DATA FOR GROUND-WATER TEST HOLE NEAR NICOLAUS

CENTRAL VALLEY AQUIFER PROJECT

CALIFORNIA

By James J. French, R. W. Page, and G. L. Bertoldi

U.S. GEOLOGICAL SURVEY

Open-File Report 83-273

National Regional Aquifer Systems Analysis Program

Sacramento, California
September 1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, SECRETARY

GEOLOGICAL SURVEY

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CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION TABLE

In this report some measurements are given in inch-pound units and some laboratory data are reported in International System of Units. Conversion factors from inch-pound units to International System of Units are listed below. To convert from International System of Units to inch-pound units multiply by the reciprocal of the conversion shown.

Multiply	By	To obtain
acres	0.4047	hm^2 (square hectometers)
ft (feet)	0.3048	m (meters)
ft/d (feet per day)	0.00243	mD (millidarcies)
ft^2 (square feet)	0.0929	m^2 (square meters)
ft^2/yr (square feet per year)	0.0929	m^2/yr (square meters per year)
inches	25.40	mm (millimeters)
lb/in^2 (pounds per square inch)	703.1	kg/m^2 (kilograms per square meter)
lb/ft^2 (pounds per square foot)	4.881	kg/m^2 (kilograms per square meter)
lb/ft^3 (pounds per cubic foot)	16.02	kg/m^3 (kilograms per cubic meter)
mi (miles)	1.609	km (kilometers)

Temperature is reported in degrees Celsius (°C). To convert to degrees Fahrenheit (°F) use:

$$\text{Temperature °F} = 1.8 (\text{temperature °C}) + 32$$

ALTITUDE DATUM

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the both the United States and Canada, formerly called mean sea level.

TRADE NAMES

The use of brand, firm, or trade names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

DATA FOR GROUND-WATER TEST HOLE NEAR NICOLAUS

CENTRAL VALLEY AQUIFER PROJECT, CALIFORNIA

By James J. French, R. W. Page, and G. L. Bertoldi

ABSTRACT

This report provides preliminary data for the third of seven test holes drilled as a part of the Central Valley Aquifer Project, which is part of the National Regional Aquifer Systems Analysis Program. The test hole was drilled in the SW¼NE¼ sec. 2, T. 12 N., R. 3 E., Sutter County, Calif., about 1½ miles northwest of the town of Nicolaus. Drilled to a depth of 1,150 feet below land surface, the hole is cased to a depth of 100 feet with 16-inch diameter casing and equipped with three piezometer tubes to depths of 311, 711, and 1,071 feet. A 5-foot well screen is set in sand at the bottom of each piezometer. Each screened interval has a cement plug above and below it to isolate it from other parts of the aquifer, and the well bore is filled between the plugs with sediment.

Thirty-one cores and 28 sidewall cores were recovered. Laboratory tests were made for mineralogy, consolidation, grain-size distribution, Atterberg limits, X-ray diffraction, thermal conductivity, and chemical quality of water. Geophysical and thermal gradient logs were made.

The hole is sampled periodically for chemical analysis and measured for water level in the three tapped zones.

This report presents methods used to obtain field samples, laboratory procedures, and the data obtained.

INTRODUCTION

The ground-water test hole near Nicolaus (12N/3E-2G) (fig. 1) is the third of a series of test holes drilled as part of the Central Valley Aquifer Project (CVAP). CVAP, as a part of the National Regional Aquifer Systems Analysis Program, will evaluate the entire Central Valley (fig. 2) for its optimum ground-water potential. In the Sacramento Valley, the northern part of the Central Valley, geologic and hydrologic data below a depth of a few hundred feet are scarce. Most water wells in the Sacramento Valley are less than 300 feet deep (Olmsted and Davis, 1961, p. 137), but the potentially usable aquifer may extend to a depth of 2,500 feet (Bertoldi, 1979, p. 13).

The test hole was drilled and piezometer tubes were installed to provide data on confining beds, hydraulic connection between permeable units, chemical quality of the water, thermal gradient, mineral composition, and head differentials. The data are given in this report and include descriptions of rock cuttings coming out of the borehole, drill cores, sidewall cores, and geophysical logs. Also included are laboratory reports on mineralogy, consolidation, grain-size distribution, Atterberg limits, X-ray diffraction, thermal conductivity, thermal gradient, chemical quality of water, and water levels.

This report presents all the data obtained in these tests. In a few instances, the reporting laboratory's measuring units or definitions have been changed to conform to U.S. Geological Survey usage.

The site near Nicolaus was selected to facilitate correlation of lithology across part of the Sacramento Valley, including an ash bed and a diatomaceous clay found in test hole 12N/1E-34Q near Zamora, Calif. (French and others, 1982, table 1). Neither the ash nor the clay were found in test hole 12N/3E2G. Also, the site was selected in order to determine if ground water in this part of the valley is confined.

WELL-NUMBERING SYSTEM

The well-numbering system used by the U.S. Geological Survey in California indicates the location of wells according to the rectangular system for the subdivision of public land. For example, in the well 12N/3E-2G, the first two segments designate the township (T. 12 N.) and the range (R. 3 E.); the third number gives the section (sec. 2); and the letter indicates the 40-acre subdivision of the section, as shown in the accompanying diagram. A final digit is a serial number for wells in each 40-acre subdivision (12N/3E-2G1). For this site, the three piezometers were assigned serial numbers.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

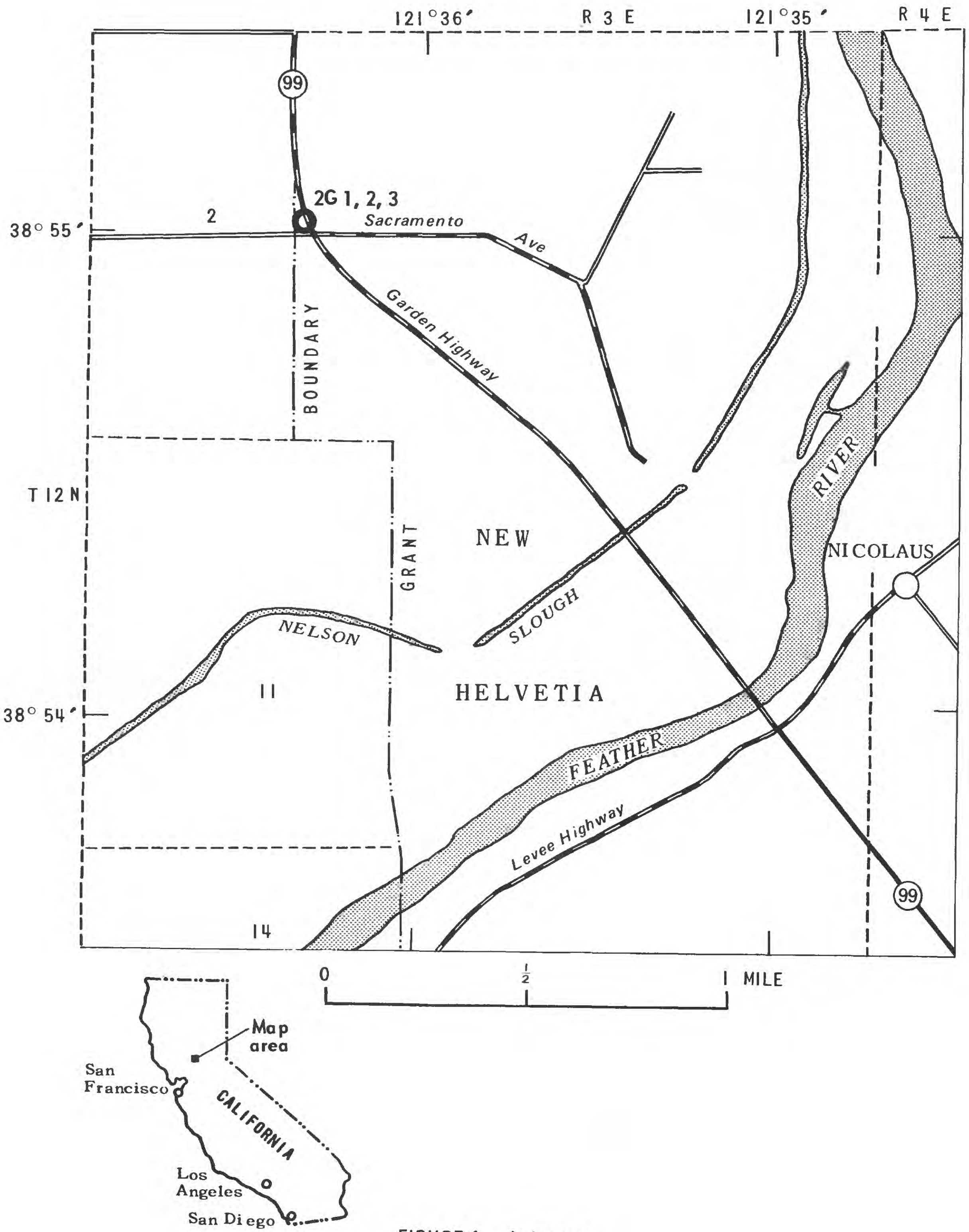

FIGURE 1. – Index map

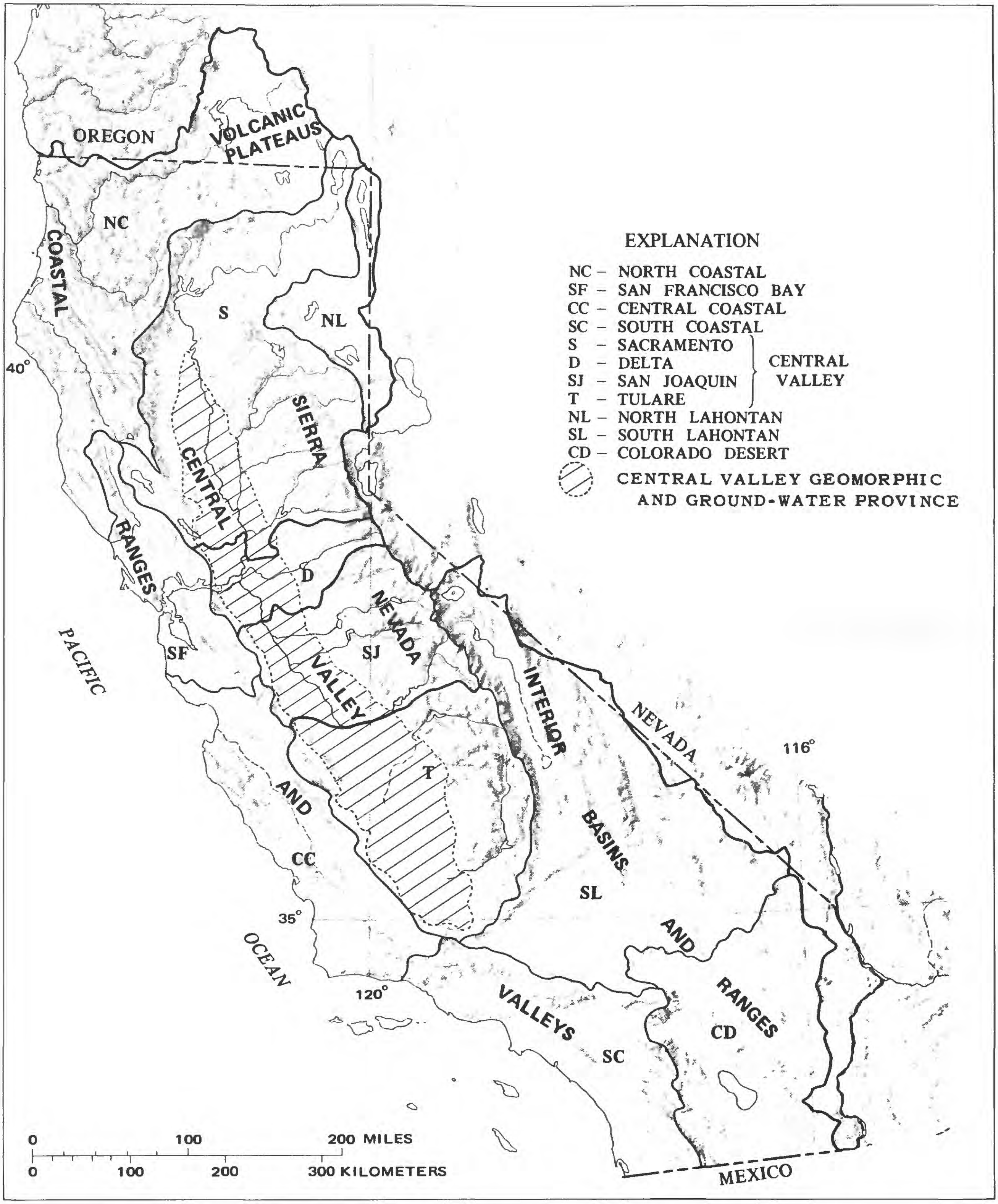

FIGURE 2. – Subregions and landforms of the California Region. (Modified from Thomas and Phoenix, 1976, p. E3).

PHYSICAL DESCRIPTION OF THE TEST HOLE

The test hole was started in alluvium December 18, 1979, and bottomed at 1,150 feet in olive-gray siltstone February 29, 1980. It was drilled by a mud-rotary rig using roller cone bits. Bit sizes used were 22 inches to a depth of about 100 feet, 11 inches to 760 feet, and 6-3/4 inches to bottom. The test hole is cased with 16-inch-diameter cemented steel casing from land surface to 100-foot depth (fig. 3).

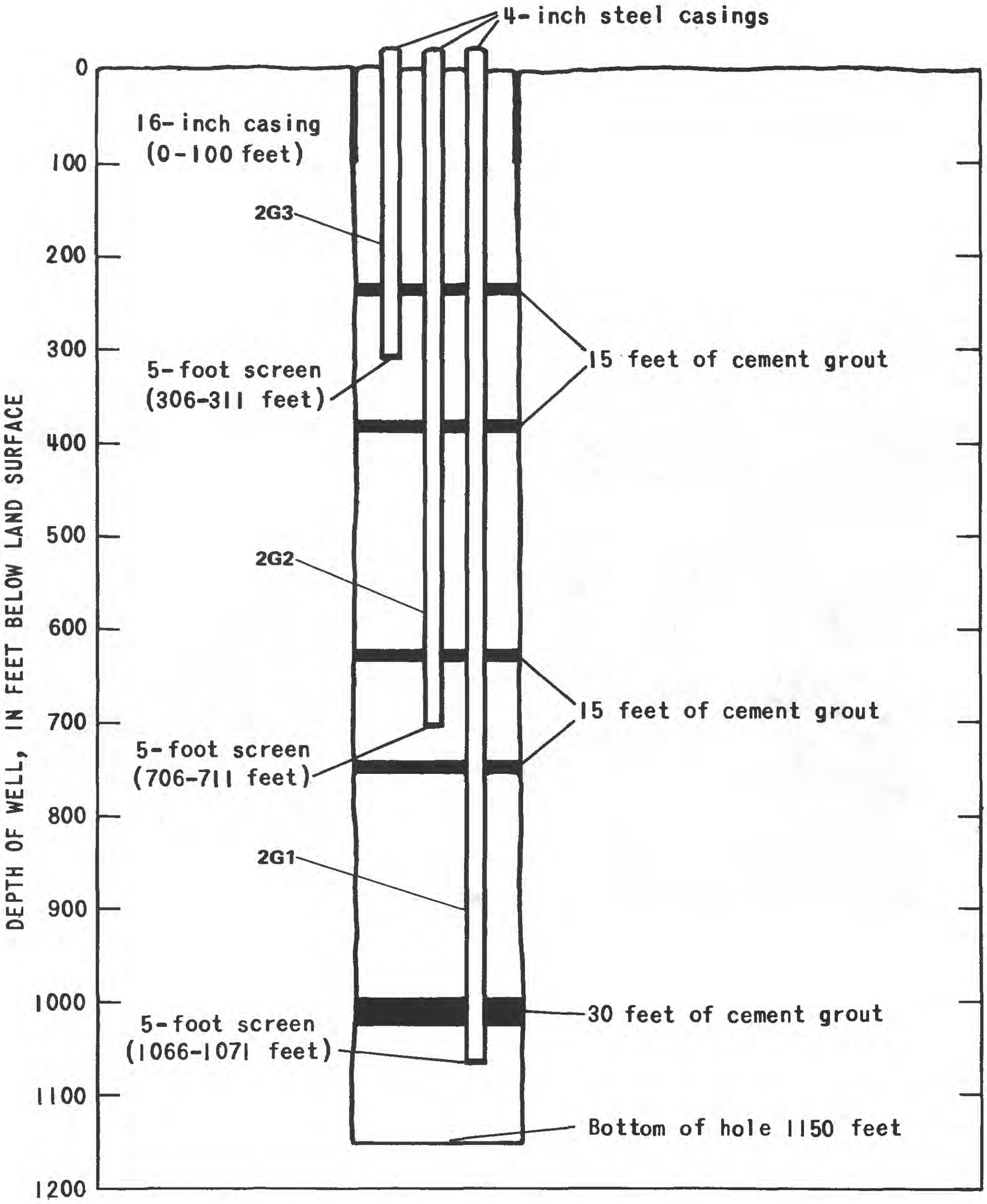

FIGURE 3. – Diagram of construction of test hole near Nicolaus.

Three 4-inch-diameter steel piezometers were installed at depths of 311 (G3), 711 (G2), and 1,071 (G1) feet. The bottom 5 feet of each piezometer is screened to provide access to the aquifer. Each screened interval has a cement plug above and below it to isolate it from other parts of the aquifer. The cement plugs were implaced at depth intervals as follows: 227-242 feet, 375-390 feet, 622-637 feet, 739-754 feet, and 995-1,025 feet. Between the plugs, the well bore was filled with sediment.

During the drilling of the test hole, rock cuttings coming out of the bore hole were continuously monitored and collected at frequent intervals. Thirty-one drill cores and 28 sidewall cores were recovered. The cores are to be stored in the California Well Sample Repository in Bakersfield, Calif.

The test hole was finished with a 7-foot-square concrete slab surrounding the hole, and a 6-foot-square sheet metal shelter built over it (fig. 4). The top of well casings above land surface are: G1, 1.57 feet; G2, 1.56 feet; and G3, 1.59 feet.

FIGURE 4. — Test-hole structure.

CUTTINGS AND CORE DESCRIPTIONS

The descriptions given in table 1 are for the depth interval indicated, from top to bottom, unless only a single depth is given. The single depths indicate that the description is for that depth only, not an interval. The log was constructed from all available data, including cuttings, cores, and geophysical logs. All depths are from land-surface altitude, which is 32.54 feet above the National Geodetic Vertical Datum of 1929.

The elements of a sample description are sediment type and texture, color, sorting, rounding, and cementation. Any or all these elements, plus any pertinent comments, were used by the geologist at the drill site to describe each sample.

Color descriptions follow the Rock Color Chart of the Geological Society of America (Goddard and others, 1948). This color chart has color chips for comparison with the cuttings and each chip is designated with a code. The code consists of a color name and an alphanumeric system which describes hue, value, and chroma. An example of this code is: light-olive-gray 5Y5/2, where the color name is defined by hue (5Y), value (5), and chroma (2). Samples and cores were described when moist under artificial light.

Texture descriptions follow the National Research Council (1947) classification of grain size (table 2).

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G

Test hole 12N/3E-2G. Altitude of land surface, 32.54 feet. Drilled by Water Development Corp. in 1979 and 1980. Screens at 306-311 feet (G3); 706-711 feet (G2); 1,066-1,071 feet (G1).

