010	CO	PCI/L	22.5	8	7	.	Cobalt-60
024	CS-137	PCI/L	20	8	4	.	Cesium-137
034	RU	PCI/L	172.5	8	8 ***	.	Ruthenium-106
121	SR	PCI/L	5	8	4	.	Strontium-90
124	U-CHEM	UG/L	.725	8	0	.	Natural uranium
A04	ZINC	PPB	5	208	91	.	Zinc
A05	CALCIUM	PPB	50	208	0	.	Calcium
A12	NICKEL	PPB	10	435	418	.	Nickel
A13	COPPER	PPB	10	435	271	1300 EPAP	Copper
A16	ALUMNUM	PPB	150	435	381	.	Aluminum
A50	MAGNES	PPB	0	191	0	.	Magnesium
A61	TETRANE	PPB	10	435	435 ***	5 EPAP	Tetrachloromethane
A64	METHONE	PPB	10	435	434	.	Methyl ethyl ketone
A67	1,1,1-T	PPB	10	435	430	200 EPAP	1,1,1-trichloroethane
A68	1,1,2-T	PPB	10	435	433	.	1,1,2-trichloroethane
A69	TRICENE	PPB	10	435	428	5 EPAP xxx	Trichloroethylene
A70	PERCENE	PPB	10	435	412	.	Perchloroethylene
A71	OPXYLE	PPB	10	435	435 ***	440 EPAP	Xylene-o,p
B14	M-XYLE	PPB	10	435	435 ***	440 EPAP	Xylene-m
C70	CYANIDE	PPB	10	430	427	.	Cyanide
C78	SULFIDE	PPB	1000	430	421	.	Sulfide
C80	AMMONIU	PPB	50	430	255	.	Ammonium ion
H18	FZINC	PPB	5	167	110	.	Zinc, filtered
H19	FCALCIU	PPB	50	167	0	.	Calcium, filtered
H25	FNICKEL	PPB	10	167	168	.	Nickel, filtered
H26	FCOPPER	PPB	10	167	107	1300 EPAP	Copper, filtered
H28	FALUMIN	PPB	150	167	165	.	Aluminum, filtered
H32	FMAGNES	PPB	0	167	0	.	Magnesium, filtered

TABLE E.6. Sample Summary for Constituent List of WAC 173-303-9905 June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits	Limit Agency Exceeded	Full name
A01	BERYLAM	PPB	5	24	24 ***	.	.	Beryllium
A02	OSMIUM	PPB	300	24	24 ***	.	.	Osmium
A03	STRONUM	PPB	300	24	24 ***	.	.	Strontium
A15	ANTIONY	PPB	100	251	251 ***	.	.	Antimony
A23	THALIUM	PPB	10	24	23	.	.	Thallium
A24	THIOURA	PPB	200	219	217	.	.	Thiourea
A25	ACETREA	PPB	200	24	24 ***	.	.	1-acetyl-2-thiourea
A26	CHLOREA	PPB	200	24	24 ***	.	.	1-(o-chlorophenyl) thiourea
A27	DIETROL	PPB	200	24	24 ***	.	.	Diethylstilbesterol
A28	ETHYREA	PPB	200	24	24 ***	.	.	Ethylenethiourea
A29	NAPHREA	PPB	200	24	24 ***	.	.	1-naphthyl-2-thiourea
A32	PHENREA	PPB	200	24	24 ***	.	.	N-phenylthiourea
A40	DDD	PPB	1	24	24 ***	.	.	DDD
A41	DDE	PPB	1	24	24 ***	.	.	DDE
A42	DDT	PPB	1	24	24 ***	.	.	DDT
A43	HEPTLOR	PPB	1	24	24 ***	0	EPAP	Heptachlor
A44	HEPTIDE	PPB	1	24	24 ***	0	EPAP	Heptachlor epoxide
A46	DIELRIN	PPB	1	24	24 ***	.	.	Dieldrin
A47	ALDRIN	PPB	1	24	24 ***	.	.	Aldrin
A48	CHLOANE	PPB	1	24	24 ***	0	EPAP	Chlordane
A49	END01	PPB	1	24	24 ***	.	.	Endosulfan I
A52	END02	PPB	1	10	10 ***	.	.	Endosulfan II
A62	BENZENE	PPB	10	251	251 ***	5	EPAP	Benzene
A63	DIOXANE	PPB	500	251	251 ***	.	.	Dioxane
A65	PYRIDIN	PPB	500	251	251 ***	.	.	Pyridine
A66	TOLUENE	PPB	10	251	251 ***	2000	EPAP	Toluene
A72	ACROLIN	PPB	10	24	24 ***	.	.	Acrolein
A73	ACRYILE	PPB	10	24	24 ***	.	.	Acrylonitrile
A74	BISTHER	PPB	10	24	24 ***	.	.	Bis(chloromethyl) ether
A75	BROMONE	PPB	10	24	24 ***	.	.	Bromoacetone
A76	METHBRO	PPB	10	24	24 ***	.	.	Methyl bromide
A77	CARBIDE	PPB	10	24	24 ***	.	.	Carbon disulfide
A78	CHLBENZ	PPB	10	24	24 ***	.	.	Chlorobenzene
A79	CHLTHER	PPB	10	24	24 ***	.	.	2-chloroethyl vinyl ether
A81	METHCHL	PPB	10	24	24 ***	.	.	Methyl chloride
A82	CHMTHER	PPB	10	24	24 ***	.	.	Chloromethyl methyl ether
A83	CROTONA	PPB	10	24	24 ***	.	.	Crotonaldehyde
A84	DIBRCHL	PPB	10	24	24 ***	.	.	1,2-dibromo-3-chloropropane
A85	DIBRETH	PPB	10	24	24 ***	.	.	1,2-dibromoethane
A86	DIBRMET	PPB	10	24	24 ***	.	.	Dibromomethane
A87	DIBUTEN	PPB	10	24	24 ***	.	.	1,4-dichloro-2-butene
A88	DICDIFM	PPB	10	24	24 ***	.	.	Dichlorodifluoromethane
A89	1,1-DIC	PPB	10	24	24 ***	.	.	1,1-dichloroethane
A90	1,2-DIC	PPB	10	24	24 ***	5	EPAP	1,2-dichloroethane
A91	TRANDCE	PPB	10	28	24	70	EPAP	xxx Trans-1,2-dichloroethene
A92	DICETHY	PPB	10	24	24 ***	7	EPAP	1,1-dichloroethylene
A94	DICPANE	PPB	10	24	24 ***	6	EPAP	1,2-dichloropropane
A95	DICPENE	PPB	10	24	24 ***	.	.	1,3-dichloropropene
A96	NNDIEHY	PPB	10	24	24 ***	.	.	N,N-diethylhydrazine
A97	1,1-DIM	PPB	3000	24	24 ***	.	.	1,1-dimethylhydrazine
A98	1,2-DIM	PPB	3000	24	24 ***	.	.	1,2-dimethylhydrazine
A99	HYDRSUL	PPB	10	24	24 ***	.	.	Hydrogen sulfide

TABLE E.6. (contd)

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
B01	IODOMET	PPB	10	24	24 ***	.	Iodomethane
B02	METHACR	PPB	10	24	24 ***	.	Methacrylonitrile
B03	METHTHI	PPB	10	24	24 ***	.	Methanethiol
B04	PENTACH	PPB	10	24	24 ***	.	Pentachloroethane
B05	1112-tc	PPB	10	24	24 ***	.	1,1,1,2-tetrachlorethane
B06	1122-tc	PPB	10	24	24 ***	.	1,1,2,2-tetrachlorethane
B08	BROMORM	PPB	10	24	24 ***	.	Bromoform
B09	TRCMEOL	PPB	10	24	24 ***	.	Trichloromethanethiol
B10	TRCMFLM	PPB	10	24	24 ***	.	Trichloromonofluoromethane
B11	TRCPANE	PPB	10	24	24 ***	.	Trichloropropane
B12	123-trp	PPB	10	24	24 ***	.	1,2,3-trichloropropane
B13	VINYIDE	PPB	10	24	24 ***	1 EPAP	Vinyl chloride
B15	DIETHY	PPB	10	24	24 ***	.	Diethylarsine
B19	ACETILE	PPB	3000	24	24 ***	.	Acetonitrile
B20	ACETOPH	PPB	10	24	24 ***	.	Acetophenone
B21	WARFRIN	PPB	10	24	24 ***	.	Warfarin
B22	ACEFENE	PPB	10	24	24 ***	.	2-acetylaminofluorene
B23	AMINOYL	PPB	10	24	24 ***	.	4-aminobiphenyl
B24	AMIISOX	PPB	10	24	24 ***	.	5-(aminomethyl)-3-isoxazolol
B25	AMITROL	PPB	10	24	24 ***	.	Amitrole
B26	ANILINE	PPB	10	24	24 ***	.	Aniline
B27	ARAMITE	PPB	10	24	24 ***	.	Aramite
B28	AURAMIN	PPB	10	24	24 ***	.	Auramine
B29	BENZCAC	PPB	10	24	24 ***	.	Benz[c]acridine
B30	BENZAAN	PPB	10	24	24 ***	.	Benz[a]anthracene
B31	BENDICM	PPB	10	24	24 ***	.	Benzene, dichloromethyl
B32	BENTHOL	PPB	10	24	24 ***	.	Benzenethiol
B33	BENDINE	PPB	10	24	24 ***	.	Benzidine
B34	BENZBFL	PPB	10	24	24 ***	.	Benzo[b]fluoranthene
B35	BENZJFL	PPB	10	24	24 ***	.	Benzo[j]fluoranthene
B36	PBENZQU	PPB	10	24	24 ***	.	P-benzoquinone
B37	BENZCHL	PPB	10	24	24 ***	.	Benzyl chloride
B38	BIS2CHW	PPB	10	24	24 ***	.	Bis(2-chloroethoxy) methane
B39	BIS2CHE	PPB	10	24	24 ***	.	Bis(2-chloroethyl) ether
B40	BIS2EPH	PPB	10	28	24	.	Bis(2-ethylhexyl) phthalate
B41	BROPHEN	PPB	10	24	24 ***	.	4-bromophenyl phenyl ether
B42	BUTBENP	PPB	10	24	24 ***	.	Butyl benzyl phthalate
B43	BUTDINP	PPB	10	24	24 ***	.	2-sec-butyl-4,6-dinitrophenol
B44	CHALETH	PPB	10	24	24 ***	.	Chloroalkyl ethers
B45	CHLANIL	PPB	10	24	24 ***	.	P-chloroaniline
B46	CHLCRES	PPB	10	24	24 ***	.	P-chloro-m-cresol
B47	CHLEPOX	PPB	10	24	24 ***	.	1-chloro-2,3-epoxypropane
B48	CHLNAPH	PPB	10	24	24 ***	.	2-chloronaphthalene
B49	CHLPHEN	PPB	10	24	24 ***	.	2-chlorophenol
B50	CHRYSEN	PPB	10	24	24 ***	.	Chrysene
B51	CRESOLS	PPB	10	24	24 ***	.	Cresols
B52	CYCHDIN	PPB	10	24	24 ***	.	2-cyclohexyl-4,6-dinitrophenol
B53	DIBAHAC	PPB	10	24	24 ***	.	Dibenz[a,h]acridine
B54	DIBAJAC	PPB	10	24	24 ***	.	Dibenz[a,j]acridine
B55	DIBAHAN	PPB	10	24	24 ***	.	Dibenz[a,h]anthracene
B56	DIBCGCA	PPB	10	24	24 ***	.	7H-dibenzo[c,g]carbazole
B57	DIBAEPY	PPB	10	24	24 ***	.	Dibenzo[a,e]pyrene

TABLE E.6. (contd)

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
B58	DIBAHYP	PPB	10	24	24 ***	.	Dibenzo[a,h]pyrene
B59	DIBAIPY	PPB	10	24	24 ***	.	Dibenzo[a,i]pyrene
B60	DIBPHTH	PPB	10	24	24 ***	.	Di-n-butyl phthalate
B61	12-dben	PPB	10	240	240 ***	.	1,2-dichlorobenzene
B62	13-dben	PPB	10	240	240 ***	.	1,3-dichlorobenzene
B63	14-dben	PPB	10	240	240 ***	.	1,4-dichlorobenzene
B64	DICHBEN	PPB	10	24	24 ***	.	3,3'-dichlorobenzidine
B65	24-dchp	PPB	10	24	24 ***	.	2,4-dichlorophenol
B66	26-dchp	PPB	10	24	24 ***	.	2,6-dichlorophenol
B67	DIEPHTH	PPB	10	24	24 ***	.	Diethyl phthalate
B68	DIHYSAF	PPB	10	24	24 ***	.	Dihydrosafrole
B69	DIMETHB	PPB	10	24	24 ***	.	3,3'-dimethoxybenzidine
B70	DIMEAMB	PPB	10	24	24 ***	.	P-dimethylaminoazobenzene
B71	DIMBENZ	PPB	10	24	24 ***	.	7,12-dimethylbenz[a]anthracene
B72	DIWEYLB	PPB	10	24	24 ***	.	3,3'-dimethylbenzidine
B73	THIONOX	PPB	10	24	24 ***	.	Thiofanox
B74	DIMPHAM	PPB	10	24	24 ***	.	Alpha, alpha-dimethylphenethylamine
B75	DIMPHEN	PPB	10	24	24 ***	.	2,4-dimethylphenol
B76	DIMPHTH	PPB	10	24	24 ***	.	Dimethyl phthalate
B77	DINBENZ	PPB	10	24	24 ***	.	Dinitrobenzene
B78	DINCRES	PPB	10	24	24 ***	.	4,6-dinitro-o-cresol and salts
B79	DINPHEN	PPB	10	24	24 ***	.	2,4-dinitrophenol
B80	24-dint	PPB	10	24	24 ***	.	2,4-dinitrotoluene
B81	26-dint	PPB	10	24	24 ***	.	2,6-dinitrotoluene
B82	DIOPHTH	PPB	10	24	24 ***	.	Di-n-octyl phthalate
B83	DIPHAMI	PPB	10	24	24 ***	.	Diphenylamine
B84	DIPHHYD	PPB	10	24	24 ***	.	1,2-diphenylhydrazine
B85	DIPRNIT	PPB	10	24	24 ***	.	Di-n-propylnitrosamine
B86	ETHWINE	PPB	10	24	24 ***	.	Ethyleneimine
B87	ETHMETS	PPB	10	24	24 ***	.	Ethyl methanesulfonate
B88	FLUDRAN	PPB	10	24	24 ***	.	Fluoranthene
B89	HEXC BEN	PPB	10	240	240 ***	.	Hexachlorobenzene
B90	HEXC BUT	PPB	10	24	24 ***	.	Hexachlorobutadiene
B91	HEXC CYC	PPB	10	24	24 ***	.	Hexachlorocyclopentadiene
B92	HEXC ETH	PPB	10	24	24 ***	.	Hexachloroethane
B93	INDENOP	PPB	10	24	24 ***	.	Indeno(1,2,3-cd)pyrene
B94	ISOSOLE	PPB	10	24	24 ***	.	Isosafrole
B95	WALOILE	PPB	10	24	24 ***	.	Malononitrile
B96	MELPHAL	PPB	10	24	24 ***	.	Melphalan
B97	METHAPY	PPB	10	24	24 ***	.	Methapyrilene
B98	METHNYL	PPB	10	24	24 ***	.	Metholonyl
B99	METAZIR	PPB	10	24	24 ***	.	2-methylaziridine
C01	WETCHAN	PPB	10	24	24 ***	.	3-methylcholanthrene
C02	WETBISC	PPB	10	24	24 ***	.	4,4'-methylenebis(2-chloroaniline)
C03	METACTO	PPB	10	24	24 ***	.	2-methylactonitrile
C04	METACRY	PPB	10	24	24 ***	.	Methyl methacrylate
C05	METMSUL	PPB	10	24	24 ***	.	Methyl methanesulfonate
C06	METPROP	PPB	10	24	24 ***	.	2-methyl-2-(methylthio) propionaldehyde
C07	METHIOU	PPB	10	24	24 ***	.	Methylthiouracil
C08	NAPHQUI	PPB	10	24	24 ***	.	1,4-naphthoquinone
C09	1-napha	PPB	10	24	24 ***	.	1-naphthylamine
C10	2-napha	PPB	10	24	24 ***	.	2-naphthylamine

TABLE E.6. (contd)

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
C11	NITRANI	PPB	10	24	24 ***	.	P-nitroaniline
C12	NITBENZ	PPB	10	24	24 ***	.	Nitrobenzene
C13	NITPHEN	PPB	10	24	24 ***	.	4-nitrophenol
C14	NNIBUTY	PPB	10	24	24 ***	.	N-nitrosodi-n-butylamine
C15	NNIDIEA	PPB	10	24	24 ***	.	N-nitrosodiethanolamine
C16	NNIDIEY	PPB	10	24	24 ***	.	N-nitrosodiethylamine
C17	NNIDIME	PPB	10	24	24 ***	.	N-nitrosodimethylamine
C18	NNIMETH	PPB	10	24	24 ***	.	N-nitrosomethylethylamine
C19	NNIURET	PPB	10	24	24 ***	.	N-nitroso-N-methylurethane
C20	NNIVINY	PPB	10	24	24 ***	.	N-nitrosomethylvinylamine
C21	NNIMORP	PPB	10	24	24 ***	.	N-nitrosomorpholine
C22	NNINICO	PPB	10	24	24 ***	.	N-nitrosornicotine
C23	NNIPIPE	PPB	10	24	24 ***	.	N-nitrosopiperidine
C24	NITRPYR	PPB	10	24	24 ***	.	Nitrosopyrrolidine
C25	NITRTOL	PPB	10	24	24 ***	.	5-nitro-o-toluidine
C26	PENTCHB	PPB	10	240	240 ***	.	Pentachlorobenzene
C27	PENTCHN	PPB	10	24	24 ***	.	Pentachloronitrobenzene
C28	PENTCHP	PPB	10	24	24 ***	220 EPAP	Pentachlorophenol
C29	PHENTIN	PPB	10	24	24 ***	220 EPAP	Phenacetin
C30	PHENINE	PPB	10	24	24 ***	.	Phenylenediamine
C31	PHTHEST	PPB	10	24	24 ***	.	Phthalic acid esters
C32	PICOLIN	PPB	10	24	24 ***	.	2-picoline
C33	PRONIDE	PPB	10	24	24 ***	.	Pronamide
C34	RESERPI	PPB	10	24	24 ***	.	Reserpine
C35	RESORCI	PPB	10	24	24 ***	.	Resorcinol
C36	SAFROL	PPB	10	24	24 ***	.	Safrol
C37	TETRCHB	PPB	10	240	240 ***	.	1,2,4,5-tetrachlorobenzene
C39	TETRCHP	PPB	10	24	24 ***	.	2,3,4,6-tetrachlorophenol
C40	THIURAM	PPB	10	24	24 ***	.	Thiuram
C41	TOLUDIA	PPB	10	24	24 ***	.	Toluenediamine
C42	OTOLHYD	PPB	10	24	24 ***	.	O-toluidine hydrochloride
C43	TRICHLB	PPB	10	240	240 ***	.	1,2,4-trichlorobenzene
C44	245-trp	PPB	10	24	24 ***	.	2,4,5-trichlorophenol
C45	246-trp	PPB	10	24	24 ***	.	2,4,6-trichlorophenol
C46	TRIPHOS	PPB	10	24	24 ***	.	0,0,0-triethyl phosphorothioate
C47	SYMTRIN	PPB	10	24	24 ***	.	Sym-trinitrobenzene
C48	TRISPHO	PPB	10	24	24 ***	.	Tris(2,3-dibromopropyl) phosphate
C49	BENZOPY	PPB	10	24	24 ***	.	Benzo[a]pyrene
C50	CHLNAPZ	PPB	10	24	24 ***	.	Chlornaphazine
C51	BIS2ETH	PPB	10	24	24 ***	.	Bis(2-chloroisopropyl)ether
C52	HEXAENE	PPB	10	162	162 ***	.	Hexachloropropene
C53	HYDRAZI	PPB	3000	24	24 ***	.	Hydrazine
C54	HEXACHL	PPB	10	240	240 ***	.	Hexachlorophene
C55	NAPHTHA	PPB	10	240	240 ***	.	Naphthalene
C56	123TRI	PPB	10	240	240 ***	.	1,2,3-trichlorobenzene
C58	135TRI	PPB	10	240	240 ***	.	1,3,5-trichlorobenzene
C59	1234TE	PPB	10	240	240 ***	.	1,2,3,4-tetrachlorobenzene
C60	1235TE	PPB	10	240	240 ***	.	1,2,3,5-tetrachlorobenzene
C61	TETEPYR	PPB	100	24	24 ***	.	Tetraethylpyrophosphate
C62	CHLLATE	PPB	100	116	116 ***	.	Chlorobenzilate
C63	CARBPHI	PPB	2	24	24 ***	.	Carbophenothion

TABLE E.6. (contd)

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits	Full name
						Limit Agency Exceeded	
C64	DISULFO	PPB	2	24	24 ***	.	Disulfoton
C65	DIMETHO	PPB	5	24	24 ***	.	Dimethoate
C66	METHPAR	PPB	2	24	24 ***	.	Methyl parathion
C67	PARATHI	PPB	2	24	24 ***	.	Parathion
C71	FORMALN	PPB	500	251	251 ***	.	Formalin
C79	KEROSEN	PPB	10000	240	240 ***	.	Kerosene
C81	ETHYGLY	PPB	10000	219	219 ***	.	Ethylene glycol
C86	DIOXIN	PPB	.1	224	224 ***	.	Dioxin
C87	CITRUSR	PPB	1000	24	24 ***	.	Citrus red
C88	CYANBRO	PPB	3000	24	24 ***	.	Cyanogen bromide
C89	CYANCHL	PPB	3000	24	24 ***	.	Cyanogen chloride
C90	PARALDE	PPB	3000	24	24 ***	.	Paraldehyde
C91	STRYCHN	PPB	50	116	116 ***	.	Strychnine
C92	MALHYDR	PPB	500	116	116 ***	.	Maleic hydrazide
C93	NICOTIN	PPB	100	116	116 ***	.	Nicotinic acid
C94	ACRYIDE	PPB	3000	24	24 ***	0 EPAP	Acrylamide
C95	ALLYLAL	PPB	3000	24	24 ***	.	Allyl alcohol
C96	CHLORAL	PPB	3000	24	24 ***	.	Chloral
C97	CHLACET	PPB	3000	24	24 ***	.	Chloroacetaldehyde
C98	CHLPROP	PPB	3000	24	24 ***	.	3-chloropropionitrile
C99	CYANOQN	PPB	3000	24	24 ***	.	Cyanogen
H01	DICPROP	PPB	3000	24	24 ***	.	Dichloropropanol
H03	ETHCARB	PPB	3000	24	24 ***	.	Ethyl carbamate
H04	ETHCYAN	PPB	3000	24	24 ***	.	Ethyl cyanide
H05	ETHOXID	PPB	3000	24	24 ***	.	Ethylene oxide
H06	ETHMETH	PPB	3000	24	24 ***	.	Ethyl methacrylate
H07	FLUOROAC	PPB	3000	24	24 ***	.	Fluoroacetic acid
H08	GLYCIDY	PPB	3000	24	24 ***	.	Glycidylaldehyde
H09	ISOBUTY	PPB	3000	24	24 ***	.	Isobutyl alcohol
H10	METZINE	PPB	3000	24	24 ***	.	Methyl hydrazine
H11	PROPYLA	PPB	3000	24	24 ***	.	N-propylamine
H12	PROPYNO	PPB	3000	24	24 ***	.	2-propyn-1-ol
H15	2,4,6-T	PPB	1	22	22 ***	.	2,4,6-T
H33	BERYLL	PPB	5	6	6 ***	.	Beryllium, filtered
H34	OSMIUM	PPB	300	6	6 ***	.	Osmium, filtered
H35	STRONT	PPB	300	6	6 ***	.	Strontium, filtered
H36	ANTIMO	PPB	100	6	6 ***	.	Antimony, filtered
H40	FTHALLI	PPB	10	6	6 ***	.	Thallium, filtered
I01	ACETONE	PPB	.	2	0	.	
I02	HEXANE	PPB	0	2	0	.	
I03	MECYPEN	PPB	0	1	0	.	
I04	MEBUPHT	PPB	0	1	0	.	
I28	TAF	PPB	0	2	0	.	
I63	BHT	PPB	.	1	0	.	
I99	UNKNOWN	PPB	0	4	0	.	

