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INVESTIGATION OF GROUND WATER RESOURCES AND SALT WATER INTRUSION IN THE COASTAL AREAS OF NORTHEAST FLORIDA

By

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Finally, the authors would like to thank the many private land owners who allowed the use of their wells for the project wide network.

CONVERSION FACTORS

For the use of those readers who may prefer to use metric units, the conversion factors for the English units used in this report are listed below:

Multiple English Unit	By	To Obtain Metric Unit
inches (in)	25.4	millimeters (mm)
feet (ft)	0.3048	meters (m)
square feet (ft^2)	0.0929	square meters (m^2)
miles	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
acres	4.047×10^3	square meters (m^2)
	4.047×10^{-1}	square hectometers (hm^2)
acre feet (acre ft)	1,233	cubic meters (m^3)
gallons (gal)	3.785	liters (l)
gallons per minute (gal/min)	6.309×10^{-2}	liters per second (l/s)
Million gallons per day (Mgal/d)	0.04381	cubic meters per second (m^3/s)
feet squared per day (ft^2/d)	0.0929	meters squared per day (m^2/d)
gallons per minute per foot [(gal/min)/ft]	0.207	liters per second per meter (l/s)/m
feet per day (ft/d)	0.3048	meters per day (m/d)
feet per day per foot [(ft/d)/ft]	1.0	meters per day per meter [(m/d)/m]

Temperature in degrees Celsius can be converted to degrees Fahrenheit as follows:

$$^{\circ}F = 9/5\ ^{\circ}C + 32$$

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ABSTRACT

Ground water resources and salt water intrusion in the coastal areas of northeastern Florida were evaluated. Aquifer characteristics were determined for the three systems occurring in the study area, namely, the Floridan, secondary artesian, and shallow aquifers. Water levels and water quality were periodically measured for each aquifer. Available potable water resources in the Floridan aquifer were estimated using safe yield approximations.

Trilinear plotting, Stiff patterns, and factor analysis were used to interpret water quality data which aided in establishing the origin and distribution of chemical constituents found in waters of the various aquifers. Cross sections and a fence diagram were also used to illustrate the location of the 250 and 1,000 mg/l chloride interfaces.

Five "areas of vital concern" were proposed. Area 1 includes the Fernandina Beach cone of depression. Area 2 includes the coastal shallow clastic and secondary artesian aquifers. Area 3 includes the Floridan aquifer transitional area at Fort George Island. Area 4 includes the Anastasia Formation and Floridan aquifer transitional zone near St. Augustine. Area 5 includes the agricultural areas of Hastings and Bunnell which exhibit connate intrusion.

INTRODUCTION

GENERAL STATEMENT OF THE PROBLEM

In the coastal region of northeastern Florida, surface water bodies are undesirable sources of municipal supply due to upstream salinity of the river system, high pollution susceptability, and seasonal variations in water availability. Therefore, ground water sources have become increasingly important, and their general condition has become a major concern. Nassau, Duval, St. Johns, and Flagler Counties, (Figure 1) rely almost solely on ground water from the Floridan aquifer as a potable water source. In areas where the Floridan aquifer is intruded by mineralized waters, limited shallow aquifer supplies are available. Ground water withdrawals have caused extensive cones of depression in the potentiometric surface of the Floridan aquifer in a few areas. Salt water contamination has been linked to the expanding cones by several investigators.

Leve (1966) reported minor salt water contamination in a few deep wells generally below 1,800 feet within the Floridan aquifer in both the Jacksonville and Fernandina Beach areas. More recent studies by Fairchild and Bentley (1977) have shown the need to limit well depth to less than 1,150 feet in the Fernandina Beach area. R. W. Harden's (1979) report has significantly increased the availability of data on water quality in the Fernandina area. The report concluded that chloride increases in some wells deeper than 1,200 feet were caused by well interference, interzonal mixing, and imperfect plugging, and not a result of incipient, large-scale connate intrusion. Continual connate intrusion increases are creating future development problems on Fort George Island (Jacksonville Area Planning Board, 1977).

A more critical salt water intrusion problem exists in the Floridan aquifer in the coastal areas of Flagler County. In Flagler County, potable water occurs at depths shallower than 120 feet along the coast as compared to 1,300 feet in

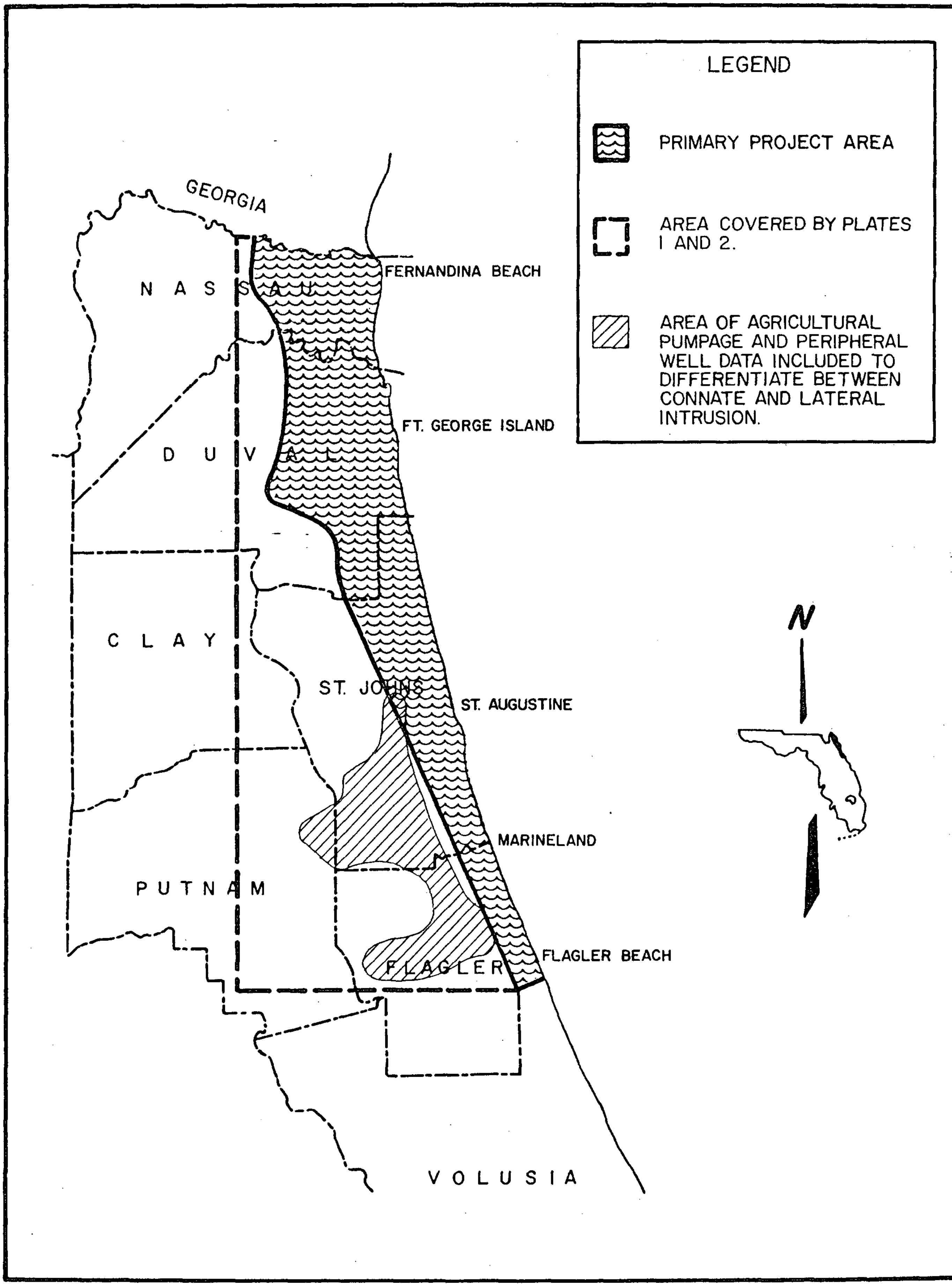


FIGURE 1. -- Primary Boundary and Supplementary Field Data Collection Areas

Nassau County. Shallow aquifer well yields along the Atlantic Coastal Ridge in both St. Johns and Flagler Counties appear to be sufficient to provide necessary supplies for the immediate future. However, barrier island supplies are severely limited. Increasing population will create significant stress on the shallow aquifer during the next 20 years. These extra stresses will probably create a need for the development of supplemental supplies or advanced treatment in parts of St. Johns and Flagler Counties.

Salt water contamination also exists further inland in parts of Flagler and St. Johns Counties within the Floridan aquifer. It is usually attributed to excessive agricultural water use. Although some of these contaminated areas may be the result of natural hydrogeologic conditions, i.e. the Haw Creek area in Flagler County, at least two areas of contamination are associated with cones of depression in the heavily pumped agricultural area.

In this report, primary responsibility for the preparation of major sections was as follows:

Geology of the Coastal Zone -- James M. Frazee, Jr.

Geohydrology of the Coastal Zone -- James M. Frazee, Jr.

Geochemical Patterns of the Coastal Zone -- Donnie R. McClaugherty

Available Potable Water Resources -- James M. Frazee, Jr.

PREVIOUS INVESTIGATIONS

An attempt was made to gather previously published material to meet project objectives and as an alternative source of information for the readers. Table 1 lists those publications used in part by the authors. Reports are separated by county, areal studies, and by general subject headings.

TABLE 1. -- A Listing of Previously Published Reports Covering the Project Area

Author Year	General Subject
Nassau County	
Leve (1961)	Fernandina Beach Ground water reconnaissance
Fairchild and Bentley (1977) Stewart and Counts (1958) Stewart and Croft (1960) R. W. Harden and Assoc. (1979)	Saline intrusion and general ground water data for Georgia border and Fernandina Beach
Pride (1958) Leve (1968)	Baker County, Surface and Ground water reconnaissance
Derragon (1955)	Reconnaissance study
Cole (1944)	Stratigraphy
Duval County	
Derragon (1955) Leve (1961, 1966)	Reconnaissance
Fairchild (1972) Causey and Phelps (1978)	Shallow aquifer
Causey (1975) Leve (1978)	Hydrologic map reports
Fairchild (1976) Causey, Stone, Backer (1975) Leve and Goolsby (1967) U. S. Corps of Engineers	Water availability
St. Johns and Flagler Counties	
Stringfield and Cooper (1951) Brooks (1961)	Offshore springs
Munch, Ripy, and Johnson (1979)	Agricultural use and connate intrusion
Unklesbay (1945) Geraghty and Miller (1976)	Ground water quality and quantity of shallow clastics for St. Augustine area

TABLE 1. (CONTINUED)

Author and Year	General Subject
St. Johns and Flagler Counties	
Bermes (1958)	
Tarver (1958)	
Bermes, Leve, and Tarver (1963)	Reconnaissance
Cooke (1945)	
Vernon (1951)	Geology
Collins and Howard (1928)	
Black and Brown (1951)	Chemical quality
ICDC (1978)	Palm Coast and Eastern Flagler County ground water system study in detail
Gomberg (1978)	Halifax Plantation and Flagler-Volusia border pump tests and ground water reconnaissance
Area-Wide Studies	
Matson and Sanford (1913)	Reconnaissance
Sellards and Gunter (1913)	"
Stringfield, Warren, and Cooper (1941)	"
Stringfield (1966)	"
Cooper, Kenner, and Brown (1953)	"
Pirnie (1927)	"
Cooper (1944)	"
Leve (1961)	"
Stringfield (1936)	Potentiometric maps
Stringfield (1966)	"
Laughlin and Hayes, May 1977 (1977)	"
Watkins, Laughlin, and Hayes, September 1977 and May 1978 (1979)	"
Cooke (1945)	Geology
Vernon (1951)	"
Puri (1957)	"
Puri and Vernon (1964)	"

TABLE 1. (CONTINUED)

Author and Year	General Subject
Area-Wide Studies (Continued)	
Collins and Howard (1928)	Water Quality
Black and Brown (1951)	"
Florida State Board of Health (1960), (1965), (1969a), (1969b)	"
Irwin and Healy (1978)	"
Healy (1977)	
Leach (1978)	Water Use
White (1970)	Geomorphology
Pirkle, Yoho, and Hendry (1970)	Sea Level Stands and Terraces
Phelps (1978)	Recharge
Black, Brown, and Pearce (1953)	Salt Intrusion
Manheim (1967)	Continental slope

OBJECTIVES

Seven principal objectives were developed to provide solutions to recognized hydrologic problems in the project area.

1. Delineate the occurrence and movement of ground water in all aquifer systems in the study area.

2. Monitor salt water intrusion in the shallow aquifer and the Floridan aquifer, including the monitoring of the 1,000 ppm isochlor.

3. Differentiate between connate salt water intrusion and modern lateral salt water encroachment.

4. Delineate the fresh water/salt water interface in aquifer systems present.

5. Quantify the available potable water in the various aquifer systems.

6. Determine the relationship between ground water withdrawals and salt water intrusion in the various aquifers in the study area.

7. Analyze the data collected to formulate a management tool to help guide future utilization of ground water resources in the area.

METHODOLOGY

Since each of the seven objectives are rather broad in scope, the investigators have relied substantially on previously published data. Data were collected where gaps appeared in existing information. Six basic work areas were selected to meet project needs.

1. Gather, record, and catalog all historic information; and identify areas missing background data.

2. Inventory existing water wells to determine areal water use by aquifer and to document areas of salt water intrusion.

3. Establish a network of monitoring wells in the Floridan and shallow clastic aquifers to depict seasonal water level fluctuations and short term water quality trends using: (a) a test drilling program to fill gaps in hydrogeologic data, (b) a two-dimensional sampling network to interpret interface relationships with depth and location, and (c) a select group of recorders for detailed hydrograph analysis.

4. Initiate a geophysical logging program to determine local geology and to delineate the fresh water/salt water interface.

5. Analyze water quality graphically and statistically to differentiate between connate and laterally intruded waters.

6. Determine aquifer coefficients for the various aquifers by field testing and hydrograph recession analysis.

CLIMATIC CONDITIONS

The climate of the area is classified as humid subtropical. Characteristic of this type of climate is the comparatively high annual rainfall, moderate annual temperatures with low diurnal and seasonal extremes, and high humidity.

Rainfall is greatest during the months of June through September, occurring as short duration showers and thunderstorms. Hurricanes and other tropical disturbances may also contribute substantial amounts of rainfall. In the winter months, rainfall is normally associated with frontal activity.

Figure 2 shows the yearly rainfall departures from the 30-year normal at Gainesville for the years 1940 through 1977 and the cumulative rainfall departures from normal for Gainesville and St. Augustine for the period 1940 through 1978. Cumulative rainfall departure represents the running sum of yearly rainfall departures since 1940. As evidenced by the graph, there has been a negative cumulative rainfall departure for Gainesville since 1953. Except for two brief

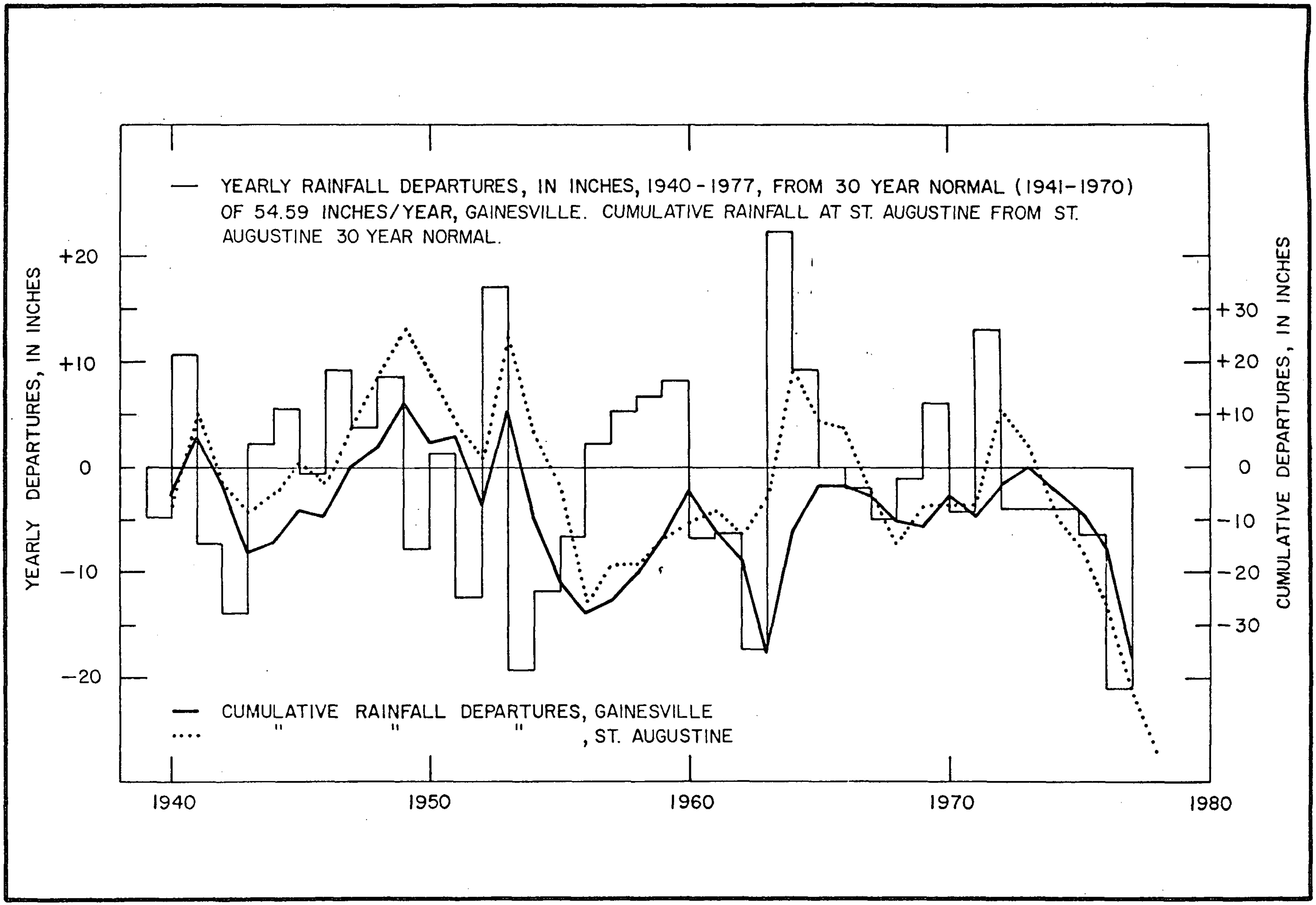


FIGURE 2. -- Yearly and Cumulative Departures from Normal, 1940-1977, for Gainesville and Cumulative Departures for St. Augustine for the Period 1940-1978

periods from 1963 to 1966 and 1971 to 1973, a negative cumulative departure has existed at St. Augustine since 1954. Beginning in 1973, both stations show a steadily increasing deficit in rainfall.

An isohyetal map of mean annual rainfall for the District from the period 1941 to 1970 is shown in Figure 3. Figure 4 shows rainfall in the District for water year 1978. A comparison of Figures 3 and 4 shows rainfall for water year 1978 to be below the mean in the coastal study area, ranging from a few inches below the mean in south Flagler County to seven inches below the mean in the Fernandina Beach area.

Rainfall occurrence correlates inversely with water use. Peak use generally occurs in late fall and spring during periods of minimal rainfall. Lawn irrigation water use is the major factor during peak periods. Other peaks associated with agriculture may correlate with similar minimal rainfall periods dependent on crop growth cycles.

WATER USE

Nassau County

In Nassau County, the Floridan aquifer is the major source of ground water for municipal, domestic (self-supplied), and industrial use. Minor amounts of ground water are also derived from shallow aquifer systems for domestic use.

Industry is the largest user of ground water in the Fernandina Beach area. In 1940 the pulp and paper industry pumped about 32 Mgal/d from the Floridan aquifer. Pumpage gradually increased to 52 Mgal/d in 1957, but has remained relatively stable, fluctuating between 50 and 60 Mgal/d since 1961 (Fairchild and Bentley, 1977, p. 6). In 1975 the pulp and paper industry used 57.64 Mgal/d (Leach, 1978, p. 20), of which 45 Mgal/d was used conjunctively for thermoelectric power generation.

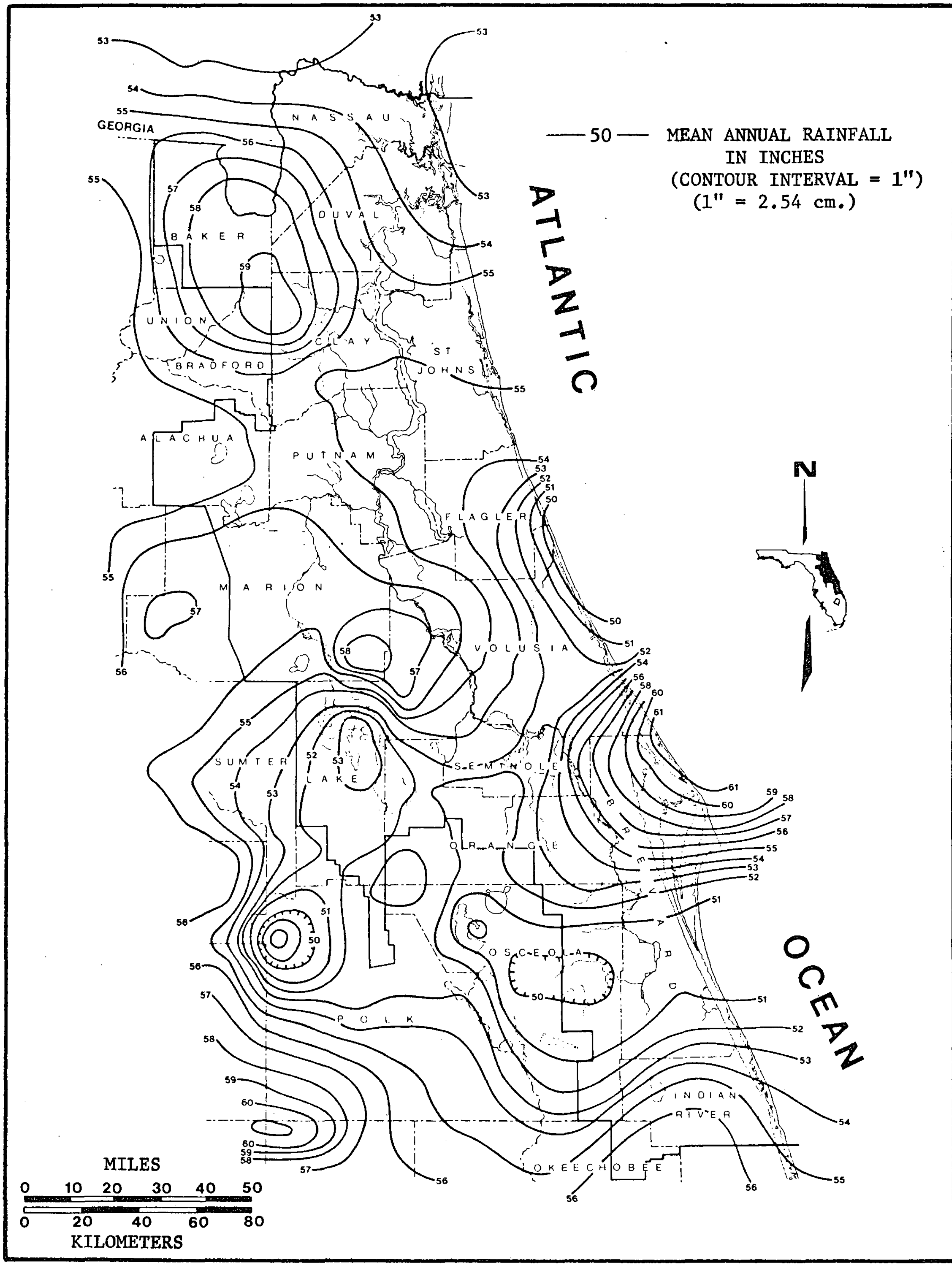


FIGURE 3. -- Mean Annual Rainfall in the SJRWMD, 1941-1970

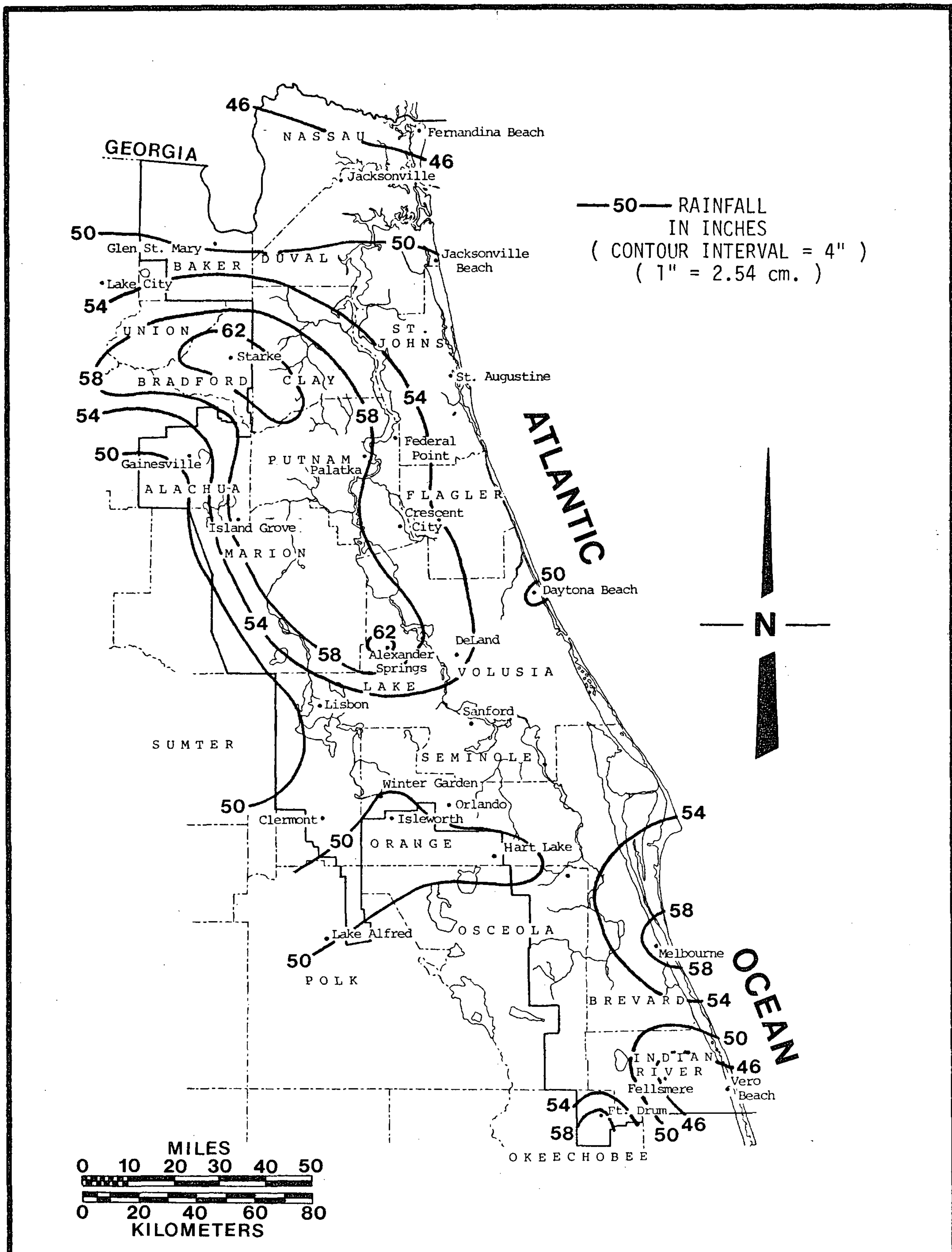


FIGURE 4. -- Rainfall in the SJRWMD, 1978 Water Year

Municipal use in Fernandina Beach rose from 2.4 Mgal/d in 1975 (Leach, 1978, p. 12) to 2.54 in 1977 (Hedges, 1979), an increase of 5-1/2 percent.

Including minor amounts used for domestic and irrigation purposes, total fresh ground water withdrawn from Nassau County in 1975 was estimated to be 63 Mgal/d (Leach, 1978, p. 40), of which 91 percent is used by the pulp and paper industry.

Duval County

In Duval County the primary source of ground water is also by the Floridan aquifer. The major uses of ground water in Duval County are for municipal and industrial supplies. Large withdrawals for municipal and industrial use are located in the study area near the western primary boundary causing a cone of depression.

In 1975 the estimated amount of ground water pumped by water suppliers in Duval County was 95.42 Mgal/d (Leach, 1978, p. 12). Of the 95.42 Mgal/d pumped, 69.46 was used for public supply, 7.54 Mgal/d for industry, 13.20 Mgal/d for commercial use, and 5.22 for air conditioning purposes (Leach, 1978, p. 12). In the municipality of Jacksonville, public water supply pumpage was 55.26 Mgal/d in 1977 (Hedges, 1979).

In addition to public water supply, industrial self-supplied ground water use in 1975 was 48.63 Mgal/d (Leach, 1978, p. 20). The major user was the pulp and paper industry.

In the coastal areas of Duval County, the principal ground water users are municipalities and the U. S. Navy. In 1977 Jacksonville Beach used 2.31 Mgal/d, Neptune Beach pumped 0.92 Mgal/d, and Atlantic Beach used 1.28 Mgal/d (Hedges, 1979). The U. S. Naval Station at Mayport uses an average of 1.5 Mgal/d from two Floridan wells.

A recent area of concern is Fort George Island where minor contamination of the Floridan aquifer by saline water has occurred. It has been estimated that pumpage from the well owned by the Fort George Island Club is 0.1 Mgal/d. Domestic usage of ground water in the area is also about 0.1 Mgal/d. A pumpage of 0.25 Mgal/d has been assumed as a generous estimate of ground water use for Fort George Island (Jacksonville Area Planning Board, 1977, p. 7).

Considering all uses of fresh ground water in Duval County, total ground water withdrawal was calculated to be 156 Mgal/d in 1975 (Leach, 1978, p. 40). For 1975 the U. S. Corps of Engineers' water supply report (U. S. Corps of Engineers, 1979) estimates total use to be 162 Mgal/d not including agricultural use which Leach (1978) estimated to be 1.80 Mgal/d.

St. Johns County

In northern coastal St. Johns County and in inland areas, the Floridan aquifer is the principal source of domestic and small public supplies.

Ground water from the shallow aquifer is used mainly in St. Augustine and south along the coast due to the high chloride concentrations in waters of the Floridan aquifer. This water is used both for public supply and domestic use. The Anastasia Sanitary District, whose well field is located southeast of St. Augustine on the barrier islands, presently mixes water from a Floridan aquifer well with shallow aquifer water of the Anastasia Formation.

In 1975 ground water use for public supply was estimated to be 2.67 Mgal/d (Leach, 1978, p. 13). Domestic use was 2.39 Mgal/d, and industrial use was only 2.0 Mgal/d (Leach, 1978, p. 17 and 21). The City of St. Augustine pumped 2.77 Mgal/d in 1977 (Hedges, 1979).

Intensive agricultural withdrawals occur seasonally to the west of the study area in south central St. Johns County in the vicinity of Hastings, Spuds, and Elkton. Water use for agricultural irrigation in 1975 was 28.78 Mgal/d (Leach, 1978, p. 28).

The estimate for fresh ground water withdrawn in St. Johns County in 1975 is 35.94 Mgal/d (Leach, 1978, p. 41).

Flagler County

In Flagler County shallow aquifers are the principal source for domestic and public supplies. In Bunnell a shall bed near the base of the Hawthorn Formation supplies water for public supply. Ground water usage in Bunnell in 1977 was 0.21 Mgal/d (Hedges, 1979). The Flagler Beach well field also uses these shell beds for its water supply. The total amount of ground water used for public supply in Flagler County for 1975 was 0.62 Mgal/d (Leach, 1978, p. 12) and 0.38 Mgal/d for individual domestic supply (Leach, 1978, p. 16).

Intensive agricultural withdrawals occur to the west of the study area. Water Use for agricultural irrigation in 1975 was 8.39 Mgal/d (Leach, 1978, p. 27). Water from the Floridan aquifer is used for irrigation. The total amount of fresh ground water used in Flagler County in 1975 has been estimated to be 9.39 Mgal/d (Leach, 1978, p. 40).

GEOLOGY OF THE COASTAL ZONE

GENERAL GEOLOGIC STRUCTURE AND DEPOSITION

The rocks of the Northeast Florida coastal area can be divided by age and sedimentary characteristics into four hydrogeologically significant subdivisions: Eocene and Oligocene limestones; early to middle Miocene clay, limestone, and layers of interbedded sand and shell; late Miocene clay, sand, shell, and limestone lenses; and Pleistocene to Recent sand and shell with clay lenses, locally called surficial clastics. In general, sediment thickness overlying the basement complex of granite and other crystalline rocks is approximately 5,000 feet (Cederstrom, Boswell, and Tower, 1979, p. 05). The rock unit nomenclature used in this report conforms to the usage of the Bureau of Geology except for the Ocala Formation which is considered by the Bureau to be a Group.

A fence diagram, Plate 4, illustrates general geologic structure and stratigraphic thickness. Generally, the Eocene limestones dip to the north and west except near Flagler Beach where they dip to the southeast. Oligocene limestones of the Suwannee Formation overlie the Eocene limestones in only two areas on Plate 4. The presence of Oligocene rocks may be attributable, in part, to structural displacements.

The Hawthorn Formation generally thickens to the north and west and is thin or absent in southern Flagler County. The surficial clastics generally thicken above the Hawthorn Formation where coastal ridges occur.

Below, stratigraphic units are discussed in order of decreasing age. Table 2 shows a generalized geologic column for the Northeast Florida area similar to one presented by Snell and Anderson (1970, p. 7, figure 2).

Eocene Limestones

For the purposes of this study, the Eocene Age deposits shown on Table 2 are separated into the Lake City, Avon Park, and Ocala limestones.

The Lake City limestone of middle Eocene Age consists of alternating blue-gray to tan dolomite and white to brown, massive or porous limestone beds with interbedded and disseminated peat. The dolomite zones are relatively dense, indurated, crystalline and non-porous, whereas the limestone beds possess generally medium to high porosity. Bermes, Leve, and Tarver (1963, p. 25) found the contact of the Lake City with the Avon Park to be unconformable in several St. Johns County locations where rounded pebbles of limestone and dolomite and thin layers of white to green, calcareous clay were identified along the contact. Leve (1966, p. 14) identified locally thin beds of lignite along the contact in Nassau and Duval Counties.

The Avon Park limestone of middle Eocene Age consists of alternating white to red-brown dolomite and tan, granular limestone beds with disseminated and occasional thin beds of peat. Hard dolomite beds are usually found at the contact with the Lake City limestone. In areas where the formation is thinnest (approximately 50 feet), it consists almost entirely of hard, dense, non-porous dolomite such as in Duval County. Highest porosities are found in the beds of cavernous limestone.

The Ocala limestone of late Eocene Age consists of relatively soft, white to cream to tan, chalky to granular, massive limestone. Porosity is derived from both intergranular porosity and cavernous openings. Geophysical logs of wells HGM-1 and D-164 show response patterns indicative of Oligocene sediments thought to be Suwannee limestone overlying the Ocala limestone.

TABLE 2. -- General Lithology of Formations Penetrated by Water Wells in Coastal Nassau, Duval, St. Johns, and Flagler Counties (After Snell and Anderson, 1970)

Series	Formation		GENERAL LITHOLOGY	AQUIFER(S)	WATER-BEARING PROPERTIES
Pleistocene and Recent	Undifferentiated deposits 0-150 feet	Surficial Clastics	Sand, coquina, including the Anastasia Formation in coastal islands, and sandy clay lenses.	Shallow sand shallow shell-sand or coquina aquifer.	Small to moderate amounts of water. Anastasia may produce large quantities at the type location.
Miocene	Undifferentiated deposits 0-100 feet		Sand, shell, and silty clay; Cream to brown, soft, friable limestone as basal beds.	Shallow sand and shell, and shallow-rock zone of Duval and Nassau Co.	Yield small quantities of water to shell and sand beds. Yields moderate quantities of water to shallow-rock wells.
	Hawthorn Fm. 0-250 feet		Clay, sandy clay, sand, interbedded shell, weathered sandy limestone. Hard basal dolomitic limestone.	Secondary artesian	Moderate yields recorded throughout the project area.
Oligocene	Suwannee Limestone 0-10 feet		Gray to cream, clayey to granular.	Floridan Aquifer	Large quantities of water with variable quality. Generally good in Nassau and Duval Counties. Connate water present in Ocala and deeper formations in parts of St. Johns and Flagler Counties.
Eocene	Ocala Limestone 50-450 feet		White to cream to tan, chalky to granular, massive limestone. Dolomite beds in lower deposits.		
	Avon Park Limestone 50-400 feet		White to reddish brown, hard, dense limestone and dolomite with porous and chalky zones.		Yields large amounts of water from porous zones.
	Lake City Limestone 100-500 feet		Buff to brown porous and white to brown massive limestone; gray to tan dolomite; peat		Water yields vary. Dense zones poorly permeable. Good yields in Duval County.

Early to Middle Miocene Deposits

Puri and Vernon (1964, p. 117, 119, 145-146) described these deposits collectively as the Hawthorn Formation. This formation consists of diverse lithologic units described by Pirkle, et al., (1970, p. 18-19) as marine in origin. The most widely used identifying characteristic of the Hawthorn is the occurrence of phosphorite in sands, clays, and dolomites of the formation. Locally, variations in thickness are common where weathering of Eocene limestone has occurred. The Hawthorn Formation, which is the principal confining zone of the Floridan aquifer, exhibits low permeability.

Late Deposits

Vernon (1951, figures 13 and 33) described the sediments overlying the Hawthorn Formation in the study area as Late Miocene in age. Leve (1966, p. 18-19) described the deposits that overly the Hawthorn in Nassau and Duval Counties as "interbedded gray-green calcareous silty clay and clayey sand; fine to medium grained, well sorted sand, shell; and cream to brown soft, friable limestone." The limestone at the Nassau and Duval County test drilling sites is greenish to white and is underlain by green phosphatic clayey shell and sand deposits.

This limestone section in Duval County is called the shallow-rock zone by U. S. Geological Survey investigators and extends throughout Duval and Nassau Counties. The shallow-rock zone pinches out or is weathered to a shell-sand zone with discontinuous beds of interfingering thin limestone to the east and south. Bermes, et al., (1963, p. 31) described the sediments in St. Johns and Flagler Counties as "interbedded lenses of marine, fine to medium sand, shell, and green, calcareous, silty clay." The contact with Pleistocene deposits appears to be gradational with fairly distinct color changes from grays to greens or tans to grays.

Pleistocene and Recent Deposits

In general, Pleistocene sediments are undifferentiated and highly variable. Leve (1966, p. 19) found relatively thin sections of sediments averaging 20 feet in thickness, in central and eastern Duval and Nassau Counties.

Probably the most significant deposit overlying the Miocene clastics is the Anastasia Formation which generally occurs along the coastal islands and inland for approximately three miles. Puri and Vernon (1964, p. 282-283) describe the type area on Anastasia Island as "sandy coquina of mollusks held loosely together by calcareous cement." Bermes, Leve, and Tarver (1963, p. 32-33) found evidence of shell beds inland five and eight miles from the coast in St. Johns and Flagler Counties, respectively, which they conjectured were stringers of the Anastasia Formation.

