GEOLOGIC AND HYDROLOGIC DATA COLLECTED AT TEST HOLES NC-1 AND NC-3, GUAYNABO AND SAN JUAN, EASTERN PUERTO RICO

By Jesus Rodríguez-Martínez, Richard A. Scharlach, and Arturo Torres-González

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square
	Flow	
gallon per minute (gal/min)	0.06308	liter per second

Abbreviated water-quality units used in report:

microsiemens per centimeter at 25 degrees Celsius (µS/cm)

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By Jesús Rodríguez-Martínez[1], Richard A. Scharlach[2], and Arturo Torres-González[1]

ABSTRACT

Test holes NC-1 and NC-3 were drilled in the municipalities of Guaynabo and San Juan, respectively, during 1986, as part of a study of the aquifers in the Northern Coastal Province of Puerto Rico. These test holes were drilled to the depths of 635 and 375 feet below land surface, respectively. Hydrologic and geologic data collected include continuous core, water samples, head measurements, geophysical logs, and estimates of the hydraulic properties of the water-bearing zones. Detailed petrological and microfaunal analyses of the core were used to determine the mineralogical content, ages, and paleoenvironments of deposition.

The core recovered from test hole NC-1 was from two formations of middle Tertiary age: these were, in descending order, the Cibao Formation and Mucarabones Sand. The core recovered from test hole NC-3 was from three formations: these were, in descending order, the Cibao Formation, the Mucarabones Sand, and undifferentiated igneous rocks of early Tertiary or Late Cretaceous age. Five and seven artesian water-bearing zones were encountered in test holes NC-1 and NC-3, respectively. The water-bearing zones in the two test holes contained brackish water.

INTRODUCTION

Aquifers of the Northern Coastal Province of Puerto Rico are part of a coastward-thickening wedge of highly karstified platform carbonates and minor clastic rocks of Oligocene to Holocene age. This sequence flanks the central mountains of Cretaceous and early Tertiary age, and extends near Aguada in the western part of the island to Loíza, about 30 mi east of San Juan and comprises an area of approximately 700 mi^2.

Limited hydrologic and geologic data are available for the subsurface coastal areas of northern Puerto Rico. As part of a cooperative study between the U.S. Geological Survey and the Commonwealth of Puerto Rico (Torres-González and Wolansky, 1984), 15 test holes were drilled (fig. 1) to better understand the geologic and hydrologic characteristics of the aquifers and confining units of the Northern Coastal Province. The results of these test holes are being documented in a series of reports.

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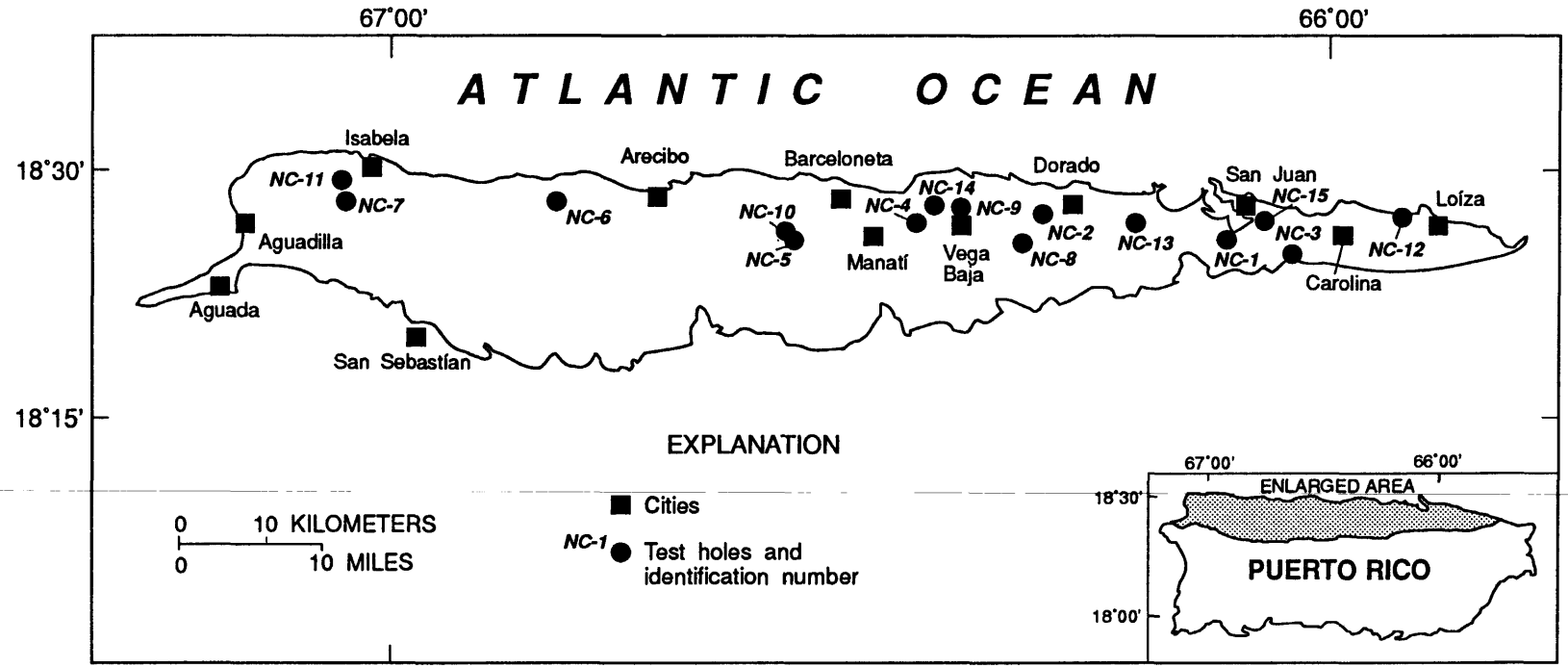

Figure 1.--Areal extent of the Northern Coastal Province of Puerto Rico and the location of cities, test wells, and test holes.

Purpose and Scope

This report presents the geologic and hydrologic data collected at test holes NC-1 and NC-3, drilled in 1986 in the municipalities of Guaynabo and San Juan, respectively, in eastern Puerto Rico. The data collected at these test holes include water levels, lithologic descriptions, and water chemistry of the major aquifers at the sites. These data will aid the correlation of major hydrogeologic and geologic units and help quantify the direction and rate of ground-water flow in the Northern Coastal Province.