*** - Indicates all samples were below detection limits

xxx - Indicates that regulatory limits were exceeded

EPA - based on limits given in 40CFR 285, Appendix III,
 EPA Interim Primary Drinking Water Standards
 EPAP - based on proposed Maximum Contaminant Levels

TABLE E.7. Sample Summary for Constituent List of Tag-alongs June 1985 Through April 1987

Code	Constituent Name	Units	Detection Limit	Samples	Below Detection	Regulatory Limits Limit Agency Exceeded	Full name
A14	VANADUM	PPB	5	435	232	.	Vanadium
A18	POTASUM	PPB	100	435	0	.	Potassium
A80	CHLFORM	PPB	10	323	124	.	Chloroform
A93	METHYCH	PPB	10	261	200	.	Methylene chloride
C76	PHOSPHA	PPB	1000	429	427	.	Phosphate
H27	FVANADI	PPB	5	167	98	.	Vanadium, filtered
H30	FPOTASS	PPB	100	167	0	.	Potassium, filtered

TABLE E.8. Sample Summary for Constituent List of Contamination Indicators June 1985 Through April 1987

Constituent Code	Name	Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
191	CONDUCT	UMHO	394	1	0	.	279	259	88.6	31.7	143	566
199	PH		393	0.1	0	.	7.06	7.1	0.594	8.4	3.9	8.6
C88	TOX	PPB	406	100	371	.	164	59.6	696	425.2	1.62	9160
C89	TDC	PPB	406	1000	311	.	848	736	718	84.5	-107	8030

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TABLE E.9. Sample Summary for Constituent List of Drinking Water Standards June 1985
Through April 1987

Constituent Code Name	Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
109 COLIFRM	MPN	430	2.2	382	1	3.55	3	3.86	108.7	0	43
111 BETA	PCI/L	414	8	4	50	15	11.8	10.9	72.5	0.719	113
181 RADIUM	PCI/L	429	1	383	5	0.0718	0.05	0.132	184.4	-0.121	1.55
212 LOALPHA	PCI/L	429	4	20	15	15.9	11.4	19.3	121.2	-1.04	208
A06 BARIUM	PPB	435	6	0	1000	38.7	34	39.3	101.8	7	719
A07 CADMIUM	PPB	435	2	416	10	2.08	2	0.487	22.5	2	7
A08 CHROMIUM	PPB	435	10	401	50	11.1	10	12.1	109.2	10	257
A10 SILVER	PPB	435	10	434	50	10	10	0.432	4.3	10	19
A20 ARSENIC	PPB	435	5	411	50	5.14	5	1.11	21.7	5	23
A21 MERCURY	PPB	435	0.1	415	2	0.382	0.1	1.3	357.8	0.1	9.9
A22 SELENIUM	PPB	435	5	431	10	5.07	5	0.787	15.1	5	17
A51 LEADGF	PPB	435	5	399	50	5.5	5	3.33	60.6	5	48
C72 NITRATE	PPB	429	500	12	45000	16100	17400	7320	45.5	500	38000
C74 FLUORID	PPB	429	500	318	1400	584	500	190	33.7	500	1870
H20 FBARIUM	PPB	167	6	0	1000	33.6	31	17.6	52.3	11	125
H21 FCADMIU	PPB	167	2	166	10	2.01	2	0.155	7.7	2	4
H22 FCHROMI	PPB	167	10	165	50	10.1	10	0.987	9.6	10	21
H37 FARSENI	PPB	167	5	158	50	5.15	5	1.24	24.1	5	20
H41 FLEAD	PPB	167	5	161	50	5.05	5	0.464	9.2	5	10.7

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TABLE E.10. Summarized by Constituent List of Constituent List of Site Specific June 1985 Through April 1987

Constituent Code Name	Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Q10 CO 80	PCI/L	8	22.5	7	.	1.84	3	3.7	225.7	-5.08	6.08
Q24 CS-137	PCI/L	8	20	4	.	3.89	5.12	3.83	93.4	-3.33	7.26
121 SR 90	PCI/L	8	5	4	.	0.419	0.424	0.201	48.1	0.148	0.716
124 U-CHEM	UG/L	8	0.725	0	.	18	13.3	15.9	88.1	4.01	47.8
A04 ZINC	PPB	208	5	91	.	11.3	5	17.1	151.3	5	178
A05 CALCIUM	PPB	208	50	0	.	29600	24400	12900	43.5	10300	76100
A12 NICKEL	PPB	435	10	416	.	10.5	10	4.93	46.8	10	95
A13 COPPER	PPB	435	10	271	1300	17.1	10	28.4	166.6	10	516
A16 ALUMNUM	PPB	435	150	381	.	190	150	347	182.7	150	7060
A50 MAGNES	PPB	191	0	0	.	6420	5420	2740	42.6	3370	14600
A64 METHONE	PPB	435	10	434	.	10	10	0.048	0.6	10	11
A67 1,1,1-T	PPB	435	10	430	200	10.4	10	4.87	46.8	10	83
A68 1,1,2-T	PPB	435	10	433	.	10	10	0.708	7.0	10	23
A69 TRICENE	PPB	435	10	426	5	9.94	10	1.31	13.2	2.4	22
A70 PERCENE	PPB	435	10	412	.	10.5	10	3.4	32.4	10	55
C70 CYANIDE	PPB	430	10	427	.	10	10	0.221	2.2	10	14
C78 SULFIDE	PPB	430	1000	421	.	1010	1000	131	13.0	1000	3000
C80 AMMONIU	PPB	430	50	255	.	96.6	50	110	114.1	48.3	1630
H18 FZINC	PPB	167	5	110	.	11.8	5	23.6	200.1	5	156
H19 FCALCIU	PPB	167	50	0	.	29000	23400	12900	44.7	10600	76700
H25 FNICKEL	PPB	167	10	166	.	10	10	0.155	1.5	10	12
H26 FCOPPER	PPB	167	10	107	1300	12.3	10	5.16	41.9	10	48
H28 FALUMIN	PPB	167	150	165	.	153	150	42.8	27.9	150	703
H32 FMAGNES	PPB	167	0	0	.	6380	5390	2710	42.6	3260	14800

E.19

TABLE E.11. Summarized by Constituent List of Quality Characteristics June 1985 Through April 1987

Constituent Code Name	Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
A11 SODIUM	PPB	435	100	0	.	18400	14700	9220	58.2	1220	87800
A17 MANGESE	PPB	435	5	359	.	9.49	5	21.5	228.8	5	367
A19 IRON	PPB	435	50	173	.	215	63	892	414.0	50	14900
C73 SULFATE	PPB	429	500	3	.	21200	17800	10400	49.2	500	53600
C75 CHLORID	PPB	429	500	1	.	13700	11600	9070	68.4	500	72200
H24 FSODIUM	PPB	167	100	0	.	19400	14000	22900	118.2	3910	258000
H29 FMANGAN	PPB	167	5	134	.	11.1	5	16.5	148.5	5	90
H31 FIRON	PPB	167	50	140	.	108	50	408	376.7	50	4870
H57 LPHENOL	PPB	39	1	30	.	1.38	1	1.04	76.1	1	5.89

TABLE E.12. Summarized by Constituent List of Tag-alongs June 1985 Through April 1987

Constituent Code Name	Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
A14 VANADUM	PPB	435	5	232	.	7.3	5	4.33	59.3	5	36
A18 POTASUM	PPB	435	100	0	.	3870	3470	1540	39.7	1230	10300
A80 CHLFORM	PPB	323	10	124	.	13.9	11	5.75	41.3	10	42
A93 METHYCH	PPB	261	10	200	.	226	10	1730	765.9	3	27500
C76 PHOSPHA	PPB	429	1000	427	.	1010	1000	114	11.3	1000	3240
H27 FVANADI	PPB	167	5	98	.	6.32	5	2.53	40.1	5	15
H30 FPOTASS	PPB	167	100	0	.	3890	3410	2000	51.3	1230	17300

TABLE E.13. Summarized by Constituent List of WAC 173-303-9905 June 1985 Through April 1987

Constituent Code Name Units	Samples	Detection Limit	Below Detection	Regulatory Limit	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
A23 THALIUM PPB	24	10	23		10	10	0	0.0	10	10
A24 THIOURA PPB	219	200	217		208	200	79.2	38.1	200	1090
A91 TRANDCE PPB	28	10	24	70	15.6	10	15.8	101.6	10	71
B40 BIS2EPH PPB	28	10	24		13.5	10	10.6	78.4	10	50

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FIGURE E.1. Areas of Four Groups of RCRA Monitoring Wells

Wells Adjacent to the Trenches
Constituent=212 LOALPHA PC/L Screening Limit=15

Wells Immediately Downgradient
Constituent=212 LOALPHA PC/L Screening Limit=15

(a)

(b)

FIGURE E.2. Changes in Levels of Gross Alpha over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

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FIGURE E.2. (contd)

Wells Adjacent to the Trenches
Constituent=A16 ALUMNUM PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A16 ALUMNUM PPB EPA Limit=None

(b)

FIGURE E.3. Changes in Levels of Aluminum over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the South
Constituent=A16 ALUMNUM PPB EPA Limit=None

(d)

FIGURE E.3. (contd)

Wells Adjacent to the Trenches
Constituent=H28 FALUMIN PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=H28 FALUMIN PPB EPA Limit=None

(b)

FIGURE E.4. Changes in Levels of F-Aluminum over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H28 FALUMIN PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=H28 FALUMIN PPB EPA Limit=None

(d)

FIGURE E.4. (contd)

Wells Adjacent to the Trenches
Constituent=C80 AMMONIU PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=C80 AMMONIU PPB EPA Limit=None

(b)

FIGURE E.5. Changes in Levels of Ammonium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=C80 AMMONIU PPB EPA Limit=None

Wells Generally to the South
Constituent=C80 AMMONIU PPB EPA Limit=None

(c)

(d)

FIGURE E.5. (contd)

Wells Adjacent to the Trenches
Constituent=A20 ARSENIC PPB EPA Limit=50

(a)

Wells Immediately Downgradient
Constituent=A20 ARSENIC PPB EPA Limit=50

(b)

FIGURE E.6. Changes in Levels of Arsenic over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A20 ARSENIC PPB EPA Limit=50

(c)

Wells Generally to the South
Constituent=A20 ARSENIC PPB EPA Limit=50

(d)

FIGURE E.6 (contd)

Wells Adjacent to the Trenches
Constituent=H37 FARSENI PPB EPA Limit=50

(a)

Wells Immediately Downgradient
Constituent=H37 FARSENI PPB EPA Limit=50

(b)

FIGURE E.7. Changes in Levels of F-Arsenic over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H37 FARSENI PPB EPA Limit=50

Wells Generally to the South
Constituent=H37 FARSENI PPB EPA Limit=50

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(c)

(d)

FIGURE E.7. (contd)

Wells Adjacent to the Trenches
Constituent=A06 BARIUM PPB EPA Limit=1000

(a)

Wells Immediately Downgradient
Constituent=A06 BARIUM PPB EPA Limit=1000

(b)

FIGURE E.8. Changes in Levels of Barium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.38

(d)

FIGURE E.8. (contd)

Wells Adjacent to the Trenches
Constituent=H2O FBARIUM PPB EPA Limit=1000

(a)

Wells Immediately Downgradient
Constituent=H2O FBARIUM PPB EPA Limit=1000

(b)

FIGURE E.9. Changes in Levels of F-Barium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H2O FBARIUM PPB EPA Limit=1000

(c)

Wells Generally to the South
Constituent=H2O FBARIUM PPB EPA Limit=1000

(d)

FIGURE E.9. (contd)

Wells Adjacent to the Trenches
Constituent=111 BETA PCI/L Screening Limit=50

(a)

Wells Immediately Downgradient
Constituent=111 BETA PCI/L Screening Limit=50

(b)

FIGURE E.10. Changes in Levels of Gross Beta over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=111 BETA PCI/L Screening Limit=50

(c)

Wells Generally to the South
Constituent=111 BETA PCI/L Screening Limit=50

(d)

FIGURE E.10. (contd)

E.43

Wells Adjacent to the Trenches
Constituent=A05 CALCIUM PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A05 CALCIUM PPB EPA Limit=None

(b)

FIGURE E.11. Changes in Levels of Calcium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.44

Collection date

FIGURE E.11. (contd)

Wells Adjacent to the Trenches
Constituent=H19 FCALCIU PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=H19 FCALCIU PPB EPA Limit=None

(b)

FIGURE E.12 Changes in Levels of F-Calcium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E. 46

(d)

FIGURE E.12. (contd)

E.47

Wells Adjacent to the Trenches
Constituent=C75 CHLORID PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=C75 CHLORID PPB EPA Limit=None

(b)

FIGURE E.13 Changes in Levels of Chloride over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
 Constituent=C75 CHLORID PPB EPA Limit=None

(c)

Wells Generally to the South
 Constituent=C75 CHLORID PPB EPA Limit=None

(d)

FIGURE E.13. (contd)

Wells Adjacent to the Trenches

Constituent=ABO CHLFORM PPB EPA Limit=None

(a)

Wells Immediately Downgradient

Constituent=ABO CHLFORM PPB EPA Limit=None

(b)

FIGURE E.14 Changes in Levels of Chloroform over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A80 CHLFORM PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A80 CHLFORM PPB EPA Limit=None

(d)

FIGURE E.14. (contd)

Wells Adjacent to the Trenches
Constituent=A08 CHROMIUM PPB EPA Limit=50

Wells Immediately Downgradient
Constituent=A08 CHROMIUM PPB EPA Limit=50

(a)

(b)

FIGURE E.15 Changes in Levels of Chromium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.52

Collection date

FIGURE E.15. (contd)

Wells Adjacent to the Trenches
Constituent=109 COLIFRM MPN EPA Limit=1

(a)

Wells Immediately Downgradient
Constituent=109 COLIFRM MPN EPA Limit=1

(b)

FIGURE E.16 Changes in Levels of Coliform Bacteria over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.54

(d)

FIGURE E.16. (contd)

Wells Adjacent to the Trenches
Constituent=191 CONDUCT UMHO EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=191 CONDUCT UMHO EPA Limit=None

(b)

FIGURE E.17 Changes in Levels of Conductivity over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

5.3

The graph displays the monthly variation of the number of eggs per female for the 1985-1986 season. The Y-axis represents the number of eggs (0 to 600). The X-axis represents the collection date (JUN85 to JUN87). Multiple lines represent different groups, with data points labeled with numbers (e.g., 37, 82, 47, 310, 21). The data shows significant fluctuations, with peaks often reaching 310 or 470 eggs per female.

(d)

FIGURE E.17. (contd)

Wells Adjacent to the Trenches
Constituent=A13 COPPER PPB EPA Limit=1300

(a)

Wells Immediately Downgradient
Constituent=A13 COPPER PPB EPA Limit=1300

(b)

FIGURE E.18 Changes in Levels of Copper over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A13 COPPER PPB EPA Limit=1300

Wells Generally to the South
Constituent=A13 COPPER PPB EPA Limit=1300

(c)

(d)

FIGURE E.18. (contd)

Wells Adjacent to the Trenches
Constituent=H26 FCOPPER PPB EPA Limit=1300

(a)

Wells Immediately Downgradient
Constituent=H26 FCOPPER PPB EPA Limit=1300

(b)

FIGURE E.19. Changes in Levels of F-Copper over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H26 FCOPPER PPB EPA Limit=1300

(c)

Wells Generally to the South
Constituent=H26 FCOPPER PPB EPA Limit=1300

(d)

FIGURE E.19. (contd)

Wells Immediately Downgradient
Constituent=C74 FLUORID PPB EPA Limit=1400

FIGURE E.20. Changes in Levels of Fluoride over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=C74 FLUORID PPB EPA Limit=1400

(c)

Wells Generally to the South
Constituent=C74 FLUORID PPB EPA Limit=1400

(d)

FIGURE E.20. (contd)

Wells Adjacent to the Trenches
Constituent=A19 IRON PPB EPA Limit=None

Wells Immediately Downgradient
Constituent=A19 IRON PPB EPA Limit=None

(a)

(b)

FIGURE E.21 Changes in Levels of Iron over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.64

(d)

FIGURE E.21. (contd)

E.65

Wells Adjacent to the Trenches
Constituent=H31 FIRON PPB EPA Limit=None

Collection date

(a)

Wells Immediately Downgradient
Constituent=H31 FIRON PPB EPA Limit=None

Collection date

(b)

FIGURE E.22. Changes in Levels of F-Iron over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
 Constituent=H31 FIRON PPB EPA Limit=None

(c)

Wells Generally to the South
 Constituent=H31 FIRON PPB EPA Limit=None

(d)

FIGURE E.22. (contd)

E.67

Collection date
(a)

Wells Immediately Downgradient
Constituent=A50 MAGNES PPB EPA Limit=None

Collection date
(b)

FIGURE E.23. Changes in Levels of Magnesium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A50 MAGNES PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A50 MAGNES PPB EPA Limit=None

(d)

FIGURE E.23. (contd)

Constituent=H32 FMAGNES PP8 EPA Limit=None

(a)

Constituent=H32 FMAGNES PPB EPA Limit=None

(b)

FIGURE E.24. Changes in Levels of F-Magnesium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.70

(d)

Wells Adjacent to the Trenches
Constituent=A17 MANGESE PPB EPA Limit=None

Wells Immediately Downgradient
Constituent=A17 MANGESE PPB EPA Limit=None

(a)

(b)

FIGURE E.25. Changes in Levels of Manganese over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A17 MANGESE PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A17 MANGESE PPB EPA Limit=None

(d)

FIGURE E.25. (contd)

E.73

Collection date

FIGURE E.26. Changes in Levels of F-Manganese over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H29 FMANGAN PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=H29 FMANGAN PPB EPA Limit=None

(d)

FIGURE E.26. (contd)

Wells Adjacent to the Trenches
Constituent=A93 METHYCH PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A93 METHYCH PPB EPA Limit=None

(b)

FIGURE E.27. Changes in Levels of Methoxychlor over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
 Constituent=A93 METHYCH PPB EPA Limit=None

(c)

Wells Generally to the South
 Constituent=A93 METHYCH PPB EPA Limit=None

(d)

FIGURE E.27. (contd)

E.77

Wells Adjacent to the Trenches
Constituent=A12 NICKEL PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A12 NICKEL PPB EPA Limit=None

(b)

FIGURE E.28. Changes in Levels of Nickel over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A12 NICKEL PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A12 NICKEL PPB EPA Limit=None

(d)

FIGURE E.28. (contd)

Wells Adjacent to the Trenches
Constituent=C72 NITRATE PPB EPA Limit=45000

(a)