Undifferentiated Recent deposits include coastal dune ridges and primary dunes, sand and clay along stream courses, and inland fresh water marsh deposits.

GEOMORPHOLOGY

White (1970, p. 86) discussed the formation of the Atlantic Coastal Ridge (Plate 1) and marine terrace deposition along the northeast Florida coastal lowlands. As it appears in Duval County (Leve, 1966, p. 10 and Cooke, 1945, p. 248), the Central Park Ridge is made up of the Penholoway and Talbot terraces. The ridge is poorly defined in Nassau County where it has been severely modified by erosion. In St. Johns and Flagler Counties, it appears that the Talbot terrace defines the Atlantic Coastal Ridge (Plate 1). East of the main ridge, scattered remnants of the Silver Bluff and Pamlico terraces are found at lower altitudes.

The barrier islands developed as remnants of the Pamlico terrace parallel with the central axis of the Atlantic Coastal Ridge. These same deposits (remnants of the Pamlico terrace) also form the coastal lowlands. Drainage courses from the Silver Bluff terrace, found along parts of the coastal lagoons, form the present intracoastal waterway. Along parts of the barrier islands, the primary dunes form what White (1970) has called coastal beach ridges. The dunes reach impressive dimensions along Ponte Vedra Beach and parts of Amelia Island.

GEOHYDROLOGY OF THE COASTAL ZONE

OCCURRENCE OF CONFINING BEDS

Minor confining beds of clays and clayey materials occur locally throughout the surficial clastic deposits. Of major significance is the thickness and relative permeability of the underlying Hawthorn Formation (Plate 4) also known as the principal confining zone of the Floridan aquifer. This formation strongly influences leakage to or from the Floridan.

In coastal Nassau and Duval Counties, the Hawthorn Formation provides a barrier retarding the migration of saline water in the shallow aquifers toward the Floridan aquifer. Inversely, shallow aquifer well fields in St. Johns and Flagler Counties are protected from saline Floridan aquifer water by a thin but adequate confining bed.

Hard dolomitic limestone beds occurring at the contact between the Hawthorn Formation and Ocala limestone and intermittently in deeper limestone formations also retard the upward movement of saline water. Leve (1966, p. 25) noted the existence of impermeable Avon Park dolomitic zones in the Fernandina Beach area of Nassau County.

ARTESIAN AQUIFERS

Two principal aquifers are found in the artesian system. The secondary artesian aquifer is made up of sand and shell deposits found within the Hawthorn Formation, and the Floridan aquifer consists of permeable limestones including variable thicknesses of basal Hawthorn limestone.

Secondary Artesian Aquifer

Secondary artesian aquifers are found throughout most of the project area within the Hawthorn Formation. These aquifers are made up of thin lenses of sand, shell, and weathered limestone. In St. Johns and Flagler Counties, these lenses are between 1 and 15 feet thick (Bermes, et al., 1963). In eastern Flagler County, some small parks and public campgrounds tap the secondary artesian aquifer at about 90 feet. The aquifer is rarely more than 5 to 10 feet thick in this area and produces small to moderate amounts of water. In Nassau and Duval Counties, sandy shell beds interbedded with marls and limey clays were found to be a potential source of water in the Hawthorn Formation. At Ft. Caroline in central Duval County, the aquifer is principally coarse sand with intermittent shell and limey or marly shell beds beginning approximately 200 feet below land surface.

Water quality and quantity vary greatly. In Flagler County near Bulow Ruins, Floridan connate water leaks upward through thin layers of green clay and dolomitic limestone. Water quality at Bulow Ruins is marginal (200 mg/l chlorides), and well yields are low to moderate dependent on aquifer thickness. At Ft. Caroline, well yields range up to 90 gal/min for a six-inch well and produce water of potable quality.

Recharge to secondary artesian aquifers is dependent on leakage through the surrounding beds of lower permeability. In Nassau and Duval Counties, recharge originates principally from surficial clastic aquifers. Leakage from the Floridan aquifer is insignificant in most areas. In St. Johns and Flagler Counties, recharge occurs from the surficial clastics supplemented by upward leakage from the Floridan aquifer, mainly in south Flagler County.

Floridan Aquifer

Cooper, *et al.*, (1953, p. 17-29) provides a good discussion of the Floridan aquifer in Northeast Florida. Generally, the aquifer is made up of limestone formations (Table 2) underlying an area including Florida, coastal Georgia and Alabama, and South Carolina.

Potential yield varies significantly throughout the areal extent of the aquifer, and water quality varies within the project area. One well in Jacksonville is reported to yield almost 10 Mgal/d. According to Leve (1966, p. 33), the following well yields are representative of Duval and Nassau Counties:

WELL DIAMETER (inches)	WELL YIELD (gal/min)
2 - 6	natural flow generally up to 500
6	some wells yield as much as 1,000
8 - 12	natural flow generally less than 2,000
10 - 12	some wells in deeper zones may yield as much as 5,000 - 6,000

The major producing zone in the vicinity of Jacksonville is within the Lake City limestone. Well yields decrease in St. Johns and Flagler Counties.

Water in the Floridan is potable throughout Nassau and Duval Counties. Water quality deteriorates in St. Johns and Flagler Counties. Highly mineralized connate water is found throughout the Floridan in eastern Flagler County and within 300 feet of the surface further inland.

Potentiometric Fluctuations

The potentiometric surface of the Floridan aquifer for May 1978 is shown on Plate 1. According to Fairchild (1977, p. 49), the potentiometric surface has generally declined as much as 20 feet in Duval County and 14 feet in St. Johns County during the past 30 years. Healy (1974, figure 21, p. 25) showed declines in Jacksonville and Fernandina areas for a 20-year period ending in 1970 of 12 to 18 feet, respectively. Overall, potentiometric levels in the entire project area generally declined at least six feet during that 20-year period. Leve (1966, p. 46) noted that water levels were declining between 0.5 and 2.0 feet per year in Nassau and Duval Counties. General declines, project wide, range from 0.4 to 1.2 feet per year on an average since the middle 1950's and as much as 2.9 feet per year during the past 10 years in Duval and Nassau Counties due to deficit rainfall and increased withdrawal (Fairchild and Bentley, 1977; Leve, 1966, 1978; and Bermes, et al., 1963).

Potentiometric fluctuations due to rainfall events are common to all artesian wells in the project area. Typical potentiometric fluctuations are illustrated in the following examples. The hydrograph of well F-176 (Figure 5) which taps the top seven feet of the Ocala limestone in an area of discharge correlates closer to rainfall recharging the Floridan on the Deland Ridge (Figure 6 and Plate 1) than local Bulow Ruins records (Figure 5). In general, long term, cumulative rainfall produces smoother, smaller amplitude rises with time in the Floridan aquifer as compared to shallow, non-artesian systems (Figure 5) where wells will show immediate reaction to local rainfall events and fairly rapid discharge to nearby surface water bodies.

Figure 7 shows hydrographs of Floridan wells F-165 and F-158 as compared to the hydrograph for shallow shell-sand well F-164. These wells are located at Palm Coast along the Atlantic Coastal Ridge (Plate 1). Fluctuations in the

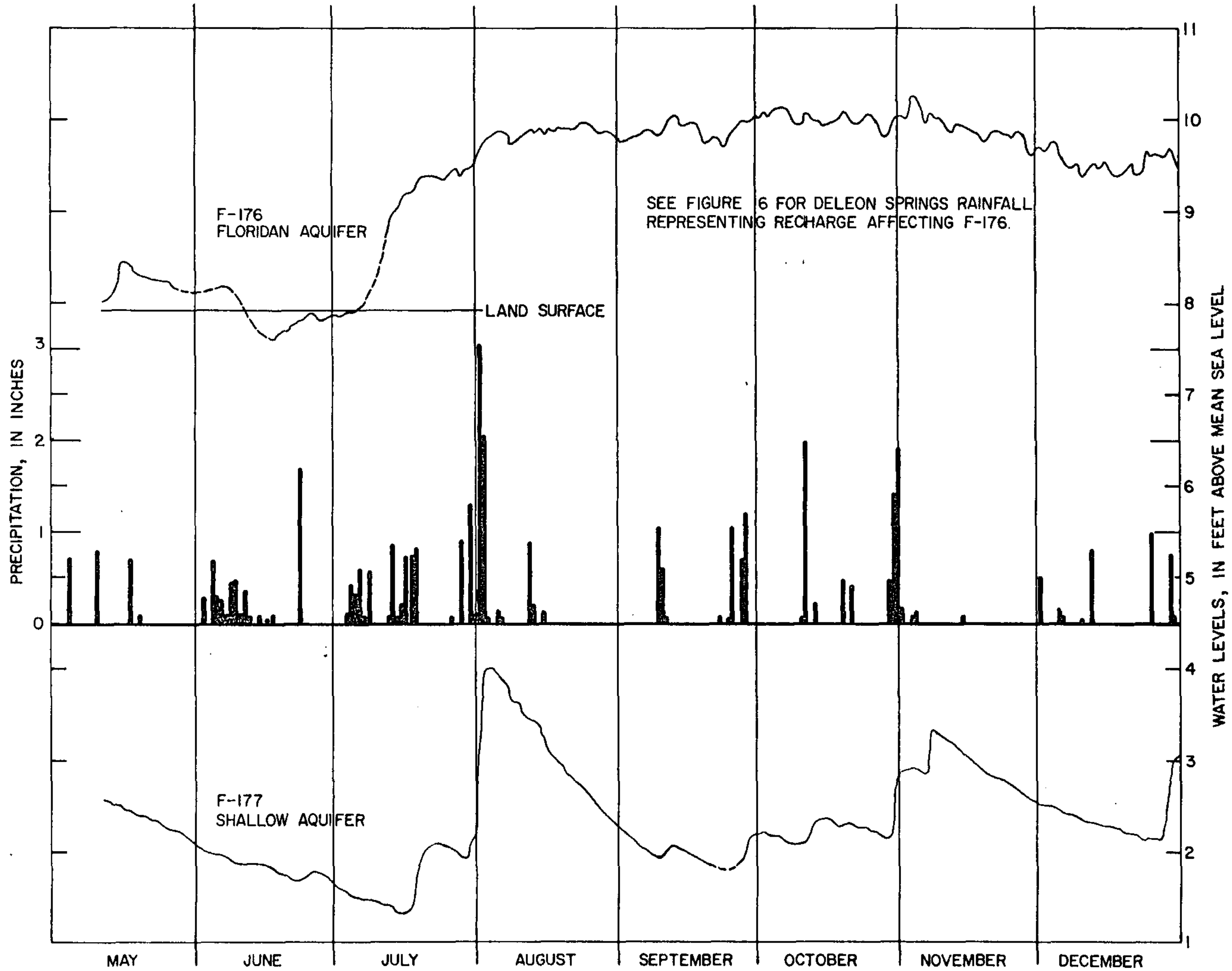


FIGURE 5. -- Hydrographs of a Shallow (F-177) and Floridan (F-176) Aquifer Well Compared With Local Rainfall at Bulow Ruins

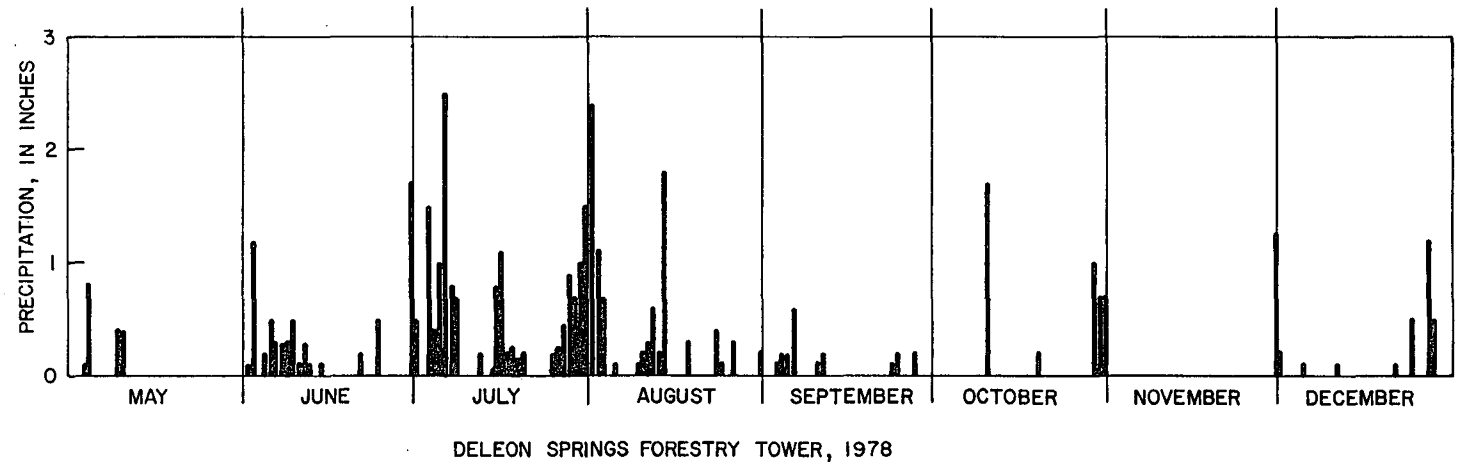


FIGURE 6. -- Precipitation at Deleon Springs Forestry Tower Representing the Input to the Floridan Aquifer Monitored at Bulow Ruins

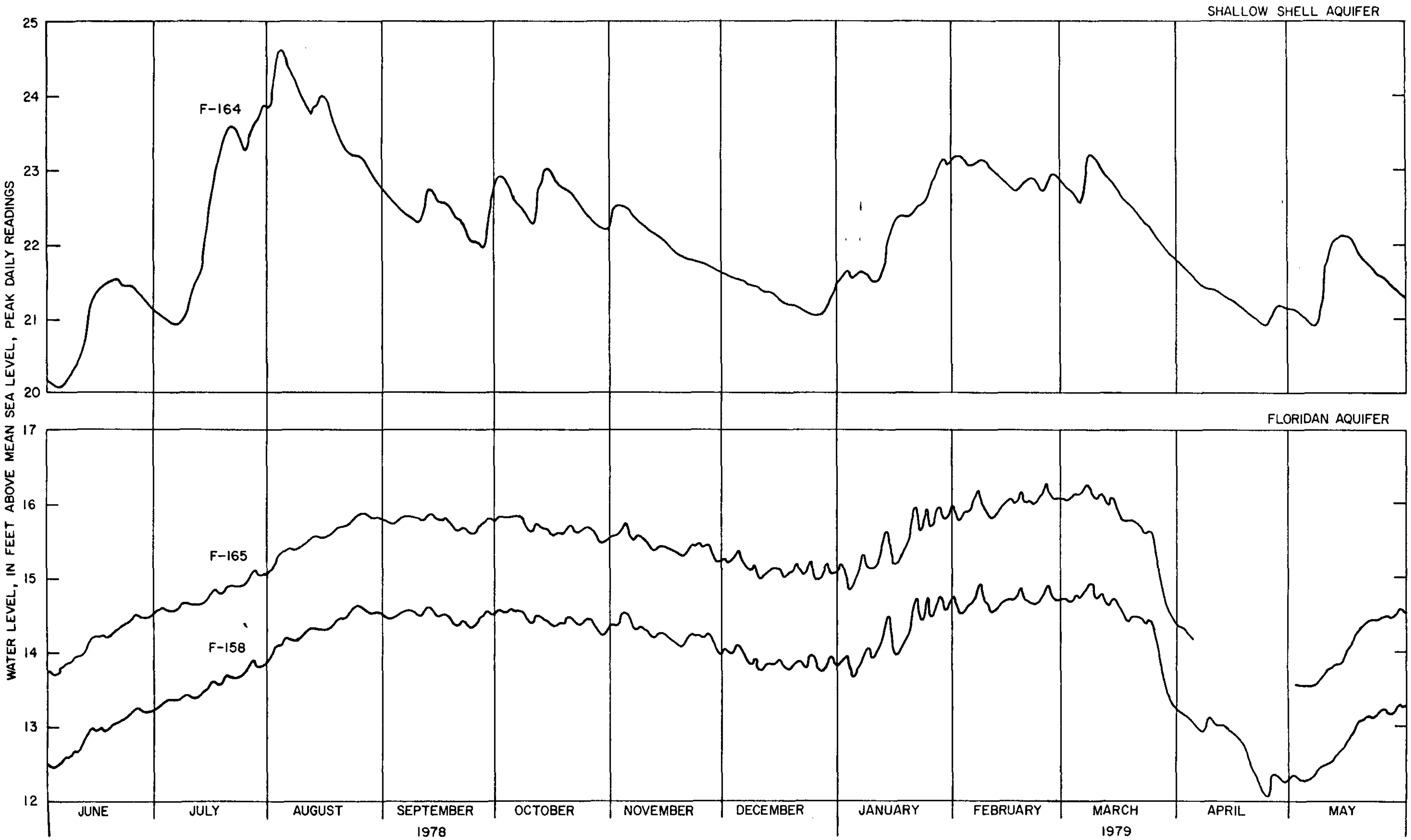


FIGURE 7. -- Water Level Fluctuations for Two Floridan Aquifer Wells and a Shallow Shell Well at Palm Coast

Floridan wells mimic those of the shallow well but are less pronounced. This pattern suggests potential local recharge to the Floridan aquifer. Rainfall data indicate a higher correlation between the Floridan and local rainfall events then was evidenced at Bulow Ruins in the discharge area.

Water level fluctuations shown in Figure 8 for well N-3 in the Fernandina area are representative of industrial pumpage. Well N-3 is directly affected by local pulp industry withdrawals. During holiday shut-downs in July and December, water levels recover rapidly and then decline as each plant again returns to full production. Drawdowns at N-3 approach 30 feet when all plants are at normal production levels.

The hydrograph of well SJ-226 (Figure 9), located in the Hastings farming area of St. Johns County, illustrates water level fluctuations due to large irrigation withdrawals. The hydrograph segment shows a typical drawdown event during the irrigation season of approximately 16 feet.

Earth tides (tidal effects) and barometric fluctuations are apparent in wells throughout the coastal zone. Earth tide fluctuations increase in wells located closer to seaward discharge points. A hydrograph of F-200, located at Washington Oaks, is shown in Figure 10 and illustrates changes in water levels due to barometric changes and tidal events for one week in May, 1979.

Recharge Areas

Infiltration of rainfall through the upper clastic deposits to the Floridan aquifer can occur through breaches in the confining beds such as sinkholes or sink hole lakes. Recharge can also take place when water levels in the shallow aquifer are higher than the potentiometric levels in the Floridan aquifer and downward leakage occurs through permeable materials.

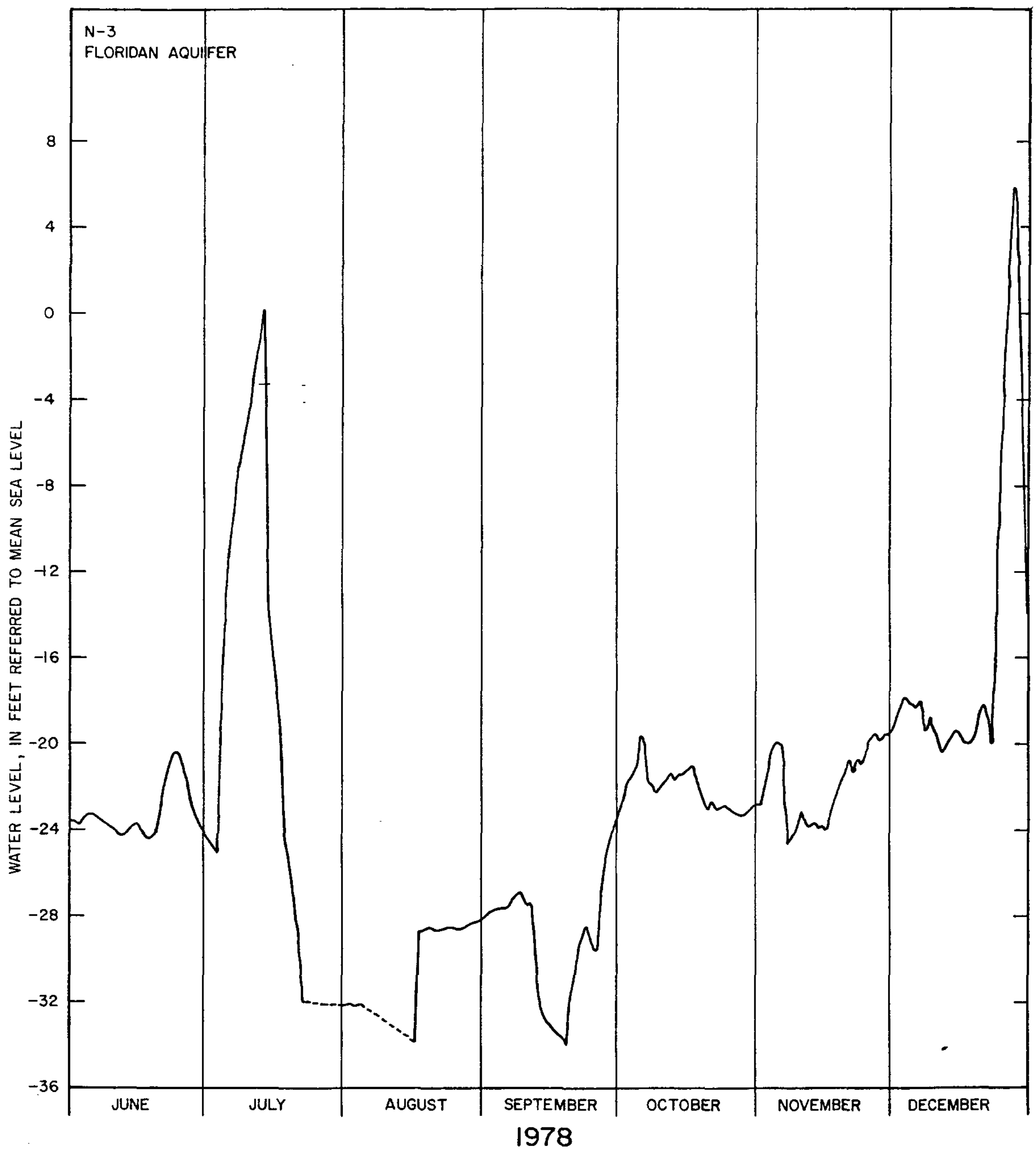


FIGURE 8. -- Typical Water Level Fluctuations Due to Industrial Pumpage of the Floridan Aquifer in the Fernandina Beach Area, Nassau County, Florida

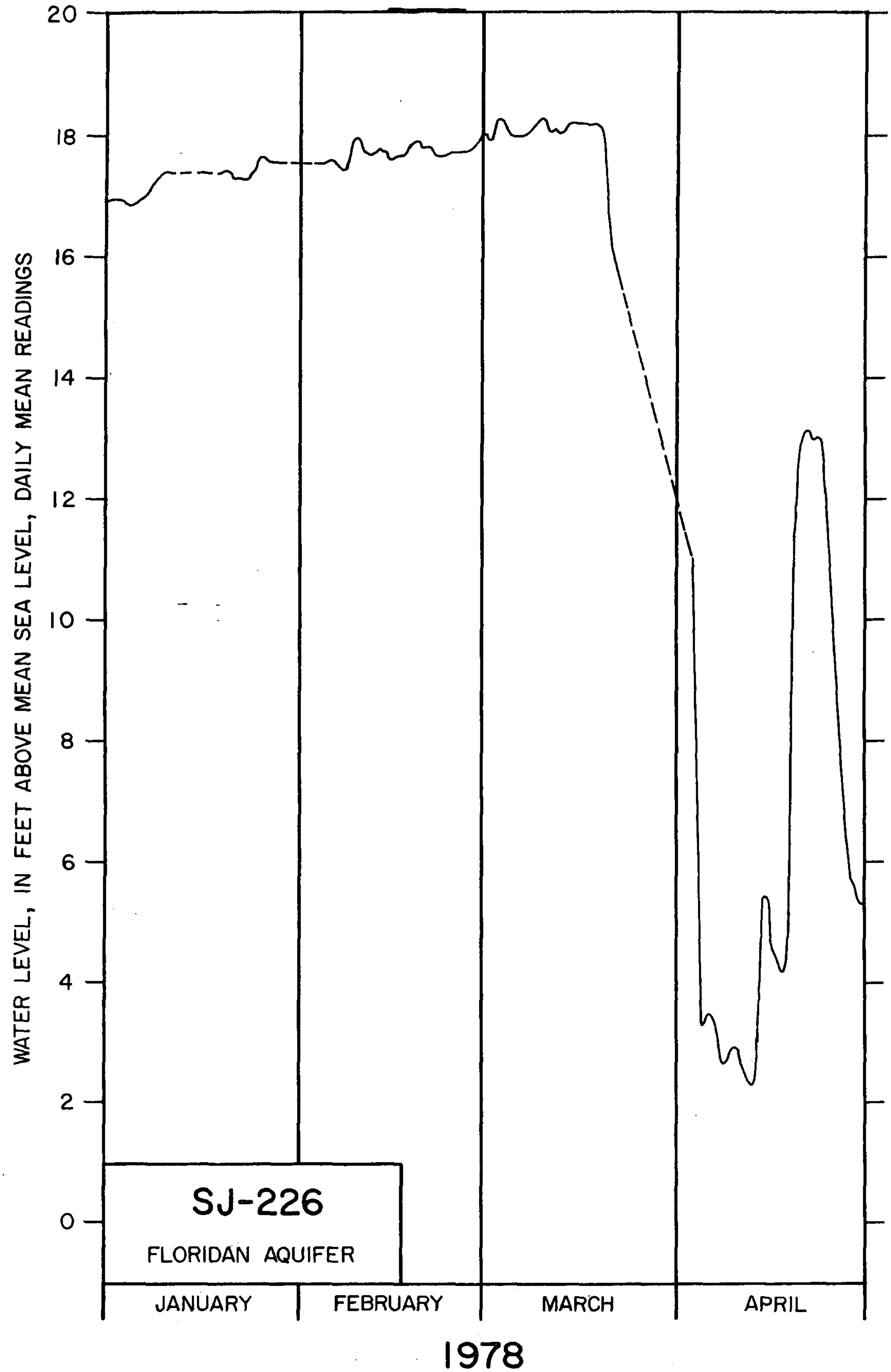


FIGURE 9. -- Typical Water Level Fluctuations Due to Agricultural Pumpage in a Connate Floridan Aquifer Well Near Hastings, Florida

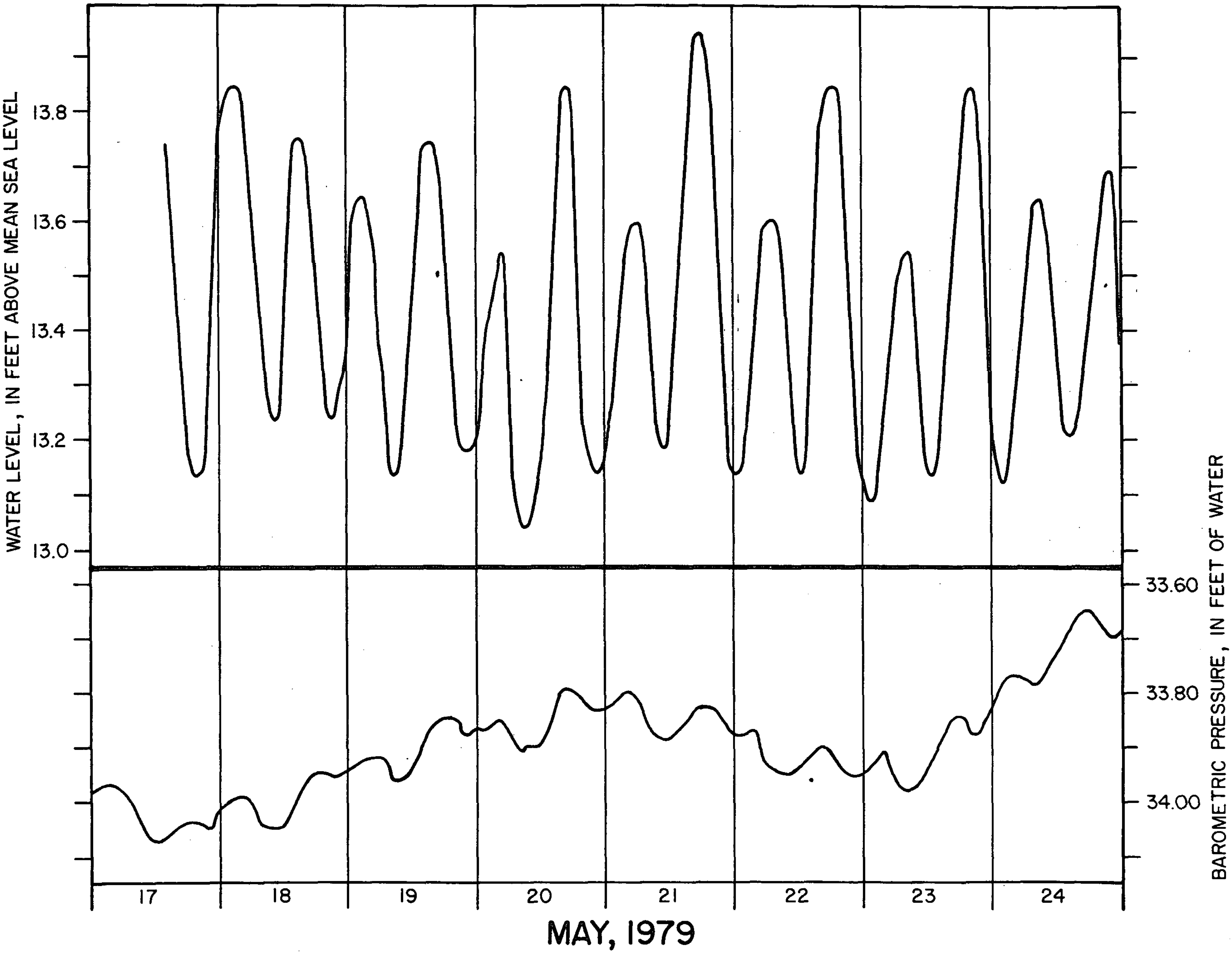


FIGURE 10. -- Water Level Fluctuations Compared With Barometric Change at Washington Oaks for a Floridan Aquifer Well F-200

Recharge to the Floridan aquifer occurs west of the primary project boundary in the Lakes Region, and the Crescent City and Deland Ridges to the south of the Lakes Region (Plate 1). Several investigators have determined Floridan aquifer recharge rates for these areas (Table 3). Quantitative differences in recharge rates for similar areas usually relate to the methodology used and to inherent problems with recharge estimating techniques. Variable recharge rates between major recharge areas in the District, i.e. Lakes Region, Crescent City, and Deland Ridges, are related to land cover, surficial geology, and precipitation variables. Down gradient approximations of available water in the Floridan aquifer will vary with these recharge estimates.

The Lakes Region and the Crescent City and Deland Ridges provide most of the recharge to the project area. Other minor areas of recharge straddle the Talbot and Penholoway terraces of eastern Flagler, central St. Johns, and central Duval Counties. As water use increases, most of the water which formerly recharged the Floridan aquifer in these minor areas will be intercepted by wells tapping shallower semi-artesian shell beds in Flagler and St. Johns Counties or the shallow-rock zone of Duval and Nassau Counties.

Recharge areas located in parts of southeastern Georgia are extensive and apparently input large quantities of water to the Floridan aquifer. Flows are directed towards significant municipal and industrial withdrawal points along the coast. The Gilman Paper Company withdrawal located on the north side of the Fernandina cone of depression probably receives substantial quantities of water from this Georgia recharge flow. Due to probable induced westerly flows to the east side of the Fernandina cone, Georgia recharge flows may be supplementing available recharge quantities within Florida. Quality appears to be stable at both points (Stringfield, 1966 and R. W. Harden and Associates, 1979).

TABLE 3. -- Recharge Rates for Selected Areas West of the Coastal Zone Providing Water to the Floridan Aquifer Within the Project Area

Investigator(s)	Area	Recharge Rate (gal/d)/mi²	Recharge Rate inches/yr
Callahan (1964)	Southeastern Coastal Plain	47,700-524,600[5]	1.-11.
Clark and others (1964)	Lakes Region	85,700	1.8
Yobbi and Chappell (1979)	Lakes Region	800,000[1]	16.8
Knochenmus (1971)	Deland Ridge	620,000	13.
Ross and others (1979)	Crescent City Ridge	238,000[2]	5.
Leve (oral comm., 1972)	East of Lakes Region (East Baker/West Duval Counties)	11,000[3]	.25
Phelps (1978)	Orange Creek Basin	502,200[4]	10.5
	Black Creek (North Prong)	128,300	2.7
	Santa Fe (Eastern sub-basin)	264,200	5.54

[1] The investigators feel the rate may be high and should be closer to the Deland Ridge value.

[2] The value may be an indicator of low permeabilities in an area connecting the Lakes Region and the Deland Ridge.

[3] The low rate is considered characteristic of the increasing confining bed thickness and lower relative permeabilities.

[4] Based on water budget method for water year 1972.

[5] General range of values reported by Callahan (1964) and Cederstrom _et al_. (1979), p. 022.

Areas of Natural or Induced Discharge

Generally, discharge from the Floridan aquifer occurs throughout the project area except along the higher terraces (Atlantic Coastal Ridge). Discharge occurs as well withdrawals, both controlled and wild, as leakage to overlying formations, and as offshore spring discharges. The area offshore between St. Augustine and Brevard County to the south is considered to be the area of potential spring development due to thinning or absence of confining beds (Stringfield and Cooper, 1951, p. 66 and Brooks, 1961, p. 131).

The submarine spring two and one-half miles off Crescent Beach in St. Johns County (Rosenau, et al., 1977, p. 443) is the only documented offshore spring discharge in the project area, although the potential for the existence of springs is good along the coast south of St. Augustine to Brevard County. The fact that this spring, which is approximately 69 feet in diameter according to Stringfield, et al. (1951, p. 63) is not filled with sediment indicates a large discharge. Brooks (1961, p. 129) indicated a discharge of approximately 26 Mgal/d, but inferred a possible range of 6.5 to 196 Mgal/d. These figures were based on a calculated ratio of mixing between spring water and ocean water as determined by chemical analysis. The surface boil was estimated at 1,500 cfs by Brooks.

Upward leakage induced, in part, by ground water withdrawals within cones of depression appear to be significantly increasing the volume of water entering the Jacksonville cone. This pumpage induced discharge from storage, and underflow will increase with decreasing potentiometric head. The rate of leakage will depend on the existence of postulated faults and dolomitic layers in the Jacksonville area (Leve, 1966, p. 13, and others). The apparent reversal of upward leakage patterns appears to be insignificant in Fernandina Beach.

Aquifer Characteristics

Values found within the study area for the coefficient of transmissivity and storage for the Floridan aquifer are listed in Table 4.

TABLE 4. -- Transmissivity and Storage Coefficients for the Floridan Aquifer in the Study Area as Reported by Previous Investigators[1]

County	Transmissivity (T) (gal/d/ft	Storage Coefficient (S) (dimensionless)
Duval	54,000 to 2,244,000	1.72×10^{-2} to 2.08×10^{-4}
Flagler	190,000 to 280,000	1.9×10^{-4} to 9.0×10^{-4}
Nassau	159,000	2.5×10^{-4}
Putnam	275,000 to 360,000	9.4×10^{-4}
St. Johns	173,000 to 290,000	1.57×10^{-4} 5.9×10^{-4}

[1] Values were collected from reports listed in Table 1.

T values appear to vary significantly depending on well construction, thickness of aquifer penetrated, and geology. Higher T values generally indicate greater aquifer penetration in the test well.

A flow net of the Crescent Beach offshore spring was constructed to describe transmissivities at the spring discharge point and near the shoreline two and one-half miles west at Crescent Beach. Figure 11 shows the spring location and flow cells describing hypothesized flow to the spring. A T value of 7,130 ft^2/d or 53,300 gal/d/ft was calculated for the shoreline area. A

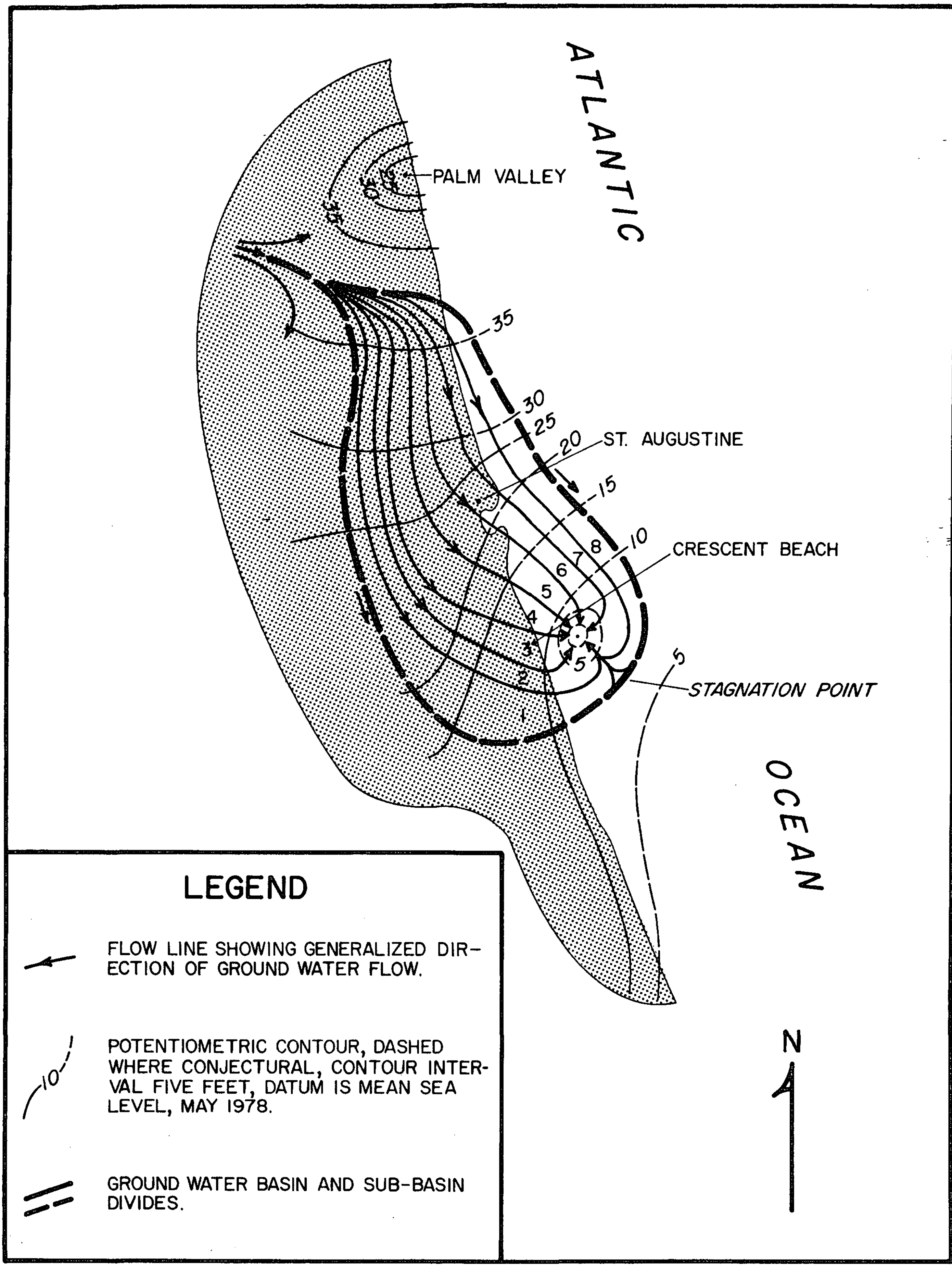


FIGURE 11. -- Diagrammatic View of the Crescent Beach Offshore Spring Showing the Flow Net Analysis Grid

calculation of spring bore transmissivity resulted in a T of 185,000 ft^2/d or 1,386,000 gal/d/ft. The higher value would be expected due to the larger solution cavities within the limestone near the spring bore.