Depth (feet) From	To	Description
CUTTINGS		
0	82	Clay, silt, and sand, very fine to medium, silty sandy clay, some gravel very fine to medium; overall light-olive-brown 5Y5/6 to grayish-olive-green 5GY/32.
--	10	Silt, dark-yellowish-brown 10YR4/2, some plant material and caliche.
--	20	Clay, silt, and sand, clay light-olive-gray 5Y5/2 to light-olive-brown 5Y5/6, silt to sand, medium; overall light-olive-gray 5Y5/2 to pale-olive 10Y6/2, some plant material.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
--	30	Clay, with some silt and hard nodules; clay, light-olive-brown 5Y5/6; nodules, light-olive-brown 5Y5/6 to moderate-brown 5YR3/4, some plant material.
--	40	Clay, silty, sandy, occasional nodules of hard clay, clay, moderate-olive-brown 5Y4/4 to grayish-olive 10Y4/2, with some clay, grayish-olive 10Y4/2, nodules of hard clay, same color, sand, very fine, overall grayish-olive 10Y4/2 to olive-gray 5Y3/2, some plant material.
--	50	Clay, dusky-yellow-green 5GY5/2 to grayish-olive 10Y4/2, some plant material.
--	60	Clay, silt, and sand; clay, grayish-olive 10Y4/2, silt to medium sand, overall grayish-olive 10Y4/2 to olive-gray 5Y3/2, some plant material.
--	70	Silt and clay, grayish-olive 10Y4/2, some plant material.
--	80	Clay with silt and sand; clay, grayish-olive 10Y4/2, silt to medium sand, grayish-olive 10Y4/2 to olive-gray 5Y3/2, occasional very coarse sand grains, subangular, medium to high sphericity, mostly light grains, white N9 to light-olive-gray 5Y6/1, some dark grains, olive-gray 5Y4/1 to brownish-black 5YR2/1, occasional flakes of mica to 0.08 inch.
82	85	Sand with gravel, finer sands grayish-olive 10Y4/2 to olive-gray 5Y3/2, sand, medium to coarse with some very coarse sand to very fine gravel, coarse grains subangular to subrounded, medium to low sphericity; coarse sand, 2/3 dark grains, medium-dark-gray N4 and dark-greenish-gray 5GY4/1 to grayish-black N2, 1/3 light grains, white N9 to medium-light-gray N6 and light-olive-gray 5Y6/1.
85	92	Gravel, very fine to medium, with silt, clayey; gravel dark-greenish-gray 5GY4/1 to olive-black 5Y2/1 and grayish-black N2, some light grains, white N9 to yellowish-gray 5Y8/1, subrounded to rounded, low sphericity; clayey silt grayish-olive 10Y4/2.
92	100	Clay, silt, and sand; clay, dusky-yellow-green 5GY5/2 to grayish-olive 10Y4/2, silt and sand, overall grayish-olive 10Y4/2 to grayish-olive-green 5GY/32, some plant material.
--	100	Clay, silty, dusky-yellow-green 5GY5/2, some plant material.
100	117	Sand at base, silt, clayey, dusky-yellow-green 5GY5/2, some plant material.
SIDEWALL CORE NO. 60		
--	117	Sand, very fine grained, silty, olive-gray 5Y3/2, hard.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
CUTTINGS		
117	135	Sand, very fine to medium, olive-gray 5Y3/2, hard, some silt.
135	149	Clay, silty, dusky-yellow-green 5GY5/2.
149	162	Sand, olive-gray 5Y3/2.
--	155	Sand, fine, olive-gray 5Y3/2.
162	165	Silt, clayey, dusky-yellow-green 5GY5/2.
--	165	Sand, fine grained, some gravel, olive-gray 5Y3/2.
165	183	Gravel, fine to coarse, cobbles, some sand; gravel, fine to coarse, some larger pieces broken by drill bit, 70 percent black N1, 20 percent yellowish-gray 5Y8/1, 10 percent grayish-olive-green 5GY3/2 and varigated, poor sorting, 40 percent angular, 60 percent well rounded, spherical to elongate, some tabular, very clean, mostly metamorphic, some light and dark grains, igneous.
SIDEWALL CORE NO. 54		
--	171	Gravel, olive-black 5Y2/1, broken piece 0.8 inch, original piece could have been to 1.6 inch, smooth, well rounded, probably metamorphic, some broken pieces of black and white igneous rock 0.3 to 0.4 inch, smooth, rounded, broken.
CUTTINGS		
183	192	Clay, blue, 5B-/-; silt, olive-gray 5Y4/1.
SIDEWALL CORE NO. 52		
--	186	Silt, olive-gray 5Y4/1, individual grains are clear, white, brown, green.
CUTTINGS		
192	200	Sand, silty.
200	245	Clay and silty clay, blue, light-olive-gray 5Y5/2 to greenish-gray 5GY6/1.
SIDEWALL CORE NO. 50		
--	204	Clay, greenish-gray 5GY6/1, hard.
SIDEWALL CORE NO. 49		
--	220	Clay, silty, light-olive-gray 5Y5/2, hard.
SIDEWALL CORE NO. 48		
--	236	Clay, olive-gray 5Y4/1, plastic.
CUTTINGS		
245	264	Clay, and sandy clay, with some silt, sand, and gravel, light-olive-gray 5Y5/2 to grayish-blue-green 5BG5/2.

Depth (feet) From	To	Description
SIDEWALL CORE NO. 47		
--	249	Silt and sand, grayish-olive 10Y4/2, very fine sand, hard.
CORE NO. 1		261-264 feet. Recovered 2.5 feet.
Top---------261		Gravel and sand; gravel medium to coarse, smallest 0.4 inch, largest 1.2 inches, mostly black N1, and varigated light and dark grains, well rounded, elongate to suboval, metamorphic and igneous; sand silty, medium to fine.
261	261.1	Gravel, clay, and some sand; gravel coarse to very coarse, 0.7 to 1.4 inches, black, N1, rounded, elongate to oval, mostly black chert, also very light-gray quartzite N8, and mottled yellow-brown pebbles, clay grayish-olive 10Y4/2, plastic, sandy, sand mostly fine, occasional coarse, black N1, rounded particles.
261.1	261.6	Clay very sandy, and sand, outward appearance is fine sand but clay predominates after washing through sieve (0.001 inch), grayish-olive 10Y4/2, sandy throughout, no discrete pieces of pure clay; sand, very fine to fine, a few coarse particles, clear and light colors with 30 percent black N1 subangular to rounded, overall sample is firm but friable.
261.6	262.9	Clay, grayish-olive 10Y4/2, sandy as above but more clay, occasional thin clay streak.
262.9	263.5	Clay, silty, light-olive-gray 5Y5/2, hard.
Bottom------264		Clay, grayish-olive 10Y4/2, slick.
CUTTINGS		
264	284	Clay, sandy, some gravel, sand, and silt; clay olive-green 5Y3/2, some dusky-yellow-brown 10YR2/2, hard, sand medium to very coarse, rounded, spherical, frosted.
CORE NO. 2		281-284 feet. Recovered 1.8 feet.
Top---------281		Clay, silty, and gravel; clay grayish-olive 10Y4/2, sticky; gravel, coarse 0.8-1.0 inch, black N1 and mottled grayish-black N2, subangular.
281	281.5	Clay, silty, between light-olive-gray 5Y5/2 and grayish-olive 10Y4/2, hard (reported very soft on fresh, moist core), scattered fine to very coarse sand.
281.5	281.9	Clay, gravel, and some sand; clay as above but more sand; gravel, a few scattered tabular pebbles 0.8 x 0.2 inch, rounded, chert, dark-gray N3.
--	281.9	Silt, thin layer, sandy, olive-gray 5Y4/1, crumbly, sand very fine to fine, about 20 percent of sample.

Depth (feet) From	To	Description
281.9	282.8	Clay, silty, olive-gray 5Y3/2, scattered fine sand.
Bottom------284		Clay, dusky-yellow-brown 10YR2/2.
CUTTINGS		
284	300	Clay, dark-greenish-gray 5GY4/1, sticky streaks of medium sand.
300	302	Clay, olive-gray 5Y4/1.
SIDEWALL CORE NO. 46		
--	300	Clay, olive-gray 5Y4/1, sticky.
CUTTINGS		
302	315	Sand, very fine to medium, angular to rounded.
CORE NO. 3		308-311 feet. Recovered 3 feet.
Top---------308		Sand, very fine to fine, subangular to rounded, pink, white, and black particles; overall moderate-olive-brown 5Y4/4.
308	309.9	Sand, fine to medium, mostly clear and milky quartz, 20 percent each light-olive 10Y5/4 and black N1, angular to subrounded, mostly loose but some crumbly pieces seem to have silt as cementing agent.
309.9	310.5	Sand, as above except very fine to fine.
Bottom------311		Sand as above, fine to medium.
CUTTINGS		
315	328	Clay and silty clay.
328	340	Sand, fine, olive-gray 5Y3/2, quartz, mica, black minerals, some clay in thin layers.
340	355	Clay and silty clay, light-olive-gray 5Y5/2 to olive-gray 5Y5/2.
CORE NO. 4		346-349 feet. No recovery.
Top---------346		Clay, silty, olive-gray 5Y3/2, one pebble 0.4 by 1.6 inches, black N1, well rounded (on top of core barrel).
Bottom------349		Clay, silty, light-olive-gray 5Y5/2 (on bottom of core barrel).
CUTTINGS		
355	361	Sand, silty, medium to coarse, light-olive-gray 5Y5/2, subangular to rounded, much clear quartz.
361	364	Clay, silt, and sandy and silty clay, olive-gray 5Y3/2 to dark-yellowish-brown 10YR4/2.
CORE NO. 5		361-364 feet. Recovered 3 feet.
Top---------361		Clay, silty, moderate-olive-brown 5Y4/4.

Depth (feet) From	To	Description
361	361.2	Clay, sandy, and sand, very fine to fine; alternating layers of grayish-olive 10Y4/2 and olive-gray 5Y3/2, very plastic, clay oozed out of core barrel upon extrusion, sand in thin partings.
361.2	363.7	Clay, silty and silt; clay, grayish-olive 10Y4/2, silt predominates in lower part, olive-gray 5Y3/2, some fine sand.
Bottom------364		Silt, sandy and sand, very fine to fine; clay dark-yellowish-brown 10YR4/2.
CUTTINGS		
364	375	Sand, silty, fine to coarse, subrounded to angular, 30 percent quartz.
375	400	Clay, silty clay, and silt, grayish-olive 10Y4/2 to olive-gray 5Y3/2.
SIDEWALL CORE		
--	379	Silt, clayey, grayish-olive 10Y4/2.
CORE NO. 6		391-394 feet. Recovered 2.2 feet.
Top---------391		Clay, grayish-olive 10Y4/2, slick, some silt.
391	391.5	Clay, silty, and sand, some gravel; clay, olive-gray 5Y3/2 mottled with grayish-olive 10Y4/2; sand, scattered, coarse to very coarse, subangular to angular.
391.5	393.2	Clay, silty, sandy, and sand, very fine to medium; clay olive-gray 5Y3/2, crumbly; sand, some scattered coarse particles, most sand washes through a 0.01 inch sieve, coarse particles subangular to rounded.
Bottom------394		Silt, light-olive-gray 5Y5/2, hard.
CUTTINGS		
400	403	Sand, fine to medium, 60 percent light colors, 40 percent dark, subangular to rounded.
403	410	Silt, light-olive-gray 5Y5/2.
410	412	Clay, sandy, fine, light-olive-gray 5Y5/2.
412	420	Clay, light-olive-gray 5Y5/2.
420	425	Sand, silty, and silt, light-olive-gray 5Y5/2.
CORE NO. 7		421-424 feet. Recovered 1.5 feet.
Top---------421		Sand, silty, fine to very coarse, light-olive-gray 5Y5/2, subangular to rounded (larger particles), metamorphics and quartz.
421	421.1	Silt, clayey, some sand; overall light-olive-gray 5Y5/2, hard; sand all sizes but very coarse is rare, much lost through 0.01 inch screen, appears dark but only 30 percent are black or gray, most are clear quartz and light colors, two black pebbles rounded but broken; larger 1.2 inch, smaller 0.8 inch, grayish-black N2, angular to subrounded.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
421.1	422.5	Sand, very fine to fine, some medium, 40 percent passed through 0.01 inch screen, black and gray give overall dark color but only 40 percent are black or gray, rest are clear or light, angular to subrounded; some silt acts as a binder for sand, but pieces are crumbly and friable. Iron stain as streaks of moderate-reddish-brown 10R4/6 and yellow.
Bottom------424		Sand as above with some silt. Iron stain as above.
CUTTINGS		
425	453	Clay, silt, and sand; clay, light-olive-gray 5Y5/2, sand, fine to coarse, light and dark particles equal, a few specks of red.
SIDEWALL CORE NO. 42		
--	430	Silt, light-olive-gray 5Y5/2, hard, some very fine sand.
SIDEWALL CORE NO. 41		
--	444	Clay, light-olive-gray 5Y5/2, plastic.
CORE NO. 8		451-454 feet. Recovered 3 feet.
Top---------451		Silt, clayey, some very fine to coarse sand and some gravel, light-olive-gray 5Y5/2, sticky.
451	452.8	Clay, silty grayish-olive 10Y4/2, becomes very soft when wet.
452.8	453	Sand, silty, moderate-olive-brown 5Y4/4 overall, very fine, all goes through 0.01 inch screen, mostly clear or light.
Bottom------454		Sand, silty, very fine to fine, subangular to rounded, mostly rounded clear quartz, crumbly.
CUTTINGS		
453	462	Sand and silty sand, fine to medium, moderate-olive-brown 5Y4/4, some silt.
--	461	Sand, silty, fine to medium, rounded to subangular, mostly clear quartz and light colored particles.
SIDEWALL CORE NO. 39		
--	462	Sand, very fine, some fine, subangular, well sorted, friable.
CUTTINGS		
462	484	Clay, some silt, and sandy silt, moderate-olive-brown 5Y4/4.
--	470	Sand, silty, fine to medium, particles darker than above, subangular to rounded.

Depth (feet) From	To	Description
CORE NO. 9		481-484 feet. Recovered 2 feet.
Top---------481		Silt, sandy, some clay, moderate-olive-brown 5Y4/4, sand, very fine to fine, some coarse.
481	48(?)	Clay, silty, moderate-olive-brown 5Y4/4.
48(?)	48(?)	Silt, between light-olive-brown 5Y5/6 and moderate-olive-brown 5Y4/4.
482(?)	483	Silt, clayey, moderate-olive-brown 5Y4/4, very soft when wet, less than 5 percent sand, medium to coarse, subangular to rounded.
Bottom------484		Sand, silty, very fine to fine, some medium, clear quartz 70 percent, dark and black N1 particles 30 percent, subangular, loose.
CUTTINGS		
484	488	Sand, silty, very fine to fine, some medium.
488	495	Clay, silt, some sand, moderate-olive-brown 5Y4/4.
--	492	Sand, silty, light and dark colors equal, moderate-olive-brown 5Y4/4.
495	505	Clay, silty clay and silt, dark-yellowish-brown 10YR4/2 to grayish-olive 10Y4/2.
CORE NO. 10		501-504 feet. Recovered 2 feet.
Top---------501		Silt with some very fine to very coarse sand, light-olive-gray 5Y5/2.
501	501.13	Clay, dark-yellowish-brown 10YR4/2.
501.13	501.2	Clay, silty, olive-gray 5YR3/2.
501.2	503	Clay, silty, grayish-olive 10Y4/2.
Bottom------504		
CUTTINGS		
505	538	Sand, some clay, sand, medium to coarse, well sorted, overall dark color with black, white, green, and pink, some clear quartz grains, subangular to rounded, most grains spherical.
SIDEWALL CORE NO. 35		
--	513	Clay, dark-yellowish-brown 10YR4/2, very runny (probably mud cake).
CUTTINGS		
538	556	Clay and silt, some sand, some moderate-olive-brown 5Y4/4.
SIDEWALL CORE NO. 31		
--	539	Clay, moderate-olive-brown 5Y4/4.
CUTTINGS		
540	545	Sand, as at 505-538.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
SIDEWALL CORE NO. 30		
--	545	Clay and silt, sandy, moderate-olive-brown 5Y4/4, sand fine grained, less than 10 percent.
CUTTINGS		
556	563	Gravel, fine to very fine, some sand, medium to coarse, some clay; gravel and sand subrounded to rounded, some iron stains.
CORE NO. 11		555-558 feet. Recovered 1 foot.
Top---------555		
--	557.2	Gravel, fine to very fine, some coarse sand, black, clear, and olive particles about equal, some dark-red particles, subrounded to rounded, spherical to elongate, some olive clay matrix.
--	557.4	Same with more clay.
--	557.5	Same with pieces of clay, grayish-brown 5YR3/2, and some medium gravel, 0.3-0.6 inch.
--	557.7	Same with iron staining.
--	557.8	Same with more clay, less gravel.
--	558.0	Same, one pebble, greenish-black 5G2/1, 1.0 x 2.2 inch, rounded smooth, elongate.
Bottom------559		
SIDEWALL CORE NO. 29		
--	561	Sand, fine to very fine, rounded to subrounded, mostly clear and milky quartz, black particles, clean, loose.
CUTTINGS		
563	567	Clay, silty, light-olive-gray 5Y5/2.
SIDEWALL CORE NO. 28		
--	565	Clay, silty, light-olive-gray 5Y5/2.
CUTTINGS		
567	578	Clay, silty, silt, and some sand, light-olive-gray 5Y5/2.
578	598	Sand, medium to coarse, and silt; sand, dark color, black, white, and olive particles, subangular to rounded.
598	605	Silt and clay, light-olive-brown 5Y5/2 to olive-gray 5Y3/2.
SIDEWALL CORE NO. 26		
--	598	Silt, light-olive-brown 5Y5/2.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
CORE NO. 12		601-604 feet. Recovered 1.9 feet.
Top---------601		
601	601.9	Clay, silty, olive-gray 5Y3/2, some sand and small amounts of gravel, iron-stained streaks.
601.9	602.9	Clay, hard, moderate-olive-brown 5Y4/4, plant fragments and molds of plant fragments.
Bottom------604		Clay, light-olive-gray 5Y5/2, hard.
CUTTINGS		
605	612	Sand, medium to coarse, moderate-olive-brown 5Y4/4.
612	617	Clay, silty, olive-gray 5Y3/2 to light-olive-gray 5Y5/2.
617	622	Sand, very fine to fine.
SIDEWALL CORE NO. 25		
--	620	Sand, silty, very fine to fine, olive-gray 5Y3/2, cohesive, may be a clay binding.
CUTTINGS		
622	639	Clay and silty clay, grayish-olive-green 5GY3/2 to dusky-yellow-green 5GY5/2.
CORE NO. 13		623-626 feet. Recovered 1.8 feet.
Top---------623		Clay, sandy, dusky-yellowish-brown 10YR2/2.
623	623.5	Clay, silty, olive-gray 5Y3/2.
623.5	624.8	Clay, grayish-olive-green 5GY3/2 at top, dusky-yellow-green 5GY5/2 and siltier at bottom.
Bottom------626		
CUTTINGS		
639	643	Sand, medium to very coarse, and chunky silt, some clay, sand, 40 percent clear or milky quartz, 40 percent black N1, 20 percent gray, and vari-colored, angular to rounded, some platey particles.
643	684	Clay, silty clay, silt, some sand and gravel.
CORE NO. 14		651-654 feet. Recovered 1.85 feet.
Top---------651		Clay, sandy, and sand; clay dusky-yellow-green 5Y5/2; sand less than 10 percent of sample, mixed, mostly fine but ranges from silt to coarse with occasional fine gravel particles.
651.2	652.1	Clay, silty, olive-gray 5Y4/1, about 5 percent coarse sand, black N1 and white N9, no clear quartz.
652.1	652.7	Clay and gravel; clay, silty, olive-gray 5Y3/2, no sand; gravel, coarse to very coarse (0.8-1.4 inch), dark-gray N3, rounded, smooth, spherical to oblong, quartzite, milky to transluscent and chert.
--	652.85	Clay, silty, moderate-olive-brown 5Y4/4.
Bottom------654		Clay, silty, light-olive-gray 5Y5/2.

