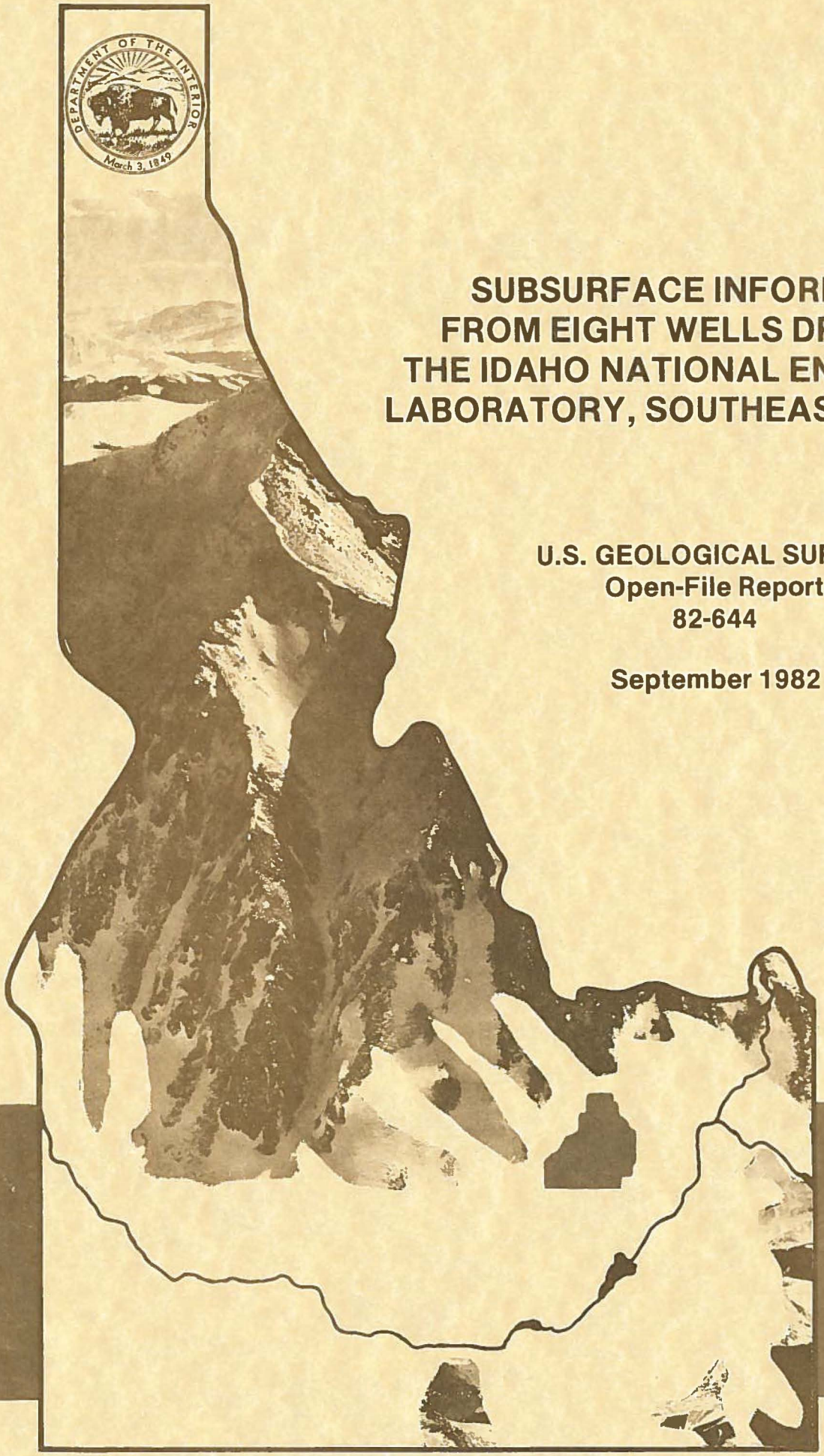
RR

Received on Friday
4 march 1983

IDO-22063

SUBSURFACE INFORMATION FROM EIGHT WELLS DRILLED AT THE IDAHO NATIONAL ENGINEERING LABORATORY, SOUTHEASTERN IDAHO



U.S. GEOLOGICAL SURVEY
Open-File Report
82-644

September 1982

PREPARED FOR THE U.S.
DEPARTMENT
OF ENERGY

Printed in the United States of America

Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
NTIS Price Codes: Printed Copy A03
Microfiche A01

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights. References herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

SUBSURFACE INFORMATION FROM EIGHT WELLS DRILLED AT THE IDAHO NATIONAL ENGINEERING LABORATORY, SOUTHEASTERN IDAHO

By Flora J. Goldstein and Willis D. Weight

U.S. GEOLOGICAL SURVEY

Open-File Report 82-644

Prepared in cooperation with the

U.S. Department of Energy

August 1982

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information write to:

U.S. Geological Survey
Water Resources Division
Project Office
Idaho National Engineering Laboratory
CF-690, Room 164, P.O. Box 2230
Idaho Falls, Idaho 83401

CONTENTS

	Page
Abstract	1
Introduction	1
Purpose and scope	3
Acknowledgments	3
Methods of determining subsurface hydrogeology	3
Completion diagrams	6
Lithology diagrams	6
Caliper logs	6
Gamma-gamma logs	8
Natural gamma logs	9
Neutron logs	9
Drilling, completion, and interpretive documentation	10
Wells 30 and Highway 1	10
Wells 97, 98, and 99	14
Wells 100 and 101	20
RWMC production well	26
Summary	26
Selected references	29

ILLUSTRATIONS

Figure 1.	Relief map of Idaho showing location of the INEL, Snake River Plain, and generalized ground-water flow lines of the Snake River Plain aquifer (from Barraclough, Lewis, and Jensen, 1981)	2
2.	Map showing location of wells, selected facilities, and pertinent geographic features in the INEL vicinity	5
3.	Diagrams showing well completion, lithology, and geophysical logs for well 30	7
4.	Hydrographs for the three piezometers in well 30	12
5.	Diagrams showing well completion, lithology, and geophysical logs for well Highway 1	13
6.	Hydrographs for the three piezometers in well Highway 1	15
7.	Diagrams showing well completion, lithology, and geophysical logs for well 97	16
8.	Diagrams showing well completion, lithology, and geophysical logs for well 98	17
9.	Diagrams showing well completion, lithology, and geophysical logs for well 99	18
10.	Hydrographs for wells 97, 98, and 99	19
11.	Discharge of the Big Lost River downstream from Mackay Reservoir (from Lewis and Goldstein, 1982)	21

Page

12. Diagrams showing well completion, lithology, and geophysical logs for well 100 22
13. Diagrams showing well completion, lithology, and geophysical logs for well 101 23
14. Hydrographs for wells 100 and 101 24
15. Hydrograph for Arbor Test well 25
16. Diagrams showing well completion, lithology, and geophysical logs for the Radioactive Waste Management Complex well 27

TABLE

Table 1. Drilling schedule and well data for eight observation wells at the Idaho National Engineering Laboratory 4

FACTORS FOR CONVERTING INCH-POUND UNITS TO METRIC UNITS

The following factors can be used to convert inch-pound units published herein to the International System (SI) of metric units.

Multiply inch-pound units	By	To obtain metric units
inches (in.)	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
gallons (gal)	3.785	liters(L)
acre-feet (acre-ft)	1,233	cubic meters (m^3)
feet per mile (ft/mi)	0.1894	meters per kilometer (m/km)
curies (Ci)	3.70×10^{10}	becquerel (Bq)

SUBSURFACE INFORMATION FROM EIGHT WELLS DRILLED AT THE IDAHO NATIONAL ENGINEERING LABORATORY, SOUTHEASTERN IDAHO

By

Flora J. Goldstein and Willis D. Weight

ABSTRACT

The Idaho National Engineering Laboratory (INEL) covers about 890 square miles of the eastern Snake River Plain, in southeastern Idaho. The eastern Snake River Plain is a structural basin which has been filled with thin basaltic lava flows, rhyolitic deposits, and interbedded sediments. These rocks form an extensive ground-water reservoir known as the Snake River Plain aquifer.

Six wells were drilled and two existing wells were deepened at the INEL from 1969 through 1974. Interpretation of data from the drilling program confirms that the subsurface is dominated by basalt flows interbedded with layers of sediment, cinders, and silicic volcanic rocks.

Water levels in the wells show cyclic seasonal fluctuations of maximum water levels in winter and minimum water levels in mid-summer. Water levels in three wells near the Big Lost River respond to changes in recharge to the Snake River Plain aquifer from the Big Lost River. Measured water levels in multiple piezometers in one well indicate increasing pressure heads with depth. A marked decline in water levels in the wells since 1977 is attributed to a lack of recharge to the Snake River Plain aquifer.

INTRODUCTION

The Idaho National Engineering Laboratory (INEL) covers about 890 square miles and is located near the central part of the eastern Snake River Plain (fig. 1). The eastern Snake River Plain is a structural basin, 200 miles long and 50 to 70 miles wide, which is filled with basaltic lava flows, silicic volcanic rocks, and sediments. Underlying the plain, and composed of the aforementioned rock types, is an extensive ground-water reservoir known as the Snake River Plain aquifer--a major aquifer in Idaho. Aqueous chemical and radioactive wastes are discharged to shallow ponds and to shallow or deep wells at the INEL. Waste constituents enter the aquifer following percolation through the unsaturated zone or by direct disposal.

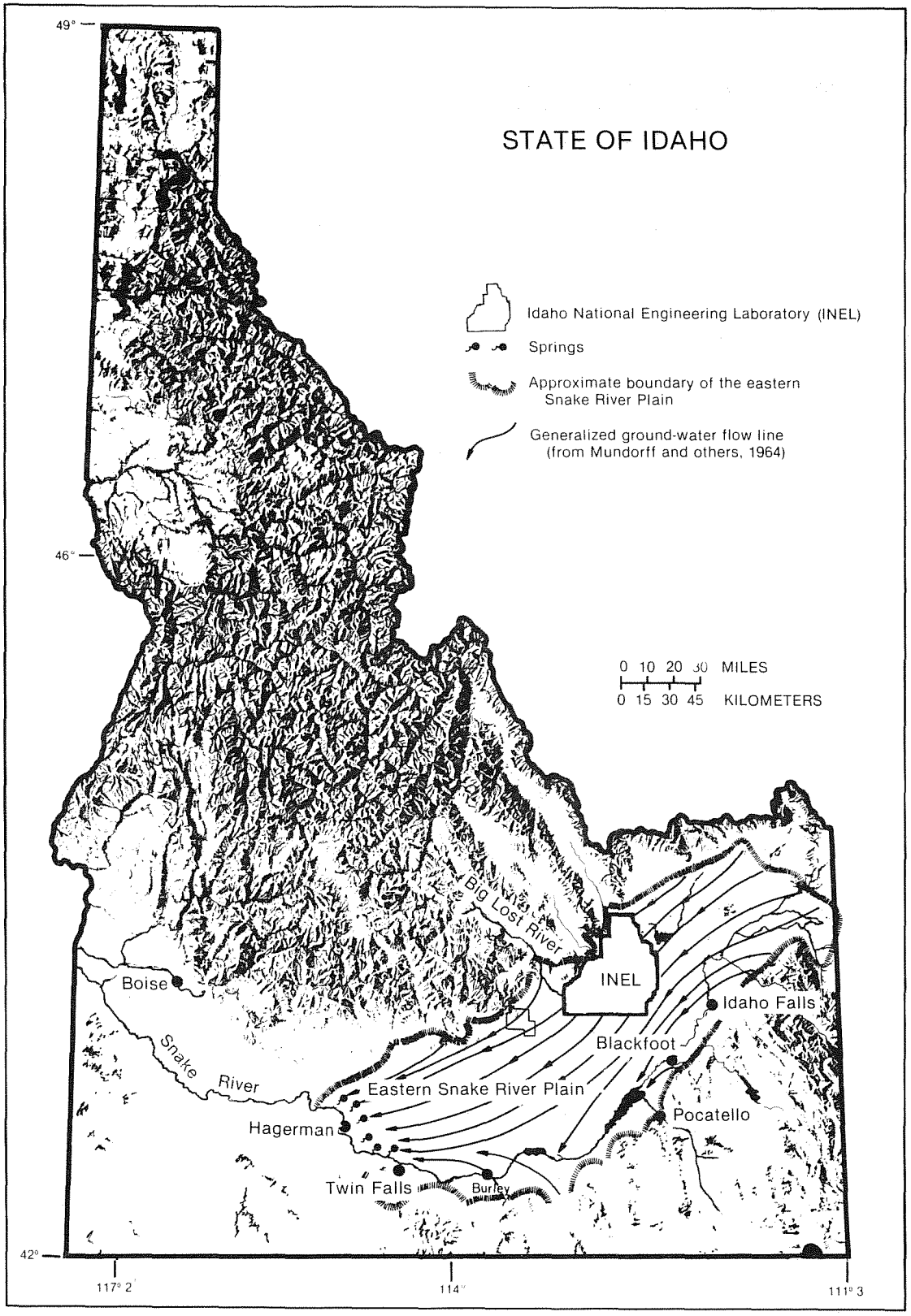


Figure 1. Relief map of Idaho showing location of the INEL, Snake River Plain, and generalized ground-water flow lines of the Snake River Plain aquifer (from Barraclough, Lewis, and Jensen, 1981).