SHALLOW CLASTIC AQUIFERS

Clastic aquifers are found throughout the northeast Florida coastal zone. They provide water for domestic, irrigation, and municipal supplies. The hydrologic properties of each aquifer vary with land surface altitude, proximity to salt water bodies, the thickness of the fresh water lense, the thickness and permeability of sediments, and aquifer use. Plate 4 illustrates the varying thicknesses of the clastic deposits. Shallow ground water generally includes water in the zone of saturation under water table or non-artesian conditions. In some instances, partially confined aquifers are formed by the presence of intermittent clay lenses or the limestone deposits lying at the base of Miocene clastics.

Effective recharge occurs locally where both excellent soil recharge potentials (Frazee, 1979, sheet 6) and sediment permeability is high. Soil recharge potential shows the ability of a soil type to provide potential recharge water to the unconsolidated materials below 80 inches. The quantity of water stored within the fresh water lense varies with the interstitial space available in the aquifer. During prolonged droughty periods, above normal quantities of water are released from storage and move down gradient towards surface water discharge channels and for the fresh water/salt water interface. The fresh water/salt water interface defines the zone of quality where chlorides exceed 250 mg/l and increase further down gradient.

Recharge directly effects the rate of rise and decline of water levels, accounting for a large part of the fluctuations illustrated by hydrographs. These fluctuations indicate a change in storage within the aquifer. Water levels tend to reflect land surface altitudes but with less relief. Within the study area, water levels are generally 10 to 35 feet below land surface on higher ground and approach land surface toward the coastal lowlands, swamps, or surface water bodies. Largest water level fluctuations occur in recharge areas. Where the unconfined aquifer is directly or indirectly connected to the artesian aquifer in recharge areas, fluctuations of the potentiometric surface of the artesian aquifer will reflect fluctuations of the water table.

Shallow aquifer discharge occurs as natural seepage to surface water bodies, leakage to deeper aquifers where downward head differentials between aquifers exist, evapotranspiration losses, and pumpage from wells tapping the aquifer.

Chemical quality is generally within potable standards. Varying levels of iron, acidity, and color are present throughout the coastal zone. Temperatures seasonally range from 19° to 27° Celsius.

Well yields vary with well depth, diameter, development and construction techniques, seasonal water level fluctuations, and location. Land surface altitude is a very important factor influencing both well yield and quality, especially where salt water intrusion is a problem.

Thirteen years ago, Leve (1966, p. 24) predicted that the shallow aquifer would provide a valuable alternate source of water in areas where the Floridan aquifer is intruded. Recently Cederstrom (1979, p. 021) also indicated the importance of shallow aquifers as storage reservoirs recharging the major artesian aquifer. Since this report was compiled, the use of shallow aquifers has continually increased, and their potential as a water source has become an important factor to consider in developments throughout the coastal zone.

A detailed discussion of shallow clastic aquifers follows. The study area was divided into ten sub-areas to illustrate the differences between the barrier islands (sub-areas 1-5) and inland evirons (sub-areas 6-10).

Figure 12 outlines the ten sub-areas and shows the locations of shallow aquifer cross-sections A through H. These cross-sections illustrate chloride distribution in the sub-surface.

General Properties and Extent of Aquifers Along the Barrier Islands

The barrier island section includes those sub-areas which are located between Flagler Beach and Fernandina Beach east of the intracoastal waterway (see Figure 12). In some areas, island width is less than 2,000 feet. Vegetation varies greatly from bare sand dunes along the tidal lines to heavily wooded hammocks where the island width is greatest. Land surface altitudes vary from mean sea level (msl) along the shoreline to over 50 feet above msl in central Fernandina Beach. Some primary dunes rise to over 40 feet above msl.

Shallow fresh water lenses provide water to wells along most of the barrier islands. These lenses form as a result of the differences in density between fresh and salt water causing the fresh water to accumulate above the salt water. In equilibrium, the salt water/fresh water interface would be maintained at a point dependent on average rainfall, water levels, and land surface altitudes.

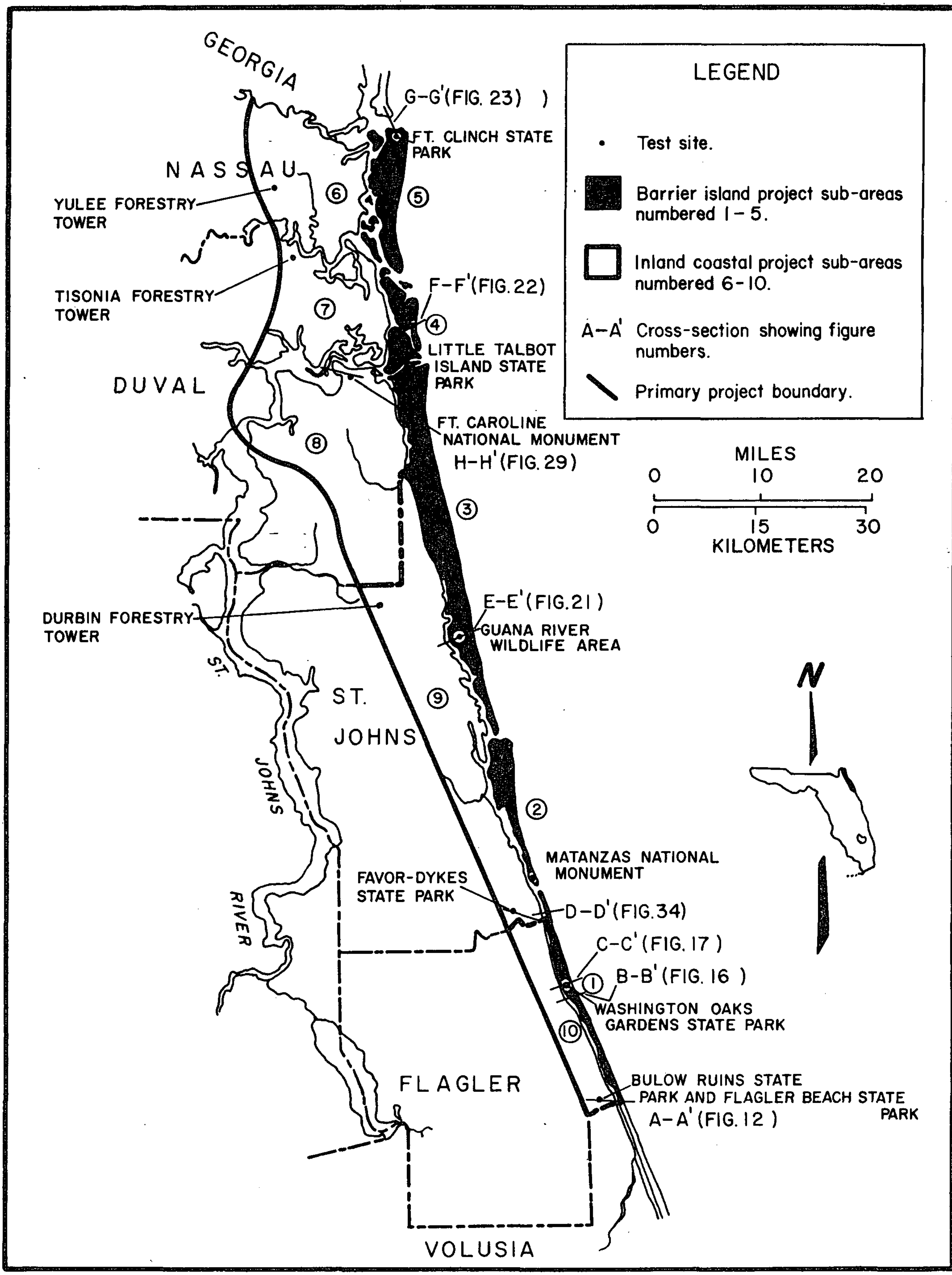


FIGURE 12. -- Coastal Zone Project Sub-Areas Showing Test Site Locations

Shallow confining clay lenses provide some barrier to lateral and upward migration of saline water. In areas where these clay lenses are deeper, intermittent, or missing, availability of potable supplies is very dependent on regular rainfall replenishment to prevent intrusion as a result of pumping. Barrier island rainfall is generally less than inland areas as is shown on Figures 3 and 4.

Aquifer water quality along the barrier islands is generally more variable than inland areas. Naturally occurring mineral concentrations in water generally vary significantly. Shallow clay lenses effect the degree of mineralization by controlling the movement of connate or lateral intrusion.

Sub-Area 1 -- Flagler Beach to Matanzas Inlet

Flagler Beach is located near the Volusia County line (Plate 1, Figure 12). The barrier island, including a central ridge above 15 feet in altitude, is less than 0.4 mile wide. The City of Flagler Beach abandoned 32 shallow wells along the central ridge and converted to a Floridan aquifer supply near Bunnell due to saline intrusion. Water from shallow wells along the ridge is still used to irrigate lawns. Water samples evaluated from well F-175 near the ocean shore at Flagler Beach State Park indicate that at a depth equivalent to mean sea level, intrusion is already apparent. Chloride concentrations have exceeded 1,600 mg/l at 18 feet below land surface; water levels have declined below one foot above mean sea level during the period of record. Extending these data to the central ridge where a thin lense of usable water exists, wells should not be drilled deeper than mean sea level. Well yields are marginal for most domestic or lawn watering needs. Figure 13 shows cross-section A-A' that extends between the Atlantic Coastal Ridge and Flagler Beach. The clastic shallow aquifer is intruded east of Bulow Ruins except for minor fresh water lenses.

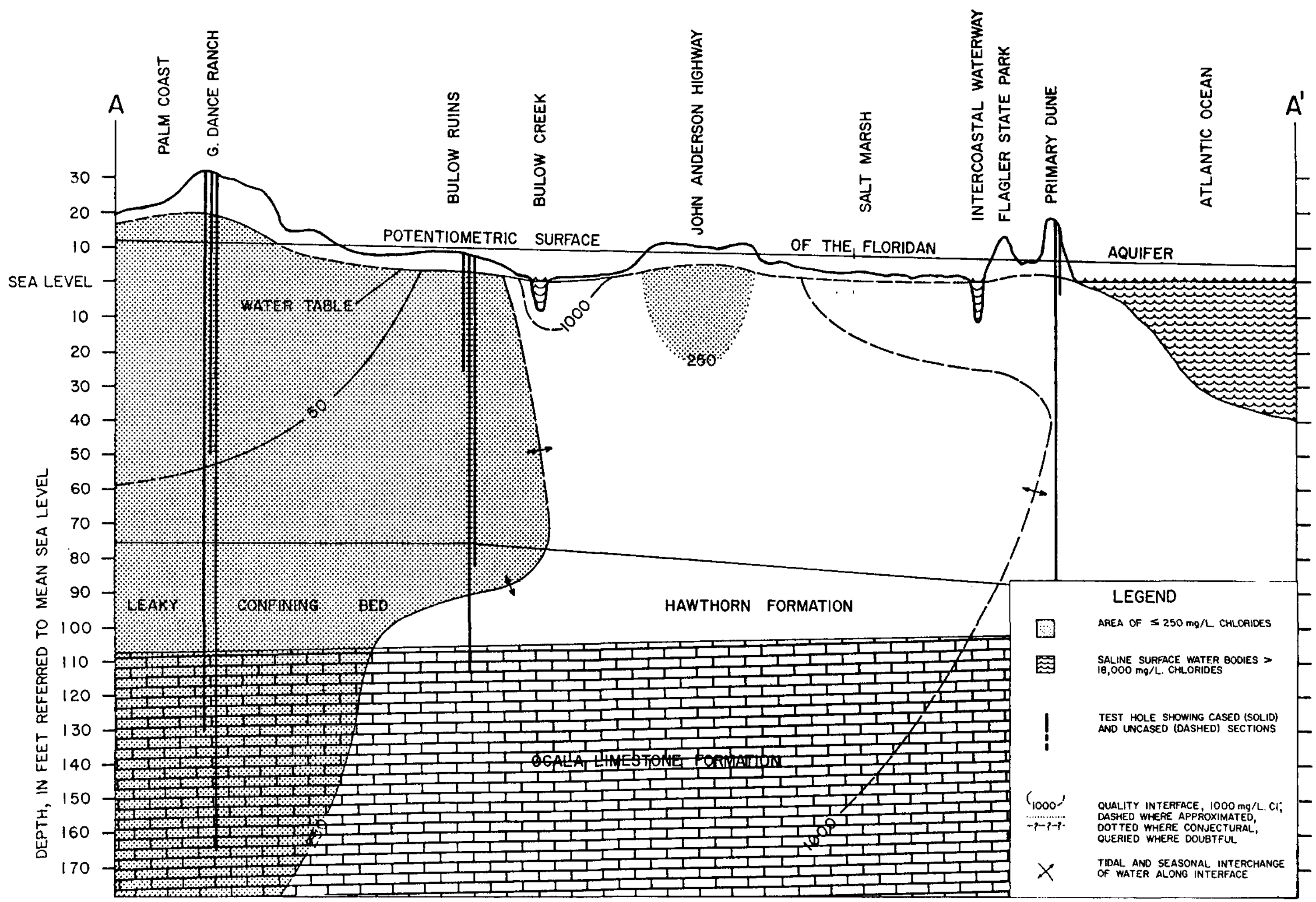


FIGURE 13. -- Cross Section A-A' Showing Quality Interfaces for the Bulow Ruins and Flagler Beach Test Sites

Areas immediately north of Flagler Beach are similar in aquifer characteristics with the exception of Painter's Hill. Water table wells supply limited quantities of potable water in that area.

Less than six miles north of Flagler Beach, the barrier island widens to form the "hammock area." This area averages approximately 0.8 mile wide through its six mile length. Within the "hammock area", three shallow aquifer types are found: an unconsolidated sand aquifer parallels the intracoastal waterway, a shell-sand aquifer is located centrally west of A1A, and the Anastasia Formation crops out along the ocean east of A1A.

Cross-section C-C' at Washington Oaks (Figure 14) shows the relationship between water quality, as represented by chloride concentrations, and geology. Table 5 illustrates the change of chloride concentration with depth at Washington Oaks for two drilling sites. Plate 2 shows the location of the three aquifer types and their intrusion potentials. Surface water samples from mosquito control ditches (Plate 2) just west of the primary dunes have chloride concentrations averaging 180 mg/l.

Figure 15 illustrates the daily fluctuations for shallow wells F-178 and F-191 as compared to Floridan aquifer well F-200 at Washington Oaks. Location of wells will vary the effects of tidal events on water levels. Figure 16 shows daily high readings for wells F-178, F-181, and F-191 for the period May 1978 to May 1979 compared with local rainfall. Wells F-181 and F-191 show distinctly different water level fluctuations from well F-178 which is affected by tidal change. Well F-178 reflects rainfall events as small peaks and rapid recessions. The other wells, F-181 and F-191, exhibit peaks of greater magnitude and longer term recessions for the rainfall events shown on Figure 16. Aquifer storage of recharge is greater inland as exhibited by F-181 and F-191 than in F-178 where retention is less due to aquifer materials and hydraulic gradients.

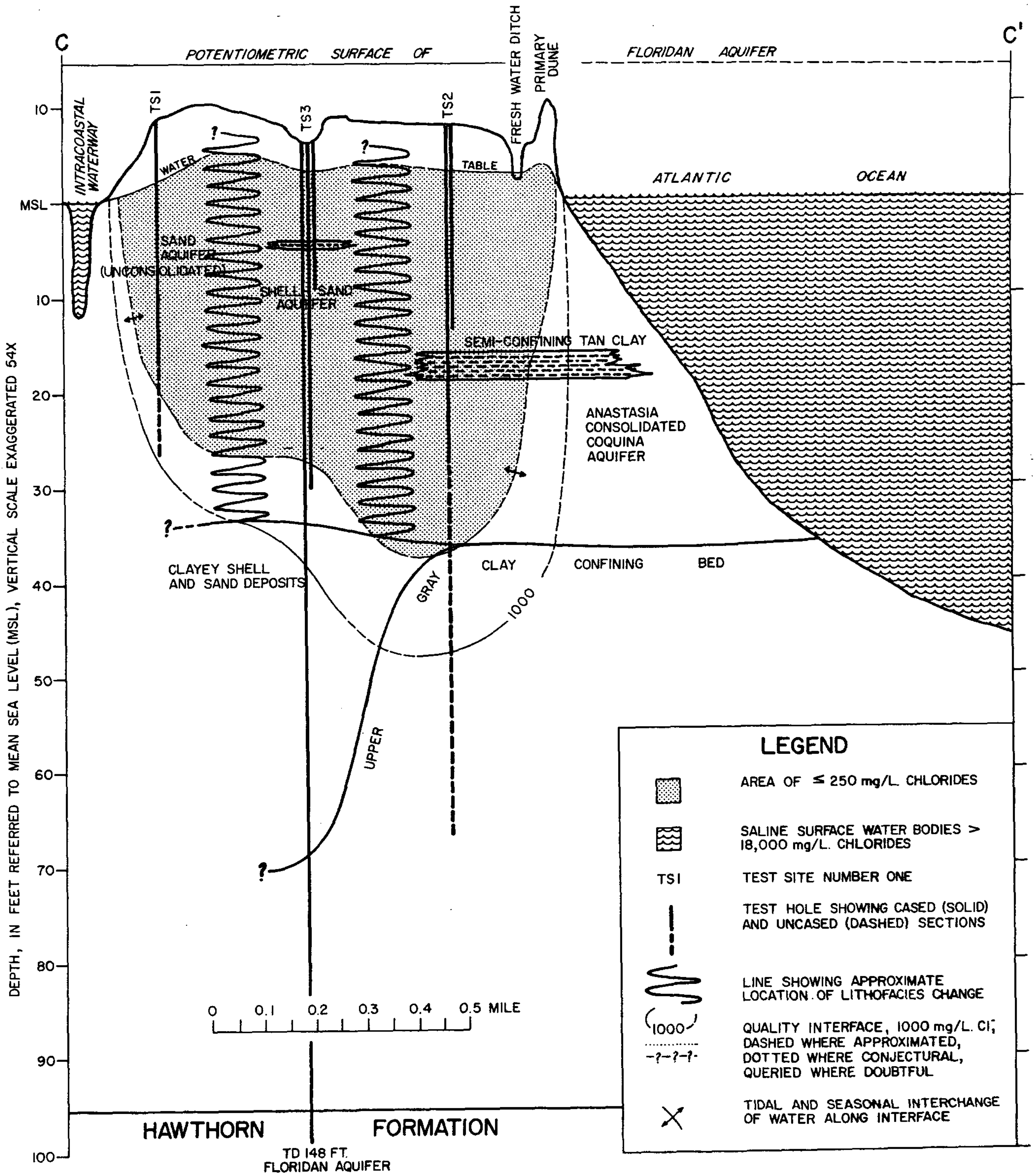


FIGURE 14. -- Cross Section C-C' at Washington Oaks State Gardens Showing Quality Interfaces, Test Sites, and Surficial Clastics

TABLE 5. -- Chloride Concentrations With Depth at Washington Oaks Gardens for Two Sites

	Depth (feet)	Cl^- (mg/1)
Beach Site at F-181	21	134
	24--------------------clay semi-confining zone	
	30	155
	35.5	145
	40	140
	45--------------------clay confining zone	
	50	740
	187	1760
Central Site at F-191	4	60
	11--------------------shell begins	
	15	17
	35	252
	35 (pumped)	280+
	75--------------------clay confining zone	
	97--------------------Hawthorn formation	
	135--------------------Ocala limestone	
	148	1830

Note: For locations of wells F-181 and F-191, see Plate 2, Washington Oaks State Gardens inset.

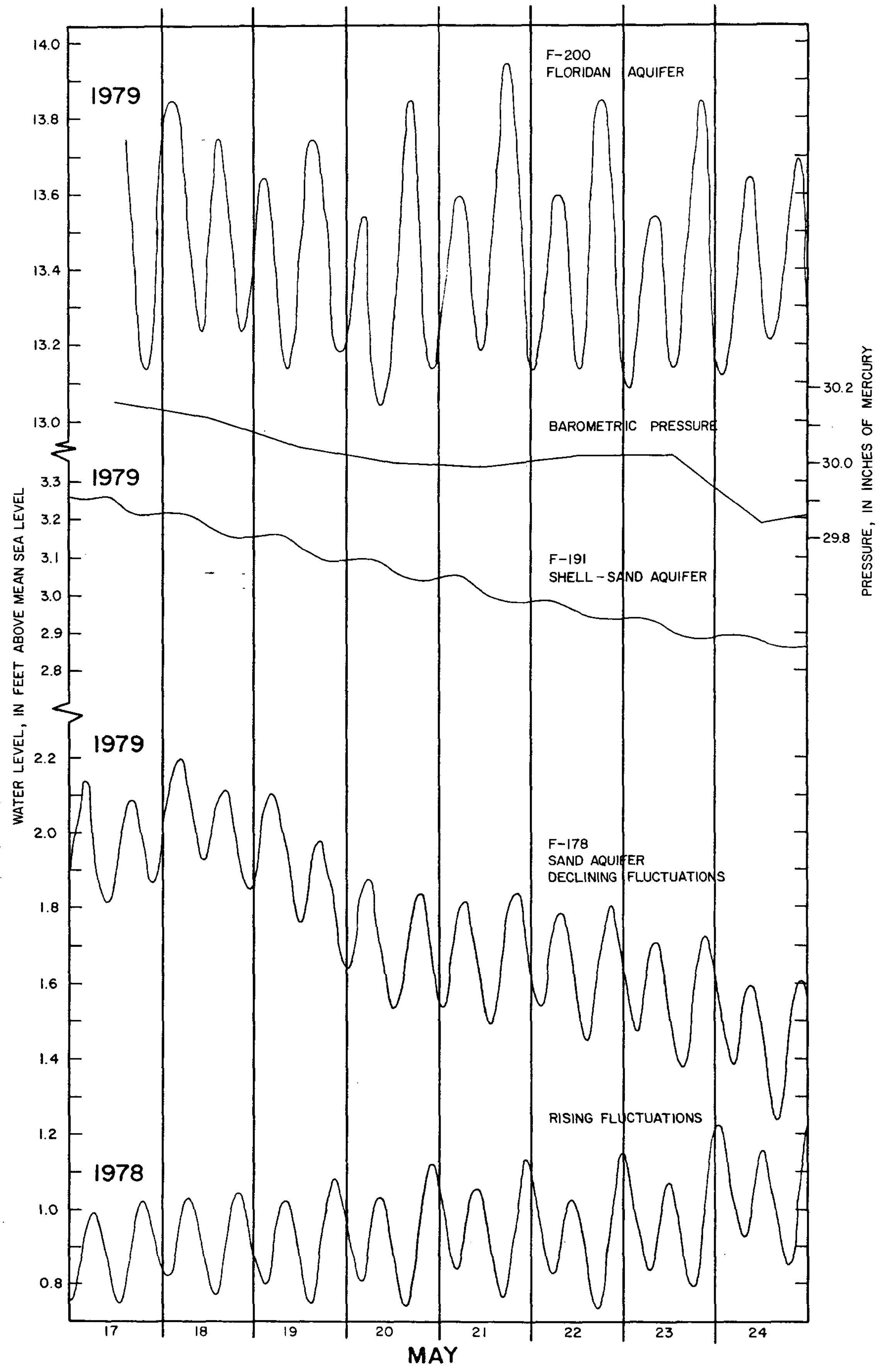


FIGURE 15. -- Water Level Fluctuations for Shallow Wells Compared to the Potentiometric Surface of the Floridan Aquifer and Barometric Pressure at Washington Oaks State Gardens

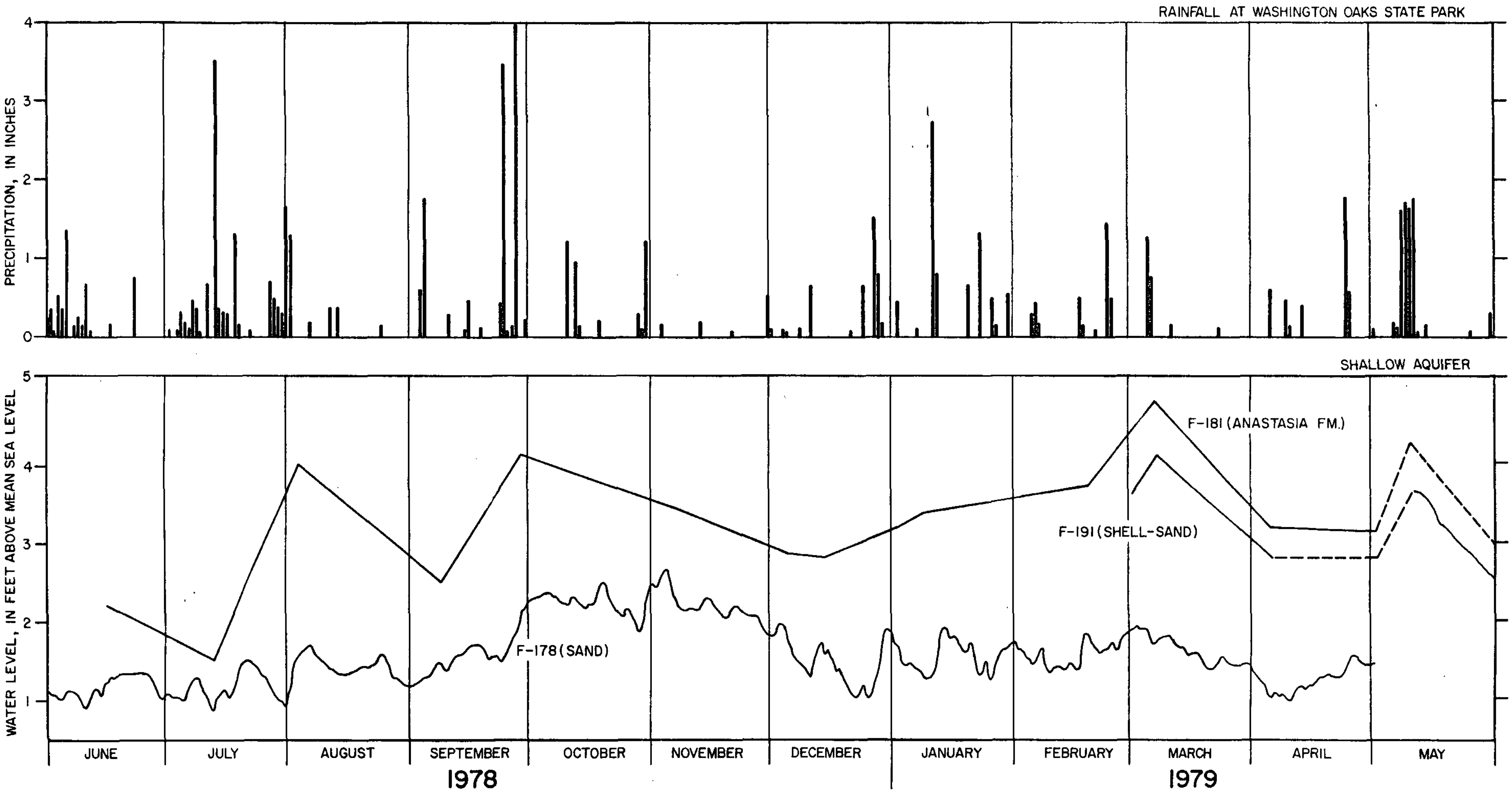


FIGURE 16. -- Water Level Fluctuations for Shallow Wells Compared With Precipitation Recorded at Washington Oaks State Gardens, Florida

Figure 17 shows rainfall at Marineland two miles north of Washington Oaks. A comparison of the two rainfall records shows considerable variations in events and intensities.

Tidal effects on well F-178 are significant. A time delay between tidal and water level fluctuations at well F-178 was calculated to be 3.28 hours (Walton, 1970, p. 176). A determination of actual time delay of three hours was made using the hydrograph of well F-178 and tide schedules. The intrusion potential is high in the sand aquifer where water levels approach mean sea level during droughty periods. Any pumping during low water level periods would reverse the hydraulic gradient and cause intrusion.

The hydrograph of well F-191, located at mid-island, shows water level responses due to vegetational demand on the shell-sand aquifer. The water level declines during peak daylight hours and reaches a minimum during mid-afternoon; then it rises slightly reacting to a decrease in water demand by the hammock vegetation. The water level decline is caused by transpiration at a rate exceeding lateral ground water inflow from higher ridges to the east and west of F-191. The water level use occurs when the transpiration rate is less than inflow (McWhorter, 1977, p. 47-48). The rise is slight during periods of hydrograph recession as is illustrated by Figure 15. Floridan aquifer well F-200 is included (Figure 15) to compare tidal influence, water level fluctuations, and barometric changes between deep and shallow aquifers.

Seasonal water level fluctuations of the three aquifer types (Figure 16) correlate favorably with local rainfall events. However, comparison with rainfall from Marineland for the same period (Figure 17) does not yield as good a correlation and illustrates a problem encountered when site specific data are not available. The shallow sand aquifer well F-178 illustrates the lowest water levels and the greatest tidal effect due to its location near the island discharge

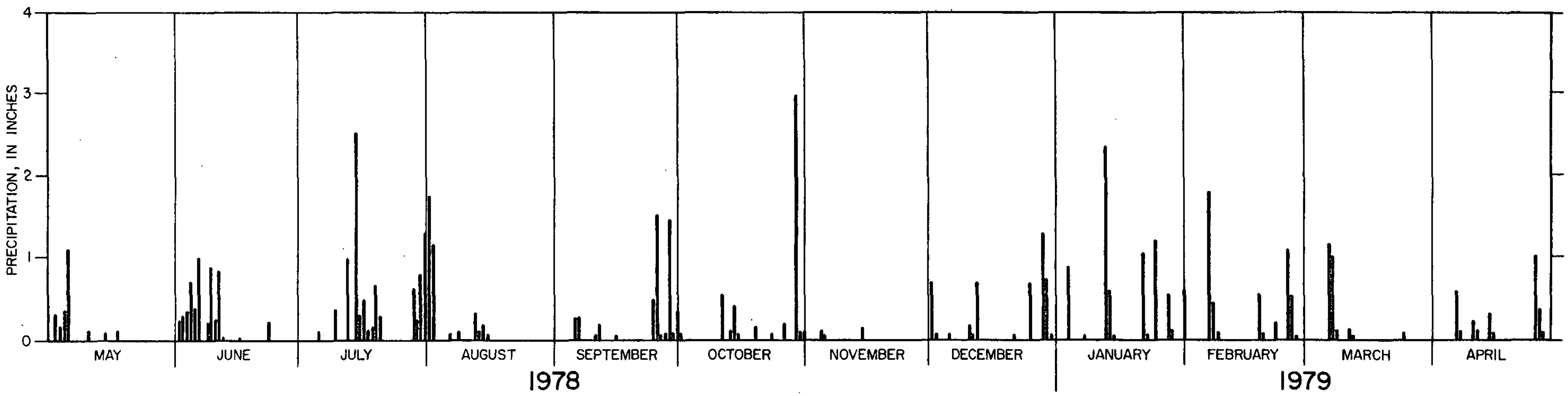


FIGURE 17. -- Daily Precipitation Recorded at Marineland, Florida

boundary. Wells F-191 and F-181 are located at higher land surface altitudes and demonstrate little or no tidal effect.

Estimates of ground water flow characteristics were determined at Washington Oaks State Gardens for each of the three aquifer types. An aquifer test was conducted in the central shell-sand type to determine transmissivity (T) using Boulton's delayed yield technique as discussed in Pickett (1965, Reprint Series No. 47), Walton (1970, p. 154-157), and Bureau of Reclamation (1977, p. 132-140); specific capacity determinations for the eastern coquina aquifer were used to approximate T by the Theis method (1963, p. 332-336); and graphical solutions of T/S were made using three well hydrograph recessions as discussed by Rorabaugh (1960, p. 314-323).

A value for T of 21,400 gal/d/ft or 2,860 ft^2/d was determined for the central shell-sand aquifer by matching early drawdown data to Boulton's type curves. The May 1979 hydrograph recession of well F-191 shown on Figure 18 yielded a T/S of 103,590 gal/d/ft. A specific yield (S) value of 2.06×10^{-1} was determined using the T value of 21,400 gal/d/ft.

A specific capacity test for well F-181 penetrating the Anastasia Formation resulted in a value of 4.65 (gal/min)/ft of drawdown. A T of 8,000 gal/d/ft or 1,070 ft^2/d was estimated from the specific capacity data. A T/S value was determined to be 28,109 gal/d/ft, and an S of 2.85×10^{-1} was derived using the above data. A permeability of greater than 15 in/hr was estimated for the upper 35 feet penetrated by well F-181.

F-178 on the west side of Washington Oaks monitors the shallow sand aquifer. A T/S of 8,270 gal/d/ft was estimated by averaging tidal effects over the recession event. A T of 1,320 gal/d/ft or 176 ft^2/d resulted from an S estimate of 1.6×10^{-1} obtained in similar sediments at Bulow Ruins. A calculation of water interchanged by tidal action between the aquifer and the intracoastal waterway

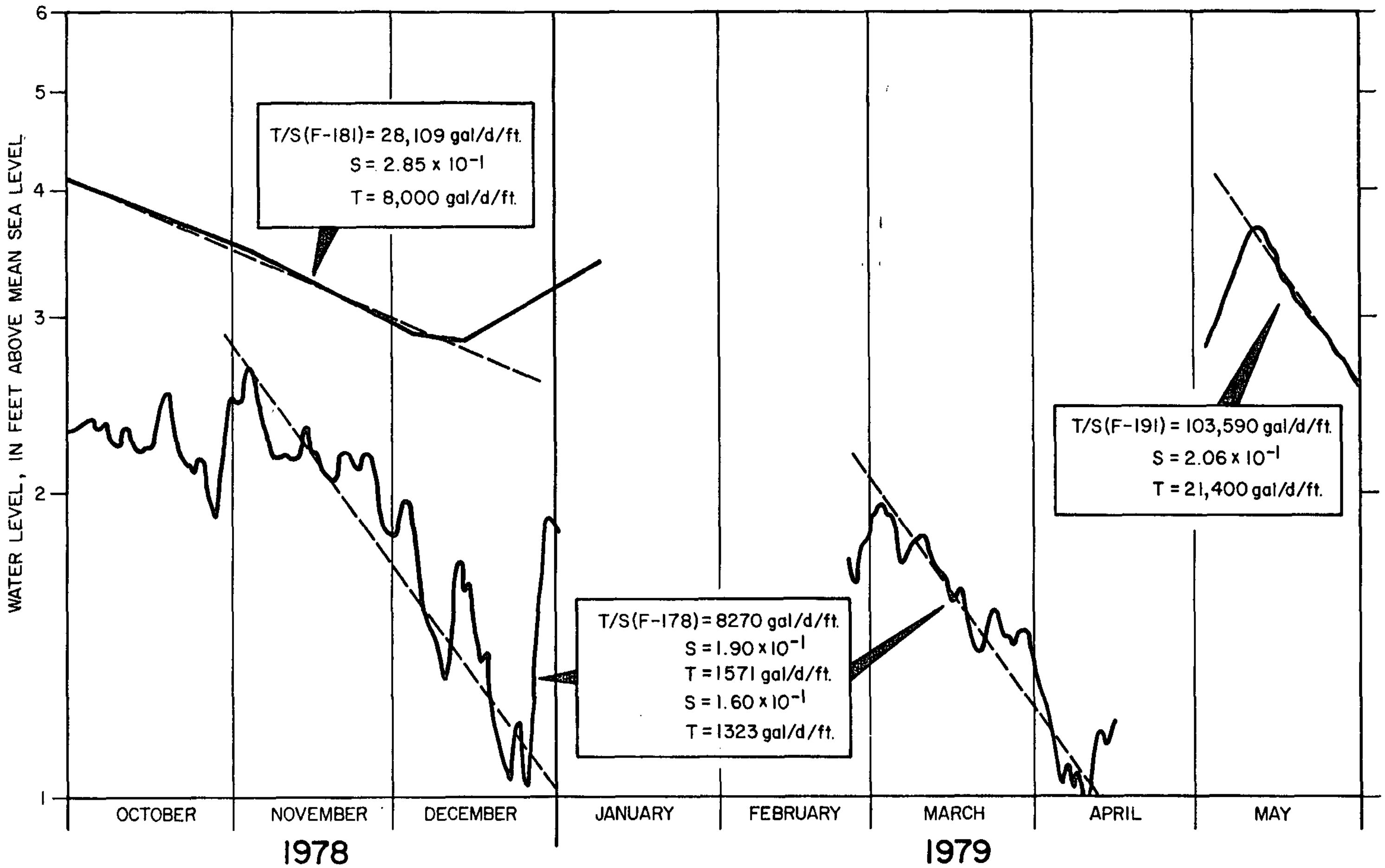


FIGURE 18. -- Plot of Water Levels on Semi-Logarithmic Scale for F-178, F-181, and F-191 and Graphical Solution of T/S

showed a potential transfer of 100,000 gal/ft of shoreline. It is felt that the west edge of the island has the poorest potential for aquifer development and the maximum potential for lateral salt water intrusion.

Cross-section B-B' (Figure 19) located in the south "hammock area" shows surface saline contamination caused by free-flowing Floridan wells discharging connate water. Water originating from these wells filled several coquina pits east of A1A. Due to the relatively high permeability of the Anastasia Formation in the area, 1,700 mg/l chloride Floridan aquifer water entered the shallow aquifer and flowed down gradient towards the intracoastal waterway. Samples taken from shallow well F-192 at the Rocks Motel, located down gradient from the coquina pits, show chloride concentrations of 1,760 mg/l, which is approximate by the concentration in the Floridan aquifer.

Sub-Area 2 -- Anastasia Island

Anastasia Island averages 0.25 miles in width to Crescent Beach where the island widens towards the Anastasia and Conch Island peninsulas east of St. Augustine (Plate 1). Water suitable for non-potable use is generally found south of Crescent Beach. North of Crescent Beach, minimal potable supplies are available and north of St. Augustine Beach, abundant supplies are available from the Anastasia Formation.

The Anastasia Sanitary District (ASD) water lines terminate at Summer Haven just south of Matanzas Inlet. Potable water is distributed by the ASD from wells tapping the Anastasia Formation and mixed with a Floridan aquifer water source on the Anastasia Peninsula. Geraghty and Miller (1976) reported the water table aquifer on the Anastasia Peninsula to be sufficient to supply up to 1 Mgal/d or the equivalent of 6,700 families.

