Prepared in cooperation with the
SOUTH FLORIDA WATER MANAGEMENT DISTRICT

INTRODUCTION

The principal source of freshwater in southeast Florida is the surficial aquifer system. The surficial aquifer system is composed of upper Cenozoic sediments that are hydraulically connected and are mostly under water-table conditions. The most permeable unit of this system is the Biscayne aquifer, the major and only formally named unit of this system, which extends northward into Broward County and parts of eastern Palm Beach County. The Biscayne aquifer is a highly permeable limestone and sandstone sequence that occurs at or near land surface in most of Dade County (Parker and others, 1955). In western Dade County, the highly permeable Pleistocene limestones and sandstones are separated from the underlying Pliocene limestone and sandstone of moderate permeability by a thick sequence of Pliocene clastic sediments that have low permeability and, in places, are practically impermeable. These Pliocene clastics make up the base of the Biscayne aquifer in this area, but are absent in eastern Dade County where the limestones and sandstones of Pleistocene and Pliocene age are in direct contact. Accordingly, in eastern Dade County the Pliocene limestone and sandstone are included in the Biscayne aquifer, whereas in western Dade County they make up a separate, unnamed lower aquifer within the surficial aquifer system. The base of the surficial aquifer system throughout Dade County is delineated at the top of a thick sequence of relatively impermeable clay and silt in the lower part of the Tamiami Formation and the upper part of the Hawthorn Formation. Locally, the base of the aquifer system consists of semi-indurated claystone and siltstone interbedded with sand of low to moderate permeability.

This report describes the geologic framework of the surficial aquifer system in Dade County, Fla. (fig. 1). It is part of a long-term intensive study begun by the U.S. Geological Survey in 1979, in cooperation with the South Florida Water Management District, to describe the geology, hydrologic characteristics, and ground-water quality of the surficial aquifer system in Dade and Broward Counties. A similar report has been published on the geology of the surficial aquifer system in Broward County (Causaras, 1985).

A total of 33 test wells were drilled completely through the surficial aquifer system and into the underlying, relatively impermeable units of the Tamiami and Hawthorn Formations to obtain the data needed to describe the geology of the surficial aquifer system. The test wells were rotary drilled with an open-end bit using the reverse-air dual-wall method. This method provided geologic samples superior to those obtainable by most other methods, in that the samples are uncontaminated by drilling fluid and were large enough for describing sedimentary characteristics. Detailed lithologic logs were made from microscopic examination of rock cuttings and cores obtained from these wells and are presented in this report. These logs were used to prepare geologic sections that show the lithologic variations, thickness of the lithologic units, and different geologic formations that comprise the aquifer system.

METHODS

The lithologic logs presented in this report were made from microscopic examination of the well cuttings and cores collected during the drilling phase. Other methods such as stain, dilute hydrochloric acid tests, and geophysical logs were used when additional aid was needed in identifying and describing the samples and in correlating stratigraphic units. Folk's 1962 classification of carbonate rocks was used in classifying rocks with a calcium carbonate content of 50 percent or more (Folk, 1968). The standard Wentworth terrigenous grain-size classification (Pettijohn, 1957, p. 27) was used in classifying sediments and rocks consisting of less than 50 percent calcium carbonate. A modifying term was added to the description of the terrigenous samples if a foreign size content of more than 10 percent but less than 50 percent was present. A silty sand contains more than 10 percent silt, a clayey silt contains more than 10 percent clay, and a sandy clay contains more than 10 percent but less than 50 percent sand. The same guideline was used for carbonate rocks so that a sandy limestone contains more than 10 percent sand. The percentage of a given constituent was determined by using the "Comparison Chart for Visual Percentage of Estimation" *from* Terry and Chilingar (*in* Scholle, 1978, p. x). The constituent rock fragments found in some samples are noted in the lithologic descriptions in the abbreviated form RF. The colors indicated by the chart numbers in parentheses are based on the "Rock-Color Chart" by Goddard and others (1948) and were assigned while the samples were damp.