Wells Immediately Downgradient
Constituent=C72 NITRATE PPB EPA Limit=45000

(b)

FIGURE E.29. Changes in Levels of Nitrate over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the South
Constituent=C72 NITRATE PPB EPA Limit=45000

(d)

FIGURE E.29. (contd)

Wells Adjacent to the Trenches
Constituent=199 PH EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=199 PH EPA Limit=None

(b)

FIGURE E.30. Changes in Levels of pH over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the South
Constituent=199 PH EPA Limit=None

Constituent=199 PH EPA Limit=None

Constituent=199 PH EPA Limit=None

(c)

(d)

FIGURE E.30. (contd)

Wells Adjacent to the Trenches
Constituent=A18 POTASUM PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A18 POTASUM PPB EPA Limit=None

(b)

FIGURE E.31. Changes in Levels of Potassium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A18 POTASUM PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A18 POTASUM PPB EPA Limit=None

(d)

FIGURE E.31. (contd)

58.3

(b)

FIGURE E.32. Changes in Levels of F-Potassium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H3O FPOTASS PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=H3O FPOTASS PPB EPA Limit=None

(d)

FIGURE E.32. (contd)

E.87

Wells Adjacent to the Trenches
Constituent=181 RADIUM PC/L EPA Limit=5

Collection date

(a)

Wells Immediately Downgradient
Constituent=181 RADIUM PC/L EPA Limit=5

Collection date

(b)

FIGURE E.33. Changes in Levels of Radium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=181 RADIUM PCI/L EPA Limit=5

(c)

Wells Generally to the South
Constituent=181 RADIUM PCI/L EPA Limit=5

(d)

FIGURE E.33. (contd)

Wells Immediately Downgradient
Constituent=A11 SODIUM PPB EPA Limit=None

FIGURE E.34. Changes in Levels of Sodium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A11 SODIUM PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A11 SODIUM PPB EPA Limit=None

(d)

FIGURE E.34. (contd)

E.91

Wells Adjacent to the Trenches
Constituent=H24 FSODIUM PPB EPA Limit=None

Collection date

(a)

Wells Immediately Downgradient
Constituent=H24 FSODIUM PPB EPA Limit=None

Collection date

(b)

FIGURE E.35. Changes in Levels of F-Sodium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
 Constituent=H24 FSODIUM PPB EPA Limit=None

Wells Generally to the South
 Constituent=H24 FSODIUM PPB EPA Limit=None

(c)

(d)

FIGURE E.35. (contd)

Wells Adjacent to the Trenches
Constituent=C73 SULFATE PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=C73 SULFATE PPB EPA Limit=None

(b)

FIGURE E.36. Changes in Levels of Sulfate over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=C73 SULFATE PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=C73 SULFATE PPB EPA Limit=None

(d)

FIGURE E.36. (contd)

Wells Adjacent to the Trenches
Constituent=C69 TOC PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=C69 TOC PPB EPA Limit=None

(b)

FIGURE E.37. Changes in Levels of Total Organic Carbon over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=C69 TOC PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=C69 TOC PPB EPA Limit=None

(d)

FIGURE E.37. (contd)

E.97

Wells Adjacent to the Trenches

Constituent=C68 TOX PPB EPA Limit=None

(a)

Wells Immediately Downgradient

Constituent=C68 TOX PPB EPA Limit=None

(b)

FIGURE E.38. Changes in Levels of Total Organic Halogen over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=C68 TOX PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=C68 TOX PPB EPA Limit=None

(d)

FIGURE E.38. (contd)

Wells Adjacent to the Trenches
Constituent=A69 TRICENE PPB EPA Limit=5

Wells Immediately Downgradient
Constituent=A69 TRICENE PPB EPA Limit=5

(a)

(b)

FIGURE E.39. Changes in Levels of Trichloroethylene over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A69 TRICENE PPB EPA Limit=5

(c)

Wells Generally to the South
Constituent=A69 TRICENE PPB EPA Limit=5

(d)

FIGURE E.39. (contd)

Wells Adjacent to the Trenches
Constituent=A14 VANADIUM PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A14 VANADIUM PPB EPA Limit=None

(b)

FIGURE E.40. Changes in Levels of Vanadium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=A14 VANADUM PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=A14 VANADUM PPB EPA Limit=None

(d)

FIGURE E.40. (contd)

Wells Adjacent to the Trenches
Constituent=H27 FVANADI PPB EPA Limit=None

Wells Immediately Downgradient
Constituent=H27 FVANADI PPB EPA Limit=None

(a)

(b)

FIGURE E.41. Changes in Levels of F-Vanadium over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

E.104

Collection date

FIGURE E.41. (contd)

E.105

Wells Adjacent to the Trenches
Constituent=A04 ZINC PPB EPA Limit=None

(a)

Wells Immediately Downgradient
Constituent=A04 ZINC PPB EPA Limit=None

(b)

FIGURE E.42. Changes in Levels of Zinc over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
 Constituent=A04 ZINC PPB EPA Limit=None

(c)

Wells Generally to the South
 Constituent=A04 ZINC PPB EPA Limit=None

(d)

FIGURE E.42. (contd)

E.107

Wells Adjacent to the Trenches
Constituent=H18 FZINC PPB EPA Limit=None

Collection date

(a)

Wells Immediately Downgradient
Constituent=H18 FZINC PPB EPA Limit=None

Collection date

(b)

FIGURE E.43. Changes in Levels of F-Zinc over Time, June 1985 to April 1987, in Samples from 300 Area Wells a) Adjacent to the Trenches, b) Immediately Downgradient from the Trenches, c) Generally to the North, and d) Generally to the South. The horizontal solid line marks detection limit.

Wells Generally to the North
Constituent=H18 FZINC PPB EPA Limit=None

(c)

Wells Generally to the South
Constituent=H18 FZINC PPB EPA Limit=None

(d)

FIGURE E.43. (contd)

APPENDIX F

SOIL SAMPLE ANALYTICAL RESULTS

APPENDIX F

SOIL SAMPLE ANALYTICAL RESULTS

Appendix F contains the raw data listing for the analyses of soil samples collected from the 300 Area Process Trenches and the dike separating the trenches. The soil samples were collected between April and September 1986.

Table F.1 presents data for soils from the two process trenches and contains results for those constituents that were present at levels above detection limits. Samples were collected from the trench at 200-ft intervals away from the inlet weir and were collected at three depths where possible. The sample designations used in Table F.1 are as follows:

Trench: E - East; W - West

Interval (in 100-ft increments away from weir): 1-16

Depth: LA - loose sediments at surface

SA - 4 in. below surface

DA - 18 in. below surface

Thus E1DA indicates East Trench, taken as close to weir as possible and at a depth of approximately 18 in. below the surface.

Table F.2 presents data for soils taken from wells drilled into the dike separating the two trenches. The wells were drilled at six locations along the dike and samples were taken at 5-ft intervals down to 40 ft. The sample designations used in Table F.2 are as follows:

Well number: 1A-6A (well 1 is the northernmost)

Sample depth: 5, 10, 15, 20, 25, 30, 35, or 40 ft

TABLE F.1. Soil Sample Analytical Results Above Detection Limit

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E1DA	SAMPLE DATE	E1LA	SAMPLE DATE	E1SA	SAMPLE DATE	E2DA
COLIFRM	MPN	2.20E+00			08/08/88	1.60E+01				
BERYLAM	UG/G	5.00E-01	08/08/88	8.00E-01	08/08/88	4.00E+00	08/08/88	3.00E+00		
STRONUM	UG/G	3.00E+01	08/08/88	4.60E+01	08/08/88	1.44E+02	08/08/88	1.43E+02	08/04/88	4.30E+01
ZINC	UG/G	5.00E-01	08/08/88	2.82E+02	08/08/88	6.84E+02	08/08/88	8.95E+02	08/04/88	1.99E+02
CALCIUM	UG/G	5.00E+00	08/08/88	6.22E+03	08/08/88	1.02E+04	08/08/88	1.42E+04	08/04/88	7.75E+03
BARIIUM	UG/G	6.00E-01	08/08/88	1.47E+02	08/08/88	3.72E+02	08/08/88	4.60E+02	08/04/88	1.38E+02
CADMIUM	UG/G	2.00E-01	08/08/88	4.00E+00			08/08/88	1.70E+01	08/04/88	9.00E+00
CHROMIUM	UG/G	1.00E+00	08/08/88	6.10E+01	08/08/88	1.75E+02	08/08/88	2.98E+02	08/04/88	3.20E+01
SILVER	UG/G	1.00E+00	08/08/88	6.90E+01	08/08/88	1.70E+02	08/08/88	2.45E+02	08/04/88	8.00E+00
SODIUM	UG/G	1.00E+01	08/08/88	2.85E+02	08/08/88	1.01E+03	08/08/88	7.96E+02	08/04/88	3.43E+02
NICKEL	UG/G	1.00E+00	08/08/88	8.60E+01	08/08/88	3.54E+02	08/08/88	4.28E+02	08/04/88	8.20E+01
COPPER	UG/G	1.00E+00	08/08/88	1.81E+03	08/08/88	7.32E+03	08/08/88	8.47E+03	08/04/88	6.51E+02
VANADIUM	UG/G	5.00E-01					08/08/88	2.07E+02	08/04/88	3.60E+01
ANTIMONY	UG/G	1.00E+01	08/08/88	3.10E+01	08/08/88	1.22E+02	08/08/88	6.40E+01		
ALUMINUM	UG/G	1.50E+01	08/08/88	5.92E+03	08/08/88	1.33E+04	08/08/88	1.38E+04	08/04/88	6.48E+03
MANGANESE	UG/G	5.00E-01	08/08/88	2.20E+02	08/08/88	3.84E+02	08/08/88	5.66E+02	08/04/88	4.93E+02
POTASSIUM	UG/G	1.00E+01	08/08/88	5.89E+02	08/08/88	8.50E+02	08/08/88	7.69E+02	08/04/88	5.25E+02
IRON	UG/G	5.00E+00	08/08/88	1.74E+03	08/08/88	2.06E+04	08/08/88	3.55E+04	08/04/88	2.52E+04
ARSENIC	UG/G	5.00E-01			08/08/88	1.02E+01				
MERCURY	UG/G	1.00E-01	08/08/88	2.07E+01	08/08/88	5.84E+01	08/08/88	6.94E+01	08/04/88	6.96E+00
MAGNESIUM	UG/G	5.00E+00	08/08/88	2.94E+03	08/08/88	3.41E+03	08/08/88	3.43E+03	08/04/88	4.71E+03
LEAD	UG/G	5.00E-01	08/08/88	6.02E+01	08/08/88	1.34E+02	08/08/88	2.30E+02	08/04/88	8.55E+01
TOLUENE	UG/G	1.00E-02			08/08/88	2.00E-02				
OPXYLE	UG/G	1.00E-02			08/08/88	3.00E-02				
M-XYLE	UG/G	1.00E-02			08/08/88	2.00E-02				
TOX	UG/G	1.00E+00	08/08/88	6.20E+00	08/08/88	2.40E+00	08/08/88	1.72E+01	08/04/88	2.30E+00
TOC	UG/G	1.00E+01	08/08/88	2.41E+02	08/08/88	5.13E+02	08/08/88	4.79E+02	08/04/88	1.16E+02
NITRATE	UG/G	1.00E+00			08/08/88	5.89E+00				
SULFATE	UG/G	1.00E+00			08/08/88	6.63E+01				
FLUORIDE	UG/G	1.00E+00			08/08/88	3.18E+00				
CHLORIDE	UG/G	1.00E+00			08/08/88	2.52E+01				
SULFIDE	UG/G	1.00E+01			08/08/88	7.86E+01				
AMMONIUM	UG/G	5.00E-01			08/08/88	1.40E+01				
ACETONE	UG/G	0.00E+00			08/08/88	1.70E-01				

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E2LA	SAMPLE DATE	E2SA	SAMPLE DATE	E3LA	SAMPLE DATE	E3SA
COLIFRM	MPN	2.20E+00			08/04/88	1.80E+01	08/04/88	2.20E+00		
BERYLAM	UG/G	5.00E-01	08/04/88	3.00E+00			08/04/88	2.00E+00		
STRONUM	UG/G	3.00E+01	08/04/88	8.50E+01	08/04/88	3.50E+01	08/04/88	9.90E+01		
ZINC	UG/G	5.00E-01	08/04/88	1.27E+02	08/04/88	1.44E+02	08/04/88	1.87E+02	08/04/88	9.00E+01
CALCIUM	UG/G	5.00E+00	08/04/88	7.03E+03	08/04/88	8.96E+03	08/04/88	7.94E+03	08/04/88	5.99E+03
BARIUM	UG/G	8.00E-01	08/04/88	1.82E+02	08/04/88	1.18E+02	08/04/88	1.88E+02	08/04/88	9.60E+01
CADMIUM	UG/G	2.00E-01			08/04/88	8.00E+00	08/04/88	9.00E+00	08/04/88	9.00E+00
CHROMIUM	UG/G	1.00E+00	08/04/88	5.51E+02	08/04/88	2.80E+01	08/04/88	1.58E+02	08/04/88	3.60E+01
SILVER	UG/G	1.00E+00	08/04/88	1.25E+02	08/04/88	9.00E+00	08/04/88	8.80E+01	08/04/88	2.00E+00
SODIUM	UG/G	1.00E+01	08/04/88	4.89E+02	08/04/88	3.08E+02	08/04/88	7.24E+02	08/04/88	3.58E+02
NICKEL	UG/G	1.00E+00	08/04/88	3.77E+02	08/04/88	8.50E+01	08/04/88	2.08E+02	08/04/88	4.70E+01
COPPER	UG/G	1.00E+00	08/04/88	2.26E+03	08/04/88	5.68E+02	08/04/88	2.87E+03	08/04/88	4.29E+02
VANADIUM	UG/G	5.00E-01			08/04/88	3.30E+01	08/04/88	1.98E+02	08/04/88	4.20E+01
ANTIMONY	UG/G	1.00E+01	08/04/88	1.28E+02			08/04/88	1.17E+02		
ALUMINUM	UG/G	1.50E+01	08/04/88	5.93E+03	08/04/88	5.70E+03	08/04/88	7.05E+03	08/04/88	5.94E+03
MANGANESE	UG/G	5.00E-01	08/04/88	1.32E+02	08/04/88	5.90E+02	08/04/88	1.55E+02	08/04/88	2.39E+02
POTASSIUM	UG/G	1.00E+01	08/04/88	2.75E+02	08/04/88	5.14E+02	08/04/88	4.42E+02	08/04/88	5.00E+02
IRON	UG/G	5.00E+00	08/04/88	1.93E+04	08/04/88	2.24E+04	08/04/88	1.81E+04	08/04/88	2.79E+04
ARSENIC	UG/G	5.00E-01			08/04/88	3.98E+00	08/04/88	2.78E+00		
MERCURY	UG/G	1.00E-01	08/04/88	3.57E+01	08/04/88	5.92E+00	08/04/88	2.19E+01	08/04/88	1.87E+00
MAGNESIUM	UG/G	5.00E+00	08/04/88	1.86E+03	08/04/88	4.53E+03	08/04/88	3.01E+03	08/04/88	5.60E+03
LEAD	UG/G	5.00E-01	08/04/88	2.01E+02	08/04/88	2.85E+01	08/04/88	4.88E+02	08/04/88	1.92E+01
PERCHLORATE	UG/G	1.00E-02			08/04/88	1.00E-02	08/04/88	1.00E-02		
BENZENE	UG/G	1.00E+00					08/04/88	1.40E+01		
CHRYSEN	UG/G	1.00E+00					08/04/88	1.20E+01		
BENZOPYRENE	UG/G	1.00E+00					08/04/88	2.50E+01		
TOXICITY	UG/G	1.00E+00	08/04/88	1.20E+01	08/04/88	2.00E+00	08/04/88	2.68E+01	08/04/88	1.80E+00
TOC	UG/G	1.00E+01	08/04/88	5.27E+02	08/04/88	9.78E+01	08/04/88	4.55E+02	08/04/88	9.85E+01
NITRATE	UG/G	1.00E+00			08/04/88	1.40E+00				
SULFATE	UG/G	1.00E+00			08/04/88	1.63E+00	08/04/88	4.33E+00		
FLUORIDE	UG/G	1.00E+00			08/04/88	1.02E+00	08/04/88	1.48E+00		
CHLORIDE	UG/G	1.00E+00			08/04/88	1.13E+01	08/04/88	2.07E+01		
SULFIDE	UG/G	1.00E+01					08/04/88	3.10E+01		
AMMONIUM	UG/G	5.00E-01			08/04/88	5.20E-01	08/04/88	2.09E+01		

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E4SA	SAMPLE DATE	E5SA	SAMPLE DATE	E6SA	SAMPLE DATE	E7DA
COLIFRM	MPN	2.20E+00			08/04/88	1.60E+01				
BERYLAM	UG/G	5.00E-01					07/30/88	1.00E+00		
STRONUM	UG/G	3.00E+01					07/30/88	3.70E+01		
ZINC	UG/G	5.00E-01	08/04/88	7.30E+01	08/04/88	6.30E+01	07/30/88	2.39E+02	07/30/88	1.39E+02
CALCIUM	UG/G	5.00E+00	08/04/88	4.19E+03	08/04/88	5.90E+03	07/30/88	4.97E+03	07/30/88	4.42E+03
BARIUM	UG/G	6.00E-01	08/04/88	7.00E+01	08/04/88	9.10E+01	07/30/88	1.78E+02	07/30/88	1.10E+02
CADMIUM	UG/G	2.00E-01	08/04/88	1.10E+01	08/04/88	1.00E+01	07/30/88	1.30E+01	07/30/88	1.00E+01
CHROMIUM	UG/G	1.00E+00	08/04/88	3.30E+01	08/04/88	3.70E+01	07/30/88	2.28E+02	07/30/88	6.70E+01
SILVER	UG/G	1.00E+00					07/30/88	1.07E+02	07/30/88	2.20E+01
SODIUM	UG/G	1.00E+01	08/04/88	3.09E+02	08/04/88	2.77E+02	07/30/88	2.89E+02	07/30/88	2.04E+02
NICKEL	UG/G	1.00E+00	08/04/88	3.30E+01	08/04/88	3.30E+01	07/30/88	2.32E+02	07/30/88	9.60E+01
COPPER	UG/G	1.00E+00	08/04/88	3.88E+02	08/04/88	3.82E+02	07/30/88	1.99E+03	07/30/88	8.07E+02
VANADIUM	UG/G	5.00E-01	08/04/88	5.90E+01	08/04/88	4.30E+01	07/30/88	1.10E+02	07/30/88	4.70E+01
ALUMINUM	UG/G	1.50E+01	08/04/88	4.47E+03	08/04/88	4.82E+03	07/30/88	1.09E+04	07/30/88	7.68E+03
MANGANESE	UG/G	5.00E-01	08/04/88	2.43E+02	08/04/88	2.78E+02	07/30/88	3.03E+02	07/30/88	3.11E+02
POTASSIUM	UG/G	1.00E+01	08/04/88	3.93E+02	08/04/88	3.96E+02	07/30/88	9.11E+02	07/30/88	6.99E+02
IRON	UG/G	5.00E+00	08/04/88	2.88E+04	08/04/88	2.79E+04	07/30/88	3.37E+04	07/30/88	2.67E+04
ARSENIC	UG/G	5.00E-01			08/04/88	1.75E+00			07/30/88	1.38E+01
MERCURY	UG/G	1.00E-01	08/04/88	2.27E+00	08/04/88	2.73E+00	07/30/88	5.23E+00	07/30/88	1.17E+00
MAGNESIUM	UG/G	5.00E+00	08/04/88	4.81E+03	08/04/88	4.68E+03	07/30/88	5.03E+03	07/30/88	4.97E+03
LEAD	UG/G	5.00E-01	08/04/88	1.48E+01	08/04/88	1.63E+01	07/30/88	1.36E+02	07/30/88	2.92E+01
TOXICITY	UG/G	1.00E+00			08/04/88	1.00E+00	07/30/88	8.20E+00	07/30/88	1.78E+01
TOTAL CHLORIDE	UG/G	1.00E+01	08/04/88	8.39E+01	08/04/88	8.89E+01	07/30/88	8.48E+01	07/30/88	1.52E+02
CYANIDE	UG/G	1.00E+00							07/30/88	1.30E+00
NITRATE	UG/G	1.00E+00			08/04/88	2.67E+00			07/30/88	1.65E+01
SULFATE	UG/G	1.00E+00			08/04/88	3.65E+00			07/30/88	6.81E+00
FLUORIDE	UG/G	1.00E+00			08/04/88	1.07E+00			07/30/88	1.03E+00
CHLORIDE	UG/G	1.00E+00			08/04/88	7.74E+00				
AMMONIUM	UG/G	5.00E-01							07/30/88	6.20E-01