The INEL was established in 1949 for the development, construction, and testing of nuclear reactors by the U.S. Atomic Energy Commission (USAEC). In 1949, the USAEC requested that the U.S. Geological Survey (USGS) investigate the hydrogeologic conditions at the Laboratory prior to the development of reactor operations. The initial work was replaced by a continuing program to investigate the natural hydrogeologic regime and to monitor the effects of activities of the INEL on that regime.

Purpose and Scope

Six wells were drilled and two existing wells were deepened at INEL from 1969 through 1974 (see table 1). This report describes construction of these wells and summarizes information gained about the subsurface geology and hydrology by the drilling program. There is a continuing need for expansion of the data base at INEL to increase knowledge of the subsurface geology, hydrology, and geochemistry of the ground-water system. The expanded well monitoring network, which resulted from this program, also aids in studying radioactive- and chemical-waste migration in the aquifer.

The six wells, labeled 97, 98, 99, 100, 101, and RWMC Production (the Radioactive Waste Management Complex well) on figure 2, were drilled under three separate USAEC contracts. The two deepened wells, 30 and Highway 1, were drilled under the direction of the U.S. Bureau of Reclamation (USBR).

Acknowledgments

This study was partially sponsored and funded by the U.S. Department of Energy (USDOE). The USGS project at the INEL is coordinated through J. P. Hamric, Director, Nuclear Fuel Cycle and Waste Management Division; J. B. Whitsett, Chief, Radioactive Waste Programs Branch; and M. Marcy Williamson, Director, Radiological and Environmental Sciences Laboratory, Idaho Operations Office.

Deepening of two observation wells was funded by and was under the direction of the USBR. Detailed lithologic descriptions of the deepened parts of the boreholes were made by USBR geologists and were made available to the USGS office at the INEL.

METHODS OF DETERMINING SUBSURFACE HYDROGEOLOGY

Geophysical logs are a method of obtaining hydrogeological information about the subsurface. Lithologic characteristics that can be interpreted from such logs include formation resistivity, porosity, and bulk density. Hydrologic properties deduced from logs include permeability, water resistivity, water temperature, and percentage of moisture in the unsaturated zone. Four geophysical logs are shown for each well

Table 1.--Drilling schedule and well data for eight observation wells at the Idaho National Engineering Laboratory

Well number or name	Drilling Date	Total depth (feet)	Piezometer or casing diameter (inches)	Perforation intervals and casing lengths (feet below LSD)	Water level below LSD (feet)	Date of measurement
30	April 1953	405	8-inch casing,	0-326		
			perforations:	276-290		
				300-317		
	July-Dec 1969	1,006	2-inch piezometer C	290-300	262.90	1-28-70
			3/4-inch piezometer B	392-397	260.89	1-28-70
			1-inch piezometer A	717-722	254.04	1-28-70
Highway 1	Nov 1950	683	10-inch casing	0-108		
	July 1969	1,302	3/4-inch piezometer C	643-648	581.00	7-23-69
			3/4-inch piezometer B	909-914	580.36	7-23-69
			3/4-inch piezometer A	1,120-1,125	580.40	7-23-69
97	June-July 1973	511	8-inch casing	0-47	367.76	7-21-73
			6-inch casing	0-135		
			4-inch casing	0-370		
98	July 1973	500	8-inch casing	0-160	396.80	7-21-73
			6-inch casing	0-405		
			4-inch casing,	400-500		
			perforations:	400-420		
				465-500		
99	Aug-Sept 1974	450	8-inch casing	0-35	385.13	10-29-74
			6-inch casing	0-348		
			4-inch casing	305-450		
			perforations:	350-450		
100	Sept 1974	750	6-inch casing	0-660	671.73	9-24-74
101	Aug-Sept 1974	865	8-inch casing	0-25	766.37	9-24-74
			6-inch casing	0-770		
			4-inch casing	750-865		
			perforations:	750-865		
RWMC	June-Nov 1974	685	18-inch casing	0-108	571.30	11-20-74
			14-inch casing	0-562		
			10-inch casing,	0-658		
			perforations:	590-610		
				625-635		

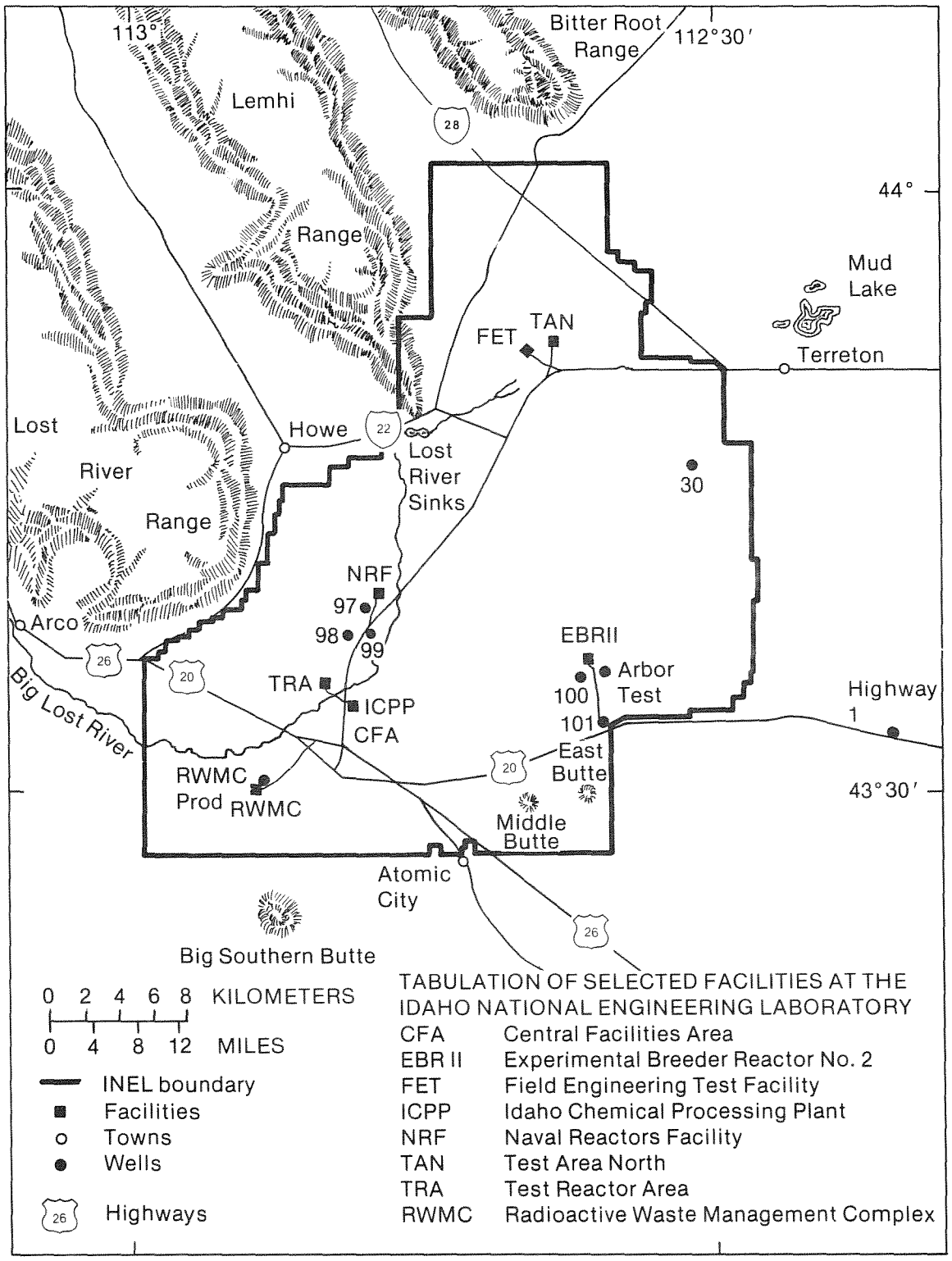


Figure 2. Map showing location of wells, selected facilities, and pertinent geographic features in the INEL vicinity.

described in this report: caliper, gamma-gamma, natural gamma, and neutron. The principles and applications of these geophysical logs will be discussed in following sections of this report. The geophysical logs are on file at the USGS office at the INEL.

Water levels were measured by steel tape and represent depths to water from land surface. Information such as current water-level measurements or geochemical water-analyses data may be obtained from the USGS office at the INEL.

Completion Diagrams

Completion diagrams are based primarily on the drillers' daily logs. Drilling specifications, including types and dimensions of casing, casing lengths, borehole sizes, cementing and perforating programs, and installation of piezometer tubing, are determined from the drillers' daily logs and geophysical logs.

Lithology Diagrams

Interpretation of the subsurface lithology is based on geophysical and drillers' logs. The accuracy of lithologic interpretation by a driller depends upon the driller's ability to describe cutting returns and to interpret the bit action and drilling rate. Drillers' logs may aid in yielding a reasonably accurate depiction of the subsurface when supplemented by geophysical logs.

The rock types, illustrated on the lithology diagram (fig. 3), are generalized because of the small scale required for publication. In some cases, several thin lithologic units were grouped together. However, all significant lithologic zones are delineated.

The rock types penetrated during the drilling program include basalt flows, sediments, cinders, and silicic volcanic rocks. Individual basalt flows beneath the INEL range in thickness from about 6 to 95 feet. In most cases, individual flows may be recognized on geophysical logs and correspond to drillers' logs.

Caliper Logs

Caliper logs record the drill-hole diameter in uncased parts of the well and the inside diameter of the casing. The logging tool contains three extendable feeler arms which trace the wall of the borehole. These logs are probably accurate to the nearest inch. Factors affecting hole size may include the drilling method used, rock type, permeability and porosity, and the "washing out" of saturated sediment zones.

Caliper logs are useful for location of fractures and cavernous zones, and aid in the interpretation of other logs. During well construction, caliper logs may be used to determine where to set casing, cement casing, or place packing material.