Relative porosity abundance and type were determined only for cores and rock cuttings of adequate size. Porosity abundance was visually estimated and described in the lithologic logs by using the following qualitative terms: virtually nonporous, slightly porous, moderately porous, porous, and very porous. Choquette and Pray's (1972, p. 169-182) classification of basic porosity types was used in classifying pores and pore systems in carbonate rocks.

GEOLOGY

The surficial aquifer system in Dade County is composed of limestone, sandstone, sand, shell, lime mud, silt, clay, claystone, siltstone, and an admixture of these materials. These sediments were deposited during the Pliocene through Holocene Epochs and were assigned (Parker and others, 1955, p. 160) to the following general ascending order of stratigraphic sequence that varies depending on the area: Tamiami Formation, Caloosahatchee Marl, Fort Thompson Formation, Key Largo Limestone, Anastasia Formation, Miami Oolite, Pamlico Sand, and Lake Flirt Marl. The Caloosahatchee Marl was not encountered in any of the wells drilled for the Dade County and Broward County study (Causaras, 1985).

Geologic sections A-A′ through K-K′ (sheets 1, 2, and 3) show some of the variations in the sediments that compose the surficial aquifer system. The base of the surficial aquifer system is an indulating erosional surface (unconformity), causing the aquifer to range in thickness from about 140 feet in southeastern Dade County to more than 280 feet in northeastern Dade County. The surficial aquifer system is composed of distinct lithologic units with numerous facies changes that were brought about primarily by changes in sea level. A contrast in lithologies exists between western and eastern Dade County, defined as the areas west and east of State Road 27 (SR-27, fig. 1). In the western area, the surficial aquifer system is primarily an admixture of sand, silt, lime mud, and shell hash that separates the limestone of the Pleistocene Fort Thompson Formation from the limestone unit of the Pliocene Tamiami Formation; but in the eastern part it is primarily composed of limestone, sandstone, and shelly sand (see sections B-B′ through E-E′, sheets 1 and 2). North of the Tamiami Trail, the lithology of the aquifer system is similar to that in Broward County (Causaras, 1985), in that the western area is primarily limestone with some lime mud and sand interbedded with sandstone, and the eastern area is primarily sandy limestone, sandstone, and sand (see sections A-A′ and F-F′, sheets 1 and 2).

The Pamlico Sand (late Pleistocene) includes all the marine terrace deposits younger than the Pleistocene Anastasia Formation (Parker and Cooke, 1944, p. 75) and consists of nonfossiliferous, very fine to coarse quartz sand (averaging medium) that is generally well sorted. The absence of fossils is probably caused by the dissolution of calcite or aragonite shell material by percolating water. The Pamlico Sand is usually cream to brown in color, depending on the amount of iron mineral coating the quartz grains. The Pamlico Sand was penetrated in eastern Dade County generally north of the Tamiami Trail in the vicinity of test wells G-3299, G-3300, G-3306, and G-3307 (sections A-A′ and B-B′, sheet 1). In these test wells, the sand overlies and fills cavities in the Miami Oolite.

In some wells drilled in The Everglades and in coastal marshes, as much as 3 feet of the Lake Flirt Marl was penetrated filling in the troughs of the undulating erosion surface of the Miami Oolite. The Lake Flirt Marl is an upper Pleistocene to Holocene freshwater lake deposit, consisting of an admixture of silt, clay-size particles, micrite, and freshwater snails that may contain an appreciable amount of peat and organic soil.

The uppermost lithologic unit of the surficial aquifer system in most of Dade County consists of the oolitic and bryozoan limestone facies of the Miami Oolite. The Pleistocene Miami Oolite is white to pale orange, except in parts of the county where differential chemical deposition of waterborne minerals such as iron-oxide (Parker and others, 1955, p. 102) stain the limestone bright orange. Both the oolitic and bryozoan facies are riddled with solution holes (vugs), giving the limestone a honeycombed pattern that makes the formation very porous. Along the western shore of Biscayne Bay, south of the Tamiami Trail, are numerous outcrops and canal cuts of the Miami Oolite in which the limestone is crossbedded and solution holes are often filled with detritus. The Miami Oolite ranges in thickness from about 3 to 32 feet and is thickest in southeastern Dade County near test wells G-3313, G-3315, and G-3320 (see sections C-C′ through E-E′, sheet 2). It becomes thinner to the northwest where it interfingers with the Fort Thompson Formation (see sections A-A′ and B-B′, sheet 1), and east of SR-826 on Tamiami Trail where it is overlain by the Pamlico Sand and interfingers with the Anastasia Formation.