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E7LA	SAMPLE DATE	E7SA	SAMPLE DATE	E8DA	SAMPLE DATE	E8SA
BERYLAM	UG/G	5.00E-01	07/30/88	4.00E+00						
STRONUM	UG/G	3.00E+01	07/30/88	8.50E+01						
ZINC	UG/G	5.00E-01	07/30/88	2.85E+02	07/30/88	1.11E+02	07/30/88	9.30E+01	07/30/88	8.40E+01
CALCIUM	UG/G	5.00E+00	07/30/88	5.08E+03	07/30/88	4.43E+03	07/30/88	4.88E+03	07/30/88	4.18E+03
BARIUM	UG/G	8.00E-01	07/30/88	2.75E+02	07/30/88	8.20E+01	07/30/88	8.90E+01	07/30/88	8.80E+01
CADMIUM	UG/G	2.00E-01	07/30/88	8.00E+00	07/30/88	9.00E+00	07/30/88	1.10E+01	07/30/88	1.00E+01
CHROMUM	UG/G	1.00E+00	07/30/88	4.33E+02	07/30/88	3.90E+01	07/30/88	4.60E+01	07/30/88	2.70E+01
SILVER	UG/G	1.00E+00	07/30/88	1.70E+01	07/30/88	9.00E+00	07/30/88	7.00E+00	07/30/88	2.00E+00
SODIUM	UG/G	1.00E+01	07/30/88	3.17E+02	07/30/88	2.00E+02	07/30/88	2.79E+02	07/30/88	2.28E+02
NICKEL	UG/G	1.00E+00	07/30/88	3.29E+02	07/30/88	4.90E+01	07/30/88	4.90E+01	07/30/88	3.90E+01
COPPER	UG/G	1.00E+00	07/30/88	3.04E+03	07/30/88	8.08E+02	07/30/88	5.35E+02	07/30/88	5.80E+02
VANADUM	UG/G	5.00E-01			07/30/88	4.40E+01	07/30/88	8.40E+01	07/30/88	5.50E+01
ANTIONY	UG/G	1.00E+01	07/30/88	4.70E+01						
ALUMNUM	UG/G	1.50E+01	07/30/88	1.14E+04	07/30/88	4.67E+03	07/30/88	8.24E+03	07/30/88	5.74E+03
MANGESE	UG/G	5.00E-01	07/30/88	2.60E+02	07/30/88	2.33E+02	07/30/88	2.70E+02	07/30/88	2.91E+02
POTASUM	UG/G	1.00E+01	07/30/88	9.10E+02	07/30/88	5.53E+02	07/30/88	5.56E+02	07/30/88	5.81E+02
IRON	UG/G	5.00E+00	07/30/88	3.52E+04	07/30/88	1.95E+04	07/30/88	2.79E+04	07/30/88	2.81E+04
MERCURY	UG/G	1.00E-01	07/30/88	8.22E+00	07/30/88	5.70E-01	07/30/88	8.60E-01	07/30/88	2.90E-01
MAGNES	UG/G	5.00E+00	07/30/88	3.89E+03	07/30/88	3.47E+03	07/30/88	4.45E+03	07/30/88	4.63E+03
LEADGF	UG/G	5.00E-01	07/30/88	3.48E+02	07/30/88	1.83E+01	07/30/88	1.50E+01	07/30/88	8.68E+00
TOX	UG/G	1.00E+00	07/30/88	2.74E+01	07/30/88	8.40E+00	07/30/88	5.80E+00	07/30/88	4.50E+00
TOC	UG/G	1.00E+01	07/30/88	2.95E+02	07/30/88	9.18E+01	07/30/88	9.87E+01	07/30/88	1.05E+02

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E9DA	SAMPLE DATE	E9SA	SAMPLE DATE	E10DA	SAMPLE DATE	E10SA
STRONUM	UG/G	3.00E+01							07/23/88	3.50E+01
ZINC	UG/G	5.00E-01	07/23/88	1.04E+02	07/23/88	8.80E+01	07/23/88	1.10E+02	07/23/88	1.05E+02
CALCIUM	UG/G	5.00E+00	07/23/88	4.54E+03	07/23/88	4.68E+03	07/23/88	4.47E+03	07/23/88	5.80E+03
BARIUM	UG/G	6.00E-01	07/23/88	8.20E+01	07/23/88	9.00E+01	07/23/88	9.00E+00	07/23/88	1.05E+02
CADMIUM	UG/G	2.00E-01	07/23/88	1.00E+01	07/23/88	1.10E+01	07/23/88	1.00E+01	07/23/88	1.10E+01
CHROMIUM	UG/G	1.00E+00	07/23/88	3.80E+01	07/23/88	2.50E+01	07/23/88	3.10E+01	07/23/88	2.00E+01
SILVER	UG/G	1.00E+00	07/23/88	1.00E+01	07/23/88	8.00E+00	07/23/88	7.00E+00		
SODIUM	UG/G	1.00E+01	07/23/88	2.48E+02	07/23/88	2.32E+02	07/23/88	2.21E+02	07/23/88	2.29E+02
NICKEL	UG/G	1.00E+00	07/23/88	4.90E+01	07/23/88	3.30E+01	07/23/88	4.90E+01	07/23/88	3.90E+01
COPPER	UG/G	1.00E+00	07/23/88	5.82E+02	07/23/88	5.83E+02	07/23/88	4.43E+02	07/23/88	3.22E+02
VANADIUM	UG/G	5.00E-01	07/23/88	4.70E+01	07/23/88	4.80E+01	07/23/88	4.80E+01	07/23/88	5.80E+01
ALUMINUM	UG/G	1.50E+01	07/23/88	8.25E+03	07/23/88	5.87E+03	07/23/88	8.11E+03	07/23/88	9.74E+03
MANGANESE	UG/G	5.00E-01	07/23/88	2.88E+02	07/23/88	2.83E+02	07/23/88	2.87E+02	07/23/88	2.72E+02
POTASSIUM	UG/G	1.00E+01	07/23/88	5.78E+02	07/23/88	5.20E+02	07/23/88	5.83E+02	07/23/88	1.04E+03
IRON	UG/G	5.00E+00	07/23/88	2.45E+04	07/23/88	2.59E+04	07/23/88	2.44E+04	07/23/88	2.85E+04
ARSENIC	UG/G	5.00E-01							07/23/88	5.57E+00
MERCURY	UG/G	1.00E-01	07/23/88	5.80E-01	07/23/88	2.70E-01	07/23/88	5.30E-01	07/23/88	2.50E-01
THALIUM	UG/G	1.00E+00							07/23/88	1.38E+00
MAGNES	UG/G	5.00E+00	07/23/88	4.59E+03	07/23/88	4.82E+03	07/23/88	4.89E+03	07/23/88	5.49E+03
LEADGF	UG/G	5.00E-01	07/23/88	1.11E+01	07/23/88	1.04E+01	07/23/88	1.18E+01	07/23/88	8.23E+00
METHYCH	UG/G	1.00E-02							07/23/88	3.00E-02
BUTBENP	UG/G	1.00E+00							07/23/88	3.30E+00
TOX	UG/G	1.00E+00	07/23/88	1.18E+01	07/23/88	4.00E+00	07/23/88	5.10E+00	07/23/88	2.20E+00
TOC	UG/G	1.00E+01	07/23/88	1.02E+02	07/23/88	9.90E+01	07/23/88	9.05E+01	07/23/88	8.47E+01
NITRATE	UG/G	1.00E+00							07/23/88	8.94E+00
SULFATE	UG/G	1.00E+00							07/23/88	4.77E+00
FLUORID	UG/G	1.00E+00							07/23/88	1.40E+00

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E11DA	SAMPLE DATE	E11SA	SAMPLE DATE	E12DA	SAMPLE DATE	E12SA
ZINC	UG/G	5.00E-01	07/23/88	9.70E+01	07/23/88	1.56E+02	07/23/88	7.90E+01	07/23/88	1.06E+02
CALCIUM	UG/G	5.00E+00	07/23/88	4.75E+03	07/23/88	4.77E+03	07/23/88	5.32E+03	07/23/88	4.97E+03
BARIUM	UG/G	8.00E-01	07/23/88	8.20E+01	07/23/88	9.50E+01	07/23/88	9.10E+01	07/23/88	9.10E+01
CADMIUM	UG/G	2.00E-01	07/23/88	1.10E+01	07/23/88	1.20E+01	07/23/88	1.10E+01	07/23/88	1.10E+01
CHROMIUM	UG/G	1.00E+00	07/23/88	1.40E+01	07/23/88	3.50E+01	07/23/88	1.30E+01	07/23/88	2.70E+01
SILVER	UG/G	1.00E+00			07/23/88	1.80E+01			07/23/88	7.00E+00
SODIUM	UG/G	1.00E+01	07/23/88	2.24E+02	07/23/88	2.29E+02	07/23/88	2.87E+02	07/23/88	2.37E+02
NICKEL	UG/G	1.00E+00	07/23/88	2.70E+01	07/23/88	6.70E+01	07/23/88	2.80E+01	07/23/88	4.10E+01
COPPER	UG/G	1.00E+00	07/23/88	1.74E+02	07/23/88	5.79E+02	07/23/88	1.58E+02	07/23/88	3.64E+02
VANADIUM	UG/G	5.00E-01	07/23/88	4.00E+01	07/23/88	6.10E+01	07/23/88	4.90E+01	07/23/88	5.00E+01
ALUMINUM	UG/G	1.50E+01	07/23/88	5.35E+03	07/23/88	7.20E+03	07/23/88	5.60E+03	07/23/88	6.98E+03
MANGANESE	UG/G	5.00E-01	07/23/88	3.16E+02	07/23/88	3.08E+02	07/23/88	3.36E+02	07/23/88	3.06E+02
POTASSIUM	UG/G	1.00E+01	07/23/88	4.74E+02	07/23/88	6.72E+02	07/23/88	5.35E+02	07/23/88	6.79E+02
IRON	UG/G	5.00E+00	07/23/88	2.37E+04	07/23/88	2.74E+03	07/23/88	2.60E+04	07/23/88	2.58E+04
MERCURY	UG/G	1.00E-01	07/23/88	2.30E-01	07/23/88	7.70E-01	07/23/88	2.80E-01	07/23/88	4.40E-01
MAGNESIUM	UG/G	5.00E+00	07/23/88	4.80E+03	07/23/88	4.89E+03	07/23/88	4.87E+03	07/23/88	5.08E+03
LEAD	UG/G	5.00E-01	07/23/88	5.87E+00	07/23/88	1.37E+01	07/23/88	5.59E+00	07/23/88	1.05E+01
TOX	UG/G	1.00E+00	07/23/88	7.40E+00	07/23/88	1.44E+01	07/23/88	2.46E+01	07/23/88	1.86E+01
TOC	UG/G	1.00E+01	07/23/88	5.57E+01	07/23/88	1.32E+02	07/23/88	5.76E+01	07/23/88	1.21E+02

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E13DA	SAMPLE DATE	E13LA	SAMPLE DATE	E13SA	SAMPLE DATE	E14DA
COLIFRM	MPN	2.20E+00							07/21/88	1.80E+01
BERYLAM	UG/G	5.00E-01			07/21/88	9.00E-01				
STRONUM	UG/G	3.00E+01			07/21/88	3.30E+01				
ZINC	UG/G	5.00E-01	07/21/88	7.00E+01	07/21/88	2.68E+02	07/21/88	8.00E+01	07/21/88	7.90E+01
CALCIUM	UG/G	5.00E+00	07/21/88	5.25E+03	07/21/88	4.10E+03	07/21/88	4.95E+03	07/21/88	4.83E+03
BARIUM	UG/G	8.00E-01	07/21/88	8.40E+01	07/21/88	1.46E+02	07/21/88	8.70E+01	07/21/88	8.80E+01
CADMIUM	UG/G	2.00E-01	07/21/88	1.00E+01	07/21/88	8.00E+00	07/21/88	1.00E+01	07/21/88	9.00E+00
CHROMIUM	UG/G	1.00E+00	07/21/88	9.00E+00	07/21/88	1.64E+02	07/21/88	9.00E+00	07/21/88	1.30E+01
SILVER	UG/G	1.00E+00			07/21/88	7.80E+01				
SODIUM	UG/G	1.00E+01	07/21/88	2.74E+02	07/21/88	1.82E+02	07/21/88	2.95E+02	07/21/88	2.80E+02
NICKEL	UG/G	1.00E+00	07/21/88	1.70E+01	07/21/88	1.78E+02	07/21/88	2.00E+01	07/21/88	2.50E+01
COPPER	UG/G	1.00E+00	07/21/88	1.13E+02	07/21/88	1.71E+03	07/21/88	1.39E+02	07/21/88	1.71E+02
VANADIUM	UG/G	5.00E-01	07/21/88	5.20E+01	07/21/88	4.50E+01	07/21/88	5.00E+01	07/21/88	4.60E+01
ALUMINUM	UG/G	1.50E+01	07/21/88	5.58E+03	07/21/88	7.91E+03	07/21/88	5.84E+03	07/21/88	6.14E+03
MANGANESE	UG/G	5.00E-01	07/21/88	3.16E+02	07/21/88	1.82E+02	07/21/88	3.78E+02	07/21/88	3.26E+02
POTASIUM	UG/G	1.00E+01	07/21/88	5.24E+02	07/21/88	7.65E+02	07/21/88	5.37E+02	07/21/88	6.04E+02
IRON	UG/G	5.00E+00	07/21/88	2.87E+04	07/21/88	2.12E+04	07/21/88	2.51E+04	07/21/88	2.34E+04
ARSENIC	UG/G	5.00E-01							07/21/88	2.00E+00
MERCURY	UG/G	1.00E-01	07/21/88	3.00E-01	07/21/88	2.80E+00	07/21/88	3.00E-01	07/21/88	3.00E-01
MAGNESIUM	UG/G	5.00E+00	07/21/88	4.90E+03	07/21/88	4.08E+03	07/21/88	4.58E+03	07/21/88	4.86E+03
LEAD	UG/G	5.00E-01	07/21/88	6.00E+00	07/21/88	1.92E+01	07/21/88	3.50E+00	07/21/88	5.70E+00
TOX	UG/G	1.00E+00	07/21/88	1.06E+01	07/21/88	1.54E+01	07/21/88	6.20E+00	07/21/88	8.50E+00
TOC	UG/G	1.00E+01	07/21/88	1.07E+02	07/21/88	4.47E+02	07/21/88	1.07E+02	07/21/88	1.60E+02
NITRATE	UG/G	1.00E+00							07/21/88	1.49E+01
SULFATE	UG/G	1.00E+00							07/21/88	3.41E+00
FLUORIDE	UG/G	1.00E+00							07/21/88	1.00E+00
CHLORIDE	UG/G	1.00E+00							07/21/88	1.78E+00

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E14SA	SAMPLE DATE	E15DA	SAMPLE DATE	E15SA	SAMPLE DATE	E16LA
BERYLAM	UG/G	5.00E-01							08/08/88	1.50E+00
STRONUM	UG/G	3.00E+01							08/08/88	1.01E+02
ZINC	UG/G	5.00E-01	07/21/88	8.90E+01	07/21/88	1.09E+02	07/21/88	1.73E+02	08/08/88	1.16E+03
CALCIUM	UG/G	5.00E+00	07/21/88	4.23E+03	07/21/88	4.90E+03	07/21/88	5.32E+03	08/08/88	8.82E+03
BARIUM	UG/G	8.00E-01	07/21/88	8.80E+01	07/21/88	9.80E+01	07/21/88	1.07E+02	08/08/88	4.91E+02
CADMIUM	UG/G	2.00E-01	07/21/88	9.00E+00	07/21/88	1.00E+01	07/21/88	1.10E+01	08/08/88	2.80E+01
CHROMUM	UG/G	1.00E+00	07/21/88	1.20E+01	07/21/88	1.80E+01	07/21/88	3.30E+01	08/08/88	4.81E+02
SILVER	UG/G	1.00E+00			07/21/88	4.00E+00	07/21/88	1.30E+01	08/08/88	4.05E+02
SODIUM	UG/G	1.00E+01	07/21/88	2.17E+02	07/21/88	2.54E+02	07/21/88	2.82E+02	08/08/88	3.55E+02
NICKEL	UG/G	1.00E+00	07/21/88	2.70E+01	07/21/88	3.80E+01	07/21/88	6.80E+01	08/08/88	3.71E+02
COPPER	UG/G	1.00E+00	07/21/88	2.14E+02	07/21/88	2.81E+02	07/21/88	5.01E+02	08/08/88	6.55E+03
VANADUM	UG/G	5.00E-01	07/21/88	4.30E+01	07/21/88	4.40E+01	07/21/88	5.20E+01	08/08/88	6.20E+01
ALUMNUM	UG/G	1.50E+01	07/21/88	6.10E+03	07/21/88	6.58E+03	07/21/88	8.57E+03	08/08/88	1.35E+04
MANGESE	UG/G	5.00E-01	07/21/88	3.78E+02	07/21/88	3.15E+02	07/21/88	3.16E+02	08/08/88	1.21E+02
POTASUM	UG/G	1.00E+01	07/21/88	6.31E+02	07/21/88	6.53E+02	07/21/88	7.75E+02	08/08/88	6.99E+02
IRON	UG/G	5.00E+00	07/21/88	2.25E+04	07/21/88	2.45E+04	07/21/88	2.79E+04	08/08/88	2.47E+04
MERCURY	UG/G	1.00E-01	07/21/88	4.00E-01	07/21/88	8.00E-01	07/21/88	1.30E+00	08/08/88	1.80E+01
MAGNES	UG/G	5.00E+00	07/21/88	4.49E+03	07/21/88	5.02E+03	07/21/88	5.80E+03	08/08/88	2.95E+03
LEADGF	UG/G	5.00E-01	07/21/88	6.80E+00	07/21/88	1.04E+01	07/21/88	9.70E+00	08/08/88	1.00E+02
TOX	UG/G	1.00E+00	07/21/88	1.28E+01	07/21/88	5.20E+00	07/21/88	7.00E+00	08/08/88	2.00E+00
TOC	UG/G	1.00E+01	07/21/88	1.55E+02	07/21/88	1.69E+02	07/21/88	2.19E+02	08/08/88	7.31E+02

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	E18SA
COLIFRM	MPN	2.20E+00	08/08/88	1.60E+01
STRONUM	UG/G	3.00E+01	08/08/88	3.00E+01
ZINC	UG/G	5.00E-01	08/08/88	2.82E+02
CALCIUM	UG/G	5.00E+00	08/08/88	5.58E+03
BARIUM	UG/G	8.00E-01	08/08/88	1.35E+02
CADMIUM	UG/G	2.00E-01	08/08/88	1.30E+01
CHROMIUM	UG/G	1.00E+00	08/08/88	7.80E+01
SILVER	UG/G	1.00E+00	08/08/88	6.80E+01
SODIUM	UG/G	1.00E+01	08/08/88	2.69E+02
NICKEL	UG/G	1.00E+00	08/08/88	7.40E+01
COPPER	UG/G	1.00E+00	08/08/88	1.19E+03
YANADUM	UG/G	5.00E-01	08/08/88	4.80E+01
ALUMNUM	UG/G	1.50E+01	08/08/88	7.13E+03
MANGESE	UG/G	5.00E-01	08/08/88	2.13E+02
POTASUM	UG/G	1.00E+01	08/08/88	5.68E+02
IRON	UG/G	5.00E+00	08/08/88	2.53E+03
ARSENIC	UG/G	5.00E-01	08/08/88	4.32E+00
MERCURY	UG/G	1.00E-01	08/08/88	3.98E+01
THALIUM	UG/G	1.00E+00	08/08/88	1.00E+00
MAGNES	UG/G	5.00E+00	08/08/88	4.69E+03
LEADGF	UG/G	5.00E-01	08/08/88	2.98E+01
METHYCH	UG/G	1.00E-02		
TOX	UG/G	1.00E+00		
TOC	UG/G	1.00E+01	08/08/88	1.98E+02
NITRATE	UG/G	1.00E+00		
SULFATE	UG/G	1.00E+00	08/08/88	1.77E+01
FLUORID	UG/G	1.00E+00	08/08/88	1.19E+00
CHLORID	UG/G	1.00E+00	08/08/88	3.55E+00
SULFIDE	UG/G	1.00E+01		
AMMONIU	UG/G	5.00E-01	08/08/88	2.10E+00
ACETONE	UG/G	0.00E+00		
UNKNOWN	UG/G	0.00E+00		
MOLSULF	UG/G			

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W1DA	SAMPLE DATE	W1LA	SAMPLE DATE	W1SA
COLIFRM	MPN	2.20E+00			08/18/88	2.40E+03		
BERYLAM	UG/G	5.00E-01			08/18/88	2.00E+00		
OSMIUM	UG/G	3.00E+01			08/18/88	4.50E+01		
STRONUM	UG/G	3.00E+01	08/18/88	4.10E+01	08/18/88	2.42E+02		
ZINC	UG/G	5.00E-01	08/18/88	1.17E+02	08/18/88	9.30E+01	08/18/88	9.20E+01
CALCIUM	UG/G	5.00E+00	08/18/88	8.44E+03	08/18/88	8.17E+03	08/18/88	4.00E+03
BARIUM	UG/G	8.00E-01	08/18/88	1.04E+02	08/18/88	2.22E+02	08/18/88	8.00E+01
CADMIUM	UG/G	2.00E-01	08/18/88	8.00E+00			08/18/88	8.00E+00
CHROMUM	UG/G	1.00E+00	08/18/88	1.60E+01	08/18/88	1.70E+01	08/18/88	8.00E+00
SILVER	UG/G	1.00E+00			08/18/88	4.40E+01		
SODIUM	UG/G	1.00E+01	08/18/88	3.51E+02	08/18/88	5.83E+02	08/18/88	2.45E+02
NICKEL	UG/G	1.00E+00	08/18/88	3.40E+01	08/18/88	1.05E+02	08/18/88	1.80E+01
COPPER	UG/G	1.00E+00	08/18/88	3.99E+02	08/18/88	1.87E+03	08/18/88	1.47E+02
VANADUM	UG/G	5.00E-01	08/18/88	2.80E+01			08/18/88	4.50E+01
ANTIONY	UG/G	1.00E+01			08/18/88	9.60E+01		
ALUMNUM	UG/G	1.50E+01	08/18/88	7.68E+03	08/18/88	5.22E+03	08/18/88	5.45E+03
MANGESE	UG/G	5.00E-01	08/18/88	3.19E+02	08/18/88	2.21E+02	08/18/88	1.98E+02
POTASUM	UG/G	1.00E+01	08/18/88	8.25E+02	08/18/88	2.84E+02	08/18/88	5.52E+02
IRON	UG/G	5.00E+00	08/18/88	2.50E+04	08/18/88	7.48E+03	08/18/88	2.11E+04
ARSENIC	UG/G	5.00E-01			08/18/88	3.40E+00		
MERCURY	UG/G	1.00E-01	08/18/88	1.19E+00	08/18/88	4.08E-01	08/18/88	2.59E-01
MAGNES	UG/G	5.00E+00						
LEADGF	UG/G	5.00E-01	08/18/88	2.22E+00	08/18/88	2.04E+01	08/18/88	7.87E+00
TOX	UG/G	1.00E+00	08/18/88	2.00E+00	08/18/88	7.47E+01		
TOC	UG/G	1.00E+01	08/18/88	8.88E+01	08/18/88	4.67E+02	08/18/88	4.41E+01
SULFIDE	UG/G	1.00E+01			08/18/88	1.05E+01		
AMMONIU	UG/G	5.00E-01			08/18/88	3.31E+01		
UNKNOWN	UG/G	0.00E+00			08/18/88	2.80E+00		
NC19HC	UG/G				08/18/88	5.00E+02		
NC21HC	UG/G				08/18/88	5.70E+02		
NC22HC	UG/G				08/18/88	5.40E+02		
DMNAPHT	UG/G				08/18/88	1.56E+03		