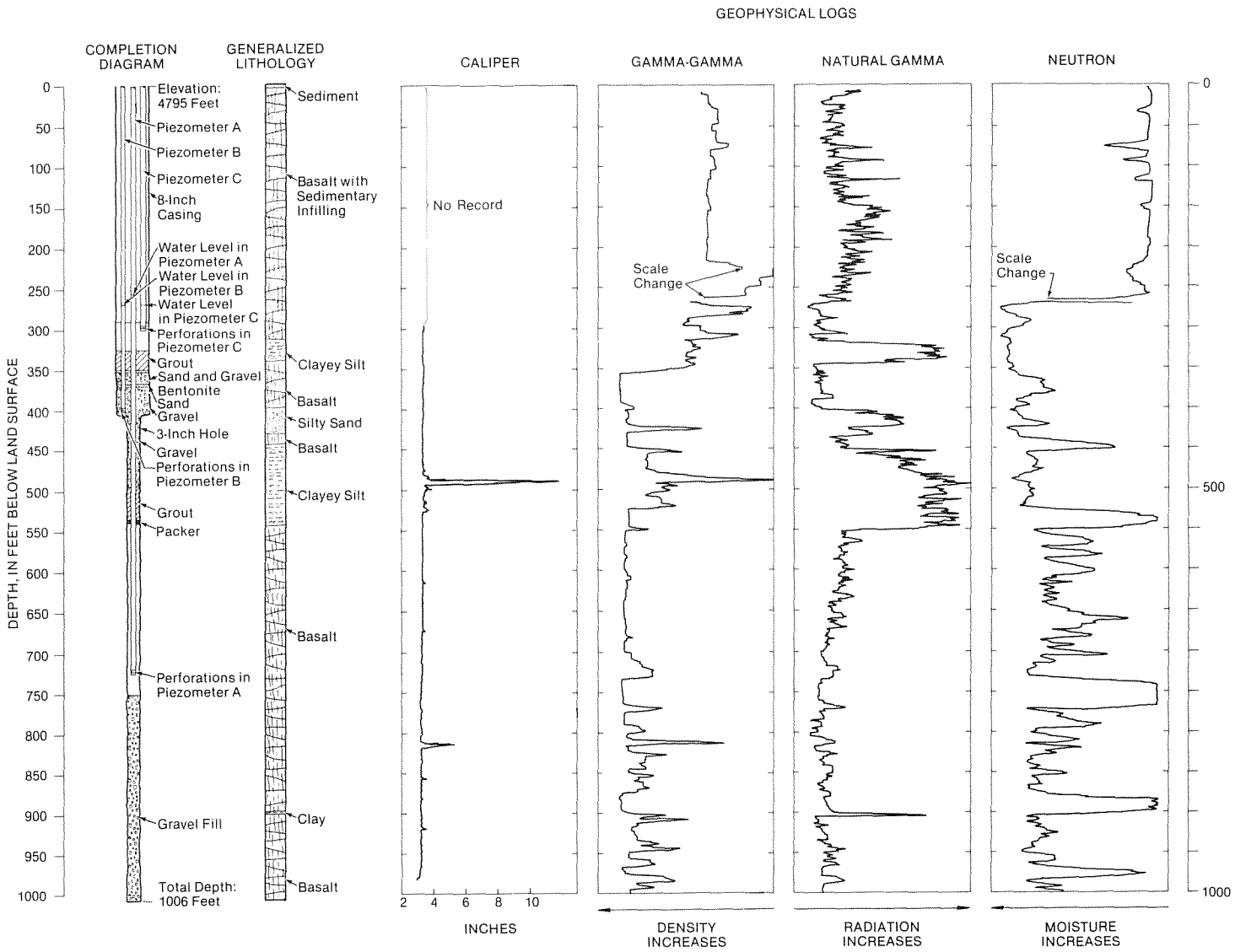


Figure 3. Diagrams showing well completion, lithology, and geophysical logs for well 30.

Gamma-Gamma Logs

Gamma-gamma logs are a recorded measurement of gamma-radiation intensity from a source after it is backscattered or absorbed within a drill hole, the borehole fluid, or surrounding media (Chase and others, 1964). Cobalt-60 or cesium-137 are used as sources of gamma radiation. In this study, an eight millicurie (8 mc) source of cobalt-60, shielded from a sodium iodide detector, was used in the logging probe. In a sodium iodide scintillation gamma-radiation detector, a gamma ray impinging on a sodium iodide crystal causes a scintillation or emission of a flash of visible light. A photomultiplier tube detects each scintillation and transforms it into a pulse of electrical energy. These electrical signals are recorded to form a log of gamma-radiation responses.

The intensity of backscattered gamma energy is proportional to the electron density in the medium surrounding the probe. Although gamma-gamma logs are sometimes referred to as "density" logs, other factors, in addition to density, influence the logs. These include porosity, water saturation, changes in fluid type, hole diameter, cement grouting outside the casing, and the presence and thickness of casing. Because many factors influence gamma-gamma logs, their detailed interpretation requires considerable experience.

General characteristics and principles applicable to gamma-gamma log interpretation are outlined below:

1. Positive deflections, or deflections trending to the right, indicate increased gamma-ray backscatter due to increased porosity, decreased rock density, or increased hole diameter (fig. 3).
2. Negative deflections, or deflections trending to the left, indicate decreased porosity, increased rock density, or decreased hole diameter (fig. 3).

Other significant factors affecting the percentage of gamma radiation absorbed and scattered are:

1. size, type, and strength of source,
2. distance between the source and detector,
3. thickness of casing, and
4. fluid in the borehole

The log shows a marked negative deflection when the probe enters the ground water (fig. 3). Water surrounding the probe greatly reduces the backscatter intensity recorded on the log. This effect is more pronounced in large diameter wells than in small diameter wells because those of large diameter hold more water.

Another factor that causes general negative deflection below the water table is the increased bulk density of saturated rocks. Bulk-density studies of representative rock types at the INEL show that bulk density increases markedly when dry rocks become saturated (G. H. Chase, written commun., 1966).

Natural Gamma Logs

A natural gamma log is a record of gamma radiation emitted by naturally occurring radioisotopes. The natural radioisotopes in the INEL area are potassium-40, bismuth-214, lead-214, actinium-228, thorium-232, and uranium-238 (Barraclough, Robertson, and Janzer, 1976). The gamma sonde measures total gamma radiation without distinguishing between individual contributions of the various radioisotopes.

The probe used for recording the gamma log contains a sodium iodide scintillation gamma-radiation detector of the type described in the "Gamma-Gamma Logs" section. Higher levels of gamma radiation appear on the log as positive, or right, deflections whereas lower levels appear as negative, or left, deflections (fig. 3).

A factor that complicates the interpretation of natural gamma logs is the proximity effect. The intensity of gamma radiation increases rapidly as a source is moved nearer to a detector; therefore, a quantity of material near the probe will display a higher gamma intensity than an equally intense quantity of similar material farther away. Considerations such as the type of fluid in the well, hole diameter, casing thickness, rock density, and the energy of emitted radiation are also important. These factors affect the range at which the probe can detect radioactivity (its radius of investigation).

Sediments have a greater concentration of naturally occurring radioisotopes than basalts (Chase and others, 1964) and exhibit positive deflections on the log, whereas, basalts exhibit negative deflections (fig. 3). Positive deflections can also be caused by sediment-filled voids and fractures in the basalt, accumulation of caved sediments downhole behind the casing, and radioisotopes discharged to the subsurface. The discharged radioisotopes accumulate in sediments, especially clays, by ion exchange and adsorption of radioactive ions on the sediment matrix.

Neutron Logs

Neutron logs are used to measure the moisture content above the water table and the total porosity below the water table. The source and the detector are arranged in the logging probe so that the recorded curve is a function of the hydrogen content in the borehole and the surrounding matrix (Keys and MacCary, 1971).

A neutron is an electrically neutral atomic particle. High-energy neutrons are produced by collisions between alpha particles and beryllium nuclei. The sonde used for recording the logs depicted in this report employs an alpha emitting radioisotope, americium-241, that was mixed with beryllium and sealed to form a 3-curie neutron source. The high-energy neutrons emitted by the americium-beryllium source collide with atomic nuclei of fluids in a well, well casing, and rock materials. The neutrons are slowed by multiple collisions to velocities corresponding to an energy of 0.025 electron volt or less, called "thermal" neutrons, and

can be captured and counted by the neutron detector (Keys and MacCary, 1971). Hydrogen is the most effective element in slowing down neutrons because the nucleus of the hydrogen atom has approximately the same mass as a neutron. The velocity and thus the energy of a neutron is greatly reduced following a collision with a hydrogen nucleus. When colliding with a nucleus much larger and heavier than itself, a neutron rebounds with most of its original velocity and energy.

The radius of investigation of a neutron probe in saturated rocks ranges from about 6 inches in rocks of high porosity to 2 feet in rocks of little or no porosity. Neutron logs are less affected by well casing and mud or cemented casing than are other geophysical logs. Some factors that do affect neutron logs are: water in the well, perched water bodies, well diameter, and the presence of hydrocarbons or other hydrogenous materials in the well.

A large negative deflection occurs as a neutron probe enters the water in a well (fig. 3). This deflection indicates a decreased neutron count at the detector. The decreased count occurs because more neutrons are absorbed by an aqueous environment than an air environment. This negative deflection can be used to determine the water level at the time of logging. Negative deflections also occur when the neutron probe enters a perched water body and where the probe encounters hydrated material. Hydrated material may be erroneously interpreted as having high porosity.

DRILLING, COMPLETION, AND INTERPRETIVE DOCUMENTATION

Wells 30 and Highway 1

In 1969, the USBR conducted a drilling program in conjunction with construction of the Teton Dam. The purpose of the program was to deepen existing shallow wells in order to obtain information about the lower part of the Snake River Plain aquifer and to equip the wells with multiple piezometers. This information would later be used for water-resources management. Permission was granted by the USGS and the USDOE to deepen wells 30 and Highway 1. Detailed descriptions of the lithology of the deepened parts of the wells were prepared by USBR geologists.

Well 30 was initially drilled to a depth of 405 feet in April 1953. The well was cased to 360 feet with 8-inch casing and perforated in two places from 276 to 290 feet and 300 to 317 feet. Between July 27 and December 5, 1969, the well was deepened from 405 to 1,006 feet and two piezometers were set in the borehole; a 1-inch diameter piezometer, A, and a 3/4-inch diameter piezometer, B (table 1).

An attempt was made to measure the water level inside the 8-inch casing in June 1978; but, the casing was bridged at 268 feet, preventing measurements below this depth. On November 13, 1979, the well was cleaned out and a 300-foot, 2-inch piezometer (piezometer C-fig. 3) installed. Piezometer C was welded to a cross support at the top of the hole where piezometers A and B were also welded. The bottom 10 feet of piezometer C is perforated and taps the same aquifer zone as the 8-inch casing.

The geophysical logs shown on figure 3 indicate that the upper part of the subsurface is dominated by a series of basalt flows interbedded with sediments. Three thick sediment zones are present: at 315 to 343 feet, 400 to 435 feet, and 445 to 548 feet below land surface. The remaining 550 feet is primarily basalt with a thin bed of silt and clay at 890 feet below land surface.

The hydrographs of the three piezometers in well 30 (fig. 4) show cyclic annual fluctuations, with maximum water levels generally in January or February and minimums generally in July or August. It is also apparent that significant head differences occur in water levels measured in the piezometers. The water level in piezometer A was about 8 feet higher than the water level in piezometer B and 10 feet higher than the level in piezometer C, indicating increasing pressure heads with depth.

Piezometer A is perforated below the three thick sediment zones, piezometer B is perforated at a depth between the two uppermost sediment zones, and piezometer C is perforated above all three sediment zones (fig. 3). The measured water levels may indicate that piezometers A and B tap parts of the aquifer system that are under artesian pressure; and piezometer C taps that part of the aquifer under atmospheric pressure and represents water-table conditions.

Well 30 is downgradient, approximately 4 miles southwest, from an area known as the "Mud Lake-Market Lake" barrier (Crosthwaite, 1973). The barrier has been defined as a transition zone from a subsurface dominated by interlayered sediments and basalt northeast of the zone to a subsurface dominated by basalt southwest of the zone that extends from Monteview to Idaho Falls (Crosthwaite, 1973, fig. 3). The hydraulic gradient steepens from 2 feet per mile upgradient of the barrier zone to 30 feet per mile in the barrier zone, then flattens to about 3 feet per mile downgradient toward the south-southwest.

Ground water in the transition area is under water-table conditions in the uppermost part of the saturated zone and artesian conditions in its deeper parts (Crosthwaite, 1973). Therefore, the hydrogeologic conditions present near well 30 are probably influenced by the Mud Lake-Market Lake barrier zone.