Underlying and interfingering with the Miami Oolite in this area are lenses and layers of the Anastasia Formation consisting of porous to very porous, sandy, shelly limestone and nodular and shelly sandstone interbedded with sand and shelly sand. These materials are thickest to the northeast toward Broward County where they are more than 180 feet thick below land surface (Causaras, 1985). The Anastasia Formation thins to the south in the vicinity of test wells G-3312 and G-3313 (section C-C′, sheet 2) where it is overlain by and interfingers with the Fort Thompson Formation and the Key Largo Limestone. The Fort Thompson Formation underlies the Miami Oolite in most of Dade County and outcrops in the northwestern part of The Everglades where it interfingers with the Miami Oolite. The contact between the Miami Oolite and the Fort Thompson Formation is usually denoted by the presence of a subaerial crust containing intraclasts and stained by iron oxide.

The Fort Thompson Formation consists of a series of alternating shallow marine, brackish-water, and freshwater limestones. The marine limestone is porous to very porous and pale orange to yellowish gray containing corals, bryozoans, abundant mollusks including *Chione cancellata*, and the benthic foraminifer Archais angulatus. The species *Archais* sp. is commonly found on thalassia grass beds behind reefs and are abundant in patch reefs and outer reef tracts (Steinker, 1977). The marine limestone, in places, may grade to a moderately porous, brackish-water estuarine limestone containing both freshwater snails (*Helisoma* sp.) and marine clams. The freshwater limestone is gray, very well cemented, generally slightly to moderately porous, and contains abundant snail remains including *Helisoma* sp. and *Ameria* sp. This freshwater limestone unit may either be in sharp contact with the marine limestone or occurs transitionally with the brackish-water limestone. Where the contact is sharp, freshwater limestone clasts are embedded in a matrix of the marine limestone, giving the rock a brecciated texture and showing that the freshwater limestone has locally been broken up and reworked into the marine limestone. The Fort Thompson Formation is wedge shaped and is thickest between SR-27 and the coastal area, thinning westward to a featheredge in Collier County (Schroeder and Klein, 1954).

In eastern Dade County, localized lenses of the Key Largo Limestone interfinger with the Miami Oolite, Anastasia Formation, and Fort Thompson Formation (see sections C-C′, I-I′, J-J′, and K-K′, sheets 2 and 3). The Key Largo Limestone is highly crystalline, very porous, and reefal containing corals (*Montastrea* sp.), large bryozoans, and mollusks. The Key Largo Limestone crops out near the Monroe-Dade County boundary (see test well G-3395, section I-I′, sheet 3).

Below the Pleistocene deposits in western Dade County (see sections A-A′ through E-E′, sheets 1 and 2) are numerous lenses and layers of low permeability sand, shells, lime mud, silt, and an admixture of these materials. These interbedded materials form the base of the Biscayne aquifer in western Dade County and were assigned to the Pliocene Tamiami Formation by Parker (*in* Schroeder and others, 1958, p. 10, figs. 7-10). Mansfield (1939, p. 16) thought that the fauna of the sand penetrated in a ditch along the Tamiami Trail, 42 miles west of Miami (near test well G-3301, section B-B′, sheet 1), was probably closely related to the limestone unit that he called the Buckingham Formation. Parker and others (1955, p. 87) concluded that the Buckingham Formation is merely a facies of the Tamiami Formation. Recent paleontological studies by E.J. Petuch (Florida International University, oral commun., 1984) indicate that these clastic materials are of Buckingham age (late Pliocene), but are not part of the Tamiami Formation. In this report, these sediments are assigned to the Tamiami Formation (Parker and others, 1955, p. 85, pl. 9, cross-section F-F′) to maintain continuity in terminology until these paleontological studies are completed.

