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CULEBRA TRANSPORT PROGRAM

TEST PLAN: HYDRAULIC TESTS AT WELLS WQSP-1, WQSP-2, WQSP-3, WQSP-4, WQSP-5, WQSP-6, AND WQSP-6A AT THE WASTE ISOLATION PILOT PLANT (WIPP) SITE

Wayne A. Stensrud
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6850 Austin Center Boulevard
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October 6, 1995

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REVISION HISTORY

This is the original edition of this Test Plan. The purpose and content of any future changes and/or revisions will be documented and described in this section of revised editions.

DEFINITIONS OF ACRONYMS

amsl	above mean sea level
bgs	below ground surface
btc	below top of casing
CAO	Carlsbad Area Office (of DOE)
CMR	Central Monitoring Room
DAS	Data-Acquisition System
DOE	(United States) Department of Energy
EEG	Environmental Evaluation Group (State of New Mexico)
EPA	(United States) Environmental Protection Agency
ES&H	Environmental Safety and Health
GET	General Employee Training
gpm	gallons per minute
HP	Hewlett Packard
h.p.	horsepower
HTC	Hydraulic-Test Coordinator
JHA	job hazard analysis
MOC	Management and Operating Contractor
MSDS	Material Safety Data Sheet
NIST	National Institute for Standards and Technology
PA	Performance Assessment
PHA	Preliminary Hazard Assessment
PI	Principal Investigator
psi	pounds per square inch
QA	Quality Assurance
QAP	Quality Assurance Procedure
QAPD	Quality Assurance Program Description
SNL	Sandia National Laboratories
SOP	Safe Operating Procedure
SWCF	Sandia WIPP Central Files
TOP	Technical Operating Procedure
WID	Waste Isolation Division (of Westinghouse)
WIPP	Waste Isolation Pilot Plant
WQSP	Water Quality Sampling Program

1. INTRODUCTION

1.1 Summary

This Test Plan describes the purpose, objectives, design, equipment, and methodologies for hydaulic tests to be performed by Sandia National Laboratories (SNL) in seven Water Quality Sampling Program (WQSP) wells at the Waste Isolation Pilot Plant (WIPP) site located in southeastern New Mexico (Figure 1-1). The wells were drilled by the Waste Isolation Division (WID) of Westinghouse Electric Corporation during September and October 1994 to provide locations for long-term water-quality monitoring. The locations of the WQSP wells are shown on Figure 1-2.

1.2 Purpose

In September and October 1994, six wells (WQSP-1 through 6) were drilled and completed in the Culebra Dolomite Member of the Rustler Formation as part of the WQSP. The wells were drilled to provide optimum conditions for long-term water-quality monitoring. The wells were located to establish water-quality baseline data and to provide control points up and down gradient from the WIPP exclusive-use area in compliance with the WIPP water-quality monitoring requirements. In addition, SNL provided input on the location of these wells with respect to future hydrologic testing by SNL. A seventh well, WQSP-6A was drilled in October 1994 and completed through a portion of the Dewey Lake Redbeds after fluid production was noted in that horizon during drilling of WQSP-6. Pumping tests are planned for all seven wells, although slug tests may have to be performed in wells WQSP-3 and WQSP-6 because of low Culebra transmissivity at those locations. These tests will provide data for use in estimating the transmissivity and formation pressure of the Culebra and Dewey Lake, and these estimates will be used to aid in the calibration of WIPP-site groundwater flow models.

The following sections of this Test Plan describe in detail the program objectives, test equipment, testing-and-monitoring procedures, data-acquisition plan, data-quality objectives, quality-assurance requirements, pretest data, test-design analysis, deployment of personnel, regulatory requirements, safety, and reporting procedures. Because these wells have not been previously tested, the design pumping rates and detailed activity schedules are difficult to specify in advance. The Test Plan will, therefore, emphasize the general procedures to be followed for each type of test anticipated. Additionally, field conditions during the testing of the wells may dictate that specific program adaptations be adopted. All program adaptations will be approved

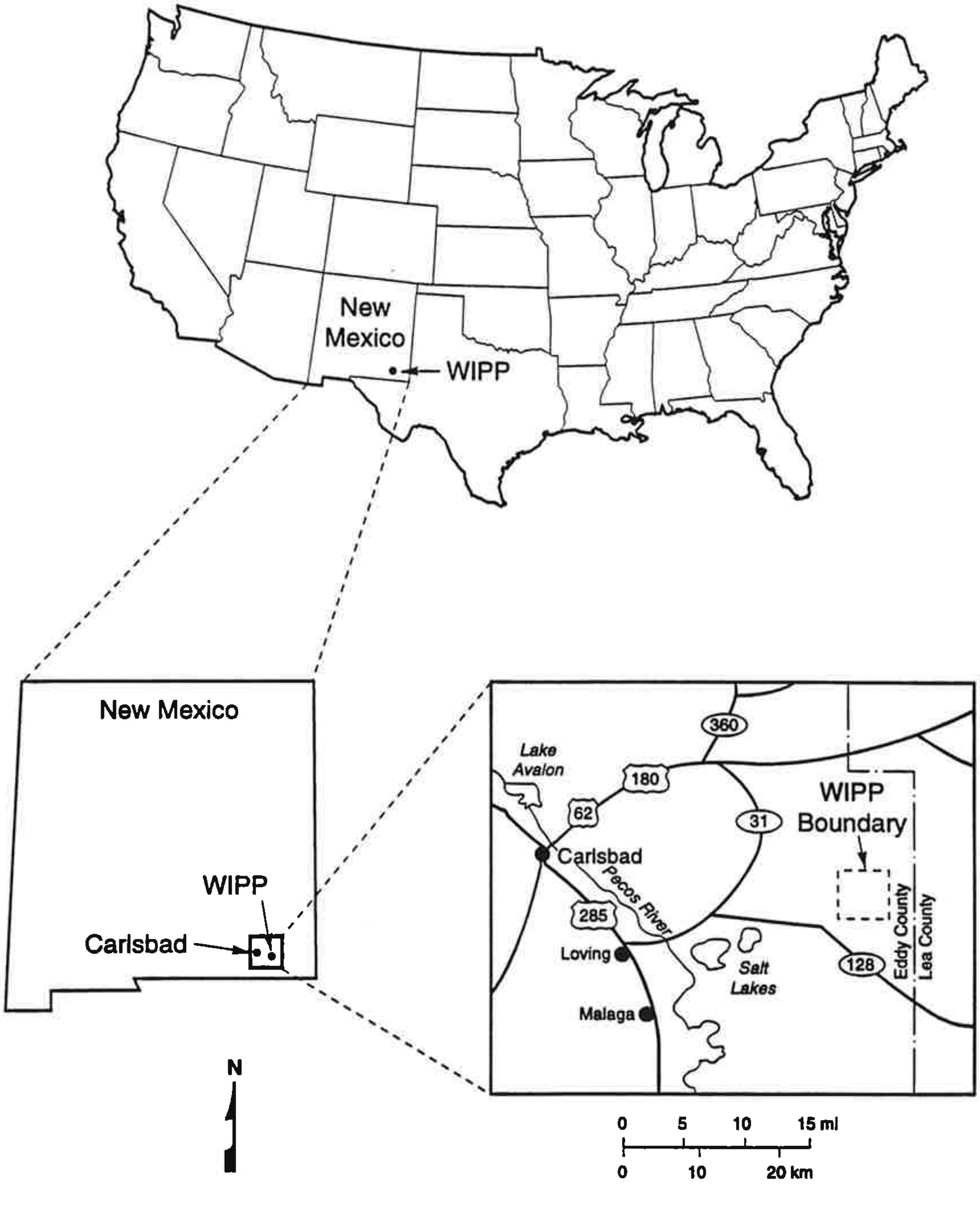

Figure 1-1. Location of the WIPP site.

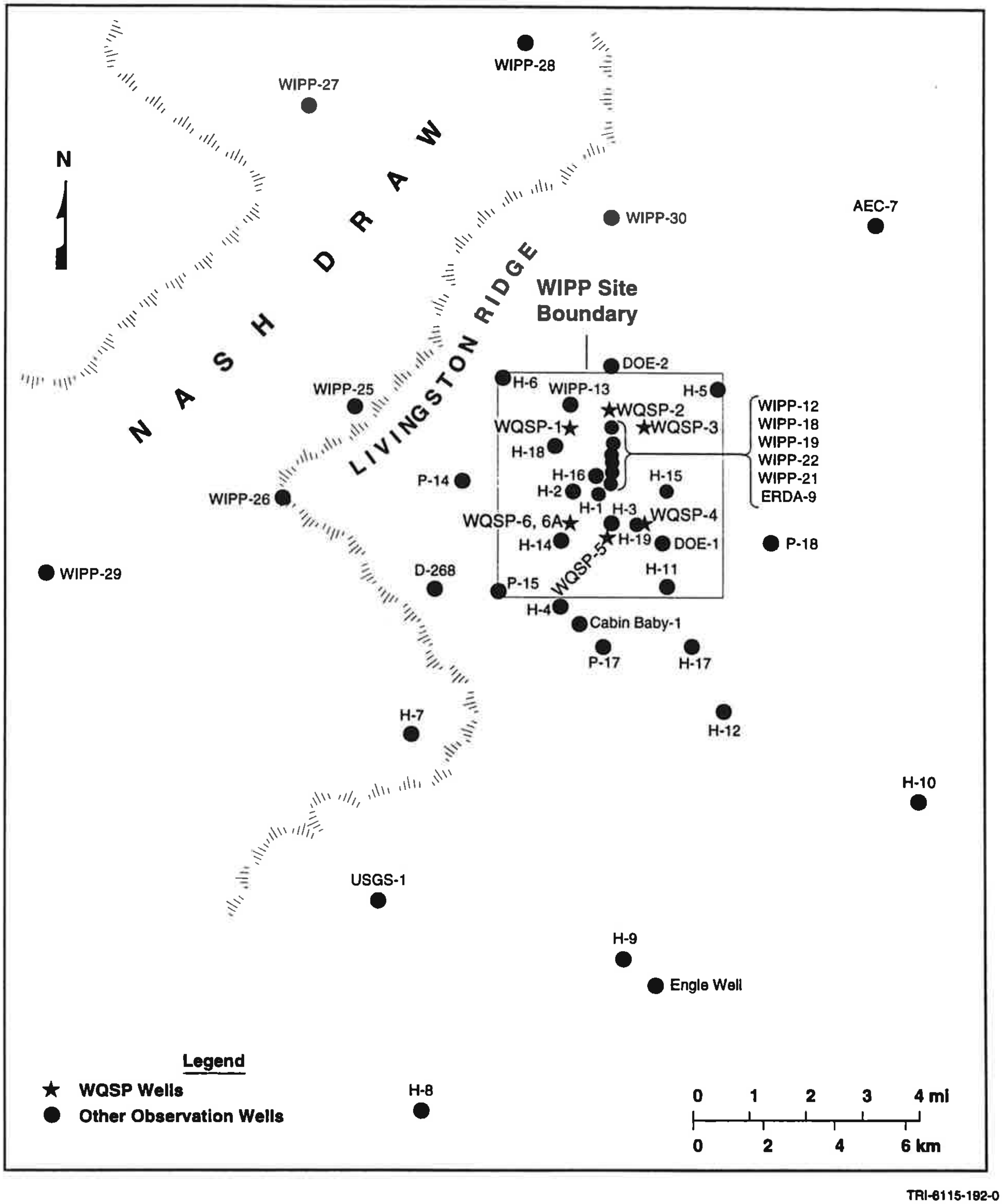

Figure 1-2. Locations of WQSP wells.

by the SNL Principal Investigator (PI). All phases of the program will be conducted and documented in accordance with the SNL WIPP Quality Assurance Program Description (QAPD) and applicable QA implementing procedures.

2. REGULATORY AND PERMIT REQUIREMENTS

The Westinghouse Waste Isolation Division (WID) is responsible for ensuring that WIPP-site activities are conducted in accordance with applicable federal, state, and local regulatory requirements. The WID is responsible for assessing regulatory impact and compliance and for obtaining necessary permits. Appropriate National Environmental Policy Act (NEPA) checklists governing the proposed testing at the WQSP wells have been generated and approved. SNL is responsible for ensuring that all contracted experimental work performed by SNL contractors at the WIPP site meets all applicable federal, state, and local regulatory requirements. The WID has obtained permits for the WQSP wells from the New Mexico State Engineer. These permits govern the drilling, completion, and pumping of those wells. Pumping restrictions applicable to this Test Plan are discussed below along with plans for the disposal of the pumped water.

2.1 Limitations on Pumping

The permits issued by the New Mexico State Engineer for the WQSP wells limit the maximum allowable volume that can be withdrawn from each of the wells during any year to three acre-feet (977,486 gallons). Therefore, totalizing flow meters must be used on the discharge lines from each of the wells to monitor cumulative discharge during all pumping activities. The initial meter readings must be reported to the State Engineer when the meters are installed and the meter readings on the first days of January, April, July, and October of each year must be submitted to the State Engineer by the tenth days of those months. This information will be provided by the Hydraulic-Test Coordinator (HTC) or his designee to the WID NEPA Coordinator on the first working day of each applicable month. The WID NEPA Coordinator is responsible for transmitting the information to the State Engineer. In addition, the WID NEPA Coordinator is required to notify the State Engineer's Office 48 hr in advance of any pumping tests.

2.2 Water Disposal

A 130-barrel liquid-storage tank will be moved to each test location prior to the start of testing and used to store the fluid produced during any pretest pumping periods, and all discharge during the pumping-test phase. The discharge water produced during testing will be removed by a licensed brine hauler and transported to the evaporation basin located at the H-19 hydropad.

3. COMPLIANCE JUSTIFICATION

The preliminary performance assessments of the WIPP (e.g., WIPP PA Dept., 1993) have shown that physical and/or chemical retardation occurring as radionuclides are transported through the Culebra can make a significant contribution to WIPP's compliance with 40 CFR 191B. Modeling of transport through the Culebra requires, first, a conceptual model of the mechanisms and processes governing that transport and, second, quantitative estimates of the parameters required for numerical simulation of those processes. The data developed from the testing of the WQSP wells will contribute quantitative estimates of the Culebra's hydraulic parameters to aid in the numerical simulation of groundwater flow and transport. The Culebra Transport Program represents the combined efforts of the SNL Geohydrology (6115) and WIPP Chemical and Disposal Room Processes (6748) Departments to provide the conceptual understanding and data necessary to construct a numerical model for Culebra transport.