Well Highway 1 was drilled to a depth of 683 feet by the cable-tool method in November 1950. The upper 108 feet of the well was cased with 10-inch casing and the remaining 574 feet was open hole (fig. 5). Deepening of the well, from 683 to 1,302 feet began on July 1 and ended on July 25, 1969. Three 3/4-inch piezometers, A, B and C, were placed in the well (table 1). The bottom of piezometer A was set at a depth of 1,297 feet with perforations between 1,292 and 1,297 feet. The piezometer broke off at 1,173 feet and, therefore, the well was backfilled with sand, gravel, and grout to 1,147 feet. The piezometer was then perforated from 1,120 to 1,125 feet. The upper part of the borehole is dominated by basalt interbedded with thin sediment layers. A clay deposit occurs between 270 and 287 feet below land surface. The deepened part of the borehole penetrates sediments, basalt, and silicic volcanic

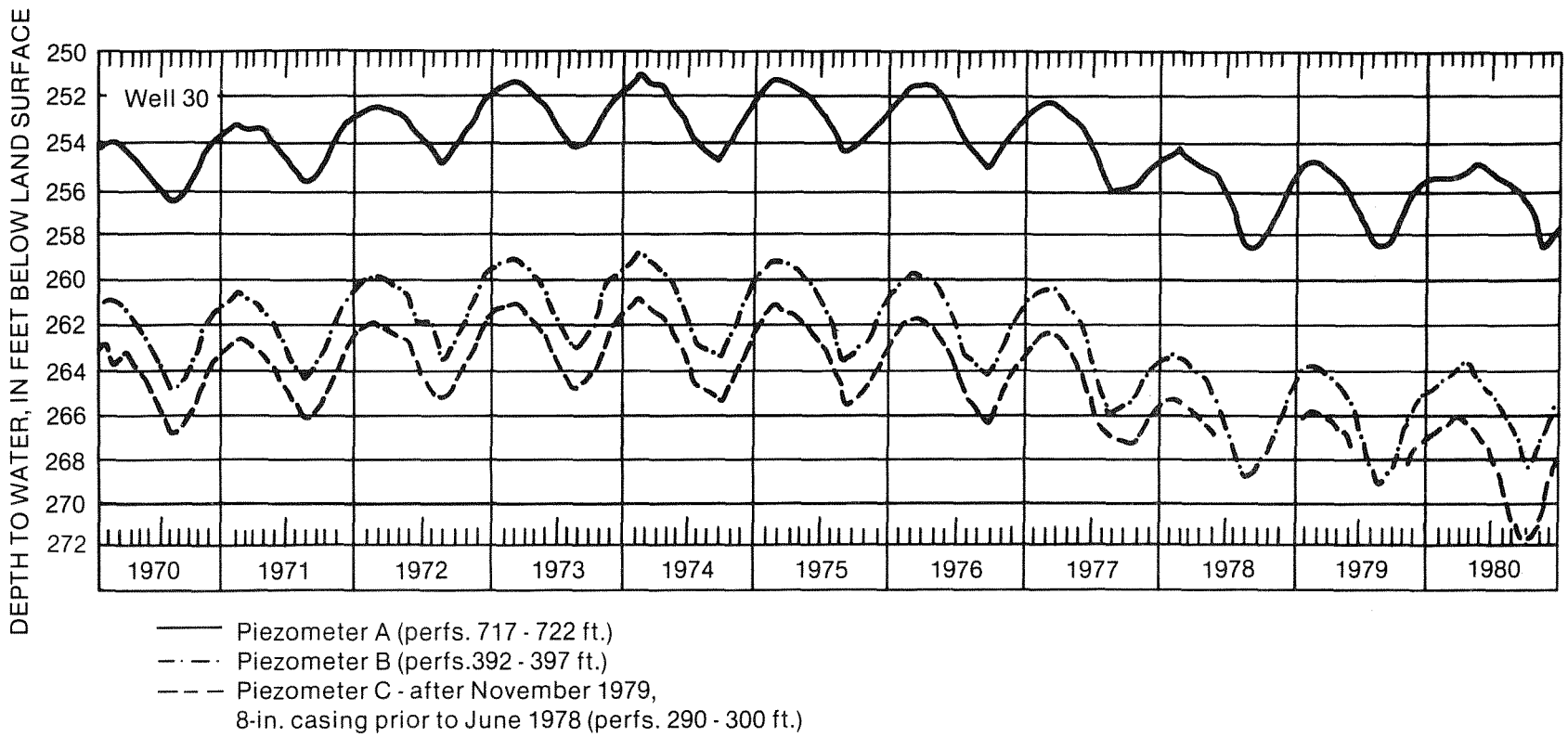


Figure 4. Hydrographs for the three piezometers in well 30.

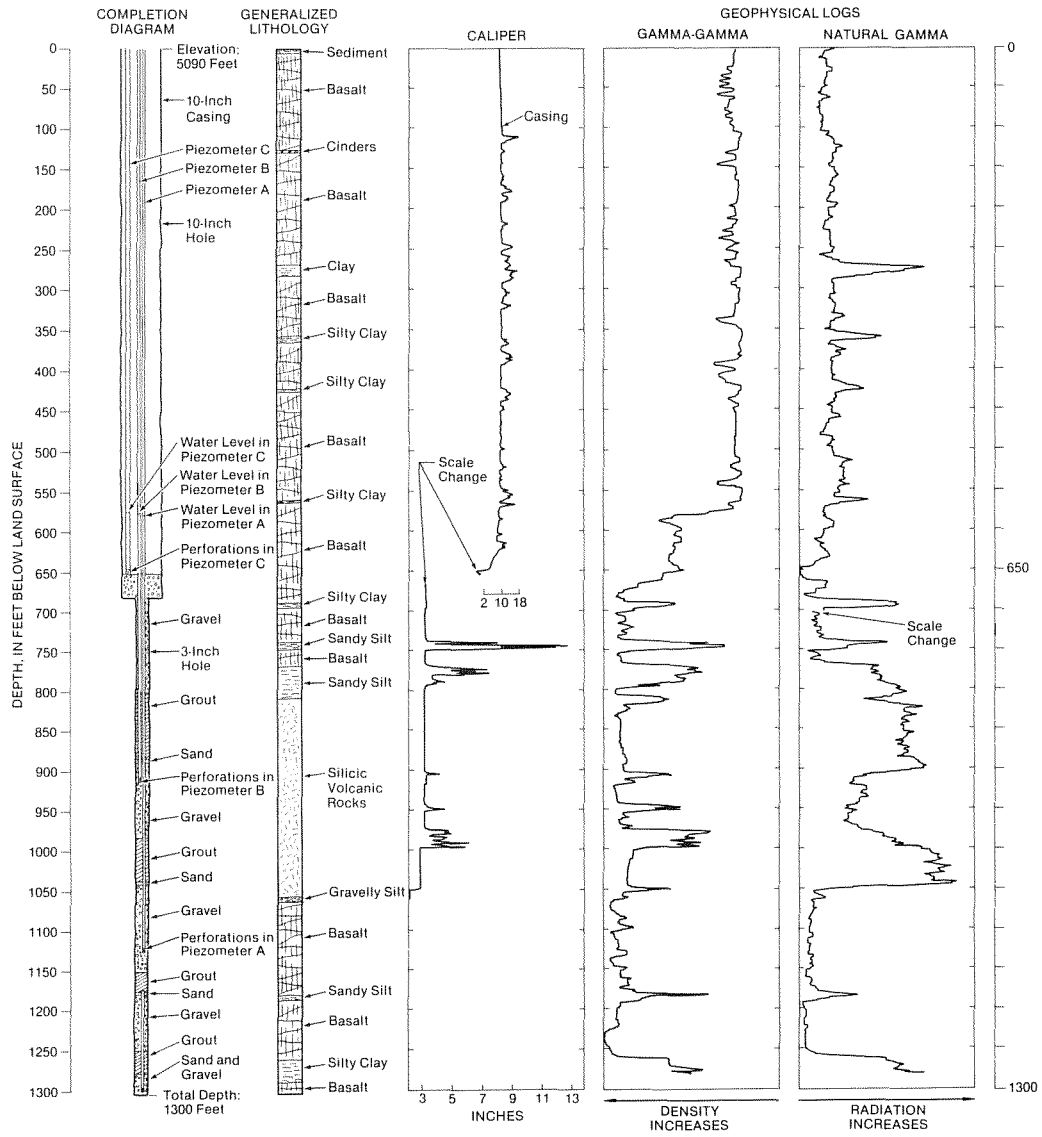


Figure 5. Diagrams showing well completion, lithology, and geophysical logs for well Highway 1.

rocks. The silicic-rock zone is 250 feet thick and extends from 810 to 1,060 feet below land surface. The silicic zone is overlain by a bed of sandy silt, about 40 feet thick, and is underlain by a thin bed of gravelly silt.

The hydrographs for the three piezometers in the Highway 1 well from 1971 through 1980 are shown on figure 6. There is no significant head difference with depth as in well 30 (fig. 4). The water levels, measured monthly, show seasonal fluctuations, with maximums in December or January and minimums in June or July. It is apparent that piezometer C water level has a slightly greater seasonal fluctuation than A and B water levels. The water level in piezometer C is higher than the other two piezometer water levels from January until the first part of May and is lower from June to December. The water level in piezometer C may be affected more by irrigation well pumping than the other two piezometer water levels. This may indicate that pumping effects are more pronounced in the upper part of the Snake River Plain aquifer than in the lower part.

In 1977 the hydrographs show a marked decline in water levels (fig. 6). This decline, from 1977 to 1980, is recorded in several wells that penetrate the Snake River Plain aquifer (Lewis and Goldstein, 1982). The decline is probably a result of below average precipitation for those years and hence less recharge to the ground-water system.

Wells 97, 98, and 99

Wells 97, 98, and 99 were drilled to fill existing gaps in the INEL hydrologic data network downgradient from the Naval Reactor Facility (NRF) (fig. 2). The three wells were drilled by the air-rotary method during 1973 and 1974 (table 1).

The subsurface lithologic sequence penetrated by wells 97, 98, and 99 is similar in that it is dominated by basalt interbedded with several sediment deposits (figs. 7, 8, and 9). Surficial sediments range in thickness from 10 feet in well 98 to 38 feet in well 97. A correlatable sediment bed, ranging in thickness from 22 to 42 feet, occurs in all three wells. In well 97, this bed is from 113 feet to 135 feet below land surface; in well 98, from 118 feet to 160 feet; in well 99, from 93 feet to 115 feet.

Hydrographs for wells 97, 98, and 99 from 1973 through 1980 are shown in figure 10. The water level in well 97 is measured monthly. The water level in well 98 was measured monthly during the years 1973 and 1974, quarterly during 1975 and 1976, and is presently being measured annually. Well 99 was measured a total of seven times from 1974 through 1975 and annually since 1976.