The Tamiami ("Buckingham" facies) sediments have numerous facies due to the variable depositional environments in which they formed, ranging from reef, to beach, to lagoonal, and terrestrial. Because of the numerous and frequent facies changes that may occur within a short distance, the different facies were grouped as a unit body of sediments (sections B-B′ through K-K′, sheets 1, 2, and 3). In western Dade County, these sediments are underlain by the limestone which was described by Mansfield (1939, p. 8) as the prototype of the Tamiami Formation. The sediments thin toward the east where they interfinger with the limestone unit of the Tamiami Formation (sections B-B′ through E-E′, sheets 1, 2, and 3).

The limestone of the Tamiami Formation is gray, loosely to well cemented, and contains a shallow marine, nearshore faunal assemblage with abundant pelecypods (*Pecten* sp. and *Ostrea* sp.), gastropods (*Turritella* sp.), pink barnacles (*Balanus* sp.), and echinoids (including *Encope* sp.). The limestone is porous to very porous and makes up a significant part of the surficial aquifer system in western Dade County from the Tamiami Trail northward into Broward County. In eastern and coastal Dade County, the gray limestone decreases in thickness and, in places, grades into loosely to well cemented sandstone, and interfingers with layers and lenses of shelly sand and sand interbedded with claystone and siltstone.

The limestone unit of the Tamiami Formation is underlain by a clastic unit of the Tamiami Formation which consists of gray to green, very coarse to fine grained, shelly sand and sandstone that contains phosphorite, heavy minerals, and mica as accessory minerals and was deposited in an inner shelf environment. This sand and sandstone unit grades vertically and interfingers with a shelly, silty, calcareous sand, siltstone, and claystone. The lower clastic unit of the Tamiami is moderately porous to virtually nonporous and is unconformably underlain by the shelf deposits of the Hawthorn Formation.

The Hawthorn Formation is Miocene in age and consists of gray to green, sandy, calcareous silt and sandy, silty, calcareous clay that contains scarce macrofossils and that is cemented, in places, into a claystone and siltstone. The claystone and siltstone contain both benthic and planktonic foraminifers with the latter less abundant and usually underdeveloped in size. This underdevelopment indicates a marginal growth habitat, possibly one that was located between a shallow and deeper continental shelf. The claystone or siltstone is generally interbedded with well sorted, medium-grained sand that contains garnet and other heavy minerals. This sand yields from low to moderate quantities of water.