4. OBJECTIVES

Six wells drilled and completed in the Culebra and a seventh well drilled and completed in the Dewey Lake Redbeds by Westinghouse for the WQSP at WIPP will be hydraulically tested. The Culebra wells will be tested to obtain data with which to estimate hydraulic parameters of the Culebra in areas where there is uncertainty concerning the regional transmissivity distribution. Four of the WQSP wells are located on the four corners of the WIPP exclusive-use area. A fifth well is located about 0.75 mile north of the center of the northern WIPP exclusive-use-area boundary and the sixth well is located about 0.75 mile south of the center of the southern exclusive-use-area boundary (Figure 1-2). The locations for the six WQSP wells were selected by Westinghouse to optimize conditions for monitoring the water quality of the Culebra for the WQSP. Westinghouse also conferred with SNL, the NM Environment Department (NMED), the New Mexico Environmental Evaluation Group (EEG), and the Environmental Protection Agency (EPA) on the locations of these wells in order to optimize their usefulness by providing hydrologic information in areas where no testing has been previously performed. All six wells have been cleaned of drilling fluid and developed to provide hydraulic connection with the Culebra. The specific objectives of this test program are:

- to provide data with which to estimate the Culebra's hydraulic parameters at these well locations; and
- to provide hydrologic response data from other wells near the center of the WIPP site to improve calibration of groundwater flow models.

WQSP-6A was drilled and completed through a portion of the Dewey Lake Redbeds in October 1994 after groundwater was produced from that horizon during drilling of WQSP-6. The specific objectives of testing the Dewey Lake Redbeds are:

- to provide data with which to estimate the Dewey Lake's hydraulic parameters including transmissivity and hydraulic head; and
- to provide data with which to define an appropriate conceptual model for flow in the Dewey Lake.

5. EXPERIMENTAL PROCESS DESCRIPTION

5.1 Overview of the Testing Program

SNL has been granted permission by Westinghouse to enter the WQSP wells drilled in the fall of 1994 to perform hydraulic tests. The testing program will probably consist of pumping tests in all wells, although slug tests may be performed in WQSP-3 and WQSP-6 if those wells cannot sustain pumping tests. The data provided by the tests will be used to estimate hydraulic parameters of the Culebra and the Dewey Lake Redbeds.

Prior to the start of hydrologic testing, water levels will be measured in those wells that may be influenced by testing. These measurements will serve to define the pretest conditions for this testing program. Water-level measurements will be supplemented with those collected by Westinghouse as part of the WIPP Water-Level Monitoring Program.

The pumping tests will involve operation of the submersible pumps installed by Westinghouse into the WQSP wells following WIPP-approved test procedures. Installation and operation of flow-control systems will be closely coordinated with Westinghouse to avoid damage to the pumps. A pressure transducer will be installed into the water-level-measurement access tubing to allow monitoring of the borehole fluid pressure during both the pumping and recovery phases of hydraulic testing. The wells will be pumped for a period of up to 72 hours based on evaluation of the test data by the SNL Principal Investigator (PI) or the HTC. Upon completion of pumping, the formation fluid pressure will be monitored for a recovery period as much as three times as long as the pumping period, or a time period determined by the SNL PI or the HTC.

In wells WQSP-3 and WQSP-6, either low-production pumping tests or slug tests will be performed to determine formation hydraulic parameters because preliminary well-development pumping indicated that the permeability of the formation in these wells is too low to sustain a pumping test at a pumping rate of one gallon per minute (gpm) or greater. Slug tests consist of either a rapid addition of a known volume of formation fluid to the water-level-measurement access tubing or operating the submersible pump at maximum production for a period of several minutes to affect a quasi-instantaneous fluid removal analogous to a slug-withdrawal test. The borehole-fluid-pressure response to the removal or addition of fluid will be monitored using a downhole pressure transducer installed in the water-level-measurement access tubing. These fluid-pressure data will be used to estimate formation hydraulic parameters.

5.2 Pretest Data

5.2.1 Borehole Histories

<u>WQSP-1</u> - Well WQSP-1 was drilled between September 13 and 16, 1994 to a total depth of 737.0 ft below ground surface (bgs). The borehole was drilled through the Culebra and extends 15.0 ft into the unnamed lower member of the Rustler Formation. The well was drilled to a depth of 693 ft bgs using compressed air as the drilling fluid. The interval from 693 to 737 ft bgs (the total depth) was drilled using air mist with a foaming agent as the drilling fluid. WQSP-1 was drilled to 695.6 ft bgs using a 9⅞-inch drill bit and was cored from 695.6 to 737.0 ft bgs using a 5¼-inch core bit to cut 4-inch-diameter core. After coring, WQSP-1 was reamed to 9⅞ inches in diameter to total depth. WQSP-1 was cased from the surface to 737 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 702 to 727 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 640 to 651 ft bgs and with 8/16 Brady gravel from 651 to 737 ft bgs. Based on core log results, the Culebra is located from 699.0 to 722.0 ft bgs. See Figure 5-1.

<u>WQSP-2</u> - WQSP-2 was drilled between September 6 and 12, 1994 to a total depth of 846.0 ft bgs. The borehole was drilled through the Culebra and extends 12.3 ft into the unnamed lower member of the Rustler Formation. The well was drilled to a depth of 800 ft bgs with a 9⅞-inch drill bit using compressed air as the drilling fluid. The interval from 800 to 845 ft bgs (the total depth) was drilled with a 5¼-inch core bit to cut 4-inch-diameter core using air mist with a foaming agent as the drilling fluid. After coring, WQSP-2 was reamed to 9⅞ inches in diameter to total depth. WQSP-2 was cased from the surface to 846 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 811 to 836 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 790 to 793 ft bgs and with 8/16 Brady gravel from 793 to 846 ft bgs. Based on core log results, the Culebra is located from 810.1 to 833.7 ft bgs. See Figure 5-2.

<u>WQSP-3</u> - Well WQSP-3 was drilled between October 21 and 26, 1994, to a total depth of 880.0 ft bgs. The borehole was drilled through the Culebra and extends 8.6 ft into the unnamed lower member of the Rustler Formation. The well was drilled to a total depth of 880 ft bgs using compressed air as the drilling fluid. The borehole was cleaned using air mist with a foaming agent. WQSP-3 was drilled to 833 ft bgs using a 9⅞-inch drill bit and was cored from

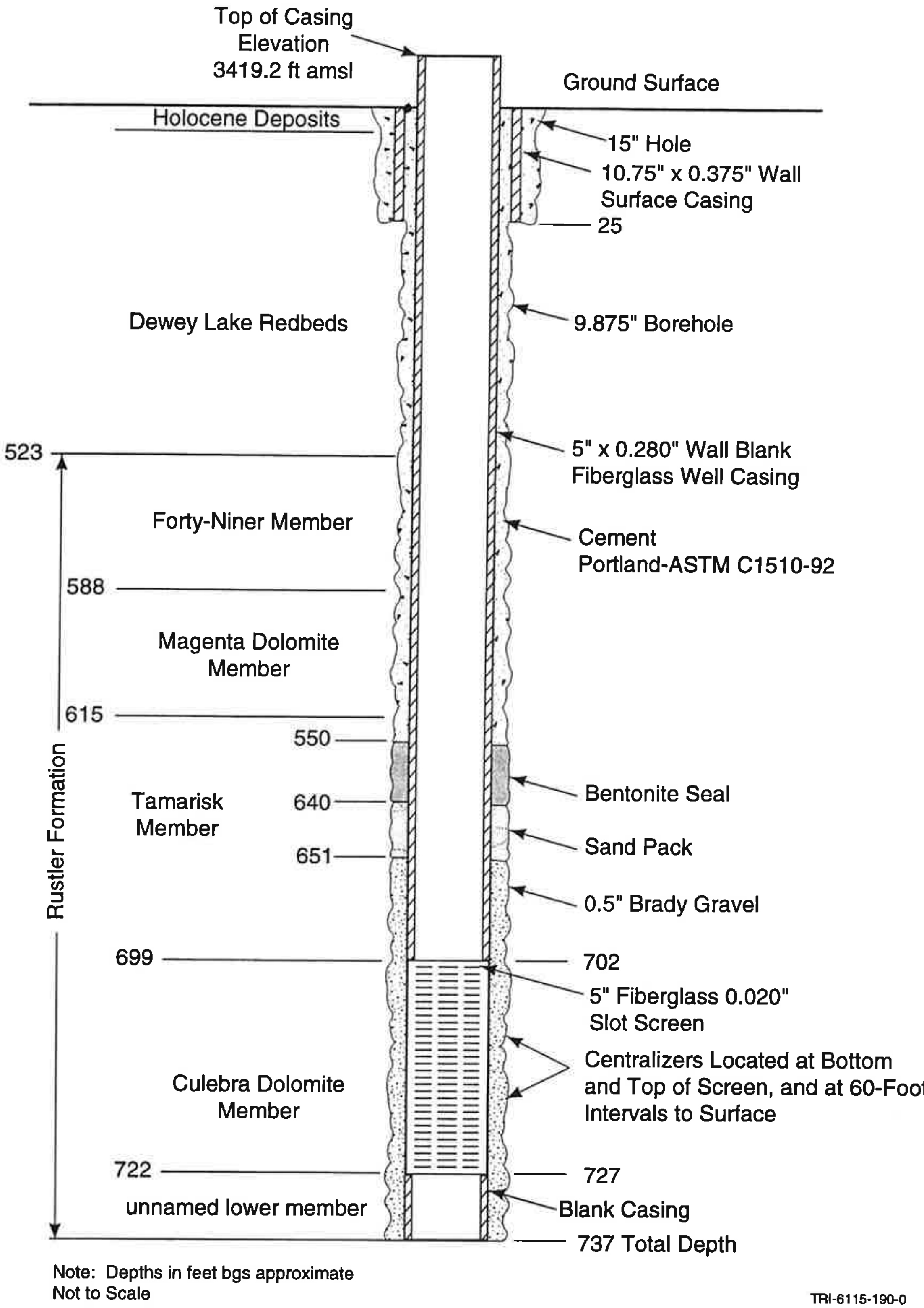

Figure 5-1. As-built configuration of well WQSP-1.

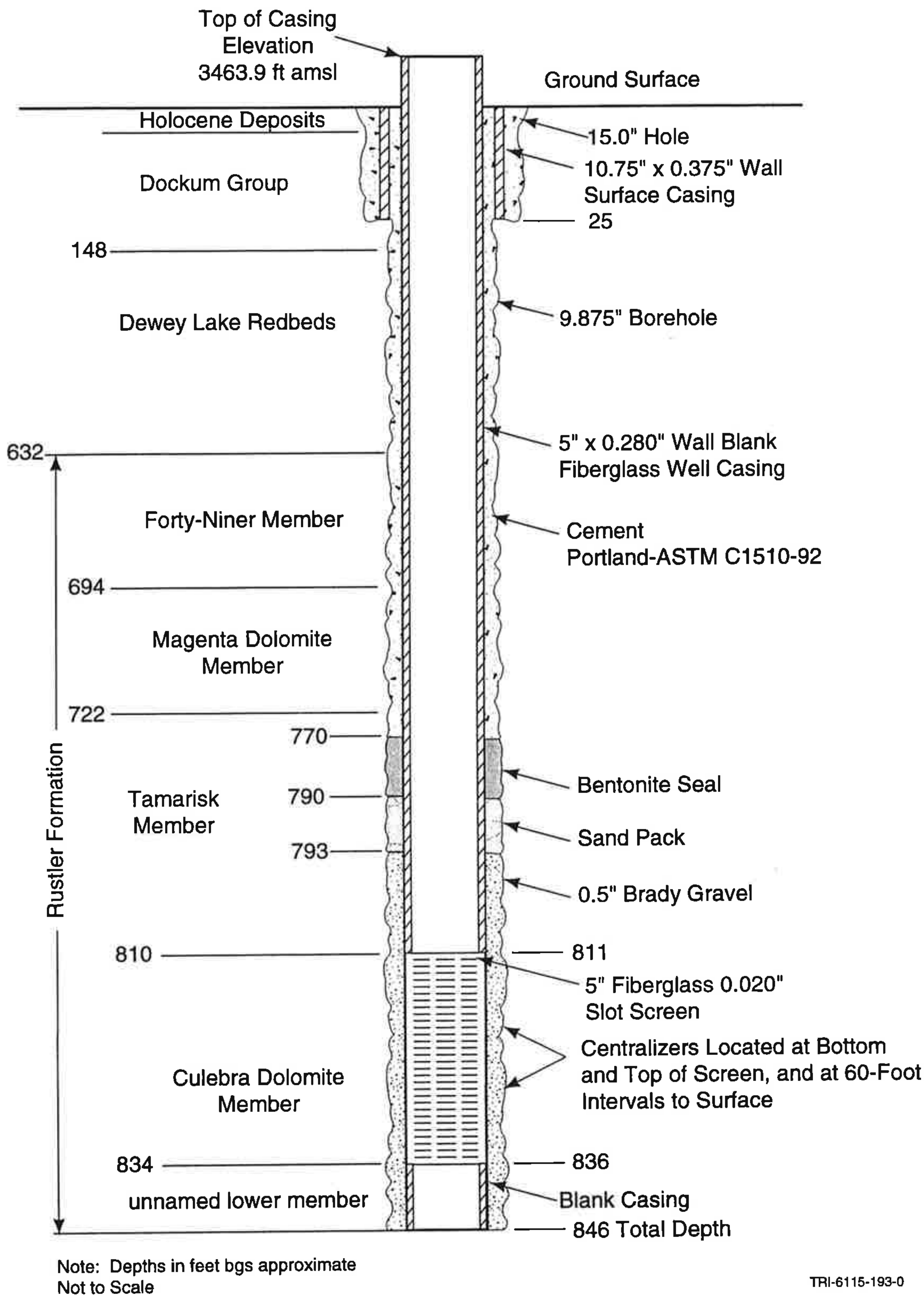

Figure 5-2. As-built configuration of well WQSP-2.

833.0 to 879.0 ft bgs using a 5¼-inch core bit to cut 4-inch-diameter core. After coring, WQSP-3 was reamed to 9⅞ inches in diameter to a total depth of 880 ft bgs. WQSP-3 was cased from the surface to 880 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 844 to 869 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 827 to 830 ft bgs and with 8/16 Brady gravel from 830 to 880 ft bgs. Based on core log results, the Culebra is located from 844.0 to 870.4 ft bgs. See Figure 5-3.