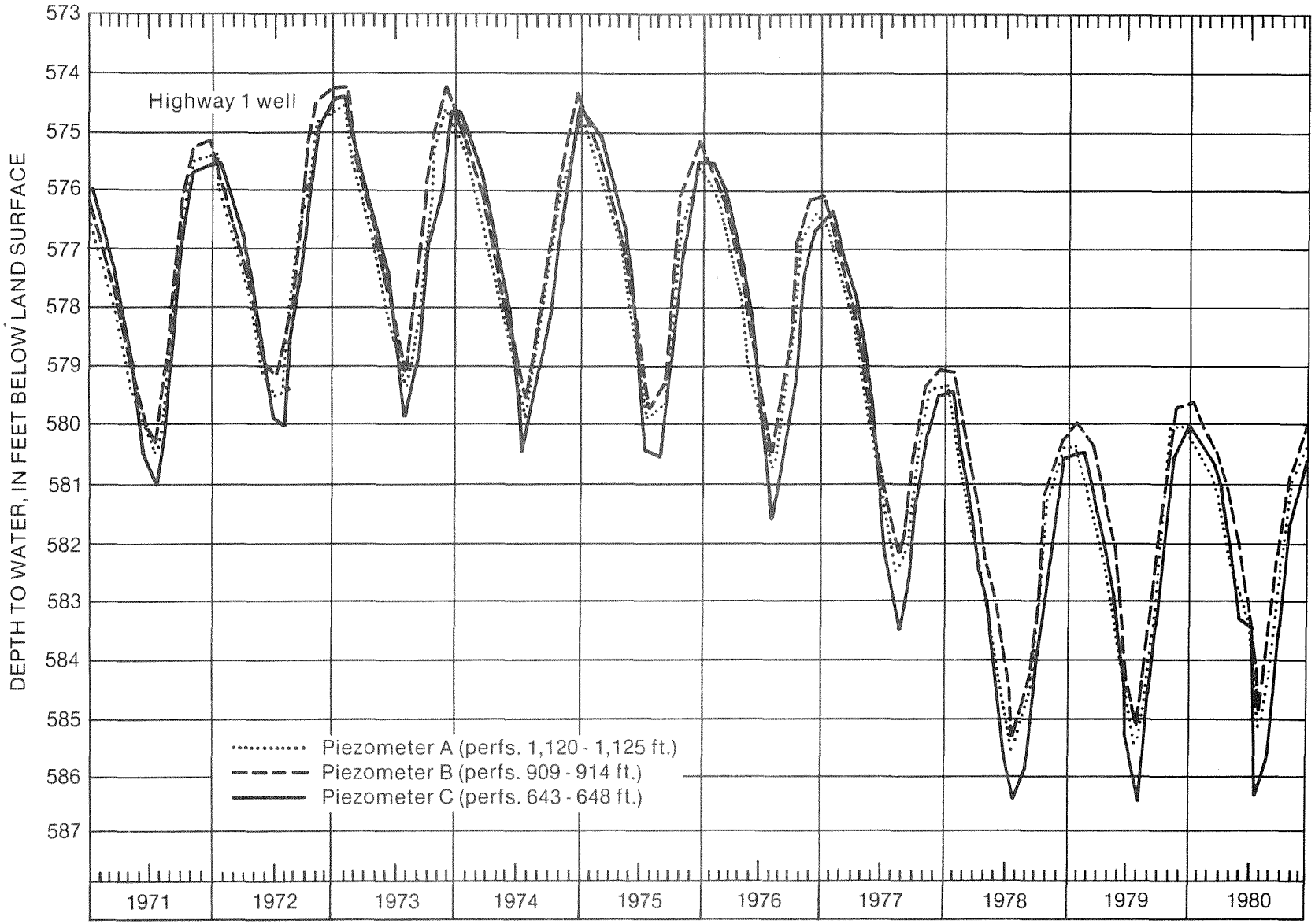


Figure 6. Hydrographs for the three piezometers in well Highway 1.

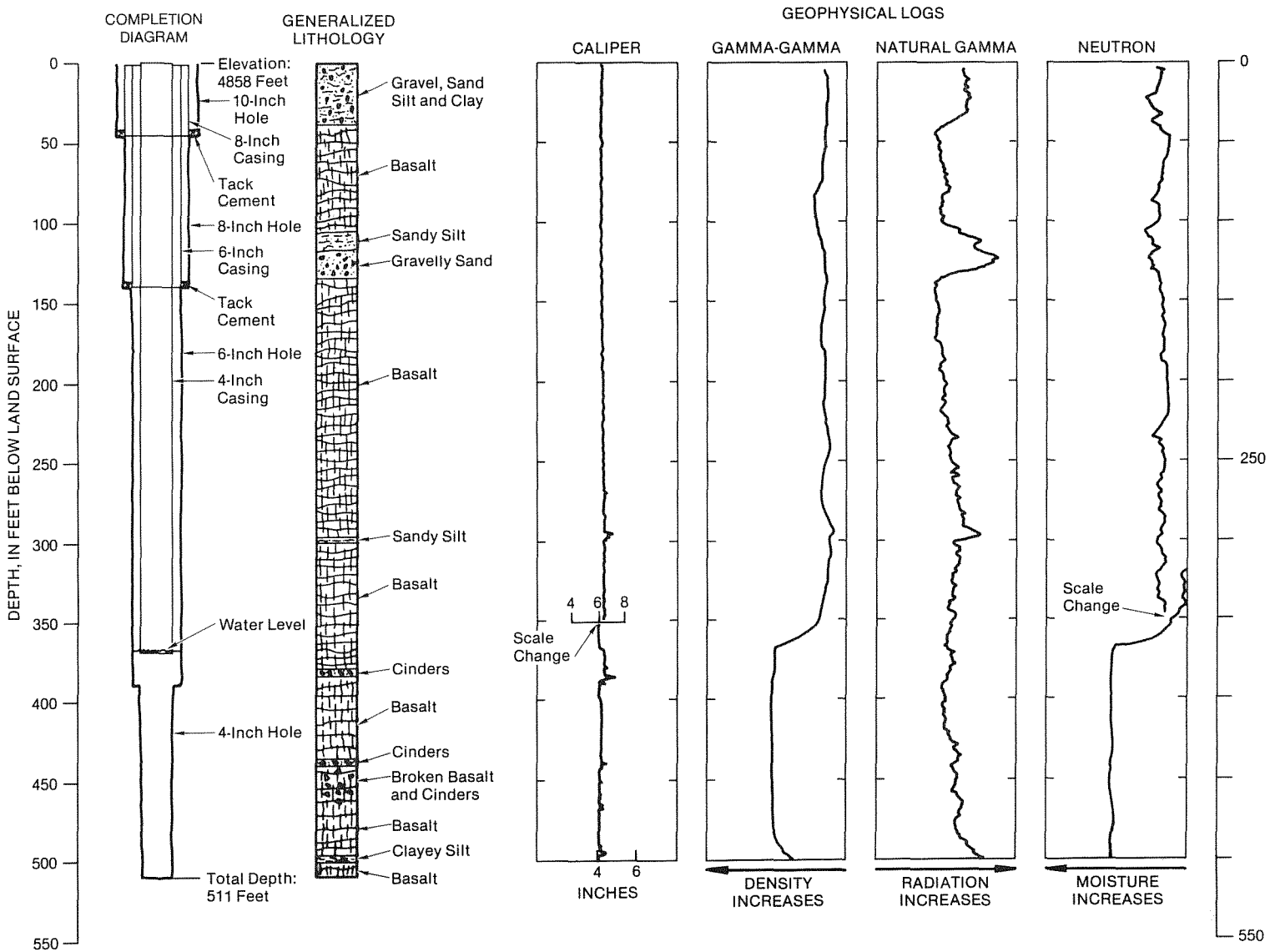


Figure 7. Diagrams showing well completion, lithology, and geophysical logs for well 97.

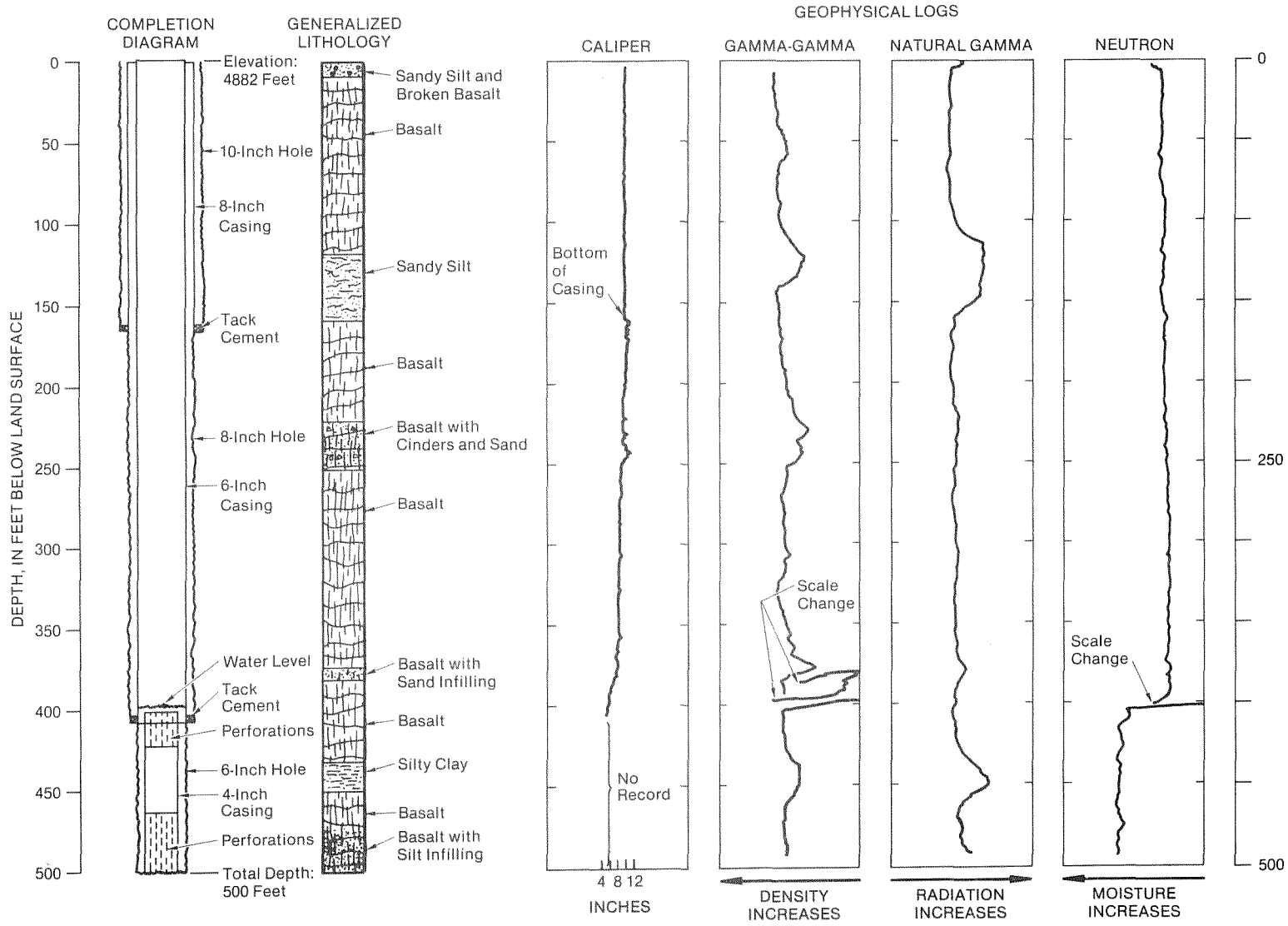


Figure 8. Diagrams showing well completion, lithology, and geophysical logs for well 98.

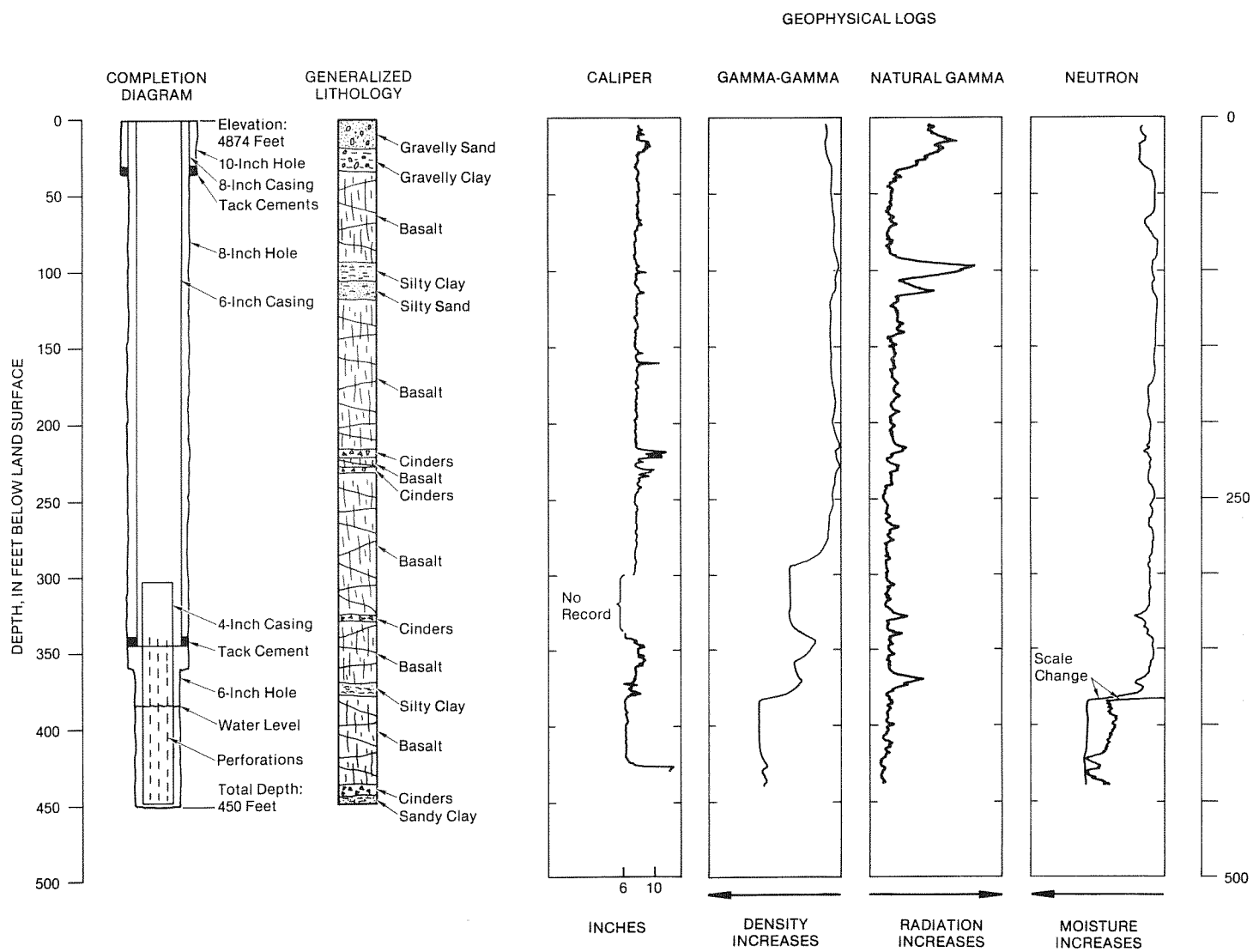


Figure 9. Diagrams showing well completion, lithology, and geophysical logs for well 99.