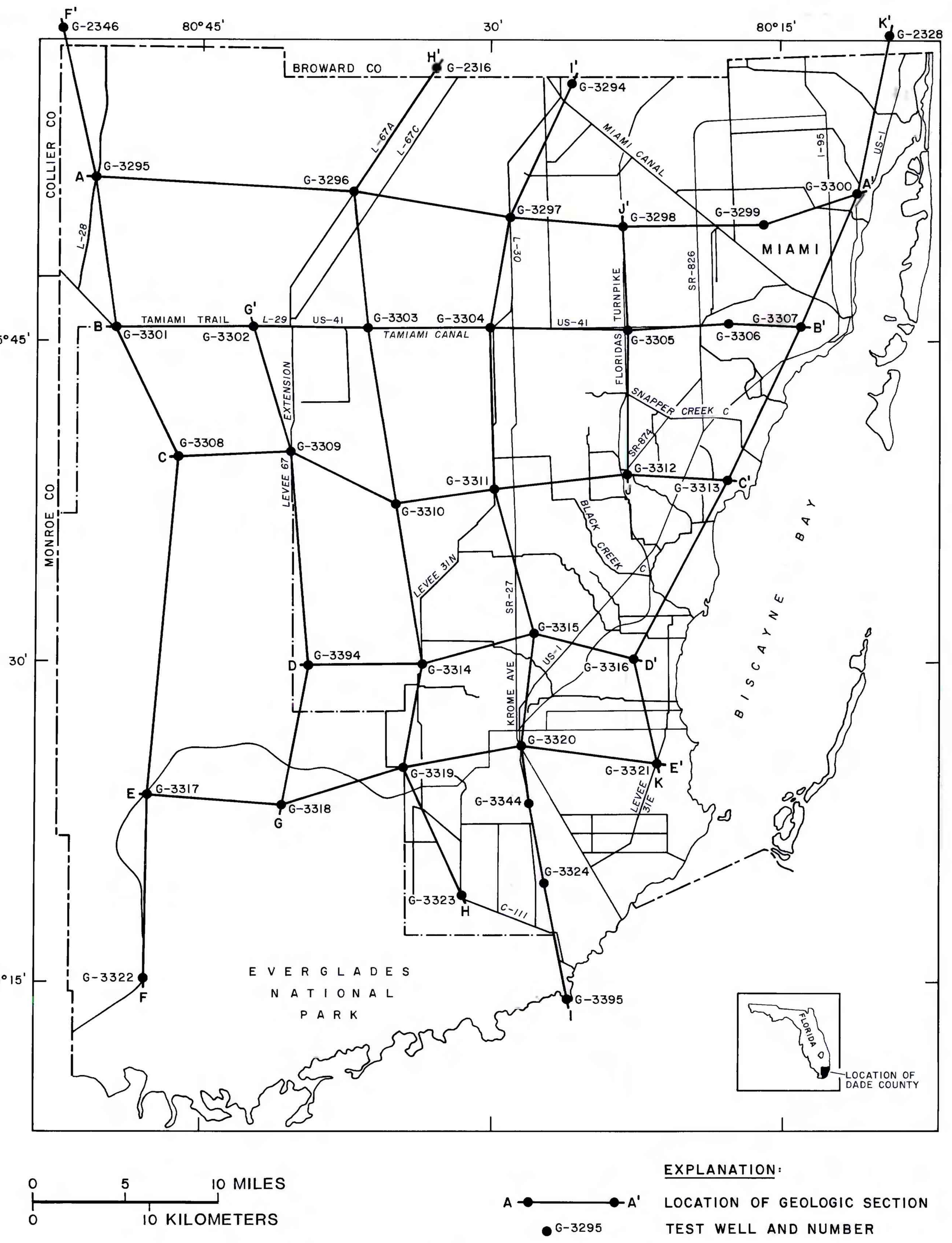

Figure 1.–Location of test wells and geologic sections in Dade County.

In many of the test wells, the lower clastic deposits of the Tamiami seem to grade into the Hawthorn clastic deposits or are mixed with reworked Hawthorn clastic sediments. In these wells, the symbol "Tth" was used for Tamiami Formation and Hawthorn Formation undifferentiated. In the coastal areas of northern Dade County near well G-3300 (section A-A′, sheet 1), instead of the Hawthorn clastic, a pale-green, loosely cemented, outer shelf limestone unit with abundant bethonic and planktonic foraminifers was penetrated from about 210 to 320 feet below land surface. This low permeability limestone is probably of Hawthorn age, and together with the slightly porous to virtually nonporous clastic deposits of both the Tamiami and Hawthorn Formations, delineates the base of the surficial aquifer system in Dade County.