Depth (feet) From	To	Description
CORE NO. 15		681-684 feet. Recovered 1.9 feet.
Top---------	681	Clay and gravel; clay, silty dusky-yellow-green 5GY5/2, gravel, coarse 0.6-1.2 inch, rounded, smooth, spherical, milky quartzite and gray chert.
681	681.9	Silt, clayey with some sand, grayish-olive-green 5GY3/2 and moderate-olive-brown 5Y4/4.
681.9	682.7	Clay, sandy, and sand, very fine to fine; clay, moderate-olive-brown 5Y4/4, pieces of light colored material 0.2 to 0.3 inch.
682.7	682.9	Silt, moderate-olive-brown 5Y4/4, vuggy light colored material in veins, porous.
Bottom------	684	Silt, dark-yellowish-brown 10YR4/2, crumbly.
CUTTINGS		
684	694	Sand, some clay and silt; sand, medium to very coarse, larger particles white or black, smaller particles brown, green, and pink, subangular to rounded.
694	701	Clay, some silt and sand, moderate-olive-brown 5Y4/4.
701	718	Sand, silty, some gravel and silt; sand, medium to very coarse, larger particles white or black, smaller particles brown, green, or pink, subangular to rounded; gravel, varigated colors, angular to subrounded.
SIDEWALL CORE NO. 22		
--	705	Sand, silty, medium to coarse, medium particles are clear, black N1, and various colors, fair sorting, coarse particles (20 percent) are clear or milky quartz, rounded, subangular to rounded, friable.
CORE NO. 16		711-714 feet. Recovered 1.5 feet.
Top---------	711	Silt, sandy, olive-gray 5Y3/2, sand mostly fine, some coarse, some gravel; rounded quartz.
711.2	711.4	Silt, sandy, light-olive-gray 5Y5/2, sand mostly fine to medium with some very coarse sand and fine gravel up to 0.3 inch, some clay, grayish-olive 10Y4/2, slick.
--	711.4	Sand, silty, some clay, gravel up to 0.6 inch; sand very fine to medium, some coarse to very coarse, some dark colors, subangular to rounded, much clear quartz; gravel, medium, rounded, some broken, quartzite, gray and black chert; gravel is less than 10 percent of sample.
711.6	712.5	Sand, medium to very coarse, some fine gravel, one pebble 0.8 x 1.6 inch; sand, 50 percent dark, 30 percent clear quartz, 20 percent miscellaneous colors, clean, no clay or silt; gravel, rounded, elongate, clear quartz and black, pebble olive-black-chert 5Y2/1, smooth.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
Bottom------714		Silt, sand and gravel; silt, olive-gray 5Y3/2, loose; sand, fine to medium, some coarse, subangular to rounded; occasional gravel 0.3 inch, rounded.
CUTTINGS		
718	730	Clay, olive-gray 5Y3/2.
SIDEWALL CORE NO. 21		
--	721	Clay, olive-gray 5Y3/2, gritty.
CUTTINGS		
730	738	Sand.
SIDEWALL CORE NO. 20		
--	737	Sand, fine to very fine, rounded to subangular, clear and milky quartz about equal to dark particles, some pink, green, and a little mica, crumbly.
CUTTINGS		
738	752	Clay, silty, some nodules, moderate-olive-brown 5Y4/4 to grayish-olive 10Y4/2.
CORE NO. 17		741-744 feet. Recovered 1.9 feet.
Top---------741		Clay, silty, moderate-olive-brown 5Y4/4.
741	742.4	Silt, clayey, some sand, grayish-olive 10Y4/2, very hard when dried.
742.4	742.6	Silt, hard, moderate-olive-brown 5Y4/4, vugs, apparently root tubes, some coated with dark crystalline material, hard.
742.6	742.9	Clay, silty, olive-gray 5Y3/2, hard; silt, sandy, olive-gray 5Y3/2, hard, vugs as above.
Bottom------744		Silty clay as above.
CUTTINGS		
752	770	Sand, medium to coarse, some clay, some fine sand, subangular to round, mostly clear quartz and olive colors, fine grains are black N1.
CORE NO. 18		761-764 feet. Recovered 1.0 foot.
Top---------761		
763	763.2	Clay, silty, olive-gray 5Y3/2, light-olive-gray 5Y5/2, and light-olive-brown 5Y5/6.
763.2	763.8	Sand, fine to medium, mostly light colored, 30 percent black, rounded to subangular, clean, no silt, loose.
763.8	764	Sand as above but cohesive, hard, with partings of silty clay, olive-black 5Y2/1 to greenish-black 5GY2/1.
Bottom------764		Sand as above.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
CUTTINGS		
770	790	Clay, silt, sand, fine to coarse, and silty sand; sand, with layers of clayey silt, subangular to rounded, 80 percent black or dark, 20 percent clear quartz.
CORE NO. 19		781-784 feet. Recovered 2.6 feet.
Top---------781		Silt, sandy, with pebble, moderate-olive-brown 5Y4/4, sand 10 percent coarse, subangular, black and white, pebble, 0.6 x 0.8 inch, grayish-black N2, rounded smooth, could be debris from above.
781	781.7	Sand, fine to very fine, silty, rounded, mostly clear quartz, friable.
781.7	783.6	Silt, olive-gray 5Y3/2, some very fine sand, clay partings in bottom 1 foot.
Bottom------784		Clay, brownish-black 5YR2/1 and light-olive-gray 5Y5/2, looks like core of hard siltstone was pushing through the soft clay, the bottom part of the core interval probably was clay.
CUTTINGS		
790	801	Sand and clay, silty, some gravel, sand medium to very coarse, mostly brown, olive, and black, clear or milky quartz about 20 percent, subangular to subrounded; clay, olive-gray 5Y3/2 to olive-black 5Y2/1.
801	810	Silt, clay, light-olive-gray 5Y5/2, gravel near top.
CORE NO. 20		801-804 feet. Recovered 2.1 feet.
Top---------801		Gravel with silty clay, gravel fine to medium, some pebbles to 1.6 inch, subrounded to subangular, quartz 30 percent, dark metamorphics 50 percent, silty clay probably is in thin stringers.
801	803	Silt, clayey, light-olive-gray 5Y5/2, some scattered medium sand, iron staining in partings and vugs, hard, no silt or sand in lower 1 foot.
Bottom------803.1		Clay, silty, light-olive-gray 5Y5/2, vuggy.
CUTTINGS		
810	822	Sand, fine to very coarse, silt and clay, some gravel, clay light-olive-gray 5Y5/2, sand mostly dark, poor sorting, subangular to rounded.
822	845	Clay, silty, silt, some sand, fine to coarse, and some gravel; clay, light-olive-gray 5Y5/2 to moderate-olive-brown 5Y4/4, sand, clear, white, poorly sorted, angular to rounded.
CORE NO. 21		822-825 feet. Recovered 2.5 feet.
Top---------822		Clay and gravel; clay, moderate-olive-brown 5Y4/4; gravel rounded, milky quartzite, gray chert.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
822	822.4	Silt, clayey, some fine sand, grayish-olive 10Y4/2.
822.4	823.7	Silt, clayey, some fine sand, olive-gray 5Y3/2.
823.7	824.5	Clay, silty, moderate-olive-brown 5Y4/4.
Bottom------825		Clay and gravel; clay, light-olive-gray 5Y5/2; gravel, fine to medium, rounded.
CORE NO. 22		842-845 feet. Recovered 2.5 feet.
Top---------842		Clay, silty, light-olive-gray 5Y5/2.
842	842.2	Clay, silty, light-olive-gray 5Y5/2, fine sand, less than 10 percent.
842.2	843.3	Clay, silty, moderate-olive-brown 5Y4/4, small worm tubes.
843.3	844.1	Silt, between olive-gray 5Y3/2 and olive-black 5Y2/1, hard, worm tubes, some sand, probably less than 10 percent, coarse to very coarse, angular, black or dark.
844.1	844.5	Silt as above, with about 20 percent sand as above.
Bottom------845		Silt, olive-gray 5Y3/2.
CUTTINGS		
845	866	Silt, sand, fine to very coarse, and silty clay; silt and clay, light-olive-gray 5Y5/2, grayish-olive-green 5GY3/2, and moderate-olive-brown 5Y4/4, sand 20 percent black N1, some white N9, and overall earthy color, subangular to angular.
SIDEWALL CORE NO. 17		
--	851	Silt with some fine to very fine sand, loose.
CORE NO. 23		863-866 feet. Recovered 2.6 feet.
Top---------863		Sand, very coarse to coarse, rounded and angular, earthy particles look like reworked siltstone, round, hard, clear and milky quartz, and black particles are angular, little if any silt, one piece of woody material 1/2-inch long may be artifically introduced.
863	863.1	Clay and sand, coarse to very coarse, some fine gravel to 0.2 inch, clay moderate-olive-brown 5Y4/4, iron stain light-brown 5YR5/6; sand, mostly black and dark colors, angular to subrounded, 20 percent milky or clear, clay and sand about equal in sample.
863.1	864.4	Sand, very fine, olive-gray 5Y3/2, loose, friable, becoming more firm with depth.
864.4	865.2	Sand, very fine, as above with near-horizontal streaks of silt.
865.2	865.3	Sand, fine to medium, and silt, sand olive-gray 5Y3/2, angular, silt interspersed, not layered.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
865.3	865.4	Silt, sandy, light-olive-gray, fairly hard, fine sand about 10 percent.
865.4	865.6	Clay, light-olive-brown 5Y5/6, vuggy.
Bottom------	866	Silt, moderate-olive-brown 5Y4/4, hard, chunky.
CUTTINGS		
866	883	Clay, silt and sand beds (induction log), no samples because of thin mud.
883	886	Clay, sand, and gravel, some silt.
CORE NO. 24		883-886 feet. Recovered 2.0 feet.
Top---------	883	Clay, sand, coarse and very coarse, and gravel; clay olive-gray 5Y3/2; sand medium, mostly olive and black, angular to rounded, 10 percent clear quartz; gravel, mostly black N1, to dark-gray N3, rounded, tabular.
883	883.8	Clay, sand, coarse to very coarse, and gravel; clay, grayish-olive 10Y4/2, some silt; sand, black and olive, rounded to subangular, 10 percent milky and clear quartz; gravel, smooth, grayish-black N2 chert and olive-black 5Y2/1 quartzite, rounded, some fine sand and silt below 883.2.
883.8	884.2	Gradual transition to clay with less gravel and sand.
884.2	885	Clay, silty, moderate-olive-brown 5Y4/4, hard, occasional medium sand, rounded, a thin layer of grayish-white silt at 884.8.
Bottom------	886	Silt, sandy, very hard, between light-olive-gray 5Y5/2 and olive-gray 5Y3/2, root cavities and vugs.
CUTTINGS		
886	893	Clay and silt, light-olive-gray 5Y5/2 to moderate-olive-brown 5Y4/4, soft.
893	903	Sand, silty, medium to very coarse, olive 10Y6/2 to 10Y5/4 including milky quartz, black N1, pink, green, and olive grains, fair sorting, subangular to rounded.
903	906	Sand, silty and clayey, silt, and clay, some gravel.
CORE NO. 25		903-906 feet. Recovered 1.9 feet.
Top---------	903	Sand, silty, very fine, washes through a 65-mesh (0.01 inch) screen, olive-gray 5Y3/2, cohesive, some coarse sand and gravel may be from above.
903	903.2	Sand, silty, very fine as above, olive-gray 5Y3/2, some rust colored iron staining.
903.2	903.4	Sand, clayey, coarse to very coarse, and gravel, very fine, olive-gray 5Y3/2 and dark colors, 20 percent black, 10 percent clear or white, subangular to well rounded, mostly spherical, olive particles are reworked siltstone or fine sandstone.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
903.4	903.6	Sand, very fine to fine, overall brownish at top, olive at bottom, friable to loose.
903.6	904	Silt, moderate-olive-brown 5Y4/4, soft but cohesive.
904	904.3	Silt, light-olive-gray 5Y5/2, dry color is light-olive-gray 5Y6/1, powdery.
904.3	906	Clay, silty, grayish-olive 10Y4/2, fairly hard.
Bottom------906		Silt, clayey with disseminated sand, some gravel.
CUTTINGS		
906	920	Clay, silty and sandy, some sand, grayish-olive 10Y4/2, cohesive but soft.
SIDEWALL CORE NO. 15		
--	917	Silt, moderate-olive-brown 5Y4/4, cohesive and soft.
CUTTINGS		
920	963	Sand, medium to very coarse, gravel, some silt and clay; sand, light-olive-gray 5Y5/2, black 40 to 60 percent, olive 40 percent or less and white 20 percent, poor sorting near base, angular to rounded, and darker colored, scattered chunks of clay, light-olive-gray 5Y5/2, few samples.
CORE NO. 26		943-946 feet. Recovered 2.3 feet.
Top---------943		Gravel, very fine to medium (up to 0.4 inch), and sand, fine to medium, rounded, some silt; gravel, 50 percent black and olive, 50 percent white N9 and light-gray N7, subangular to rounded.
943	944.9	Sand, medium to coarse, and silt, some gravel; overall olive-gray 5Y3/2, iron staining, sand, medium (up to 0.5 inch), 50 percent black, 30 percent olive or dark, 20 percent light, subangular to rounded; gravel, quartzite, rounded but not spherical, black, jagged, some sand grains cemented to black gravel, cement does not effervesce, becomes coarser and more gravelly below 943.6 feet.
944.9	945.3	Sand, overall light-olive-gray 5Y5/2 to light-olive-brown 5Y5/6, fine to medium, similar to above and much light-colored silt; sand, rounded to subangular, 50 percent dark, 50 percent clear and light, silt acts as cement but pieces are friable, coarse to very coarse sand in bottom 0.2 foot.
Bottom------946		Silt, sand, fine to coarse, and gravel, medium to very coarse (up to 1.4 inch); sand, 50 percent light, 25 percent black, 25 percent olive, subangular to rounded; gravel, loose, all black or dark-gray to olive-chert, rounded, one 3/4-inch black obsidian pebble.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
CUTTINGS		
963	983	Clay and silt, some sand, olive-gray 5Y3/2, cohesive but crumbly, locally hard.
SIDEWALL CORE NO. 10		
--	968	Sand, very fine to fine, some silt, olive-gray 5Y3/2, cohesive but crumbly.
CUTTINGS		
983	996	Sand, some silty, silt, and clay, some gravel.
CORE NO. 27		983-986 feet. Recovered 2.1 feet.
Top---------983		Sand, silty, fine to coarse, subangular to rounded, light-olive-gray 5Y5/2, mostly olive, 15 percent black, 10 percent white.
983	983.1	Silt with clay, sand, fine to very coarse, and gravel; silt, dusky-yellowish-brown 10YR2/2, yellow iron stains; clay disseminated as cementing agent; sand, mostly black or dark, rounded to angular, one piece of black and white granite, 0.3 x 0.8 inch, rounded but broken, platelet, black minerals etched slightly.
983.1	984.6	Silt, sandy with veins of clay, hard, some fine sand; silt olive-gray 5Y3/2; sand, well sorted, rounded, about 20 percent of sample, chunks of clay below 983.3 feet, yellowish-gray 5Y7/2, becoming more crumbly below 983.5 feet.
984.6	985.1	Sand, fine to medium, and silt, top is a sandy silt, olive-gray 5Y3/2, becoming sandier below, bottom is silty sand, dark-yellowish-brown 10YR4/2, entire unit is cohesive but friable.
Bottom------986		Silty sand as above with pieces of clay dusky-brown 5YR/2/2.
CUTTINGS		
996	1,023	Clay, silt, and very fine sand, few samples.
SIDEWALL CORE		
--	998	Clay, silty, grayish-brown 5YR3/2, very little of core recovered.
CUTTINGS		
1,023	1,046	Clay and silt, dusky-yellow-brown 10YR2/2 to moderate-yellowish-brown 10YR5/4, some sand, very fine to coarse, poorly sorted, subangular to rounded.
CORE NO. 28		1,023-1,026 feet. Recovered 2.4 feet.
Top---------1,023		Silt and fine sand, washes through a 0.008 inch sieve, gravel probably from above.

Depth (feet) From	To	Description
1,023	1,023.1	Clay, silty, dark-yellowish-brown 10YR4/2, yellow and rust staining.
1,023.1	1,023.6	Sand, silty, very fine to fine, most goes through a 0.008 inch sieve, mottled dusky-green 5G3/2 and dusky-yellow-green 5GY5/2, cohesive but not hard, occasional pebble, to 0.50 inch, rounded.
1,023.6	1,024	Clay, silty with sand, moderate-olive-brown 5Y4/4, sand, all sizes mostly medium and coarse, mostly olives and browns, with black, white and varigated, rounded to subangular, disseminated, makes up about 20 percent of sample, more clay and coarser sand near bottom.
1,024	1,024.4	Clay, moderate-brown 5YR3/4, a few scattered sand grains.
1,024.4	1,025.4	Clay, silty, moderate-olive-brown 5Y4/4, some sand, scattered.
Bottom-----	1,026	Sand, silty, very fine, dark-yellowish-brown 10YR4/2, crumbles into flat platey chunks 0.3 inch thick.
SIDEWALL CORE NO. 6		
--	1,045	Silt, sandy, dusky-yellow-brown 10YR2/2, crumbly and fragile; sand, fine to very fine.
CUTTINGS		
1,046	1,058	Sand and gravel, some silt, few samples.
CORE NO. 29		1,055-1,058 feet. Recovered 2.5 feet.
Top-------	1,055	Sand, coarse to very coarse, silty, some clay, sand, some fine, olive and brown with some black, few white or clear, subangular to rounded; clay, dark-yellowish-brown 10YR4/2, in small (0.2 inch) pieces; fine sand in clay.
1,055	1,055.7	Sand, very coarse to coarse, very silty, some clay; sand, olive and brown 60 percent, black 20 percent, pink, green, and yellow, 15 percent, white 5 percent, subangular to rounded; clay, dark-yellowish-brown 10YR4/2, in small pieces as above, fine sand in clay, unit becomes coarser below 1,055.5 feet with some fine gravel.
1,055.7	1,055.9	Gravel, fine and very fine, almost no sand and little silt, some clay matrix, angular to subrounded, some rounded, angular particles are sandy siltstone grayish-brown 5YR3/2, 0.2-0.3 inch, subrounded particles mostly black, rounded particles are milky or green ranging from moderate-yellow-green 5GY7/4, to grayish-olive-green 5GY3/2 and dusky-green 5G3/2 (serpentine ?) occasional pyrite.