Improved shallow aquifer quality in the northern half of the island appears to be related to improving water quality in the Floridan aquifer due to upward

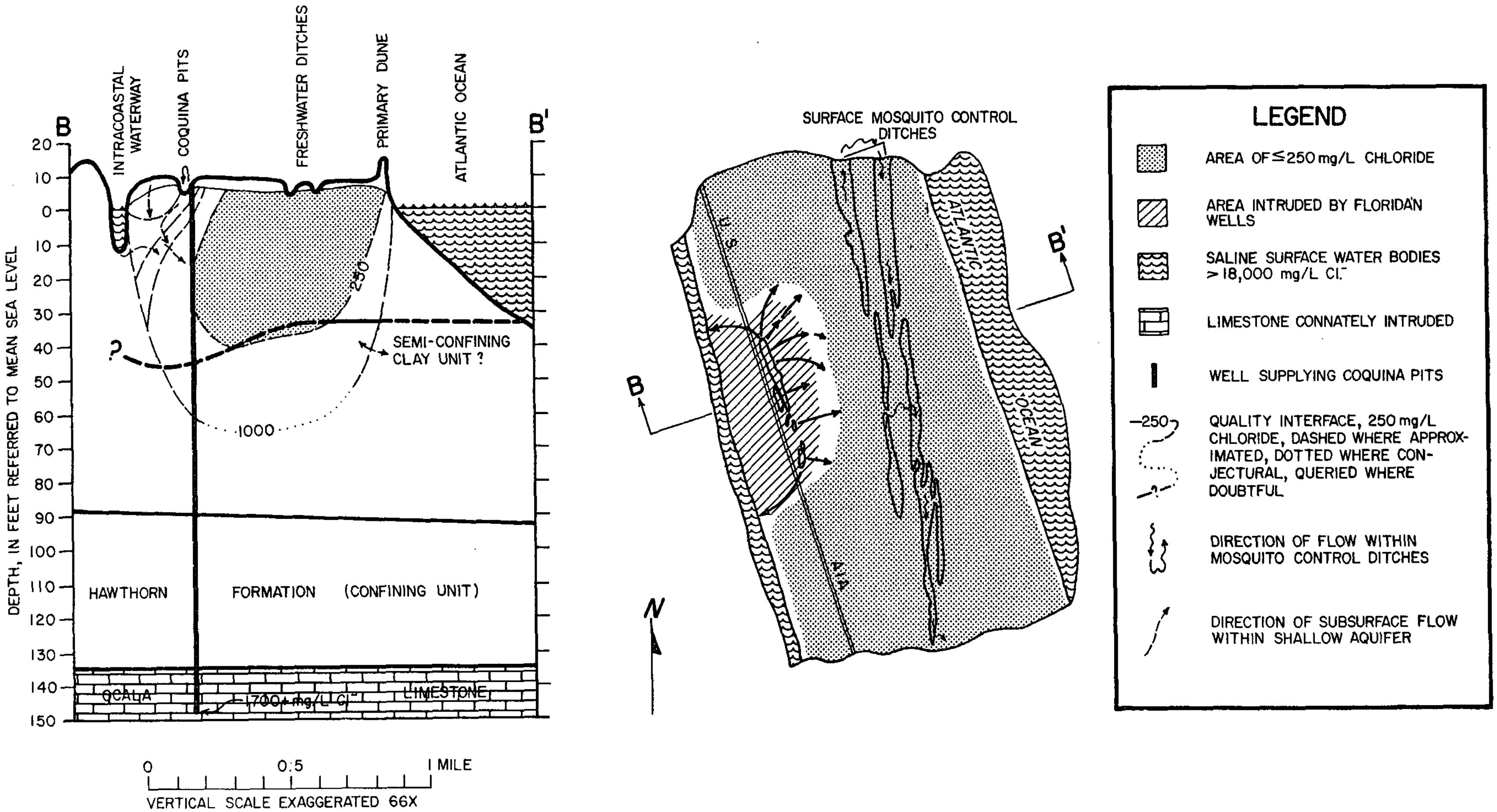


FIGURE 19. -- Cross Section B-B' Showing Shallow Aquifer Pollution by Discharge from Connately Intruded Floridan Wells

leakage and flow patterns north of SJ-480 (Plate 1) and more permeable thicknesses of coquina and loose shell. North of the connate water boundary line of the Floridan aquifer (Plate 2), water from well SJ-485 indicates a significant improvement in quality. This indicates a deepening of the shallow fresh water/salt water interface to a point within the Hawthorn Formation approximately 140 feet below land surface. Well SJ-486 located near SJ-485 has a chloride concentration of less than 75 mg/l in an area with the 250 mg/l interface estimated to be 80 feet below land surface. The Floridan fresh water/salt water interface would be expected below a depth of 700 feet in this area. Based on local well data, chloride concentrations of 1,000 mg/l appear to start near 460 feet, and 250 mg/l levels occur at 400 feet.

Ft. Matanzas National Monument records indicate a history of shallow aquifer problems. Figure 20 documents the effects of shallow sand-point well pumping on specific conductance; conductance readings are related to chloride concentrations graphically on the same figure. Base level conductance is 1,000 mhos which is equivalent to 180 mg/l chloride. Rainfall events relate to conductance decreases and indicate the importance of rainfall in maintaining fresh water lense thickness. Increased irrigation pumpage at Ft. Matanzas will only further dewater the present lense.

Just north of Ft. Matanzas National Monument, a Floridan aquifer connate intrusion problem exists similar to the "hammock area" of sub-area 1. A series of ponds were constructed for fish culture using Floridan aquifer well water. The hydraulic gradient dips towards the intracoastal waterway, therefore minimizing damage to local shallow aquifer users who, for the most part, are located to the east and up gradient.

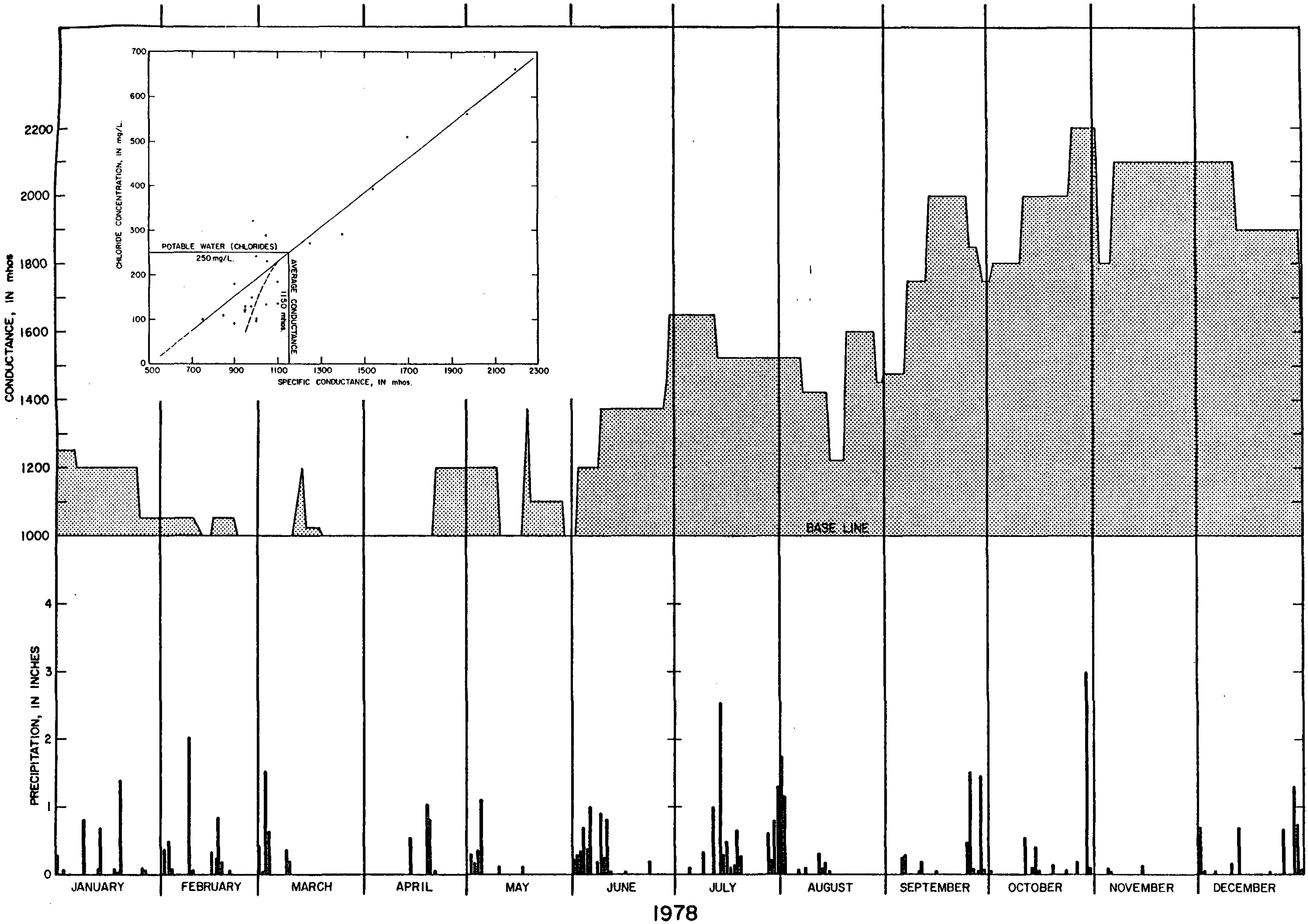


FIGURE 20. -- Specific Conductance for Shallow Wells at Ft. Matanzas National Monument Compared With Rainfall at Marineland

Sub-Area 3 -- Vilano Beach to Mayport

Sub-area 3 is 38 miles long and varies in width from 0.4 mile at Vilano Beach to three miles wide north of South Ponte Vedra Beach (Figure 12). Increasing island width and higher land surface altitudes along both the primary dunes and island interior provide ample shallow fresh water lenses.

Those residences served by municipal well fields use water pumped from Floridan aquifer wells currently supplying potable water. Individuals with private wells have adequate supplies of potable water from either the shallow or Floridan aquifers.

Shallow aquifers tapped by wells include the near surface sand-shell deposits and a shallow-rock aquifer similar to the one that occurs inland. Clastic sediments less than 50 feet thick make up the sand-shell aquifer. Most wells range from 10 to 30 feet deep and are of small diameter between 1¼ inches to 2 inches. Causey and Phelps (1978) report that at Hanna Park (Plate 1) the shallow water table at 15 feet produced 40 gal/min from permeable shell beds. Most wells produce less than 10 gal/min where sands predominate in the producing zone. Leve (1966) stated that the relatively thick and permeable sands along Duval and Nassau County beaches can yield as much as 25 gal/min from 1¼ inch sand points driven 10 to 30 feet deep. Production in that range or better is found in the Hanna Park area sections of primary dune near Ponte Vedra. Annual water level flucutations in shallow wells range from two to five feet.

Causey and Phelps (1978) included 13 Duval County test sites in their report. Site 2, located at Hanna Park, is within sub-area 3 (Plate 1). Table 6 lists three test sites including Hanna Park showing chloride concentrations with depth. Mayport and Hanna Park are examples of areas where local lateral intrusion has occurred in the shallow sand-shell aquifer below 15 feet and in deeper

TABLE 6. -- Chloride Concentrations with Depth at Three Sites Between Vilano Beach and Mayport with Confining Zones and Principal Aquifers Listed

Site	Depth (feet)	Cl^- (mg/l)
Guana River Wildlife Management Area near South Ponte Vedra Beach	-----------9-15 strong sulfide smell in sand and shell	
	20-24	120
	-----------30-40 gray clay confining bed	
	54	50
	58	60
	-----------105 Hawthorn Formation	
	-----------277 Ocala Limestone (Floridan)	
	433	120
Hanna Park near Mayport (Site 2) (Leve, 1976) (Causey and Phelps, 1978, p. 10, 16-17, and 28-29)	10	18-20
	31	30
	-----------37-42 clay confining zone	
	60	50
	-----------Principal sand-shell aquifer	
	63	440-480
	-----------130 Hawthorn Formation	
	-----------200-250 Secondary artesian aquifer	
	-----------510± Ocala Limestone (Floridan)	
	618	20
Mayport (Franks, 1979, oral comm. and personal observation)	-----------5 blue-gray clay zone intermittent	
	10	<250
	-----------40-50 best producing zone 18-20 gal/min	
	50	>4000
	-----------53 cemented sand	
	55	
	-----------87 Hawthorn Formation	

shallow-rock zones, respectively. The shallow-rock zone is present in sub-area 3 as a sand-shell zone intruded laterally from the coast.

Shallow sand-shell and shallow-rock wells show a rapid response to local rainfall events. This response is due to high sediment permeabilities. Downward percolation in areas of septic tank usage will present a potential problem especially where municipal water supplies are not available.

Cross-section E-E' shows the Guana River Wildlife Management Area (Figure 21) near South Ponte Vedra Beach. Along the higher land surface altitudes, wildlife ponds are presently supplemented with Floridan aquifer water to maintain artificial surface water elevations. Downward percolation of pond water (120 mg/l Cl^-) has increased local shallow aquifer chloride concentration from original values of less than 60 mg/l Cl^- to higher values. Deeper zones at 58 feet still yield concentrations of 60 mg/l Cl^-. Water from the unconfined aquifer exhibits a strong H_2S odor. Floridan aquifer quality is potable (Plate 2) in the South Ponte Vedra area with the salt water/fresh water interface estimated at 1,300 feet below mean sea level. The Ghyben-Herzberg equation would indicate a shallow salt water/fresh water interface approximately 220 feet below land surface. The relationship between the thickening Hawthorn Formation and the salt water/fresh water interface is not known. Figure 21 illustrates the lack of data within the Hawthorn Formation and a corresponding lack of knowledge concerning isochlor configuration. The upward leakage of Floridan aquifer water is also thought to affect the shape of the interface, but the extent of alteration is unknown.

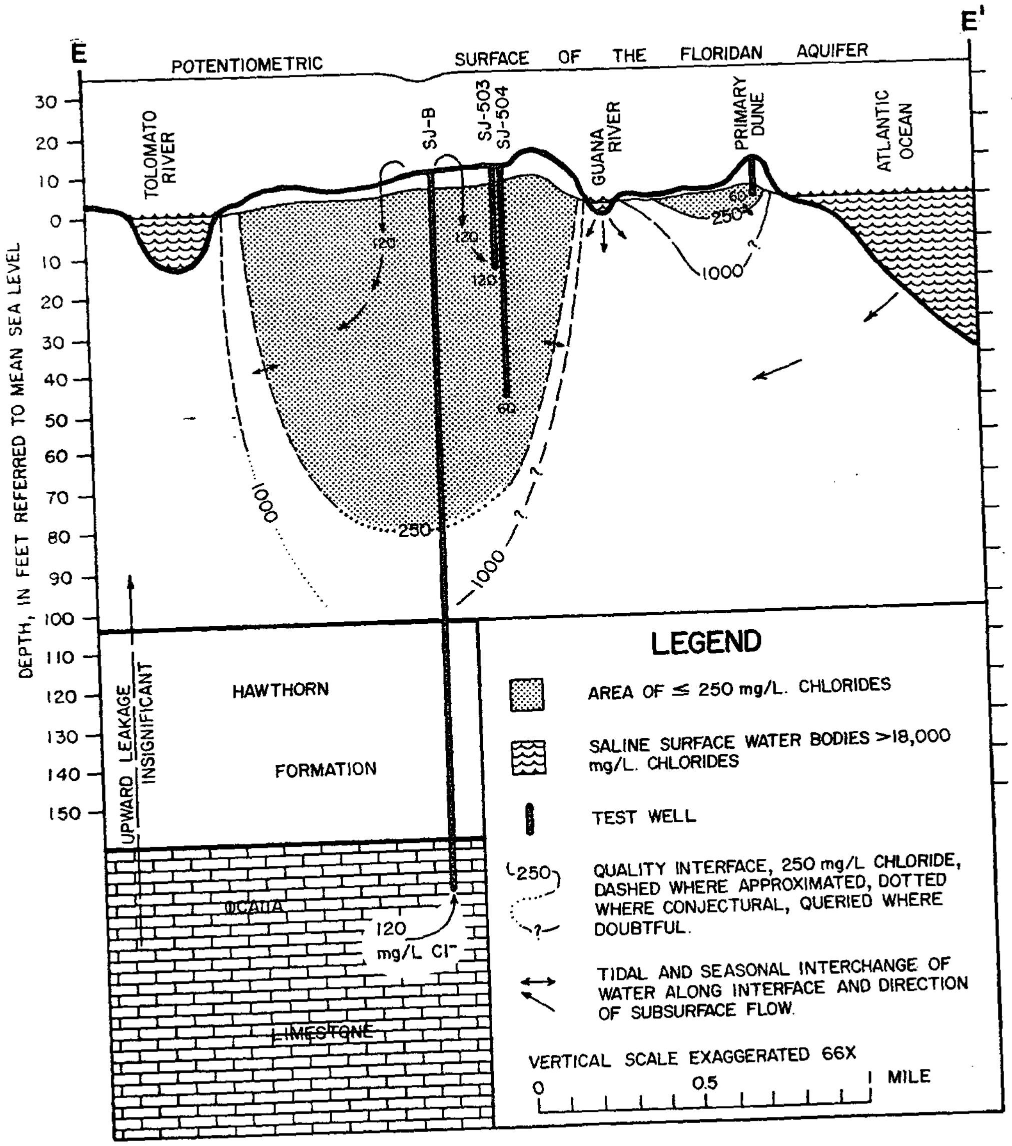


FIGURE 21. -- General Cross Section E-E' of the Guana River Wildlife Management Area, South Ponte Vedra Beach, Florida, Showing Quality Interfaces

Sub-Area 4 -- Fort George and Little Talbot Islands

Fort George Island is approximately two miles long and 0.9 mile wide (Figure 12). Little Talbot Island is four miles long and 0.5 mile wide near the area of wells D-11, 12, and 13 (Plate 1). The highest land surface altitudes occur on Fort George Island where Mt. Cornelia is 60 feet above mean sea level.

There is minimal shallow aquifer use on Fort George Island as water from Floridan wells is potable, including golf course area wells (Plate 2) which show initial stages of connate intrusion. The shallow aquifer is recharged locally by rainfall. Upward leakage of Floridan aquifer water occurs due to upward head differentials between the Floridan and shallow aquifers. However, this leakage is thought to be insignificant due to thick Hawthorn Formation confining beds.

The shallow aquifer has marginal quality and quantity characteristics. The shallow sand-shell aquifer is approximately 50 feet thick. Due to lateral intrusion, poor quality will probably preclude the use of this aquifer for water supply, except for the fresh water lense present in the upper 20 feet. Below the lense, quality degrades rapidly and pumpage may create significant intrusion problems depending on well location. Usage of the shallow aquifer is recommended only for limited utility purposes because of potential septic tank contamination, high intrusion potential (Plate 2), and limited yields as predicted by Geraghty and Miller (1977). Geraghty and Miller concluded that five inches of water per year is available for shallow aquifer recharge. Existing consumptive uses will further reduce available water in the aquifer. The shallow aquifer has an estimated storage capacity of 9.5 Mgal of water (Geraghty and Miller, 1977), of which the safe yield is estimated to be 0.3 Mgal/d. Geraghty and Miller (1977) emphasized that overpumping would surely initiate salt water intrusion.

The shallow-rock zone underlies both islands at a depth of 80 to 100 feet below mean sea level. As shown on cross-section E-E' (Figure 22), the rock and clayey shell deposits are intruded laterally.

Table 7 shows chloride concentrations with depth for wells D-11, 12, and 13 located on the south tip of Little Talbot Island (Plate 1). With the exception of a very shallow fresh water lense in the shallow aquifer on Little Talbot Island, both water table and shallow-rock zones are intruded and unusable for most purposes. Figure 23 shows periodic water levels and chloride concentrations for the three wells mentioned above. The upper two zones at 22 and 44 feet react to rainfall rapidly in comparison to the deeper zone at 88 feet. Increasing clay fractions retard downward leakage of recharge.

Sub-Area 5 -- Amelia Island

Amelia Island is approximately 13 miles long and 0.7 to 2 miles wide with the narrower portions at the south end (Figure 12). Highest land surface altitudes occur in Fernandina Beach where the most dependable shallow aquifer supplies are found. The lower half of Amelia Island south of Fernandina Beach is similar to barrier island areas to the south. Fresh water lenses occur at shallow depths and at higher land surface altitudes. More dependable supplies are obtained from the Floridan aquifer.

Cross-section G-G' through Fernandina Beach shows the occurrence of potable water (shaded area of Figure 24) in the shallow aquifer. Wells N-16 and N-19 shown in cross-section G-G' penetrate the shallow rock aquifer (Figure 24). Samples of N-19 taken during drilling indicate lateral salt water intrusion from the St. Marys River. In the Ft. Clinch area and south towards Old Fernandina, salt water intrusion is noticeable even in shallow sand wells 30

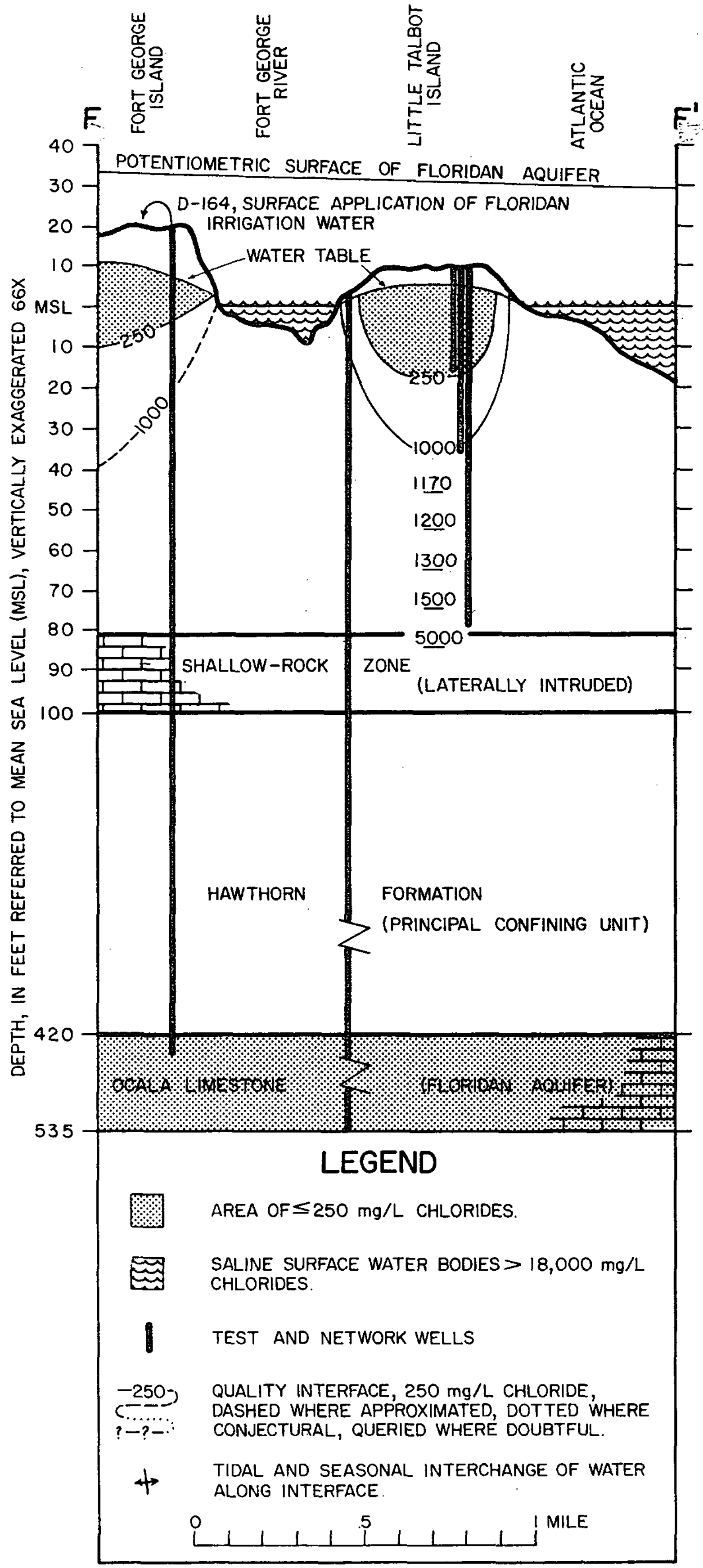


FIGURE 22. -- Cross Section F-F' Showing Quality Interfaces for Little Talbot and Eastern Fort George Islands, Florida

TABLE 7. -- Chloride Concentrations With Depth for a Set of Test Wells D-11, 12, and 13 at Little Talbot Island State Park

Depth (feet)	Cl^- (mg/l)
24	45
----------30-40 dark green clay semi-confining zone	
35	570
44	1045
55	1170
64	1200
74	1300
84	1500
----------85± top of shallow rock aquifer (see Note)	
88	4420
----------100 top of Hawthorn formation	
----------450 top of Ocala limestone	
535	22

Note: Chloride concentration in the shallow rock aquifer rose to 7125 mg/l in February 1979.

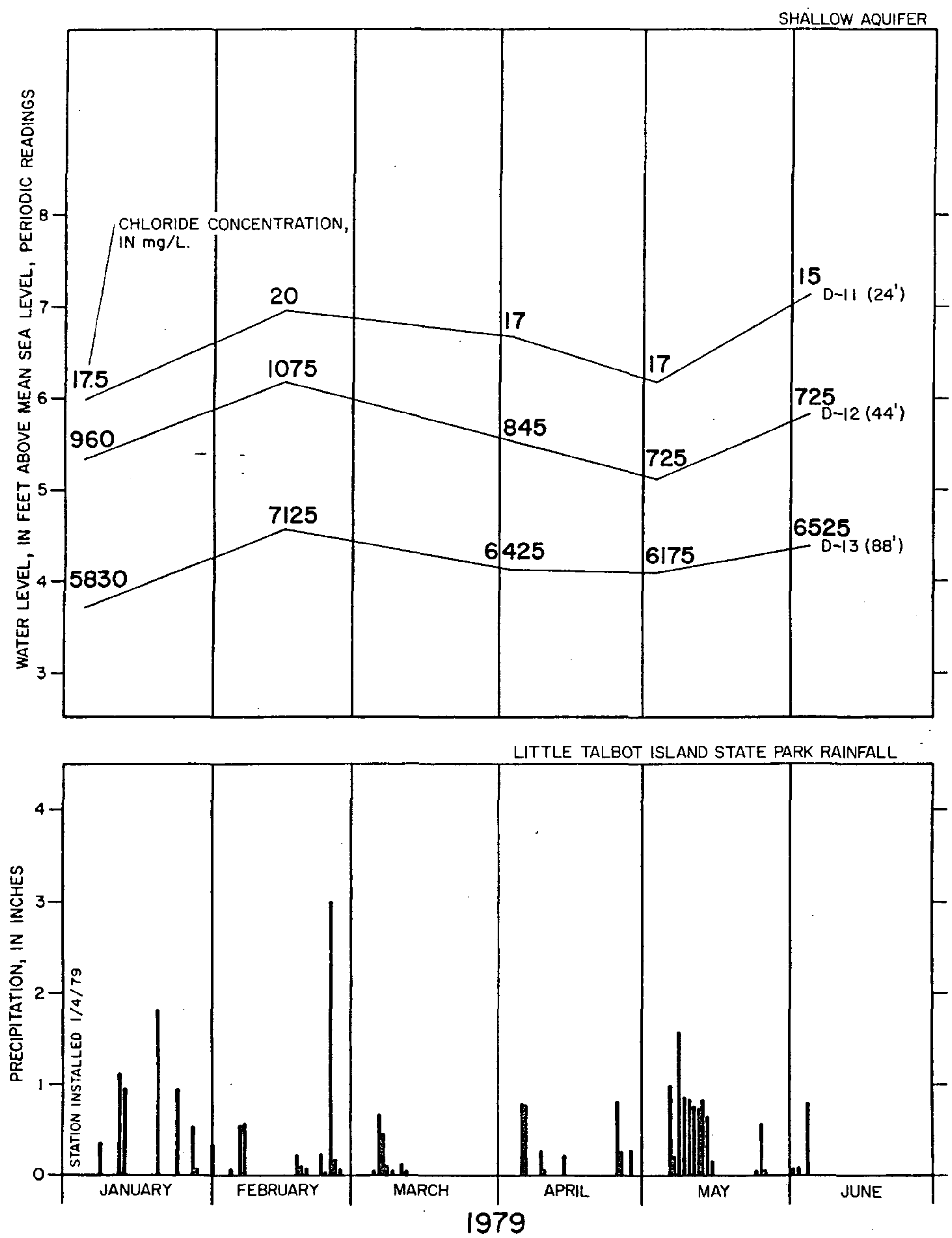


FIGURE 23. -- Water Level Fluctuations and Chloride Concentrations for Three Well Depths at Little Talbot Island State Park Compared With Rainfall

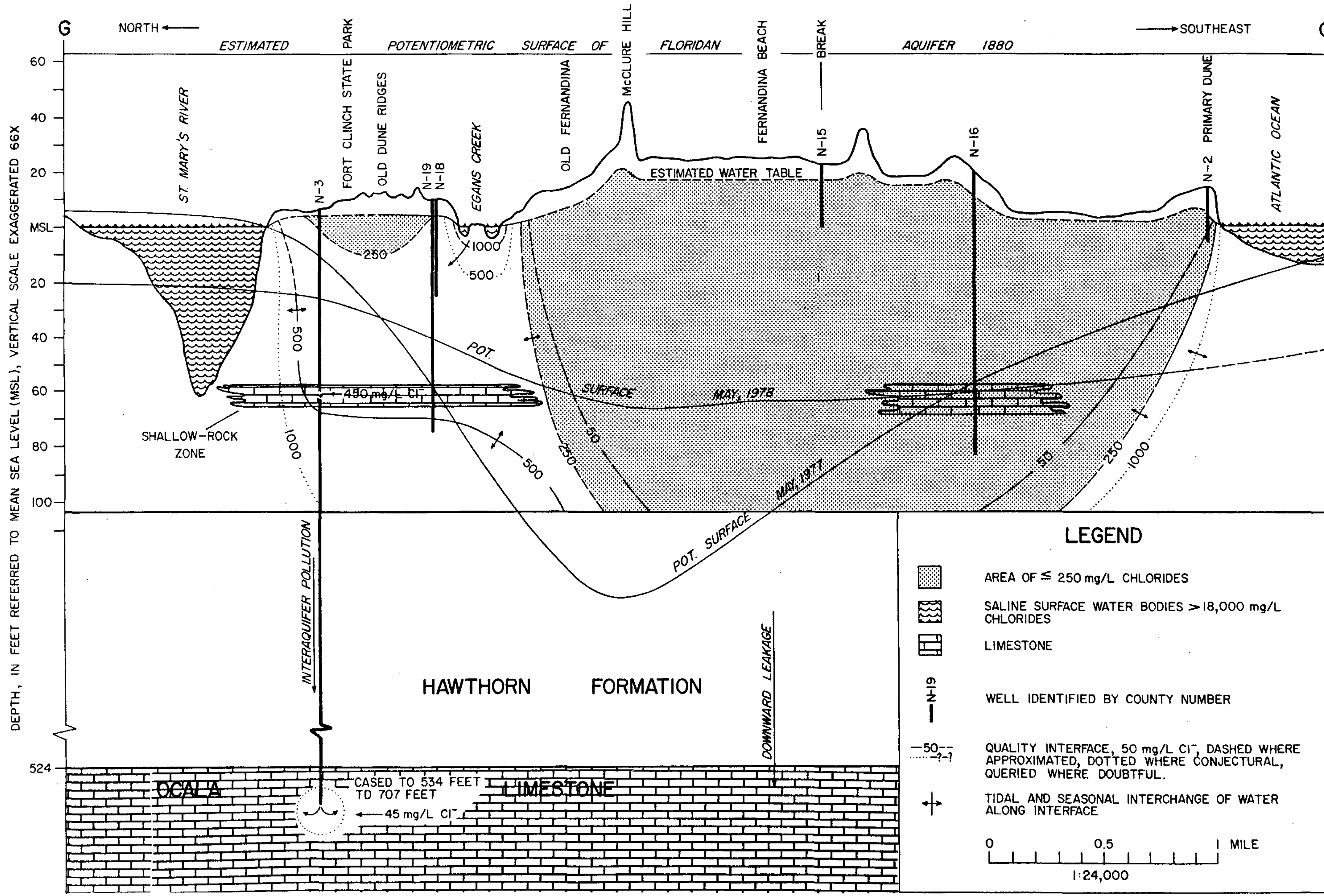


FIGURE 24. -- Cross Section G-G' Through Fernandina Beach Showing Quality Interfaces, Potentiometric Contours, and Intrusion Problems

feet deep. Higher land surface altitudes south of Old Fernandina receive adequate quantities of rainfall to maintain a local lense of fresh water above the Hawthorn Formation. Water quality within the Hawthorn Formation was not determined.

Local head differentials between the shallow aquifers and the Floridan aquifer have created a tendency for downward leakage to the limestone aquifer. Quantities, thought to be insignificant, will depend on relative permeabilities of clays within the Hawthorn Formation. At Ft. Clinch, intruded shallow aquifer water is transferred directly into the Floridan aquifer by well N-3 located near the Fort (Figure 24). The problem is thought to be caused by a damaged step well seal at 62 feet below mean sea level. Downhole samples taken prior to pumping yield chloride concentrations of 450 mg/1, which is the present quality of the shallow aquifer at 62 feet. After sufficient pumping, however, samples contain 45 mg/1 Cl^- which is the Floridan aquifer quality at approximately 550 to 700 feet below land surface in this area. Without the current drawdowns in the Floridan aquifer, leakage would be upward.

Water levels and chloride concentrations (Appendix A) for test wells N-18 (shallow sand aquifer) and N-19 (shallow-rock aquifer) were monitored periodically beginning in September 1978. Recessions appear to be longer, and the recovery after significant rainfall events appears to be less rapid in the shallow-rock zone than in the shallow sand aquifer.

With the exception of locally high iron concentrations, water from both rock and shallow sand wells is generally of potable quality. Leve (1966, p. 23) stated that the local shallow-rock aquifer is suitable for most domestic, irrigation, and industrial uses. This is generally the case along the higher ridges (Figure 23). Wells will produce 50 to 80 gal/min from the shallow-rock aquifer in comparison to 15 to 25 gal/min for shallow sand wells 10 to 30 feet deep. Generally, there is adequate water of good quality in the shallow aquifer for all supplemental uses (irrigation, heat pumps, etc.) except near the north beach areas and Ft. Clinch where shallow lenses are thin, and in some instances, absent.

General Properties and Extent of Aquifers of Inland Coastal Areas

Sub-areas 6 through 10 (shown on Figure 12) include inland sections of the project east of I-95 and west of the intracoastal waterway.

Generally, shallow aquifer quality and quantity improves to the north and at higher land surface altitudes along the Atlantic Coastal Ridge. The shallow sand aquifers have extremely variable storage and flow coefficients throughout the four coastal counties. Most investigations have concluded that the use of locally derived shallow aquifer parameters over large areas is inappropriate.

In Flagler and St. Johns Counties, the deeper shell aquifers are excellent producers of good quality potable water along the Atlantic Coastal Ridge. In Duval and Nassau Counties, a shallow-rock zone overlying the Hawthorn Formation produces the most dependable quantities of potable water.

Sub-Area 6 -- Nassau County Inland Area

This portion of the study area includes Nassau County east of I-95. Shallow aquifer quality and quantity varies significantly between the high land surface altitudes near Yulee (Figure 12) and the lowlands of the estuarine marsh and islands near the intracoastal waterway. The shallow aquifer system is a series of relatively thin permeable zones separated by a number of relatively thin confining beds.

The Yulee test site includes two permeable zones. A shallow sand aquifer overlies clay at 19 feet. This aquifer is droughty and undependable. At 45 feet, a very coarse sand, shell, and clay zone provides well yields of adequate quantity to satisfy domestic needs. The deeper zone below 45 feet shows properties similar to the shallow-rock zone. Leve (1966) and others have found the shallow-rock zone is generally 10 to 40 feet thick and 50 to 100 feet below land surface in areas south of Yulee. The type zone usually consists of limestone, sand and shell but grades to sand and shell beds moving away from central Duval County. Yulee test well N-20 will yield 10 to 15 gal/min through a 2-inch casing screened in the sand and shell.

The estuaries west of Amelia Island are generally underlain by saline intruded shallow sand aquifers. Throughout this area small islands rise above the tidally affected areas creating local, fresh, shallow, ground water lenses. Piney Island just south of Amelia River and west of the intracoastal waterway is a good example. Here residents pump from a shallow fresh water lense of limited areal extent artificially recharged by two 'wild flowing' Floridan aquifer wells yielding potable quality water. The infiltration of artesian water has increased the thickness of the fresh water lense and created a controlled subsurface "pumped reservoir". Below the lense, wells 50 to 80 feet deep tap shallow sand and shell zones intruded laterally from the river and estuaries. The shallow-rock wells, penetrating a green limestone at about 100 feet, are fresh and indicate the presence of a confining zone above the limestone that effectively seals the shallow-rock zone from the upper intruded zones. Chloride concentrations are 60 mg/l in the shallow-rock aquifer and 500 to 600 mg/l in the lower sand aquifer above the rock aquifer and below the fresh water lense.

Southeast of Piney Island at the intracoastal waterway, the shallow-rock aquifer is intruded. At 60 feet, the chloride concentrations increase to 3,100 mg/l and continue at that concentration to the bottom of the shallow-rock aquifer and lower secondary artesian zones within the Hawthorn Formation. The upper shallow sand aquifer has a chloride concentration of 300 to 900 mg/l and water levels 3 to 5 feet higher than the shallow-rock and lower secondary artesian zones around 100 and 200 feet below land surface, respectively.

The shallow sand aquifer is of marginal quality throughout coastal Nassau County. The deeper shallow-rock aquifer is the most dependable shallow water source except along the estuarine islands where intrusion is a problem. The Floridan aquifer is the best alternative throughout the coastal areas of Nassau County.

Sub-Areas 7 and 8 -- Duval County Coastal Area

Sub-areas 7 and 8 include the Duval County area east of I-95. Varied land surface altitudes give rise to a variety of shallow aquifer settings. Sub-areas 7 and 8 exhibit similar recharge characteristics, although higher land surface altitudes and thinner confining beds found in Sub-area 8 improve quality and quantity, respectively, of recharge to the Floridan aquifer, especially along the coastal ridge.

The shallow sand aquifer has a low well yield potential over most of the area. Relatively high water levels vary between land surface and six feet below land surface in response to altitude increases. Aquifer thickness varies between several feet and 50 feet. Causey and Phelps (1978) discussed shallow aquifer conditions at seven sites within sub-areas 7 and 8 (Table 8). In Sub-area 7 a sand zone, approximately 62 feet thick with clay lenses present, is indicated at Site 12. Water samples indicated low iron concentrations in the upper 16 feet of the section. Site 13 was divided into three shallow zones, all of which were clayey with poor water quality.