WQSP-4 - Well WQSP-4 was drilled between October 5 and 10, 1994, to a total depth of 800.0 ft bgs. The borehole was drilled through the Culebra and extends 9.2 ft into the unnamed lower member of the Rustler Formation. The well was drilled to a depth of 740.5 ft bgs with a 9⅞-inch drill bit using compressed air as the drilling fluid. The interval from 740.5 to 798.0 ft bgs was cored using a 5¼-inch core bit to cut 4-inch-diameter core using air mist with a foaming agent as the drilling fluid. After coring, WQSP-4 was reamed to 9⅞ inches in diameter to a total depth of 800 ft bgs. WQSP-4 was cased from the surface to 800 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 764 to 789 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 752 to 755 ft bgs and with 8/16 Brady gravel from 755 to 800 ft bgs. Based on core log results, the Culebra is located from 765.6 to 790.8 ft bgs. See Figure 5-4.

WQSP-5 - Well WQSP-5 was drilled between October 12 and 19, 1994, to a total depth of 681.0 ft bgs. The borehole was drilled through the Culebra and extends 10.6 ft into the unnamed lower member of the Rustler Formation. The well was drilled to a depth of 676 ft bgs using compressed air as the drilling fluid. The borehole was cleaned using air mist with a foaming agent. WQSP-5 was drilled to 648 ft bgs using a 9⅞-inch drill bit and was cored from 648.0 to 676.0 ft bgs using a 5¼-inch core bit to cut 4-inch-diameter core. After coring, WQSP-5 was reamed to 9⅞ inches in diameter to a total depth of 681 ft bgs. WQSP-5 was cased from the surface to 681 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 646 to 671 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 623 to 626 ft bgs and with 8/16 Brady gravel from 626 to 681 ft bgs. Based on core log results, the Culebra is located from 648.0 to 674.4 ft bgs. See Figure 5-5.

WQSP-6 - Well WQSP-6 was drilled between September 26 and October 3, 1994, to a total depth of 616.6 ft bgs. The borehole was drilled through the Culebra and extends 9.7 ft into the

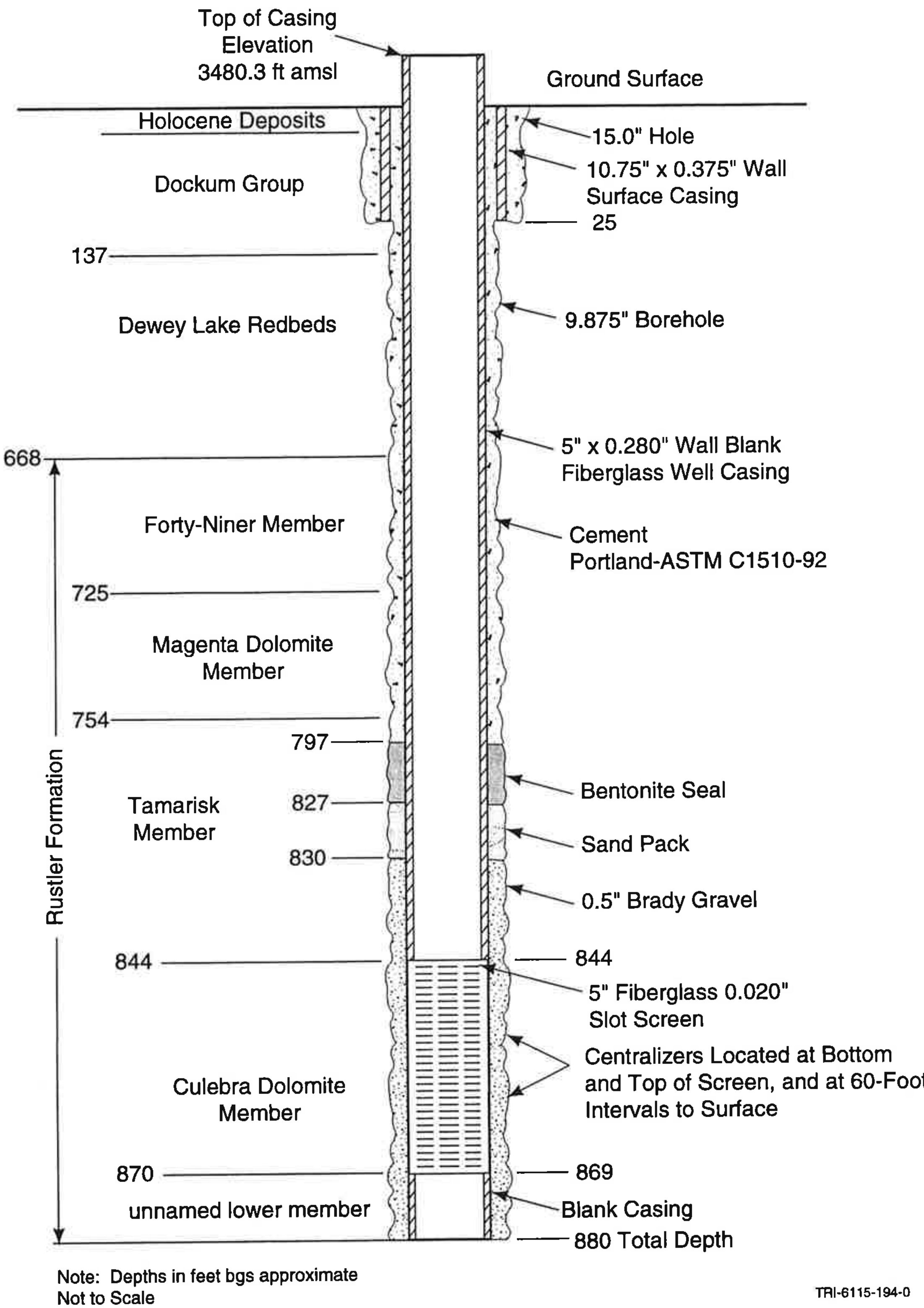

Figure 5-3. As-built configuration of well WQSP-3.

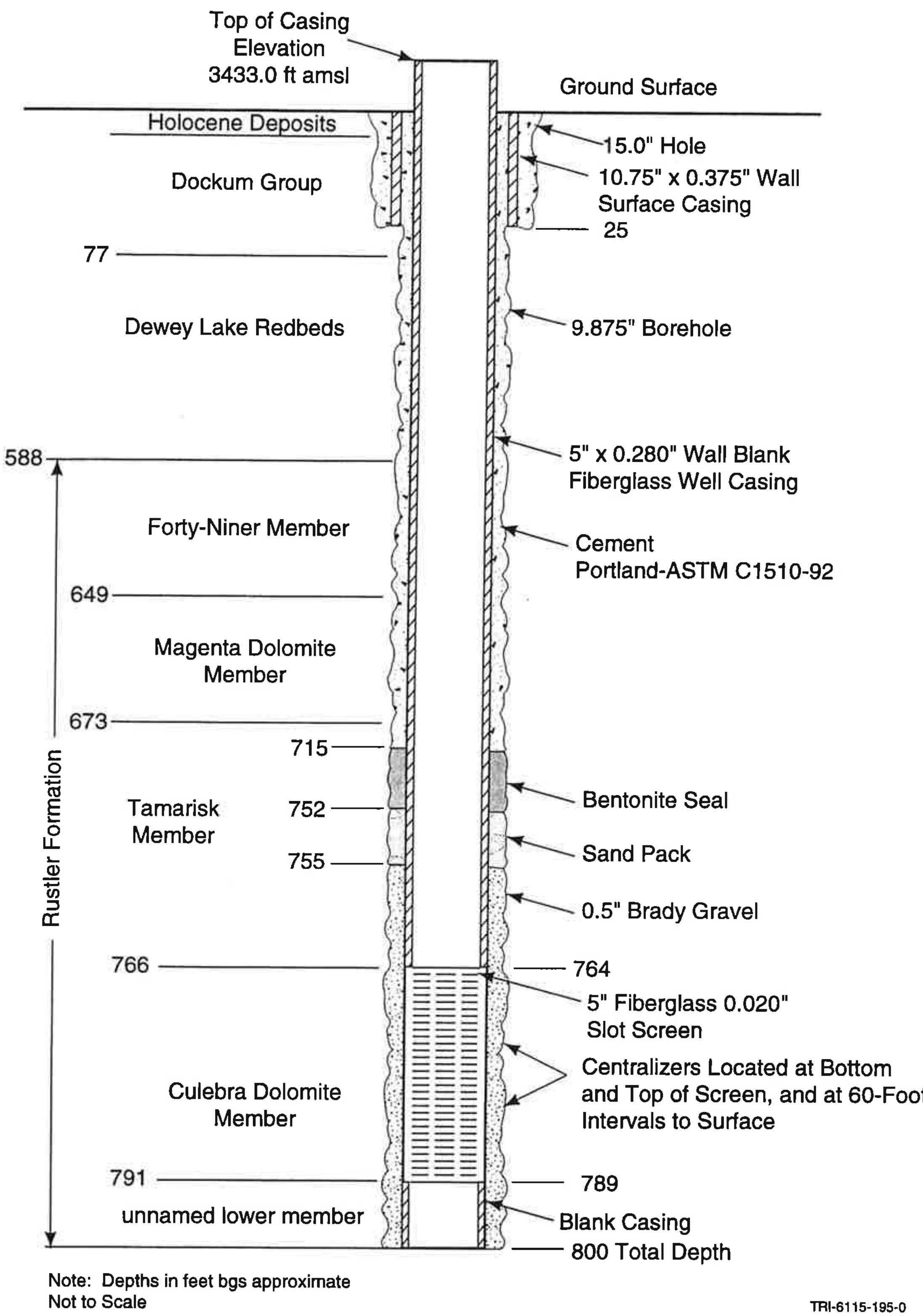

Figure 5-4. As-built configuration of well WQSP-4.

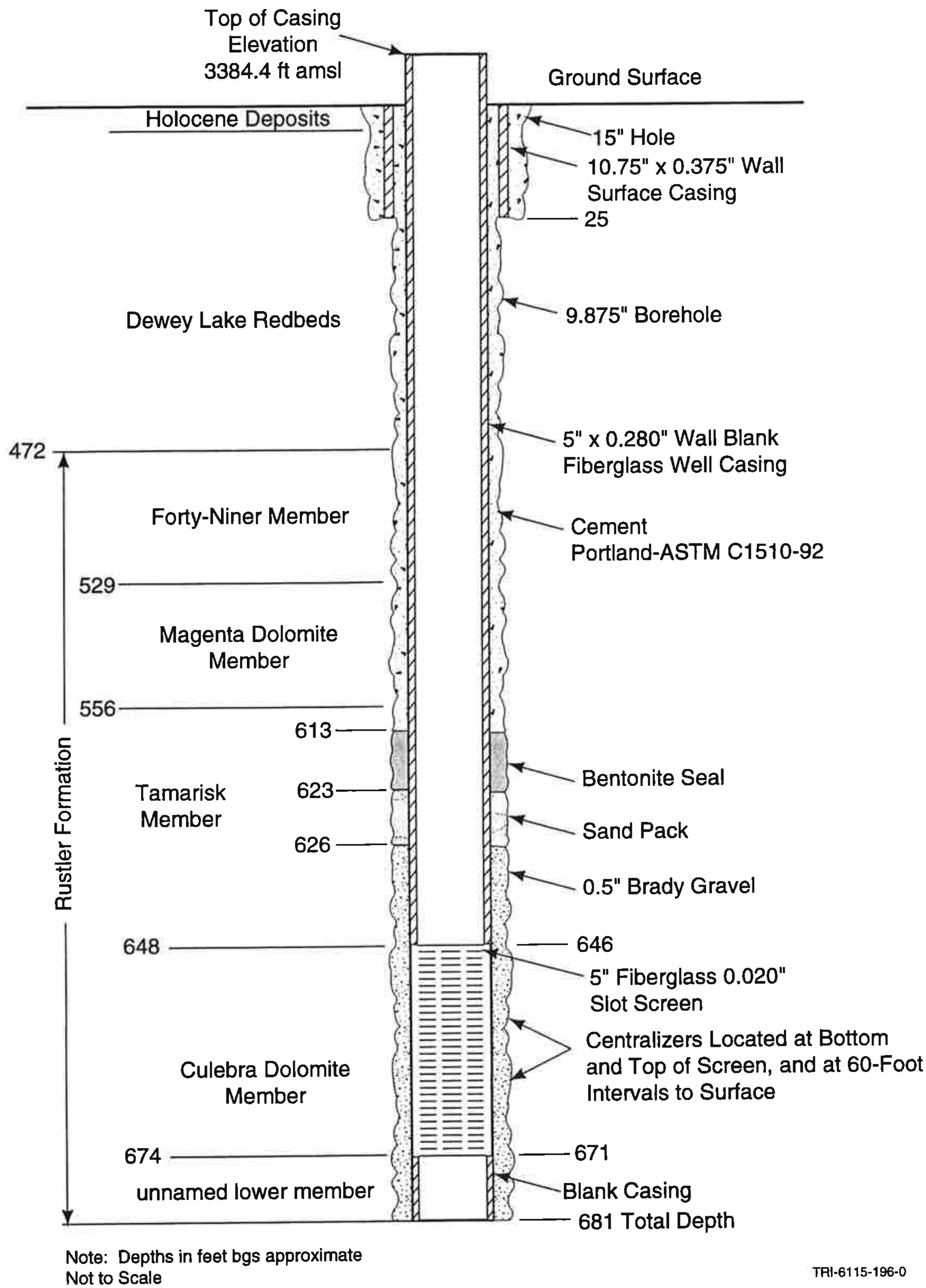

Figure 5-5. As-built configuration of well WQSP-5.

unnamed lower member of the Rustler Formation. The well was drilled to a depth of 367 ft bgs using compressed air as the drilling fluid. The interval from 367 to 616 ft bgs (the total depth) was drilled using brine as the drilling fluid. WQSP-6 was drilled to 568 ft bgs using a 9⅞-inch drill bit and was cored from 568 to 616 ft bgs using a 5¼-inch core bit to cut 4-inch-diameter core. After coring, WQSP-6 was reamed to 9⅞ inches in diameter to a total depth of 616.6 ft bgs. WQSP-6 was cased from the surface to 616 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen across the Culebra interval from 581 to 606 ft bgs. The annulus between the borehole wall and casing/screen is packed with sand from 567 to 570 ft bgs and with 8/16 Brady gravel from 570 to 616.6 ft bgs. Based on core log results, the Culebra is located from 582.0 to 606.9 ft bgs. See Figure 5-6.