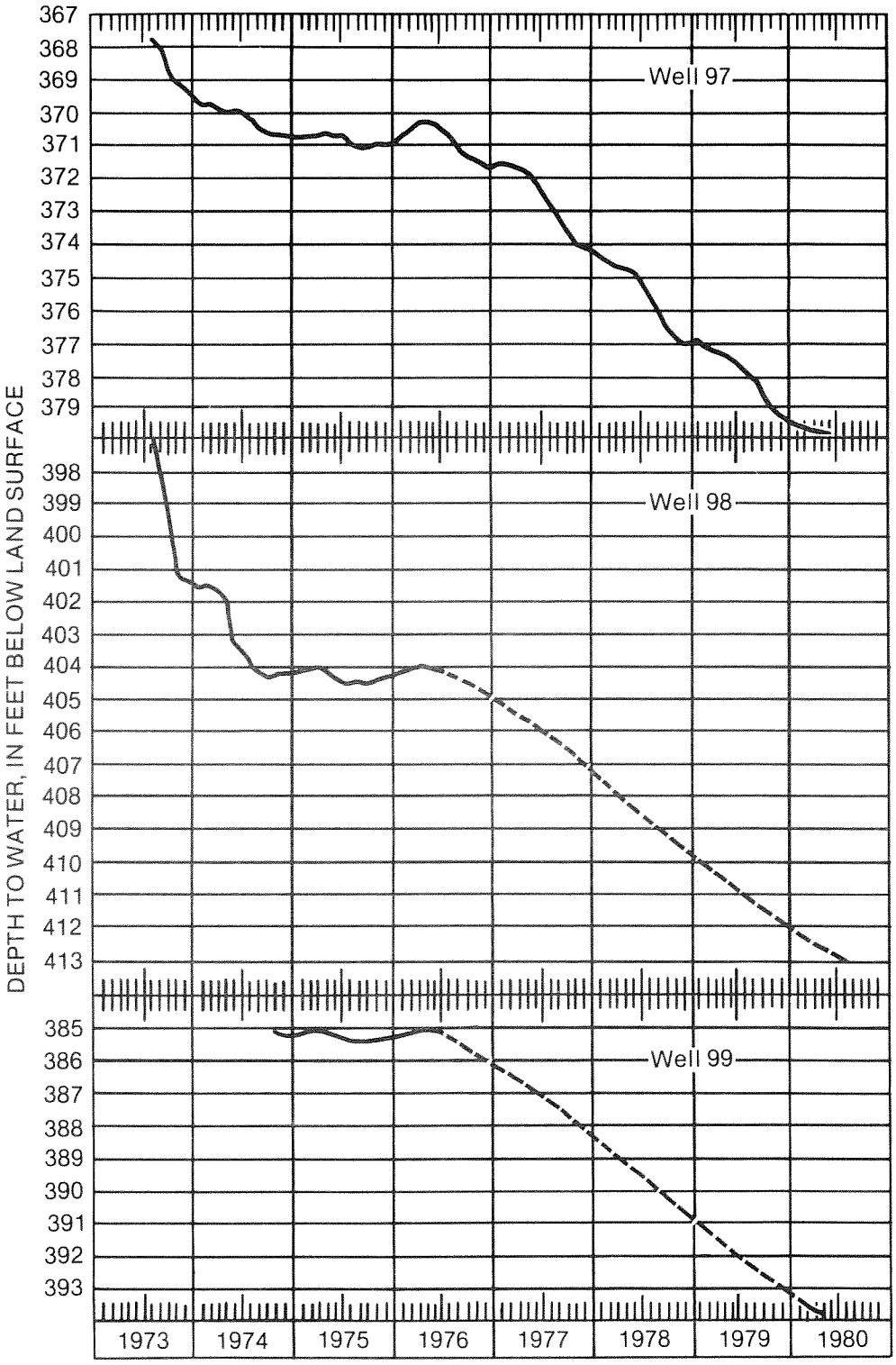


Figure 10. Hydrographs for wells 97, 98, and 99.

Wells 97, 98, and 99 are near the Big Lost River (fig. 2), the major stream flowing onto the INEL. Water levels in these wells appear to show the effects of flow in the river. The river terminates in playas or sinks (fig. 2), but reaches them only during years of high flow. In most years, the river loses its entire flow to the subsurface of the plain and recharges the underlying aquifer prior to reaching the sinks. The record of discharge in the Big Lost River below Mackay Reservoir is shown in figure 11. There was a marked decrease from the above average discharge of about 320,000 acre-feet for 1974 and 1975 to about 160,000 acre-feet during 1977. From 1977 to 1981 very little or no water has flowed through the INEL; therefore, recharge to the Snake River Plain aquifer from the river in the vicinity of INEL was negligible. The significant decrease in the water levels in the three wells from 1977 to 1980 (fig. 10) apparently is attributable to a lack of recharge from the river.

Wells 100 and 101

Wells 100 and 101 were drilled downgradient from the Experimental Breeder Reactor II (EBR-II) (fig. 2). Drilling of the wells began August 8, and terminated September 20, 1974 (table 1).

The subsurface lithologic sequence penetrated by well 100 is dominated by basalt flows interbedded with two thin sediment zones; a 6-foot-thick deposit from 382 to 388 feet and an 8-foot deposit from 664 to 672 feet below land surface (fig. 12). The subsurface lithologic sequence penetrated by well 101 is predominantly basalt flows interbedded with a 5-foot-thick sediment zone at a depth of 316 feet, and an 11-foot sediment deposit at 780 feet below land surface (fig. 13).

Quarterly water-level measurements in wells 100 and 101 were made during 1975; in 1976, water levels were measured twice. Water-level measurements were made annually thereafter, to and including 1980. The hydrographs for wells 100 and 101 are shown in figure 14. The poor definition of the water-level curves after 1976 is due to limited data for 1977 through 1980. A more precise examination of the water-level fluctuations in wells 100 and 101 may be made by comparing them with the hydrograph (fig. 15) of the Arbor Test well which is about 1-1/4 miles east of well 100, and 2-1/2 miles north of well 101. Total depth of the Arbor Test well is 790 feet with perforated casing between 679 and 730 feet and between 737 and 787 feet below land surface. The well taps the same part of the aquifer as wells 100 and 101. Monthly measurements have been made in the Arbor Test well since 1958 (Barraclough, Lewis, and Jensen, 1981, fig. 19). The water level in the well follows a pattern of seasonal fluctuations: maximum water levels in January or February, and minimum water levels in August or September. The water levels in wells 100 and 101 in 1975 and 1976 behaved similarly to those in the Arbor Test well. Therefore, well 100 and 101 water levels would probably show a similar pattern for later years, if more measurements had been made.

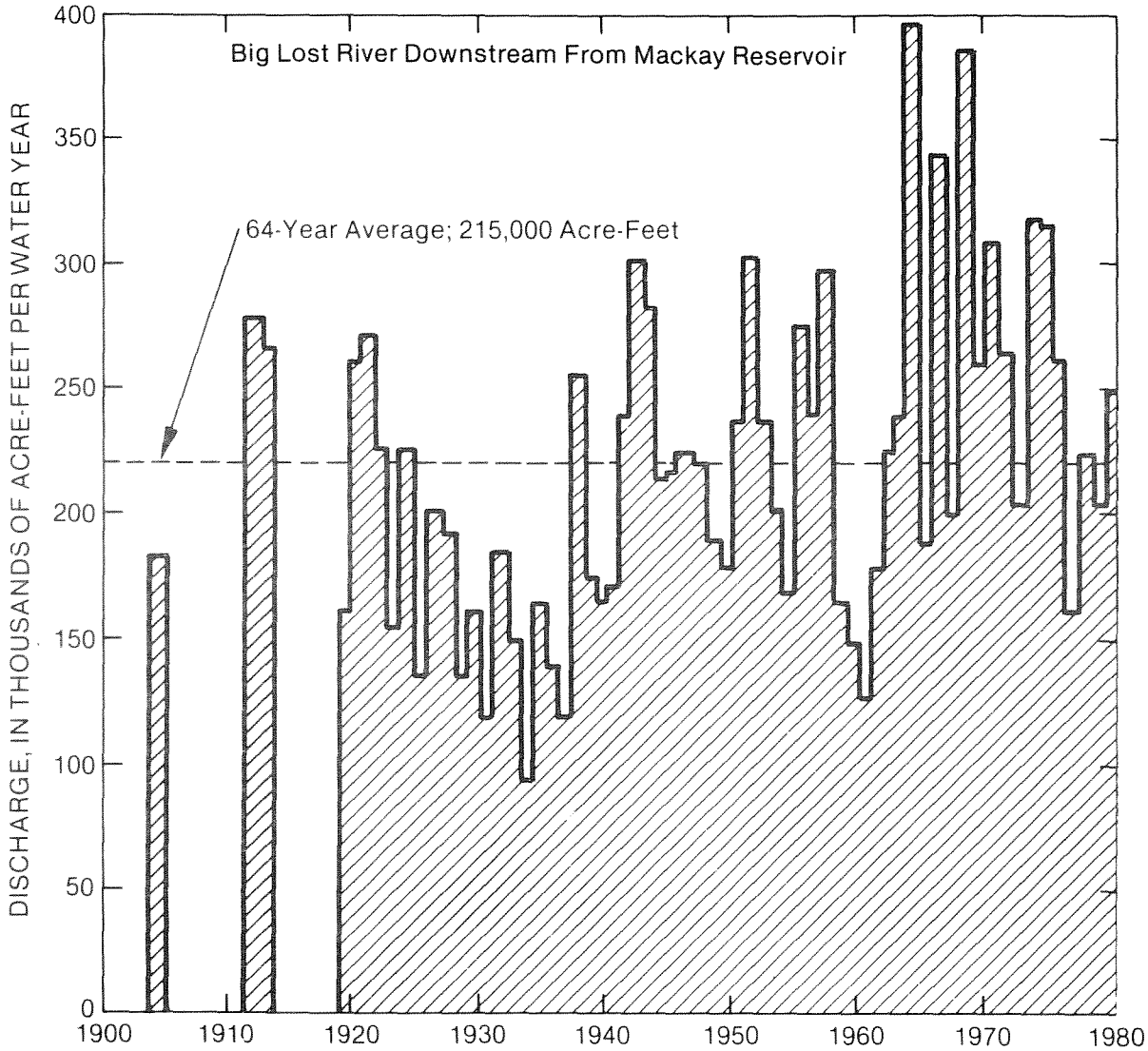


Figure 11. Discharge of the Big Lost River downstream from Mackay Reservoir (from Lewis and Goldstein, 1982).