Water samples at Tisonia test well D-14 near Site 13 indicate marginal quality with 0.36 iron and an acidic pH of 5.7. Pipe corrosion and iron staining problems would occur at this site. The Tisonia test well penetrates a sand zone containing layers of acidic organic pan formed by fresh water swamp deposition. It is semi-confined by clays and organic pans and has a thickness of

TABLE 8. -- Partial List of Test Data from Seven Shallow Aquifer Sites[1/]
Discussed in Causey and Phelps (1978) for the
Shallow-Rock Zone in Duval County, Sub-Areas 7 and 8

	D-245 (G068) Site 1	Site 3	D-247 (G063) Site 4	Site 5	Site 11	Site 12	Site 13
Depth (feet)	53-62	65-82	85-103	41-49	43-68	65-85	85-105
Thickness (feet) of production zone	11	11	22	8	22	21	18
Production (gal/min)	18	30	10	18	6	45	37
Drawdown (feet)	21.4	15.9	9.7	23.1	18.8	17.4	16.3
Specific capacity (gal/min/ft)	0.8	1.9	1.0	0.8	0.3	2.6	2.3
Water level (feet) referred to land surface	-3.6	-9.1	-15.3	-1.9	-6.2	-8.1	-8.5
Maximum potential yield (gal/min)[2/]	40	121	71	31	12	78-157	67-182
Iron, mg/l	1.5	.03	0.03	12.0	6.8	0.88	0.06
Cl^-, mg/l	22	10	10	12	18	15	18
pH, units	6.8	--	--	--	6.8	6.9	7.4
Site Altitude	22	45	50	15	15	25	22

1/ See Plate 1 for the locations of each site discussed in the table.

2/ A graphic technique described by Johnson (1966, p. 107) which relates drawdown, yield, and specific capacity was used to calculate the maximum potential yield. (Causey and Phelps, 1978, p. 23) approximately 23 feet. A shallow perched water table overlies a clay layer at ten feet (see Appendix C-1 for a complete log).

The sub-area 8 shallow sand aquifer ranges from several feet to more than 70 feet thick, contains little or no clay, and overlies the shallow-rock aquifer. Causey's sites 1, 3, 4, 5, and 11 indicate low pH values near 5.0 and 5.5 and widely variable iron concentrations between .02 and 12.0 mg/l. In general, these conditions are similar to sub-area 7 except that sand sediments are thicker and well yields are greater along sand ridges (Plate 1).

Local shallow artesian conditions along the shores of the St. Johns River are caused by confining beds overlying the shallow sand aquifer (Leve, 1966, p. 21). An example is found at Ft. Caroline National Monument where high sand hills and intermittent shallow clay lenses form artesian conditions at lower land surface altitudes near the river. Cross-section H-H' (Figure 25) illustrates the occurrence of a local clay lense of tan to red brown clays overlying very coarse sand and shell deposits that are recharged from high sand hills to the east. An overlying perched water table reacts with similar, but more rapid, fluctuations during rainfall events. The water table aquifer discharges to Shipyard Creek.

The shallow-rock zone is the most laterally extensive shallow aquifer in Duval County. The shallow-rock aquifer is absent in peripheral parts of Duval County where sand and shell zones replace the green limestone characteristic of the zone. Local variations are present throughout its range. Fairchild (1972, p. 29) stated that water level fluctuations in rock wells range from 2 to 5 feet.

Well yields may be as high as 200 gal/min under optimum conditions. Causey and Phelps (1978) calculated transmissivities ranging from 250 to 1,300 ft^2/d (1,870 to 9,724 gal/d/ft) using specific capacities and a method presented by Brown (1963, p. 337) that assumes artesian conditions. A storage coefficient

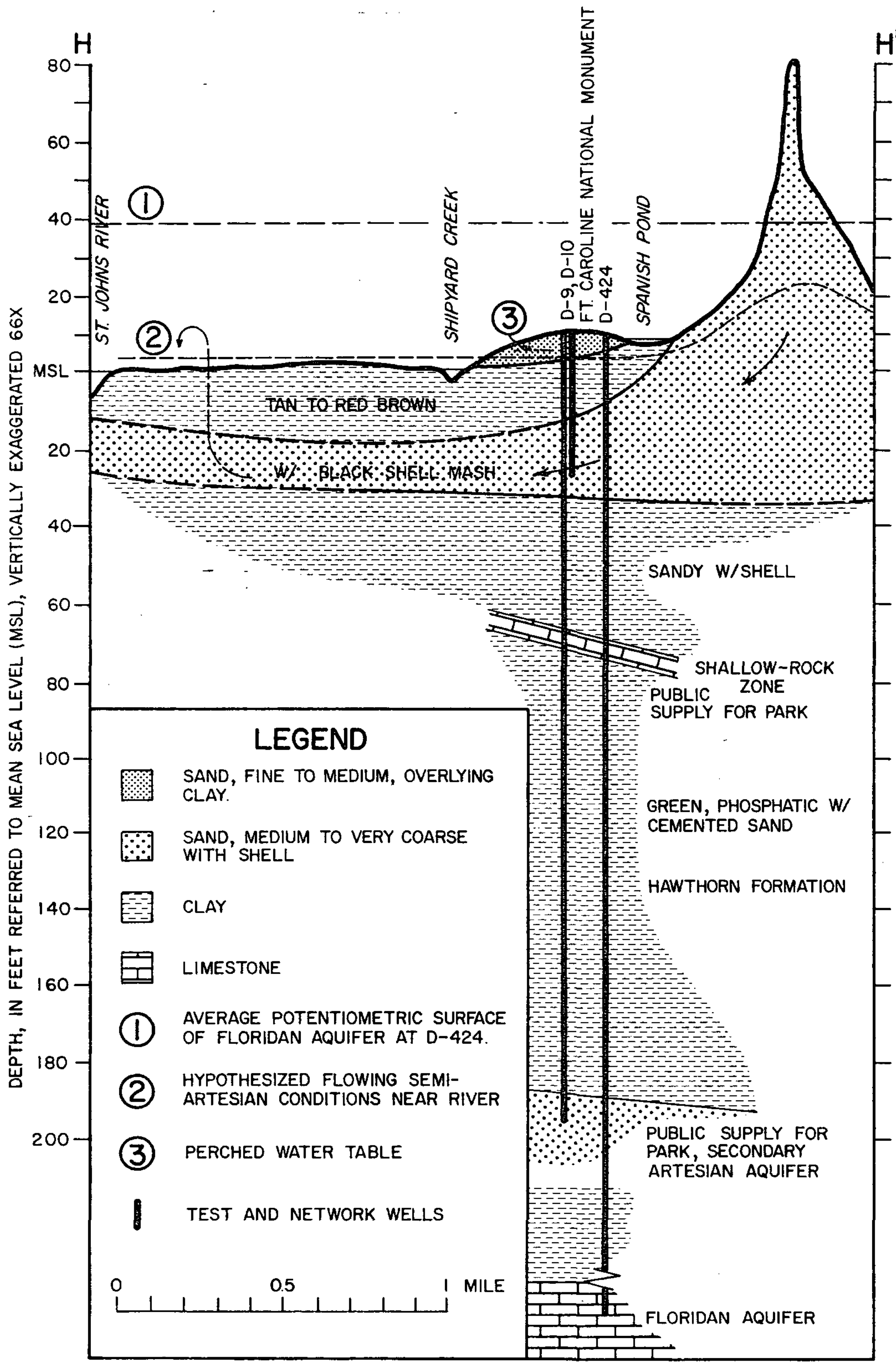


FIGURE 25. -- Generalized Cross Section H-H' at Ft. Caroline National Monument Showing Geology and Aquifers Known to be Present in Local Area

of 2 x 10^{-4} was assumed by Causey and Phelps (1978) in their calculation.

Sites 3 and 4 are located on excellent recharge areas and exhibit slightly higher specific capacities. Ft. Caroline is also located along the central section of Duval County, and the shallow-rock zone produces good quantities of water with minimal development. Test well D-10 produces yields similar to Ft. Caroline supply well D-5 when adjustments are made for diameter and pump capacity. At lower altitudes and in areas where limestone is not present, specific capacities and maximum potential yields decrease significantly for the shallow-rock aquifer and associated shell-sand deposits.

Periodic water-level and rainfall measurements for sites 1 (D-245) and 4 (D-247) were collected during the project period. The significant difference in the range of fluctuations appears to be due to the greater depth to the shallow-rock aquifer at site 4 (Table 8) and more permeable shell-sand deposits above the aquifer sampled at site 1 causing fluctuations similar to water table aquifers. Site 4 also includes a clay confining zone (Causey and Phelps, 1978, p. 11), whereas site 1 has a semi-confining sandy clay zone. During the aquifer tests at site 4, no change was observed in the water table aquifer (Causey and Phelps, 1978, p. 18).

Visher and Hughes (1969, 1 sheet) and Fairchild (1972, p. 30) estimated recharge to the shallow-rock aquifer of 8 inches per year and 10 to 16 inches per year, respectively. Considering figures for recharge derived throughout the project area, a 12 to 14-inch range is more often the case. The Central Park Ridge (Atlantic Coastal Ridge in Duval County, Plate 1) is the key recharge area.

The shallow-rock aquifer offers the greatest potential for development in these sub-areas. Yields should be ample in most areas.

Sub-Area 9 -- St. Johns County

Shallow aquifers in northern St. Johns and southern Duval Counties have similar properties along the coastal ridge. Sandy-shell beds overlying the Hawthorn Formation comprise the shallow-rock aquifer. For northern St. Johns County the shallow sand aquifer, which exhibits relatively high permeability, is the major shallow aquifer. Thin beds of permeable sands occur in all but the Atlantic Coastal Ridge (Plate 1). Relatively thin sections of permeable shallow sand aquifer are found in most of St. Johns County along the coast east of the coastal ridge and south towards St. Augustine where shell deposits with relatively high permeability occur at greater depths. Both St. Johns County and St. Augustine are planning future withdrawals from these shell deposits. Logs of test wells drilled by the U. S. Geological Survey indicate that as much as 28 feet of shell, sand, and marly clays capable of producing significant quantities of water occur southwest of St. Augustine. St. Johns County plans to produce an estimated 3.5 Mgal/d from a 21.5-acre well field within the shell-sand aquifer (Ground Water Age, 1979, p. 27). These high permeability zones of sand and shell thin in a westerly direction where Geraghty and Miller (1976) found transmissivities of less than 50,000 gal/d/ft in the nine-mile swamp area. T values as high as 300,000 gal/d/ft occur in the Anastasia Formation east of St. Augustine where shell beds of very high permeability are found.

Figure 26 shows data collected for four shallow wells within eastern St. Johns County. Chloride concentrations generally improve with increasing land surface altitude even at considerable depth. Well locations, from left to right, are progressively farther from the coast. Test drilling at Durbin Tower (SJ-500) showed the presence of 68 feet of clastic deposits of fine sands, organic pans, and low permeability clay lenses underlain by green, impervious clay. Static water levels are usually below 18 feet. SJ-493 and 494 are

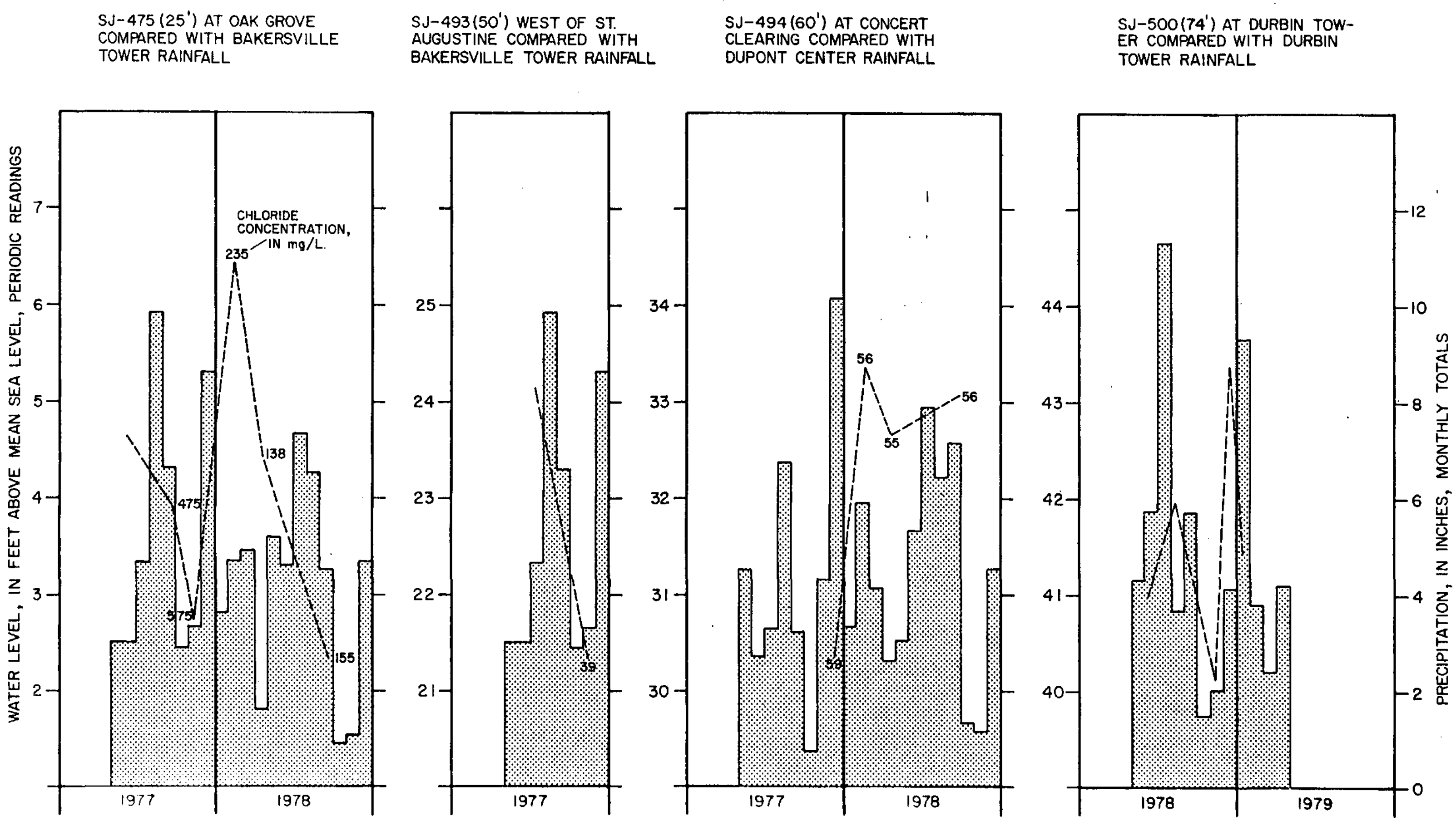


FIGURE 26. -- Periodic Water Levels, Chloride Concentrations, and Monthly Rainfall at Four Observation Wells in St. Johns County

northeast and southeast, respectively, of the proposed county well field.

SJ-475 is located in an area of transient intrusion problems. The freshening of water samples taken during 1978 indicate increased local infiltration creating a thicker fresh water lense. The source of the additional infiltration may be drain field infiltration, rainfall, or excessive lawn irrigation from other sources.

Cross-section D-D' (Figure 27) drawn through Faver Dykes State Park shows isochlor configuration within the clastic deposits. SJ-499 was drilled on a high sand hill west of the Park water supply. The water supply is marginal with chlorides rising above 250 mg/l during periods of high demand. The hill area contains large quantities of potable water in the shallow aquifer. Maximum yields were found 55 feet below land surface. The upper surficial clastics consist of 90 feet of fine to medium sands overlying the Hawthorn Formation. Chloride concentrations are less than 50 mg/l at 45 feet.

Figure 28 compares water level fluctuations for SJ-499 with rainfall within the Park. Under static conditions, the minimum water level appears to be approximately nine feet above mean sea level. A specific capacity value of 5 (gal/min)/ft of drawdown was calculated and indicates a T value of 8,000 to 10,000 gal/d/ft for the medium gray sand. The Park should have a sufficient water supply with approximately nine feet of allowable drawdown in an area far enough from the salt water/fresh water interface.

Sub-Area 10 -- Flagler County

Previous studies (Bermes, et al., 1963) have identified a multi-leveled aquifer system consisting of surficial sand aquifers generally less than 20 feet thick throughout the county, and a deeper, more permeable artesian-like, shell-sand aquifer below 50 feet. Along the Atlantic Coastal Ridge (Plate 1), permeable

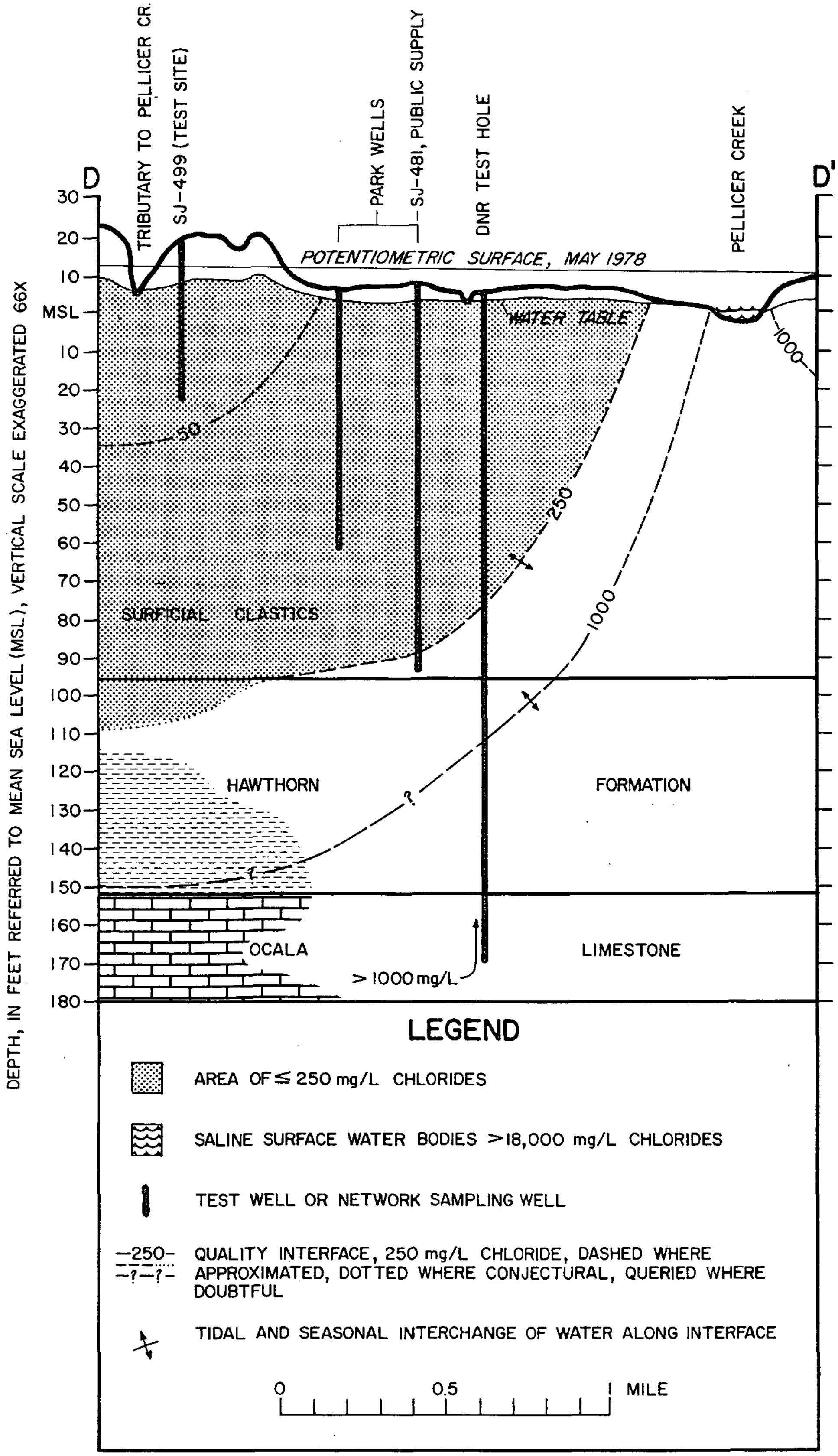


FIGURE 27. -- Cross Section D-D' at Faver Dykes State Park Showing Quality Interfaces

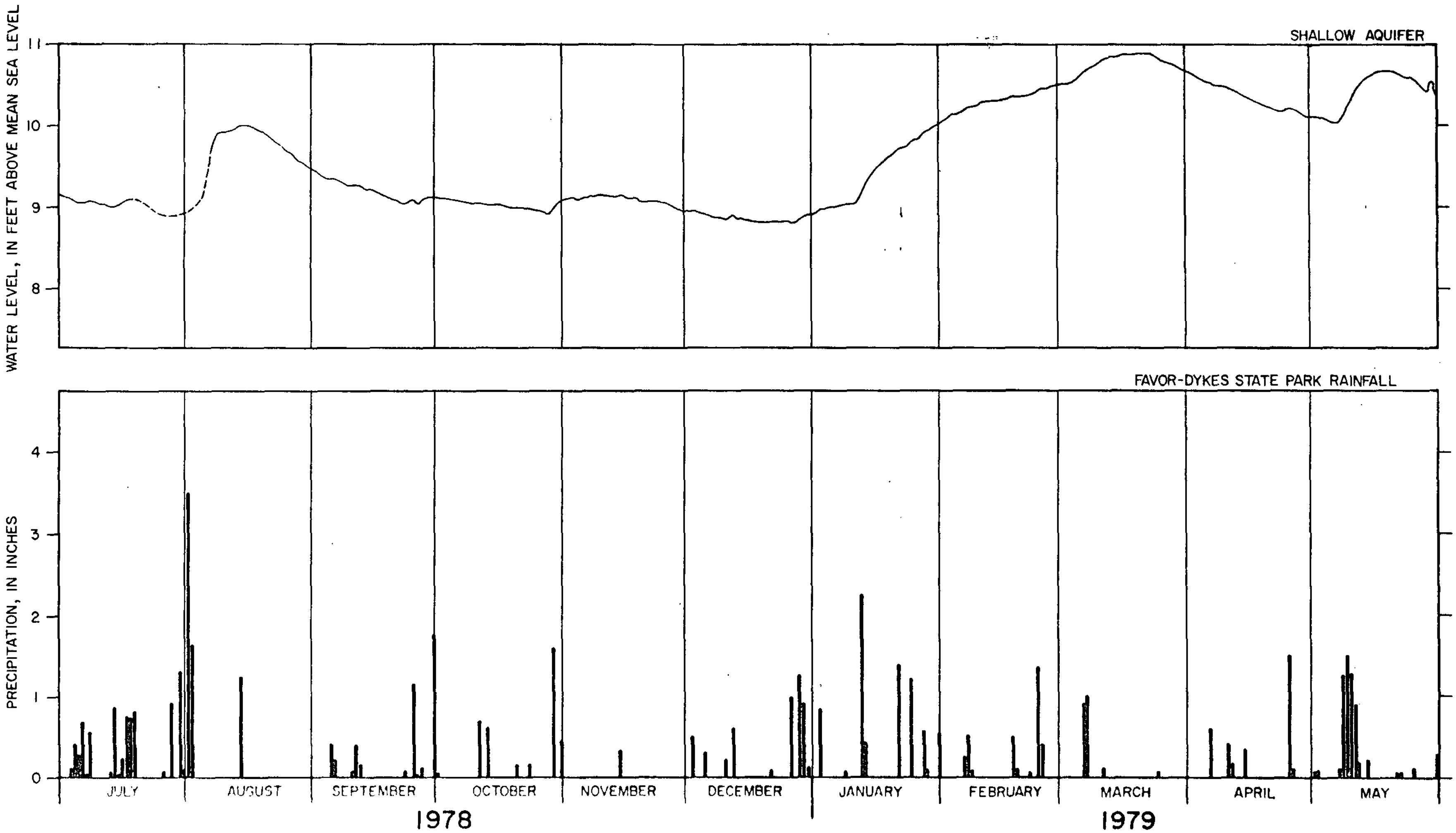


FIGURE 28. -- Water Level Fluctuations Compared With Local Rainfall at Faver Dykes State Park for SJ-499

zones of sand and shell thin to the west and thicken to the east. The most permeable zones appear to occur between 60 to 80 feet and 90 to 100 feet.

The high yield clastic deposits pinch out east of I-95 along the primary project boundary. Palm Coast consultants have concluded that a "low permeability barrier" may protect well fields west of I-95 from lateral intrusion (ICDC, 1978, p. 4-14). Test drilling at Bulow Ruins showed that clays increase east of I-95 and may provide some deterent to lateral intrusion.

However, maintenance of adequate local recharge will probably provide the most effective deterent against intrusion. According to CH2M Hill, recharge along the Talbot Terrace in Flagler County varies from 10 in/yr in the south to 12 in/yr to the north and central sections. U. S. Geological Survey studies in Volusia County (Knochenmus, 1971) indicate an average recharge rate of 13 in/yr.

Palm Coast will eventually incorporate large areas of eastern Flagler County and pump an estimated 30 to 50 Mgal/d from four proposed shallow and Floridan aquifer well fields. At Palm Coast the area of recommended clastic aquifer development (ICDC, 1978) outlined by CH2M Hill (Plate 1) was substantiated by application of a soil recharge delineation method (Plate 1) devised by Frazee (1979, sheet 6). The "highest relative permeability zones" discussed by Bermes, et al. (1963) also align favorably with the recommended area.

Optimum aquifer conditions are found along the north central section of the recommended area. Transmissivities range from 813 to 7,020 ft^2/d or 6,080 to 52,510 gal/d/ft with values increasing as the shell beds contain less fines and clays. Areas along the eastern boundary exhibit specific capacities of 0.8 to 3.7 (gal/min)/ft because of increased clay content, whereas high transmissivity zones to the northwest have specific capacities exceeding 20 (gal/min)/ft.

Knochenmus (1971, p. 31) estimated a storage coefficient of 0.25 for the clastic aquifer in Volusia County. This aquifer is equivalent to the surficial sand and shell aquifer and not the deeper shell sand zone in Flagler County which has a storage coefficient nearer artesian values ($S = 1 \times 10^{-4}$) according to CH2M Hill (ICDC, 1978).

The hydrograph for well F-164 (Figure 7) compares water level fluctuations in the shell-sand zone with local Floridan aquifer wells. Winter rains have provided recharge to the shallow aquifer as is evidenced by rises in water levels during the past two years (Figure 7). Note also that the summer wet season had been deficient except for July. Increased well field production coupled with continued deficit rainfall would limit maximum allowable well yields in future years.

Figure 13 shows cross-section A-A' that extends from the coastal ridge south of Palm Coast through Bulow Ruins to Flagler Beach. The 250 mg/l isochlor lies generally east of Bulow Ruins near Bulow Creek, and is affected by recharge along the coastal ridge that creates a fresh water wedge presently limiting westerly intrusion. The leaky confining beds of Hawthorn clay and weathered phosphatic limestone and shell allow insignificant upward leakage from the connately intruded Floridan aquifer because of small upward head differentials (Figure 5).

Figure 5 shows the rainfall at Bulow Ruins and water level fluctuations for the Floridan and shallow sand aquifers. It was found that rainfall recorded on the Deland Ridge (Figure 6) more closely correlated with the Bulow Ruins Floridan aquifer record.

A T/S value of 136,685 gal/d/ft was calculated from a 1978 recession period. Substituting a T value of 22,800 gal/d/ft, calculated from specific capacity data, an S value of 1.6×10^{-1} was computed. Work done by Gomberg (1978, p. 11) at Halifax Plantation (Plate 1, insert 3) to the southwest yielded a T of 26,000 gal/d/ft. At Halifax Plantation, the aquifer is almost twice as thick, and chlorides are less than half those at Bulow Ruins. Because only marginal potable quality water is now available at Bulow Ruins (Table A-2) in the secondary artesian aquifer, the park, at some future date, may wish to utilize the shallow sand aquifer as a supplementary or primary supply.

The greatest shallow aquifer concern in Flagler County is the effects of projected future development on the quantity and quality of the ground water resource. The eastern inland section of the county will undergo significant increases in water demand in the near future which will require employment of optimum management techniques to prevent westerly movement of the salt water/ fresh water interface.

GEOCHEMICAL PATTERNS OF THE COASTAL ZONE

INTRODUCTION

Analysis of water quality data was directed toward establishing the origin and distribution of chemical constituents found in waters of the various aquifers in the study area. To accomplish this, several methods of analysis were used including trilinear plotting, Stiff patterns, fence diagrams, and factor analysis. These methods allowed interpretation of the relationship of chemical parameters to the following: (1) origin of salt water intrusion (connate vs. modern), (2) identification of the fresh water/salt water interface, (3) lithology of the different aquifers, and (4) salt water intrusion resulting from ground water withdrawal.

One hundred and twenty-one well sites were selected for measurement of various chemical constituents, including 63 Floridan aquifer wells, 13 Hawthorn Formation wells, and 44 shallow aquifer wells. Samples were measured in the field for specific conductivity, temperature, pH, bicarbonate, and carbonate; and in the laboratory for chloride, sulfate, calcium, magnesium, sodium, potassium, fluoride, iron, strontium, and sulfide. Results of the analyses are presented in Appendix Table A-2.

To augment these data, chemical analyses from an additional 70 wells sampled by the USGS were included in the study. These samples represent water taken from the Floridan aquifer mainly in Duval and Nassau Counties. Analysis of these data is also listed in Appendix Table A-2. Because the 70 USGS wells were not tested for all chemical constituents previously mentioned, these analyses were utilized only in methods requiring measurements of major anions and cations.

GRAPHICAL METHODS

Graphical representation can be an effective method for comparing water quality analyses. Trilinear diagrams (Piper, 1944), Stiff diagrams (Stiff, 1951), and fence diagrams were used to demonstrate differences and similarities in water quality. The trilinear diagram was selected because general water quality types, intrusion, and other trends could be delineated. Stiff patterns were used in conjunction with the trilinear diagram to show specific changes in water composition between aquifers in intruded and non-intruded areas. A fence diagram was used to indicate boundaries of intrusion three dimensionally.

In trilinear plotting, the major ionic constituents (calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, and carbonate) are plotted as percents on a diamond-shape figure. The central field of the trilinear diagram, Figure 29, shows all water types which occurred throughout the area. Points representing samples from similar environments plotted together on the diagram. Each cluster of points is labeled according to which aquifer the samples are taken from and to degree of saline intrusion. Divisions on the diagram include fresh water, connate water, sea water, and transitional waters. The arrows indicate the direction of movement across the diagram that points will follow as the degree of intrusion, either by connate or sea water, increases. It should be pointed out that the divisions are general, and that exceptions are known to occur.

Back (1960, 1961, and 1966), while working on a ground water study in the Atlantic Coastal Plain, developed a classification scheme for the trilinear diagram which delineated various hydrochemical facies. A hydrochemical facies was defined as a means of describing the chemical character of water solutions in the various aquifers (Back, 1961). Terminology used to designate hydrochemical facies is shown in Figure 30. This terminology will be used to describe the various facies found in this section of the coastal area.

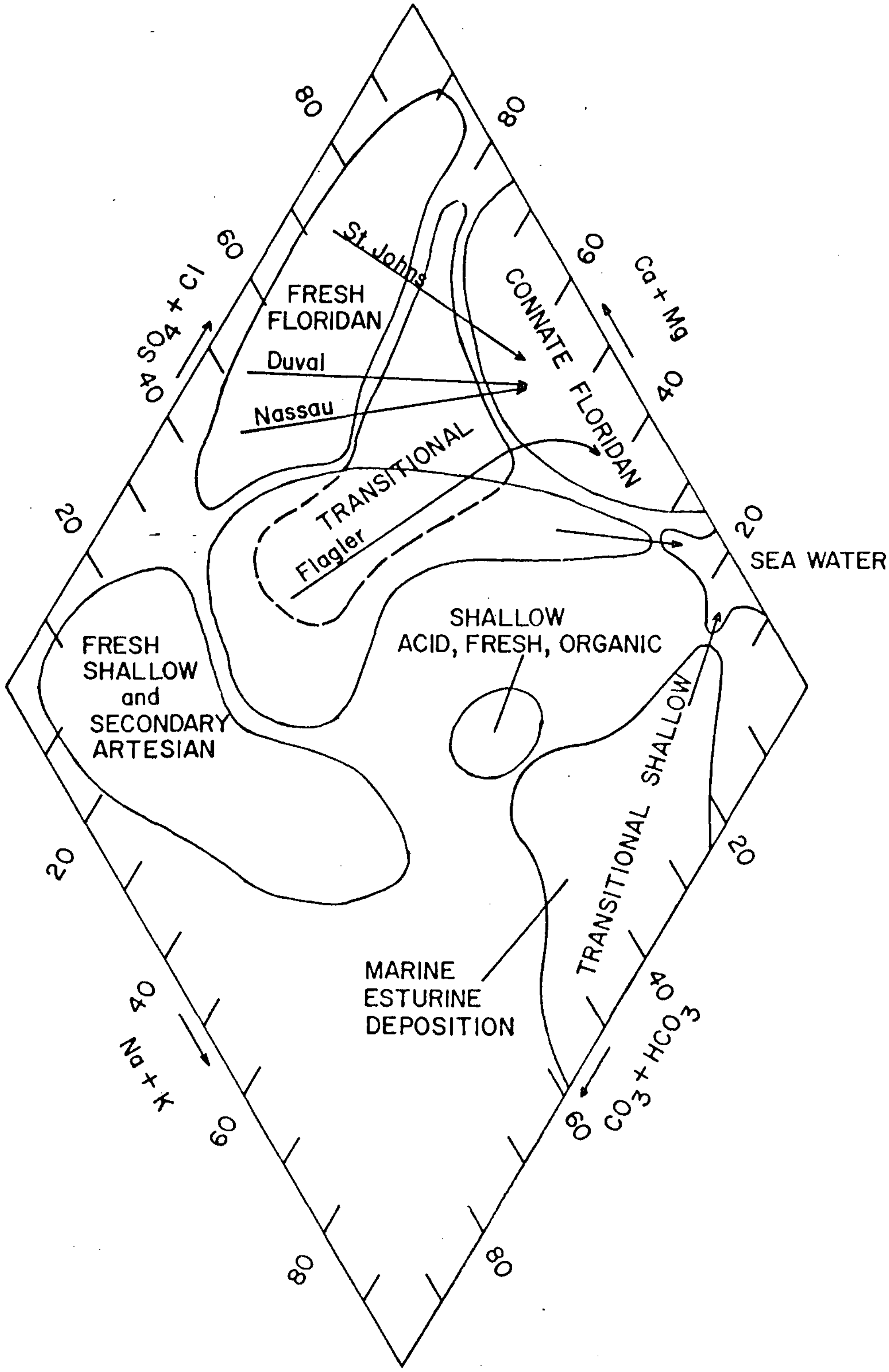


FIGURE 29. -- Classification of Water Types Found in the Study Area

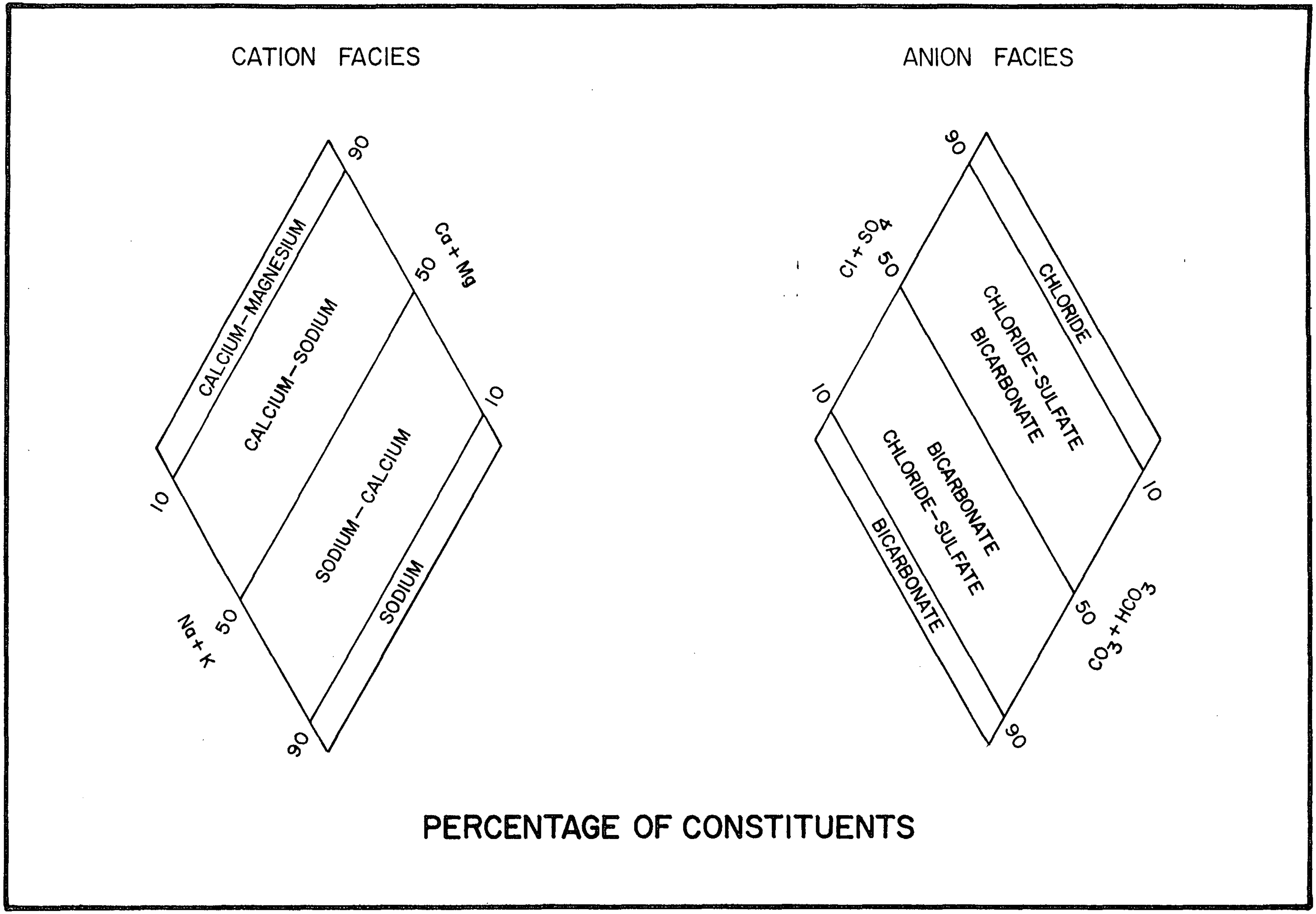


FIGURE 30. -- Terminology for Hydrochemical Facies

Due to the abundance of calcareous materials found in the aquifers of the study area, most waters sampled were of a calcium/magnesium or calcium/sodium character. As intrusion occurs, the water character grades into the sodium/calcium facies caused by the dominance of sodium ions in saline water.

Points representing samples from the shallow aquifer and secondary artesian system generally group together on the diagram (Figure 29). Fresh water samples from these aquifers are of a bicarbonate to bicarbonate/chloride/sulfate character. The bicarbonate ions are the major anion constituents and originate from the solution of calcium carbonate by percolating ground water made acid by dissolved carbon dioxide gas from the atmosphere and soil (Back, 1960, p. 91). Points clustering in the transitional area represent samples whose chemical character may be designated as bicarbonate/chloride/sulfate changing to chloride/sulfate/bicarbonate as salinity increases. Sea water and water from shallow wells presently being intruded by sea water are characterized by the chloride facies.

The major geochemical difference between waters from the shallow/secondary aquifers and the Floridan aquifer is the anion proportions. Compared to the predominantly bicarbonate type water in shallower formations, fresh water from the Floridan aquifer is mainly of the chloride/sulfate/bicarbonate type with sulfate being the dominant anion. Overall, dissolved solids in these fresh waters are low. Consequently, a minor increase in any anion can make it proportionally the largest. In this case, sulfate (the major anion) is being dissolved from minor amounts of gypsum in the Floridan aquifer. There are a few fresh water samples from the Floridan that were of a chloride character. These wells, having very low ionic concentrations, had slightly higher chlorides, making chloride the predominant anion.