WQSP-6A - Well WQSP-6A was drilled between October 31 and November 1, 1994, to a total depth of 225.0 ft bgs. The borehole was drilled through a water-producing zone in the Dewey Lake Redbeds that had been previously encountered while drilling well WQSP-6. The well was drilled to a depth of 225 ft bgs using compressed air as the drilling fluid. The borehole was cleaned using air mist with a foaming agent. WQSP-6A was drilled to 160 ft bgs using a 9⅞-inch drill bit and was cored from 160.0 to 220.0 ft bgs using a 5¼-inch core bit to cut 4-inch-diameter core. After coring, WQSP-6A was reamed to 9⅞ inches in diameter to a total depth of 225 ft bgs. WQSP-6A was cased from the surface to 225 ft bgs with 5-inch (0.280-inch wall) blank fiberglass casing with in-line 5-inch-diameter fiberglass 0.020-inch slotted screen from 190 to 215 ft bgs. The annulus between the borehole wall and the casing/screen is packed with sand from 172 to 175 ft bgs and with 8/16 Brady gravel from 175 to 225 ft bgs. See Figure 5-7.

5.2.2 Testing and Water-Level Histories

Well-development pumping has been performed by Westinghouse on each of the WQSP wells to remove drilling mud and fluids from the well and to develop the well for future water-quality sampling and hydrologic testing. Provided in Table 5-1 is a list of the wells pumped, the durations of pumping, and the estimated average pumping rates. Water-level data from the wells are shown in Figures 5-8 through 5-14.

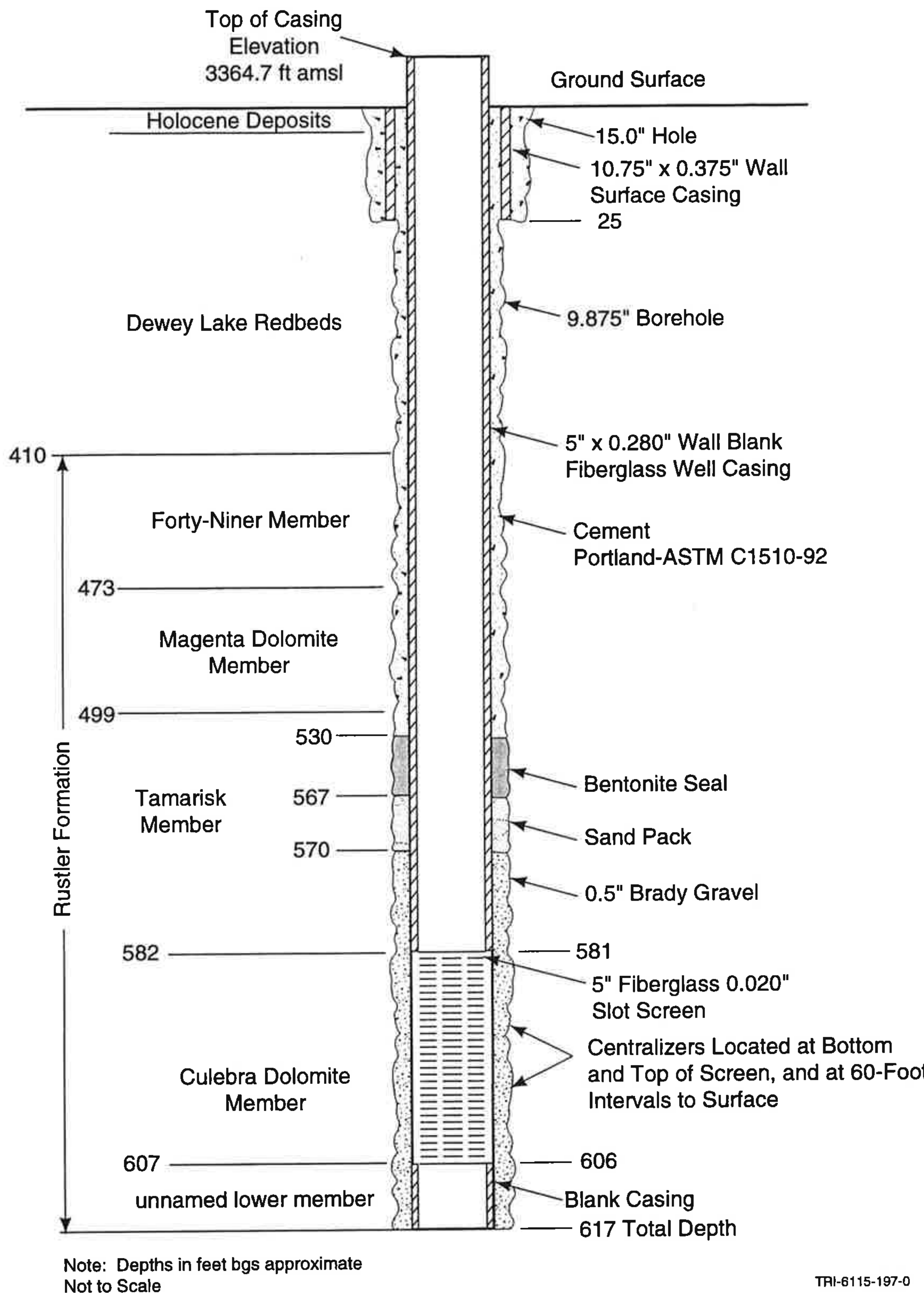

Figure 5-6. As-built configuration of well WQSP-6.

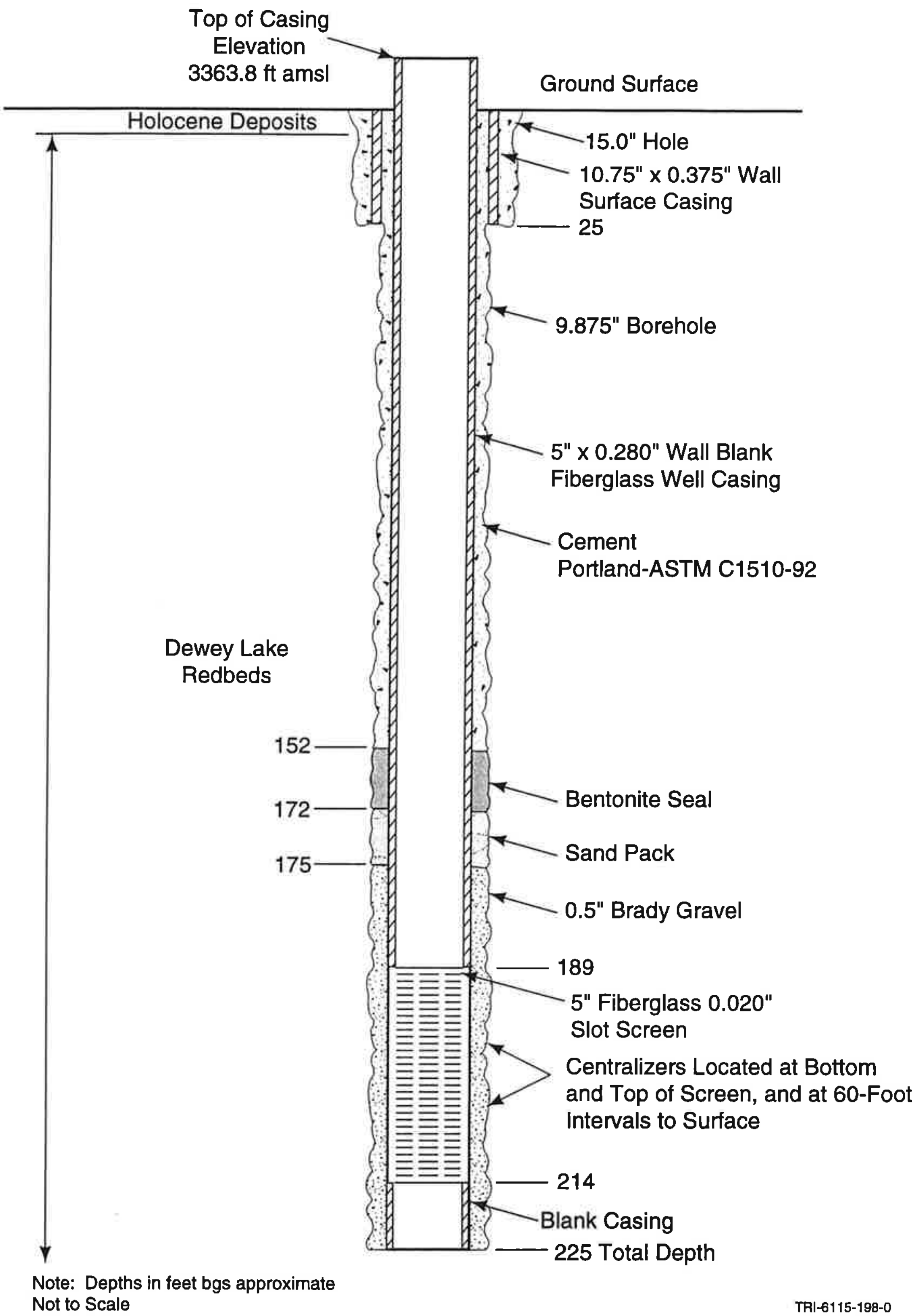

Figure 5-7. As-built configuration of well WQSP-6A.

Table 5-1. Well-development pumping exercises in WQSP wells.

WELL	DATE PUMPED	DURATION OF PUMPING (hr)	EST. PUMPING RATE (gpm)
WQSP-1	October 28, 1994	3.0	10.9
WQSP-2	October 27, 1994	3.5	10.4
WQSP-3	November 1, 1994	2.25	0.8
WQSP-4	October 13, 1994 October 14, 1994	4.0 ~3.25	8.0 8.0
WQSP-5	October 25, 1994	4	1.8-2.0
WQSP-6	October 10, 1994	4	0.5-0.75
WQSP-6A	November 2, 1994	1.3	28.0

5.3 Personnel and Work Schedules

All field tasks will be performed by the field-operations team. Two to three members of the field team will prepare each well pad, including assembly of the testing equipment, the DAS, and the discharge-measurement/flow-regulation system. During the early stages of pumping tests, up to four persons may be required to monitor and regulate discharge rates, monitor the DAS, perform water-quality measurements, and measure water levels in nearby monitoring wells. During the recovery phase, staffing will be reduced as flow control, discharge measurements, and water-quality monitoring tasks will no longer be required. The pumping tests typically will be accomplished using two twelve-hour shifts or three eight-hour shifts per day with minimum two-person crews per shift, with one person responsible for monitoring the pumping rate, water-quality measurements, and DAS and generator monitoring. The second person will be responsible for water-level monitoring. The recovery period will require DAS and generator monitoring, and water-level measurements. The SNL PI and/or the HTC will determine actual staffing levels at the times of the tests.

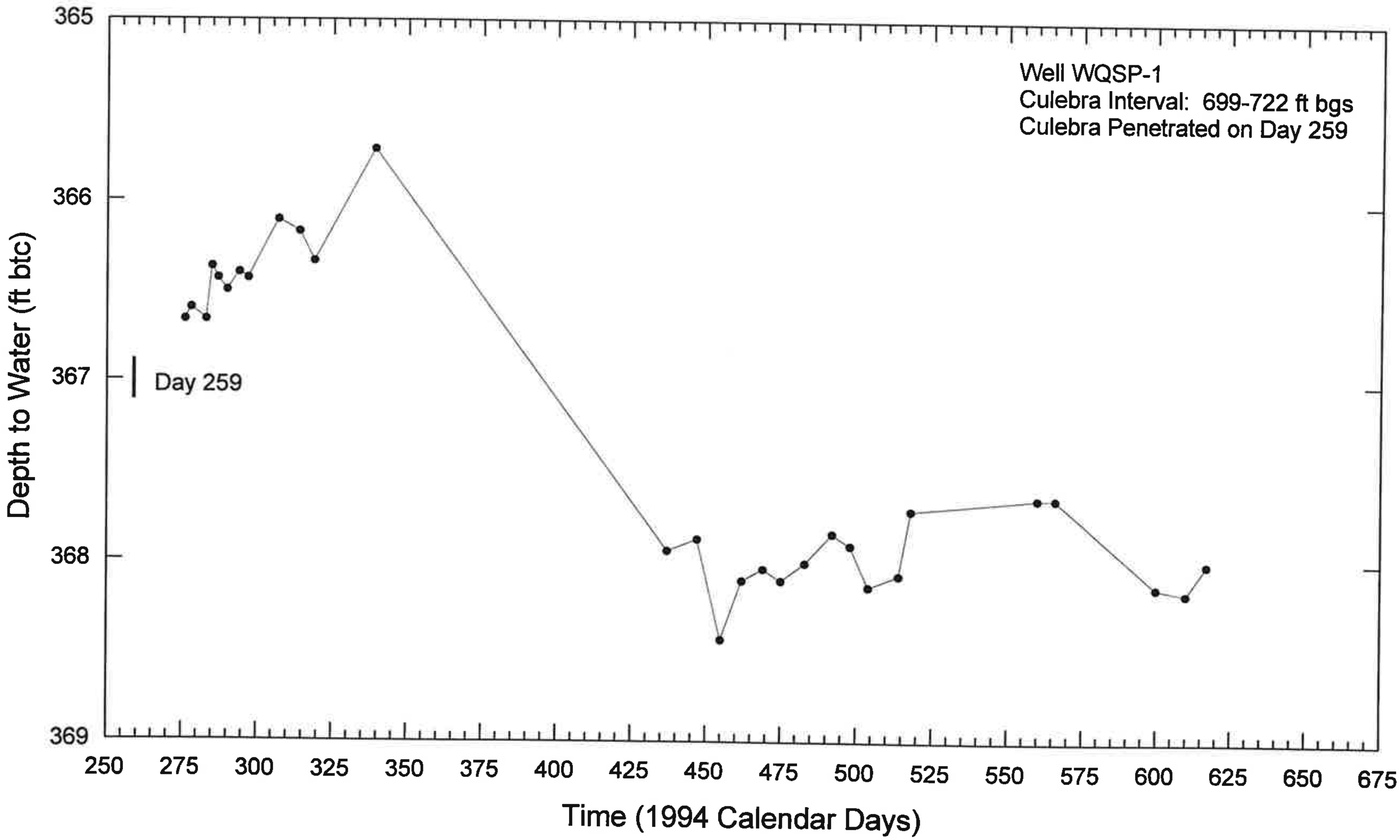

Figure 5-8. Water-level measurements in WQSP-1.