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W2DA	SAMPLE DATE	W2SA	SAMPLE DATE	W3DA	SAMPLE DATE	W3LA
COLIFRM	MPN	2.20E+00			08/23/88	4.00E+00	09/10/88	1.80E+01	09/10/88	1.60E+01
BERYLAM	UG/G	5.00E-01	08/23/88	1.00E+00	08/23/88	1.80E+00			09/10/88	3.00E+00
STRONUM	UG/G	3.00E+01	08/23/88	7.40E+01	08/23/88	1.58E+02	09/10/88	3.70E+01	09/10/88	2.28E+02
ZINC	UG/G	5.00E-01	08/23/88	3.98E+02	08/23/88	8.45E+02	09/10/88	1.55E+02	09/10/88	2.49E+02
CALCIUM	UG/G	5.00E+00	08/23/88	4.84E+03	08/23/88	9.34E+03	09/10/88	5.04E+03	09/10/88	7.50E+03
BARIUM	UG/G	8.00E-01	08/23/88	1.78E+02	08/23/88	4.85E+02	09/10/88	9.20E+01	09/10/88	2.98E+02
CADMIUM	UG/G	2.00E-01	08/23/88	8.00E+00	08/23/88	1.90E+01	09/10/88	8.00E+00		
CHROMIUM	UG/G	1.00E+00	08/23/88	1.31E+02	08/23/88	1.54E+02	09/10/88	2.20E+01	09/10/88	1.38E+02
SILVER	UG/G	1.00E+00	08/23/88	1.10E+02	08/23/88	1.47E+02	09/10/88	7.00E+00	09/10/88	8.80E+01
SODIUM	UG/G	1.00E+01	08/23/88	5.29E+02	08/23/88	1.39E+03	09/10/88	3.34E+02	09/10/88	1.44E+03
NICKEL	UG/G	1.00E+00	08/23/88	1.03E+03	08/23/88	4.70E+03	09/10/88	1.88E+02	09/10/88	1.55E+03
COPPER	UG/G	1.00E+00	08/23/88	2.23E+03	08/23/88	3.94E+03	09/10/88	7.01E+02	09/10/88	5.84E+03
VANADUM	UG/G	5.00E-01	08/23/88	4.30E+01	08/23/88	8.00E-01	09/10/88	1.90E+01	09/10/88	7.00E+01
ANTIONY	UG/G	1.00E+01	08/23/88	1.80E+01	08/23/88	2.80E+01			09/10/88	6.40E+01
ALUMNUM	UG/G	1.50E+01	08/23/88	1.05E+04	08/23/88	1.78E+04	09/10/88	5.30E+03	09/10/88	1.89E+04
MANGESE	UG/G	5.00E-01	08/23/88	1.18E+03	08/23/88	6.74E+03	09/10/88	4.85E+02	09/10/88	1.70E+03
POTASUM	UG/G	1.00E+01	08/23/88	7.00E+02	08/23/88	7.27E+02	09/10/88	4.40E+02	09/10/88	6.48E+02
IRON	UG/G	5.00E+00	08/23/88	2.34E+04	08/23/88	4.58E+04	09/10/88	1.92E+04	09/10/88	2.30E+04
ARSENIC	UG/G	5.00E-01			08/23/88	5.40E+00			09/10/88	2.56E+00
MERCURY	UG/G	1.00E-01	08/23/88	8.78E+00	08/23/88	2.29E+01	09/10/88	1.31E+00	09/10/88	9.38E+00
SELENUM	UG/G	5.00E-01			08/23/88	8.50E+00			09/10/88	8.09E+00
MAGNES	UG/G	5.00E+00					09/10/88	3.47E+03	09/10/88	2.82E+03
LEADGF	UG/G	5.00E-01	08/23/88	4.90E+01	08/23/88	1.88E+02	09/10/88	3.15E+01	09/10/88	2.42E+02
PERCENE	UG/G	1.00E-02			08/23/88	8.50E+00	09/10/88	1.00E-02	09/10/88	1.10E-01
TRANDCE	UG/G	1.00E-02							09/10/88	4.00E-02
METHYCH	UG/G	1.00E-02							09/10/88	4.00E-02
TOX	UG/G	1.00E+00	08/23/88	9.60E+00	08/23/88	4.88E+01	09/10/88	1.20E+00	09/10/88	5.20E+00
TOC	UG/G	1.00E+01	08/23/88	9.05E+01	08/23/88	2.23E+02	09/10/88	4.85E+01	09/10/88	1.53E+02
CYANIDE	UG/G	1.00E+00			08/23/88	1.04E+00				
NITRATE	UG/G	1.00E+00			08/23/88	2.28E+01				
SULFATE	UG/G	1.00E+00			08/23/88	2.04E+01	09/10/88	4.70E+00	09/10/88	9.04E+00
FLUORID	UG/G	1.00E+00			08/23/88	3.58E+00			09/10/88	1.42E+00
CHLORID	UG/G	1.00E+00			08/23/88	8.06E+00	09/10/88	1.39E+00	09/10/88	6.30E+00
SULFIDE	UG/G	1.00E+01					09/10/88	2.80E+01	09/10/88	3.00E+01
AMMONIU	UG/G	5.00E-01			08/23/88	4.40E+00	09/10/88	5.00E-01	09/10/88	3.20E+00

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W3SA	SAMPLE DATE	W4DA	SAMPLE DATE	W4SA	SAMPLE DATE	W5DA
BERYLAM	UG/G	5.00E-01	09/10/86	2.00E+00			09/10/86	6.00E-01		
STRONUM	UG/G	3.00E+01	09/10/86	9.40E+01						
ZINC	UG/G	5.00E-01	09/10/86	4.13E+02	09/10/86	1.00E+02	09/10/86	2.14E+02	09/10/86	1.10E+02
CALCIUM	UG/G	5.00E+00	09/10/86	8.38E+03	09/10/86	3.36E+03	09/10/86	4.22E+03	09/10/86	4.04E+03
BARIUM	UG/G	6.00E-01	09/10/86	2.50E+02	09/10/86	6.30E+01	09/10/86	9.70E+01	09/10/86	8.70E+01
CADMIUM	UG/G	2.00E-01	09/10/86	9.00E+00	09/10/86	6.00E+00	09/10/86	8.00E+00	09/10/86	7.00E+00
CHROMIUM	UG/G	1.00E+00	09/10/86	9.20E+01	09/10/86	1.80E+01	09/10/86	5.00E+01	09/10/86	1.40E+01
SILVER	UG/G	1.00E+00	09/10/86	6.20E+01	09/10/86	6.00E+00	09/10/86	2.30E+01	09/10/86	3.00E+00
SODIUM	UG/G	1.00E+01	09/10/86	6.87E+02	09/10/86	1.67E+02	09/10/86	1.97E+02	09/10/86	2.06E+02
NICKEL	UG/G	1.00E+00	09/10/86	1.80E+03	09/10/86	6.20E+01	09/10/86	1.22E+02	09/10/86	5.20E+01
COPPER	UG/G	1.00E+00	09/10/86	2.58E+03	09/10/86	5.06E+02	09/10/86	1.29E+03	09/10/86	5.94E+02
VANADIUM	UG/G	5.00E-01	09/10/86	5.00E+01	09/10/86	2.70E+01	09/10/86	1.18E+02	09/10/86	3.90E+01
ANTIMONY	UG/G	1.00E+01	09/10/86	1.40E+01						
ALUMINUM	UG/G	1.50E+01	09/10/86	1.10E+04	09/10/86	4.22E+03	09/10/86	5.83E+03	09/10/86	4.77E+03
MANGANESE	UG/G	5.00E-01	09/10/86	2.72E+03	09/10/86	1.93E+02	09/10/86	3.16E+02	09/10/86	1.85E+02
POTASSIUM	UG/G	1.00E+01	09/10/86	6.97E+02	09/10/86	3.92E+02	09/10/86	4.76E+02	09/10/86	4.50E+02
IRON	UG/G	5.00E+00	09/10/86	2.63E+04	09/10/86	1.70E+04	09/10/86	2.11E+04	09/10/86	2.09E+04
MERCURY	UG/G	1.00E-01	09/10/86	1.28E+01	09/10/86	8.10E-01	09/10/86	7.44E-01	09/10/86	1.98E-01
MAGNESIUM	UG/G	5.00E+00	09/10/86	3.84E+03	09/10/86	3.08E+03	09/10/86	3.49E+03	09/10/86	3.61E+03
LEAD	UG/G	5.00E-01	09/10/86	9.20E+01	09/10/86	2.00E+01	09/10/86	1.42E+01	09/10/86	9.90E+00
TOX	UG/G	1.00E+00	09/10/86	1.20E+00						
TOC	UG/G	1.00E+01	09/10/86	1.18E+02	09/10/86	5.97E+01	09/10/86	7.89E+01	09/10/86	5.58E+01

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W5LA	SAMPLE DATE	W5SA	SAMPLE DATE	W6DA	SAMPLE DATE	W6SA
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
COLIFRM	MPN	2.20E+00			09/10/88	1.60E+01				
BERYLAM	UG/G	5.00E-01	09/10/88	3.00E+00						
STRONUM	UG/G	3.00E+01	09/10/88	1.75E+02						
ZINC	UG/G	5.00E-01	09/10/88	2.50E+02	09/10/88	1.60E+02	09/10/88	5.30E+01	09/10/88	4.90E+01
CALCIUM	UG/G	5.00E+00	09/10/88	4.79E+03	09/10/88	3.87E+03	09/10/88	4.20E+03	09/10/88	3.81E+03
BARIUM	UG/G	8.00E-01	09/10/88	2.34E+02	09/10/88	7.10E+01	09/10/88	8.00E+01	09/10/88	5.90E+01
CADMIUM	UG/G	2.00E-01			09/10/88	7.00E+00	09/10/88	7.00E+00	09/10/88	8.00E+00
CHROMUM	UG/G	1.00E+00	09/10/88	4.78E+02	09/10/88	3.50E+01	09/10/88	1.50E+01	09/10/88	5.00E+00
SILVER	UG/G	1.00E+00	09/10/88	1.38E+02	09/10/88	1.70E+01				
SODIUM	UG/G	1.00E+01	09/10/88	1.11E+03	09/10/88	1.83E+02	09/10/88	1.82E+02	09/10/88	1.60E+02
NICKEL	UG/G	1.00E+00	09/10/88	1.48E+03	09/10/88	1.28E+02	09/10/88	2.30E+01	09/10/88	1.50E+01
COPPER	UG/G	1.00E+00	09/10/88	4.14E+03	09/10/88	9.25E+02	09/10/88	2.32E+02	09/10/88	1.99E+02
VANADUM	UG/G	5.00E-01			09/10/88	4.20E+01	09/10/88	3.20E+01	09/10/88	3.40E+01
ANTIONY	UG/G	1.00E+01	09/10/88	8.70E+01						
ALUMNUM	UG/G	1.50E+01	09/10/88	1.74E+04	09/10/88	7.58E+03	09/10/88	4.38E+03	09/10/88	4.01E+03
MANGESE	UG/G	5.00E-01	09/10/88	2.92E+02	09/10/88	1.88E+02	09/10/88	2.22E+02	09/10/88	2.08E+02
POTASUM	UG/G	1.00E+01	09/10/88	8.00E+02	09/10/88	5.80E+02	09/10/88	3.70E+02	09/10/88	4.29E+02
IRON	UG/G	5.00E+00	09/10/88	2.22E+04	09/10/88	2.15E+04	09/10/88	2.17E+04	09/10/88	1.96E+04
ARSENIC	UG/G	5.00E-01			09/10/88	5.20E-01				
MERCURY	UG/G	1.00E-01	09/10/88	1.13E+01	09/10/88	2.00E-01	09/10/88	2.01E-01		
MAGNES	UG/G	5.00E+00	09/10/88	2.20E+03	09/10/88	4.23E+03	09/10/88	4.25E+03	09/10/88	3.60E+03
LEADGF	UG/G	5.00E-01	09/10/88	4.40E+02	09/10/88	2.57E+01	09/10/88	1.26E+01	09/10/88	3.80E+00
TOX	UG/G	1.00E+00	09/10/88	4.70E+00						
TOC	UG/G	1.00E+01	09/10/88	2.15E+02	09/10/88	3.93E+01	09/10/88	2.61E+01	09/10/88	1.40E+01
NITRATE	UG/G	1.00E+00			09/10/88	3.23E+00				
SULFATE	UG/G	1.00E+00			09/10/88	2.55E+00				
CHLORID	UG/G	1.00E+00			09/10/88	1.16E+00				
SULFIDE	UG/G	1.00E+01			09/10/88	2.49E+01				

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W7DA	SAMPLE DATE	W7SA	SAMPLE DATE	W8DA	SAMPLE DATE	W8LA
COLIFRM	MPN	2.20E+00	08/25/88	2.10E+02						
BERYLAM	UG/G	5.00E-01							08/25/88	1.00E+00
STRONUM	UG/G	3.00E+01	08/25/88	3.20E+01					08/25/88	9.30E+01
ZINC	UG/G	5.00E-01	08/25/88	7.10E+01	08/25/88	5.30E+01	08/25/88	9.80E+01	08/25/88	3.14E+02
CALCIUM	UG/G	5.00E+00	08/25/88	1.00E+04	08/25/88	3.18E+03	08/25/88	4.83E+03	08/25/88	5.51E+03
BARIUM	UG/G	8.00E-01	08/25/88	1.03E+02	08/25/88	5.30E+01	08/25/88	9.40E+01	08/25/88	2.11E+02
CADMIUM	UG/G	2.00E-01	08/25/88	9.00E+00	08/25/88	8.00E+00	08/25/88	1.00E+01	08/25/88	8.00E+00
CHROMIUM	UG/G	1.00E+00	08/25/88	2.70E+01	08/25/88	1.40E+01	08/25/88	2.50E+01	08/25/88	2.98E+02
SILVER	UG/G	1.00E+00					08/25/88	4.00E+00	08/25/88	1.46E+02
SODIUM	UG/G	1.00E+01	08/25/88	1.89E+02	08/25/88	1.94E+02	08/25/88	2.84E+02	08/25/88	5.43E+02
NICKEL	UG/G	1.00E+00	08/25/88	3.30E+01	08/25/88	5.00E+01	08/25/88	5.80E+01	08/25/88	6.80E+02
COPPER	UG/G	1.00E+00	08/25/88	1.04E+02	08/25/88	2.74E+02	08/25/88	4.25E+02	08/25/88	3.23E+03
VANADIUM	UG/G	5.00E-01	08/25/88	3.70E+01	08/25/88	3.50E+01	08/25/88	8.00E+01	08/25/88	8.00E+01
ANTIMONY	UG/G	1.00E+01							08/25/88	4.10E+01
ALUMINUM	UG/G	1.50E+01	08/25/88	1.85E+04	08/25/88	4.37E+03	08/25/88	5.93E+03	08/25/88	1.29E+04
MANGANESE	UG/G	5.00E-01	08/25/88	4.43E+02	08/25/88	1.98E+02	08/25/88	2.77E+02	08/25/88	3.32E+02
POTASSIUM	UG/G	1.00E+01	08/25/88	1.87E+03	08/25/88	3.88E+02	08/25/88	5.31E+02	08/25/88	1.04E+03
IRON	UG/G	5.00E+00	08/25/88	2.70E+04	08/25/88	1.71E+04	08/25/88	2.74E+04	08/25/88	3.07E+04
ARSENIC	UG/G	5.00E-01	08/25/88	8.20E+00						
MERCURY	UG/G	1.00E-01	08/25/88	2.20E-01	08/25/88	5.30E-01	08/25/88	7.00E-01	08/25/88	1.09E+01
LEAD	UG/G	5.00E-01	08/25/88	1.78E+01	08/25/88	4.40E+00	08/25/88	1.59E+01	08/25/88	1.88E+02
TOX	UG/G	1.00E+00	08/25/88	2.30E+00	08/25/88	1.20E+00	08/25/88	8.60E+00	08/25/88	1.78E+01
TOC	UG/G	1.00E+01	08/25/88	1.49E+01	08/25/88	5.88E+01	08/25/88	9.19E+01	08/25/88	2.73E+02
NITRATE	UG/G	1.00E+00	08/25/88	3.14E+00						
SULFATE	UG/G	1.00E+00	08/25/88	2.07E+00						
CHLORIDE	UG/G	1.00E+00	08/25/88	3.32E+00						

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W8SA	SAMPLE DATE	W9DA	SAMPLE DATE	W9LA	SAMPLE DATE	W9SA
BERYLAM	UG/G	5.00E-01					08/18/88	1.00E+00		
STRONUM	UG/G	3.00E+01					08/18/88	4.80E+01		
ZINC	UG/G	5.00E-01	08/25/88	1.34E+02	08/18/88	8.00E+01	08/18/88	2.91E+02	08/18/88	1.20E+02
CALCIUM	UG/G	5.00E+00	08/25/88	4.61E+03	08/18/88	5.38E+03	08/18/88	8.93E+03	08/18/88	3.95E+03
BARIUM	UG/G	8.00E-01	08/25/88	1.02E+02	08/18/88	8.00E+01	08/18/88	1.76E+02	08/18/88	7.40E+01
CADMIUM	UG/G	2.00E-01	08/25/88	1.10E+01	08/18/88	9.00E+00	08/18/88	1.00E+01	08/18/88	9.00E+00
CHROMIUM	UG/G	1.00E+00	08/25/88	2.90E+01	08/18/88	1.00E+01	08/18/88	1.30E+02	08/18/88	1.70E+01
SILVER	UG/G	1.00E+00	08/25/88	9.00E+00			08/18/88	1.14E+02	08/18/88	8.00E+00
SODIUM	UG/G	1.00E+01	08/25/88	2.78E+02	08/18/88	2.31E+02	08/18/88	3.09E+02	08/18/88	2.29E+02
NICKEL	UG/G	1.00E+00	08/25/88	8.50E+01	08/18/88	1.80E+01	08/18/88	1.43E+02	08/18/88	4.70E+01
COPPER	UG/G	1.00E+00	08/25/88	5.21E+02	08/18/88	2.40E+02	08/18/88	1.81E+03	08/18/88	5.68E+02
VANADIUM	UG/G	5.00E-01	08/25/88	7.30E+01	08/18/88	4.70E+01	08/18/88	9.80E+01	08/18/88	5.00E+01
ANTHONY	UG/G	1.00E+01	08/25/88	1.30E+01						
ALUMINUM	UG/G	1.50E+01	08/25/88	8.30E+03	08/18/88	5.40E+03	08/18/88	9.91E+03	08/18/88	5.27E+03
MANGANESE	UG/G	5.00E-01	08/25/88	3.01E+02	08/18/88	3.08E+02	08/18/88	2.83E+02	08/18/88	2.58E+02
POTASSIUM	UG/G	1.00E+01	08/25/88	5.48E+02	08/18/88	5.15E+02	08/18/88	9.78E+02	08/18/88	5.51E+02
IRON	UG/G	5.00E+00	08/25/88	2.70E+04	08/18/88	2.49E+04	08/18/88	2.75E+04	08/18/88	1.99E+04
MERCURY	UG/G	1.00E-01	08/25/88	1.28E+00	08/18/88	1.73E-01	08/18/88	5.14E+00	08/18/88	3.38E-01
LEAD	UG/G	5.00E-01	08/25/88	1.51E+01	08/18/88	5.88E+00	08/18/88	1.43E+02	08/18/88	1.30E+01
TOX	UG/G	1.00E+00	08/25/88	2.20E+00	08/18/88	1.50E+00	08/18/88	5.05E+00	08/18/88	1.00E+00
TOC	UG/G	1.00E+01	08/25/88	1.12E+02	08/18/88	5.53E+01	08/18/88	1.54E+02	08/18/88	1.08E+02