Transitional Floridan water is delineated by the chloride/sulfate/bicarbonate facies as well, but is closer to the sodium/calcium cation facies than fresh Floridan waters as shown on the central field of the trilinear diagram

(Figure 29). As salinity increases in the transition zone from fresh to intruded type waters, the major anion constituent changes from sulfate to chloride; and as the water becomes highly saline, it grades into the chloride facies.

In summary, fresh shallow waters are of a calcium/sodium/bicarbonate character; and as intrusion takes place, there is a gradation into the sodium/calcium/chloride facies. Fresh Floridan waters lie in the chloride/sulfate/bicarbonate anion facies and calcium/sodium cation facies. When intruded, Floridan waters are in the chloride/sodium/calcium facies.

An objective of geochemical interpretation was to determine whether salt water intrusion has occurred as a result of modern lateral sea water intrusion or as a result of the upward migration of connate salt water trapped at the time of deposition or at times of higher sea level. As previously mentioned, sea water and saline shallow water are characterized by the same geochemical facies, i.e. their ion ratios plot in the same section on the central field of the trilinear diagram, which reinforces the idea that the presence of saline water in the shallow aquifer is caused by modern sea water encroachment.

To aid in the determination of connate intrusion, samples of Floridan water were taken in the inland farming areas of Putnam, St. Johns, and Flagler Counties and along the coast in the study area. Comparisons were made between inland intruded waters that may be of connate origin and saline Floridan waters collected on the coast that may have undergone modern sea water intrusion. Ionic ratios for all intruded Floridan water, whether inland or coastal, plotted together on the central field of the trilinear diagram but separately from the ionic ratios for ocean water and saline shallow waters. This suggests that saline Floridan waters sampled along the coast may not be of modern sea water intrusion but of a connate origin instead.

Interpretation of the central field of the trilinear diagram (Figure 29) suggests regional changes in the chemical character of Floridan waters. Most Floridan waters from the farming areas of Putnam, St. Johns, and Flagler Counties as well as the coastal areas of Flagler County and south St. Johns County are labeled "Connate Floridan". Floridan waters just north and south of St. Augustine are termed "transitional" as are waters from the Fort George Island area of Duval County. With that one exception, samples from Duval and Nassau and northern St. Johns Counties are labeled "Fresh Floridan".

There were a few exceptions to the trends discussed above. Samples from four Floridan wells in Flagler County (F-184, F-185, F-186, and F-187), classified as transitional, plot in the same area as transitional shallow and secondary artesian aquifer samples. This overlap is due to a higher concentration of bicarbonate than in other Floridan waters sampled.

Another point of interest about the central field of the trilinear diagram is the area labeled "Transitional Shallow Aquifer Marine Estuarine Deposits". This area is defined by the type of water sampled from four shallow wells (D-12, N-18, N-19, and SJ-485). Three of these wells were drilled by the District and are known to be completed below clay lenses in the shallow aquifer. Clays and oyster shells recovered during drilling have been interpreted as originating in an estuarine environment. These wells yielded water characterized by the sodium/calcium or sodium facies and had higher Na/Cl ratios than transitional shallow waters which were of the calcium/sodium facies. Higher sodium concentrations relative to chloride concentrations in the waters from these estuarine deposits are probably due to the exchange of sodium in the clay with calcium from the ground water.

To demonstrate in more detail specific changes in chemical composition between different water types, representative wells were chosen from each area, and Stiff (1951) patterns were plotted (Figures 31, 32, and 33). In Stiff patterns, there are four parallel horizontal axes extending from each side of a single vertical axis. The cations are plotted on the left side and the anions on the right side as milliequivalents per liter. The points are connected to give the diagram a pattern. Widths of the patterns are an indication of total ionic concentration (Hem, 1970, p. 260). Water from the same area would be expected to have similar characteristic patterns. This method is another means by which to compare and correlate water types, and is a good way to note chemical changes as intrusion occurs by observing changes in the patterns.

Figures 31, 32, and 33 demonstrate the relationships of the Stiff patterns to the areas on the central field of the trilinear diagram. In the upper left hand corner of each figure, the cation and anion sequences used for the "patterns" are listed. The base scale is also shown. Patterns labeled 1X are plotted to the base scale. Other scales used were 5X (five times base scale), 10X (ten times base scale), and 50X (fifty times base scale).

All Stiff patterns in Figure 31 represent water from the Floridan aquifer. Differences in patterns from fresh to saline Floridan waters are illustrated. Well SJ-434 is a fresh Floridan well and contains low amounts of sodium and chloride. From the transitional group, Well SJ-412 has slightly higher sodium and chloride concentrations. Moving into the intruded section, water from that area, accordingly, has great increases in sodium and chloride. In general, most intruded Floridan waters are low in bicarbonate and have substantial amounts of sulfate. One interesting item to note is P-87 and SJ-430 have almost identical patterns. Well P-87 is in the inland farming area, and SJ-430 is on the coast. This, again, supports the theory that intrusion in both wells is of connate origin.

Stiff diagrams in Figure 32 are plotted from shallow water samples. Once again, sodium and chloride concentrations are low in fresh water and increase

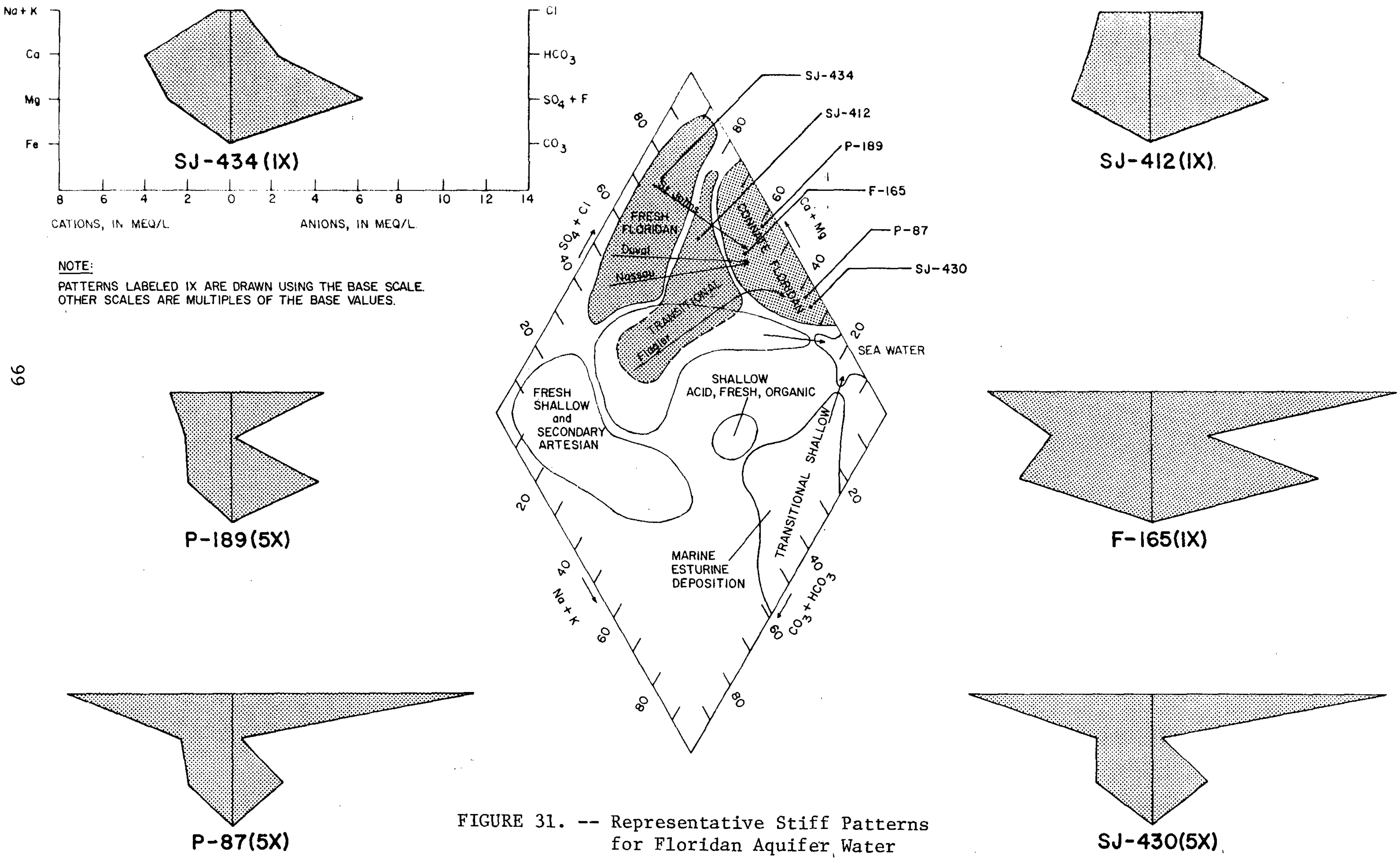


FIGURE 31. -- Representative Stiff Patterns for Floridan Aquifer Water

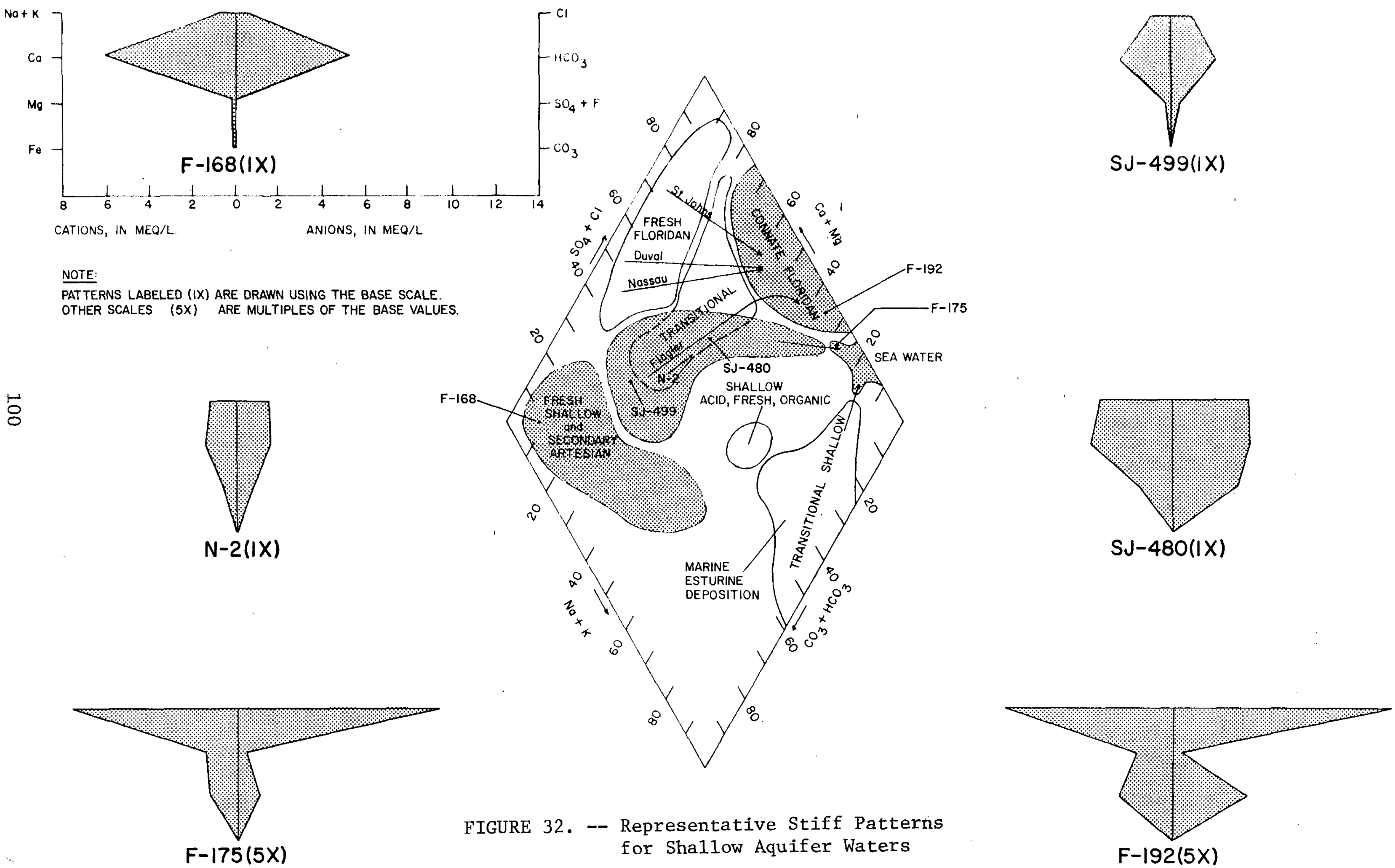


FIGURE 32. -- Representative Stiff Patterns for Shallow Aquifer Waters

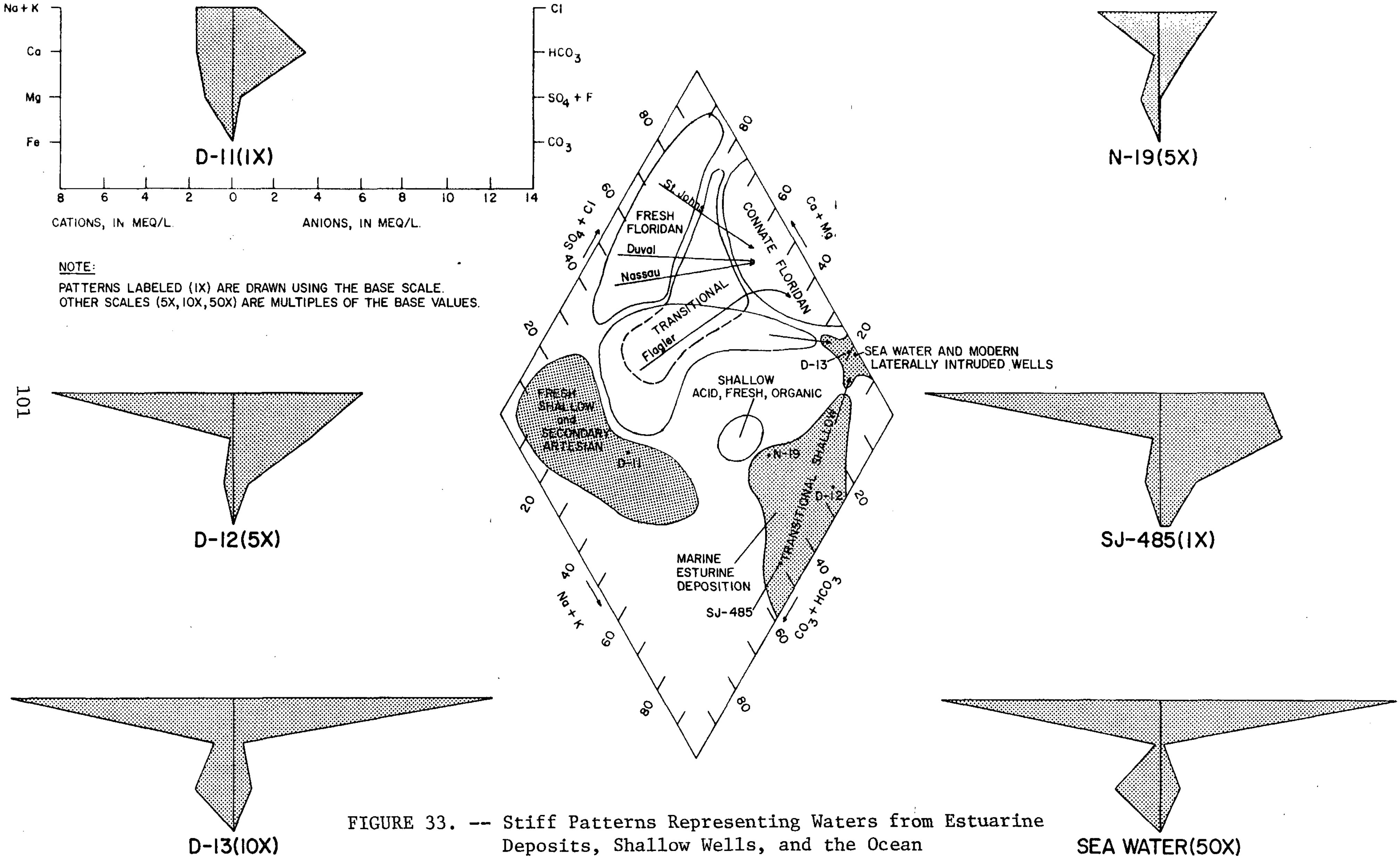


FIGURE 33. -- Stiff Patterns Representing Waters from Estuarine Deposits, Shallow Wells, and the Ocean

in transitional and intruded waters. Two differences are noted in the patterns for shallow and Floridan waters; these are the higher concentration of bicarbonate present in fresh shallow waters and the higher sulfate concentrations in Floridan waters. The Stiff pattern for well F-192 is more similar to connately intruded Floridan patterns in Figure 31 than patterns describing water from F-175. F-175, completed to a depth of 18 feet, is located on the coast and is intruded by sea water. Although shallow well F-192 is highly saline, it plots in the connately intruded Floridan section on the central field of the trilinear diagram. This is due to the fact that water from connately intruded Floridan wells used to fill nearby fish ponds has infiltrated the shallow coquina aquifer tapped by well F-192.

Stiff patterns for D-11, D-12, and D-13 are shown in Figure 33. As previously discussed, these wells were drilled at Little Talbot Island in close proximity to the coast. As depth increases with each well, so do chloride concentrations. The chloride concentrations for D-11, D-12, and D-13 are 38 mg/1, 1,060 mg/1, and 4,300 mg/1, respectively. The unique patterns for each well are shown in Stiff diagrams, and changes in each constituent are clearly illustrated.

D-11, N-19, and SJ-485 were mentioned previously as probably representing waters influenced by estuarine clay deposits. The patterns show a proportionately higher content of sodium to calcium.

The Stiff pattern for sea water is also presented in Figure 33. Note the similarities between sea water and the waters from wells D-13 and F-175 (Figure 32) that are intruded by sea water. Furthermore, note the difference between this distinct pattern and the patterns shown for F-192 (Figure 32), P-87 and SJ-430 (Figure 31), which represent Floridan connate waters.

It becomes apparent after examining the central field of the trilinear diagram and Stiff patterns that intrusion is one of the major processes affecting water type. A fence diagram, (Plate 3), was used to illustrate intrusion taking place in the study area. The fence diagram provides a three-dimensional means of illustrating the distribution of chloride in ground waters. The fresh water/salt water interface is delineated by the 250 mg/l isochlor, and the 1,000 mg/l isochlor is also shown. What follows is a discussion of chloride distribution in the Floridan aquifer.

In general, moving from Flagler Beach up the coast to just south of St. Augustine, chloride concentrations in the Floridan aquifer are above 1,000 mg/l. North of St. Augustine to Fernandina Beach, chloride concentrations are less than 250 mg/l; and in a small section of the Floridan aquifer around St. Augustine, chloride concentrations are between 250 and 1,000 mg/l.

In the east/west transect from F-174 to F-66, chloride concentrations range between 250 to 1,000 mg/l. In the vicinity of well PS-2, there is a small area where chloride concentrations are below 250 mg/l. This is probably caused by local recharge. Continuing north on the fence diagram, the next east/west transect shows chloride concentrations in the Floridan remain above 1,000 mg/l to the vicinity of well F-161 where they then range between 1,000 to 250 mg/l. Moving west starting at SJ-430, chloride concentrations decline from above 1,000 mg/l to between 1,000 mg/l and 250 mg/l, then to below 250 mg/l, and approaching the farming area, again increase to above 250 mg/l.

In the southwest inland section of the diagram, chloride concentrations in the Floridan range from 250 to 1,000 mg/l except in the intensely cultivated agriculture areas where chloride concentrations go above 1,000 mg/l. These higher chloride concentrations are caused by upconing of deeper saline water due to pumping (Munch, et al., 1979). In the north section of the inland area and in the northern most east/west transect, chloride concentrations in the Floridan are all below 250 mg/l.

STATISTICAL METHODS

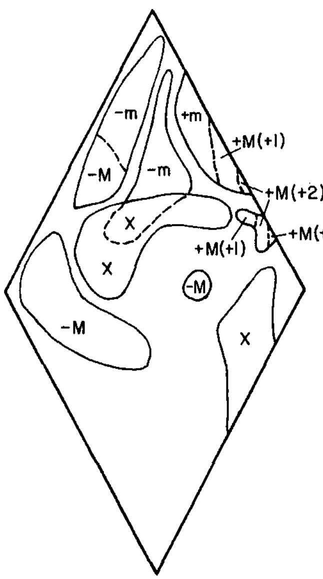
Factor analysis was used in the study to see if more information on the different water types could be obtained. The factoring method used was R-mode factor analysis with iterations (Davis, 1973). Orthogonal varimax rotation was performed with Kaiser normalization. R-mode analysis was employed to show the interrelationships among the variables (Klovan, 1975).

The graphical methods, trilinear plotting and Stiff patterns, present information on a limited number of variables (generally the major chemical constituents). With factor analysis, more variables can be analyzed to obtain additional information about the system and to reinforce interpretations made from graphical methods. Factor analysis has proven successful in other studies as a valuable tool for geochemical interpretation (Lawrence & Upchurch, 1976; Dalton & Upchurch, 1978).

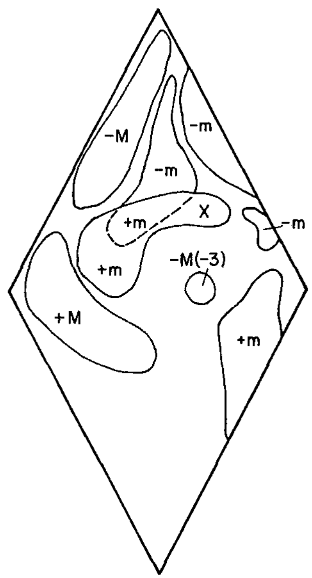
The basic function of factor analysis is data reduction. The factor analysis program first develops an array of correlation coefficients for a set of variables which, in the present study, is comprised of the eight major ion constituents used in trilinear plotting plus specific conductivity, fluoride, pH, iron, and sulfide. Carbonate was combined with bicarbonate because carbonate was present in only a few of the samples and only in very low concentrations.

By use of statistical techniques, variables are grouped into smaller sets of interrelated variables referred to as factors. In the study area, three factors were obtained; they represent the process-response relationships of intrusion, source conditions, and enrichment of fluoride from clay layers. These factors accounted for 79 percent of the variance in the data. The variables that comprise each factor are listed in Figure 34. A printout of the factor analysis run is presented in Appendix D.

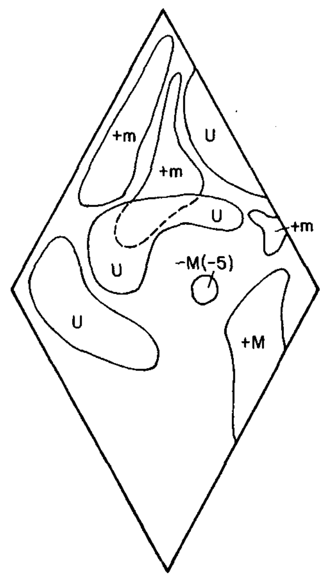
FACTOR I			FACTOR II			FACTOR III		
VARIABLES: SPECIFIC CONDUCTANCE, CHLORIDE, SULFATE, CALCIUM, MAGNESIUM, SODIUM, AND POTASSIUM			VARIABLES: BICARBONATE, CARBONATE, IRON, NEGATIVE SULFATE, AND NEGATIVE SULFIDE			VARIABLES: FLUORIDE AND pH		
POSITIVE	NEGATIVE	X OR U	POSITIVE	NEGATIVE	X OR U	POSITIVE	NEGATIVE	X OR U
CONNATE F, SEA WATER, AND INTRUDED S	FRESH F, TRANSITIONAL F, FRESH S, AND ACID S WELLS	TRANSITIONAL S, AND S ESTURINE	FRESH S, S ESTURINE, TRANSITIONAL S	S ACID, SEA WATER, F FRESH, TRANSITIONAL F, CONNATE F	INTRUDED S	ESTURINE S, SEA WATER, TRANSITIONAL F, FRESH F	S ACID	CONNATE F, INTRUDED S, TRANSITIONAL S, AND S FRESH



INTRUSION



SOURCE CONDITIONS



FLUORIDE ENRICHMENT

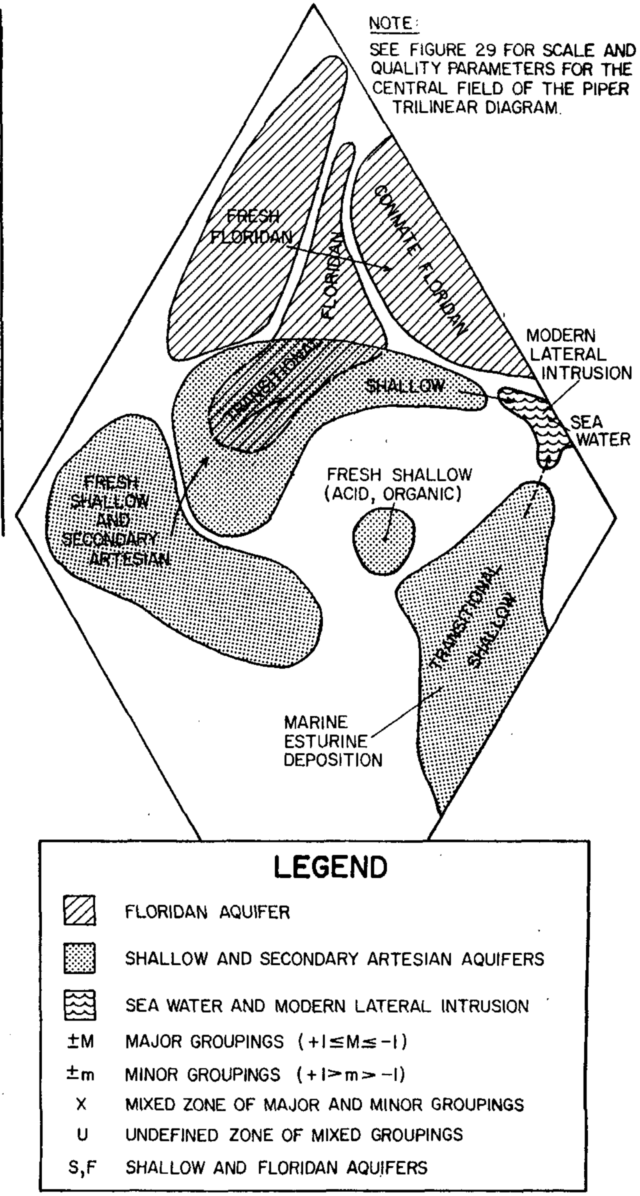


FIGURE 34. -- Distribution of Factor Scores for Each Factor and a Listing of Variables that Comprise Each Factor

After the factors were identified, factor scores were calculated for each sample. These scores indicate the importance of each factor (or process) at that sample site. To illustrate the relationships between the factors generated and water types identified by graphical methods, factor scores were plotted on the central field of the trilinear diagram. The technique of plotting factor scores on trilinear diagrams was first used by Dalton and Upchurch (1978) to indicate water quality trends. Figure 34 illustrates the distribution of factor scores for each factor on central fields of trilinear diagrams. Major groupings are defined as having a score equal to or less than -1 or equal to or greater than +1, indicating a strong negative or positive response, respectively, to the factor (Dalton and Upchurch, 1978, p. 229). Minor groupings have scores between 0 to -1 or 0 to +1. A mixed zone is a combination of positive and negative groupings. Minor groupings and mixed zones may indicate important trends. However, three zones of undefined mixed groupings occur for which no definitive trends could be established.

Factor I contains the variables specific conductance, chloride, sulfate, calcium, magnesium, sodium, and potassium. On Figure 34, Factor I shows a gradient from high factor scores in areas on the diagram representing saline waters to low factor scores in areas representing fresh waters; therefore, Factor I is interpreted to represent the process of salt water intrusion. Sea water has a socre of +3 with some fresh shallow and fresh Floridan waters having scores below -1; waters plotting in the transitional portions of the diagram have intermediate scores. Factor scores are negative toward the bicarbonate portion of the diagram and positive toward the chloride end. The factor analysis program indicates that Factor I is by far the most statistically significant factor identified. Factor I accounts for 53 percent of the variability in the data.

Factor II is represented by the variables bicarbonate, carbonate, iron, sulfate, and sulfide. Bicarbonate, carbonate, and iron load positively, while sulfate and sulfide load negatively, indicating an inverse relationship. As shown in Figure 34, factor scores for Factor II generally group positive for shallow waters and negative for Floridan waters. This indicates shallow waters are higher in bicarbonate concentrations than Floridan waters. The difference in bicarbonate concentrations may most conveniently be explained by the existence of different conditions in the source or recharge areas for these waters.

Samples of fresh shallow waters in the study area are generally higher in bicarbonate than Floridan waters. This may be interpreted as indicating the presence of carbon dioxide and possibly calcium carbonate in the soil horizons through which the source water percolates and the presence of calcium carbonate in the aquifers. However, in the noncoastal areas of Duval and Nassau Counties, shallow waters are not appreciably different in bicarbonate than the fresh Floridan waters (from that area) and are lower in bicarbonate than other shallow waters in the study area. Shallow aquifers in these areas contain lower amounts of calcium bicarbonate; this is thought to be because they consist mainly of sand, whereas in St. Johns and Flagler Counties and along the coastal areas of Duval and Nassau Counties, the shallow aquifers contain a larger proportion of shell which may account for the higher bicarbonate concentrations.

Collectively, most Floridan waters were lower in bicarbonate than shallow waters even though the Floridan aquifer has an abundant supply of calcium carbonate. This can be explained by assuming that conditions at the source areas for waters recharging the Floridan were not conducive to the formation of carbonic acid. These conditions may be due to either rapid infiltration of rain water through highly permeable sands of low concentrations of acid producing organics in the soil or both. Factor scores for fresh Floridan waters were -1 or below and approximately -.8 to -.9 for transitional and connate Floridan waters with the exception of connate waters sampled from south Flagler County. These samples had negative factor scores approaching zero which indicates higher bicarbonate concentrations. South Flagler County is the only area in the study receiving recharge from the Deland Ridge where conditions may be more conducive to the formation of bicarbonate.

Sea water had a negative factor score for Factor II due to a high sulfate concentration and a lower bicarbonate concentration. As shallow waters plotted closer to sea water, scores for Factor II graded from positive to negative, suggesting dilution from sea water. Factor III is comprised of the variables, fluoride and pH. On Figure 34 Factor III is most strongly indicated in the section labeled "Transitional Shallow Marine Estuarine Deposits". These waters contain relatively high concentrations of fluoride thought to be derived from solution of fluorapatite minerals associated with interbedded clays. Factor scores for fresh Floridan water were also positive for Factor III. Where these water samples were obtained, the Hawthorn Formation is thick, and many wells are completed just below the Hawthorn/Floridan contact. The higher fluoride concentrations observed in these wells are thought to be derived from solution of fluorapatite minerals associated with clays in the Hawthorn Formation. Factor scores for fresh secondary artesian and shallow waters on Figure 34 are mixed (plus and minus) which is consistent with the variable stratigraphy associated with the shallow and secondary artesian aquifers.

Because of a slightly higher pH and fluoride concentration, sea water also yields positive scores for Factor III. The factor score for water from the shallow acid well is extremely negative for Factor III due to the low pH of the water.

In addition to determining the relationship between the major ions and additional variables not included in the graphical methods, and providing a means of relating each sample to each set of interrelated chemical variables, factor analysis supported interpretations previously formulated by graphical methods.

AVAILABLE POTABLE WATER RESOURCES

Generally, potable water is available area wide in one or more of the aquifer systems discussed previously. The availability of the resource depends on aquifer characteristics and water quality.

SAFE YIELDS

Ground water is a renewable natural resource. As with other resources, management is necessary to maintain supplies of potable drinking water for future generations. Thomas (1951), over 25 years ago, emphasized that aquifer overdraft constitutes the largest ground water problem in the United States. Ground water management in coastal areas of the District is essential if existing potable ground water supplies are to be available in the future. Use of safe yield concepts can provide the necessary philosophy to successfully manage the ground water resource in the coastal areas.

Safe yield may be thought of as "the amount of water which can be withdrawn without producing undesirable effects", (Walton, 1970). Safe yield is affected by a number of factors including: (1) economics, (2) water level fluctuations, (3) decreasing natural discharge, (4) changing locations of major discharge points, or the effects these points have on the potentiometric surface and basin shape, (5) developmental stress in recharge areas affecting the areal size of the areas, and (6) vegetational or crop variation in recharge areas.

Long term overdrafts remove water from storage in excess of long term average recharge. This causes landward and/or upward movement of the fresh water/salt water interface at a rate dependent on the magnitude of the overdraft and the change in hydraulic gradients.

Safe yield approximations are usually not correct for extended periods. Because many critical parameters used in safe yield calculations are in a constant state of change, the approximation should be periodically refined as increased knowledge of the system becomes available. Even so, use of the safe yield approximation is considered a useful tool with which to approach ground water basin management.

To prevent landward or upward movement of the salt water/fresh water interface, carefully derived, technically sound drawdown restrictions are necessary. The designation of maximum allowable drawdown for a particular aquifer is a function, in part, of the safe yield determination. Areal applicability of the drawdown figures depends on the regional continuity of the aquifer and aquifer parameters. Current thought sets the maximum drawdown limit at mean sea level for all aquifers where coastal hydraulic gradient changes are possible; therefore, allowable drawdown is dependent, in part, on the distance the fresh water surface is above mean sea level. In selected pumping cones, modifications of this guideline may be possible. Safe yield will decline where pumping centers are closer to the salt water/fresh water interface and will increase as pumping centers approach recharge areas.

Floridan aquifer safe yield approximations are dependent on area-wide estimates of recharge, designation of major discharge points, and definition of current ground water basin boundaries. It must be stressed that the approximations listed in this report are preliminary figures based on available knowledge and subject to modification as new studies are completed. Figure 35 delineates major discharge points and current ground water basin boundaries in the study area. Table 9 lists approximations of safe yield, recharge, water use, and overdraft percentages where applicable. The Simpson method (Simpson, 1946) referred to by Todd (1960, p. 208-211) was used to calculate minimum ground

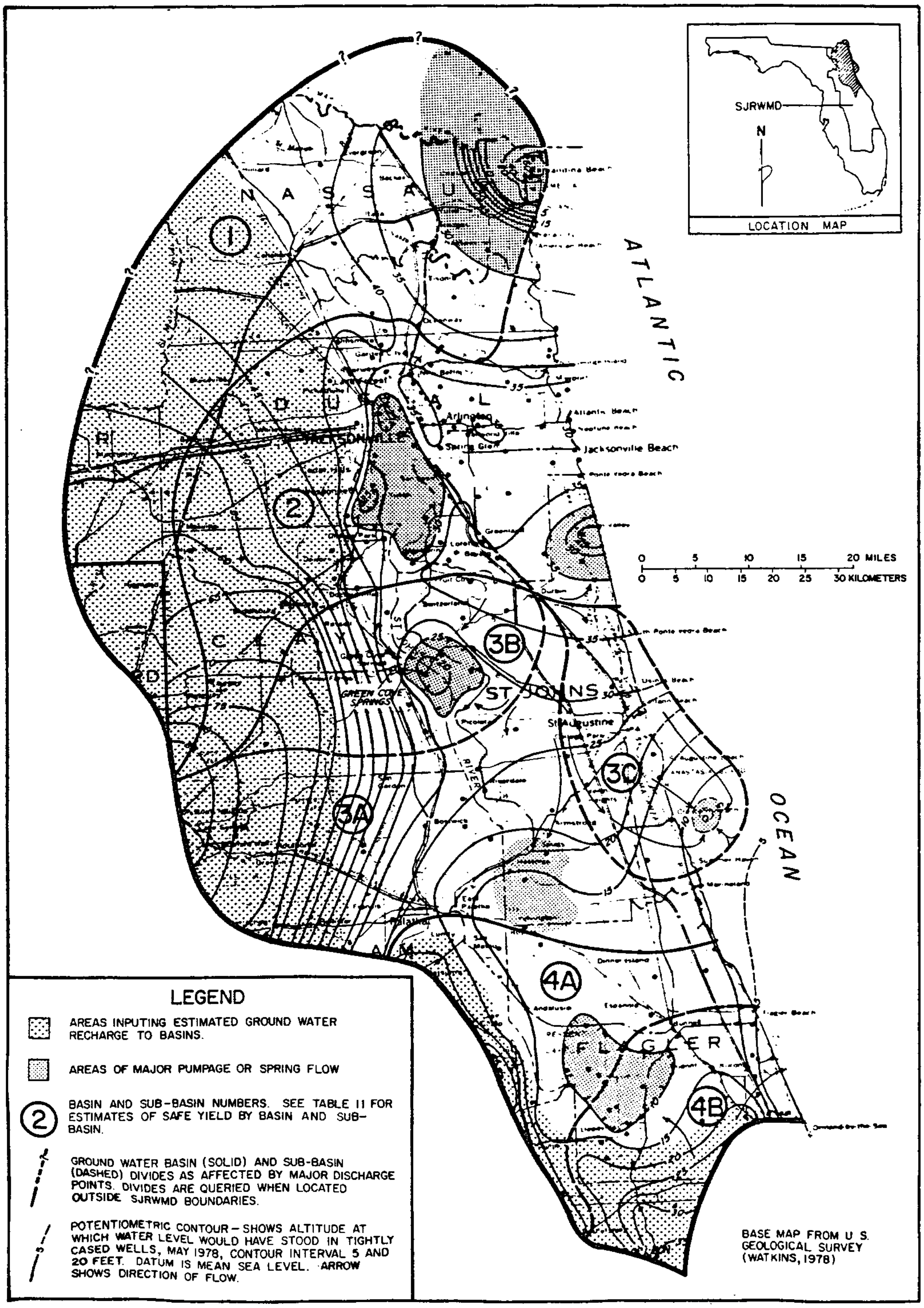


FIGURE 35. -- Ground Water Basin Divides in Northeast Florida Showing Major Discharge Points

TABLE 9. -- Approximations of Safe Yield, Recharge, and Overdraft for Indicated Ground Water Basins

Basin No.	Available Recharge Rate (Mgal/d)	Probable Safe Yield (Mgal/d)	Water Use (Leach, 1978) 1975 (Mgal/d)	Overdraft (%)
1	180[b]	150[a]	110[b]	--
2	159	150 + 130[a,c] (280)	142	--
3A	81.0	55	82	33
3B	22	9.0	2	--
3C	d	d	15-30[e]	--
4A	13	6	4-5	--
4B	50.0	34	4-6	--
	$\pm$ 510	534	359-377	

NOTES:

(a) Approximations of safe yield for Basins 1 and 2 are dependent on the hypothesized discharge boundary with sea water 74 miles offshore, the quality of ground water east of the Fernandina cone, and the impermeable nature of dolomitic beds below producing zones for both basins. See text for discussion and Appendix E for criteria.

(b) Estimated recharge potentially entering Fernandina cone from Georgia is included, but a significant quantity is probably consumed by Georgia industrial complex near the northern cone boundary. A percentage enters Fernandina area near the northeast and east boundaries. Georgia pumpage is added to Leach (1978) figures.

(c) Safe yield in excess of available recharge rates includes estimates or probable induced flow from lower potable zones in the Floridan aquifer in the Jacksonville cone area.