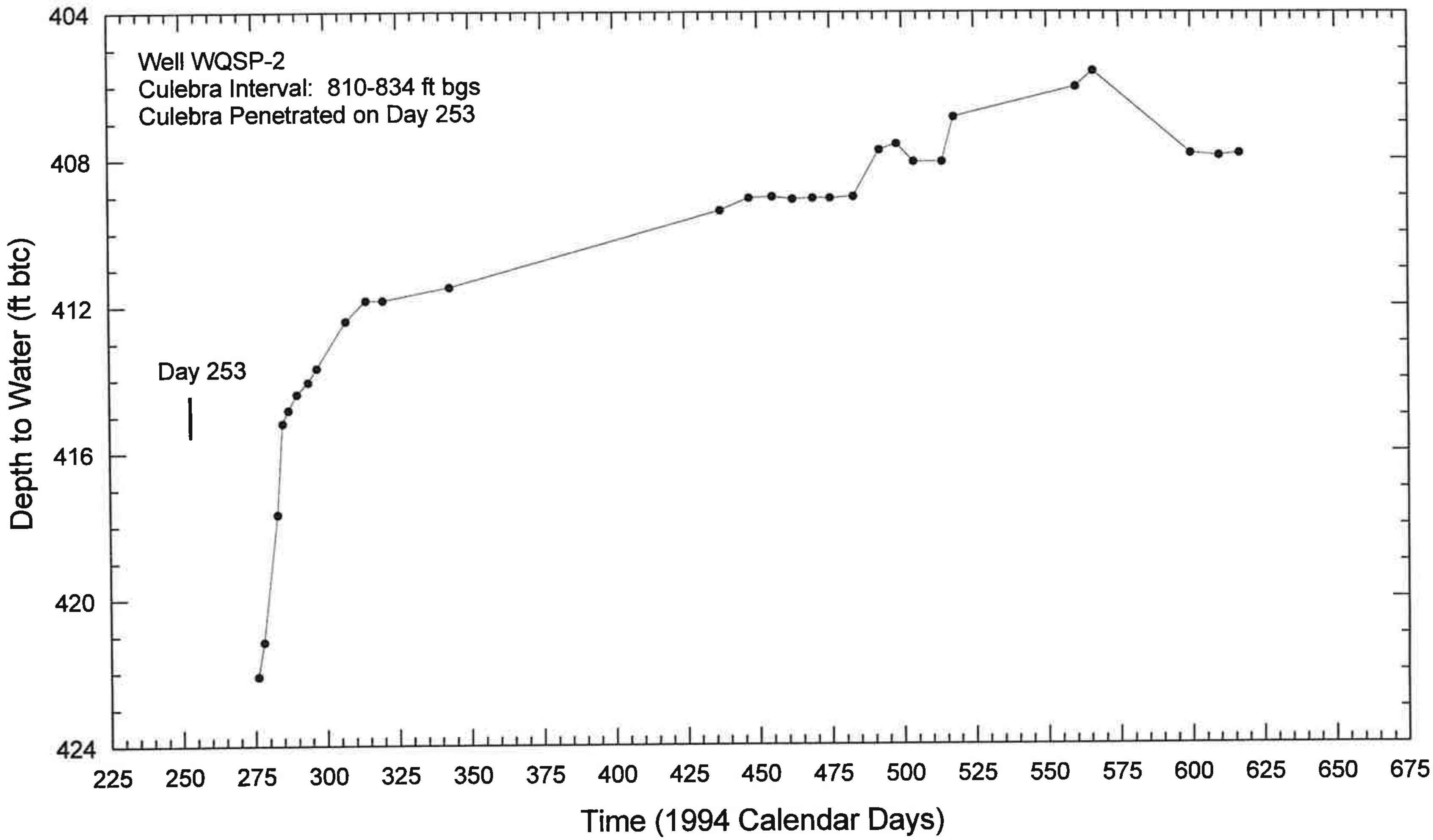

Figure 5-9. Water-level measurements in WQSP-2.

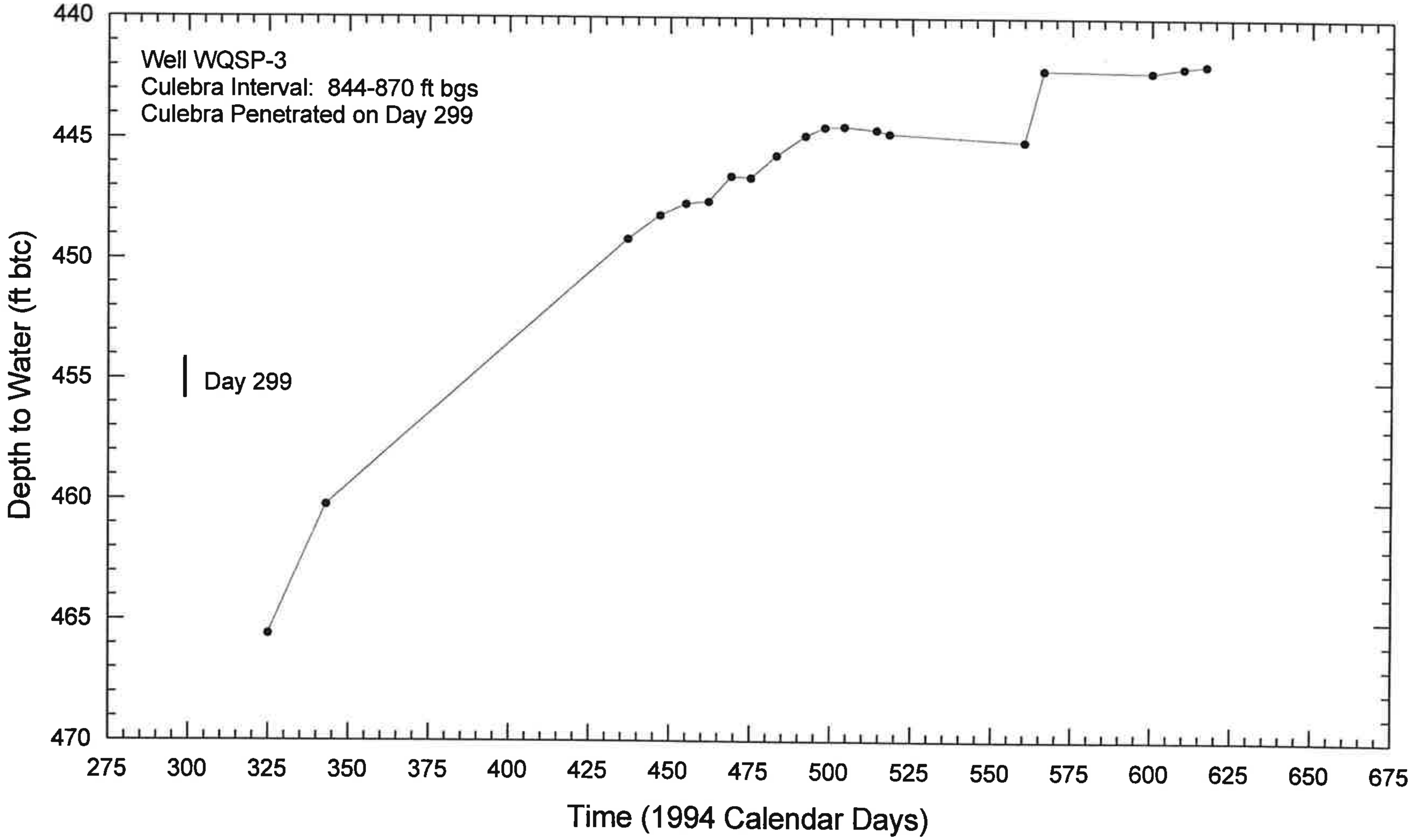

Figure 5-10. Water-level measurements in WQSP-3.

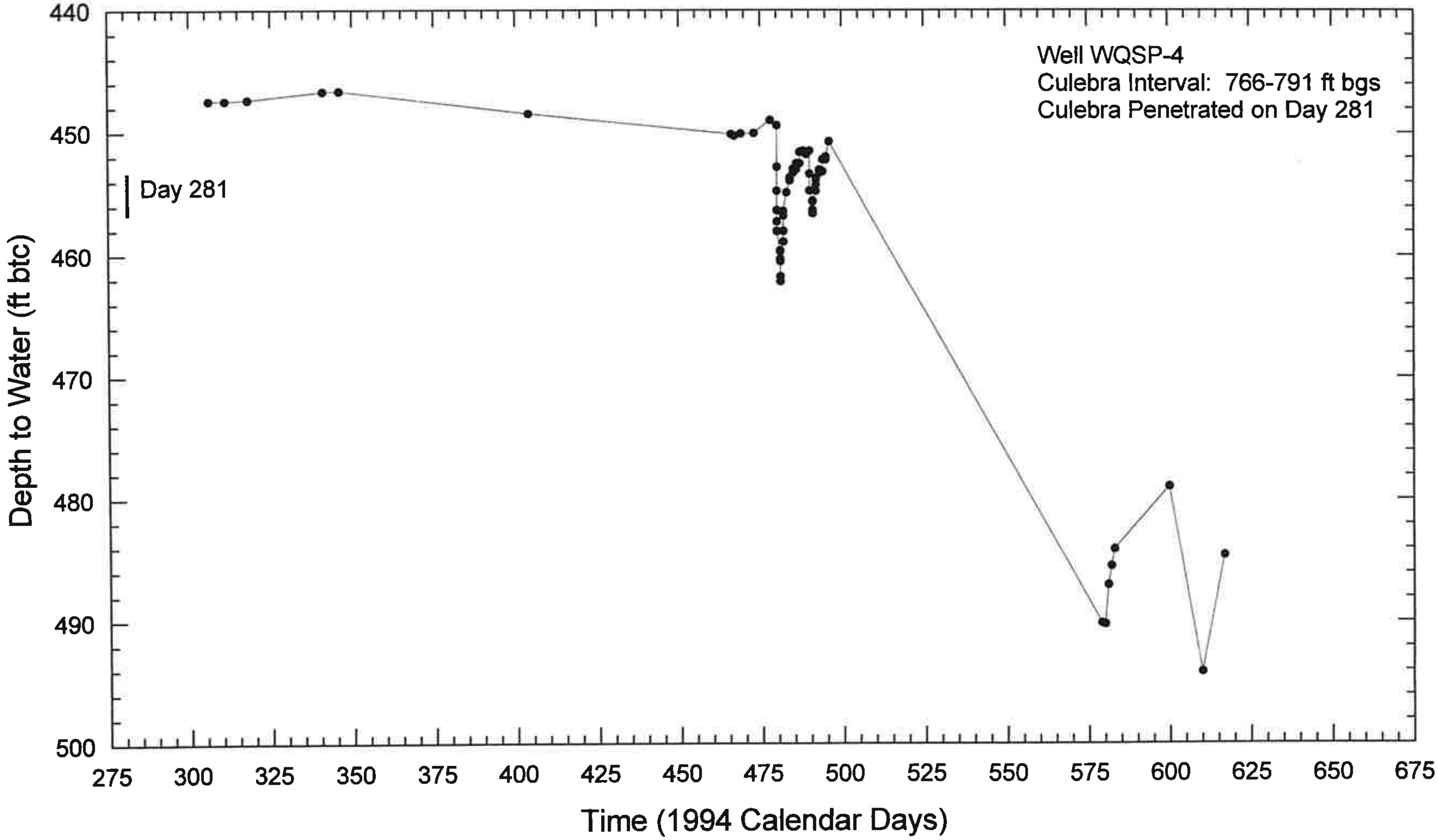

Figure 5-11. Water-level measurements in WQSP-4.

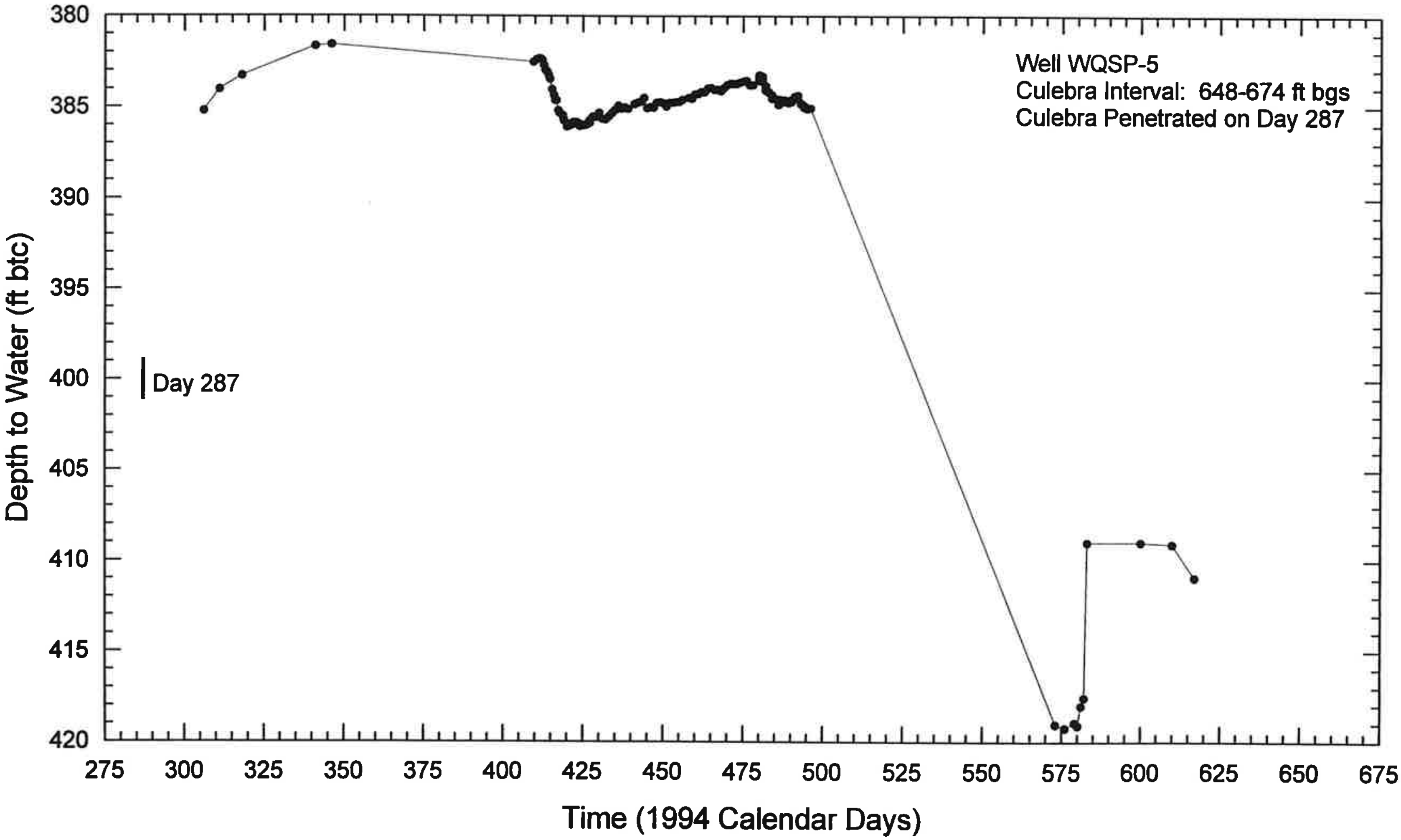

Figure 5-12. Water-level measurements in WQSP-5.