The drilling and coring program was designed to allow the collection of continuous core samples for geologic, hydrogeologic, and paleontologic analysis. Geophysical logs were run for purposes of describing and defining major geologic and hydrologic units. Water-level measurements were made and water-quality samples were collected from discrete water-bearing zones. Water-bearing units in each test hole were differentiated.

Location of Study Areas

The site of test hole NC-1 is in the Pueblo Viejo Sector of the municipality of Guaynabo, about 2 mi south of San Juan. The site is about 0.10 mi south of the intersection of Highway 165 (Avenida Los Caños) and Highway 28 (fig. 2). The land surface altitude of the site is 9 ft above mean sea level.

The site of test hole NC-3 is located on the grounds of the Army Reserve Officer Training Corps at the University of Puerto Rico, in the Rio Piedras sector of San Juan. The site is about 0.24 mi east of Avenida Barbosa and 0.12 mi south of Avenida Central (fig. 3). The land surface altitude of the site is 43 ft above mean sea level.

DATA-COLLECTION METHODS

Drilling

Test holes NC-1 and NC-3 were 3 in. in diameter and were drilled to depths of 635 and 375 ft below land surface, respectively. The holes were drilled using a hydraulic reverse air system. This system uses threaded, seamless, double-walled drill stem and pressurized air to remove cuttings and cores. As drilling progresses, pressurized air is pumped between the annulus of two walls of the drill stem forcing formation water and cores up the center of the drill stem. Cores and water are ejected from the discharge pipe into a cyclone container, which dissipates their energy and also serves as a collector.

Coring

Test holes NC-1 and NC-3 were cored continuously from land surface to the total depth. Core was retrieved and each length measured, described, and placed in wooden core boxes for preservation and storage at the University of Puerto Rico at Mayagüez. Each core box holds the equivalent of one section of drill stem or approximately 20 ft of core. A representative split of core samples was also collected for storage at the U.S. Geological Survey office in San Juan. Core recovery ranged from poor to excellent.

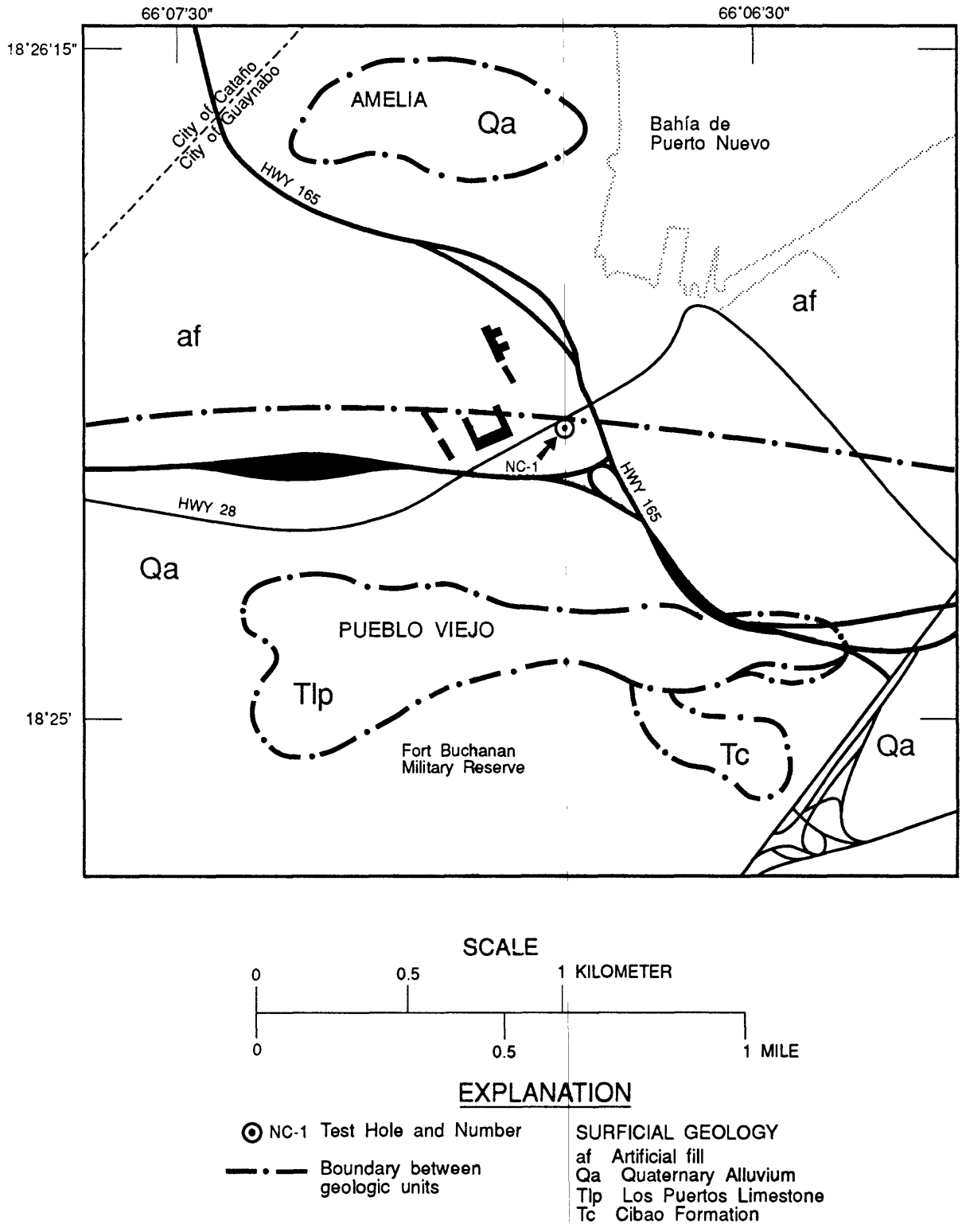

Figure 2.--Location and surficial geology at site of test hole NC-1.