(d) Recharge rate is dependent on excess from 3A, 3B, and 3C, and basin diversion from Basin 2. Safe yield extimates will be extremely variable and relatively low due to the offshore spring discharge, the effect of withdrawals on the connate interface located at St. Augustine, and the changing recharge input from 3A, 3B, and possibly 2.

(e) Figures are dependent on actual offshore spring discharge which is presently estimated.

water basin safe yield approximations. This method is designed for a pumping trough in a coastal aquifer such as occurs in northeast Florida where the recharge enters the aquifer upgradient, moves seaward to a coastal interface, and is intercepted by discharge cones potentially causing gradient changes seaward of the discharge point. Due to the probable discharge point of Floridan aquifer water along the continental slope in Basins 1 and 2, Simpson values were given reduced significance and a probable safe yield criteria (calculated or assumed) (see Appendix E) was used.

The four basins shown on Figure 35 are further divided into sub-basins where more than one major discharge point affects the main basin. Basin 1 includes the Fernandina Beach cone (Table 9). Withdrawals are centered near the coast, partly from wells in Nassau County and partly from wells in Camden County, Georgia. Current data indicates long term stable quality in the upper Floridan aquifer above 1,150 feet. Movement and/or location of the 250 mg/l isochlor towards the eastern cone boundary is only hypothesized at this time. Intrusion potentials for both lateral and connate intrusion are low (Plate 2), and current probable safe yield approximations are not being exceeded (Table 9). Basin 2 includes the City of Jacksonville cone. Water use in the basin is presently below even minimal calculated safe yield approximations.

In parts of Basins 2 and 3B including eastern Clay County, Foster (1961) indicated that 30 Mgal/d moves from the Floridan aquifer into the upper clastic aquifers through poorly constructed wells. If this figure is correct, Floridan water in storage has decreased and would have an effect on Basin 3B and 2 safe yield figures. It appears the Basin 3B safe yield approximation reflects a larger potential withdrawal than is indicated by the estimated water use of 2 Mgal/d. The Simpson method takes into account the potentiometric decline which is probably affected by this decrease in storage. This loss from storage would also suggest a reason for the calculated low safe yield approximation which is only 40.5 percent of the estimated recharge rate.

Basin 3A reflects the agricultural pumping stress near Hastings. The current safe yield approximation of 55.3 Mgal/d for the entire basin is exceeded by 33 percent. The Hastings area draws an estimated 29 Mgal/d, while the basin appears to have a total draft (1975 figures) of 82 Mgal/d. Estimates are based on Leach (1978). Current changes in well depth through partial plugging of wells will improve quality, and basic changes in irrigation practice should help reduce overdraft conditions within Basin 3A. Sub-basin 3C delineates the flow towards the Crescent Beach offshore spring. Safe yield estimates are difficult to calculate for this sub-basin due to possible diversion from Basin 2 and assumed underflow towards the spring. It appears this sub-basin received discharge from sub-basins 3A and 3B supplemented by seasonal quantities from Basin 2 dependent on Palm Valley area potentiometric fluctuations.

Basins 4A and 4B appear to have withdrawals of 79 and 18 percent of their safe yield approximations of 6.3 and 33.8 Mgal/d, respectively. The Bunnell cone of depression receives recharge from both sub-basins. Current approximations of safe yield are favorable for future development in sub-basin 4B where two major developments will be constructing well fields.

A critical problem exists in parts of sub-basins 3A, 4A, and 4B where excessive pumpage from concentrated points of agricultural withdrawal (Figure 1) and excessive well depth encourages upward movement of connate water. Studies have shown that wells in current problem areas should be less than 300 feet in depth. Studies by Munch, et al., (1979) showed that a high percentage of the flow in deeper wells comes from the top 50 feet of limestone. Therefore, adequate supply is usually available with shallower penetration.

Water supply in the coastal area is in a precarious balance south of St. Augustine, and extreme care should be taken during planning processes to prevent or limit movement of the salt water/fresh water interface either laterally or upward. The position of the interface at St. Augustine is illustrated on Plates 2 and 3. The location of the connate/fresh water interface is dependent, in part, on the flow within sub-basin 3C being directed towards the offshore spring. It is hypothesized that diversion of flow from sub-basin 3C by peripheral development could affect not only the quantity of spring flow but also ground water quality in the St. Augustine area.

Safe yield approximations for the shallow aquifer are difficult due to the variable nature of the system. In comparison to the Floridan aquifer, shallow aquifers are localized. Shallow sediments are also more susceptible to lateral sea water intrusion, hydraulic gradient changes, and seasonal fluctuations. The key to shallow aquifer management will be to require that drawdown allowances not exceed mean sea level. Each localized use will have to be evaluated independently.

WITHDRAWALS AND SALT WATER CONTAMINATION

Two areas within the primary project boundaries show indications of salt water intrusion at varying levels within the Floridan aquifer possibly related to pumpage: Fernandina Beach and Fort George Island. At Fernandina Beach, industrial pumpage has caused a large cone of depression as outlined previously in Figure 35. Current water use is thought to be within safe yield approximations. Fairchild and Bentley (1977) graphically illustrated the growing cone of depression shown on Figure 36. The central apex of the cone may not be as severe as the figure shows, depending on the selection of wells and the interpretation of recent potentiometric maps.

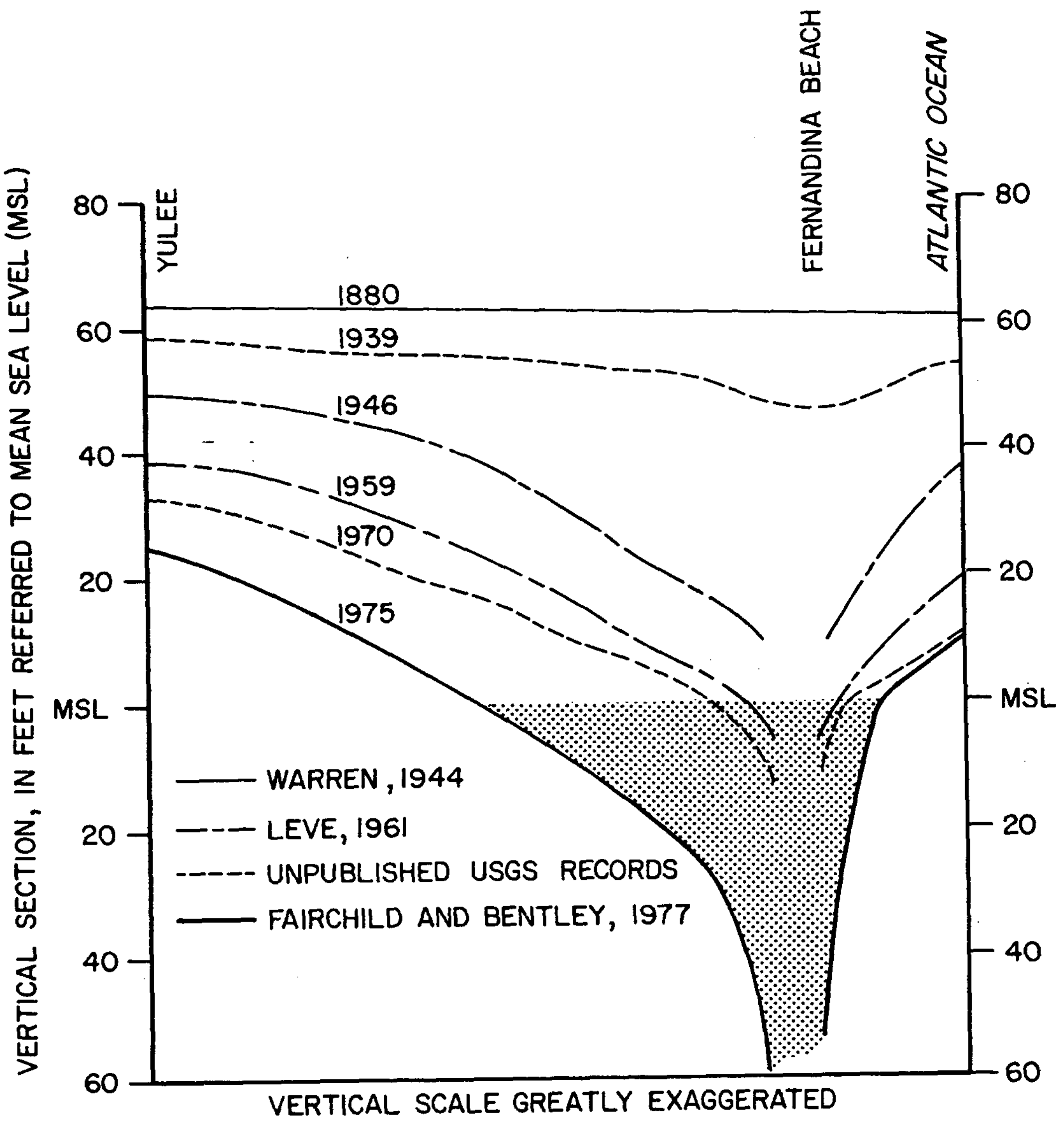


FIGURE 36. -- Cross Sections of Cone of Depression Between Yulee and Fernandina Beach for Several Measurement Periods

U. S. Geological Survey data (Fairchild and Bentley, 1977, p. 21) previously published documented increases in chloride concentrations in the deeper zones. Chlorides in the 1,820-foot zone have increased as much as 30 times the original level recorded in 1940 of approximately 30 mg/l. At 1,700 feet, chlorides have increased more than 400 percent during the period 1940-1975. This relationship of lower zone increases to upper potable zone stability was also documented in Tibbals and Frazee (1976) for a salt water monitor well. The impermeable dolomitic layers are apparently maintaining this zonal separation based on long term data.

Leve (1966, p. 46) stated that "a much greater danger than lowered pressure is that highly mineralized water would enter the zone of reduced pressure either vertically from deeper highly mineralized zones in the aquifer system or laterally from the ocean and contaminate the existing fresh water supplies in the aquifers." Current data both from U. S. Geological Survey sources and R. W. Harden (1979) now dispute this conclusion and consider the intrusion potential from both sources low as depicted on Plate 2.

A flow net analysis based on the regionalized potentiometric contours (Watkins, et al., 1979) of the steep eastern edge of the cone of depression at Fernandina Beach yields a low estimated T value of 7,000 ft^2/d or 53,000 gal/d/ft. The regionalized nature of this map allows only gross estimates of T values. The steep easterly side of the cone is apparently due to lower T values, and induced flow is occurring from the seaward side at a rate estimated to be 10-24 Mgal/d. Inward migration of outer cone water estimated to be five miles offshore may occur at a calculated rate of 56 years/mi or 280 years from the outer cone to Fernandina Beach. Data are not available further offshore to extent or improve the validity of these calculations. The above approximations indicate and reinforce the idea that a low lateral intrusion rate exists.

The change in head between the shallow and deep aquifers is increasing the potential for induced recharge of locally intruded water from the shallow to the Floridan aquifer (Figure 22). The potential for this problem exists, but its magnitude is thought to be insignificant due to impermeable Hawthorn clays.

Vertical migration of saline water upward from lower zones will be prevented as discussed by Leve and other authors by backplugging selected deeper wells to depths above the dolomite zones of the Avon Park Limestone. This places a maximum advisable depth of 1,150 feet to stay within guidelines for potable water supplies.

New data in R. W. Harden (1979) indicates little or no increase in chloride concentrations in the upper Ocala zone above 1,200 feet. The report states "no upward movement of poor quality water from the 1,200-foot zone has resulted from 40 years of pumping and more than 200 feet of artesian pressure decline." The upper zone is isolated from the lower high salinity zones due to impermeable dolomitic strata. The R. W. Harden (1979) report concludes that increases in chlorides in wells tapping both shallow zones and zones below 1,200 feet "were caused by interference effects due to increased pumpage" from wells tapping only shallow zones.

On Fort George Island, an isolated connate intrusion problem exists as a result of irrigation pumpage. Geochemical analysis of well waters in the affected area indicate a transitional stage of intrusion (Plate 2). A plume of intruded water follows the flow patterns within the Floridan aquifer. Nearby wells within the plume are affected by the local pumping activity. Figure 37 shows the effects of the irrigation pumpage at well D-164. Although pumpage is now reduced and the well is showing a definite potentiometric pressure recovery, the chlorides have continued to increase to the present peak of 200 mg/1. Geraghty and Miller indicated in their 1977 report that 1.5 Mgal/d appeared to be a maximum safe yield for the area. Precautions such as backplugging wells, eliminating any future water intensive developments, and strictly enforcing the City of Jacksonville recommendations limiting further well development on the island should be undertaken.

Problems of connate intrusion along the coast will intensify where safe yield approximations are not judiciously applied. In order to prevent worsening of an already tenuous situation in areas such as Fort George Island, demands for additional water will have to be met by water importation and/or desalinization.

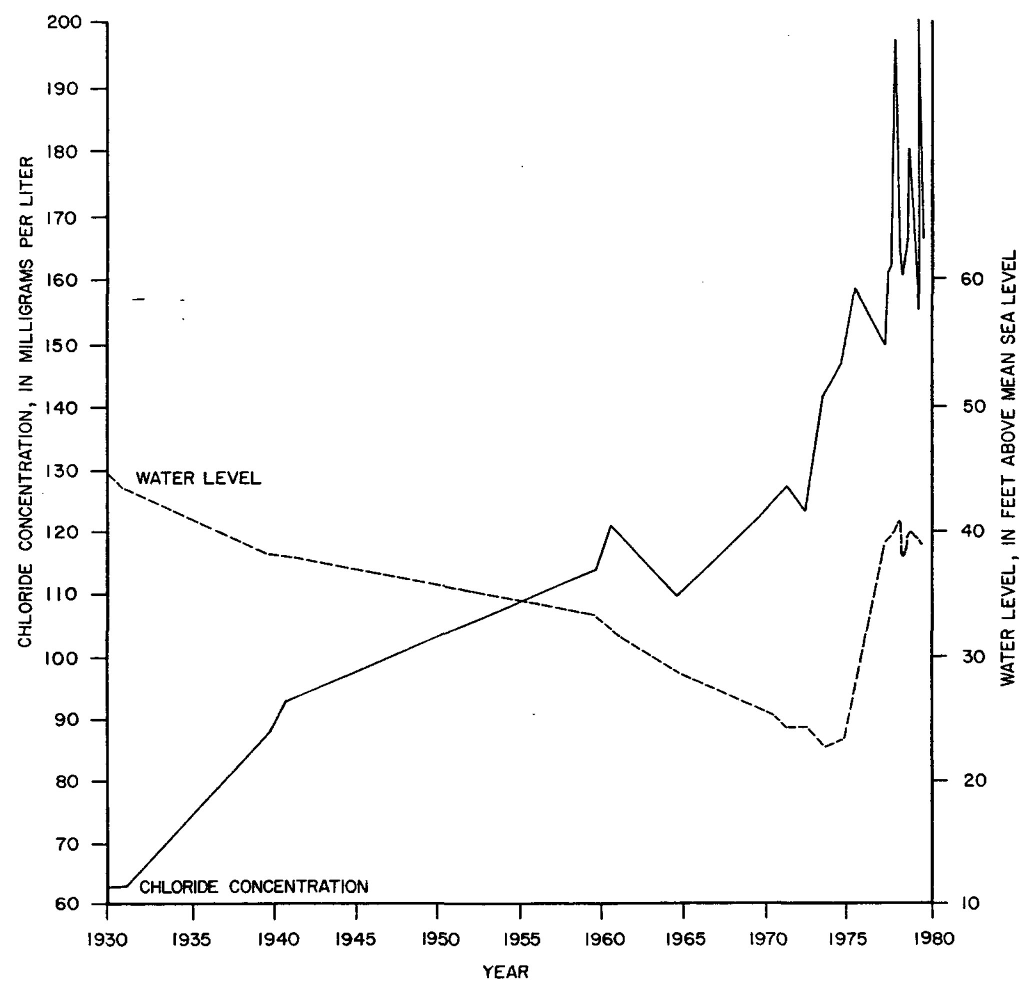


FIGURE 37. -- Water Level and Chloride Concentration for Well D-164, Fort George Island

SUMMARY AND CONCLUSIONS

Three aquifer systems are found in the study area. These include the Floridan aquifer, secondary artesian, and shallow clastic or water table aquifer.

Available potable water resources in the Floridan aquifer were estimated by safe yield approximations for designated ground water basins. Safe yield is the amount of water which can be withdrawn without producing an undesirable result. Safe yield varies depending on the method chosen and on the assumptions used in the calculations. Probable estimates of safe yield in the study area may be as high as 534 Mgal/d, while area-wide use is estimated to be 359-377 Mgal/d. The shallow aquifers are too variable to assign areal values of safe yield. The Floridan aquifer is the most dependable water source, while the shallow aquifer exhibits the greatest sensitivity to intrusion and surface pollution.

Floridan aquifer water level declines have averages 0.4 to 1.2 ft/yr since the middle 50's with declines of up to 2.9 ft/yr during the recent decade. During the same period, rainfall at Gainesville, which is located near the recharge area, had a rainfall deficit approaching 40 inches.

The Lakes Region of southwest Clay, northwest Putnam, and northeast Alachua Counties contributes the greatest portion of recharge to the Floridan aquifer of the project area averaging 12 in/yr or more. The Fernandina Beach cone receives significant quantities of recharge from southeastern Georgia. Shallow clastic aquifers in the project area respond to local recharge.

Lines of equal chloride concentration (isochlors) were plotted on seven of eight cross sections along segments of the coast. A large scale plate illustrates chloride distribution three-dimensionally on a fence diagram of local geology. "Areas of vital concern" are proposed for major aquifers within the project area.

Geochemical interpretations demonstrated that traditional descriptive and modern statistical techniques are useful approximating methods when attempting to differentiate between connate and lateral intrusion sources. Over a long period of record, trends may be identified and plotted. Waters in the Floridan aquifer were designated as fresh, transitional, or connately intruded based on their plotted location in the central field of the trilinear diagram.

Conditions in the coastal areas of Flagler, St. Johns, Duval and Nassau Counties are summarized in the following sections.

FLAGLER COUNTY

The shallow clastic and secondary artesian aquifers, and the Bunnell agricultural area were proposed as "areas of vital concern". The shallow clastic aquifers are the principal source of potable water where the Floridan aquifer is intruded. The secondary artesian aquifer provides an alternate source where inland shallow aquifers yield low quantities of water.

Although quantity of Floridan aquifer water is not a problem throughout the farming area, quality deterioration at depths below 300 feet does limit supply. The upper 50 feet of aquifer provides ample quantities of water; therefore, with proper well construction, the risk of intrusion by deep well penetration can be minimized. Floridan aquifer waters of potable quality can be tapped from the Atlantic Coastal Ridge near the northern limit of the Deland Ridge potentiometric high.

Barrier island water supplies in the shallow clastic aquifer are limited. Supplemental supplies or advanced treatment will probably be necessary for further development. Currently, the two major water quality problems of the shallow clastic aquifer on the islands are high iron concentrations and pollution of the aquifer by saline Floridan aquifer water in the "hammock area" south of Washington Oaks.

Atlantic Coastal Ridge shallow shell aquifers have the potential to supply more than 18 Mgal/d. These ridge areas also store significant quantities of local recharge which helps to stabilize the fresh water/salt water interface east of the ridge near the intracoastal waterway.

ST. JOHNS COUNTY

The coastal shallow clastic and secondary artesian aquifers, the Anastasia Formation, the Floridan aquifer transitional zone near St. Augustine, and the Hastings agricultural area were proposed as "areas of vital concern". The shallow clastic aquifers provide the principal source of potable water along the coastal islands where the Floridan aquifer is intruded south of St. Augustine. Inland the Floridan aquifer is stressed by large agricultural withdrawals and by overly deep wells, both of which result in connate intrusion.

The Anastasia Formation supplies the barrier islands with potable water in St. Johns County. It has been reported that transmissivities as high as 330,000 gal/d/ft are possible in the coquina aquifer. Maximum allowable withdrawals are estimated to be 1 Mgal/d without supplemental water from inland sources.

St. Johns County received Floridan water from two major ground water basins. Safe yield overdrafts reflect users outside the county in addition to the major agricultural withdrawals near Hastings. The agricultural use is emphasized due to the present connate intrusion problems in the farming areas.

The shell-sand aquifer along parts of the Atlantic Coastal Ridge can supply large quantities of potable water. A proposed county well field near St. Augustine will provide up to 3.5 Mgal/d. The shallow clastic aquifer at Faver Dykes State Park can supply ample quantities of water where the land surface is above 20 feet msl.

At Guana Wildlife Management Area, transitional quality Floridan water infiltrates the shallow clastic aquifer through pond augmentation. Similar shallow aquifer contamination occurs just north of Matanzas Inlet.

Offshore spring flow near Crescent Beach is reported to average 26 Mgal/d with a transmissivity of 1,386,000 gal/d/ft near the spring bore. Development near Palm Valley and along the Duval County line may affect both spring discharge and the fresh water/salt water interface located at St. Augustine.

DUVAL COUNTY

The coastal shallow clastic and secondary artesian aquifers, and the Fort George Island Floridan aquifer transitional area are proposed as "areas of vital concern". Local lateral intrusion problems occur in the shallow clastic aquifers. Excessive irrigation pumpage has caused the upward movement of connate waters on Fort George Island.

A plume of transitionally intruded water is affecting nearby landowners surrounding the Fort George Island Country Club. Water quality has deteriorated; presently chloride concentrations of 200 mg/l have been measured. The shallow aquifer system is also affected by irrigation infiltration of Floridan irrigation water through the shallow sands. Precautions such as backplugging wells, eliminating future water-intensive development, and strictly enforcing the City of Jacksonville recommendations limiting further well development on the island should be considered. Fort George Island safe yield estimates indicate 1.5 Mgal/d for the Floridan aquifer and 0.3 Mgal/d for the shallow clastic aquifer.

The shallow-rock zone is the most laterally extensive shallow aquifer in Duval County. The zone has the greatest potential as a supplementary water source, with transmissivities ranging from 1,870 to 9,700 gal/d/ft at selected test sites.

The ground water basin including the City of Jacksonville cone of depression is presently within safe yield approximations. Coastal development will play an important role in the future health of the Floridan aquifer as will overall county expansion. The Central Park Ridge recharge area separates the City cone from coastal withdrawals while acting as a buffer against cone expansion to the east.

NASSAU COUNTY

Coastal shallow clastic and secondary artesian aquifers, and the Fernandina cone of depression in the Floridan aquifer potentiometric surface are proposed as "areas of vital concern". In most areas near Fernandina Beach, local shallow clastic and shallow-rock zone wells provide potable water suitable for most domestic, irrigation, and light commercial uses. The Fernandina cone is a result of large coastal withdrawals. Based on current probable safe yield approximations, these withdrawals are within safe levels for the ground water basin including parts of Nassau County and that portion of southeastern Georgia included in the Fernandina cone.

The cone of depression surrounding Fernandina is causing a reversal of natural leakage patterns, increased mineralization at depths below 1,700 feet due to the presence of unflushed connate water, and a reversal in hydraulic gradients inducing flow from the east side of the depression cone. The cone boundary is estimated to be five miles offshore. Small quantities of laterally intruded shallow aquifer water may be leaking downward via damaged well casings towards the Floridan aquifer due to lowering of the Floridan aquifer potentiometric surface. This potential leakage is considered insignficant at the present time.

Industrial withdrawals comprise the major water use in the area. Water quality in the upper zones of the Floridan aquifer indicates little or no intrusion at this time. Recent studies have shown the need to limit well depth to less than 1,150 feet in the Fernandina area. Lower zones increase in chlorides and are therefore not recommended for potable supplies. The deeper zones below 1,800 feet indicate chloride concentrations 30 times higher than concentrations recorded in 1940 according to previously published U. S. Geological Survey reports.

RECOMMENDATIONS

1. Changes in water quality in the aquifers along the coast should be closely monitored.

2. Proposed "areas of vital concern" have been defined within the coastal zone (Plate 2). It is recommended that the District develop special management plans for these areas. Area 1 includes the Fernandina Beach industrial cone of depression. Area 2 includes barrier island and associated salt marshes inland and along the entire project area. Area 3 includes the Fort George Island Floridan transitional intrusion area. Area 4 includes the Anastasia Formation east of St. Augustine. Area 5 includes the connately intruded agricultural areas west of the primary project boundary and referred to in Munch, et al. (1979).

3. Key potable aquifers should be classified by their importance to users, and management plans should be developed to protect the resource.

4. Safe yield approximations should be regularly updated, and management plans should reflect current conditions.

5. Interaquifer pollution as a result of improper well construction should be controlled through owner cooperation when possible and through District enforcement action where practical. A current listing of known areas of interaquifer pollution should be kept by the District.

6. Where feasible, the use of shallow aquifer systems instead of the Floridan aquifer for geothermal heat pump development should be recommended strongly. A secondary use of heat pump discharge water is lawn irrigation which, in turn, recharges the shallow systems. In areas of marginal quality, return well systems should be required to minimize further saline intrusion.

7. Large users of ground water should be studied closely. Recommendations for alternate supply sources should be developed with the cooperation of the individual users. Overdraft conditions and drawdowns in excess of mean sea

level should be corrected where necessary through a long term management plan that neither places undo economic strain on individual users nor overstresses ground water basins.

8. The Water Management District should consider the necessity and feasibility of consumptive use permitting in those counties bordering the coastal zone. Floridan aquifer safe yield approximations developed in this report should not be used as permitting criteria without further interpretation and analysis.

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APPENDIX A

WATER QUALITY AND FIELD MEASUREMENT DATA

ABBREVIATIONS AND UNITS

WELL NUMBER:	F =	FLAGLER COUNTY
	SJ =	ST. JOHNS COUNTY
	D =	DUVAL COUNTY
	N =	NASSAU COUNTY
	P =	PUTNAM COUNTY
	G =	WELLS INVENTORIED BY USGS
WELL OWNER:	ICDC =	ITT COMMUNITY DEVELOPMENT CORPORATION
	DNR =	FLORIDA DEPARTMENT OF NATURAL RESOURCES
	SJRWMD =	ST. JOHNS RIVER WATER MANAGEMENT DISTRICT
	DOT =	FLORIDA DEPARTMENT OF TRANSPORTATION
	USGS =	UNITED STATES GEOLOGICAL SURVEY
	AIRPT AUTH =	AIRPORT AUTHORITY
	MEM PK =	MEMORIAL PARK
	DIST =	DISTRICT
	NAT'L PK =	NATIONAL PARK
	CO =	COUNTY
	SWD =	STOCKTON, WHATLEY & DAVIN
	FWFGC =	FRESH WATER FISH AND GAME COMMISSION
WELL DEPTH:		TOTAL WELL DEPTH IN FEET BELOW LAND SURFACE
CASE DEPTH:		CASING DEPTH IN FEET BELOW LAND SURFACE
AQ:	AQUIFER	S = SHALLOW
		A = SECONDARY ARTESIAN
		F = FLORIDAN
WATER LEVEL:	MSL =	MEAN SEA LEVEL IN FEET
	LSD =	DEPTH BELOW LAND SURFACE DATUM IN FEET
	MC =	MEASURING CONE
		TQ = TOPOGRAPHIC QUADRANGLE
		LV = LEVELED
		UN = UNDETERMINED
DATE MEASURED:		MONTH-DAY-YEAR
DASH (-):		INFORMATION NOT AVAILABLE