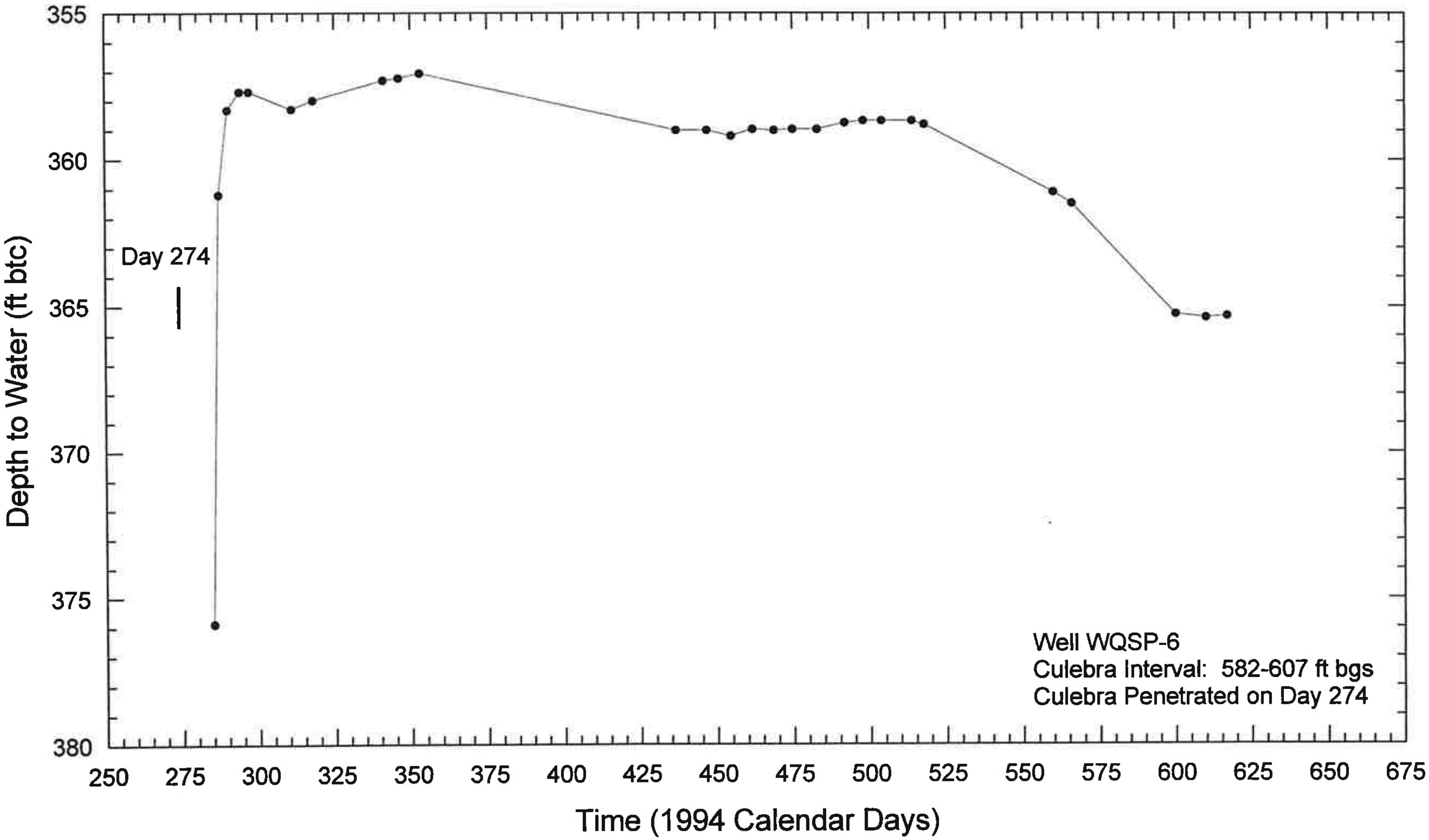

Figure 5-13. Water-level measurements in WQSP-6.

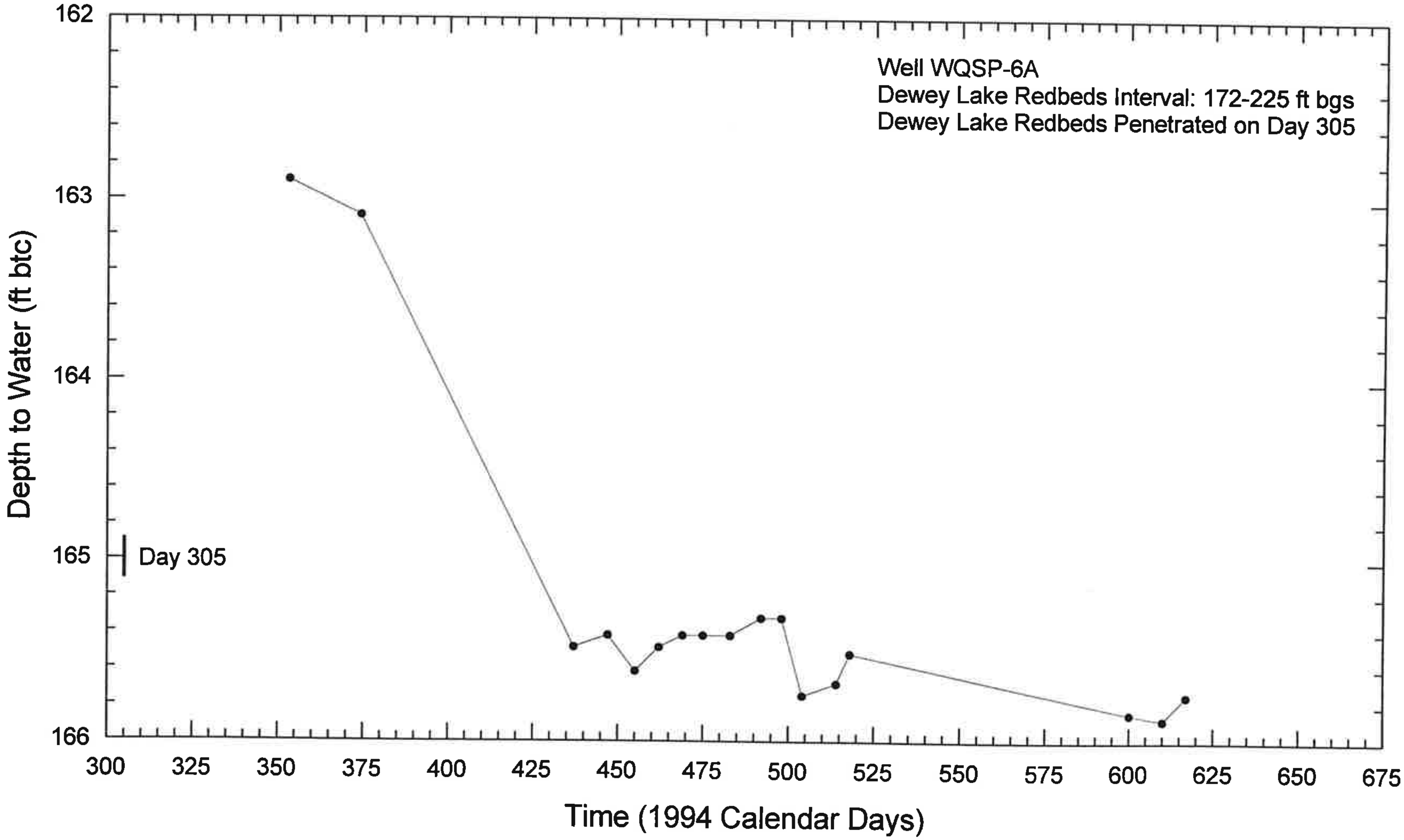

Figure 5-14. Water-level measurements in WQSP-6A.

6. INSTRUMENTATION/TEST EQUIPMENT/FACILITIES

Equipment needed for the hydraulic testing of the WQSP wells will consist of instrumentation at land surface and downhole equipment to be installed in the wells. All equipment will consist of either "off the shelf" items ordered directly from suppliers or standard equipment provided by service companies in conducting their contracted tasks. The need for specially-designed equipment is not anticipated. All equipment used for testing, including modified standard equipment, will be documented as part of the QA records. The following sections describe the equipment to be used in the well-testing program.

6.1 Submersible Pumps

Westinghouse has installed submersible pumping systems in the WQSP wells included in this test plan. The pump systems consist of multi-stage Grundfos pumps with Franklin motors. One and one-half horsepower (h.p.) pumps with 3-h.p. motors were installed in the expected low-capacity wells, WQSP-3 and WQSP-6, and 3-h.p. pumps with 5-h.p. motors were installed in the other five wells. Figure 6-1 illustrates the general configuration of the downhole equipment to be used for testing the WQSP wells. To ensure immediate flow control and regulation during testing, the submersible pumps have been installed with in-line check valves to assure that the discharge tubing will be filled with fluid at the start of pumping. The depths of the submersible pumps were measured during installation.

6.2 Data-Acquisition System

A computer-controlled data-acquisition system (DAS), as illustrated schematically in Figure 6-2, will be used to monitor and record the test data. The basic system consists of a downhole pressure transducer to measure downhole fluid pressure, an electronically monitored flow meter/flow controller, a power-excitation input to access the transducer and flow meter, a digital voltmeter to observe the voltages of the return signals, a data-control unit to access each gauge's signal, a programmable voltage standard to verify the signal output from gauge and excitation devices, and a microcomputer to store and process the data. For testing of the WQSP wells, the pressure transducer will be installed below the water level in the water-level-measurement access tubing and above the pump intake to monitor the borehole fluid pressure.

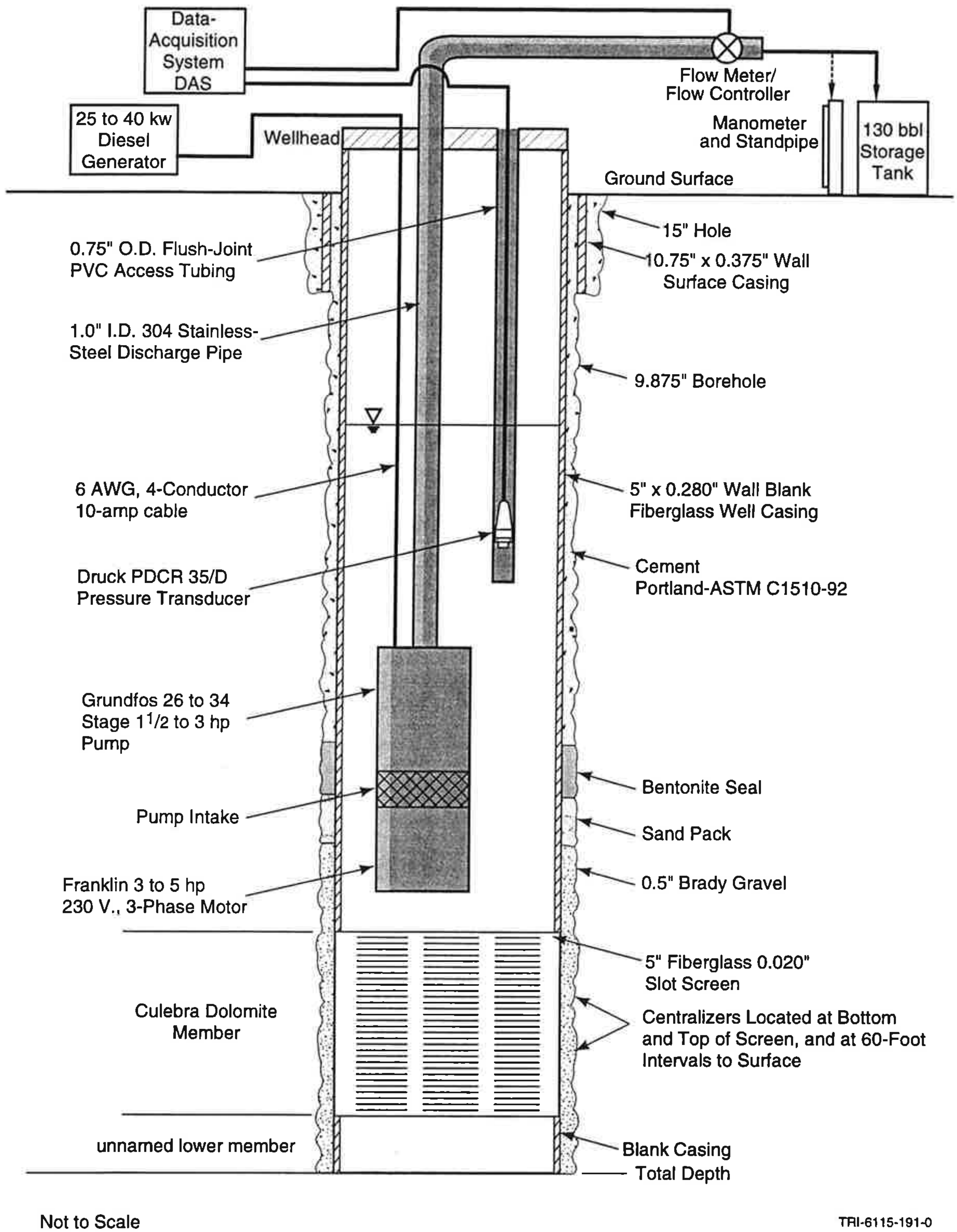

Figure 6-1. Generalized well and equipment configuration for testing.