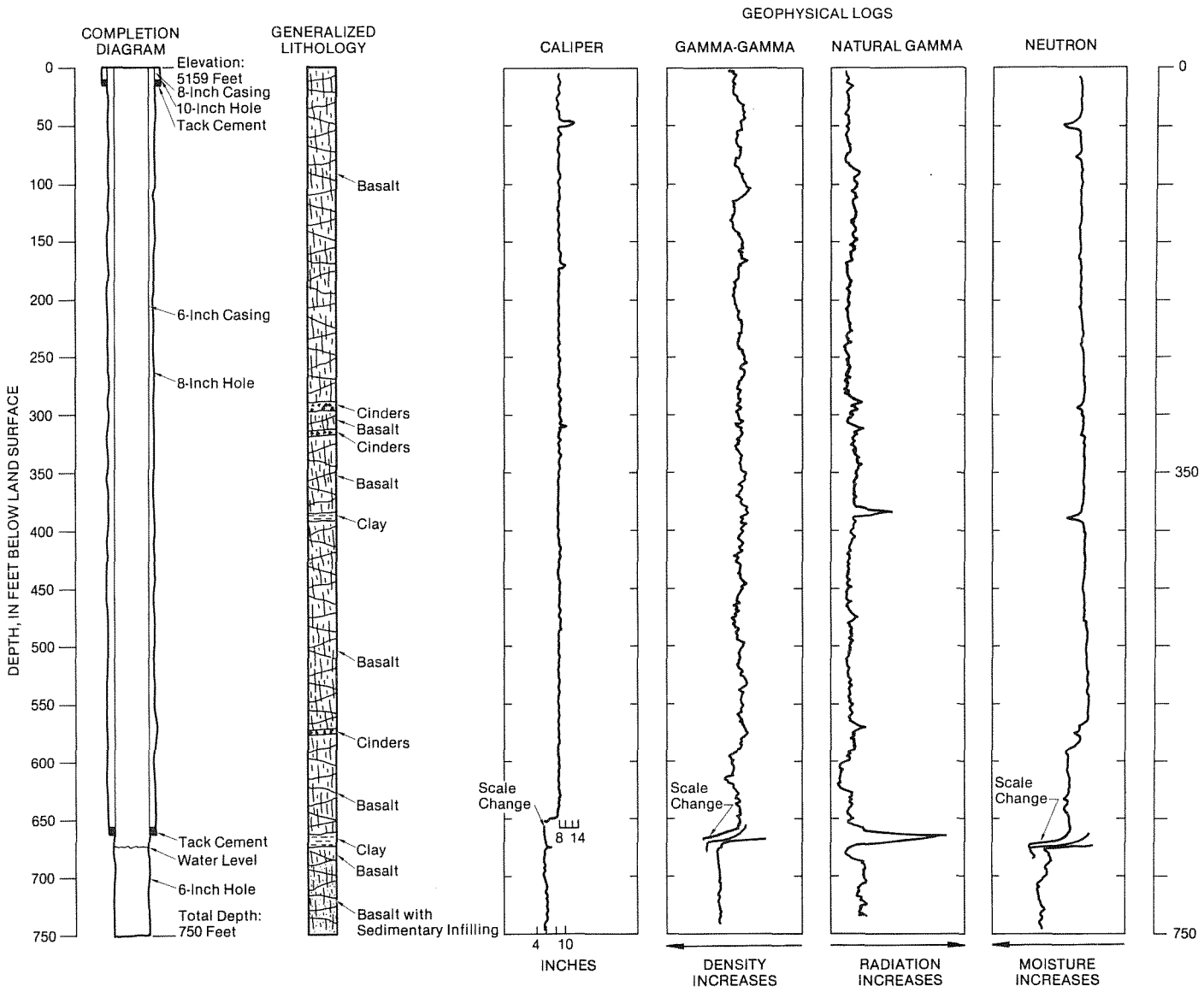


Figure 12. Diagrams showing well completion, lithology, and geophysical logs for well 100.

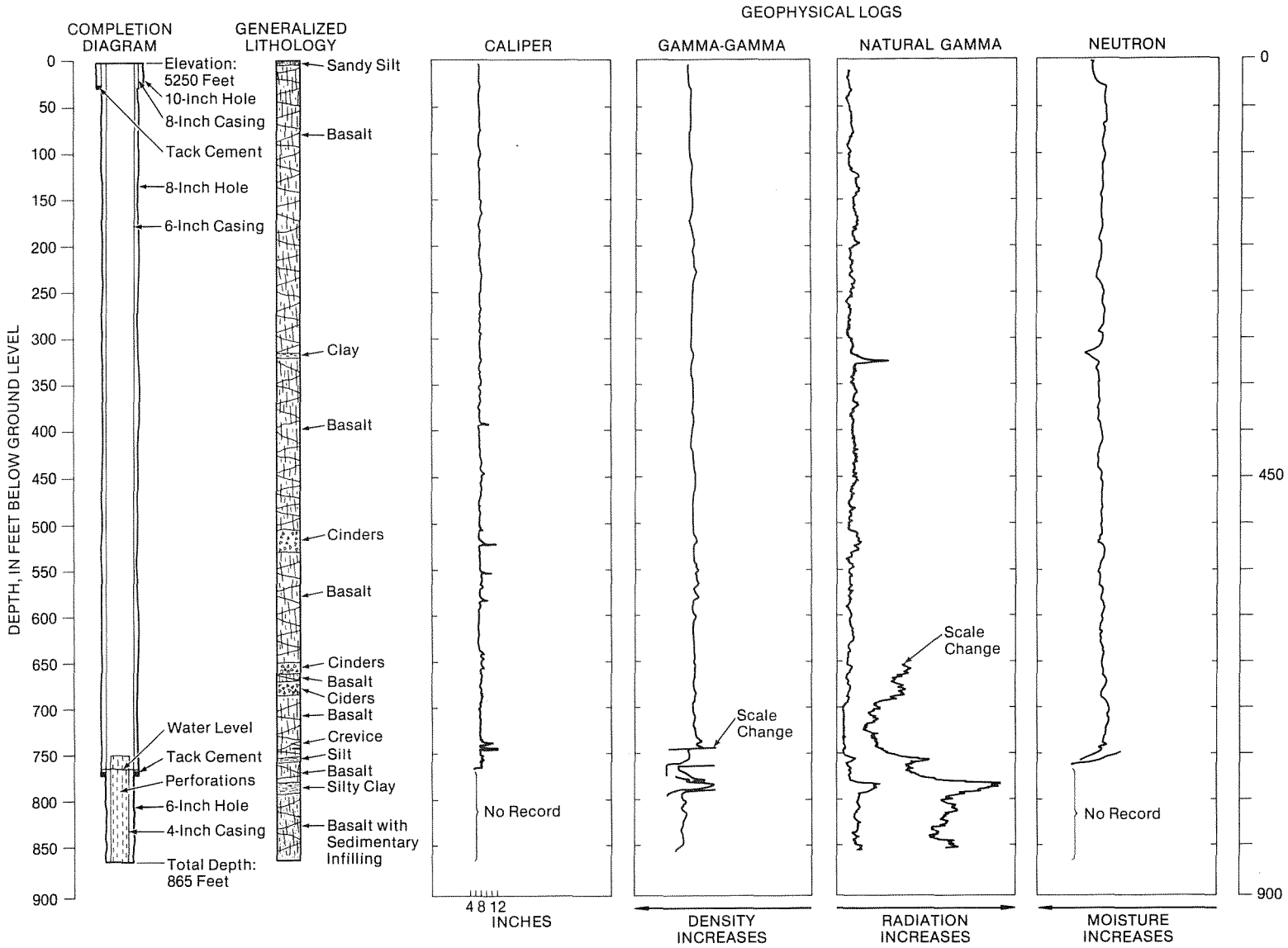


Figure 13. Diagrams showing well completion, lithology, and geophysical logs for for well 101.

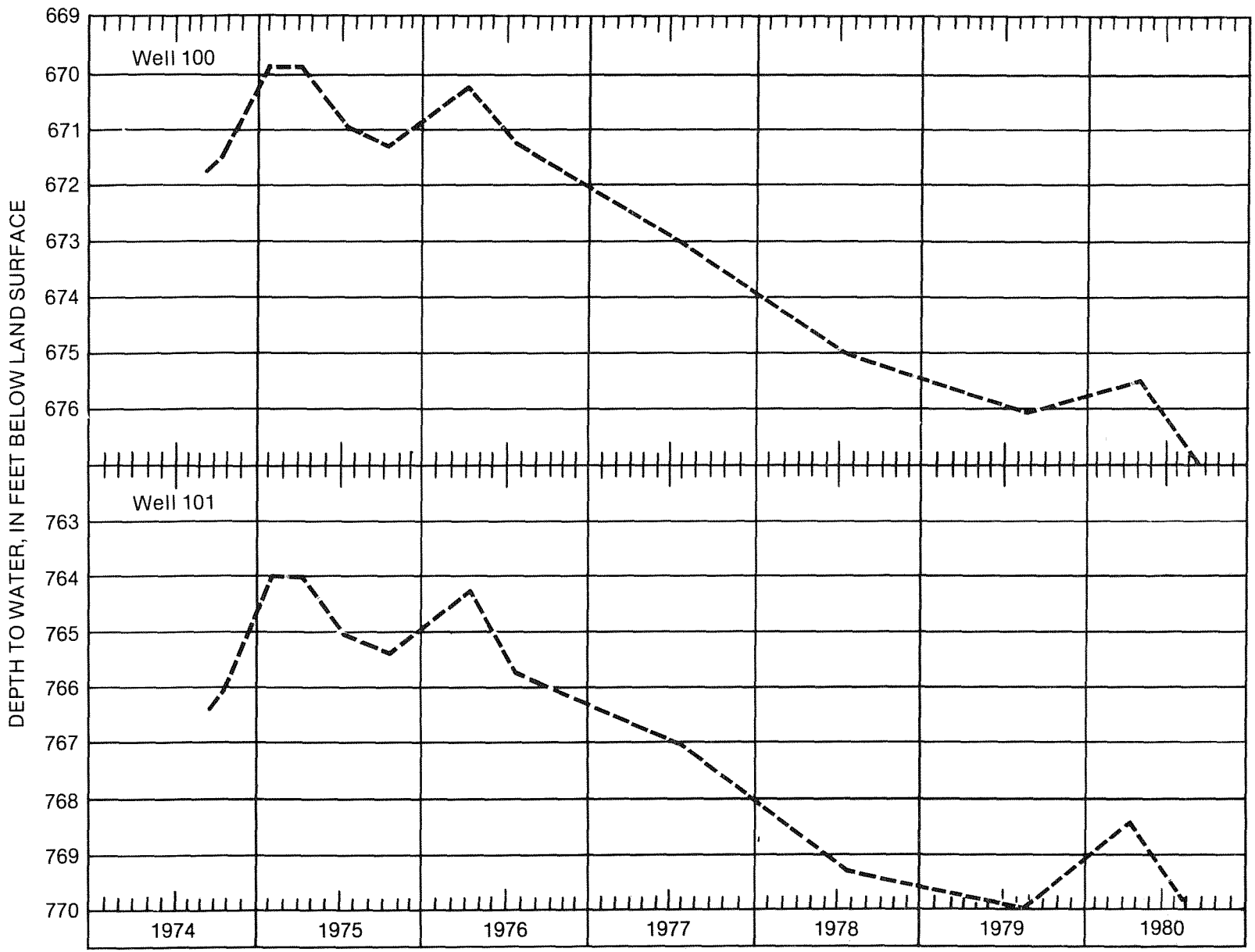


Figure 14. Hydrographs for wells 100 and 101.