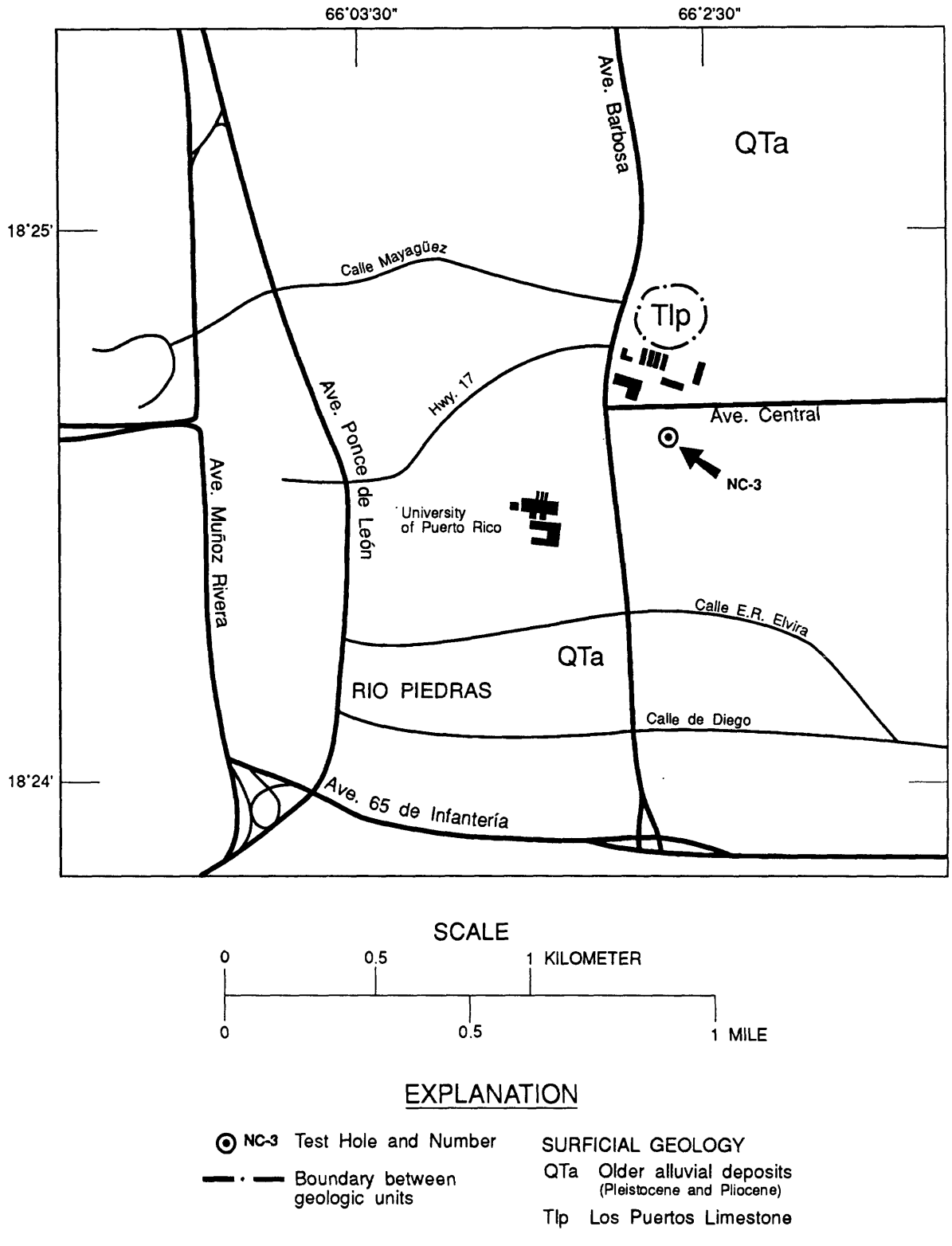

Figure 3.--Location and surficial geology at site of test hole NC-3.

Borehole Geophysics

In test hole NC-1, a suite of geophysical logs was obtained through the drill stem. Removal of the drill stem resulted in the immediate collapse of the borehole, preventing the collection of open hole geophysical log data. The geophysical readings obtained in test hole NC-1 can be used only qualitatively, because the probes of the logging unit were not calibrated.

Hydrologic Measurements

Water-level measurements were made at approximately 20 ft depth intervals, using either an electric sensor or a steel tape. Measurements were made on the inside of the drill stem before the next section of drill stem was connected. Time restrictions prohibited a full recovery of water levels. Water-level measurements also were made prior to commencement of drilling activity each day and within selected intervals identified on the basis of a noticeable increase in water ejected from the discharge pipe.

Flow measurements were made at the discharge point of the cyclone collector. Flow measurements to measure relative yields were collected as drilling proceeded. Specific-conductance measurements also were made at the discharge point of the cyclone collector and provided geochemical information on the quality of formation water.

Hydraulic continuity and a sustained minimum flow of at least 20 gal/min, measured at the discharge point of the cyclone collector, were used as criteria for differentiating water-bearing units. The water-bearing units were considered artesian zones if overlain by an impermeable layer and if the water level stood above the bottom of this confining layer.

GEOLOGIC AND HYDROLOGIC DATA

The rocks of middle Tertiary age that crop out in the Northern Coastal Province have been mapped as seven formational units by Monroe (1980). Seiglie and Moussa (1984) later modified the geologic framework described by Monroe on the basis of additional paleontologic data collected from coreholes, hole cuttings, and outcrop samples (fig. 4). They recognized that the lithologic character of these units change as they extend from their outcrop into the subsurface. This report uses the Seiglie and Moussa (1984) modifications to the nomenclature of Monroe (1980).

Test holes NC-1 and NC-3 are located in the eastern part of the middle Tertiary basin of the Northern Coastal Province of Puerto Rico. The surficial geology of the immediate area of the drilling sites consists of Quaternary and locally older deposits, and sparse, small hills of Los Puertos Limestone and Cibao Formation of middle Tertiary age.

The middle Tertiary basin is shallower toward the metropolitan area of San Juan (Monroe, 1980), which includes the municipalities of San Juan and Guaynabo. Evidence of local structural uplift in this area has been