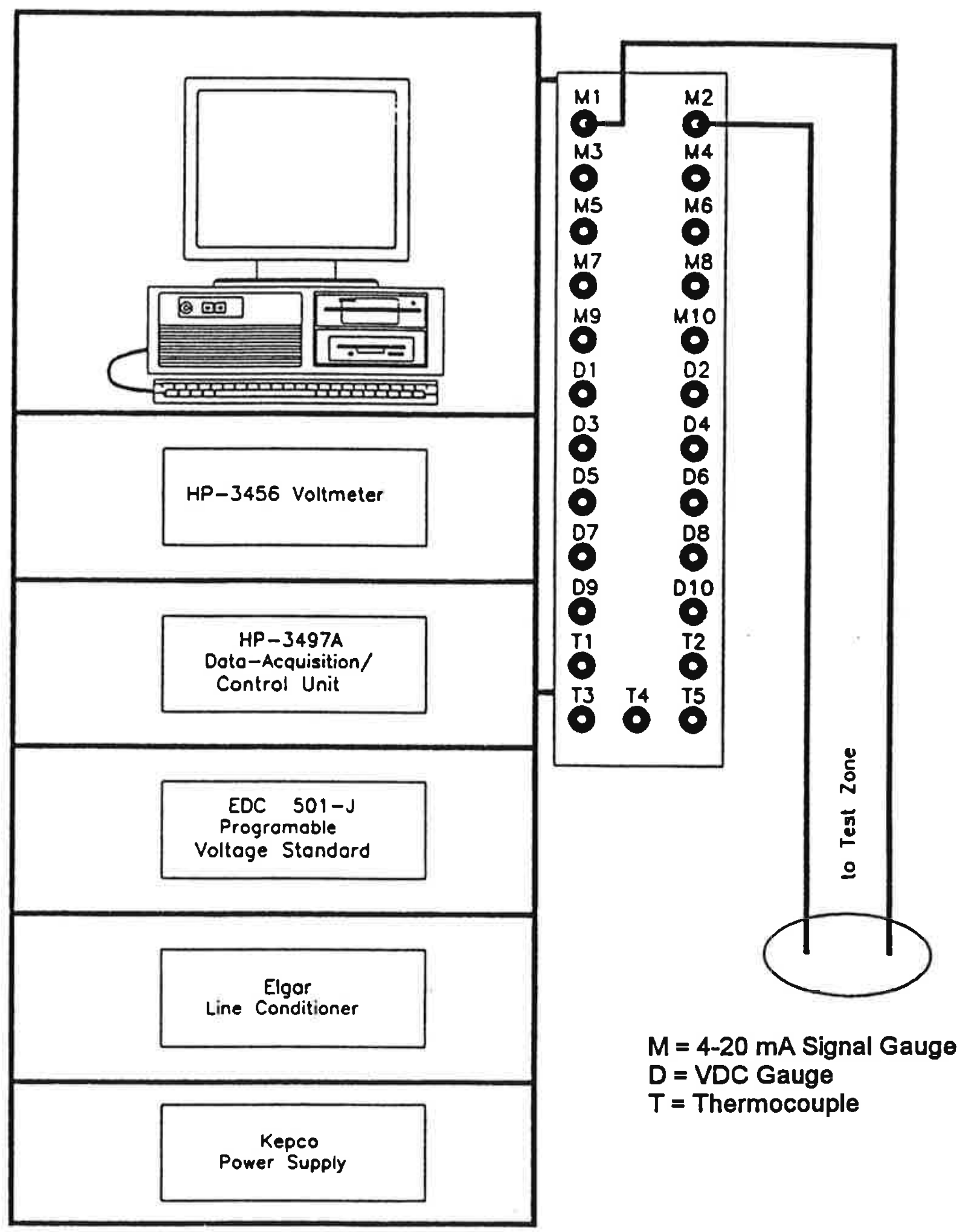

Figure 6-2. Schematic illustration of data-acquisition system.

6.3 Pressure Transducers

Fluid-pressure data will be collected using Druck PDCR 35/D 0 to 100 psig pressure transducers. The transducers require a 10 VDC input voltage input and the voltage output is monitored with a digital volt meter. Calibration of the Druck pressure transducers will be documented as required by the SNL WIPP QAPD.

6.4 Water-Level Sounders

During some of the WQSP-well pumping tests, water-levels in some nearby observation wells may be measured using the Solinst electric water-level sounders in accordance with SNL Technical Operating Procedure (TOP) 512. The Solinst meter consists of a graduated plastic tape containing two wire leads, a water-level probe at the downhole end of the tape, batteries, and a signal light and buzzer mounted on a surface reel. When the water-level probe enters the water, the electrical conductivity of the water closes the electric circuit on the tape, activating the surface light and buzzer. The water level is read directly, in feet or meters, on the graduated plastic tape at the observation-well measuring point, which will be clearly marked on the surface casing.

Drawdowns caused by pumping the test wells may be observed in other wells at the WIPP site. Therefore, before beginning testing of the WQSP wells, pretest water-level measurements will be made in some of the following WIPP-site observation wells: H-1, H-2b2, H-3b2, H-4b, H-5b, H-6b, H-11b4, H-14, H-15, H-17, H-18, WIPP-12, WIPP-18, WIPP-19, WIPP-21, WIPP-22, WIPP-30, DOE-1, DOE-2, ERDA-9, WQSP-1, WQSP-2, WQSP-3, WQSP-4, WQSP-5, WQSP-6, WQSP-6A, P-17, and P-14.

6.5 Discharge Meters

Fluid-discharge data will be collected during all production periods. The pumping-rate/discharge data will be obtained using both a totalizing flow meter and an electronic flow meter/flow controller system. An additional check on the discharge rate may be provided using a calibrated standpipe according to TOP 514.

Total discharge during pumping tests will be measured with a Carlon in-line totalizing flow meter, or equivalent. The Carlon flow meter has a ⅝-inch orifice, and is a brass-housed synthetic (non-corrosive) turbine flow meter designed for discharge rates of 1 to 20 gpm, with scale divisions of 0.1 gallons. The Carlon flow meter is a totalizing flow meter and monitors only the total volume of fluid pumped. The average pumping rate is obtained by observing the meter at the beginning and end of a time period. These time-and-volume data will be used to calculate the average discharge rate for the time period in question. The schedule may be adjusted at the discretion of the HTC or his designee depending on test results. These data will be recorded in accordance with TOP 505. The flow meter will be checked during each activity to verify that it is performing within design specifications.

In addition to the Carlon flow meter, an Endress-Hauser FTI 1943 Variomax Electromagnetic flow meter, or equivalent, may be used to measure the discharge rate during pumping tests. The Variomax is a ½-inch orifice magnetic flow meter requiring 115 VAC with a 4-20 mA signal output providing both discrete and totalizing flow measurements for pumping rates ranging from 0-15 gpm. The operation of the magnetic flow meter is based on Faraday's Law which states that the voltage induced across any conductor as it moves at right angles through a magnetic field is proportional to the velocity of that conductor. In this case, the conductor is the formation fluid flowing through a discharge pipe.

The pumping rates will be regulated using an electronically actuated flow-control valve to apply backpressure to the pump, and a Dole in-line flow-regulation valve located upstream of the flow meter. These two valves, in combination with the check valve at the pump, will prevent unregulated flow from damaging the flow meter and will prevent spurious early-time data during the pumping tests.

6.6 Water-Quality Measurement Instruments

During the pumping-test phases of the program, electrolytic conductivity, temperature, pH, and specific gravity of the produced water may be measured. These water-quality data will be considered qualitative in nature and will not be used for interpretation but only to indicate relative changes in the quality of the fluid produced from the WQSP wells. The electrolytic conductivity of the fluid will be measured with an ATI Orion benchtop conductivity meter; the temperature with a laboratory-grade mercury thermometer; pH with a Cole Parmer pH/mV meter; and the specific gravity with a laboratory-grade hydrometer. These water-quality determinations may be carried out in conjunction with non-DAS discharge-control measurements. Unusual or rapid changes in the observed electrolytic conductivity will be documented and the measurement frequency will be modified to accommodate these changes and these measurement-frequency changes will be documented in the field scientific logbook.

6.7 Diesel-Powered Generators

Diesel-powered generators will be needed to generate electricity to power equipment to be utilized for the WQSP hydraulic-testing program. Diesel-powered generators will be operated in accordance with TOP 510: Manual Start of Remote Diesel Generators. The operation of the diesel-powered generators is not a quality-affecting activity. Therefore, documentation of the activities as specified in TOP 510 (e.g., Form 146) is not mandatory. All training will be documented according to established WIPP procedures.

7. TESTING REQUIREMENTS/PROCEDURES

7.1 Testing Requirements

The testing program, testing methods, and testing equipment for the WQSP wells must meet the following requirements.

Applied testing procedures must:

1. Meet the objectives of this Test Plan.

2. Allow individual hydraulic tests to be successfully accomplished with the available equipment and the available time for testing. Hydraulic tests and testing procedures should be optimized to meet test objectives within the allotted time for testing.

3. Provide information about the conditions around the test well and between the test well and nearby wells. Because of the limited area of influence of slug tests, responses to slug tests may not be observable at other wells. However, the closest wells may be monitored during slug tests.

4. Provide data with which to estimate formation transmissivity and hydraulic head.

The testing equipment for the hydraulic testing should:

1. Provide quality data to support test objectives.

2. Perform according to design and manufacturer specifications.

3. Be calibrated, as appropriate, according to standards acceptable under the SNL QAPD.

7.2 Pretest Activities

Pretest activities will consist of moving equipment onto the WQSP well pads, setting up the equipment, and establishing the pretest water level before the installation of any downhole testing equipment. If necessary, water for slug-injection tests will be collected using the submersible pump in the test well. Use of water from the well to be tested will help to prevent unwanted density effects on the well's hydraulic responses and will not interfere with the collection of representative water-quality samples.

7.3 Testing Procedures

7.3.1 Procedures for Pumping Tests

The pumping tests will be conducted using the well configurations established by Westinghouse. Each well will be subject to similar testing operations. The wells will be tested using either a single-rate or multi-rate pumping test following TOP: Pumping Tests.

7.3.1.1 Constant-Rate Pumping Tests

Constant-rate pumping tests are conducted by operating a downhole pump at a constant rate to produce water from the test interval. The constant rates utilized for the pumping tests in the WQSP wells may be preselected after observing the wells' characteristic behavior during well-development and any WQSP sampling activities that may occur prior to the pumping test. The WQSP wells will be tested in open-hole configuration with no downhole inflatable packers or other devices to reduce the potential effect of wellbore storage. Real-time analysis of the fluid-pressure data from the downhole pressure transducers will be used by the test supervisor in conjunction with the SNL PI to establish the time when the pump is to be turned off. The testing time for a constant-rate pumping test may vary from one to several days depending on the apparent formation transmissivity and the observed fluid-pressure responses and the derivative of those responses with respect to time.

7.3.1.2 Multi-Rate Pumping Tests

Multi-rate pumping tests may be performed to provide data to define the Culebra's hydraulic parameters more definitively than can be done with data from a single-rate test. In a likely scenario, a pumping test will involve an initial pumping period during which the pump is operated at a rate less than the anticipated maximum sustainable pumping rate until such time as the test supervisor and the SNL PI are satisfied that the formation's hydraulic response to the pumping rate is adequately defined. Then the pumping rate will be increased to near the maximum sustainable rate. This second constant-rate pumping period will be continued until such time as the test supervisor and the SNL PI are satisfied that the formation's hydraulic response to the pumping rate is adequately defined. Additional constant-rate pumping periods may be added at the discretion of the SNL PI.

The multi-rate pumping tests will be conducted with the wells in open-hole configuration with no downhole inflatable packers or other devices to reduce the potential effect of wellbore storage. Real-time analysis of the fluid-pressure data from the downhole pressure transducers will be used by the test supervisor in conjunction with the SNL PI to establish the time when the pump is to be either turned off or the pumping rate is either increased or decreased for a different constant-rate period. The testing time for each constant-rate pumping period may vary from one to several days depending on the apparent formation transmissivity and the observed fluid-pressure responses and the derivative of those responses with respect to time.

7.3.2 Procedures for Slug Tests

The apparent transmissivities of the Culebra at wells WQSP-3 and WQSP-6, as inferred from responses during completed well-development activities, indicate that slug testing may be needed to evaluate those wells. Testing procedures will be based on TOP 515: Slug and Drillstem Testing. Because of the configurations of the WQSP wells, typical slug testing may not be possible. The following methodologies will be explored to determine their feasibility in performing these tests.

Slug tests require a relatively instantaneous addition (injection) or removal (withdrawal) of fluid from the well being tested. If wellhead access permits, a slug of fluid may be poured into the well casing to effect a slug-injection test. A slug-withdrawal test could be initiated by operating the pre-installed downhole pump at its maximum pumping rate for a few minutes to lower the fluid level in the well casing rapidly. The effect of the addition or removal of the fluid slug would be monitored by a downhole pressure transducer. Real-time analysis of the fluid-pressure data from the downhole pressure transducers will be used by the test supervisor in conjunction with the SNL PI to establish when to terminate the observation period for any slug test.

The addition of fluid not representative of formation fluid during slug-injection testing could compromise future attempts to characterize formation water quality at the test sites. Therefore, water for use in conducting slug-injection tests will be obtained from the wells being tested by pumping prior to testing. Because extracting water from the test wells will cause formation-pressure changes that will require an as-yet-undetermined length of recovery time, the water should be obtained as far in advance of testing as possible. Formation fluid pumped from the test wells will be stored in appropriately cleaned and labeled storage containers at the respective sites.

8. DATA-ACQUISITION PLAN

8.1 General Data Handling

Data are collected in preparation for and in the performance of hydraulic tests. Types of data include design drawings, equipment calibrations, gage and system checkouts, scientific notebooks, field test data, etc. Scientific notebooks are used to record descriptions of field operations. Field test data include water-level measurements, discharge-rate, water-quality parameters, and fluid-pressure observations. All data will be maintained in records notebooks. Records notebooks will be updated upon conclusion of the testing program for the WQSP wells. The original records notebooks will be maintained in accordance with the SNL WIPP QAPD.

8.2 Data-Acquisition System

The PERM5 DAS will be utilized for data collection for the hydraulic-testing program for the WQSP wells. The DAS has the capability to collect data as often as every 15 seconds. Actual sampling rates will be determined by the HTC in consultation with the SNL PI and documented appropriately.

8.3 Disposition of Data

Four principal types of field data will be collected during hydraulic testing: water levels, flow rates, pressures, and water-quality parameters. Water-level measurements, flow-rates, and downhole fluid-pressures may be used in calculations to provide estimates of transmissivity and hydraulic head at each test location. Except for specific gravity measurements, water-quality data are used for indication purposes only to allow monitoring the progress of the pumping tests. Estimates of formation-fluid specific gravity may be used in calculations to convert pressure head data to hydraulic head. Analysis of test data will be performed under the direction of the PI.