Depth (feet) From	To	Description
1,055.9	1,055.95	Clay and gravel, medium (up to 0.4 inch), silty; clay, dark-yellowish-brown 10YR4/2, blocky; gravel, white N9, and black N1, subangular to rounded.
1,055.95	1,057.1	Sand, medium, black N1, with light specks, rounded, outward appearance is well sorted but many fine to very fine particles wash out in pan, little silt, no clay.
1,057.1	1,057.3	Sand, silty, all sizes but medium to coarse predominates, overall mottled yellow and black, mostly black and dark when wet, silt gives the yellow tint, rounded to subangular.
1,057.3	1,057.5	Alternating beds of dark medium to coarse silty sand and sandy silt, silt beds about 0.4 inch thick, grayish-brown 5Y43/2: sand, black and red with some white, rounded to subangular, the only difference in the beds is silt content, the sand is the same, some yellow iron stain throughout.
Bottom----1,058		Sand and gravel, medium to fine, very silty; sand, mostly coarse with all sizes, poor sorting, many colors, dark to olive overall, rounded to subangular; gravel, rounded, low sphericity, pebbles are reworked sandstone.
CUTTINGS		
1,058	1,086	Sand, gravel, silt, and some clay; few samples.
SIDEWALL CORE NO. 4		
--	1,077	Clay, silty, light-olive-brown 5Y5/6, some fine to medium sand.
CORE NO. 30		1,083-1,086 feet. Recovered 2.1 feet.
Top-------1,083		Sandy clay with gravel, very fine to coarse (up to 1.4 inch); clay grayish-olive 10Y4/2, plastic, with much sand, sand very fine to very coarse, gray, black, white, angular, some rounded; gravel, rounded, some spherical others tabular, metamorphic, white and gray quartzite, serpentine (?), gray chert.
1,083	1,083.3	Clay, grayish-brown 5YR3/2, silt, sand, coarse, and gravel, very fine; sand and gravel almost all rounded and black, some flecks of pyrite, one-half inch layer of sand, medium gravel, fine, black, rounded, clay matrix, sequence repeats with less gravel and more medium to fine sand with depth, much yellow and rusty iron staining in all layers, stain crosses layering, some pebbles 0.4-1.4 inch, subangular to rounded, gray chert, milky quartzite and black minerals.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
1,083.3	1,084.1	Silt, light-olive-gray 5Y5/2 and iron staining, dark-yellowish-orange 10YR6/6, probably clay cementing agent, soft to very hard, friable, very porous, absorbs water readily.
1,084.1	1,084.9	Clay, silty, grayish-brown 5YR3/2, crumbly.
1,084.9	1,085.1	Sand, very fine, silty, moderate-olive-brown 5Y4/4, porous, hard but friable.
Bottom----1,086		Sand, silty, as above.
CUTTINGS		
1,086	1,113	Sand, silt, and clay.
1,113	1,118	Sand, very fine to very coarse, clay, and some gravel.
CORE NO. 31		1,113-1,116 feet. Recovered 2.3 feet.
Top-------1,113		Sand, very fine to medium, some coarser, and clay; sand, many colors, mostly gray N5, white N1, and tan, rounded to subangular, no black minerals except smokey quartz, clay, dark-yellowish-brown 10YR4/2, coarse sand is silty.
1,113	1,114.4	Sand, fine to medium, some very coarse, rounded to subangular, coarse fraction is angular to subrounded, medium particles are white N1, clear, or light tan, fine particles mostly black, coarse particles are light colored, little silt.
1,114.4	1,114.5	Sand, coarse to very coarse, and gravel, very fine, very silty; sand, many colors, black N1, clear and light-green 5G7/4 predominate, angular to subrounded, some pyrite; gravel, very fine, dark-yellowish-brown 10YR4/2, angular to subrounded, most are silt fragments, two pebbles, one 0.4 x 0.5 inch, rounded, spherical, specks about fine-sand size, other pebble 0.4 x 0.8 inch greenish quartzite.
1,114.5	1,114.8	Clay and gravel, fine; clay olive-gray 5Y3/2, gravel, 50 percent black or dark, 50 percent white, clear or green, some red and some pyrite, subrounded to rounded, some angular and sharp, more gravel in bottom 0.2 feet.
1,114.8	1,114.9	Clay, grayish-olive 10Y4/2, scattered fine black gravel.
1,114.9	1,115.1	Clay and gravel, some sand, very coarse; clay, dark-yellowish-brown 10YR4/2, silty, gravel as at 1,114.5-1,114.8 feet, some very coarse sand, pebbles up to 1.3 inch, some subangular, some rounded, igneous.
1,115.1	1,115.3	Sand, fine to medium, and clay; clay silty, olive-gray 5Y3/2 and light-olive-brown 5Y5/6, sand, good sorting, subangular to rounded, mostly clear quartz with equal quantities of black, green, red, and white, no silt.
Bottom----1,116		Sand and clay as at 1,115.3 feet.

TABLE 1.--Log of test hole near Nicolaus, 12N/3E-2G--Continued

Depth (feet) From	To	Description
CUTTINGS		
1,118	1,122	Clay.
1,122	1,150	Sand, very fine to very coarse, silt, hard, near basal part, some clay; sand, angular to rounded; silt, hard, chiefly light-olive-gray 5Y5/2, pyrite.
CORE NO. 32		1,147-1,150 feet. Recovered 2.3 feet.
Top-------1,147		Drilling mud and silty sand, probably not representative of interval, sand, poorly sorted, fine to medium predominates, colors varied as above but more black, subangular to rounded, one pebble 0.3 x 0.6 inch, subangular, mottled grayish-blue-green 5BG5/2, and milky, quartzite (?).
1,147	1,147.1	Drilling mud with some sand.
1,147.1	1,147.35	Sand, gravel, and clay; sand, very coarse, some coarse, some fine, mostly black with clear, green, red, and white, subangular to rounded, some pyrite; gravel, very fine to medium, up to 0.6 inch, angular to rounded, broken, colors similar to sand but many pieces of reworked sandstone, moderate-brown 5YR4/4; clay olive-gray, scattered coarse sand.
--	1,147.35	Amorphous material, thin 0.2 inch parting, very hard, black N1 with amber overtones, non-effervescent, with another 0.2 inch layer of very fine to fine sand, apparently cemented with the same material, most of the sand is clear quartz and pyrite, cementing agent masks any other colors that may be present, pyrite gives sparkling appearance.
1,147.35	1,147.9	Silt, light-olive-gray 5Y5/2, and olive-gray 5Y3/2 in streaks, hard, many minute cavities, round or sinuous like worm trails, lined with dark or amber material, 1/2-inch diameter cavity filled with pale-olive 10Y6/2 material and fine sand and some pyrite flecks.
1,147.9	1,148.4	Silt, light-olive-gray 5Y5/2, hard.
1,148.4	1,149.3	Silt and clay, silt as above; clay, in one thin (0.2 inch) layer, olive-gray 5Y3/2.
Bottom----1,150		Silt, light-olive-gray 5Y5/2, mottled or layered with clay very dusky-red 10R2/2, crumbly.
Total depth 1,150 feet		

TABLE 2.--Grain-size classification

[From National Research Council, 1947]

Name	Grade limits (diameter in inches)
Very coarse gravel	2.5- 1.3
Coarse gravel	1.3- .6
Medium gravel	.6- .3
Fine gravel	.3- .16
Very fine gravel	.16- .08
Very coarse sand	.08- .04
Coarse sand	.04- .02
Medium sand	.02- .01
Fine sand	.01- .005
Very fine sand	.005- .0025
Silt	.0025- .0002
Clay	< .0002

GEOPHYSICAL LOGS

Geophysical logs (pl. 1) made in the test hole by Schlumberger Well Services include dual induction-spherically focused electric, compensated neutron, formation density, caliper, gamma, porosity index (percentage sandstone matrix), bulk density, spontaneous potential, resistivity, and conductivity.

Induction-electric logging devices induce a current into the rocks at the borehole and record the resistivity (reciprocal of conductivity). Because the contrast between borehole mud and formation water in a freshwater system is commonly large, this device is focused to minimize the influence of the borehole mud and of the lithology above and below the focused interval.

The dual-induction log (pl. 1, log A) of the test hole included a deep induction log, in ohms per square meter per meter; a spherically focused log, in ohms per square meter per meter; a conductivity log, in millimhos per meter; and a spontaneous potential log, in millivolts.

Neutron logging devices continuously emit neutrons into the rocks around the borehole. The neutrons collide with the nuclei of the formation material, losing some of their energy with each collision. The greatest energy loss occurs when the neutron strikes a hydrogen nucleus; thus neutron logging is primarily a function of the hydrogen content of the rocks and their fluid. The compensated neutron log minimizes the influence of the borehole.

The compensated neutron-formation density log (pl. 1, log B) of the test hole included a caliper log, in inches; a gamma log, in API units[1]; compensated neutron porosity, in percent; and bulk density, in grams per cubic centimeter.

The formation density log is obtained by emitting medium-energy gamma rays into the formation. These rays act as high-velocity particles which collide with electrons in the formation. The rays lose some energy with each collision. The scattered gamma rays reach the detector and are counted as an indication of formation density. The greater the density of the formation the fewer counts in the detector, so that what is actually measured is the number of electrons per cubic centimeter.

MINERAL ANALYSES

Mineral analyses were made on seven samples by N. C. Janke, consulting geologist of Sacramento, Calif. (table 3). Identification of minerals was done using methods and classifications from Deer, Howie, and Zussman (1966) and Winchell (1951). Janke found 40 minerals or mineral series (table 4). Gravel from the 946-foot depth was analyzed for particle lithologies (table 5).

EXPLANATION OF TABLE 3

Sample depth: Depth or depth interval of sample, in feet below land surface. "Sidewall" indicates sample was taken from a device that cores the side of the borehole.

Sample texture and intervals analyzed: Sample texture is indicated by the percentages of weights retained on five sieve sizes: c/m/f/vf/p: coarse (+35) mesh, medium (-35, +60) mesh, fine (-60, +120) mesh, very fine (-120, +230) mesh, pan (-230) mesh. The coarse, c (+35) mesh material is overstated in most instances as it is, at least in part, composed of cuttings, not loose grains; the pan material, p (-230) mesh, is composed, in large part, of drilling mud.

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[1]API units are standard units for nuclear logs established by the American Petroleum Institute (1959) based on the use of a permanent calibration facility.

The size intervals chosen for analysis--medium sand, m (-35, +60) mesh, and fine sand, f (-60, +120) mesh--are common to most sediments, and contain mineral sizes most easily identified under the microscope, with the result that error in identification is minimized. Heavy-mineral suites characteristic of sediment types also tend to fall within these ranges.

Particle types as percent of interval analyzed: The first listing of particle types is based on whole-field counts ($150 \leq N$) of the monomineralic grains and composite particles, polycrystalline grains or rock fragments (L), or both, found in the light fraction--specific gravity (s.g.) ≤ 2.9. An approximation to equal-sized grains was made by weighting the counts.

K-Feldspar: Potassium or potash feldspar.
P: Plagioclase with anorthite less than 34 percent (An < 34 pct.) and with anorthite greater than 34 percent (An > 34 pct.).
Quartz - monocrystalline and polycrystalline: Quartz, chalcedony, and chert.
Lithic fragments: Rock fragments not identified as to rock type; many include interstitial plagioclase.
Light opaques: Usually composed of a mass, often semiporous, of hematite and goethite. They are alteration products of hornblende and pyroxene monocrystals or polycrystals.
Volcanic glass: Glass identified as being of volcanic origin.
Calcite: A common mineral, but found only in traces in sampled intervals.

Mean ratio Q:F:L: Ratio of quartz (Q) to total feldspar (F) - potash and plagioclase, to lithic fragments (L).

Percent heavy minerals, specific gravity > 2.9: Percentage of heavy minerals in sample. Opaques, as a percentage of the heavy minerals--magnetic and non-magnetic: Opaque, heavy minerals classified as magnetic or non-magnetic; they are indicated as a percentage of the heavy-mineral fraction only. The percentage of heavy minerals, with whole-field counts of $150 \leqq N$, is listed next (s.g. > 2.9) with the percentage of heavy opaques given below as a percentage of the heavy minerals only. Below these, the non-opaque heavy minerals are listed in a semiquantitative mode.

Detail of other non-opaque heavy minerals: Non-opaque heavy minerals as a percentage of the heavy-mineral fraction only, includes orthopyroxene (opx) and clinopyroxene (cpx).

BH and GH are used to classify very fine-grained masses with mixed indices of refraction. BH includes the classes CIIB + CIII + sideromelane + possible small amounts of CIA or CIB, and CIIA; dark green, greenish-brown, brown, red-brown, or orange-brown refractions. And GH includes CIA, CIB + CIIA + possible sideromelane, or palagonite, or both; slightly brownish-green, green, yellowish-green, pale-green, white, colorless, or very pale-brown refractions, as indicated below.

Heavy minerals (specific gravity > 2.9)

Common colors in oblique reflected light	Fine-grained designation[1] and approximate index of refraction, N	Usual constituents, others are possible
White, yellowish, pale-gray, brownish	CIA N, high	Leucoxene, other titanium minerals, clay, and often goethite (see CIII below).
Smooth, often waxy, white, colorless, green, pale-green, yellow, yellowish-green, often mottled	CIB $1.63 \leq N$ to a maximum of 1.8	Sausserite containing variable amounts of albite, clinozoisite, epidote, zoisite, and occasionally pyrophyllite and paragonite.
Blue-green	CIIA $N < 1.68$ usual, may be to 1.76	Uralite (fibrous amphibole such as actinolite) talc, epidote, or zoisite, and possibly quartz.
Dark-green, brownish-green	CIIB $1.6 < N < 1.7+$	Amphiboles, calcite, chlorite, plagioclase, pumpellyite.
Colorless to brownish	Sideromelane $N \leq 1.6$	Basic glass, often microlitic, sometimes partially altered to palagonite, commonly with calcite, chlorite, and zeolites.
Green, greenish-brown, brown to red brown or orange brown	CIII $1.7 \leq N$	Bowlingite (green to greenish-brown) and Iddingsite (brown and red mixtures). Minerals include variable amounts of: goethite, hematite, chlorites, and other phyllosilicates, and may include leucoxene.
Brick-red	Hematite $2.9- \leq N$	Particles identified as hematite may only be coated, and this is even more likely for goethite.
Yellowish-brown	Goethite $2.3- \leq N$	The indices of both of these minerals are very difficult to obtain in rapid counting of detrital aggregates; thus classification is based on color.

[1]Particles are not monomineralic or mostly glass.

TABLE 3.--Mineral analyses

[Test hole 12N/3E-2G. Mineral analyses by N. C. Janke, Consulting Geologist]

Sample depth (ft)	311 (core)		424 (core)		561 (sidewall)	
Sample texture c/m/f/vf/p	4/48/27/10/10		15/58/14/3/10		1/19/60/14/6	
Intervals analyzed	m	f	m	f	m	f
Particle types as percent of interval analyzed						
K - Feldspar	24	18	27	43	26	30
P: Plagioclase An < 34 pct. (± 4 pct.)	15	27	13	4	21	20
Plagioclase An > 34 pct. (± 4 pct.)	21	18	20	23	20	19
Quartz - monocrystalline and polycrystalline	14	14	8	6	12	22
Lithic fragments	16	6	20	14	12	5
Light opaques	-	1	-	-	-	-
Volcanic glass	1	1	1	4	-	-
Calcite	-	-	trace	trace	-	-
Others	1	4	-	3	1	3
Mean ratio Q:F:L	15:67:18	17:75:8	10:67:23	6:78:16	13:74:13	23:72:5
Pct. heavy minerals s.g. > 2.9	8	11	11	3	8	1
Opaques (as a pct. of the heavy minerals)						
Magnetic	11	12	13	8	16	10
Non-magnetic	2	2	4	4	-	-
Very abundant 24-50 pct.	[a]Hornblende					
Abundant 10-24 pct.	[b]Lithic fragments [c]Opx		[g]Opx, [h]lithic fragments, Cpx, [i]hornblende, GH, BH		[a]Hornblende [b]GH Cpx	
Common 4-10 pct.	GH BH [d]Cpx [e]Chlorite				[c]Lithic fragments, epidote + clinozoisite, [d]actinolite, [e]Opx, GH, chlorite	
Sparse 1- 4 pct.	Chloritoid [f]Hematite Clinozoisite		Epidote Ilmenite Hematite			
Rare or uncertain < 1 pct.	Oxy-chlorite Biotite Devitrified glass		Biotite, actinolite-tremolite, sphene, oxy-hornblende, titan-augite, spinel, cordierite		Pigeonite Pumpellyite Antigorite	
Comments or special characteristics	[a]Mostly green hornblende [b]A few fragments are metamorphic, the rest are tuff [c]Hypersthene, often euhedral, predominates [d]Augite-ferroaugite predominates [e]Several types including thuringite [f]Some pseudomorphic after epidote or hornblende [g]Mostly hypersthene, but a dark variety [h]Fragment ratios volc-hyp:meta:unknown=9:7:3 [i]10 pct. is green, the rest is brown				[a]Mostly green [b]Mostly augite with some diopside [c]Volcanic-hypabyssal [d]Some tremolite is included [e]Bronzite-hypersthene some cockscomb solution ends occur on both Opx and epidote-clinozoisite	

TABLE 3.--Mineral analyses - Continued

Sample depth (ft)	714 (core)		851 (sidewall)		946 (core)	
Sample texture c/m/f/vf/p	46/25/14/8/8		7/24/38/19/13		41/27/14/9/10	
Intervals analyzed	m	f	m	f	m	f
Particle types as percent of interval analyzed						
K - Feldspar	20	22	17	12	13	8
P: Plagioclase An < 34 pct. (± 4 pct.)	15	22	28	40	26	47
Plagioclase An > 34 pct. (± 4 pct.)	10	19	16	13	9	11
Quartz - monocrystalline and polycrystalline	21	15	7	6	13	10
Lithic fragments	15	9	16	10	22	9
Light opaques	3	-	2	-	-	-
Volcanic glass	3	4	-	-	-	-
Calcite	trace	trace	-	-	-	-
Others	7	6	2	6	3	3
Mean ratio Q:F:L	26:56:18	16:72:11	10:73:17	9:80:11	16:57:27	12:78:10
Pct. heavy minerals s.g. > 2.9	7	3	12	13	14	12
Opaques (as a pct. of the heavy minerals) Magnetic	9	22	8	11	11	2
Non-magnetic	2	2	-	-	5	5
Very abundant 24-50 pct.	[a]Lithic fragments				Epidote-clinozoisite	
Abundant 10-24 pct.	GH		[b]Hornblende, [a]lithic fragments, GH, BH		Opx, GH, hornblende	
Common 4-10 pct.	[b]Hornblende BH [c]Opx		[c]Opx [e]Cpx [f]Actinolite		Lithic fragments Cpx BH Ilmenite-chromite	
Sparse 1- 4 pct.	Actinolite-tremolite [d]Chlorite Epidote-clinozoisite		Epidote-clinozoisite Anthophyllite-gedrite Catapleiite		Actinolite-tremolite	
Rare or uncertain < 1 pct.	Ilmenite Red and specular hematite		Oxy-hornblende		Pyrite Anthophyllite-gedrite Oxy-hornblende	
Comments or special characteristics	[a]All fragments are volcanic-hypabyssal [b]Mostly green hornblende, brown very minor [c]Bronzite-hypersthene, some cockscomb solution ends occur on both opx and epidote-clinozoisite [d]Both brown and green varieties [e]A few diopside, most are augite [f]Some tremolite is included					

TABLE 3.--Mineral analyses - Continued

Sample depth (ft)	1,058 (core)			
Sample texture c/m/f/vf/p	51/22/11/7/8			
Intervals analyzed	m	f		
Particle types as percent of interval analyzed				
K - Feldspar	18	28		
P: Plagioclase An < 34 pct. (± 4 pct.)	27	23		
Plagioclase An > 34 pct. (± 4 pct.)	16	17		
Quartz - monocrystalline and polycrystalline	11	13		
Lithic fragments	19	11		
Light opaques	1	-		
Volcanic glass	-	-		
Calcite	-	-		
Others	4	4		
Mean ratio Q:F:L	12:67:21	14:73:13		
Pct. heavy minerals s.g. > 2.9	4	4		
Opaques (as a pct. of the heavy minerals)				
Magnetic	13	18		
Non-magnetic	-	-		
Very abundant 24-50 pct.				
Abundant 10-24 pct.	BH, [a]opx, lithic fragments, [b]hornblende			
Common 4-10 pct.	[c]Epidote-clinozosite Oxy-hornblende GH [d]Cpx			
Sparse 1- 4 pct.				
Rare or uncertain < 1 pct.	Actinolite			
Comments or special characteristics	[a]Bronzite-hypersthene [b]Green and brown [c]Green epidote predominate over colorless clinozoisite [d]Augite, rarely diopside			

TABLE 4.--Summary alphabetical list of minerals identified in samples

[The word "series" in parentheses after mineral name indicates several varities within the series were found]

Actinolite-tremolite (series)
Aegirine-augite and aegirine-acmite
Allanite
Amphiboles (Clino-, undifferentiated)
Andalusite
Anthophyllite-gedrite (series)
Antigorite
Augite-ferroaugite (series)

Basic glass (not sideromelane)
Biotite
Bronzite-ferrohypersthene (series)
Brookite

Catapleiite
Chlorite (including oxy-chlorite and undifferentiated varieties)
Chloritoid
Chromite
Clinozoisite
Cordierite

Diopside-hedenbergite (series)

Enstatite-bronzite (series)
Epidote

Glaucophane

Hematite (some specular)
Hornblende (green, brown, and oxy-varieties)
Hypersthene

Ilmenite

Leucoxene

Margarite

Olivine

Pigeonite
Plagioclase (series)
Potash feldspar (undifferentiated)
Pumpellyite
Pyrite

Sideromelane
Sphene (titanite)
Spinel

Thuringite

α-Zoisite
β-Zoisite

TABLE 5.--Gravel-particle lithologies from 946 feet

[Analysis of sample fraction which was retained by a sieve of mesh number 8 (2.36 mm)]

Lithic type	Percent
Quartz-mica tectonite	21.5
Hornblende schist or amphibolite (occasional carbonaceous streaks)	20.4
Granulite	15.4
Metahypabyssal (composition close to diabase)	7.7
Gneiss	6.4
Chlorite schist (epidote)	5.2
Metasiltstone and metagraywacke	3.8
Quartzose metaconglomerate	2.5
Metavolcanic hypabyssal	2.5
Meta-argillite (pyrite coatings very common)	2.5
Phyllite	2.3
Mixed tuff (poorly indurated)	3.8
Vitreous tuff	2.3
Obsidian pebble (0.25 inch)	0.7
Vein quartz	3.0

X-RAY DIFFRACTION

X-ray diffraction is the phenomenon of the apparent bending of X-rays passing near opaque objects. The diffraction depends on the crystal structure of the object. A single crystal substance produces a diffraction pattern of spots called a Laue pattern, and a powdered substance produces a pattern of rings called an X-ray powder pattern. From the X-ray diffraction pattern of a substance the crystal structure and the unit cell dimension can be determined.