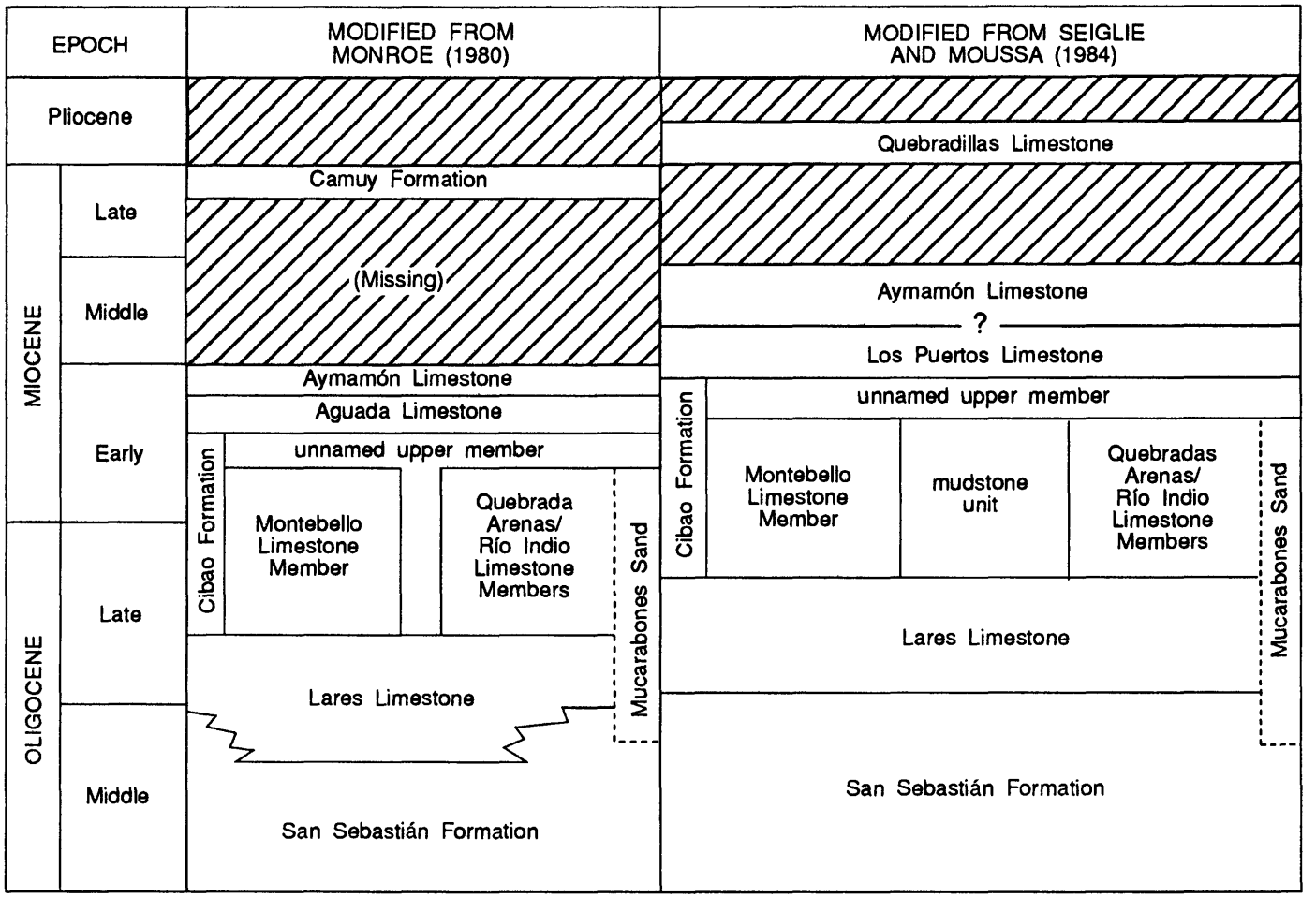

Figure 4.--Stratigraphic nomenclatures of the middle Tertiary basin of the Northern Coastal Province, Puerto Rico.

observed in the outcrop area to the south (Kaye, 1959; Monroe, 1980). Facies observed in outcrop and in subsurface indicate that this area was the last in the Northern Coastal Province to be affected by a sea transgression (Monroe, 1980; Scharlach, 1990). Before the early Miocene, while a predominantly carbonate sedimentation was taking place further west, a fluviatile-deltaic terrigenous type of sedimentation was occurring in the metropolitan area of San Juan (Monroe, 1980; Scharlach, 1990). The three uppermost units of the middle Tertiary sequence of the Northern Coastal Province, the Quebradillas Limestone, the Aymamón Limestone, and the Los Puertos Limestone, are only locally present as erosion remnants in the metropolitan area and their hydrologic importance is minimal. The Lares Limestone, which exists further west, as well as the upper part of the San Sebastián Formation and the lower part of the Cibao Formation, are replaced by the Mucarabones Sand in the metropolitan area of San Juan.

Description of Geologic Units in Test Hole NC-1

Test hole NC-1 penetrated, in descending order, surficial deposits, the Cibao Formation, and the Mucarabones Sand (table 1). The surficial deposits, 110 ft thick (0 to 110 ft in depth), are of Holocene age and are mostly claystone. The Cibao Formation of late Oligocene to early Miocene age is 195 ft-thick (110 to 305 ft in depth) and consists of: (a) a 180-ft thick section (110 to 290 ft in depth) of red algae packstone bearing miliolids and soritids wackestone-packstone, with minor interbeds of quartzose sandstone and sandy packstone and (b) a lower 15 ft-thick section (290 to 305 ft in depth) of sandstone and thin interbeds of claystone.

The lowermost 330 ft penetrated by test hole NC-1 correspond to the Mucarabones Sand of middle Oligocene to early Miocene (table 1). The Mucarabones Sand is composed of the following lithologic intervals: (a) an upper 55-ft thick section (305 to 360 ft in depth) of quartzose and lithic sandstone with minor skeletal-gastropod sandy wackestone-packstone and claystone, and (b) a lower 275-ft thick section (360 to 635 ft in depth) of quartzose and lithic sandstone, locally conglomeratic and irregularly interbedded with claystone.

Description of Geologic Units in Test Hole NC-3

Test hole NC-3 penetrated, in descending order, surficial deposits, the Cibao Formation, the Mucarabones Sand, and undifferentiated basement volcanic rocks (table 2). The surficial deposits, 70-ft thick (0 to 70 ft in depth), are of Holocene age and consist mostly of silty and sandy claystone with minor amounts of siltstone and sandstone. The Cibao Formation of late Oligocene to early Miocene age is 180-ft thick (70 to 250 ft in depth) and is composed of the following lithologic intervals: (a) a 20-ft thick section (70 to 90 ft in depth), of red algae-benthic foraminifera-oyster bearing quartz sandy, packstone-grainstone; (b) a 60-ft thick section (90 to 150 ft in depth) of claystone, locally sandy, bearing red algae, miliolids, and soritids, and interbedded with conglomeratic quartz sandstone; (c) a 60-ft thick section (150 to 210 ft in depth), of red algae-miliolid-soritid packstone-grainstone and claystone; with minor amounts of gastropod-skeletal, sandy dolomite and conglomerate, (d) a 25-ft thick section (210 to 235 ft in depth) of quartz sandstone and claystone interbedded with marl and sparse thin beds of sandy conglomerate, and (e) a 15-ft thick section, (235 to 250 ft in depth), of red algae-gastropod-Kuphus sp.-Halimeda sp. bearing packstone.