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W10DA	SAMPLE DATE	W10LA	SAMPLE DATE	W10SA	SAMPLE DATE	W11DA
BERYLAM	UG/G	5.00E-01	08/18/88	1.00E+00	08/18/88	2.00E+00	08/18/88	2.00E+00		
STRONUM	UG/G	3.00E+01			08/18/88	8.70E+01	08/18/88	8.30E+01		
ZINC	UG/G	5.00E-01	08/18/88	9.80E+01	08/18/88	4.08E+02	08/18/88	4.09E+02	08/18/88	1.30E+02
CALCIUM	UG/G	5.00E+00	08/18/88	5.48E+03	08/18/88	5.84E+03	08/18/88	5.74E+03	08/18/88	5.24E+03
BARIUM	UG/G	8.00E-01	08/18/88	9.30E+01	08/18/88	2.05E+02	08/18/88	2.04E+02	08/18/88	9.60E+01
CADMIUM	UG/G	2.00E-01	08/18/88	7.00E+00	08/18/88	8.00E+00	08/18/88	8.00E+00	08/18/88	9.00E+00
CHROMUM	UG/G	1.00E+00	08/18/88	2.80E+01	08/18/88	3.24E+02	08/18/88	3.19E+02	08/18/88	2.20E+01
SILVER	UG/G	1.00E+00	08/18/88	7.00E+00	08/18/88	2.13E+02	08/18/88	2.18E+02	08/18/88	9.00E+00
SODIUM	UG/G	1.00E+01	08/18/88	2.47E+02	08/18/88	4.90E+02	08/18/88	4.79E+02	08/18/88	2.55E+02
NICKEL	UG/G	1.00E+00	08/18/88	4.80E+01	08/18/88	7.52E+02	08/18/88	8.90E+02	08/18/88	5.90E+01
COPPER	UG/G	1.00E+00	08/18/88	3.08E+02	08/18/88	3.13E+03	08/18/88	3.13E+03	08/18/88	2.99E+02
VANADUM	UG/G	5.00E-01	08/18/88	3.70E+01	08/18/88	1.30E+01	08/18/88	1.50E+01	08/18/88	3.80E+01
ANTIONY	UG/G	1.00E+01			08/18/88	2.80E+01	08/18/88	2.80E+01		
ALUMNUM	UG/G	1.50E+01	08/18/88	9.00E+03	08/18/88	1.81E+04	08/18/88	1.57E+04	08/18/88	8.84E+03
MANGESE	UG/G	5.00E-01	08/18/88	2.80E+02	08/18/88	2.51E+02	08/18/88	2.38E+02	08/18/88	2.91E+02
POTASUM	UG/G	1.00E+01	08/18/88	1.22E+03	08/18/88	1.70E+03	08/18/88	1.82E+03	08/18/88	7.58E+02
IRON	UG/G	5.00E+00	08/18/88	2.10E+04	08/18/88	3.04E+04	08/18/88	3.04E+04	08/18/88	2.33E+04
ARSENIC	UG/G	5.00E-01					08/18/88	4.00E+00		
MERCURY	UG/G	1.00E-01	08/18/88	8.49E-01	08/18/88	5.74E+00	08/18/88	1.80E-01	08/18/88	5.13E-01
LEADGF	UG/G	5.00E-01	08/18/88	2.51E+01	08/18/88	2.48E+02	08/18/88	6.19E+00	08/18/88	1.94E+01
TOX	UG/G	1.00E+00			08/18/88	2.85E+00				
TOC	UG/G	1.00E+01	08/18/88	1.03E+02	08/18/88	4.12E+02	08/18/88	3.97E+01	08/18/88	1.38E+02
NITRATE	UG/G	1.00E+00					08/18/88	2.50E+00		
SULFATE	UG/G	1.00E+00					08/18/88	1.80E+00		
AMMONIU	UG/G	5.00E-01					08/18/88	1.30E+00		

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W11SA	SAMPLE DATE	W12DA	SAMPLE DATE	W12LA	SAMPLE DATE	W12SA
BERYLAM	UG/G	5.00E-01					06/18/88	2.00E+00		
STRONUM	UG/G	3.00E+01					06/18/88	5.90E+01		
ZINC	UG/G	5.00E-01	06/18/88	2.51E+02	06/18/88	9.80E+01	06/18/88	2.74E+02	06/18/88	1.01E+02
CALCIUM	UG/G	5.00E+00	06/18/88	4.41E+03	06/18/88	5.67E+03	06/18/88	4.87E+03	06/18/88	4.86E+03
BARIUM	UG/G	8.00E-01	06/18/88	9.80E+01	06/18/88	9.10E+01	06/18/88	1.56E+02	06/18/88	8.60E+01
CADMIUM	UG/G	2.00E-01	06/18/88	1.00E+01	06/18/88	9.00E+00	06/18/88	4.00E+00	06/18/88	9.00E+00
CHROMUM	UG/G	1.00E+00	06/18/88	6.40E+01	06/18/88	2.10E+01	06/18/88	2.36E+02	06/18/88	1.30E+01
SILVER	UG/G	1.00E+00	06/18/88	4.20E+01	06/18/88	5.00E+00	06/18/88	1.58E+02	06/18/88	2.00E+00
SODIUM	UG/G	1.00E+01	06/18/88	2.57E+02	06/18/88	2.42E+02	06/18/88	3.04E+02	06/18/88	2.01E+02
NICKEL	UG/G	1.00E+00	06/18/88	1.60E+02	06/18/88	3.50E+01	06/18/88	3.85E+02	06/18/88	2.60E+01
COPPER	UG/G	1.00E+00	06/18/88	8.03E+02	06/18/88	2.64E+02	06/18/88	2.39E+03	06/18/88	2.71E+02
VANADUM	UG/G	5.00E-01	06/18/88	4.70E+01	06/18/88	4.30E+01	06/18/88	1.40E+01	06/18/88	3.80E+01
ANTIONY	UG/G	1.00E+01					06/18/88	1.70E+01		
ALUMNUM	UG/G	1.50E+01	06/18/88	8.84E+03	06/18/88	8.90E+03	06/18/88	1.13E+04	06/18/88	8.47E+03
MANGESE	UG/G	5.00E-01	06/18/88	2.58E+02	06/18/88	3.14E+02	06/18/88	1.68E+02	06/18/88	3.07E+02
POTASUM	UG/G	1.00E+01	06/18/88	8.35E+02	06/18/88	8.77E+02	06/18/88	9.69E+02	06/18/88	8.68E+02
IRON	UG/G	5.00E+00	06/18/88	2.30E+04	06/18/88	2.38E+04	06/18/88	2.13E+04	06/18/88	2.28E+04
MERCURY	UG/G	1.00E-01	06/18/88	1.25E+00	06/18/88	4.72E-01	06/18/88	1.26E+01	06/18/88	3.39E-01
LEADGF	UG/G	5.00E-01	06/18/88	4.25E+01	06/18/88	1.43E+01	06/18/88	1.12E+02	06/18/88	9.10E+00
TOX	UG/G	1.00E+00	06/18/88	2.50E+00	06/18/88	2.00E+00	06/18/88	1.45E+01		
TOC	UG/G	1.00E+01	06/18/88	2.45E+02	06/18/88	1.22E+02	06/18/88	1.92E+02	06/18/88	8.19E+01

TABLE F.1. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	W17SA
ZINC	UG/G	5.00E-01	08/18/88	1.92E+02
CALCIUM	UG/G	5.00E+00	08/18/88	5.39E+03
BARIUM	UG/G	8.00E-01	08/18/88	9.00E+01
CADMIUM	UG/G	2.00E-01	08/18/88	1.00E+01
CHROMIUM	UG/G	1.00E+00	08/18/88	1.80E+01
SILVER	UG/G	1.00E+00	08/18/88	4.00E+00
SODIUM	UG/G	1.00E+01	08/18/88	2.50E+02
NICKEL	UG/G	1.00E+00	08/18/88	4.40E+01
COPPER	UG/G	1.00E+00	08/18/88	2.32E+02
VANADIUM	UG/G	5.00E-01	08/18/88	4.50E+01
ALUMINUM	UG/G	1.50E+01	08/18/88	7.70E+03
MANGANESE	UG/G	5.00E-01	08/18/88	2.74E+02
POTASSIUM	UG/G	1.00E+01	08/18/88	7.68E+02
IRON	UG/G	5.00E+00	08/18/88	2.80E+04
MERCURY	UG/G	1.00E-01	08/18/88	5.15E-01
LEADGF	UG/G	5.00E-01	08/18/88	1.31E+01
TOC	UG/G	1.00E+01	08/18/88	1.31E+02

TABLE F.2. Soil Sample Analytical Results Above Detection Limit

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	1A5	SAMPLE DATE	1A10	SAMPLE DATE	1A15	SAMPLE DATE	1A20
COLIFRM	MPN	3.00E+00	04/24/88	9.00E+00						
STRONUM	UG/G	3.00E+01	04/24/88	3.10E+01						
ZINC	UG/G	5.00E-01	04/24/88	4.40E+01	04/25/88	4.40E+01	04/29/88	4.00E+01	04/30/88	3.30E+01
CALCIUM	UG/G	5.00E+00	04/24/88	6.71E+03	04/25/88	6.28E+03	04/29/88	6.82E+03	04/30/88	4.98E+03
BARIUM	UG/G	6.00E-01	04/24/88	9.80E+01	04/25/88	8.80E+01	04/29/88	8.90E+01	04/30/88	7.00E+01
CADMIUM	UG/G	2.00E-01	04/24/88	5.00E-01	04/25/88	6.00E+00	04/29/88	5.00E+00	04/30/88	4.00E+00
CHROMIUM	UG/G	1.00E+00	04/24/88	1.00E+01	04/25/88	8.00E+00	04/29/88	7.00E+00	04/30/88	4.00E+00
SODIUM	UG/G	1.00E+01	04/24/88	7.47E+02	04/25/88	6.22E+02	04/29/88	5.35E+02	04/30/88	3.83E+02
NICKEL	UG/G	1.00E+00	04/24/88	6.00E+00	04/25/88	5.00E+00	04/29/88	5.00E+00	04/30/88	2.00E+00
COPPER	UG/G	1.00E+00	04/24/88	1.50E+01	04/25/88	1.80E+01	04/29/88	1.40E+01	04/30/88	1.20E+01
VANADUM	UG/G	5.00E-01	04/24/88	6.90E+01	04/25/88	7.00E+01	04/29/88	6.00E+01	04/30/88	4.80E+01
ALUMNUM	UG/G	1.50E+01	04/24/88	8.24E+03	04/25/88	6.99E+03	04/29/88	8.47E+03	04/30/88	4.65E+03
MANGESE	UG/G	5.00E-01	04/24/88	3.02E+02	04/25/88	3.10E+02	04/29/88	3.12E+02	04/30/88	2.44E+02
POTASUM	UG/G	1.00E+01	04/24/88	1.02E+03	04/25/88	8.92E+02	04/29/88	9.48E+02	04/30/88	5.62E+02
IRON	UG/G	5.00E+00	04/24/88	2.54E+04	04/25/88	2.49E+04	04/29/88	2.27E+04	04/30/88	1.95E+04
ARSENIC	UG/G	5.00E-01	04/24/88	2.80E+00						
LEADGF	UG/G	5.00E-01	04/24/88	3.09E+00	04/25/88	3.38E+00	04/29/88	3.58E+00	04/30/88	2.51E+00
TOX	UG/G	1.00E+00	04/24/88	4.95E+00						
TOC	UG/G	1.00E+01	04/24/88	2.50E+01	04/25/88	2.24E+01	04/29/88	2.33E+01		
SULFATE	UG/G	1.00E+00	04/24/88	9.86E+00						
FLUORID	UG/G	1.00E+00	04/24/88	2.02E+00						
CHLORID	UG/G	1.00E+00	04/24/88	8.43E+00						
AMMONIU	UG/G	5.00E-01	04/24/88	1.50E+00						

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	1A25	SAMPLE DATE	1A30	SAMPLE DATE	1A35	SAMPLE DATE	1A40
BERYLAM	UG/G	5.00E-01	04/30/88	4.00E+00	04/30/88	2.00E+00	04/30/88	4.00E+00	05/01/88	4.00E+00
ZINC	UG/G	5.00E-01	04/30/88	3.20E+01	04/30/88	3.80E+01	04/30/88	3.30E+01	05/01/88	2.90E+01
CALCIUM	UG/G	5.00E+00	04/30/88	5.03E+03	04/30/88	5.79E+03	04/30/88	5.14E+03	05/01/88	3.47E+03
BARIUM	UG/G	8.00E-01	04/30/88	8.90E+01	04/30/88	9.00E+01	04/30/88	8.30E+01	05/01/88	5.70E+01
CADMIUM	UG/G	2.00E-01	04/30/88	4.00E+00	04/30/88	5.00E+00	04/30/88	5.00E+00	05/01/88	4.00E+00
CHROMIUM	UG/G	1.00E+00	04/30/88	5.00E+00	04/30/88	6.00E+00	04/30/88	4.00E+00	05/01/88	5.00E+00
SODIUM	UG/G	1.00E+01	04/30/88	8.33E+02	04/30/88	5.90E+02	04/30/88	4.44E+02	05/01/88	1.81E+02
NICKEL	UG/G	1.00E+00	04/30/88	3.00E+00	04/30/88	4.00E+00	04/30/88	3.00E+00	05/01/88	2.00E+00
COPPER	UG/G	1.00E+00	04/30/88	1.20E+01	04/30/88	1.80E+01	04/30/88	1.40E+01	05/01/88	8.00E+00
VANADIUM	UG/G	5.00E-01	04/30/88	4.60E+01	04/30/88	5.70E+01	04/30/88	5.40E+01	05/01/88	8.60E+01
ALUMINUM	UG/G	1.50E+01	04/30/88	5.53E+03	04/30/88	5.89E+03	04/30/88	4.86E+03	05/01/88	4.28E+03
MANGANESE	UG/G	5.00E-01	04/30/88	2.01E+02	04/30/88	2.49E+02	04/30/88	2.35E+02	05/01/88	1.87E+02
POTASSIUM	UG/G	1.00E+01	04/30/88	5.83E+02	04/30/88	7.14E+02	04/30/88	4.34E+02	05/01/88	6.12E+02
IRON	UG/G	5.00E+00	04/30/88	8.61E+03	04/30/88	2.31E+04	04/30/88	2.10E+04	05/01/88	1.62E+04
LEAD	UG/G	5.00E-01	04/30/88	2.11E+00	04/30/88	2.69E+00	04/30/88	2.99E+00	05/01/88	2.87E+00
TOX	UG/G	1.00E+00			04/30/88	5.05E+00	04/30/88	2.50E+00	05/01/88	7.15E+00

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	2A5	SAMPLE DATE	2A10	SAMPLE DATE	2A15	SAMPLE DATE	2A20
COLIFRM	MPN	3.00E+00			05/02/88	1.10E+03				
BERYLAM	UG/G	5.00E-01			05/02/88	5.50E-01	05/05/88	6.00E-01		
ZINC	UG/G	5.00E-01	05/01/88	3.60E+01	05/02/88	4.00E+00	05/05/88	4.90E+01	05/05/88	4.80E+01
CALCIUM	UG/G	5.00E+00	05/01/88	7.55E+03	05/02/88	8.50E+03	05/05/88	7.96E+03	05/05/88	5.87E+03
BARIUM	UG/G	6.00E-01	05/01/88	8.40E+01	05/02/88	8.40E+01	05/05/88	8.50E+01	05/05/88	7.90E+01
CADMIUM	UG/G	2.00E-01	05/01/88	5.00E+00	05/02/88	5.00E+00	05/05/88	6.00E+00	05/05/88	6.00E+00
CHROMIUM	UG/G	1.00E+00	05/01/88	8.00E+00	05/02/88	7.00E+00	05/05/88	8.00E+00	05/05/88	5.00E+00
SODIUM	UG/G	1.00E+01	05/01/88	4.79E+02	05/02/88	3.93E+02	05/05/88	4.80E+02	05/05/88	3.95E+02
NICKEL	UG/G	1.00E+00	05/01/88	6.00E+00	05/02/88	5.00E+00	05/05/88	1.10E+01	05/05/88	5.00E+00
COPPER	UG/G	1.00E+00	05/01/88	1.30E+01	05/02/88	1.60E+01	05/05/88	4.10E+01	05/05/88	2.20E+01
VANADIUM	UG/G	5.00E-01	05/01/88	5.10E+01	05/02/88	4.80E+01	05/05/88	5.40E+01	05/05/88	5.20E+01
ALUMINUM	UG/G	1.50E+01	05/01/88	6.77E+03	05/02/88	5.66E+03	05/05/88	5.90E+03	05/05/88	4.55E+03
MANGANESE	UG/G	5.00E-01	05/01/88	2.79E+02	05/02/88	2.69E+02	05/05/88	2.75E+02	05/05/88	2.47E+02
POTASSIUM	UG/G	1.00E+01	05/01/88	1.03E+03	05/02/88	9.17E+02	05/05/88	8.38E+02	05/05/88	5.80E+02
IRON	UG/G	5.00E+00	05/01/88	2.02E+04	05/02/88	2.04E+04	05/05/88	2.12E+04	05/05/88	1.99E+04
ARSENIC	UG/G	5.00E-01			05/02/88	2.18E+00				
LEAD	UG/G	5.00E-01	05/01/88	2.87E+00	05/02/88	2.30E+00	05/05/88	3.00E+00	05/05/88	2.41E+00
TOX	UG/G	1.00E+00	05/01/88	3.15E+00	05/02/88	2.90E+00	05/05/88	3.50E+00		
TOC	UG/G	1.00E+01			05/02/88	1.05E+01	05/05/88	2.17E+01		
NITRATE	UG/G	1.00E+00			05/02/88	1.56E+00				
SULFATE	UG/G	1.00E+00			05/02/88	1.08E+01				
CHLORIDE	UG/G	1.00E+00			05/02/88	1.12E+00				
AMMONIUM	UG/G	5.00E-01			05/02/88	2.42E+00				

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	2A25	SAMPLE DATE	2A30	SAMPLE DATE	2A35	SAMPLE DATE	2A40
BERYLAM	UG/G	5.00E-01	05/05/88	5.70E-01						
ZINC	UG/G	5.00E-01	05/05/88	4.20E+01	05/05/88	4.80E+01	05/08/88	3.80E+01	05/08/88	3.70E+01
CALCIUM	UG/G	5.00E+00	05/05/88	8.15E+03	05/05/88	8.43E+03	05/08/88	8.56E+03	05/08/88	5.95E+03
BARIUM	UG/G	8.00E-01	05/05/88	8.30E+01	05/05/88	9.00E+01	05/08/88	8.10E+01	05/08/88	7.70E+01
CADMIUM	UG/G	2.00E-01	05/05/88	8.00E+00	05/05/88	8.00E+00	05/08/88	8.00E+00	05/08/88	8.00E+00
CHROMIUM	UG/G	1.00E+00	05/05/88	8.00E+00	05/05/88	8.00E+00	05/08/88	5.00E+00	05/08/88	4.00E+00
SODIUM	UG/G	1.00E+01	05/05/88	4.04E+02	05/05/88	5.46E+02	05/08/88	3.74E+02	05/08/88	4.56E+02
NICKEL	UG/G	1.00E+00	05/05/88	5.00E+00	05/05/88	5.00E+00	05/08/88	5.00E+00	05/08/88	4.00E+00
COPPER	UG/G	1.00E+00	05/05/88	2.10E+01	05/05/88	3.10E+01	05/08/88	1.80E+01	05/08/88	1.80E+01
VANADIUM	UG/G	5.00E-01	05/05/88	5.30E+01	05/05/88	8.80E+01	05/08/88	8.10E+01	05/08/88	8.10E+01
ALUMINUM	UG/G	1.50E+01	05/05/88	4.81E+03	05/05/88	8.12E+03	05/08/88	4.58E+03	05/08/88	5.11E+03
MANGANESE	UG/G	5.00E-01	05/05/88	3.04E+02	05/05/88	2.99E+02	05/08/88	3.00E+02	05/08/88	2.74E+02
POTASSIUM	UG/G	1.00E+01	05/05/88	4.90E+02	05/05/88	8.45E+02	05/08/88	5.05E+02	05/08/88	8.13E+02
IRON	UG/G	5.00E+00	05/05/88	2.37E+04	05/05/88	2.44E+04	05/08/88	2.49E+04	05/08/88	2.24E+04
LEAD	UG/G	5.00E-01	05/05/88	2.25E+00	05/05/88	3.31E+00	05/08/88	1.55E+00	05/08/88	2.59E+00