Seven samples of fine-grained material were submitted to Technology of Materials, Santa Barbara, Calif. Of special interest is the identification and quantification of various clay minerals in the samples. Seven X-ray diffraction charts and six electron micrographs of clay materials are included in their report, part of which is paraphrased here.

> Noticeable variations are found with respect to sampling depth. These differences are especially pronounced with regard to the kaolin content (table 6). Major crystalline phases consist of alpha quartz, a feldspar mineral, illite, kaolinite, and traces of mica. Samples from 379 and 998 feet both contain the unknown mineral d-8.5Å that was found in the previous studies on 12N/1E-34Q (near Zamora) at 2,305 feet. Two unusual samples were found; the first at 236 feet had an unusually high concentration of kaolinite (nearly 50 percent), this is much more than found in any sample in 12N/1E-34Q, and the

second at 906 feet shows very small amounts of crystalline constituents that are similar to those at 535 feet in 12N/1E-34Q. However, no diatomite was found in this sample which is most likely rich in an allophane or a volcanic ash.

The X-ray diffraction charts and micrographs are on file at the Sacramento office of the Geological Survey. Table 6 is a summary of the X-ray diffraction data.

TABLE 6.-- Summary of X-ray diffraction data

Sample depth (feet)	α-Quartz (percent)	Feld-spar (percent)	Kaolin-ite (percent)	Illite (percent)	Amorphous, by difference (percent)	Other crystalline phases
236	10-15	10-15	34-45	15-20	5-30	None
379	15-20	15-20	30-40	10-15	5-30	Unknown 8.5Å
504	10-15	15-20	5-10	None	55-70	Mica (trace)
626	10-15	10-15	25-35	None	35-55	Mica (trace)
744	10-15	5-10	5-10	None	65-80	--
906	5	5-10	5-10	None	80-85	--
998	10-15	20-30	30-40	15-20	0-25	Unknown 8.5Å

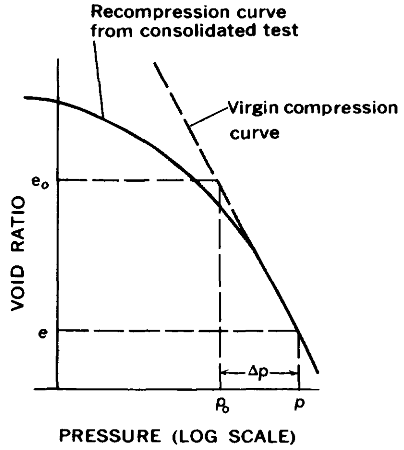
CONSOLIDATION TESTS

Consolidation tests were made on 15 samples by J. H. Kleinfelder and Associates, geotechnical consultants, Sacramento, Calif. Results from these tests show values for dry unit weight, moisture content, Atterberg limits, specific gravity, void ratio, porosity, compression index, and recompression index. Table 7 summarizes data derived from laboratory tests. Definition of the elements in table 7 as well as a description of the laboratory methods are found in Johnson, Moston, and Morris (1968, p. 10-18).

Consolidation of a soil is that gradual process which involves simultaneously a slow escape of water, a gradual compression, and a gradual pressure adjustment (Taylor, 1948, p.212). As beds of sediment are deposited layer on layer through geologic time, each layer is compressed by the layers above it. The layers attain a state of consolidation in equilibrium with the superimposed load. The layer is then called normally consolidated. In a normally consolidated layer, density will increase with depth of overburden and the void ratio will decrease. The relation between density increase and the void ratio decrease is approximately an extended straight line (virgin compression curve) on a semilogarithm graph (fig. 5). Figure 5 also shows the method for determining the compression index and the graphic explanation of the void ratio curves (Johnson and others, 1968).

TABLE 7.--Data from consolidation tests

Sample depth (feet)	Dry unit weight (lb/ft^3)	Moisture content (percentage of dry weight)	Atterberg limits		Specific gravity	Void ratio (e)	Porosity (percent)	Compression index	Recompression index
			Liquid	Plastic					
281	89	30.9	Non-plastic		2.64	0.842	0.46	0.485	0.029
391	128	16.9	28	9	2.63	.285	.22	.260	.039
421	--	--	Non-plastic		2.72	--	--	--	--
451	96	27.6	Non-plastic		2.67	.735	.42	.298	.045
481	81	39.6	Non-plastic		2.81	1.173	.54	.452	.087
501	103	22.7	36	12	2.74	.66	.40	.447	.092
601	76	41.8	56	27	2.74	1.25	.56	.97	.10
623	96	27.1	53	28	2.70	.759	.43	.262	.067
651	115	24.9	37	10	2.73	.48	.32	.334	.048
681	109	28.6	34	10	2.75	.576	.37	.403	.039
711	108	13.1	22	0	2.77	.596	.37	.23	.028
741	100	22.6	35	13	2.74	.711	.42	.503	.26
801	92	25.2	60	22	2.73	.849	.46	.322	.083
906	81	35.4	41	1	2.74	1.122	.53	--	--
1,023	98	23.9	36	3	2.67	.71	.42	.26	.065



The virgin compression curve or the field consolidation curve, for clayey soils, appears on a semilogarithmic diagram as a straight line as shown at left. This line can be represented by the equation

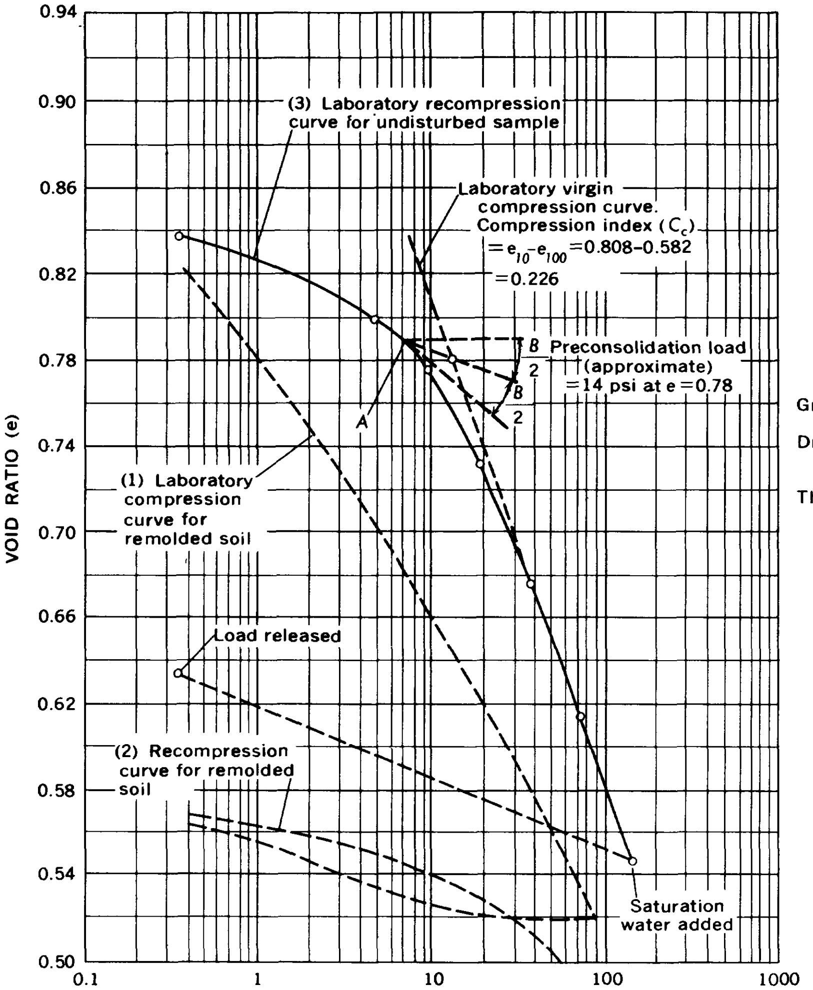
$$e = e_o - C_c \log_{10} \frac{P_o + \Delta p}{P_o}$$

in which C_c (dimensionless) is the compression index

The virgin compression curve is established by extending the straight-line part of the recompression curve. By selecting two points (e_o, p_o) and (e, p) and substituting in the above equation, C_c can be determined

$$C_c = \frac{e_o - e}{\log_{10} \frac{P_o + \Delta p}{P_o}}$$

A. METHOD OF DETERMINING THE COMPRESSION INDEX (C_c)



Graphical determination of preconsolidation load:
Draw tangent and horizontal line to point of maximum curvature (*A*)
The point of intersection between virgin compression curve and line bisecting angle *B*, is preconsolidation load and void ratio

B. VOID RATIO-LOAD CURVES AND PRECONSOLIDATION LOAD

FIGURE 5. – Void ratio-load curve, compression index, and preconsolidation load. (After Johnson, Moston, and Morris, 1968.)

ATTERBERG LIMITS

The water content in a clay is important to the consistency of the clay. As water content increases the clay changes consistency from a solid state through a plastic state to a semiliquid state. The limits of these three states are arbitrarily fixed by a standardized testing procedure and are called Atterberg limits (Atterberg, 1911). The water content, in percentage of dry weight, at the transition from the semiliquid state to the plastic state is called the liquid limit, at the transition from the plastic state to the semisolid state is called the plastic limit, and at the transition from the semisolid state to the solid state is called the shrinkage limit. A decrease in volume of the clay takes place as the water content decreases. Atterberg limits for 15 core samples are given in table 7.

GRAIN-SIZE DISTRIBUTION

Mechanical analyses of grain-size distribution were made on 15 samples by J. H. Kleinfelder and Associates, geotechnical consultants, Sacramento, Calif. (fig. 6). The procedure used was American Society for Testing and Materials designation D 422 (American Society for Testing and Materials, 1980).

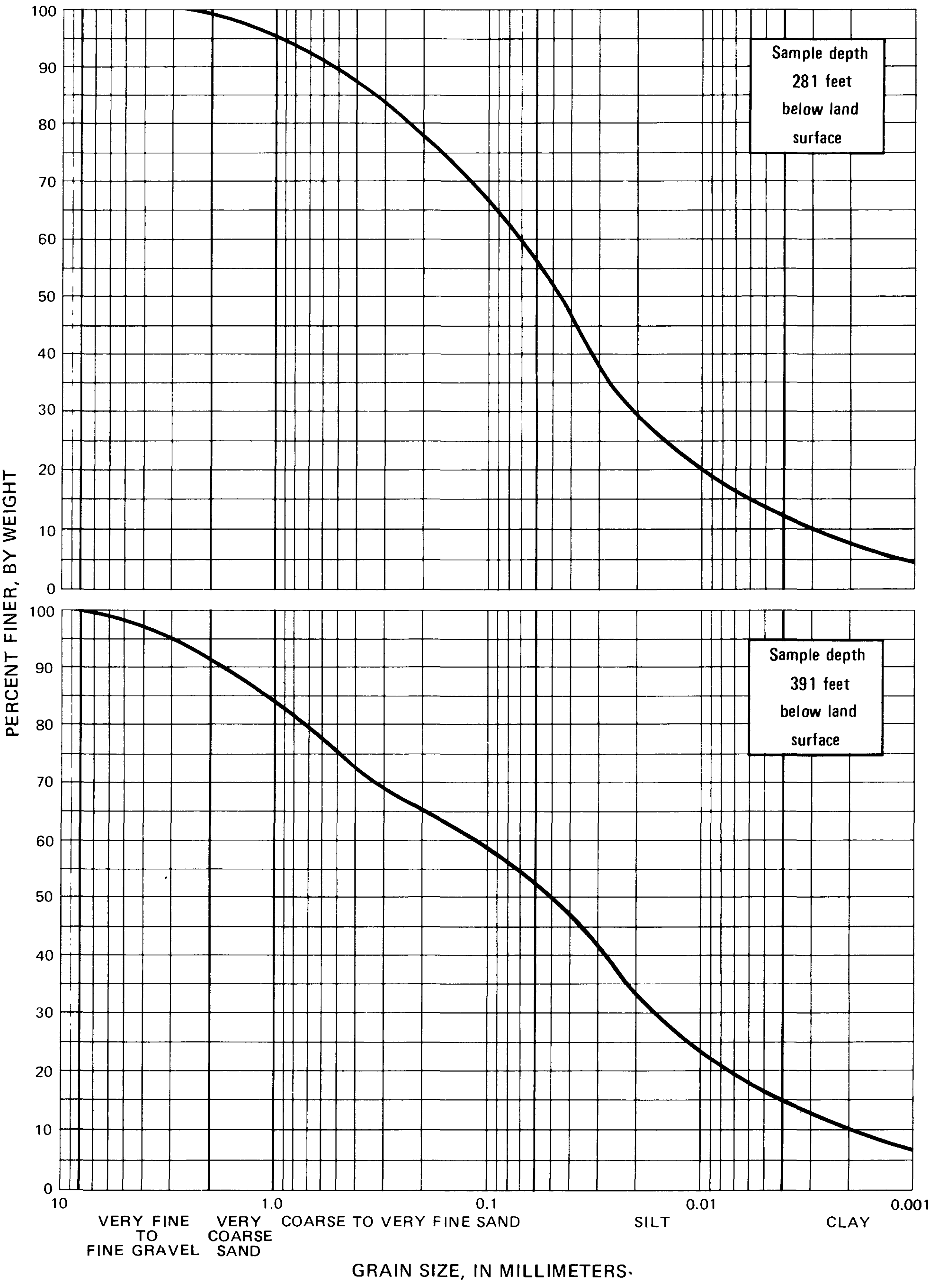


FIGURE 6. – Grain-size distribution

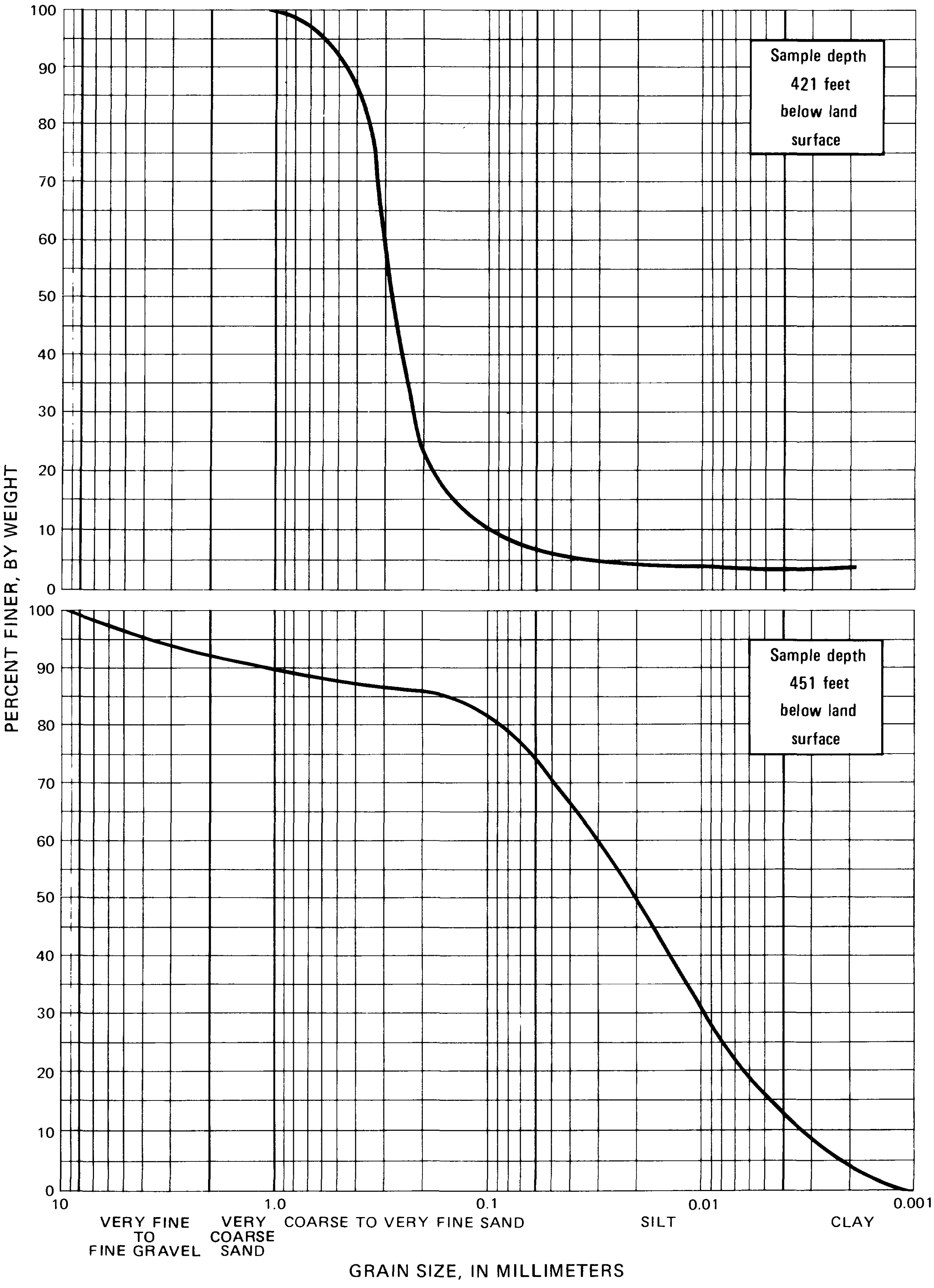


FIGURE 6. – Continued.