Table 1.--*Description of lithologic core of test hole NC-1*

Lithologic description	Depth, in feet below land surface
Holocene surficial Deposits	
Claystone, brownish red, slightly yellowish-brown and creamy white mottled; poorly to moderately consolidated; silty in part.	0-110
Late Oligocene - early Miocene **Cibao Formation**	
Packstone, white, gray, greenish gray mottled; sandy and argillaceous in part; fossils include red algae, miliolids, benthic foraminifera, mollusks, and soritids.	110-175
Packstone, dark gray, black, olive gray mottled; argillaceous and silty in part; irregularly laminated; fossils include mollusks and undifferentiated skeletal clasts; irregularly interbedded with minor carbonaceous claystone in lower part of interval.	175-200
Packstone, dark gray; medium- to coarse-grained quartz; minor clay interbeds; fossils include miliolids, thin-shelled mollusks, echinoid fragments and undifferentiated skeletal clasts.	200-250
Wackestone-packstone, dark gray; medium- to coarse-grained quartz, sandy; cross-bedded; fossils include red algae, mollusks and small benthic foraminifera.	250-290
Sandstone, green, olive-gray; medium- to coarse-grained quartz, sandy; argillaceous in part; glauconitic; cross-bedded; fossils include sparse unidentifiable skeletal clasts.	290-305
Middle Oligocene - early Miocene **Mucarabones Sand**	
Packstone, dark gray; sandy and argillaceous in part; glauconitic; fossils include soritids, red algae, encrusting red algae, and mollusks.	305-315
Sandstone, light to dark gray, quartzose, medium- to coarse-grained; sparse plagioclase; coarse sparry calcite cement.	315-330
Claystone, olive gray, calcareous; silty in part.	330-340
Packstone, same as in 305-315.	340-360
Sandstone, as in 315-330, conglomeratic; fossils include unidentified skeletal clasts, encrusting and benthic foraminifera; interbedded with minor wackestone-packstone.	360-395

Table 1.--*Description of lithologic core of test hole NC-1*--Continued

Lithologic description	Depth, in feet below land surface
Sandstone, light to dark gray, quartzose, medium- to coarse-grained; conglomeratic; plagioclase common; argillaceous in part; sparse pyroxene and chlorite; interbedded with minor claystone.	395-450
Claystone; siltstone; greenish gray, calcareous; disseminated pyrite; interbedded with minor sandy conglomerate.	450-480
Sandstone, same as in 395-450; interbedded with minor claystone.	480-510
Claystone, same as in 450-480.	510-520
Sandstone, same as 480-510.	520-550
Claystone, greenish gray; silty and sandy in part.	550-570
Sandstone, greenish gray, quartzose, coarse-grained; conglomeratic; well cemented; chlorite, feldspar, and pyroxene sparse; interbedded with conglomerate and minor claystone.	570-635

Table 2.--*Description of lithologic core of test hole NC-3*

Lithologic description	Depth, in feet below land surface
Holocene surficial deposits	
Claystone, reddish brown, light gray and black mottled; silty and sandy in part.	0-50
Sandstone, yellowish brown, quartzose, fine to medium-grained.	50-55
Claystone, brown, and orange, reddish-brown mottled; silty in part.	55-70
Late Oligocene - early Miocene **Cibao Formation**	
Packstone-grainstone, white, yellowish brown, quartz sandy; fossils include red algae, Amphistegina sp., oysters, small benthic foraminifera and echinoids.	70-90
Claystone, brown, reddish brown, white and black mottled; sandy in part.	90-110
Sandstone, yellowish brown, dark gray, coarse- to very coarse-grained, subangular; terrigenous and marine lithic clasts; a minor fraction of quartz; conglomeratic.	110-120
Claystone, bluish gray, reddish brown, white-black mottled; silty in part; fossils include red algae, miliolids, benthic foraminifera, echinoids and mollusks.	120-145
Sandstone, yellowish brown, orange mottled, quartzose, coarse- to very coarse-grained; argillaceous in part; conglomeratic; fossils include undifferentiated skeletal clasts.	145-150
Packstone-grainstone, white, brown mottled, sandy in part; fossils include red algae, Amphistegina sp., miliolids and soritids.	150-170
Claystone, bluish gray, light gray mottled, calcareous; interbedded with thin beds of packstone.	170-185
Packstone, gray, white, medium-grained; black rip-up clasts; black oxide nodules; fossils include undifferentiated skeletal clasts.	185-195
Conglomerate, green, gray, and yellowish brown, coarse-gravel sized volcanic and sedimentary clasts.	195-200
Claystone, bluish gray, and greenish gray, reddish brown mottled.	200-210
Sandstone, grayish green, fine to medium-grained, clayey and silty; grades downward to coarse-grained; fossils include undifferentiated skeletal clasts.	210-230
Claystone, dark gray, black, carbonaceous; disseminated pyrite.	230-235

Table 2.--*Description of lithologic core of test hole NC-3*--Continued

Lithologic description	Depth, in feet below land surface
Packstone, dark gray, dense; volcanic clasts; interbedded with minor siltstone and claystone; fossils include red algae, oysters, echinoids, benthic foraminifera, mollusks and Kuphus sp., Halimeda sp.	235-250
Middle Oligocene - early Miocene **Mucarabones Sand**	
Claystone, bluish gray, greenish gray, quartz sand in part.	250-260
Sandstone, dark gray, quartzose, medium- to coarse grained, poor sorting; increasingly conglomeratic toward the base; interbedded with claystone.	260-280
Claystone, dark gray, black, carbonaceous.	280-290
Claystone, greenish gray, white and reddish brown mottled; silty in part; carbonaceous in part.	290-300
Early Tertiary or Late Cretaceous **Undifferentiated Volcanic Rocks**	
Clay and sand, greenish gray, yellow mottled; weathered volcanic clasts.	300-310
Volcanic breccia, conglomeratic, dense, with angular to subangular pebbly and cobbly clasts; ferromagnesian minerals and feldspar partially weathered.	310-368
Igneous rock, dark gray, black, intrusive; black ferromagnesian phenocrysts.	368-375

The Mucarabones Sand of middle Oligocene to early Miocene age is 50 ft thick (250 to 300 ft in depth) and consists of claytone and conglomeratic quartz sandstone. Test hole NC-3 also penetrated 75 ft (300 to 375 ft in depth) of volcanic basement rock of either early Tertiary or Late Cretaceous age.