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	3A5	SAMPLE DATE	3A10	SAMPLE DATE	3A15	SAMPLE DATE	3A20
ZINC	UG/G	5.00E-01	05/07/88	3.80E+01	05/08/88	3.80E+01	05/08/88	3.80E+01	05/09/88	4.30E+01
CALCIUM	UG/G	5.00E+00	05/07/88	8.46E+03	05/08/88	8.43E+03	05/08/88	5.53E+03	05/09/88	7.45E+03
BARIUM	UG/G	6.00E-01	05/07/88	8.10E+01	05/08/88	8.80E+01	05/08/88	7.20E+01	05/09/88	1.06E+02
CADMIUM	UG/G	2.00E-01	05/07/88	5.00E+00	05/08/88	5.00E+00	05/08/88	8.00E+00	05/09/88	5.00E+00
CHROMIUM	UG/G	1.00E+00	05/07/88	7.00E+00	05/08/88	7.00E+00	05/08/88	8.00E+00	05/09/88	8.00E+00
SODIUM	UG/G	1.00E+01	05/07/88	3.09E+02	05/08/88	4.25E+02	05/08/88	4.87E+02	05/09/88	4.98E+02
NICKEL	UG/G	1.00E+00	05/07/88	6.00E+00	05/08/88	8.00E+00	05/08/88	5.00E+00	05/09/88	5.00E+00
COPPER	UG/G	1.00E+00	05/07/88	2.10E+01	05/08/88	1.80E+01	05/08/88	1.50E+01	05/09/88	1.70E+01
VANADIUM	UG/G	5.00E-01	05/07/88	4.70E+01	05/08/88	5.00E+01	05/08/88	5.50E+01	05/09/88	6.60E+01
ALUMINUM	UG/G	1.50E+01	05/07/88	8.18E+03	05/08/88	8.18E+03	05/08/88	5.68E+03	05/09/88	8.87E+03
MANGANESE	UG/G	5.00E-01	05/07/88	2.48E+02	05/08/88	2.74E+02	05/08/88	2.53E+02	05/09/88	3.13E+02
POTASSIUM	UG/G	1.00E+01	05/07/88	1.03E+03	05/08/88	9.14E+02	05/08/88	7.54E+02	05/09/88	8.80E+02
IRON	UG/G	5.00E+00	05/07/88	2.03E+04	05/08/88	2.11E+04	05/08/88	2.09E+04	05/09/88	2.48E+04
ARSENIC	UG/G	5.00E-01					05/08/88	4.65E+00		
LEAD	UG/G	5.00E-01	05/07/88	5.99E+00	05/08/88	5.10E+00	05/08/88	4.23E+00	05/09/88	5.25E+00
TOX	UG/G	1.00E+00	05/07/88	5.65E+00	05/08/88	3.50E+00	05/08/88	2.80E+00	05/09/88	2.25E+00
TOC	UG/G	1.00E+01	05/07/88	4.37E+01	05/08/88	2.30E+01	05/08/88	1.04E+01	05/09/88	1.55E+01
NITRATE	UG/G	1.00E+00					05/08/88	1.05E+00		
SULFATE	UG/G	1.00E+00					05/08/88	2.12E+01		
FLUORIDE	UG/G	1.00E+00					05/08/88	1.22E+00		
CHLORIDE	UG/G	1.00E+00					05/08/88	2.04E+00		
AMMONIUM	UG/G	5.00E-01					05/08/88	2.08E+00		

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	3A25	SAMPLE DATE	3A30	SAMPLE DATE	3A35	SAMPLE DATE	3A40
ZINC	UG/G	5.00E-01	05/09/88	4.20E+01	05/09/88	4.10E+01	05/09/88	3.90E+01	05/09/88	4.70E+01
CALCIUM	UG/G	5.00E+00	05/09/88	6.39E+03	05/09/88	5.03E+03	05/09/88	5.08E+03	05/09/88	7.21E+03
BARIUM	UG/G	6.00E-01	05/09/88	9.70E+01	05/09/88	8.20E+01	05/09/88	6.90E+01	05/09/88	9.50E+01
CADMIUM	UG/G	2.00E-01	05/09/88	6.00E+00	05/09/88	5.00E+00	05/09/88	6.00E+00	05/09/88	6.00E+00
CHROMIUM	UG/G	1.00E+00	05/09/88	6.00E+00	05/09/88	6.00E+00	05/09/88	7.00E+00	05/09/88	7.00E+00
SODIUM	UG/G	1.00E+01	05/09/88	4.32E+02	05/09/88	3.22E+02	05/09/88	2.53E+02	05/09/88	5.52E+02
NICKEL	UG/G	1.00E+00	05/09/88	5.00E+00	05/09/88	4.00E+00	05/09/88	4.00E+00	05/09/88	4.00E+00
COPPER	UG/G	1.00E+00	05/09/88	1.50E+01	05/09/88	2.10E+01	05/09/88	1.80E+01	05/09/88	1.80E+01
VANADIUM	UG/G	5.00E-01	05/09/88	6.70E+01	05/09/88	6.50E+01	05/09/88	6.30E+01	05/09/88	8.30E+01
ALUMINUM	UG/G	1.50E+01	05/09/88	5.58E+03	05/09/88	4.23E+03	05/09/88	4.34E+03	05/09/88	6.84E+03
MANGANESE	UG/G	5.00E-01	05/09/88	2.98E+02	05/09/88	2.40E+01	05/09/88	2.64E+02	05/09/88	3.14E+02
POTASSIUM	UG/G	1.00E+01	05/09/88	6.83E+02	05/09/88	5.06E+02	05/09/88	2.70E+02	05/09/88	7.19E+02
IRON	UG/G	5.00E+00	05/09/88	2.71E+04	05/09/88	2.54E+04	05/09/88	2.56E+04	05/09/88	2.74E+04
LEAD	UG/G	5.00E-01	05/09/88	4.70E+00	05/09/88	4.46E+00	05/09/88	4.37E+00	05/09/88	5.57E+00
TOX	UG/G	1.00E+00	05/09/88	4.40E+00			05/09/88	3.10E+00		
TOC	UG/G	1.00E+01	05/09/88	1.05E+01						

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	4A5	SAMPLE DATE	4A10	SAMPLE DATE	4A15	SAMPLE DATE	4A20
ZINC	UG/G	5.00E-01	05/12/88	3.70E+01	05/13/88	3.50E+01	05/13/88	4.60E+01	05/14/88	4.60E+01
CALCIUM	UG/G	5.00E+00	05/12/88	8.20E+03	05/13/88	5.09E+03	05/13/88	5.32E+03	05/14/88	5.76E+03
BARIUM	UG/G	8.00E-01	05/12/88	9.90E+01	05/13/88	8.00E+01	05/13/88	9.00E+01	05/14/88	9.00E+01
CADMIUM	UG/G	2.00E-01	05/12/88	5.00E+00	05/13/88	5.00E+00	05/13/88	5.00E+00	05/14/88	8.00E+00
CHROMIUM	UG/G	1.00E+00	05/12/88	7.00E+00	05/13/88	5.00E+00	05/13/88	9.00E+00	05/14/88	7.00E+00
SODIUM	UG/G	1.00E+01	05/12/88	4.93E+02	05/13/88	3.83E+02	05/13/88	5.13E+02	05/14/88	5.19E+02
NICKEL	UG/G	1.00E+00	05/12/88	8.00E+00	05/13/88	5.00E+00	05/13/88	8.00E+00	05/14/88	7.00E+00
COPPER	UG/G	1.00E+00	05/12/88	1.50E+01	05/13/88	1.40E+01	05/13/88	4.20E+01	05/14/88	3.70E+01
VANADIUM	UG/G	5.00E-01	05/12/88	5.30E+01	05/13/88	4.90E+01	05/13/88	5.80E+01	05/14/88	8.20E+01
ALUMINUM	UG/G	1.50E+01	05/12/88	7.13E+03	05/13/88	5.51E+03	05/13/88	5.62E+03	05/14/88	6.13E+03
MANGANESE	UG/G	5.00E-01	05/12/88	2.77E+02	05/13/88	2.47E+02	05/13/88	2.75E+02	05/14/88	2.97E+02
POTASSIUM	UG/G	1.00E+01	05/12/88	8.85E+02	05/13/88	7.32E+02	05/13/88	7.90E+02	05/14/88	7.72E+02
IRON	UG/G	5.00E+00	05/12/88	2.21E+04	05/13/88	2.07E+04	05/13/88	2.33E+04	05/14/88	2.85E+04
MERCURY	UG/G	1.00E-01					05/13/88	1.08E-01	05/14/88	1.10E-01
LEAD	UG/G	5.00E-01	05/12/88	3.31E+00	05/13/88	3.40E+00	05/13/88	3.80E+00	05/14/88	4.78E+00
TOX	UG/G	1.00E+00	05/12/88	5.90E+00			05/13/88	7.20E+00	05/14/88	4.70E+00
TOC	UG/G	1.00E+01							05/14/88	1.44E+01

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	4A25	SAMPLE DATE	4A30	SAMPLE DATE	4A35	SAMPLE DATE	4A40
COLIFRM	MPN	3.00E+00							05/14/88	7.00E+00
ZINC	UG/G	6.00E-01	05/14/88	3.20E+01	05/14/88	4.30E+01	05/14/88	3.60E+01	05/14/88	4.40E+01
CALCIUM	UG/G	6.00E+00	05/14/88	4.30E+03	05/14/88	5.53E+03	05/14/88	4.84E+03	05/14/88	5.84E+03
BARIUM	UG/G	6.00E-01	05/14/88	6.40E+01	05/14/88	1.04E+02	05/14/88	7.80E+01	05/14/88	9.30E+01
CADMIUM	UG/G	2.00E-01	05/14/88	5.00E+00	05/14/88	8.00E+00	05/14/88	8.00E+00	05/14/88	8.00E+00
CHROMIUM	UG/G	1.00E+00	05/14/88	5.00E+00	05/14/88	7.00E+00	05/14/88	8.00E+00	05/14/88	8.00E+00
SODIUM	UG/G	1.00E+01	05/14/88	2.75E+02	05/14/88	6.24E+02	05/14/88	4.04E+02	05/14/88	4.45E+02
NICKEL	UG/G	1.00E+00	05/14/88	5.00E+00	05/14/88	5.00E+00	05/14/88	3.00E+00	05/14/88	4.00E+00
COPPER	UG/G	1.00E+00	05/14/88	1.90E+01	05/14/88	2.10E+01	05/14/88	1.60E+01	05/14/88	1.80E+01
VANADIUM	UG/G	5.00E-01	05/14/88	4.80E+01	05/14/88	6.70E+01	05/14/88	6.00E+01	05/14/88	8.80E+01
ALUMINUM	UG/G	1.50E+01	05/14/88	4.02E+03	05/14/88	6.80E+03	05/14/88	4.98E+03	05/14/88	7.73E+03
MANGANESE	UG/G	5.00E-01	05/14/88	2.41E+02	05/14/88	3.12E+02	05/14/88	2.69E+02	05/14/88	2.92E+02
POTASSIUM	UG/G	1.00E+01	05/14/88	4.49E+02	05/14/88	7.84E+02	05/14/88	5.67E+02	05/14/88	8.51E+02
IRON	UG/G	5.00E+00	05/14/88	2.31E+04	05/14/88	2.86E+04	05/14/88	2.84E+04	05/14/88	2.80E+04
ARSENIC	UG/G	5.00E-01	05/14/88	2.10E+00					05/14/88	4.51E+00
LEAD	UG/G	5.00E-01	05/14/88	2.83E+00	05/14/88	4.04E+00	05/14/88	3.14E+00	05/14/88	4.17E+00
TOX	UG/G	1.00E+00	05/14/88	4.40E+00	05/14/88	4.00E+00	05/14/88	2.80E+00	05/14/88	3.90E+00
SULFATE	UG/G	1.00E+00	05/14/88	9.87E+00					05/14/88	1.67E+01
FLUORIDE	UG/G	1.00E+00							05/14/88	1.25E+00
CHLORIDE	UG/G	1.00E+00							05/14/88	1.08E+01
AMMONIUM	UG/G	5.00E-01	05/14/88	6.00E+00					05/14/88	1.50E+01
NITROGEN	UG/G	0.00E+00							05/14/88	2.50E+00

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	5A5	SAMPLE DATE	5A10	SAMPLE DATE	5A15	SAMPLE DATE	5A20
BERYLAM	UG/G	5.00E-01	05/15/88	8.00E-01	05/16/88	8.00E-01	05/19/88	8.00E-01		
ZINC	UG/G	5.00E-01	05/15/88	4.20E+01	05/16/88	4.00E+01	05/19/88	5.00E+01	05/19/88	4.30E+01
CALCIUM	UG/G	5.00E+00	05/15/88	8.83E+03	05/16/88	8.09E+03	05/19/88	7.57E+03	05/19/88	7.23E+03
BARIUM	UG/G	8.00E-01	05/15/88	1.07E+02	05/16/88	7.90E+01	05/19/88	8.00E+01	05/19/88	9.20E+01
CADMIUM	UG/G	2.00E-01	05/15/88	8.00E+00	05/16/88	8.00E+00	05/19/88	8.00E+00	05/19/88	8.00E+00
CHROMIUM	UG/G	1.00E+00			05/16/88	7.00E+00	05/19/88	1.00E+01	05/19/88	5.00E+00
SODIUM	UG/G	1.00E+01	05/15/88	5.76E+02	05/16/88	8.12E+02	05/19/88	5.54E+02	05/19/88	5.92E+02
NICKEL	UG/G	1.00E+00	05/15/88	7.00E+00	05/16/88	8.00E+00	05/19/88	7.00E+00	05/19/88	4.00E+00
COPPER	UG/G	1.00E+00	05/15/88	1.80E+01	05/16/88	1.70E+01	05/19/88	1.80E+01	05/19/88	1.70E+01
VANADIUM	UG/G	5.00E-01	05/15/88	8.80E+01	05/16/88	8.40E+01	05/19/88	8.30E+01	05/19/88	7.10E+01
ALUMINUM	UG/G	1.50E+01	05/15/88	7.70E+03	05/16/88	8.15E+03	05/19/88	5.56E+03	05/19/88	5.94E+03
MANGANESE	UG/G	5.00E-01	05/15/88	3.14E+02	05/16/88	2.92E+02	05/19/88	2.92E+02	05/19/88	3.17E+02
POTASSIUM	UG/G	1.00E+01	05/15/88	1.00E+03	05/16/88	7.69E+02	05/19/88	6.78E+02	05/19/88	7.04E+02
IRON	UG/G	5.00E+00	05/15/88	2.48E+04	05/16/88	2.48E+04	05/19/88	2.44E+04	05/19/88	2.71E+04
ARSENIC	UG/G	5.00E-01					05/19/88	1.82E+00		
LEAD	UG/G	5.00E-01	05/15/88	3.46E+00	05/16/88	2.48E+00	05/19/88	2.47E+00	05/19/88	2.47E+00
TOX	UG/G	1.00E+00	05/15/88	4.80E+00	05/16/88	1.90E+00	05/19/88	3.70E+00	05/19/88	8.10E+00
TOC	UG/G	1.00E+01	05/15/88	1.90E+01						
SULFATE	UG/G	1.00E+00					05/19/88	1.42E+01		
FLUORIDE	UG/G	1.00E+00					05/19/88	1.07E+00		
CHLORIDE	UG/G	1.00E+00					05/19/88	1.10E+00		

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	5A25	SAMPLE DATE	5A30	SAMPLE DATE	5A35	SAMPLE DATE	5A40
COLIFRM	MPN	3.00E+00					05/20/86	9.00E+00		
BERYLAM	UG/G	5.00E-01	05/19/86	8.00E+00	05/19/86	8.00E+00	05/20/86	5.00E-01	05/20/86	8.00E-01
ZINC	UG/G	5.00E-01	05/19/86	3.60E+01	05/19/86	3.70E+01	05/20/86	3.90E+01	05/20/86	3.00E+01
CALCIUM	UG/G	5.00E+00	05/19/86	5.43E+03	05/19/86	5.28E+03	05/20/86	5.53E+03	05/20/86	3.47E+03
BARIUM	UG/G	8.00E-01	05/19/86	8.80E+01	05/19/86	7.60E+01	05/20/86	9.50E+01	05/20/86	5.80E+01
CADMIUM	UG/G	2.00E-01	05/19/86	8.00E+00	05/19/86	8.00E+00	05/20/86	8.00E+00	05/20/86	4.00E+00
CHROMIUM	UG/G	1.00E+00	05/19/86	5.00E+00	05/19/86	5.00E+00	05/20/86	5.00E+00	05/20/86	4.00E+00
SODIUM	UG/G	1.00E+01	05/19/86	3.43E+02	05/19/86	4.04E+02	05/20/86	5.00E+02	05/20/86	2.38E+02
NICKEL	UG/G	1.00E+00	05/19/86	5.00E+00	05/19/86	4.00E+00	05/20/86	4.00E+00	05/20/86	2.00E+00
COPPER	UG/G	1.00E+00	05/19/86	1.50E+01	05/19/86	1.40E+01	05/20/86	1.40E+01	05/20/86	8.00E+00
VANADIUM	UG/G	5.00E-01	05/19/86	5.90E+01	05/19/86	8.70E+01	05/20/86	8.20E+01	05/20/86	5.20E+01
ALUMINUM	UG/G	1.50E+01	05/19/86	4.43E+03	05/19/86	4.28E+03	05/20/86	8.01E+03	05/20/86	3.89E+03
MANGANESE	UG/G	5.00E-01	05/19/86	2.63E+02	05/19/86	2.68E+02	05/20/86	2.85E+02	05/20/86	1.94E+02
POTASSIUM	UG/G	1.00E+01	05/19/86	4.88E+02	05/19/86	5.34E+02	05/20/86	5.78E+02	05/20/86	4.98E+02
IRON	UG/G	5.00E+00	05/19/86	2.54E+04	05/19/86	2.39E+04	05/20/86	2.39E+04	05/20/86	1.71E+04
ARSENIC	UG/G	5.00E-01					05/20/86	1.42E+00		
LEAD	UG/G	5.00E-01	05/19/86	2.60E+00	05/19/86	2.47E+00	05/20/86	2.87E+00	05/20/86	2.92E+00
TOX	UG/G	1.00E+00	05/19/86	2.00E+00	05/19/86	2.40E+00	05/20/86	2.70E+00	05/20/86	5.20E+00
SULFATE	UG/G	1.00E+00					05/20/86	1.60E+01		
FLUORIDE	UG/G	1.00E+00					05/20/86	1.54E+00		
CHLORIDE	UG/G	1.00E+00					05/20/86	2.16E+00		

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	6A5	SAMPLE DATE	6A10	SAMPLE DATE	6A15	SAMPLE DATE	6A20
COLIFRM	MPN	3.00E+00							05/22/86	7.00E+00
ZINC	UG/G	5.00E-01	05/21/86	4.30E+01	05/21/86	4.20E+01	05/22/86	4.30E+01	05/22/86	4.10E+01
CALCIUM	UG/G	5.00E+00	05/21/86	7.33E+03	05/21/86	6.27E+03	05/22/86	6.68E+03	05/22/86	6.90E+03
BARIUM	UG/G	6.00E-01	05/21/86	9.80E+01	05/21/86	8.70E+01	05/22/86	1.18E+02	05/22/86	7.40E+01
CADMIUM	UG/G	2.00E-01	05/21/86	6.00E+00	05/21/86	6.00E+00	05/22/86	9.00E+00	05/22/86	6.00E+00
CHROMIUM	UG/G	1.00E+00	05/21/86	8.00E+00	05/21/86	7.00E+00	05/22/86	6.00E+00	05/22/86	8.00E+00
SODIUM	UG/G	1.00E+01	05/21/86	6.73E+02	05/21/86	5.77E+02	05/22/86	5.82E+02	05/22/86	5.72E+02
NICKEL	UG/G	1.00E+00	05/21/86	7.00E+00	05/21/86	6.00E+00	05/22/86	5.00E+00	05/22/86	7.00E+00
COPPER	UG/G	1.00E+00	05/21/86	1.80E+01	05/21/86	1.70E+01	05/22/86	1.90E+01	05/22/86	1.80E+01
VANADIUM	UG/G	5.00E-01	05/21/86	6.80E+01	05/21/86	6.50E+01	05/22/86	6.10E+01	05/22/86	6.80E+01
ALUMINUM	UG/G	1.50E+01	05/21/86	7.66E+03	05/21/86	5.94E+03	05/22/86	6.13E+03	05/22/86	5.34E+03
MANGANESE	UG/G	5.00E-01	05/21/86	3.08E+02	05/21/86	3.02E+02	05/22/86	2.86E+02	05/22/86	2.74E+02
POTASSIUM	UG/G	1.00E+01	05/21/86	9.31E+02	05/21/86	7.17E+02	05/22/86	7.23E+02	05/22/86	6.19E+02
IRON	UG/G	5.00E+00	05/21/86	2.59E+04	05/21/86	2.39E+04	05/22/86	2.50E+04	05/22/86	2.53E+04
ARSENIC	UG/G	5.00E-01							05/22/86	7.13E+00
LEAD	UG/G	5.00E-01	05/21/86	3.52E+00	05/21/86	2.54E+00	05/22/86	2.90E+00	05/22/86	2.27E+00
TOX	UG/G	1.00E+00	05/21/86	3.50E+00	05/21/86	4.00E+00	05/22/86	1.80E+00		
TOC	UG/G	1.00E+01	05/21/86	1.80E+01						
SULFATE	UG/G	1.00E+00							05/22/86	1.23E+01
FLUORIDE	UG/G	1.00E+00							05/22/86	1.03E+00

TABLE F.2. (contd)

CONSTITUENT NAME	UNITS	DETECTION LIMIT	SAMPLE DATE	6A25	SAMPLE DATE	6A30	SAMPLE DATE	6A35	SAMPLE DATE	6A40
ZINC	UG/G	5.00E-01	05/22/88	3.70E+01	05/22/88	4.20E+01	05/23/88	3.40E+01	05/23/88	4.30E+01
CALCIUM	UG/G	5.00E+00	05/22/88	8.32E+03	05/22/88	5.97E+03	05/23/88	4.62E+03	05/23/88	5.82E+03
BARIUM	UG/G	8.00E-01	05/22/88	9.00E+01	05/22/88	1.08E+02	05/23/88	8.10E+01	05/23/88	1.09E+02
CADMIUM	UG/G	2.00E-01	05/22/88	8.00E+00	05/22/88	7.00E+00	05/23/88	6.00E+00	05/23/88	6.00E+00
CHROMIUM	UG/G	1.00E+00	05/22/88	8.00E+00	05/22/88	8.00E+00	05/23/88	8.00E+00	05/23/88	8.00E+00
SODIUM	UG/G	1.00E+01	05/22/88	5.42E+02	05/22/88	5.75E+02	05/23/88	3.33E+02	05/23/88	4.91E+02
NICKEL	UG/G	1.00E+00	05/22/88	5.00E+00	05/22/88	5.00E+00	05/23/88	7.00E+00	05/23/88	7.00E+00
COPPER	UG/G	1.00E+00	05/22/88	1.70E+01	05/22/88	1.80E+01	05/23/88	1.40E+01	05/23/88	1.90E+01
VANADIUM	UG/G	5.00E-01	05/22/88	8.70E+01	05/22/88	7.20E+01	05/23/88	8.00E+01	05/23/88	6.20E+01
ALUMINUM	UG/G	1.50E+01	05/22/88	5.49E+03	05/22/88	8.89E+03	05/23/88	4.29E+03	05/23/88	7.18E+03
MANGANESE	UG/G	5.00E-01	05/22/88	2.74E+02	05/22/88	3.44E+02	05/23/88	2.77E+02	05/23/88	3.46E+02
POTASSIUM	UG/G	1.00E+01	05/22/88	5.81E+02	05/22/88	8.67E+02	05/23/88	4.55E+02	05/23/88	8.27E+02
IRON	UG/G	5.00E+00	05/22/88	2.41E+04	05/22/88	2.70E+04	05/23/88	2.59E+04	05/23/88	2.44E+04
ARSENIC	UG/G	5.00E-01			05/22/88	2.60E+00				
LEAD	UG/G	5.00E-01	05/22/88	2.57E+00	05/22/88	2.58E+00	05/23/88	2.11E+00	05/23/88	4.07E+00
TOX	UG/G	1.00E+00	05/22/88	2.20E+00	05/22/88	3.80E+00	05/23/88	2.10E+00	05/23/88	3.40E+00
SULFATE	UG/G	1.00E+00			05/22/88	1.21E+01				
FLUORIDE	UG/G	1.00E+00			05/22/88	1.31E+00				

APPENDIX G

PROCEDURES FOR GEOPHYSICAL WELL LOGGING

APPENDIX G

PROCEDURES FOR GEOPHYSICAL WELL LOGGING

This appendix contains the written procedures for the geophysical well logging conducted in 300 Area wells during 1986. Procedures for five types of logs are included: temperature, caliper, neutron, density, and gamma.