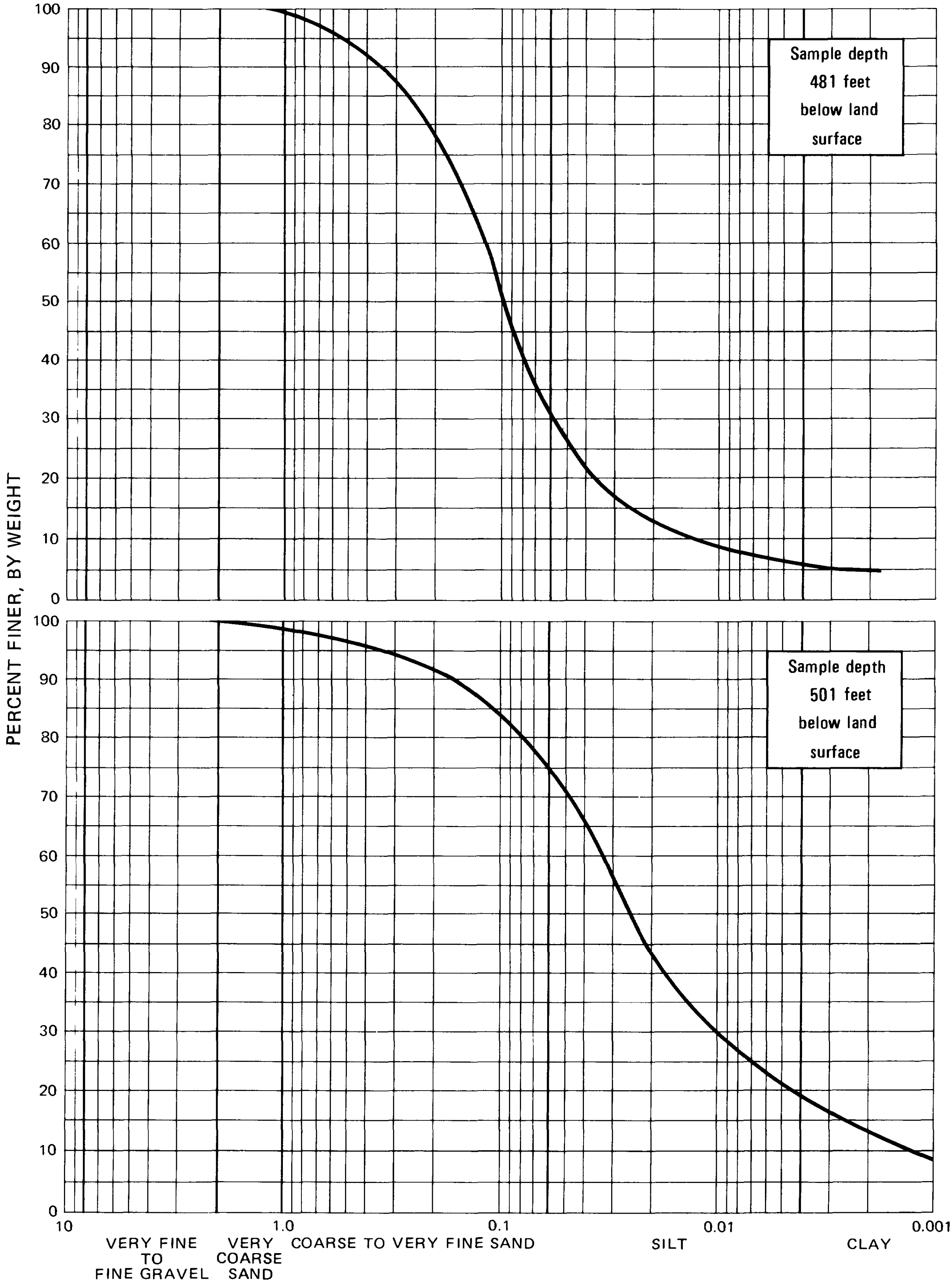


FIGURE 6. – Continued.

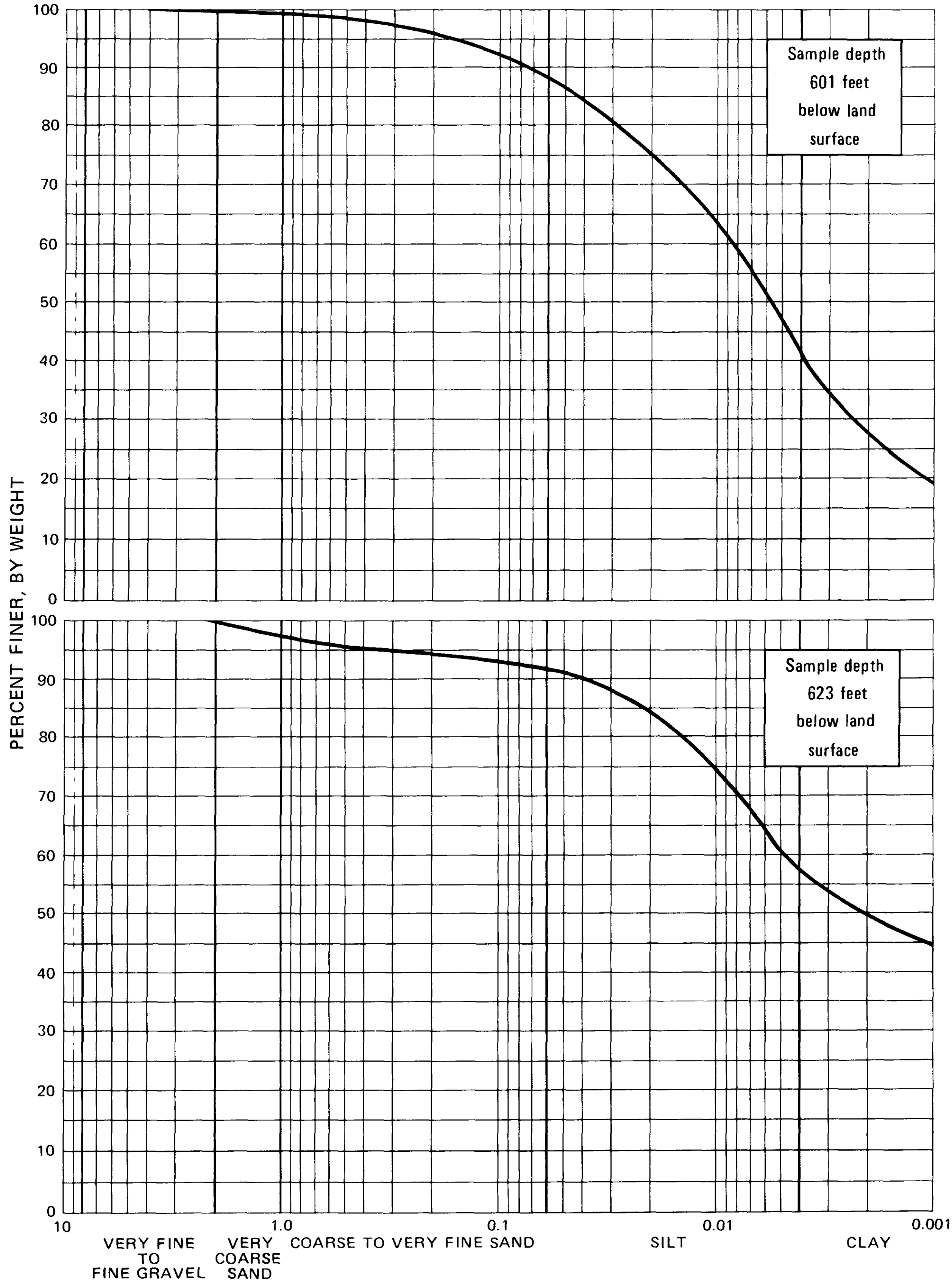


FIGURE 6. – Continued.

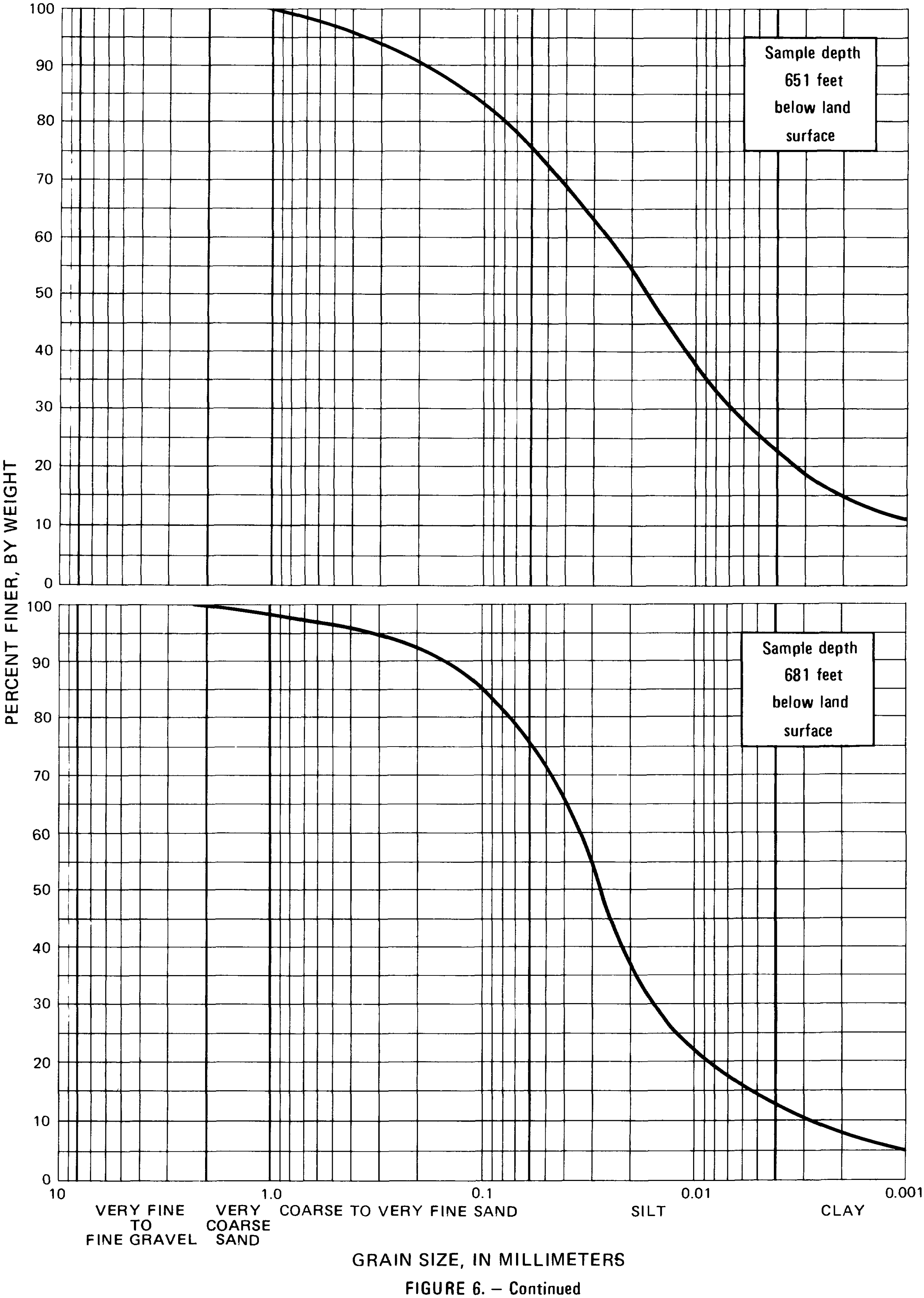


FIGURE 6. – Continued

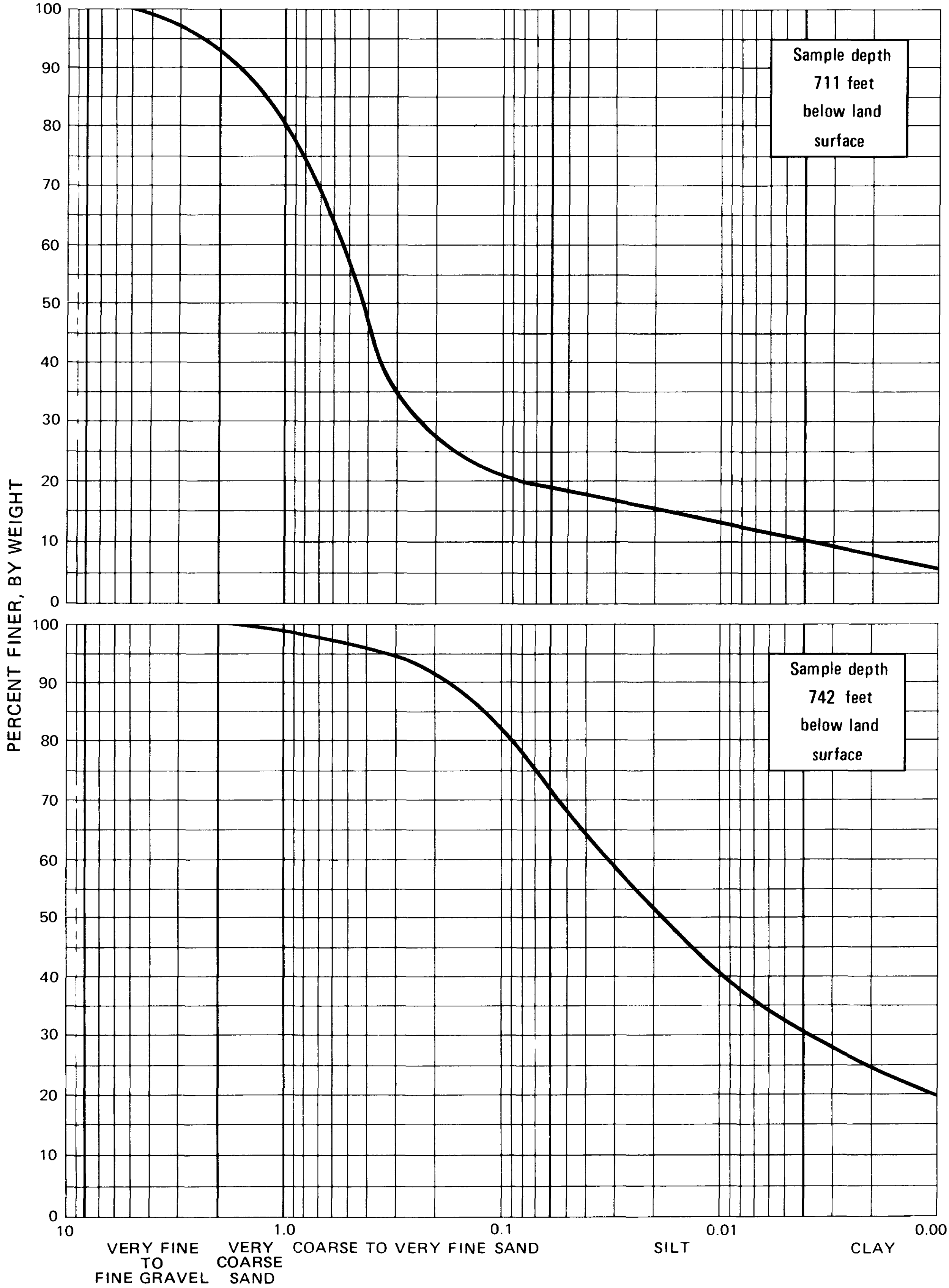


FIGURE 6. – Continued.

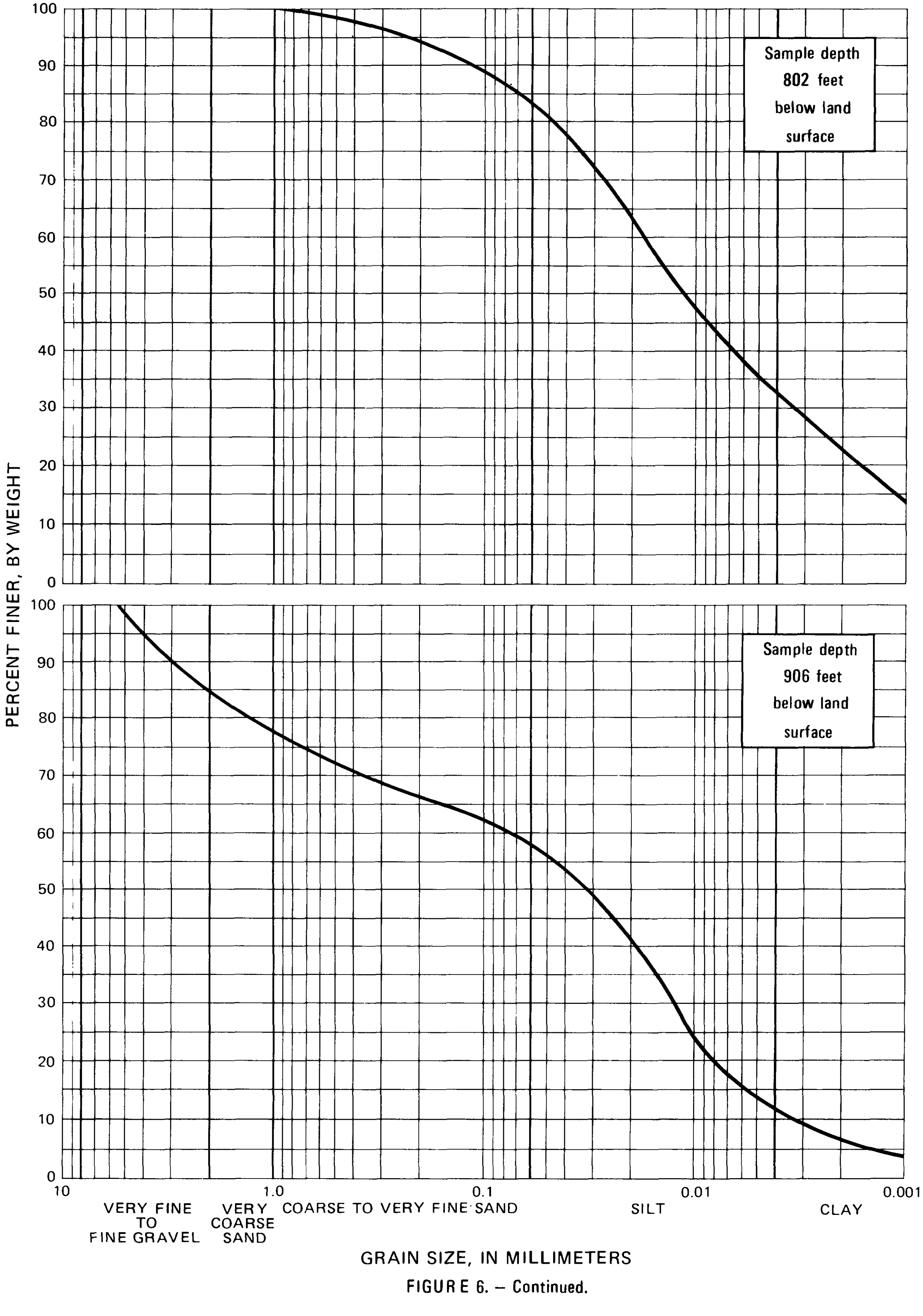


FIGURE 6. – Continued.