Description of Water-Bearing Units in Test Hole NC-1

Test hole NC-1 contains five water-bearing units; all of them artesian zones (table 3). The first artesian zone extends from 110 to 170 ft below land surface and consists of the upper part of the Cibao Formation. The second artesian zone, from 180 to 450 ft in depth, is located within the lower part of the Cibao Formation and the upper part of the Mucarabones Sand. The third, fourth, and fifth artesian zones are within the lower part of the Mucarabones Sand and extend from 480 to 510 ft, 520 to 550 ft, and 565 to 635 ft, respectively. The artesian zones are separated by confining layers.

Brackish and saline water was encountered in test hole NC-1. The specific conductance of water in the first artesian zone increased from 6,000 µS/cm at a depth of 110 ft to a maximum of 30,000 µS/cm at 150 to 170 ft (fig. 5, table 3). In the second artesian zone it generally decreased from 29,500 µS/cm in the upper part to a minimum of 500 µS/cm at 450 ft in depth. In the third and fourth artesian zones specific conductance was 1,350 µS/cm, and in the fifth artesian zone specific conductance increased from 1,350 µS/cm at 565 ft to 3,500 µS/cm at 620 ft and then decreased to 2,700 µS/cm at 635 ft (fig. 5, table 3).

The water level in the first artesian zone ranged from 11.0 to 13.0 ft below land surface (table 3). In the second artesian zone water levels ranged from 17.0 ft below land surface to 2.8 ft above land surface. In the third artesian zone water levels ranged from 7.0 to 9.0 ft above land surface, while in the fourth and fifth water levels remained constant at 9.0 and 18.0 ft above land surface, respectively. Flow, as measured at the discharge pipe, ranged from a maximum of 130 gal/min in the second zone to a minimum of 60 gal/min in the fifth artesian zone (table 3).

Table 3.--*Selected hydrologic data of test hole NC-1*

Artesian Zones	Depth below land surface, in feet	Water level in feet above(a) or below(b) land surface	Specific conductance, in microsiemens per centimeter at 25°C	Flow, in gallons per minute
	110	11.0 (b)	6,000	100
	134	11.0 (b)	6,000	100
First	150	11.0 (b)	30,000	105
	160	12.0 (b)	30,000	105
	170	13.0 (b)	30,000	100
	180	13.0 (b)	29,500	100
	195	13.0 (b)	29,000	105
	216	9.8 (b)	25,000	105
	225	11.0 (b)	24,800	105
	235	13.0 (b)	23,100	105
	252	16.0 (b)	22,500	95
Second	275	17.0 (b)	22,000	130
	296	16.0 (b)	22,000	120
	310	9.0 (b)	2,000	120
	335	5.3 (b)	11,900	120
	355	6.3 (b)	6,700	110
	395	6.3 (b)	6,500	115
	415	2.8 (a)	4,500	110
	435	0.6 (b)	2,210	110
	450	2.5 (a)	500	105
	480	7.0 (a)	1,350	105
Third	495	7.0 (a)	1,350	110
	510	9.0 (a)	1,350	110
Fourth	520	9.0 (a)	1,350	75
	550	9.0 (a)	1,350	70
	565	18.0 (a)	1,350	60
Fifth	590	18.0 (a)	1,400	60
	620	18.0 (a)	3,500	60
	635	18.0 (a)	2,700	60

Description of Water-Bearing Units in Test Hole NC-3

Test hole NC-3 penetrated seven water-bearing zones; all of them artesian (table 4). The first five zones are located within the surficial deposits and the Cibao Formation and are at the following depth intervals below land surface: 55 to 60 ft, 69 to 95 ft, 105 to 111 ft, 146 to 169 ft, and 183 to 200 ft. The sixth artesian zone, is located from 210 to 245 ft in depth below land surface, and includes the Cibao Formation. The seventh and lowest artesian zone is located within Mucarabones Sand and extends from 252 to 277 ft below land surface.

The artesian zones penetrated by test hole NC-3 produced low salinity water at rates of 20 to 90 gal/min. The specific conductance of water from these zones ranged from 610 to 900 µS/cm (fig. 6, table 4). The flow ranged from 20 gal/min in the uppermost artesian zone to a maximum of 90 gal/min in the fourth and fifth artesian zones (fig. 6, table 4). The water levels in the artesian zones ranged from about 8.5 to 18.0 ft below land surface.

Table 4.--*Selected hydrologic data of test hole NC-3*

Artesian Zones	Depth below land surface, in feet	Water level, in feet below land surface	Specific conductance, in microsiemens per centimeter at 25°C	Flow, in gallons per minute
First	55	11.0	610	20
	60	11.0	610	20
Second	69	16.0	610	60
	95	18.0	900	60
Third	105	17.0	900	60
	111	17.0	900	60
Fourth	146	8.7	790	90
	169	9.5	790	90
Fifth	183	9.5	830	90
	192	8.5	830	90
	200	8.5	830	90
Sixth	210	9.7	850	50
	230	9.8	830	50
	245	9.8	830	50
Seventh	252	9.8	830	45
	277	10.0	900	45

Description of the Geophysical Logs in Test Hole NC-1

The gamma-gamma log can be divided in four major distinct zones that correlate reasonably well with the major lithologies of test hole NC-1 (fig. 5). These zones do not correspond to the artesian zones discussed previously. An increasing trend with depth is observed in the first three gamma-gamma log zones. The first zone, with the lower values, is indicative of the extremely low effective porosity of the upper 150 ft. The second zone that extends down to 320 ft reflects the increasing effective porosity of the sandy limestone (wackestone-packstone) and the presence of interbedded sandstone. The third zone, extending to a depth of 560 ft, reflects the increased amounts of sandstone and the presence of minor conglomerate. The fourth and fifth zones that extend to the