8.4 Conversion and Documentation of Data

The field test data can be classified into two categories for the purpose of data handling: manually and digitally collected data. Manually collected data include Solinst water-level measurements, Carlon flow-meter measurements, and the water-quality measurements. Manually collected data are recorded in scientific notebooks or on specified SNL forms following the TOPs listed in Section 12.5. Manually collected data are entered into spreadsheets (i.e., EXCEL or

QPRO) and converted to appropriate units of measure (where applicable). Original data are always included in the spreadsheets along with converted data to provide traceability.

Digitally acquired data, including pressure-transducer data and flow-rate data, are collected and automatically saved and stored on a controlling computer's hard disk and on floppy disks during the progress of each test. As data files are created or modified, changes will be documented in the scientific notebook maintained at the test location. Raw data are stored in a data file (xxxxxxxx.DT2) as originally acquired voltage signals using the PERM5 (version 1.01) DAS software program. A second file, called a header file (xxxxxxxx.HD2) is also generated by PERM5. The header file contains instrument coefficients and test configuration information. At regular intervals to be established, data will be transferred to other computers and/or backup data-storage systems at separate locations other than the DAS. The raw data are converted to engineering units using the PDATA5 (version 1.0) software-conversion program. The converted data file (xxxxxxxx.CON), depending on its size, may be reduced using PARE (version 2.0), a data-reduction program. The Pared data file (xxxxxxxx.PAR) is then imported into a spreadsheet for report presentation, or into GRAPHER™ for graphics presentation. Two copies (disks) of the DT2 and HD2 input files will be submitted along with two copies of the converted output file (disks) to the SWCF at the time of submittal of the records package. In addition, one hard copy of the converted output file will be submitted with the records package. Other output files will be provided to the SWCF upon completion and approval of data reports and/or interpretive reports. Updated control lists of all acquired data will maintained at the SNL WIPP-site office. All software will be controlled as required by the SNL WIPP QAPD.

9. DATA-QUALITY OBJECTIVES

Meeting the test objectives outlined in Section 4 is not simply a matter of specifying the accuracy and/or precision of various measuring instruments. Transmissivity is adequately defined for PA purposes if known to within a factor of two or three. The presence or absence of features such as double-porosity behavior is determined more on the basis of pressure trends in log-log space than on individual measurements of pressure. Calibration of groundwater-flow models to observed hydraulic heads (or water levels) is considered successful if observed and simulated heads agree within 1.6 ft (0.5 m) (LaVenue et al., 1990). Thus, quantitative data-quality objectives are of minor importance in defining the details of the work to be performed under this Test Plan. Experience has shown that standard, off-the-shelf instruments provide measurements of adequate quality to meet both the quantitative and qualitative objectives of hydraulic testing in the Culebra and Dewey Lake.

The data-quality objectives for the instruments providing quantitative information that will be used in test interpretation are listed in Table 9-1.

Table 9-1. Data-quality objectives for instrumentation used in hydraulic tests.

Objective	Flow Meter	Barometer	Water-Level Sounder	Pressure Transducer
Range	0.2-20 gpm	10-15 psia	0-500 ft	0-100 psig
Accuracy	±0.1 gpm	±0.5 psi	±1 ft	±2 psi
Precision	±0.05 gpm	±0.1 psi	±0.1 ft	±0.5 psi

10. DESIGN ANALYSIS

The design of the hydraulic-testing program is reviewed as this Test Plan is reviewed. Because the testing equipment and methods, described in Sections 6 and 7, respectively, have been utilized previously as part of the preliminary testing on the H-19 hydropad (Saulnier and Beauheim, 1995), additional reviews are not needed.

11. PROVISIONS FOR SIGNIFICANT EVENTS

Any event occurring during the operations and activities performed under this Test Plan that may affect the quality and interpretation of the test data is deemed significant and must be documented in the field scientific notebook. This includes both unanticipated events, such as power failures, and events that are anticipated but for which the appropriate action cannot be predetermined, such as the magnitude of a change in pumping rate. The HTC will inform the PI of any significant events that occur. Significant events include, but are not limited to:

- interruptions in the power supplied by electric generators;
- failure of testing or support/ancillary equipment;
- discovery of *in situ* conditions that preclude the conduct of tests as designed;
- changes in the planned sequence of testing events;
- changes in testing parameters, such as pumping rates, that were not previously programmed or specified; and
- unanticipated or unusual test results.

12. QUALITY ASSURANCE

12.1 Hierarchy of Documents

Several types of documents are used to control work performed under this Test Plan. If inconsistencies or conflicts exist among the requirements specified in these documents, the following hierarchy shall apply:

- Memoranda or other written instructions used to modify or clarify the requirements of the Test Plan (most recent instructions having precedence over previous instructions);
- Test Plan: Hydraulic Tests at Wells WQSP-1, WQSP-2, WQSP-3, WQSP-4, WQSP-5, WQSP-6, and WQSP-6A at the Waste Isolation Pilot Plant (WIPP) Site;
- SNL WIPP Quality Assurance Procedures (see Section 12.4); and
- Technical Operating Procedures (see Section 12.5).

SNL QA concurrence will be obtained and/or correction action reports will be written for modifications to Quality Assurance Procedures implemented for work conducted under this Test Plan.

12.2 Quality-Affecting Activities

Activities performed under this Test Plan are quality-affecting with the following exceptions:

- water-quality measurements as specified in TOP 513 (see Section 6.6);
- operation of diesel-powered generators (see Section 6.7);
- assistance provided by the manufacturer/contractor in the installation of tools and testing equipment;
- support services for tasks which do not involve data collection, such as roustabouts, machining, welding, fishing services, fuel, earth moving, etc.; and
- water collection and disposal (see Section 2.2).

Activities that are not quality-affecting are not subject to the requirements of the SNL QA program.

12.3 Quality Assurance Program Description

The SNL WIPP Quality Assurance Program Description (QAPD), Rev. R, is currently in effect and has been approved by the DOE Carlsbad Area Office (CAO) for all WIPP activities assigned to SNL. The requirements and guidance specified in the QAPD are based on criteria contained in 10 CFR 830, American Society of Mechanical Engineers (ASME) NQA-1-1989 Edition (ASME, 1989a), ASME NQA-2a-1990 addenda (Part 2.7) to ASME NQA-2-1989 Edition (ASME, 1989b), ASME NQA-3-1989 Edition (excluding Basic Requirements Section 2.1 (b) and (c)) (ASME, 1989c), DOE Order 5700.6C, and 40 CFR 191. The requirements of the SNL WIPP QAPD, and any revisions thereto, are passed down and implemented through the SNL WIPP Quality Assurance Procedures.

12.4 Quality Assurance Procedures

Quality Assurance Procedures (QAPs) will be implemented in a graded manner as appropriate for the work performed under this Test Plan. The SNL PI will be responsible for identifying and documenting the specific QA requirements that apply to this Test Plan. The SNL QA Chief (or designee) will approve the graded implementation of QA requirements prior to the beginning of data-collection activities.

12.5 WIPP Technical Operating Procedures

The WIPP Technical Operating Procedures (TOPs) that may apply to work performed under this Test Plan include:

TOP 263: Sample Tracking System

TOP 277: Engineering Sketch Control

TOP 472: Intensifier Pump: Operation and Use

TOP 505: Pumping Tests

TOP 507: Installation System Verification During Gage Connection to HP-3497A Stand-Alone Data-Acquisition Systems

TOP 509: Operation of PERM DAS Program

TOP 510: Manual Start of Remote Diesel Generators

TOP 512: Depth-to-Water Measurement Using Solinst Brand Electric Sounder

TOP 513: Water Quality Data: Measurements of Specific Gravity, Conductance, pH, and Temperature

TOP 514: Verification of Totalizing Flow Meter Measurements Using a Verified Standpipe

TOP 515: Slug and Drillstem Testing

Modification to these procedures may be required during testing. Such modifications are not deviations and will not be reported as nonconformances that require corrective action. However, modifications will be documented by the HTC in the scientific notebook as they occur as part of the QA records.

12.6 Data Integrity

Care will be taken throughout the performance of the operations for this Test Plan to ensure the integrity of all data collected including documentation on hard copy and data collected on magnetic media. Duplicate copies of all data will be produced no less frequently than monthly and the duplicate copies will be maintained at separate locations to ensure that data are not lost. Data collected during testing activities shall not be released unless and until the data are reviewed and approved by the SNL PI.

12.7 Instrument Calibration

All quality-affecting work performed by or for SNL as part of this Test Plan will be done with calibrated instruments and equipment. Measurements of specific gravity, electrical conductance, pH, and temperature as specified in TOP 513 are qualitative in nature and are used only to indicate relative changes in the quality of the fluid produced from the H-19 wells. Instruments used for electrical conductance and pH measurements should meet the data-quality objectives defined by the manufacturers' specifications, but do not require calibrations traceable to NIST or other nationally recognized standards. Hydrometers and thermometers used to perform specific-gravity and temperature measurements must be certified by the manufacturer as meeting the manufacturer's specifications.

Flow meters must be certified by the manufacturer as meeting the manufacturer's specifications. The operation of flow meters will be checked in the field prior to use as directed by the HTC. Such operational checks will be documented in the scientific notebook by the HTC as part of the QA records.

Memory gauges used in measuring fluid-pressure changes in observation wells must be certified by the manufacturer as meeting the manufacturer's specifications. The operation of memory gauges will be checked in the field prior to use as directed by the HTC. Such operational checks will be documented by the HTC in the scientific notebook as part of the QA records.

If the accuracy and/or precision of data obtained from hydrometers, thermometers, flow meters, or memory gauges becomes significant, post-test calibrations or other appropriate methods of verifying the manufacturer's certifications will be performed.

12.8 Records

Records shall be maintained as described in this Test Plan and applicable QA implementing procedures. These records may consist of bound scientific notebooks, loose-leaf pages, forms, printouts, or information stored on electronic media. The HTC will ensure that the required records are maintained.

12.8.1 Required QA Records

As a minimum, the documentation of QA records will include:

- times, dates, and intervals of all hydraulic tests;
- persons performing tests;
- test procedures used;
- lists, including model and serial numbers where appropriate, of all equipment used in the tests;
- equipment-specification sheets or information;
- calibration records for all controlled equipment;
- information used to establish test depths;

- sketches of all equipment configurations, showing measured dimensions;
- photographs taken of the equipment and activities;
- a log of photographs taken of the equipment and activities;
- descriptions of activities performed;
- rationales for decisions concerning test sequences, durations, modifications to procedures, or other factors;
- manually collected data;
- data files collected by the DAS;
- a log of data files collected by the DAS;
- a log of samples collected (if any); and
- other information pertinent to the testing.

12.8.2 Miscellaneous Non-QA Records

Additional records that are useful in documenting the history of the testing activities but are considered non-QA records may be maintained and submitted to the SWCF. These records include:

- as-built diagrams of equipment supplied by contractors;
- equipment manuals and specifications;
- water-quality measurements;
- information related to operation of diesel generators;
- equipment manifests; and
- cost and billing information regarding contracted services.

These records do not support Performance Assessment or regulatory compliance and, therefore, are not quality-affecting information.

12.8.3 Submittal of Records

Records resulting from work conducted under this Test Plan, including forms and data stored on electronic media, will not be submitted to the SNL Quality Assurance Department for review and approval as specified in the WIPP procedures. Instead, the records will be assembled into a records package(s) which will be reviewed by the SNL PI and submitted to the SWCF.

13. HEALTH AND SAFETY

SNL field operations will be conducted on land controlled by the WID and the field operations team assembled for this Test Plan will follow all WID safety practices and policies. Operational safety for individual field operations will be addressed through ES&H Preliminary Hazard Assessments (PHAs) and Safe Operating Procedures (SOPs) developed by SNL. Project-specific WIPP-site safety procedures will be approved through the SNL PI, WID safety personnel, and the SNL WIPP-site Safety Advisor. ES&H SOPs applicable to the testing program include those relating to identification of potential hazards, emergency-shutdown procedures, and personnel to be contacted in case of emergencies.

13.1 Safety Requirements

All equipment will be operated in accordance with the appropriate allowable operating pressures and in accordance with the SNL ES&H pressure-safety manual. Pressure ratings for individual parts such as valves and pressure tubing will be either marked by the manufacturer with the maximum allowable operating pressure or such information will be made available in written documentation according to guidelines of the SNL Center 6700 Safety Representative for WIPP-Site Operations, or the SNL Center 6100 Pressure Safety Advisor for WIPP-site test operations.

Additional safety requirements to be observed by field personnel are:

1. appropriate use of safety shoes, safety glasses, hard hats, and protective gloves;
2. ensuring adequate fuel is available for all field vehicles, especially those traveling to remote locations;
3. proper installation and safety procedures when handling electrical submersible pumps and other electrical equipment;
4. proper procedures for operation of diesel-powered generators for on-site electric power;
5. observation of scheduled working hours and driving time;
6. familiarity with on- and off-site road conditions and driving regulations;
7. familiarity with the locations of First Aid supplies, medical support facilities, and fire extinguishers and other safety equipment;

8. familiarity with the location of lists of emergency telephone numbers and persons and offices to notify in the event of emergencies;

9. familiarity with the location of posted crew schedules; and

10. familiarity with the location of all MSDS information.

All field personnel assigned to the field operations described in this Test Plan will receive a safety briefing before the beginning of field operations. In addition, the field-site or shift supervisor will conduct weekly safety meetings. All personnel receiving safety briefings are required to sign and date the safety-briefing form as part of safety-documentation procedures. All work locations will maintain a mobile communication system. In case of accident, injury, or sudden illness, the WIPP Central Monitoring Room (CMR) will be notified immediately. The CMR will coordinate emergency response activities.

13.2 Special Training

All SNL and WIPP-site contractor personnel must receive WIPP-site General Employee Training (GET) followed by annual refreshers as part of employment requirements at WIPP. No other special training requirements are anticipated in addition to the GET and the safety briefings described above.

14. REFERENCES

American Society of Mechanical Engineers. 1989a. *Quality Assurance Program Requirements for Nuclear Facilities*. ASME NQA-1-1989 Edition. New York, NY: ASME.

American Society of Mechanical Engineers. 1989b. *Quality Assurance Requirements for Nuclear Facility Applications*. ASME NQA-2-1989 Edition. New York, NY: ASME.

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