12.0 GEOPHYSICAL WELL LOGGING

INTRODUCTION

A geophysical well log is a record of a physical property in a borehole. These records are made by lowering a sensing device into the borehole and measuring a physical property that is dependent upon the rock type, mineral components in the rock, physical or chemical properties of the rock, or the conditions in the borehole (borehole fluid, rugosity, and diameter). A geologic property can rarely be identified from a single well log. Usually several well logs are needed.

EQUIPMENT

The following equipment is necessary for borehole geophysical well logging:

- logging van with cable and winch system
- electronic surface equipment that transmits and receives information from the probes
- AC generator
- sensing probes: temperature probe, caliper, X-Y caliper, natural gamma probe, neutron probe, density (gamma-gamma) probe, spontaneous potential-resistivity probe, flowmeter, fluid-resistivity probe, and gradiometer
- chart recorder
- well head sheave
- radioactive sources (3 Ci $^{241}\text{Am}/\text{Be}$ and 125 mCi ^{137}Cs)
- logbook and trip sheet.

EQUIPMENT SETUP

In preparation for geophysical logging, park the logging van at least 60 ft from the well head. This will allow the cable to spool evenly on the drum.

Place sheave over the center of the well casing.

Extend the cable with the attached geophysical probe from the winch to the sheave so that the probe's sensing element is even with the well measuring point.

Set the mechanical registers on the cable drums to zero.

Start either of the two 6.5 KVA generators mounted at the rear corners of the logging van that supply power for the geophysical electronics. Place switches in the appropriate positions on the control panel for running the particular geophysical probing desired.

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Turn on the geophysical probes and check their proper operation and calibration before lowering them into the hole.

EQUIPMENT OPERATION

PNL's geophysical logging probes are run in accordance with detailed instructions set forth in the manuals listed below.

Copies of these manuals are kept in the logging van.

- fluid temperature, caliper, natural gamma, flowmeter, neutron, and density probes: Instruction Manual - Pulse Logging Systems, Gearhart-Owen Industries, Inc., Fort Worth, Texas.
- spontaneous potential-resistivity and fluid resistivity probes: Instruction Manual - ELM 202 Electric Log Module, Gearhart-Owen Industries, Inc., Fort Worth, Texas.
- X-Y caliper tool: X-Y Caliper Tool Operator's Manual, Gearhart Industries, Inc., Fort Worth, Texas.
- three- and four-pen modular recorder: MRP 501 Modular Recorder Operation Manual, Gearhart-Owen Industries Inc., Fort Worth, Texas.
- sonic bond probe: E. H. Peveto et al. Technical Bulletin with Operational Procedures, Number 2, for the Cement Bond Logs, Gearhart-Owen Industries, Inc., Fort Worth, Texas.
- gradiometer model GAUL-20-2: Operation Manual, Schonstedt Instrument Co., Reston, Virginia.

Van Hydraulic System

Start van engine from the cab to build up air pressure in tank. Depress van clutch, place PTO lever in engage position, and release clutch. Turn van ignition off.

Go to the back of the van. Turn on the fuse switch on operator's panel so that switches on the panel have power.

Start van engine from operator's panel and run it at idle speed - 600 to 700 RPM (check tachometer).

With the up-down hydraulic control lever in neutral, shift the transmission into the gear desired.

Place the up-down hydraulic control lever in the down position and adjust the speed with the flow regulator valve on the front of the operator's panel and with the van throttle control. Watch the tachometer and hydraulic pressure gauge on the operator's panel. Do not exceed 3,000 RPM or 1,500 psi when operating the geophysical cable reel.

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During hot weather, open the door to the hydraulic fluid reservoir so air will circulate and cool the fluid.

AC Electrical System

Open the doors to the generator compartment before starting the generator and leave them open while generator is operating. If the doors are left closed, the generator may overheat and be damaged.

Check the generator's oil before starting.

Check the control panel for the proper voltage (115) and cycles (60) output from the generator.

If one generator is overloaded, start the other generator and divide the load by switching on the control panel.

Logging

Most geophysical logs are made by lowering the probes to the bottom of the hole and then logging up. The exceptions are logging temperature, flow, and flow resistance, which are done while the probe goes down the hole. Logging speeds for the different probes range from 15 ft per minute to 100 ft per minute. To achieve these speeds, select the right gear in the transmission and the right RPM on the tachometer, and adjust the hydraulic control valve.

Logging Completion

When you have completed logging, wipe the probes clean and securely store them in the logging van to avoid damage during transport. Store the radioactive sources in their containers and place them in the logging van for return to the radioactive source storage room.

QUALITY ASSURANCE

Equipment Standardization

In an attempt to standardize log responses, a log will be made from each probe every three months in the reference well, 399-5-2. If a probe malfunctions during logging, the probe will be repaired and then run in the reference well to assure proper response.

Equipment Calibrations

Calibrate all probes in accordance with procedures set forth in the instruction manuals (see equipment operation section). It is important to calibrate geophysical probes both before and after the log is made. This double-checks the calibration and accounts for any drift of tool response due to borehole conditions. Note what calibration actions you took on the geophysical logs. This notation shall comprise documentation of the calibration.

Repeat Sections

A 50-ft repeat section of each log will be run to check on a probe's repeatability. If logs have been run in a well before, run a 50-ft overlap to check for repeatability. These repeat sections will usually be run over zones where the charts show a lot of variability or at the bottom of the hole.

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LOG NOTATIONS
AND SIGNATURES

Record in logbook all information regarding well identification, depth, type of log, well diameter, casing size, water level, date, interval logged, instrument scale used, time constant, and logging speed. The person operating the equipment must sign the log. Note any problems encountered during logging or anything that could affect equipment response.

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12.1 TEMPERATURE LOGGING

INTRODUCTION

Temperature logging provides for locating liquid level, measuring formation temperature, determining the top of the cement, detecting fluid-entry, injection profiling, and detecting casing leaks. All temperature logging is performed while lowering the tool and cable into the well, so that the influence of the tool and cable upon the ambient temperature is minimized. Maximum logging speed is 40 ft/min.

EQUIPMENT

The following equipment is necessary for temperature logging:

- logging van, reel and cable
- AC generator
- NIMS Bin electronic panel (NBP 501)
- temperature probe
- line power control module (LPM 202)
- ratemeter module (RMM 204)
- recorder (SRP 502)
- well sheave
- certified thermometer
- jug of water for calibrating.

OPERATING PROCEDURE

Set NIMS Bin panel power ON-OFF switch to ON.

Set recorder panel MAIN POWER switch to ON.

Rotate LPM CURRENT-VOLTAGE switch to CURRENT.

Rotate LPM CURRENT ADJUST to 0.

Adjust LPM INSTRUMENT POWER switch to POSITIVE.

Turn LPM CURRENT ADJUST control until current reads 50 milliamperes.

Rotate RMM MODE switch to LINE.

Rotate RMM CPS switch to 500.

Rotate RMM TC switch to 0.01.

Rotate RMM RECORDER OUTPUT to 1000.

Set RMM POSITIVE-NEGATIVE to POSITIVE.

Set RMM REVERSE-NORMAL switch to NORMAL.

Use the recorder's amplifier #2 for temperature measurements. Set ZERO at 490 and SPAN at 248. This will give a temperature range of 20°C across the 10-in. chart.

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Place the probe in the jug of water. Use a certified thermometer to read the water temperature. Set the probe to agree with the thermometer.

Use RMM SUPPRESSION control to set pen to desired position on recorder chart. For example, if the temperature span is set for 10°C to 30°C across the chart, and water temperature is 20°C, the pen would be set at the center of the chart. If temperature reaches 30°C while logging, stop logging and reset pen to left edge of the chart using the RMM SUPPRESSION control. The span will now read 30°C to 50°C. Mark on the log when you have done this.

Place probe in the well and set to proper measuring point. Tool zero is at bottom of probe.

Set UP-DOWN direction switch on recorder panel in the down position and log as the probe goes into the hole. Logging speed is usually 30 ft per minute. When the probe reaches bottom, log back up 50 ft for a system check. Temperature may vary slightly because the water has been disturbed by logging down.

Bring probe to surface and recheck its calibration by placing it in the water jug and reading the water temperature with the certified thermometer. If they disagree, log again using a different temperature probe.

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12.2 CALIPER PROBE

INTRODUCTION

The caliper-logging system provides a continuous reading of borehole diameter versus depth. Caliper logging is used to determine hole and casing diameter, and to locate caved zones, casing and absence of casing. The caliper tool is provided with different length caliper arms depending on the diameter of the hole to be measured. The 6-in. arms extend to approximately 18 in.; the 18-in. arms extend to 32 in. The maximum logging speed is 50 ft per minute.

EQUIPMENT

The following equipment is used to run caliper logs:

- logging van with cable and reel
- AC generator
- NIMS Bin electronic panel (NBP 501)
- chart recorder (SRP 502)
- line power control module (LPM 202)
- ratemeter module (RMM 204)
- caliper probe
- caliper probe calibrator
- well sheave.

OPERATING PROCEDURE

Set NIMS Bin power switch to ON.

Set recorder panel main power switch to ON.

Attach caliper tool to cable head and allow system to warm up for about 5 minutes.

Rotate LPM CURRENT-VOLTAGE switch to VOLTAGE.

Set LPM HIGH-NORMAL switch to HIGH.

Rotate LPM INSTRUMENT-POWER switch to NEGATIVE.

Adjust LPM CURRENT ADJUST control to 200 volts on red scale.

Set CURRENT-VOLTAGE switch to CURRENT (meter will read full scale). Arms will open fully in 20 to 30 seconds and current will drop to zero.

Rotate LPM INSTRUMENT POWER switch to OFF.

Rotate LPM CURRENT ADJUST TO 0.

Rotate LPM INSTRUMENT POWER switch to POSITIVE.

Adjust LPM current to read 60 milliamps.

Rotate RMM MODE switch to LINE.

Rotate RMM POS.-NEG. switch to POSITIVE.

Rotate RMM REV.-NORM. switch to NORMAL.

Rotate RMM TIME-CONSTANT switch to 1.

Rotate RMM CPS switch to 100 for probe serial number C-001 and 500 for probe serial number C-002.

Switch ON a recorder amplifier.

Depress ZERO switch on RMM and adjust pen to zero position on recorder chart with the amplifier ZERO potentiometer on recorder.

Close caliper arms by placing calibrator on them.

Bring recorder pen to its zero position by using SUPPRESSION control on RMM.

Remove calibrator, letting arms open to maximum.

Use recorder amplifier SPAN control to adjust span on chart.

Repeat opening and closing arms and adjusting SUPPRESSION control on RMM and SPAN control on recorder until desired span has been set.

Place calibrator on caliper arms.

Mark calibration settings on the recorder chart. Short arms range from 0 to 17-3/4 in. Long arms range from 0 to 32 in.

Rotate RMM MODE switch to OFF.

Rotate LPM Power switch to POSITIVE.

Rotate LPM CURRENT-VOLTAGE switch to VOLTAGE.

Adjust LPM CURRENT ADJUST to 200 volts on the red scale.

Rotate LPM CURRENT-VOLTAGE switch to CURRENT. Caliper motor will run for 20 to 30 seconds, closing the arms; current will drop to 0.

Rotate LPM instrument power switch to OFF.

Place probe in well and set it to the proper measuring point. Tool zero is at tips of tool arms.

Run tool into well to deepest point where casing size is known.

Open arms and use SUPPRESSION control on RMM to set pen on chart to match casing size with calibration.

Close arms, run tool to bottom of hole, open arms, and log as you bring the calipers up. Maximum logging speed is 25 ft per minute.

Log back into a section with known casing size for 20 ft to check for instrument drift.

Check the system by rerunning a 50-ft section. If the well has been logged before, you can overlap a 50-ft section of the hole that has been logged previously.

Close arms; bring tool to surface.

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12.4 NEUTRON PROBE

INTRODUCTION

Neutron-epithermal neutron logging is a means for determining formation hydrogen content, moisture content, and porosity. Below the water surface, the log reflects primarily rock porosity; above the water surface, it reflects formation moisture. Neutron logs are recorded continuously as the tool is either lowered or raised within the well. Neutron logs may be recorded in both gas- and liquid-filled, cased or uncased wells. Because enlargement of liquid-filled holes has significant effects, a caliper log should be recorded in zones where hole enlargement is possible, to permit correction for borehole effects. Maximum logging speed is 25 ft per minute. Procedures for use and handling of the radioactive source are described in RWP HR-9 and SRSP No. 00004.

EQUIPMENT

The following equipment is used to run neutron logs:

- logging van with cable and reel
- AC generator
- NIMS Bin electronic panel (NBP 501)
- chart recorder (SRP 502)
- line power control module (LPM 202)
- ratemeter module (RMM 204)
- neutron probe
- 3 Ci $^{214}\text{Am}/\text{Be}$ source
- well sheave.

OPERATING PROCEDURE

Connect source to probe and attach probe to cable head.

Place probe in well and set to proper measuring point. Tool zero is at the detector.

Set NIMS Bin power and chart recorder power to ON.

Rotate RMM MODE switch to LINE.

Rotate RMM SUPPRESSION and RECORDER OUTPUT controls fully clockwise.

Rotate RMM CPS switch to 1000.

Rotate RMM TC switch to 2.

Set RMM POSITIVE-NEGATIVE polarity switch to POSITIVE.

Set RMM REVERSE-NORMAL switch to NORMAL.

Rotate LPM CURRENT-VOLTAGE switch to CURRENT.

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Rotate LPM POWER switch to POSITIVE.

Adjust LPM CURRENT ADJUST to 70 milliamps.

Rotate RMM MODE switch to CAL 100.

Rotate RMM CPS switch to 100.

Switch a recorder amplifier to ON. Make sure it is plugged into the OUTPUT connection on the back of the RMM.

Depress the ZERO control on the RMM.

Adjust recorder amplifier ZERO to position pen to its zero point on the left side of the chart paper. This position will mark 0.

Release the ZERO control on the RMM.

Adjust recorder amplifier SPAN control to desired position on the right side of the recorder chart. This position will mark full scale.

Rotate RMM MODE switch to LINE.

Rotate RMM CPS switch to 1000 or 5000, depending on the formation.

Logs are generally run from the bottom of the hole to the top. Maximum logging speed is 25 ft per minute.

Check the system by rerunning a 50-ft section. If well has been run before, you can overlap a 50-ft section of the previous log.

12.5 BULK DENSITY

INTRODUCTION

Bulk density (gamma-gamma) logging is used as a more precise indicator of porosity in a highly porous or shaley formation and for formation density measurements. Bulk density logging provides best results where hole wall is uniform or in an uncased borehole. Maximum logging speed is 25 ft per minute. Procedures for use and handling of the radioactive sources are described in RWP HR-9 and SRSP No. 00004.

EQUIPMENT

The following equipment is used to run density logs:

- logging van with cable and reel
- AC generator
- NIMS Bin electronic panel (NBP 501)
- chart recorder (SRP 502)
- line power control module (LPM 202)
- ratemeter module (RMM 204)
- density probe
- 125mCi ^{137}Cs source
- well sheave.

OPERATING PROCEDURE

Connect probe to cable head.

Set NIMS Bin panel and recorder panel power switches to ON.

Rotate RMM NORMAL-REVERSE switch to REVERSE.

Rotate RMM MODE switch to LINE.

Rotate RMM SUPPRESSION control and RECORDER OUTPUT control fully clockwise.

Rotate RMM CPS switch to 500 or 1000, depending on the formation. It is preferable to use as low a setting as possible.

Rotate RMM TC switch to 3.

Set RMM POSITIVE-NEGATIVE switch to NEGATIVE.

Rotate LPM CURRENT-VOLTAGE switch to CURRENT.

Rotate LPM Power switch to POSITIVE.

Adjust LPM CURRENT ADJUST to 70 milliamps.

Rotate RMM MODE switch to 100 CAL.

Rotate RMM CPS switch to 100.

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Switch a recorder amplifier to ON, making sure that it is plugged into the OUTPUT connection on the back of the RMM.

Depress the ZERO control on the RMM.

Adjust recorder amplifier ZERO to position pen to its position on the right side of the chart paper. This position will mark 0.

Release the ZERO control on the RMM.

Adjust recorder SPAN control to desired position on the left side of the chart paper. This position will mark full scale.

Rotate RMM MODE switch to line.

Rotate RMM CPS switch to 500 or 1000.

Place probe in well and set it to the measuring point.

Run the probe to bottom of well and log up. Maximum logging speed is 25 ft per minute.

Check the system by rerunning a 50-ft section. If well has been logged before, you can overlap a 50-ft section of the previous log.

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12.6 GAMMA RAY PROBE

INTRODUCTION

The gamma ray logging system provides a means of continuously recording the gamma radiation level by depth within the borehole. The gamma response is principally related to the presence of potassium-40 but may also be influenced by minor amounts of uranium and thorium. Because of the high ^{40}K content of most clays, the gamma log ordinarily gives a high gamma response in clay zones. Clean quartz sands, on the other hand, give a low gamma response. The natural gamma log has its primary value as an indicator of lithology and is one of the most versatile tools for use in stratigraphic correlations.

Gamma ray logs may be recorded in either cased or uncased wells and in any form of borehole fluid, provided the fluid is not highly radioactive. Usual logging speed is 20 ft per minute, but it depends on the time constant selected. With higher time constants, logging speed will be slower.

EQUIPMENT

The following equipment is used to run gamma ray logs:

- logging van with cable and reel
- AC generator
- NIMS Bin electronic panel (NBP 501)
- chart recorder (SRP 502)
- line power control module (LPM 202)
- ratemeter module (RMM 204)
- gamma ray probe
- well sheave.

OPERATING PROCEDURE

Connect probe to cable head and place in well to proper measuring point. Probe zero is at the detector.

Set NIMS Bin power and chart recorder switches to ON.

Rotate RMM MODE switch to LINE.

Rotate RMM SUPPRESSION and RECORDER OUTPUT fully clockwise.

Rotate RMM CPS to 100.

Rotate RMM TC switch to 3.

Set RMM POSITIVE-NEGATIVE polarity switch to NEGATIVE.

Set RMM REVERSE-NORMAL switch to NORMAL.

Rotate LPM CURRENT-VOLTAGE switch to CURRENT.

Rotate LPM instrument power switch to POSITIVE.

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Adjust LPM CURRENT ADJUST TO 60 milliamps for probe serial number CG-27A97 and 75 milliamps for probe serial number NG-001.

Rotate RMM MODE switch to CAL 100. The CPS meter should read 100 cps at this point.

Switch a recorder amplifier to ON. Make sure this amplifier is plugged into the OUTPUT connector in the back of the RMM.

Depress the ZERO switch on the RMM.

Adjust the recorder ZERO to position pen to its position on the left side of the chart paper. This position will mark 0.

Release the ZERO switch on the RMM.

Adjust recorder SPAN control to desired position on the right side of the recorder chart. This position will mark full scale.

Rotate RMM MODE switch to LINE.

Rotate RMM CPS switch to 500.

Gamma ray logging is generally done from the bottom of the hole to top, so lower the probe to the bottom and log while raising it.

Logging speed is 15 ft per minute.

Check the system by rerunning a 50-ft section. If the well has been logged before, you can overlap a 50-ft section of the previous log.

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