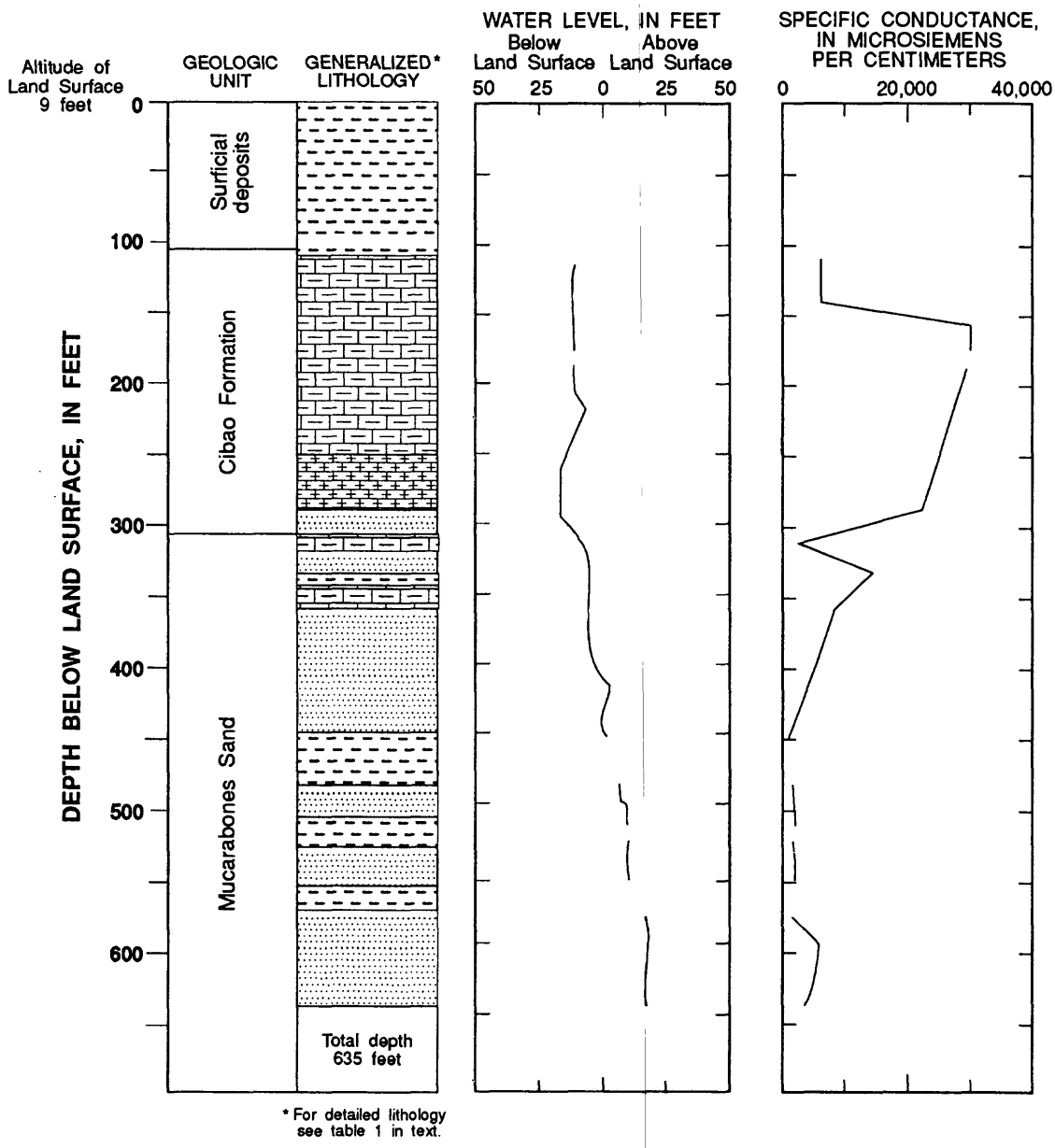

Figure 5.--Lithology, water level, specific conductance, flow data, and geophysical logs for test hole NC-1.

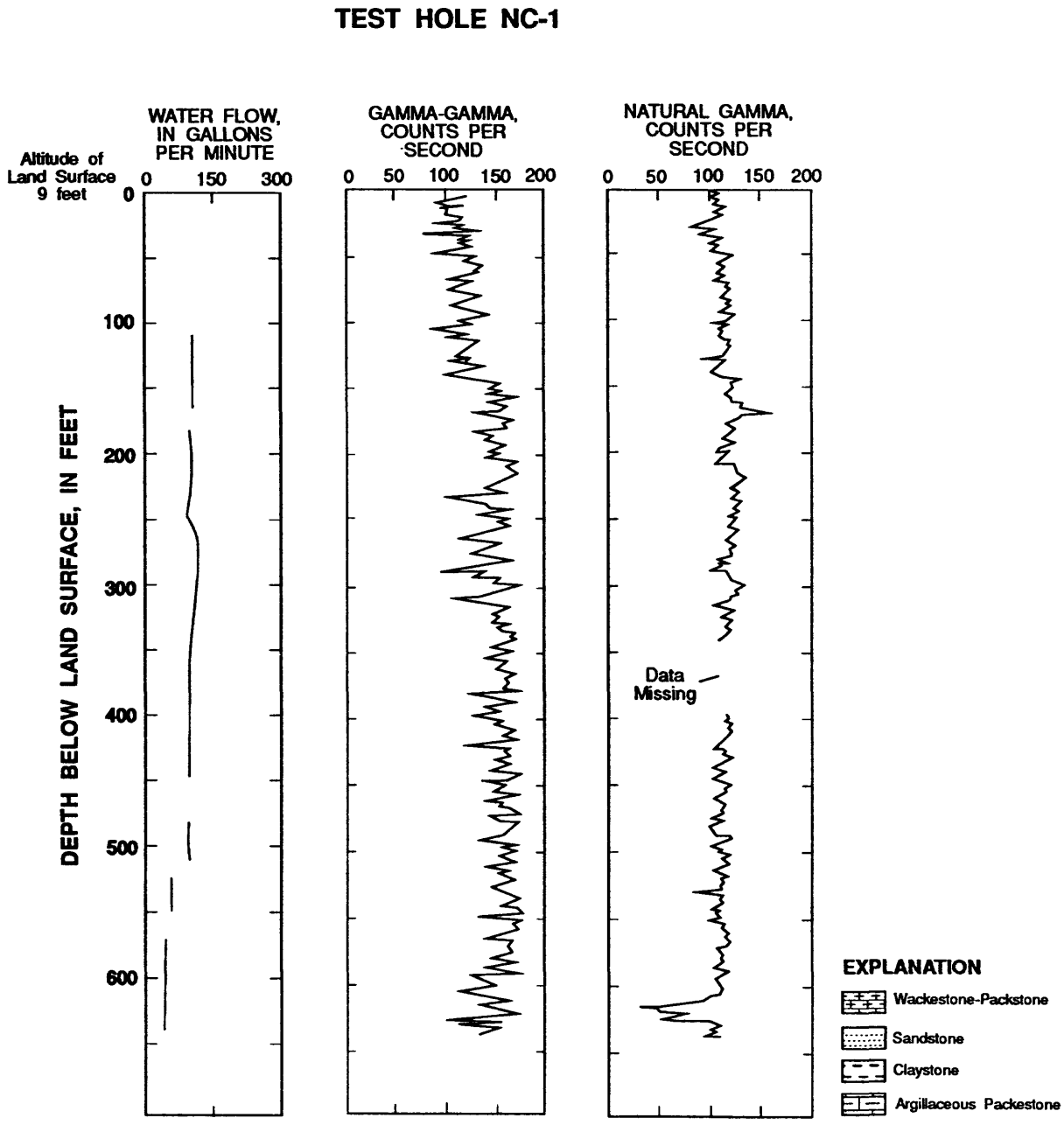

Figure 5.--Lithology, water level, specific conductance, flow data, and geophysical logs for test hole NC-1 (continued).