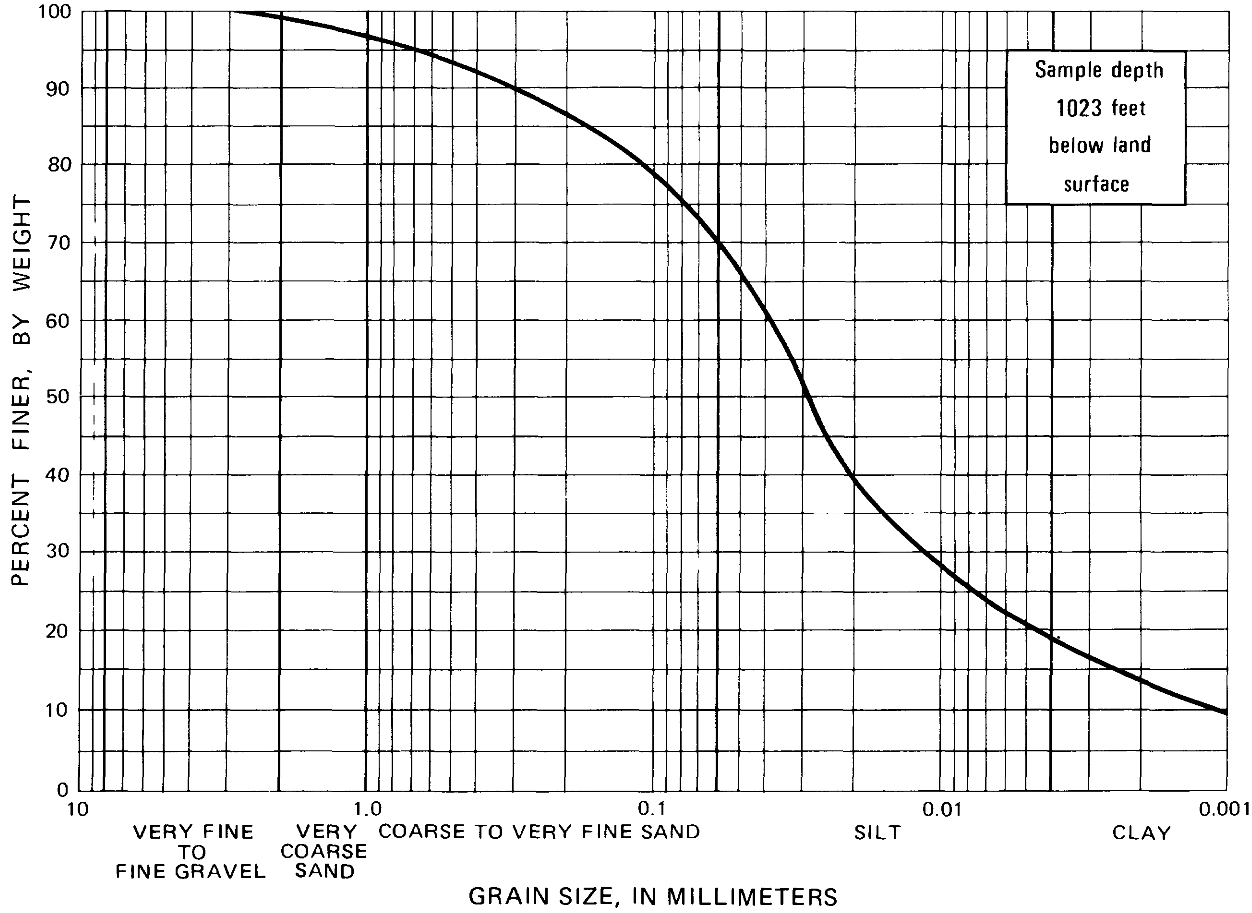


FIGURE 6. – Continued.

In 17 of the cores thermal conductivity was measured by needle probe by the Office of Earthquake Studies, Branch of Tectonophysics of the U.S. Geological Survey in Menlo Park, Calif. In this method a hypodermic needle (fig. 7), containing a heating wire and a temperature-sensing thermistor, is inserted into a part of the core. A constant electric current is applied to the heating wire and the rise in temperature is recorded. After an initial high rate of temperature increase, the rate of increase versus the logarithm of time stabilizes. The stabilized rate of temperature increase is the thermal conductivity, which depends largely on the water content and very little on the mineralogical composition of the core (Von Herzen and Maxwell, 1959). Thermal conductivities and pertinent data for 17 cores from test hole 12N/3E-2G are given in table 8.

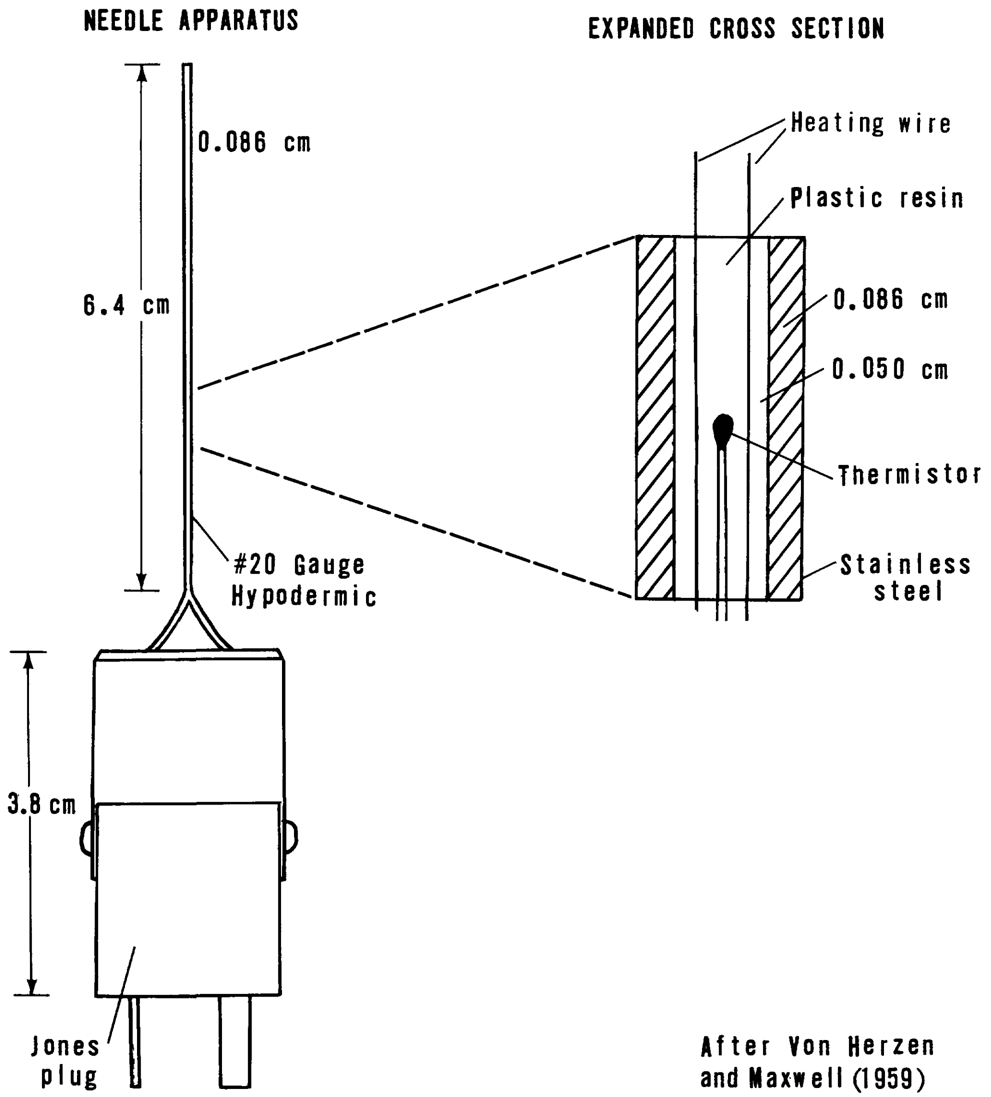


FIGURE 7. – Needle-probe apparatus for measuring thermal conductivity.

TABLE 8.--Thermal conductivity data

[All test angles are axial]

Core	Depth (feet)	Conductivity (Watt per meter Kelvin)	Core	Depth (feet)	Conductivity (Watt per meter Kelvin)
1	261	1.36	11	555	--
	264	1.18		558	1.70
2	281	1.31	12	601	1.14
	284	1.58		604	1.17
3	308	1.30	13	623	1.14
	311	1.24		626	1.58
5	361	1.33	14	651	1.29
	364	1.42		654	1.25
6	391	1.34	15	681	1.47
	394	1.45		684	1.26
7	421	1.34	16	711	1.45
	424	1.32		714	2.27
8	451	1.08	17	741	1.20
	454	1.77		744	1.54
9	481	1.19	18	763	--
	484	1.43		764	1.50
10	501	1.09			
	504	1.52			

		Number	Standard error
Average of all tests ------------------	1.30	34	0.07
Average of top tests ------------------	1.19	16	.07
Average of bottom tests ---------------	1.40	18	.13

THERMAL GRADIENT LOG

A graphic log of the thermal gradient was made by the U.S. Geological Survey's Office of Earthquake Studies, Branch of Tectonophysics (fig. 8). The thermal gradient was 17.5°C/km and the bottom-hole temperature was 24.8°C. Projected from the thermal gradient through the zero-depth axis the top-hole temperature was estimated to be 18.6°C.

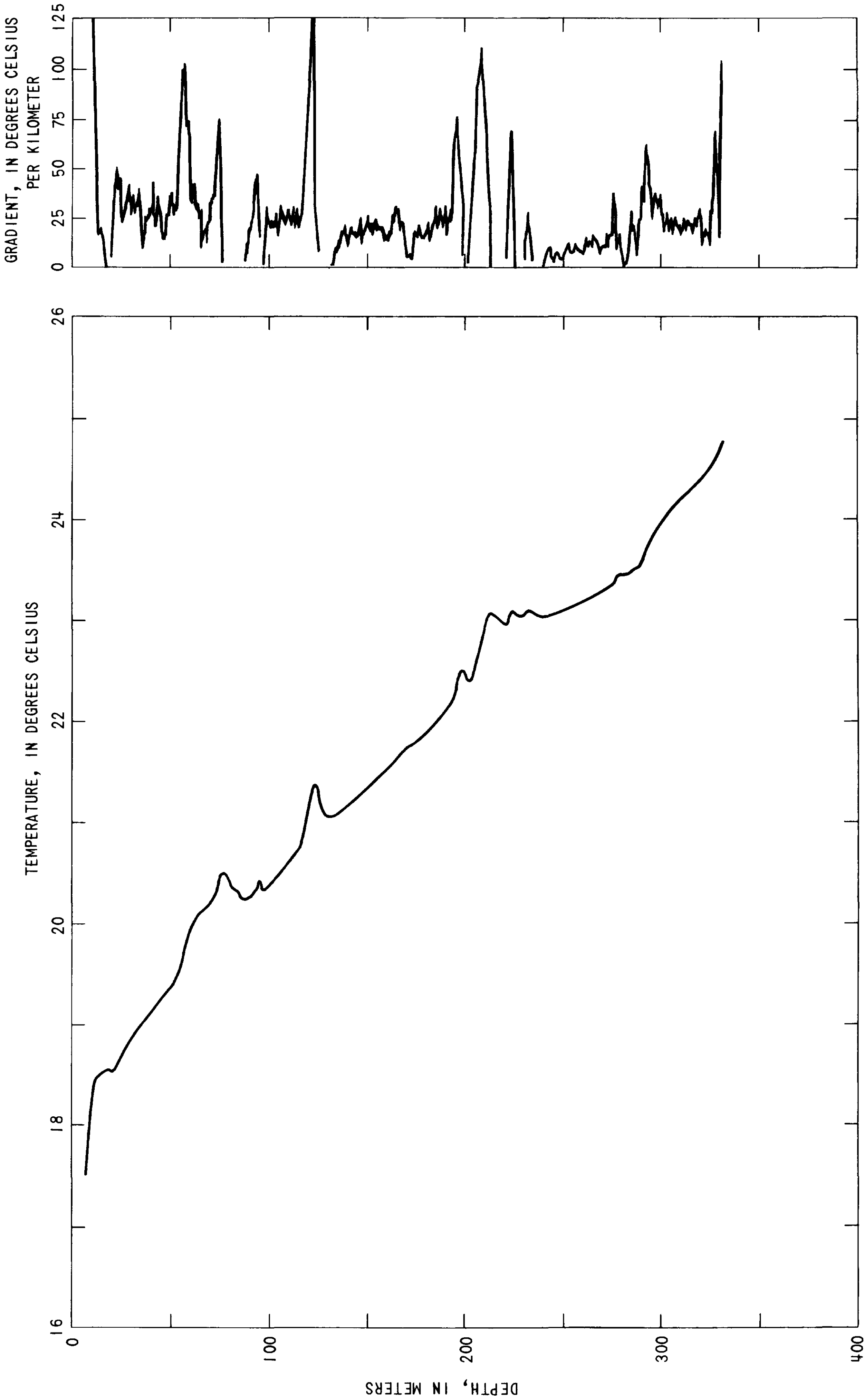


FIGURE 8. — Thermal gradient log.

CHEMICAL ANALYSES OF WATER

The chemical characteristics of the water in the three depth zones opposite the perforated intervals were obtained from water samples collected by submersible pump. In each instance a quantity of water equal to the volume of the casing was pumped out at least once before a sample was collected.

Specific conductance, pH, temperature, and alkalinity were recorded at the field site. After completing field determinations, the remaining part of the sample was split. Samples that required filtering were filtered using a 0.1-micrometer membrane. Samples to be analyzed for nutrients were chilled immediately after filtering by packing in ice. All samples were refrigerated until packed for shipping to the U.S. Geological Survey Central Laboratory in Denver, Colo.

Chemical analyses are shown in table 9. Figures 9 and 10 show the chemical differences in the water samples. Figure 9 shows plots of the ionic analyses of three samples and is a water-type classification as described by Piper (1944). Figure 10 is a classification of irrigation water based on sodium and salinity hazards according to the U.S. Salinity Laboratory Staff (1954). The water from the deep zone, 1,071 feet (G1), is a sodium-chloride type with a dissolved-solids concentration of 491 mg/L (milligrams per liter). The sodium hazard is medium and the salinity hazard is high (fig. 10). The water from the 711-foot (G2) zone is a sodium-chloride type with a dissolved-solids concentration of 553 mg/L. The sodium hazard is medium and the salinity hazard is high. The water from the shallow zone, 311 feet (G3) is a sodium-chloride type with a dissolved-solids concentration of 1,880 mg/L. The sodium hazard and the salinity hazard are both very high.

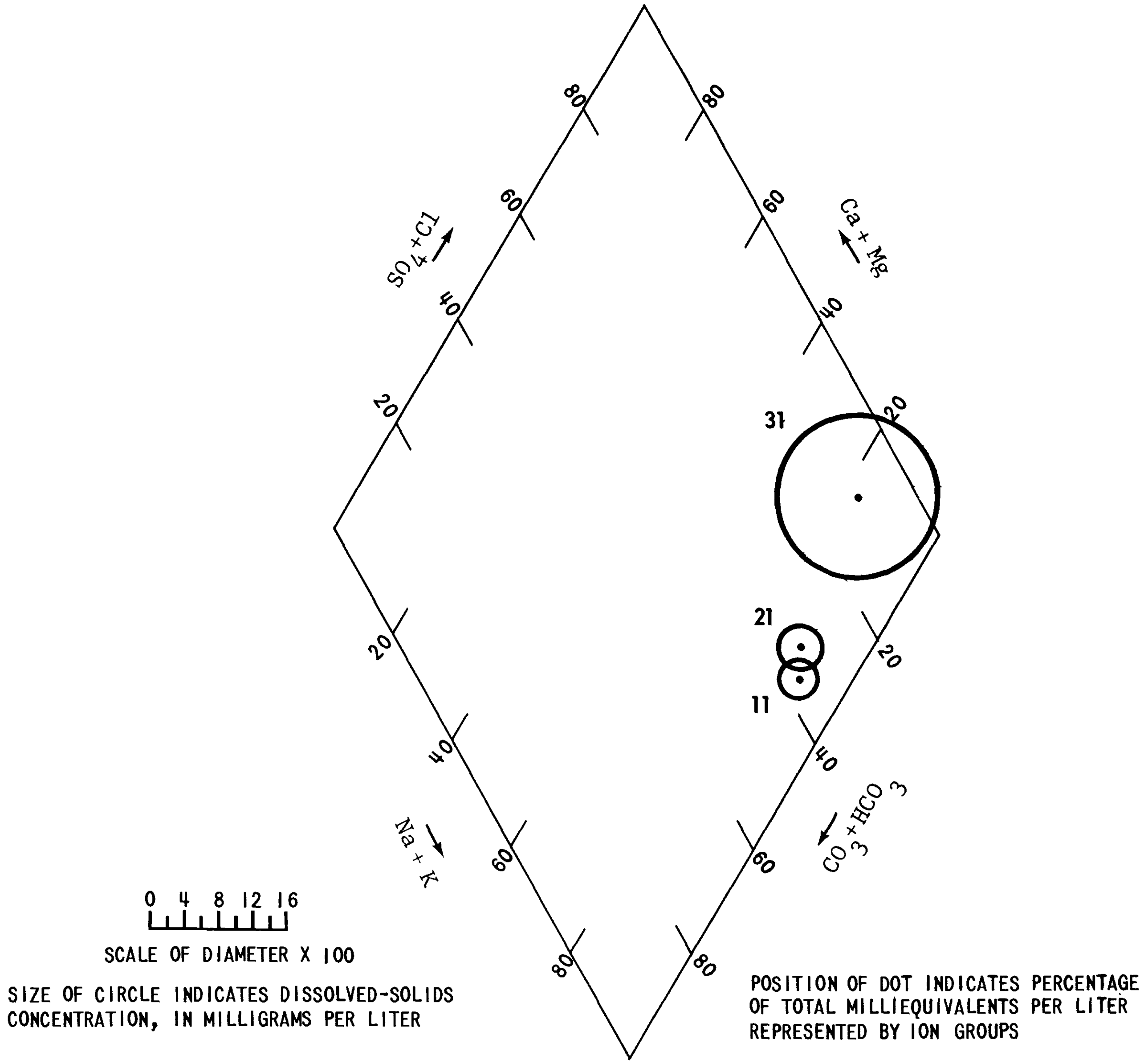
TABLE 9.--Water-quality analyses

LOCAL IDENT-I-FIER	STATION NUMBER	DATE OF SAMPLE	DEPTH OF WELL, TOTAL (FEET)	SPE-CIFIC CON-DUCT-ANCE (UMHOS)	PH (UNITS)	TEMPER-ATURE (DEG C)	HARD-NESS (MG/L AS CACO3)	HARD-NESS, NONCAR-BONATE (MG/L CACO3)	CALCIUM DIS-SOLVED (MG/L AS CA)
012N003E02G01M	385501121361901	80-04-17	1081	775	7.6	22.0	38	0	9.9
012N003E02G02M	385501121361902	80-04-17	721	905	7.9	22.5	52	0	14
012N003E02G03M	385501121361903	80-04-17	321	3140	8.3	21.0	250	100	75

DATE OF SAMPLE	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	PERCENT SODIUM	SODIUM AD-SORP-TION RATIO	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY FIELD (MG/L AS CACO3)	SULFATE DIS-SOLVED (MG/L AS SO4)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)
80-04-17	3.3	160	89	11	4.6	140	4.7	170	.2
80-04-17	4.2	190	87	11	5.4	150	1.3	210	.2
80-04-17	16	570	82	16	13	150	.6	960	.2

DATE OF SAMPLE	SILICA, DIS-SOLVED (MG/L AS SIO2)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	ALUM-INUM, DIS-SOLVED (UG/L AS AL)	ARSENIC DIS-SOLVED (UG/L AS AS)	BARIUM, DIS-SOLVED (UG/L AS BA)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)
80-04-17	56	491	494	.02	20	3	200	1000	<1
80-04-17	43	553	560	.03	--	--	--	1300	--
80-04-17	36	1880	1760	.02	--	--	--	3100	--

DATE OF SAMPLE	CHRO-MIUM, DIS-SOLVED (UG/L AS CR)	COPPER, DIS-SOLVED (UG/L AS CU)	IRON, DIS-SOLVED (UG/L AS FE)	LEAD, DIS-SOLVED (UG/L AS PB)	MERCURY DIS-SOLVED (UG/L AS HG)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO)	SELE-NIUM, DIS-SOLVED (UG/L AS SE)	SILVER, DIS-SOLVED (UG/L AS AG)	ZINC, DIS-SOLVED (UG/L AS ZN)
80-04-17	0	0	140	0	.1	21	0	0	<3
80-04-17	--	--	10	--	--	--	--	--	--
80-04-17	--	--	40	--	--	--	--	--	--



PERCENTAGE REACTING VALUES

SAMPLE NO	TUBE NO	DATE	DISSOLVED SOLIDS (mg/L)	DEPTH (feet)
11	2G1	4-17-80	491	1071
21	2G2	4-17-80	553	711
31	2G3	4-17-80	1880	311

FIGURE 9. – Water-analysis diagram.