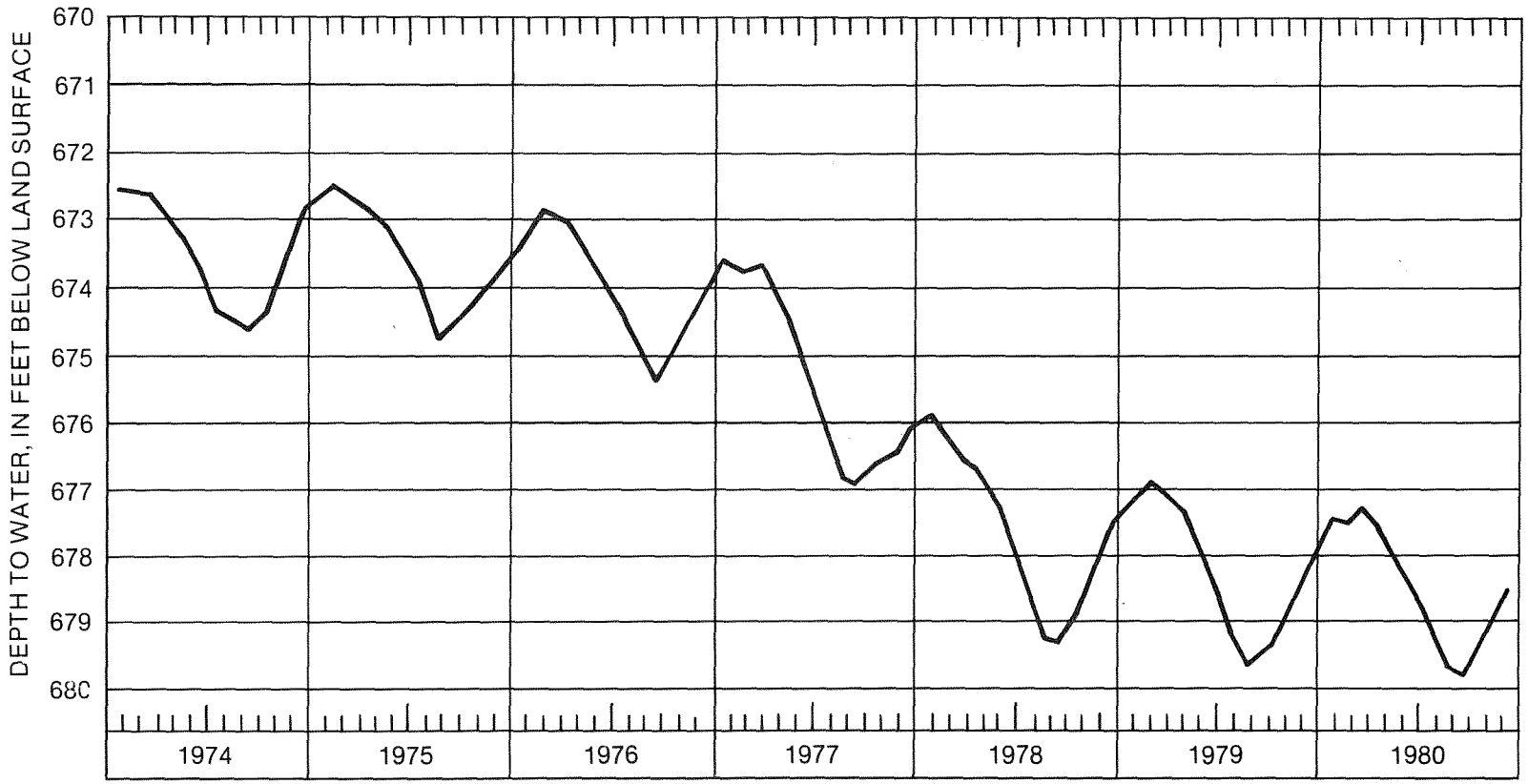


Figure 15. Hydrograph for Arbor Test well.

As previously stated, recharge to the Snake River Plain aquifer decreased after mid-1977 to 1981. Hydrographs for wells 100, 101, and Arbor Test exhibit declining water levels since that time, as do the hydrographs of wells previously described.

RWMC Production Well

Additional construction at the Radioactive Waste Management Complex (RWMC) in 1974 brought a need for a water production well. Water from this well is used for waste-water processing at the radioactive decontamination facility, fire safety, and a drinking-water supply. Although water levels in the well cannot be measured, subsurface information obtained at the time of drilling is useful in interpretation of the hydrogeologic and geochemical characteristics of the RWMC area (Barraclough, Robertson, and Janzer, 1976).

The well was drilled by the cable-tool method during June through November, 1974 to a total depth of 685 feet (table 1). Initially, the well was drilled to a depth of 562 feet. An 18-inch casing was set to a depth of 108 feet with a 14-inch casing set inside the 18-inch casing from the land surface to 562 feet. The space between the 18-inch casing and the borehole wall, and the annular space between the 14-inch and 18-inch casings were then filled with cement. The well was then drilled an additional 123 feet, and was completed as a 14-inch open hole. A 10-inch casing was then suspended from the surface to a depth of 658 feet and perforated in two zones--between 590 and 610 feet and between 625 and 635 (table 1).

Gamma-ray and drillers' logs show that the subsurface is dominated by several basalt flows interbedded with five sediment zones (fig. 16). The surficial sedimentary deposits are approximately 9 feet thick. The subsurface sediment deposits are thin except for a silty sand bed which is 17 feet thick located between 223 and 240 feet below land surface and a 24 foot bed located between 556 and 580 feet.

A 24-hour pump test was run from November 23 to November 24, 1974. The well was pumped at variable rates of about 100, 200, 350, and 400 gallons per minute. Water-level drawdown ranged from 3 to 5.5 feet depending on the pumping rate. The specific capacity of the well, after pumping 4 hours at 412 gallons per minute, was 75 gallons per minute per foot of drawdown (J. T. Barraclough, oral commun. 1981).

SUMMARY

This report describes the construction and the data obtained from drilling six wells, 97, 98, 99, 100, 101, and RWMC Production (the Radioactive Waste Management Complex well) and deepening two existing wells, 30 and Highway 1, at INEL. The information gained from the drilling program on the subsurface geology and hydrology will contribute to the data base at the INEL.

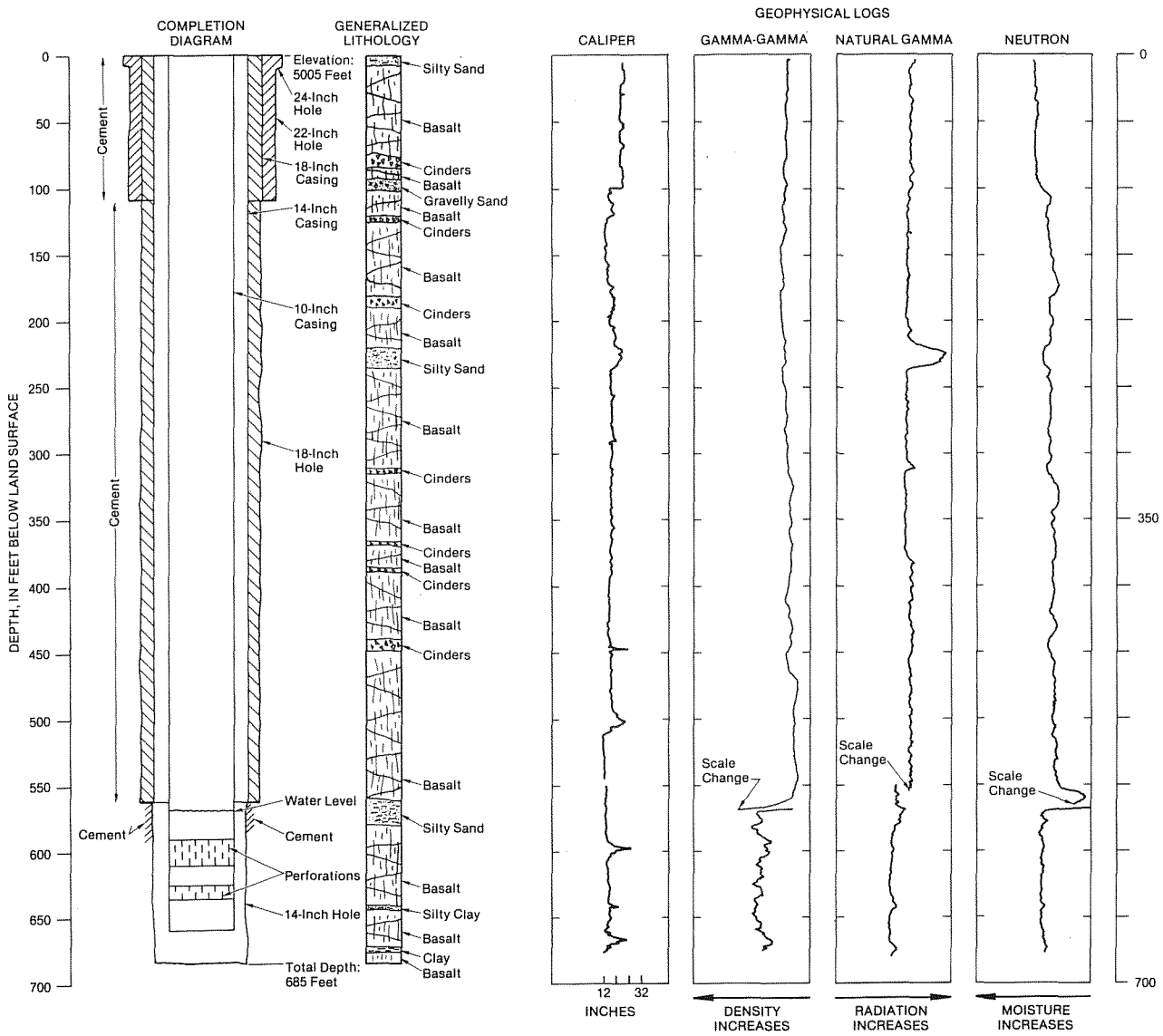


Figure 16. Diagrams showing well completion, lithology, and geophysical logs for the Radioactive Waste Management Complex well.

Geophysical logs recorded in each of the wells, supplemented by drillers' logs, indicate that the subsurface geology consists of basalt flows interbedded with sediments. Silicic volcanic rocks, 250 feet thick, were penetrated in well Highway 1.

Water levels in the wells show cyclic seasonal fluctuations of maximum water levels in the late winter and minimum water levels in the mid-summer. Multiple piezometers in Highway 1 may suggest that the effects on water levels of extensive pumping in heavily irrigated areas are more pronounced in the upper part of the Snake River Plain aquifer than in the lower part. Water levels in wells 97, 98, and 99 respond to changes in recharge to the Snake River Plain aquifer from the Big Lost River. Water levels in these wells show a general decline from 1977 to 1980. A marked decrease in water levels in the wells from 1977 to 1981 is attributed to a lack of recharge to the Snake River Plain aquifer.

Measured water levels in multiple piezometers in well 30 indicate increasing pressure with depth. The hydrogeologic conditions at well 30 may be influenced by the Mud Lake-Market Lake barrier where ground water is under water-table conditions in the uppermost part of the saturated zone and artesian conditions at greater depths.

SELECTED REFERENCES

Barraclough, J. T., Lewis, B. D., and Jensen, R. G., 1981, Hydrologic conditions at the Idaho National Engineering Laboratory, Idaho: Emphasis 1974-1978: U.S. Geological Survey Water-Resources Investigations Open-File Report 81-526, (IDO-22060) 77p.

Barraclough, J. T., Robertson, J. B., and Janzer, V. J., 1976, Hydrology of the solid waste burial ground, as related to the potential migration of radionuclides, Idaho National Engineering Laboratory, with a section on Drilling and sample analyses, by L. G. Saindon: U.S. Geological Survey Open-File Report 76-471 (IDO-22056), 183 p.

Chase, G. H., Teasdale, W. E., Ralston, D. A., and Jensen, R. G., 1964, Completion report for observation wells 1 through 49, 51, 54, 55, 56, 80 and 81 at the National Reactor Testing Station, Idaho: U.S. Geological Survey Open-File Report IDO-22045, 65 p.

Crosthwaite, E. G., 1973, A progress report on results of test-drilling and ground-water investigations of the Snake Plain aquifer, southeastern Idaho, part 1-Mud Lake region, 1969-1970 and part 2-observation wells south of Arco and west of Aberdeen: Idaho Department of Water Administration, Water Information Bulletin No. 32, 60 p.

Keys, W. S., and MacCary, L. M., 1971, Application of borehole geophysics to water-resources investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 2, chap. E1, 124 p.

Lewis, B. D., and Goldstein, F. G., 1982, Evaluation of a predictive ground-water solute-transport model at the Idaho National Engineering Laboratory, Idaho: U.S. Geological Survey Water Resources Investigtions 82-25, (IDO-22062) 71 p.

Mundorff, M. J., Crosthwaite, E. G., and Kilburn, Chabot, 1964, Ground water for irrigation in the Snake River Basin in Idaho: U.S. Geological Survey Water-Supply Paper 1654, 222p.