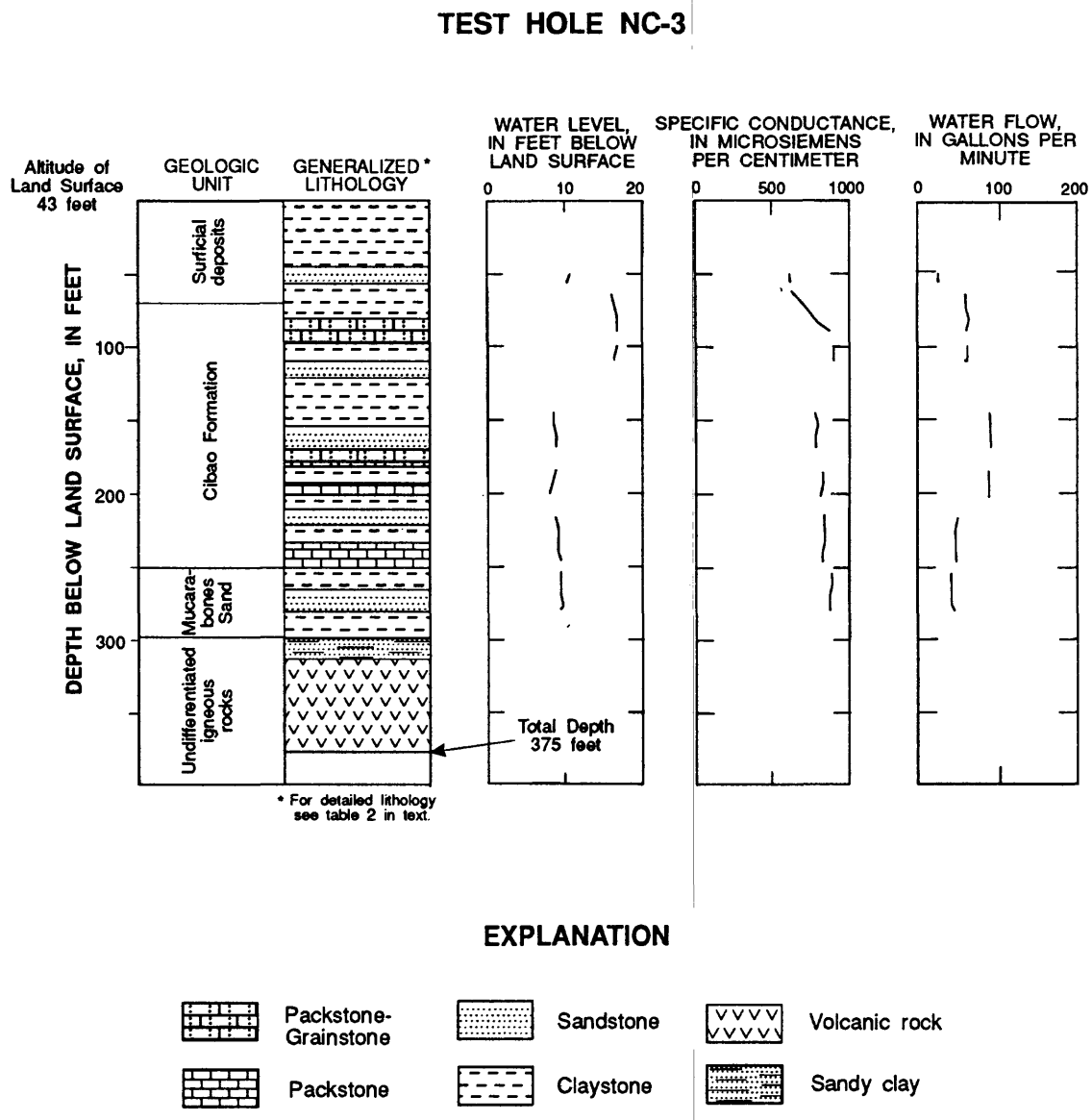

Figure 6.--Lithology, water level, specific conductance, and flow data for test hole NC-3.

bottom of the hole, show a decreasing trend that appears to be result of the well-cemented nature (reduction in porosity) of the conglomeratic sandstone. The natural gamma log shows a general decreasing trend indicative of the increasingly non-clayey nature of the main rock types with depth (fig. 4). A maximum reading was obtained between 165 to 175 ft and coincides with an interval of clayey limestone and carbonaceous claystone. A sharp break to a lower value at a depth around 610 ft apparently results from the increasingly "clean" well-cemented conglomeratic sandstone.

SUMMARY

Test holes NC-1 and NC-3 were drilled as part of a drilling program to determine the depth, thickness, and hydraulic properties of the regionally extensive aquifer system in the Northern Coastal Province of Puerto Rico. Data collected from these test holes include lithological descriptions of the core samples, water levels, specific conductance, and water flow, and for test hole NC-1, geophysical logs.

Test hole NC-1 was drilled to a depth of 635 ft below land surface. The test hole penetrated terrigenous clastics and lesser amounts of limestone. Two geologic units of late Oligocene to early Miocene and middle Oligocene to early Miocene age were penetrated: the Cibao Formation and the Mucarabones Sand. Five artesian water-bearing zones were encountered in test hole NC-1. The specific conductance of the water ranged from 500 to 30,000 µS/cm and water levels ranged from 17 ft below land surface to 18 ft above land surface. Flows, as measured at the discharge pipe of the air rotary drilling rig, ranged from 60 to 130 gal/min.

Test hole NC-3 was drilled to a depth of 375 ft below land surface. This test hole penetrated terrigenous clastics, and 75 ft of volcanic rocks in the lowermost part of the hole, and lesser amounts of limestone. Two geologic units of middle Oligocene to early Miocene age were penetrated: the Cibao Formation and the Mucarabones Sand. Seven artesian zones were encountered in test hole NC-3. The specific conductance of the water ranged from 610 to 900 µS/cm. The water level in these zones ranged from 8.5 ft to 18.0 ft below land surface and flows ranged from 20 to 90 gal/min.

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