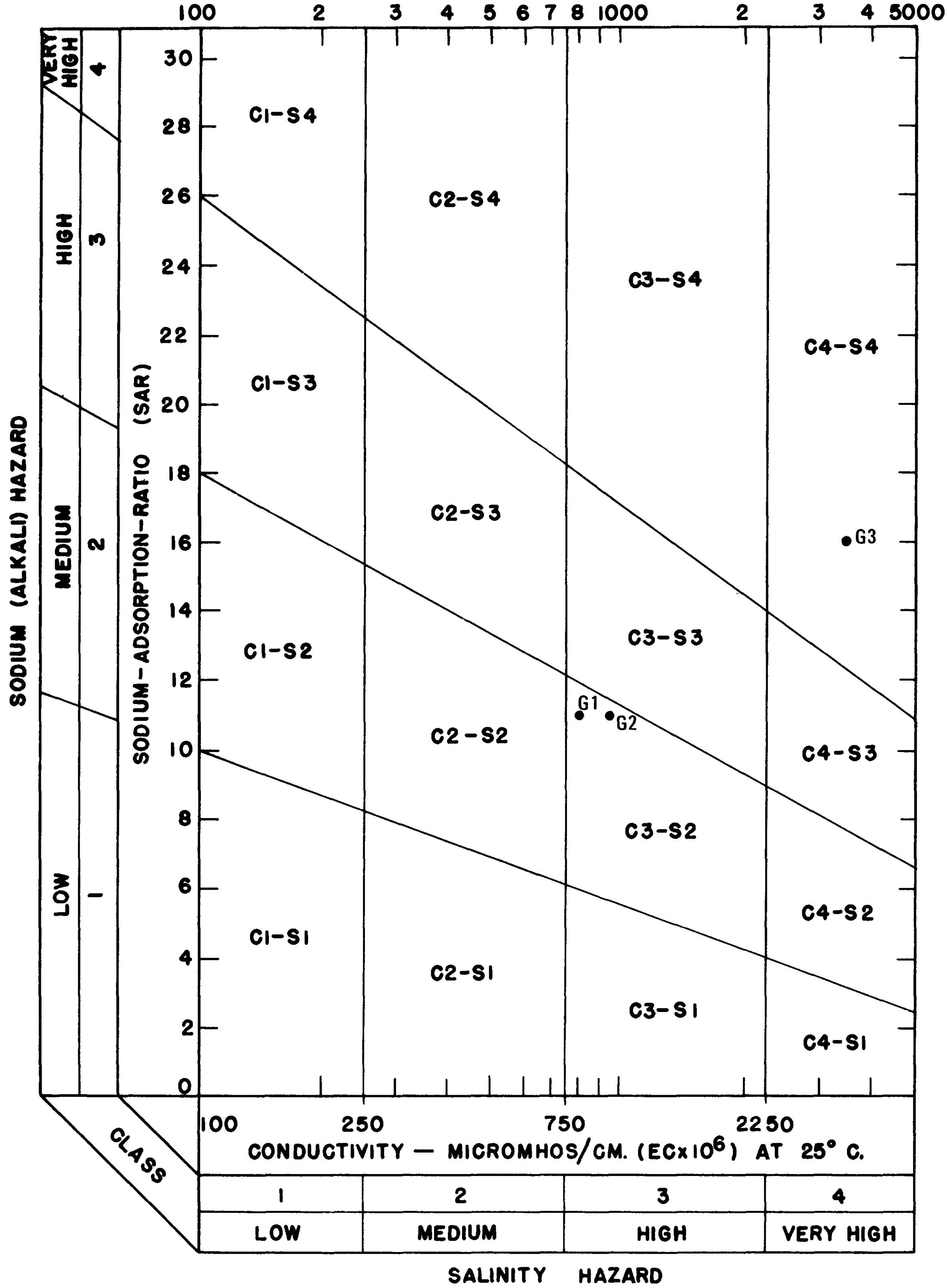


FIGURE 10. – Diagram for the classification of irrigation waters.

Water levels in three piezometers were measured periodically (table 10) and monitored continually by recorders. Hydrographs (figs. 11-13) show the fluctuation of water levels in each zone.

TABLE 10.--Records of water levels

[Altitude of land surface is 32.54 feet above National Geodetic Vertical Datum of 1929. Measuring point is top of casing]

Date	Depth to water, in feet below land surface		
	G1 depth 1,071 feet	G2 depth 711 feet	G3 depth 311 feet
Mar. 28, 1980	20.04	14.67	6.00
May 2	19.03	15.26	8.07
May 15	20.49	16.43	8.08
June 18	22.81	18.80	8.65
July 9	25.38	20.51	8.60
July 30	27.13	22.07	9.27
Aug. 20	28.52	23.17	9.63
Sept. 22	28.84	23.05	9.87
Oct. 16	26.13	21.62	10.48
Nov. 13	24.61	20.51	11.21
Dec. 16	22.88	19.59	11.21
Jan. 15, 1981	21.54	18.75	11.13
Feb. 12	20.61	17.81	9.00
Mar. 12	19.60	16.93	9.27
Apr. 9	18.92	16.31	8.50
May 5	19.02	16.59	9.63
June 2	23.72	19.56	9.90
July 6	28.96	23.31	10.04
Aug. 31	33.57	26.84	10.31
Oct. 30	28.41	23.42	11.28
Dec. 3	25.04	20.59	7.37
Jan. 4, 1982	22.47	17.89	4.11
Feb. 4	21.29	17.04	5.11
Mar. 5	19.65	15.47	3.91
Apr. 5	17.35	14.15	3.52
May 4	16.91	13.78	4.33
June 3	20.61	16.37	6.56
July 30	24.69	20.50	7.99
Aug. 27	25.98	21.62	8.51
Sept. 30	25.69	21.35	8.71
Nov. 1	22.80	19.43	9.32
Dec. 2	20.18	17.50	7.48
Jan. 31, 1983	16.42	13.66	3.19
Mar. 4	14.21	11.64	1.61
Apr. 1	14.16	11.60	2.05
May 3	13.11	11.06	3.57

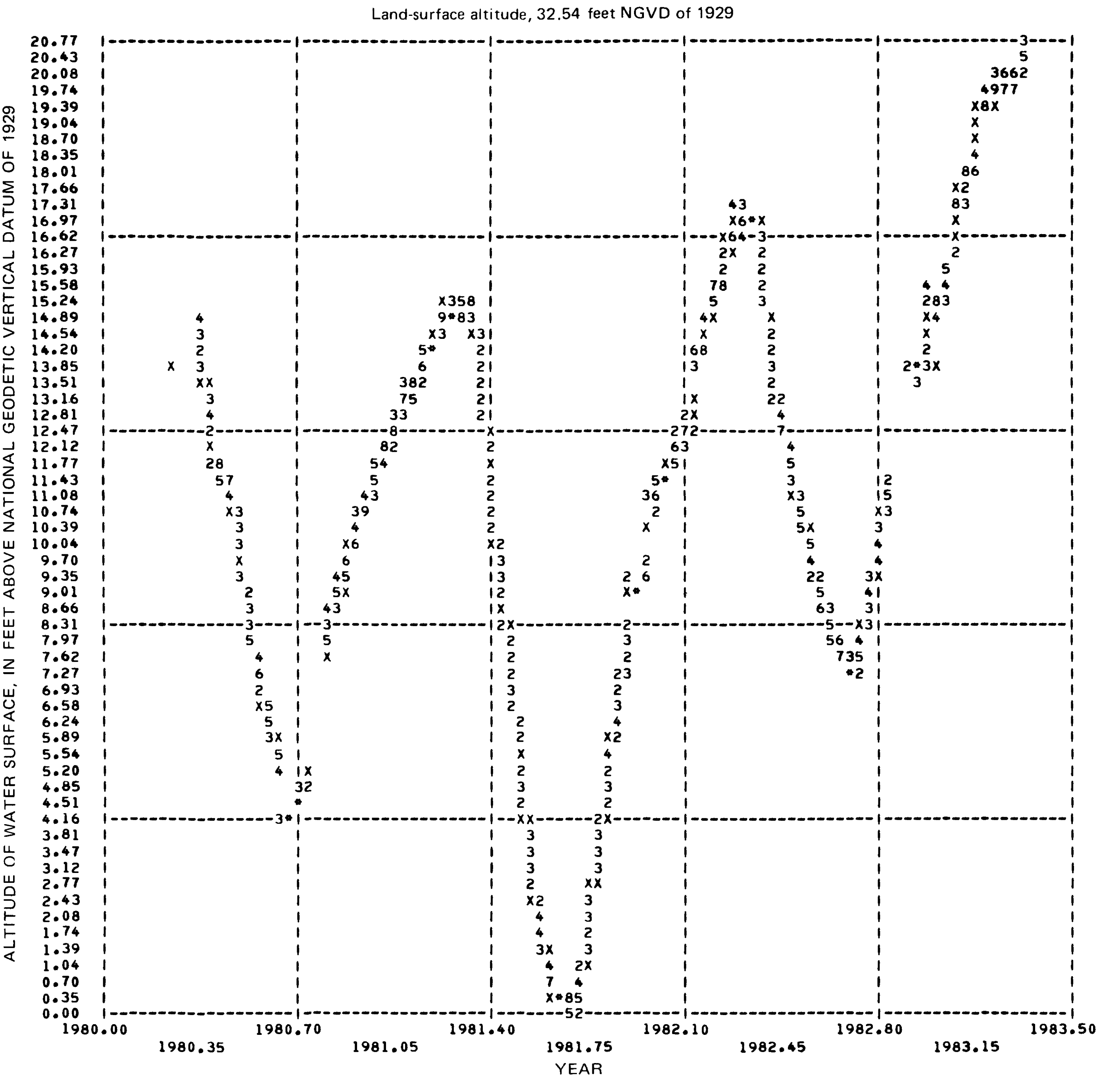


FIGURE 11. – Hydrograph of well 12N/3E–2G1 near Nicolaus, Calif. (Explanation of plot: X is used for a single Y–X plot point, numbers 2 to 9 are used for overprinted Y–X plot values, and * is used for more than 9 values.)

Land-surface altitude, 32.54 feet NGVD of 1929

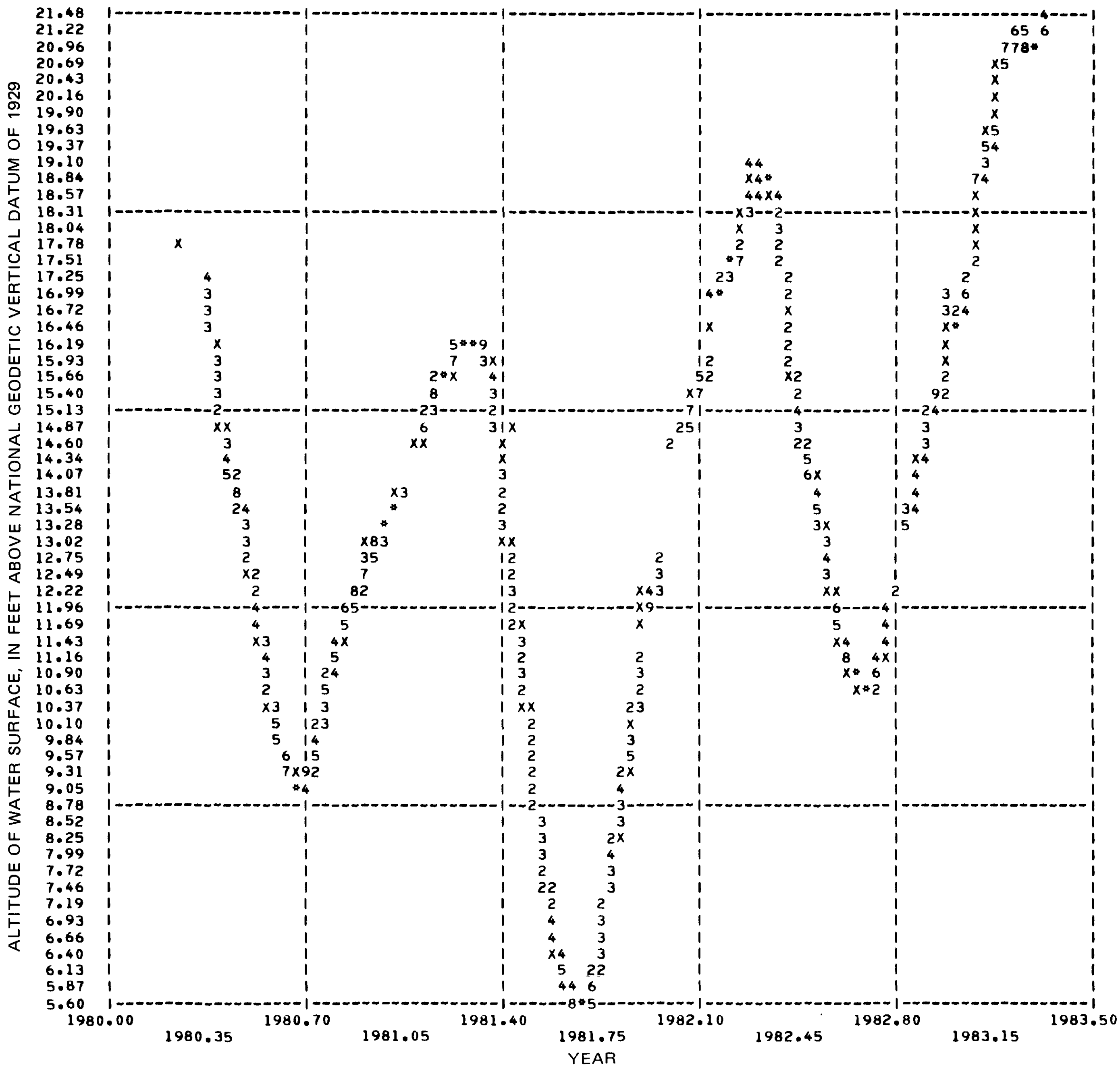


FIGURE 12. – Hydrograph of well 12N/3E–2G2 near Nicolaus, Calif. (Explanation of plot: X is used for a single Y–X plot point, numbers 2 to 9 are used for overprinted Y–X plot values, and * is used for more than 9 values.)

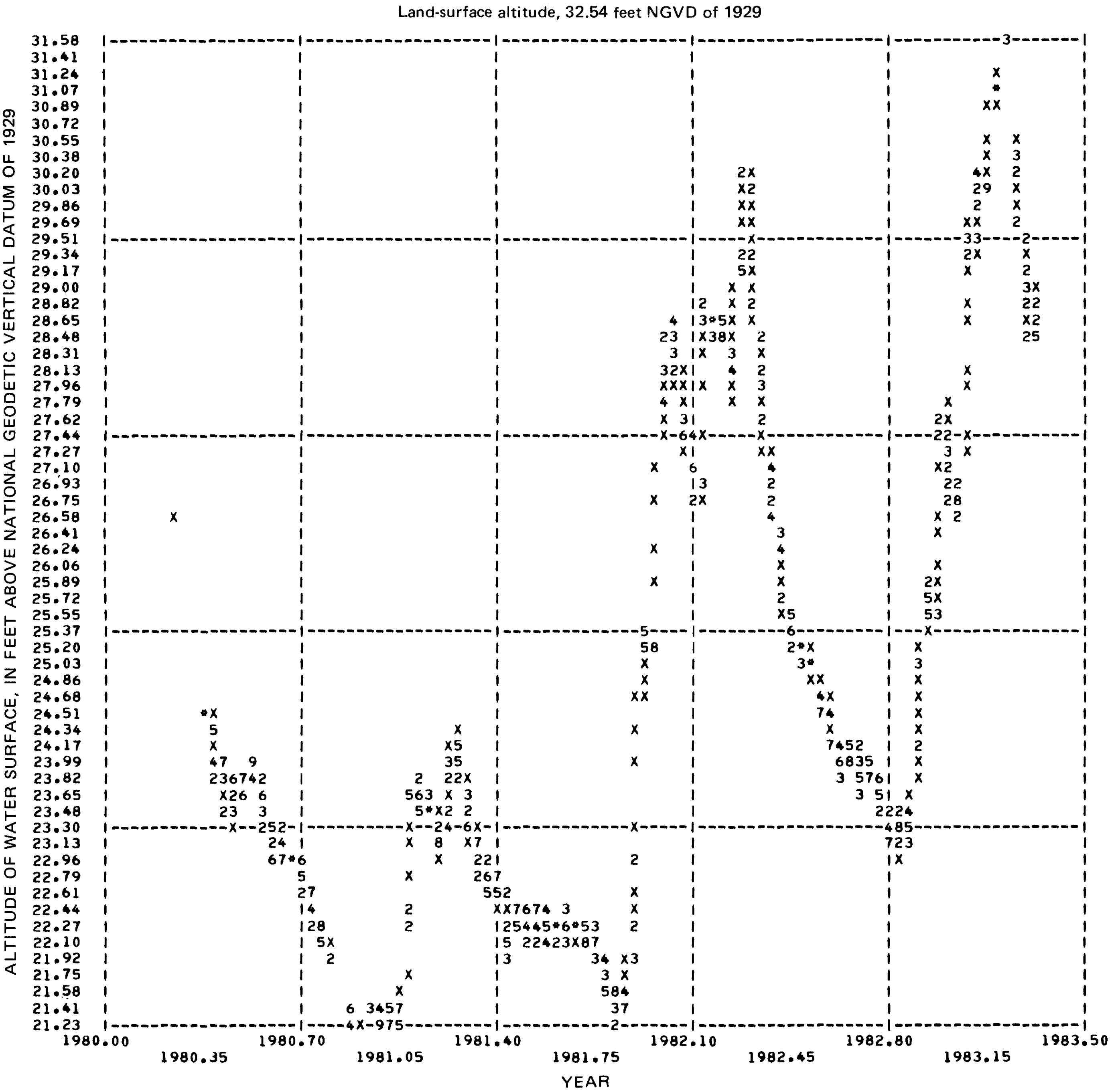


FIGURE 13. – Hydrograph of well 12N/3E–2G3 near Nicolaus, Calif. (Explanation of plot: X is used for a single Y–X plot point, numbers 2 to 9 are used for overprinted Y–X plot values, and * is used for more than 9 values.)

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