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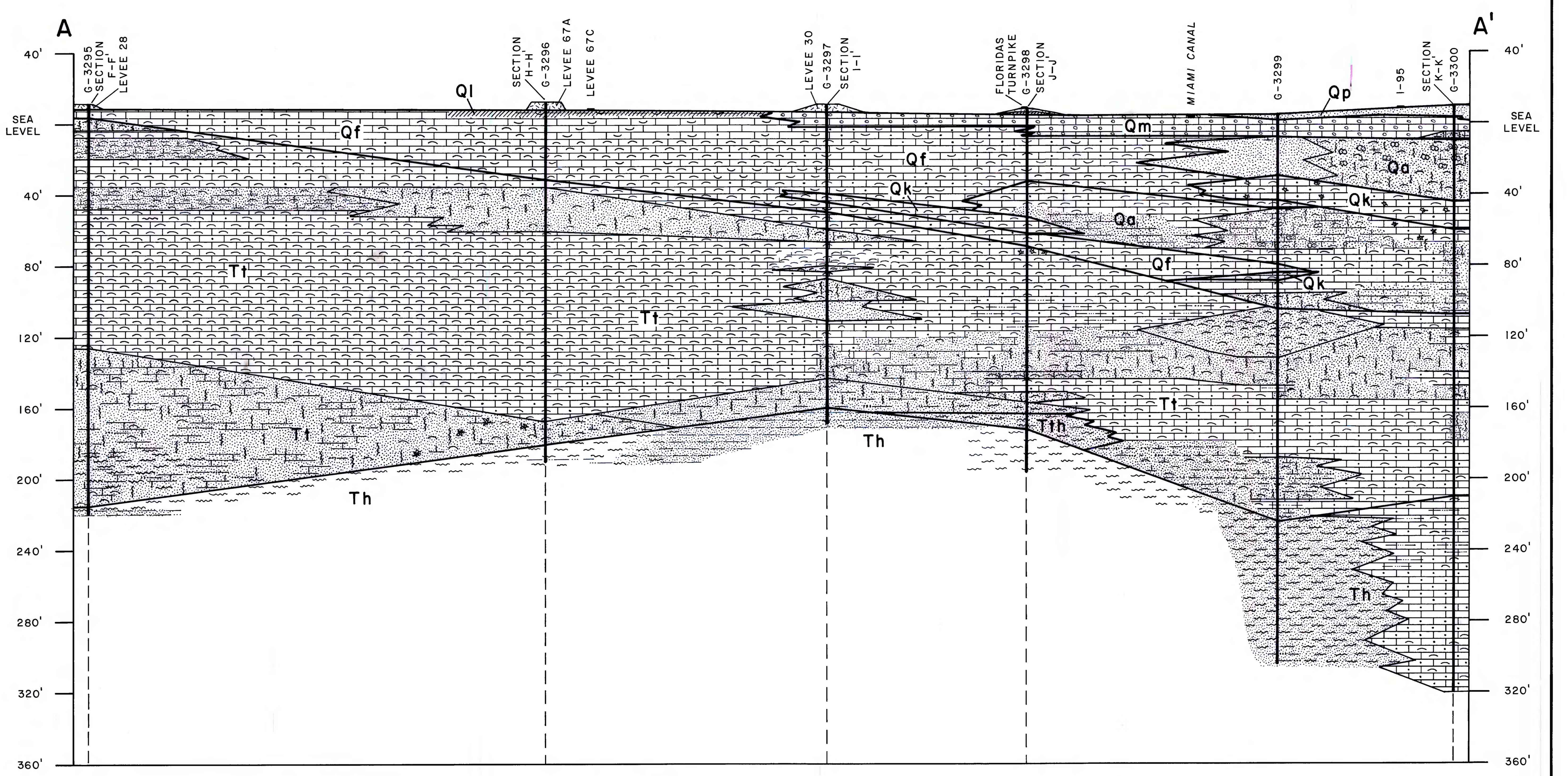
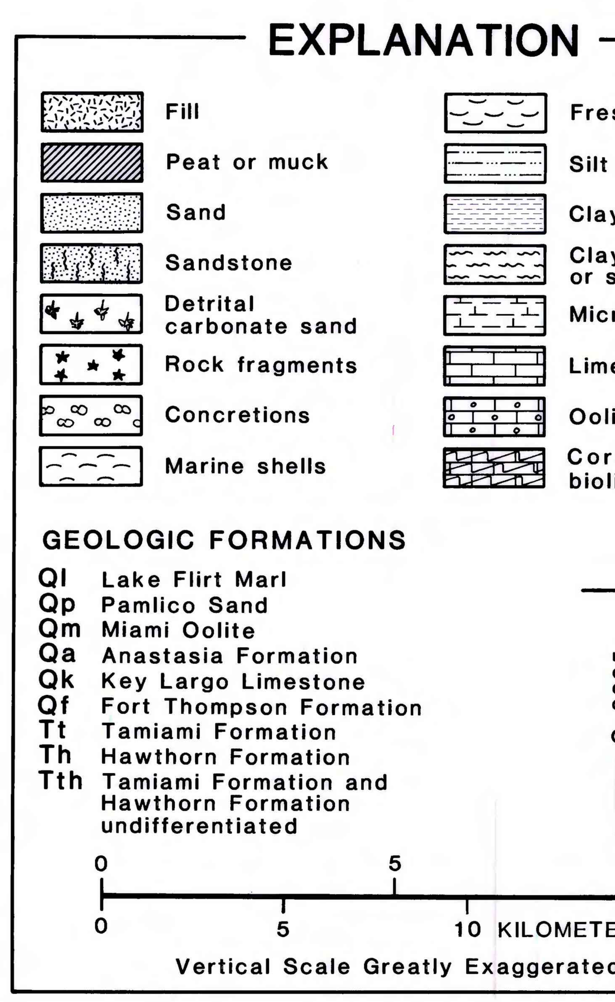
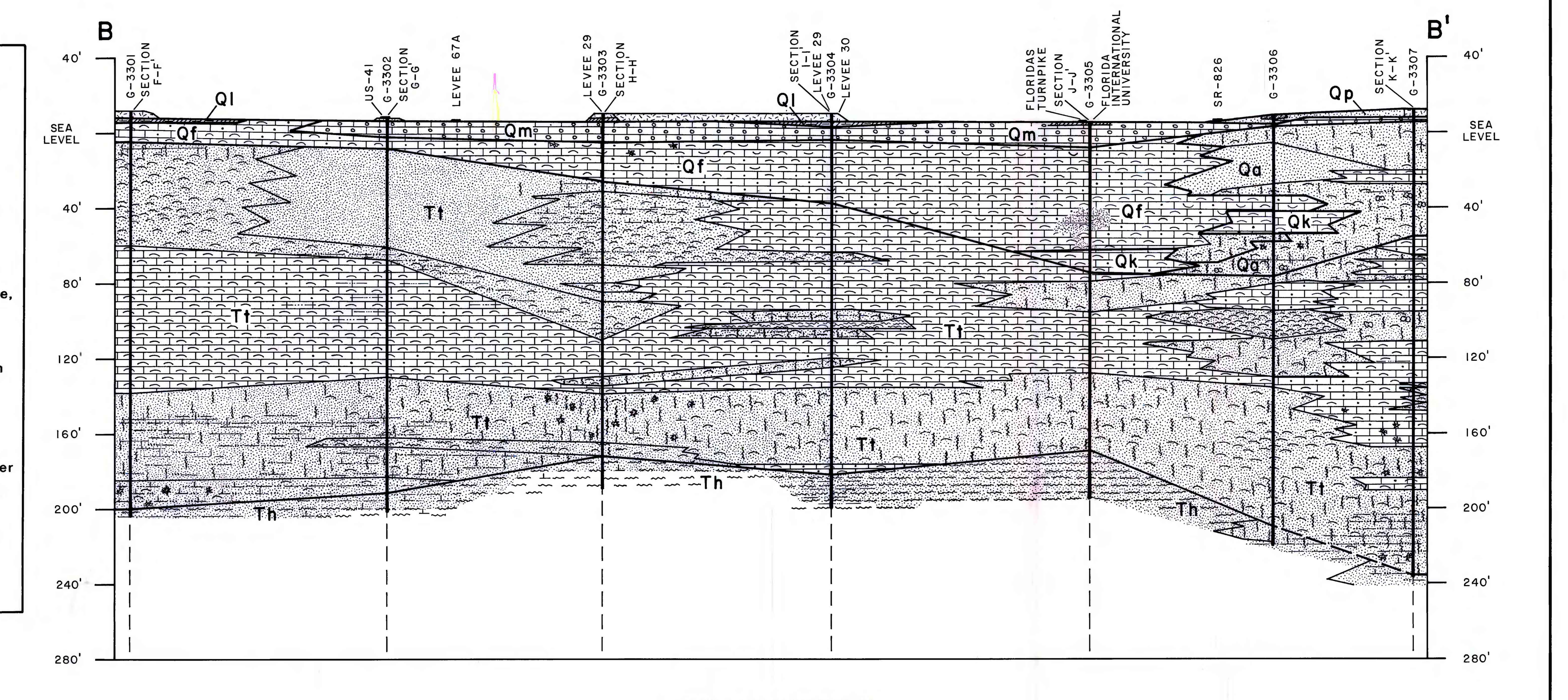


WEST-EAST SECTION A-A′





WEST-EAST SECTION B-B′

GEOLOGY OF THE SURFICIAL AQUIFER SYSTEM, DADE COUNTY, FLORIDA

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1987