TABLE A-1. WATER LEVEL MEASUREMENT DATA

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
F44	KINGS FARM	443	170	F	01-26-77	11.22	-12.12	UN
					02-01-77	11.37	-12.27	
					03-31-77	17.50	-5.99	
					05-05-77	6.61	-16.88	
					06-31-77	10.03	-13.46	
					09-22-77	10.39	-13.10	
					11-04-77	10.31	-13.18	
					11-30-77	12.06	-11.43	
					05-03-78	9.87	-13.62	
					07-12-78	12.01	-11.48	
					10-05-78	12.35	-11.14	
F66	PHILLIP FREE	198	95	F	11-14-74	9.80	-10.20	TQ
					03-12-75	10.65	-9.35	
					07-03-75	10.56	-9.44	
					09-10-75	11.49	-8.51	
					12-03-75	11.37	-8.63	
					01-14-76	10.84	-9.16	
					03-03-76	9.57	-10.43	
					04-19-76	7.94	-12.06	
					06-14-76	10.30	-9.70	
					08-19-76	11.20	-8.80	
					09-27-76	11.88	-8.12	
					01-11-77	11.80	-8.20	
					03-31-77	6.52	-13.48	
					05-20-77	6.90	-13.10	
					06-27-77	8.70	-11.30	
					07-20-77	8.89	-11.11	
					09-19-77	9.76	-10.24	
					11-01-77	9.35	-10.65	
					02-15-78	11.85	-8.15	
					05-05-78	8.31	-11.69	
					10-05-78	11.08	-8.92	
F101	DUNSON ESTATE	127	113	F	07-23-56	11.61	-2.39	TQ
					03-12-75	9.71	-4.29	
					07-03-75	9.83	-4.17	
					09-10-75	10.85	-3.15	
					12-03-75	10.87	-3.12	
					01-14-76	10.18	-3.82	
					03-03-76	8.75	-5.25	
					04-19-76	7.46	-6.54	
					06-14-76	9.60	-4.40	
					09-29-76	11.17	-2.83	
					01-11-77	11.10	-2.90	
					10-05-78	10.34	-3.66	
F126	ALLEN ESTATES	157	122	F	03-11-74	7.51	-3.49	TQ
					07-02-75	6.90	-4.10	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					09-10-75	8.35	-2.65	
					12-03-75	8.92	-2.08	
					01-14-76	8.35	-2.65	
					03-03-76	7.02	-3.98	
					04-19-76	6.35	-4.65	
					05-31-76	7.28	-3.72	
					09-29-76	8.90	-2.10	
					01-11-77	8.85	-2.15	
					03-31-77	6.99	-4.01	
					05-20-77	4.90	-6.10	
					06-27-77	5.65	-5.35	
					07-20-77	5.60	-5.40	
					09-19-77	7.27	-3.73	
					11-01-77	7.31	-3.69	
					12-01-77	8.15	-2.85	
					01-19-78	8.90	-2.10	
					02-15-78	9.09	-1.91	
					03-14-78	9.38	-1.62	
					05-03-78	6.39	-4.61	
					06-05-78	6.71	-4.29	
					07-11-78	7.93	-3.07	
					08-03-78	8.82	-2.18	
					10-05-78	8.31	-2.69	
					11-06-78	8.56	-2.44	
					12-05-78	8.12	-2.88	
F130	ICDC PALM COAST	225	102	F	05-05-77	11.25	-12.72	LV
					06-10-77	13.20	-10.77	
					07-20-77	12.03	-11.94	
					09-19-77	14.82	-9.15	
					11-01-77	14.88	-9.09	
F134	UNDETERMINED	152	134	F	04-30-75	12.80	5.80	TQ
					07-07-75	12.80	5.80	
					09-26-75	15.70	8.70	
					12-03-75	14.60	7.60	
					01-14-76	14.10	7.10	
					03-03-76	13.10	6.10	
					04-19-76	12.40	5.40	
					05-31-76	12.60	5.60	
					06-14-76	13.40	6.40	
					08-23-76	14.00	7.00	
					09-27-76	15.10	8.10	
					01-11-77	15.00	8.00	
					07-20-77	11.00	4.00	
					09-19-77	13.60	6.60	
					11-01-77	14.30	7.30	
					12-01-77	14.00	7.00	
					01-19-78	14.70	7.70	
					02-16-78	14.30	7.30	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					03-14-78	14.90	7.90	
					04-25-78	12.00	5.00	
					06-05-78	13.40	6.40	
					07-11-78	14.70	7.70	
					08-03-78	14.50	7.50	
					09-28-78	15.40	8.40	
					11-06-78	15.20	8.20	
					12-05-78	14.30	7.30	
F135	UNDETERMINED	146	101	F	-	-	-	TQ
F138	STATE OF FLA-DNR	187	-	F	-	-	-	UN
F142	OCEAN PALM GOLF COURSE	150	450	F	10-06-77	7.20	2.20	TQ
					11-01-77	8.20	3.20	
					02-16-78	8.00	3.00	
					05-04-78	6.00	1.00	
					10-02-78	8.10	3.10	
F158	PALM COAST	284	183	F	05-03-77	11.06	-15.20	LV
					07-02-77	11.78	-14.48	
					09-22-77	13.33	-12.93	
					11-02-77	13.68	-12.58	
					02-20-78	14.93	-11.33	
					05-03-78	12.43	-13.83	
					10-03-78	14.56	-11.70	
					01-11-79	13.96	-12.30	
F159	ICDC PALM COAST	99	90	A	06-29-77	16.25	-10.95	LV
					07-22-77	16.04	-11.16	
					09-22-77	16.45	-10.75	
					11-02-77	16.17	-11.03	
					12-01-77	16.82	-10.38	
					01-19-78	18.47	-8.73	
					02-20-78	19.50	-7.70	
					03-14-78	19.98	-7.22	
					05-04-78	18.19	-9.01	
					06-05-78	17.45	-9.75	
					07-11-78	18.50	-8.70	
					08-03-78	20.50	-6.70	
					10-03-78	18.82	-8.38	
					11-07-78	19.42	-7.80	
					12-12-78	18.61	-8.59	
F160	ICDC PALM COAST	200	120	F	06-10-77	11.28	-23.72	TQ
					07-22-77	11.48	-23.52	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					10-06-77	13.06	-21.94	
					11-01-77	13.45	-21.55	
					02-17-78	14.46	-20.54	
					05-09-78	12.04	-22.96	
					10-03-78	14.26	-20.74	
F161	ICDC PALM COAST	141	125	F	06-10-77	13.15	-18.56	LV
					07-22-77	13.41	-18.30	
					09-22-77	14.96	-16.75	
					11-02-77	15.25	-16.46	
					02-17-78	16.42	-15.29	
					05-04-78	14.16	-17.55	
					10-03-78	16.16	-15.55	
F162	ICDC PALM COAST	404	212	F	06-29-77	10.46	-2.54	TQ
					07-22-77	10.57	-2.43	
					09-22-77	12.17	-0.83	
					11-02-77	12.50	-0.50	
					02-15-78	13.44	0.44	
					05-04-78	11.45	-1.55	
					10-05-78	13.22	0.22	
F164	PALM COAST ICDC	94	82	S	06-08-77	19.44	-7.84	LV
					07-22-77	18.77	-8.51	
					09-23-77	19.35	-7.93	
					11-02-77	18.78	-8.50	
					02-20-78	22.99	-4.29	
					05-03-78	20.93	-6.35	
					07-12-78	21.65	-5.63	
					10-03-78	22.81	-4.47	
					01-11-79	21.53	-5.75	
F165	ICDC PALM COAST	200	127	F	06-29-77	15.17	-19.67	TQ
					10-06-77	16.91	-18.59	
					11-01-77	17.19	-18.31	
					02-17-78	18.28	-17.22	
					05-04-78	15.95	-19.55	
					07-12-78	16.74	-18.76	
					10-03-78	18.00	-17.50	
					01-10-79	15.81	-19.69	
F166	MARINELAND	227	177	F	05-31-77	9.30	4.30	TQ
					09-23-77	12.35	7.35	
					02-16-78	13.00	8.00	
					04-25-78	8.80	3.80	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
F167	ICDC PALM COAST	68	48	S	11-01-77	21.24	-3.76	TQ
					02-15-78	23.19	-1.81	
					05-03-78	21.37	-3.63	
					10-05-78	23.13	-1.87	
F168	ICDC PALM COAST	60	50	S	11-01-77	24.37	-0.63	TQ
					12-01-77	24.01	-0.99	
					01-19-78	24.65	-0.35	
					02-18-78	24.59	-0.41	
					03-18-78	24.56	-0.44	
					05-03-78	22.92	-2.08	
					06-05-78	22.57	-2.43	
					07-11-78	23.12	-1.88	
					08-07-78	24.56	-0.44	
					10-05-78	24.60	-0.40	
					11-06-78	24.55	-0.45	
					12-05-78	23.95	-1.05	
F169	STATE OF FLA-DNR	95	-	A	-	-	-	LV
F170	FRANK PORTER	127	127	F	06-01-77	6.60	2.60	TQ
					07-27-77	6.60	2.60	
					10-07-77	8.62	-4.62	
					11-01-77	7.00	3.00	
					12-01-77	6.31	2.31	
					01-19-78	9.70	5.70	
					02-16-78	9.90	5.90	
					03-22-78	9.80	5.80	
					05-04-78	7.40	3.40	
					06-05-78	5.40	1.40	
					07-11-78	0.00	0.00	
					08-07-78	8.80	4.80	
					10-02-78	9.30	5.30	
					11-07-78	-	9.60	
					12-05-78	9.56	5.56	
F171	FLORIDA PARK SERVICE	21	17	S	-	-	-	LV
F174	SJRWMD	118	110	A	01-31-78	7.24	-9.40	LV
					02-16-78	8.04	-8.60	
					03-14-78	7.98	-8.66	
					05-04-78	4.71	-11.93	
					06-05-78	5.14	-11.50	
					07-11-78	5.76	-10.88	
					07-18-78	6.19	-10.45	
					08-03-78	7.07	-9.57	
					10-02-78	7.64	-9.00	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					11-20-78	7.71	-8.93	
					11-07-78	7.47	-9.17	
					12-05-78	6.58	-10.06	
					01-08-79	6.63	-10.01	
F175	SJRWMD	17	14	S	03-14-78	0.61	-15.85	LV
					05-04-78	1.57	-14.89	
					06-05-78	1.00	-15.46	
					07-11-78	1.12	-15.34	
					07-18-78	1.03	-15.43	
					08-03-78	1.47	-14.99	
					10-02-78	2.17	-14.29	
					11-07-78	2.20	-14.26	
					12-05-78	1.68	-14.78	
					11-20-78	3.71	-12.75	
					01-16-79	1.44	-15.02	
F176	SJRWMD	120	91	F	05-02-78	5.45	-2.13	LV
					05-03-78	7.47	-0.11	
					05-11-78	7.35	-0.23	
					07-12-78	8.47	0.89	
					08-03-78	9.37	1.79	
					10-02-78	10.06	2.15	
					11-06-78	9.90	1.99	
					12-05-78	9.61	1.70	
F177	SJRWMD	43	24	S	05-02-78	3.11	-5.06	LV
					05-03-78	3.02	-5.15	
					05-11-78	2.84	-5.33	
					06-07-78	2.25	-5.92	
					07-12-78	1.69	-6.48	
					08-03-78	4.01	-4.39	
					10-02-78	2.20	-5.61	
					11-06-78	3.33	-4.48	
					12-05-78	2.47	-5.34	
F178	SJRWMD	25	20	S	05-11-78	-2.84	-11.67	LV
					05-16-78	-1.07	-9.90	
					07-12-78	0.74	-8.09	
					08-03-78	1.42	-7.41	
					09-28-78	1.91	-6.92	
					11-06-78	2.14	-6.69	
					12-05-78	1.61	-7.22	
F181	SJRWMD	35	27	S	06-15-78	2.24	-5.15	LV
					07-12-78	1.51	-5.88	
					08-03-78	4.01	-3.38	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					09-08-78	2.51	-4.88	
					09-08-78	-2.78	-10.17	
					09-08-78	-1.61	-9.00	
					09-08-78	-2.78	-10.17	
					09-08-78	-2.74	-10.13	
					09-08-78	-2.73	-10.12	
					09-08-78	-1.58	-8.97	
					09-08-78	2.53	-4.86	
					09-28-78	4.12	-3.27	
					11-06-78	3.45	-3.94	
					12-05-78	2.88	-4.51	
					12-14-78	2.81	-4.58	
					12-14-78	0.81	-6.58	
					12-14-78	-1.49	-8.88	
					12-14-78	-1.39	-8.78	
					12-14-78	-1.12	-8.51	
					12-14-78	-0.97	-8.36	
					01-08-79	3.39	-4.00	
F183	GEORGE DANCE	80	-	S	-	-	-	TQ
F184	GEORGE DANCE	200	120	F	-	-	-	TQ
F185	GEORGE DANCE	160	120	F	-	-	-	TQ
F186	CITY OF FLAGLER BEACH	147	112	F	-	-	-	TQ
F187	CITY OF FLAGLER BEACH	150	112	F	-	-	-	TQ
F188	MRS. BING	185	-	F	01-15-79	11.54	2.54	TQ
F189	MRS. BING	20	-	S	-	-	-	TQ
F190	MRS. BING	19	-	S	-	-	-	TQ
F192	MRS. LIENHOP	-	-	S	-	-	-	TQ
F193	HAROLD BASTIAN	17	14	S	-	-	-	TQ
SJ115	DOT/USGS	622	142	F	03-11-75	16.87	-21.06	LV
					04-01-77	14.08	-23.85	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					07-21-77	14.02	-23.91	
					10-06-77	12.68	-26.33	
					12-06-77	13.26	-25.75	
					01-20-78	13.99	-25.02	
					03-20-78	14.35	-24.66	
					05-04-78	15.29	-23.72	
					09-08-78	18.12	-20.89	
					01-10-79	17.20	-21.80	
SJ117	BOBINSKI	300	150	F	09-20-78	28.90	12.90	TQ
SJ200	UNDETERMINED	385	-	F	11-24-75	14.90	4.90	TQ
					01-13-76	14.00	4.00	
SJ263	DICK REID	541	177	F	09-01-75	17.73	4.68	LV
					11-24-75	13.93	0.88	
					01-13-76	14.53	1.48	
					02-25-76	8.57	-4.48	
					04-14-76	9.61	-3.44	
					05-24-76	13.40	0.35	
					08-05-76	16.14	3.08	
					09-22-76	16.93	3.88	
					01-10-77	17.93	4.88	
					03-25-77	5.51	-7.54	
					05-18-77	8.81	-4.24	
					07-18-77	13.27	0.22	
					06-27-77	11.67	-1.38	
					09-20-77	14.39	1.34	
					11-07-77	15.53	2.48	
					12-01-77	14.93	1.88	
					01-05-78	16.43	3.38	
					02-10-78	17.73	4.68	
					03-14-78	17.53	4.48	
					04-24-78	11.37	-1.68	
					06-13-78	23.75	10.70	
					07-10-78	15.66	2.61	
					08-02-78	15.63	2.58	
					09-18-78	14.93	1.88	
					11-07-78	10.36	-2.69	
					12-12-78	13.63	-0.58	
SJ317	J.W. SYKES	274	99	F	01-00-56	28.52	-4.42	LV
					03-10-75	15.06	-17.88	
					04-13-76	10.70	-22.24	
					05-26-76	22.34	-10.60	
					09-27-76	25.76	-7.18	
					01-10-77	26.44	-6.50	
					06-17-77	20.46	-12.48	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					07-29-77	22.55	-10.39	
					10-06-77	20.70	-12.24	
					11-07-77	24.10	-8.84	
					02-10-78	26.33	-6.61	
					04-25-78	14.11	-18.83	
					09-20-78	23.05	-9.89	
SJ378	SMYLEY	294	114	F	11-26-75	14.50	0.50	TQ
					01-13-76	14.25	0.25	
					02-25-76	10.58	-3.42	
					04-14-76	8.65	-5.35	
					05-19-76	11.09	-2.91	
					08-05-76	14.40	0.40	
					09-22-76	15.30	1.30	
					01-11-77	16.50	2.50	
					03-07-77	16.50	2.50	
					03-24-77	9.16	-4.84	
					05-18-77	8.63	-5.37	
					06-22-77	11.31	-2.69	
					07-18-77	12.20	-1.80	
					09-21-77	14.45	0.45	
					11-07-77	14.50	0.50	
					02-10-78	16.80	2.80	
					04-24-78	12.01	-1.99	
					09-18-78	15.15	1.15	
SJ389	SKINNERS DAIRY	301	105	F	03-10-75	19.25	-14.16	LV
					07-02-75	23.08	-10.33	
					09-08-75	25.11	-8.30	
					05-25-76	21.21	-12.20	
					06-17-77	17.27	-16.14	
					07-19-77	20.30	-13.11	
					09-21-77	22.24	-11.17	
					11-07-77	22.47	-10.94	
					11-30-77	22.95	-10.46	
					01-18-78	24.21	-9.20	
					02-07-78	24.56	-8.85	
					03-14-78	25.12	-8.29	
					04-25-78	16.31	-17.10	
					06-06-78	21.37	-12.04	
					07-10-78	22.54	-10.87	
					08-02-78	23.47	-9.94	
					09-20-78	22.58	-10.83	
					11-06-78	20.88	-12.53	
					12-11-78	22.83	-10.58	
SJ412	ST AUGUSTINE AIRPT AUTH	350	190	F	03-10-75	33.40	23.40	TQ
					06-30-75	32.80	22.80	
					09-18-75	34.00	24.00	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					05-27-76	32.30	22.30	
					05-19-77	29.60	19.60	
					07-20-77	31.30	21.30	
					09-20-77	32.20	22.20	
					11-04-77	32.80	22.80	
					01-18-78	31.80	21.80	
					06-28-77	31.90	21.90	
					02-13-78	34.00	24.00	
					03-15-78	33.60	23.60	
					07-10-78	29.80	19.80	
					08-02-78	29.80	19.80	
					09-26-78	31.60	21.60	
					12-11-78	31.90	21.90	
SJ413	P.J. MANUCY	198	195	F	01-10-75	24.89	18.80	LV
					03-10-75	25.59	19.50	
					06-30-75	25.39	19.30	
					09-18-75	24.99	18.90	
					05-31-76	21.79	15.70	
					10-19-76	25.19	19.10	
					01-13-77	26.79	20.70	
					03-30-77	22.69	16.60	
					05-19-77	19.49	13.40	
					06-30-77	20.58	14.49	
					07-20-77	22.79	16.70	
					09-19-77	26.81	20.72	
					11-03-77	26.59	20.50	
					01-25-78	25.79	19.70	
					02-08-78	25.59	19.50	
					04-26-78	21.69	15.60	
					09-21-78	23.79	17.70	
SJ414	FRANK USINA	237	200	F	05-30-77	27.50	21.50	TQ
					06-30-77	26.70	20.70	
					09-28-77	30.00	24.00	
					11-03-77	31.20	25.20	
					02-10-78	33.40	27.40	
					04-27-78	28.40	22.40	
					09-21-78	29.60	23.60	
SJ415	ARTHUR L. MARSH	253	105	F	01-10-75	21.50	16.50	TQ
					03-10-75	21.90	16.90	
					06-30-75	20.60	15.60	
					05-30-77	15.60	10.60	
					06-28-77	16.30	11.30	
					07-28-77	17.70	12.70	
					09-26-77	19.50	14.50	
					11-03-77	21.10	16.10	
					12-01-77	20.20	15.20	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					01-18-78	20.80	15.80	
					02-09-78	21.30	16.30	
					03-15-78	20.80	15.80	
					04-26-78	17.50	12.50	
					06-06-78	18.50	13.50	
					07-10-78	17.90	12.90	
					08-02-78	19.80	14.80	
					09-20-78	17.80	12.80	
					10-10-78	20.40	15.40	
					12-11-78	20.80	15.80	
SJ416	NORTH DIXIE VILLAGE	325	180	F	01-14-75	31.50	11.50	TQ
					03-10-75	31.70	11.70	
					06-30-75	30.60	10.60	
					09-18-75	32.70	12.70	
					05-27-76	30.10	10.10	
					05-19-77	28.50	8.50	
					06-28-77	30.00	10.00	
					07-20-77	30.50	10.50	
					09-20-77	31.30	11.30	
					11-04-77	32.10	12.10	
					01-25-78	32.50	12.50	
					02-13-78	32.40	12.40	
					03-22-78	31.50	11.50	
					04-27-78	29.30	9.30	
					09-26-78	31.60	11.60	
SJ429	ST AUGUSTINE MEM PK	300	168	F	-	-	-	TQ
SJ430	OCEAN VILLAS	233	189	F	05-30-77	12.00	1.00	TQ
					06-30-77	12.10	1.10	
					07-29-77	14.20	3.20	
					09-26-77	14.60	3.60	
					11-02-77	13.90	2.90	
					11-30-77	14.90	3.90	
					01-18-78	15.60	4.60	
					02-08-78	14.20	3.20	
					03-14-78	16.15	5.15	
					04-26-78	12.90	1.90	
					06-05-78	12.65	1.65	
					07-11-78	12.00	1.00	
					08-02-78	12.35	1.35	
					09-25-78	14.30	3.30	
					11-06-78	16.10	5.10	
					12-11-78	14.20	3.20	
SJ431	ANASTASIA SANITARY D	248	170	F	05-31-77	15.90	5.90	TQ
					06-30-77	15.70	5.70	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					07-28-77	17.00	7.00	
					09-26-77	19.10	9.10	
					11-02-77	20.70	10.70	
					02-07-78	20.40	10.40	
					04-26-78	17.70	7.70	
					09-25-78	18.80	8.80	
SJ432	MR HOWARD	210	-	F	01-31-75	13.10	8.10	TQ
					03-10-75	12.60	7.60	
					06-30-75	12.60	7.60	
					09-26-75	14.10	9.10	
					11-25-75	13.10	8.10	
					01-14-76	12.70	7.70	
					03-04-76	11.00	6.00	
					04-05-76	10.75	5.75	
					05-31-76	10.50	5.50	
					08-23-76	12.16	7.16	
					09-21-76	12.69	7.69	
					01-11-77	13.75	8.75	
					04-11-77	10.80	5.80	
					05-11-77	9.10	4.10	
					06-30-77	9.90	4.90	
					07-20-77	11.50	6.50	
					09-19-77	12.74	7.74	
					11-02-77	14.10	9.10	
					11-03-77	13.10	8.10	
					01-18-78	13.00	8.00	
					02-14-78	14.50	9.50	
					03-14-78	13.80	8.80	
					04-25-78	11.40	6.40	
					06-05-78	10.00	5.00	
					07-10-78	10.80	5.80	
					08-02-78	10.10	5.10	
					09-25-78	13.00	8.00	
					11-06-78	13.50	8.50	
					12-05-78	12.60	7.60	
SJ433	PITTMAN	450	-	F	01-14-75	32.60	27.60	TQ
					03-10-75	33.10	28.10	
					06-30-75	32.10	27.10	
					09-18-75	33.10	28.10	
					05-27-76	37.80	32.80	
					10-19-76	39.50	34.50	
					01-13-77	39.90	34.93	
					03-30-77	38.10	33.10	
					05-19-77	36.80	31.80	
					05-30-77	36.80	31.80	
					06-30-77	38.80	33.80	
					07-19-77	33.50	28.50	
					09-20-77	36.40	31.40	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					11-04-77	38.10	33.10	
					12-01-77	32.80	27.80	
					01-18-78	38.40	33.40	
					02-10-78	39.00	34.00	
					03-15-78	38.80	33.80	
					04-27-78	36.60	31.60	
					06-06-78	36.40	31.40	
					07-10-78	36.80	31.80	
					08-02-78	37.40	32.40	
					09-26-78	38.70	33.70	
					11-10-78	38.80	33.80	
					12-11-78	38.20	33.20	
SJ434	PONCE DE LEON RACEWAY	336	240	F	01-15-75	42.97	25.20	LV
					03-10-75	42.57	24.80	
					06-30-75	41.87	24.10	
					09-18-75	43.07	25.30	
					05-27-76	41.47	23.70	
					05-19-77	39.77	22.00	
					09-28-77	43.37	25.60	
					10-31-77	41.27	23.50	
					02-10-78	42.67	24.90	
					03-21-78	41.57	23.80	
					05-01-78	39.67	21.90	
					07-24-78	40.77	23.00	
					10-09-78	41.47	23.70	
SJ438	C.E. CHARD	350	150	F	01-14-75	33.10	29.10	TQ
					03-10-75	34.40	30.40	
					06-30-75	33.80	29.80	
					09-18-75	34.40	30.40	
					05-27-76	34.50	30.50	
					05-19-77	32.00	28.00	
					06-28-77	34.10	30.10	
					07-19-77	33.30	29.30	
					09-20-77	33.90	29.90	
					11-04-77	34.30	30.30	
					01-26-78	35.40	31.40	
					02-13-78	35.90	31.90	
					03-21-78	32.70	28.70	
					04-27-78	32.50	28.50	
					07-24-78	33.50	29.50	
					09-06-78	34.50	30.50	
					09-25-78	34.50	30.50	
					11-14-78	35.60	31.60	
					01-24-79	34.70	30.70	
					03-12-79	35.40	31.40	
SJ469	EIGHT DAYS INN	200	–	F	05-30-77	23.00	15.00	TQ

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					06-28-77	23.30	15.30	
					07-28-77	24.50	16.50	
					09-28-77	25.50	17.50	
					11-04-77	26.40	18.40	
					02-08-78	27.90	19.90	
					04-27-78	23.70	15.70	
					09-20-78	23.70	15.70	
SJ470	FLAGLER COLLEGE	450	200	F	05-30-77	18.20	12.20	TQ
					06-28-77	15.50	9.50	
					07-28-77	18.50	12.50	
					09-26-77	20.70	14.70	
					11-03-77	20.70	14.70	
					02-09-78	22.10	16.10	
					04-25-78	18.10	12.10	
					09-20-78	18.20	12.20	
SJ472	FISH CAMP	350	200	F	05-25-77	33.40	28.40	TQ
					06-30-77	34.30	29.30	
					07-25-77	34.20	29.20	
					09-28-77	36.20	31.20	
					11-04-77	35.40	30.40	
					12-01-77	35.90	30.90	
					01-18-78	34.90	29.90	
					02-10-78	36.90	31.90	
					03-15-78	37.20	32.20	
					05-01-78	33.80	28.80	
					06-06-78	33.50	28.50	
					07-10-78	32.50	27.50	
					10-09-78	34.90	29.90	
					11-10-78	35.90	30.90	
					12-06-78	36.50	31.50	
SJ473	SAWGRASS CONDOMINIUM	500	300	F	06-30-77	27.20	15.20	TQ
					07-29-77	30.80	18.80	
					11-04-77	33.60	21.60	
					03-21-78	35.90	23.90	
					05-01-78	29.00	17.00	
					10-09-78	33.20	21.20	
SJ475	OAK GROVE	25	20	S	06-02-77	4.62	-3.38	TQ
					09-28-77	3.92	-4.08	
					11-04-77	2.75	-5.25	
					02-14-78	6.42	-1.58	
					04-27-78	4.41	-3.59	
					09-26-78	2.37	-5.63	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
SJ477	ANASTASIA SANITARY D	40	15	S	06-02-77	7.17	-2.83	TQ
					07-28-77	5.88	-4.12	
					09-21-77	6.02	-3.98	
					11-04-77	5.63	-4.37	
					02-07-78	7.54	-2.46	
SJ478	G.H. TILLMAN	24	21	S	-	-	-	UN
SJ479	MRS. J. ROSS	39	33	S	-	-	-	UN
SJ480	PAUL RAYNO	15	5	S	-	-	-	UN
SJ481	FLORIDA PARK SVC	100	80	S	-	-	-	UN
SJ482	FORT MATANZAS NAT'L PK	485	155	F	05-31-77	10.70	5.70	TQ
					06-30-77	11.00	6.00	
					07-27-77	9.80	4.80	
					09-23-77	11.70	6.70	
					11-02-77	12.00	7.00	
					12-03-77	13.20	8.20	
					01-18-78	13.40	8.40	
					02-14-78	13.70	8.70	
					03-14-78	13.90	8.90	
					04-25-78	11.00	6.00	
					06-05-78	10.80	5.80	
					07-11-78	11.80	6.80	
					08-07-78	10.70	5.70	
					09-25-78	11.70	6.70	
					11-06-78	11.90	6.90	
					12-05-78	13.00	8.00	
					01-08-79	12.50	7.50	
SJ483	NATIONAL PARK SERVICE	24	21	S	-	-	-	UN
SJ484	ANASTASIA STATE PARK	370	149	F	10-11-77	16.60	11.55	TQ
					11-02-77	18.40	13.41	
					02-09-78	19.20	14.20	
					04-25-78	16.20	11.20	
					09-25-78	17.20	12.20	
SJ485	ST JOHNS CO TEST SITE	65	58	S	10-11-77	4.73	-10.27	TQ
					11-02-77	4.55	-10.45	
					11-30-77	4.70	-10.30	
					01-18-78	6.37	-8.63	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					02-07-78	6.59	-8.41	
					03-15-78	7.55	-7.45	
					04-26-78	6.86	-8.14	
					06-06-78	5.97	-9.03	
					07-11-78	3.55	-11.45	
					08-02-78	3.55	-11.45	
					09-25-78	5.76	-9.24	
					11-06-78	5.76	-9.24	
					12-11-78	4.35	-10.65	
SJ486	ST JOHNS COUNTY	16	12	S	10-11-77	4.66	-10.34	TQ
					11-02-77	4.40	-10.60	
					02-07-78	6.45	-8.55	
					04-26-78	6.70	-8.30	
					09-26-78	5.75	-9.25	
SJ487	DEE DOT RANCH	1014	300	F	05-24-77	37.50	23.50	TQ
					06-27-77	38.60	24.60	
					07-25-77	37.00	23.00	
					09-30-77	39.20	25.20	
					10-31-77	36.80	22.80	
					02-21-78	40.00	26.00	
					05-02-78	37.00	23.00	
					10-09-78	38.80	24.80	
SJ488	BOWLES	11	7	S	-	-	-	UN
SJ489	DAILEY	42	-	S	-	-	-	UN
SJ490	RICHARDSON, C.J.	18	15	S	-	-	-	UN
SJ491	SIESTA CAMPGROUND	72	72	S	-	-	-	UN
SJ492	DOSTER	19	-	S	-	-	-	UN
SJ493	UNDETERMINED	50	35	S	06-02-77	24.18	-10.82	TQ
					11-04-77	21.33	-13.67	
SJ494	CONCERT CLEARING	60	50	S	12-08-77	30.35	-4.65	TQ
					02-24-78	33.70	-1.30	
					04-25-78	32.66	-2.34	
					09-27-78	33.07	-1.93	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA		
						MSL	LSD	MC
SJ495	FLORIDA FOREST SERVICE	165	90	A	-	-	-	UN
SJ496	R.B. HORTIN	-	-	S	-	-	-	UN
SJ497	C.J. RICHARDSON	105	105	A	-	-	-	UN
SJ498	STATE OF FLORIDA	79	-	A	02-24-78	31.49	-4.51	TQ
					04-26-78	30.60	-5.40	
					06-07-78	29.52	-6.48	
					07-11-78	26.36	-9.64	
					08-02-78	29.99	-6.01	
					09-27-78	29.71	-6.29	
					11-06-78	29.15	-6.85	
					12-11-78	28.64	-7.36	
SJ499	SJRWMD	44	24	S	05-15-78	9.32	-10.68	TQ
					07-12-78	9.01	-10.99	
					08-07-78	8.67	-11.33	
					09-27-78	9.04	-10.96	
					11-06-78	9.12	-10.88	
					12-12-78	8.87	-11.13	
SJ500	SJRWMD	74	54	S	05-11-78	46.23	13.77	TQ
					06-07-78	41.00	-19.00	
					08-02-78	41.98	-18.02	
					11-10-78	40.15	-19.85	
					12-06-78	43.36	-16.64	
					01-04-79	41.46	-18.54	
SJ501	SWD, FWFGC	-	-	F	-	-	-	UN
SJ502	SWD, FWFGC	-	-	F	-	-	-	UN
SJ503	SJRWMD	58	50	S	07-05-78	4.34	-5.66	TQ
					07-07-78	3.67	-6.33	
					10-10-78	5.60	-4.40	
					11-10-78	5.46	-4.54	
					12-12-78	5.35	-4.65	
					01-04-79	5.73	-4.27	
SJ504	SJRWMD	24	20	S	06-27-78	4.85	-5.15	TQ
					07-07-78	5.08	-4.92	
					10-10-78	6.35	-3.65	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					11-10-78	6.16	-3.84	
					12-12-78	6.00	-4.00	
					01-04-79	6.88	-3.12	
D1	STATE OF FLORIDA	710	450	F	06-22-77	37.80	27.80	TQ
					07-26-77	37.40	27.40	
					09-30-77	36.80	26.80	
					11-10-77	38.10	28.10	
					02-22-78	37.60	27.60	
					05-02-78	36.70	26.70	
					09-29-78	38.40	28.40	
D2	JERNIGAN	160	-	A	-	-	-	UN
D3	CLARK	148	-	A	-	-	-	UN
D5	NATIONAL PARK SERVICE	200	97	A	-	-	-	UN
D6	STATE OF FLORIDA	535	-	F	-	-	-	UN
D7	PAUL SILVAS	110	-	A	-	-	-	UN
D9	SJRWMD	34	24	S	08-15-78	4.07	-7.93	TQ
					08-17-78	3.89	-8.11	
					10-06-78	3.40	-8.60	
					11-09-78	2.24	-9.76	
					12-13-78	2.00	-10.00	
D10	SJRWMD	204	62	A	08-10-78	1.25	-10.75	TQ
					08-14-78	2.02	-9.98	
					08-15-78	2.20	-9.80	
					08-17-78	2.00	-10.00	
					10-06-78	1.90	-10.10	
					11-09-78	0.94	-11.06	
					12-13-78	1.63	-10.37	
D11	SJRWMD	24	16	S	08-21-78	5.65	-4.35	TQ
					08-22-78	5.54	-4.46	
					09-22-78	5.82	-4.18	
					11-17-78	5.08	-4.92	
					12-07-78	5.15	-4.85	
					01-04-79	5.99	-4.01	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA		
						MSL	LSD	MC
D12	SJRWMD	44	36	S	08-22-78	5.72	-4.28	TQ
					09-22-78	5.53	-4.47	
					11-17-78	4.87	-5.13	
					11-17-78	4.58	-5.42	
					12-07-78	4.65	-5.35	
					01-04-79	5.33	-4.67	
D13	SJRWMD	88	80	S	08-17-78	3.90	-6.10	TQ
					08-21-78	4.13	-5.87	
					08-22-78	4.02	-5.98	
					09-22-78	5.50	-4.50	
					11-17-78	4.39	-5.61	
					12-07-78	3.86	-6.14	
					01-04-79	3.71	-6.29	
D14	SJRWMD	48	40	S	09-29-78	23.83	-4.17	TQ
					11-08-78	22.56	-5.44	
					12-06-78	22.34	-5.66	
					01-03-79	23.12	-4.88	
D16	EUGENE O'DONNELL	500	-	F	01-18-79	39.80	29.80	TQ
D17	J.W. LUCAS	850	-	F	01-18-79	34.50	24.50	TQ
D18	J. EDWIN GAY	800	-	F	01-18-79	36.00	24.90	TQ
D19	GEORGE REGISTER III	-	-	F	01-18-79	43.95	33.95	TQ
D20	HOWARD'S GOLD MINE	1237	537	F	01-17-79	49.90	-13.10	TQ
D21	CITY OF ATLANTIC BEACH	1009	393	F	01-17-79	33.10	23.10	TQ
D164	CLAY CO DEVELOPMENT	618	448	F	06-22-77	39.30	23.60	LV
					07-26-77	37.80	22.10	
					09-30-77	39.50	23.80	
					11-10-77	40.60	24.90	
					11-29-77	40.60	24.90	
					01-12-78	40.70	25.00	
					02-22-78	40.70	25.00	
					03-16-78	41.00	25.30	
					05-02-78	38.60	22.90	
					06-08-78	38.00	22.30	
					07-13-78	37.70	22.00	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					08-09-78	38.70	23.00	
					09-29-78	39.36	23.60	
					11-09-78	39.40	23.70	
					12-07-78	40.00	24.30	
					01-04-79	39.80	24.10	
D245	U.S.G.S.	62	44	S	05-24-77	16.39	-5.61	TQ
					10-31-77	15.80	-6.20	
					11-29-77	15.38	-6.62	
					01-18-78	17.36	-4.64	
					02-21-78	19.02	-2.98	
					03-16-78	19.05	-2.95	
					05-02-78	17.63	-4.37	
					06-08-78	17.89	-4.11	
					07-13-78	16.75	-5.25	
					08-09-78	17.62	-4.38	
					10-09-78	17.62	-4.38	
					11-10-78	17.12	-4.88	
					12-06-78	17.22	-4.78	
D247	U.S.G.S.	95	86	S	05-24-77	34.42	-15.58	TQ
					09-30-77	34.44	-15.56	
					10-31-77	34.06	-15.94	
					02-21-78	35.17	-14.83	
					05-02-78	34.47	-15.53	
					10-04-78	35.22	-14.78	
D424	NATIONAL PARK SERVICE	705	427	F	05-24-77	38.60	23.60	TQ
					06-27-77	37.90	22.90	
					07-25-77	37.30	22.30	
					09-30-77	39.40	24.40	
					10-31-77	39.40	24.40	
					11-29-77	40.30	25.30	
					01-13-78	41.30	26.30	
					02-22-78	40.30	25.30	
					03-16-78	40.80	25.80	
					05-02-78	38.40	23.40	
					06-08-78	38.50	23.50	
					07-13-78	37.40	22.40	
					08-09-78	38.30	23.30	
					10-06-78	38.00	23.00	
					11-09-78	40.20	25.20	
					12-13-78	40.20	25.20	
N1	BUCKSKIPPER	100	100	A	-	-	-	UN
N2	RODGER RUNYON	19	16	S	-	-	-	UN

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA		
						MSL	LSD	MC
N3	FLORIDA PARK SERVICE	707	534	F	06-13-77	-28.53	-36.44	LV
					07-21-77	-24.40	-32.31	
					09-22-77	-5.19	-13.10	
					10-24-77	11.95	4.04	
					11-08-77	16.19	8.28	
					11-29-77	-22.89	-30.80	
					01-12-78	-25.99	-33.90	
					02-23-78	-22.63	-30.54	
					03-16-78	-22.32	-30.23	
					05-08-78	-25.73	-33.64	
					06-08-78	-23.90	-31.81	
					07-13-78	-7.59	-15.50	
					10-04-78	-22.39	-30.30	
					11-08-78	-10.93	-18.84	
					12-07-78	-18.91	-26.82	
N5	AMELIA ISL UTILITIES	1016	509	F	06-21-77	27.20	12.20	TQ
					07-26-77	26.90	11.90	
					09-29-77	30.40	15.40	
					11-10-77	33.40	18.40	
					02-23-78	30.70	15.70	
					10-04-78	29.80	14.80	
N6	COOK	75	75	S	06-21-77	1.31	-13.69	TQ
					07-21-77	-0.02	-15.02	
					09-30-77	1.69	-13.31	
					11-08-77	2.36	-12.64	
					01-12-78	1.81	-13.19	
					02-23-78	2.76	-12.24	
					03-16-78	3.01	-11.99	
					05-08-78	3.51	-11.49	
					06-08-78	2.97	-12.03	
					08-09-78	2.26	-12.74	
					10-04-78	2.78	-12.22	
					11-08-78	2.28	-12.72	
					12-06-78	1.93	-13.07	
N16	CLIFF MCINNIS	100	100	S	-	-	-	UN
N18	SJRWMD	33	23	S	09-29-78	3.65	-8.10	LV
					11-09-78	3.63	-8.12	
					11-27-78	3.43	-8.32	
					12-07-78	3.39	-8.36	
					01-03-79	3.45	-8.30	
N19	SJRWMD	83	72	A	09-29-78	3.69	-7.98	LV
					11-09-78	3.65	-8.02	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					11-27-78	3.47	-8.20	
					12-07-78	3.04	-8.63	
					01-03-79	3.02	-8.65	
N20	SJRWMD	54	46	S	09-29-78	14.78	-7.22	TQ
					11-08-78	14.15	-7.85	
					12-06-78	13.80	-8.20	
					01-03-79	13.94	-8.06	
P57	UNDETERMINED	405	140	F	02-00-56	23.00	13.00	TQ
					09-18-78	17.70	7.70	
P77	J. BATEMAN	272	63	F	02-00-56	23.50	3.50	TQ
					03-18-75	20.49	0.49	
					06-25-75	21.30	1.30	
					09-04-75	24.10	4.10	
					11-24-75	24.70	4.70	
					01-12-76	24.00	4.00	
					02-17-76	23.58	3.58	
					03-29-76	20.06	0.06	
					04-14-76	19.80	-0.20	
					05-18-76	21.27	1.27	
					07-27-76	23.60	3.60	
					09-20-76	24.80	4.80	
					01-10-77	24.75	4.75	
					03-25-77	16.40	-3.60	
					05-18-77	24.97	4.97	
					07-18-77	27.70	7.70	
					12-15-77	24.65	4.65	
					01-20-78	25.60	5.60	
					03-21-78	25.16	5.16	
					05-12-78	22.30	2.30	
					09-05-78	25.30	5.30	
					09-18-78	23.30	3.30	
					11-16-78	22.60	2.60	
P87	MAULBURY	-	-	F	09-18-78	22.70	2.70	TQ
P100	HAFNER	236	84	F	03-18-75	19.44	-0.56	TQ
					06-26-75	20.20	0.20	
					09-04-75	23.45	3.45	
					05-18-76	20.00	0.00	
					03-25-77	17.46	-2.54	
					05-18-77	16.35	-3.65	
					06-17-77	19.93	-0.07	
					07-19-77	20.72	0.72	
					09-26-77	22.40	2.40	

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
					12-07-77	22.40	2.40	
					02-09-78	23.70	3.70	
					04-24-78	20.38	0.38	
					09-18-78	22.30	2.30	
F189	KERR REVELS	-	-	F	03-17-75	15.97	0.97	TQ
					06-17-77	19.40	4.40	
					07-18-77	18.50	3.50	
					09-23-77	21.00	6.00	
					11-07-77	19.50	5.00	
					11-28-77	20.00	5.50	
					01-05-78	15.00	5.00	
					02-07-78	20.50	6.00	
					03-21-78	19.60	5.10	
					04-25-78	16.90	2.40	
					06-06-78	18.14	3.64	
					07-10-78	19.50	5.00	
					08-02-78	19.40	4.90	
					09-18-78	20.00	5.50	
G040	BUNNELL	100	60	S	-	-	-	TQ
G042	CITY OF ST AUGUSTINE	200	-	F	-	-	-	UN
G044	GIRL SCOUTS	-	-	F	05-02-77	37.00	26.0	TQ
G045	MR. KNOWLES	600	-	F	05-11-77	42.50	26.00	TQ
G046	ST. REGIS	-	-	F	05-05-77	34.50	14.50	TQ
G047	LAND DEVELOPMENT CO	600	-	F	05-03-77	36.30	17.30	TQ
G048	G.L. OESTERREICHER	350	180	F	05-03-77	32.90	28.40	LV
G049	W.C. CLARK	487	-	F	05-06-77	36.60	15.60	TQ
G050	ST. REGIS	-	-	F	-	-	-	TQ
G051	MANDARIN UTILITY	700	360	F	05-06-77	31.05	6.05	TQ

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
G052	POWELL	-	-	F	05-05-77	38.00	14.00	LV
G053	ST. REGIS	-	-	F	05-05-77	34.20	16.20	TQ
G054	CARL MARTIN	500	200	F	05-06-77	32.50	7.50	TQ
G055	JAMES N. HUME	504	380	F	05-05-77	38.20	14.20	TQ
G057	CONGRESS INN	555	457	F	-	-	-	TQ
G058	UNDETERMINED	46	-	S	05-10-77	11.40	-3.54	TQ
G059	H.D. GABRIEL	504	420	F	05-10-77	35.00	12.00	TQ
G060	1000 OAKS	880	365	F	-	-	-	TQ
G061	J.E. DAVIS	453	-	F	05-02-77	29.80	15.80	TQ
G062	J.E. DAVIS	700	390	F	05-02-77	39.12	4.12	TQ
G063	U.S.G.S.	104.5	850	S	05-10-77	34.23	-15,77	TQ
G065	SKINNERS DAIRY	1015	-	F	05-10-77	32.40	12.40	TQ
G066	PABLO KEYS CORP	615	-	F	05-03-77	34.10	27.10	TQ
G067	FLA. CROWN UTILITY	1100	-	F	-	-	-	UN
G068	U.S.G.S.	55	47	A	05-05-77	17.10	-4.90	TQ
G069	RETARDATION CENTER	520	-	F	05-05-77	31.31	7.31	TQ
G070	CITY OF JAX BEACH	800	-	F	-	-	-	TQ
G071	CITY OF JACKSONVILLE	1234	515	F	-	-	-	TQ

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
G072	JACKSONVILLE	1179	423	F	-	-	-	TQ
G073	UNDETERMINED	62	44	S	05-10-77	8.16	-6.84	TQ
G074	U.S.G.S.	2486	752	F	09-20-77	36.40	16.40	TQ
G075	J.W. BRAZIL	2486	-	F	09-20-77	37.40	17.40	TQ
G077	JACKSONVILLE	1297	-	F	-	-	-	TQ
G078	CITY OF NEPTUNE BEACH	1050	-	F	-	-	-	TQ
G079	BELLINGER SHIPYARD	-	-	F	05-03-77	32.10	22.10	TQ
G080	ALDERMAN PARK UTL	1150	576	F	-	-	-	TQ
G081	JACKSONVILLE	1350	606	F	-	-	-	TQ
G082	ATLANTIC BEACH	1300	407	F	-	-	-	UN
G083	CITY OF JACKSONVILLE	814	578	F	-	-	-	TQ
G084	CITY OF JACKSONVILLE	1286	-	F	05-05-77	27.30	6.30	TQ
G085	U.S.G.S.	75	670	S	05-04-77	34.70	-10.30	TQ
G086	HARVEY CAPPS	490	-	F	09-14-77	33.70	23.70	TQ
G087	JACKSONVILLE	-	-	F	05-03-77	26.90	16.90	TQ
G089	R.GAY CONSTRUCTION	665	-	F	-	-	-	TQ
G090	O.C. PONCE	-	-	F	05-02-77	36.50	31.50	TQ
G091	CLAY CO DEVELOPMENT	618	448	F	05-02-77	36.61	20.61	LV

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
G092	CITY OF JACKSONVILLE	1209	545	F	-	-	-	UN
G093	JACKSONVILLE	942	-	F	05-03-77	34.49	13.49	TQ
G094	UNDETERMINED	88	70	A	05-03-77	15.22	-9.78	TQ
G095	UNION C ORE CO	680	-	F	05-09-78	28.50	14.50	LV
G096	MRS. G.WILDER	800	-	F	05-04-77	27.40	15.40	TQ
G097	AMELIA ISL CORP	1016	492	F	05-09-78	29.10	14.10	TQ
G098	R.L. WISE	1000	-	F	04-10-78	1.00	0.00	UN
G099	G.G. GERBING	580	350	F	04-04-78	12.18	2.18	LV
G100	FERNANDINA	1200	-	F	-	-	-	TQ
G101	FLA ST RD DEPT	578	-	F	-	-	-	LV
G102	SEABOARD AIRLINE RR	1000	-	F	09-07-77	27.76	-6.05	TQ
G103	RAYONIER	-	-	F	05-09-78	-25.94	-35.94	TQ
G104	CITY OF FERNANDINA	1200	-	F	-	-	-	TQ
G105	RAYONIER	1100	-	F	-	-	-	TQ
G106	FLA PUBLIC UTL	750	-	F	-	-	-	TQ
G107	RAYONIER	1062	-	F	-	-	-	TQ
G108	MR. SETHER	500	-	F	-	-	-	LV
G109	RAYONIER	1700	-	F	-	-	-	TQ

TABLE A-1 CONTD.

WELL NUMBER	WELL OWNER	WELL DEPTH	CASE DEPTH	AQ	DATE MEASURED	WATER LEVEL DATA MSL	LSD	MC
G110	FLA PUBLIC UTL	1003	-	F	-	-	-	LV
G111	CONTAINER CORP	1237	-	F	-	-	-	UN
G112	UNDETERMINED	1000	-	F	-	-	-	TQ
G113	CONTAINER CORP	1410	-	F	-	-	-	UN
G114	FLA DEPT OF PARKS	-	-	F	10-04-77	-	8.89	TQ
G115	YWL CORP	706	466	F	05-03-77	31.90	16.90	TQ

ABBREVIATIONS AND UNITS

WELL NO:	WELL NUMBER	F = FLAGLER COUNTY SJ = ST. JOHNS COUNTY D = DUVAL COUNTY N = NASSAU COUNTY P = PUTNAM COUNTY G = WELLS SAMPLED BY USGS
DATE COLL:	DATE COLLECTED = MONTH-DAY-YEAR	
TEMP:	TEMPERATURE IN DEGREES CENTIGRADE	
CA:	CALCIUM IN MG/L	
MG:	MAGNESIUM IN MG/L	
NA:	SODIUM IN MG/L	
K:	POTASSIUM IN MG/L	
SPEC COND:	SPECIFIC CONDUCTANCE IN MICROMHOS/CENTIMETER	
CL:	CHLORIDE IN MG/L	
SO4:	SULFATE IN MG/L	
S:	SULFIDE IN MG/L	
PH:	STANDARD UNITS	
HCO3:	BICARBONATE IN MG/L	
CO3:	CARBONATE IN MG/L	
FE:	IRON IN MG/L	
F:	FLUORIDE IN MG/L	
SR:	STRONTIUM IN MG/L	
DASH (-):	NOT SAMPLED	

TABLE A-2. WATER QUALITY DATA FOR WELLS IN THE SHALLOW, SECONDARY ARTESIAN, AND FLORIDAN AQUIFER

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
F66	10-05-78	23.0	153	75.7	328	6.8	3100	800.0	290.0	2.74	7.4	185.5	0.0	0.36	0.36	2.1
F101	10-05-78	23.5	163	73.5	308	7.5	2930	790.0	225.0	3.36	7.3	191.0	0.0	0.10	0.34	-
F126	03-11-74	-	-	-	-	-	-	1280.0	-	-	-	-	-	-	-	-
	07-02-75	-	-	-	-	-	-	860.0	-	-	-	-	-	-	-	-
	09-10-75	-	-	-	-	-	-	825.0	-	-	-	-	-	-	-	-
	12-03-75	-	-	-	-	-	-	860.0	-	-	-	-	-	-	-	-
	01-14-76	-	-	-	-	-	-	850.0	-	-	-	-	-	-	-	-
	03-03-76	-	-	-	-	-	-	840.0	-	-	-	-	-	-	-	-
	04-19-76	-	-	-	-	-	-	1050.0	-	-	-	-	-	-	-	-
	05-31-76	-	-	-	-	-	-	820.0	-	-	-	-	-	-	-	-
	09-29-76	-	-	-	-	-	-	840.0	-	-	-	-	-	-	-	-
	01-11-77	-	-	-	-	-	-	940.0	-	-	-	-	-	-	-	-
	03-31-77	-	-	-	-	-	-	1160.0	-	-	-	-	-	-	-	-
	05-20-77	-	-	-	-	-	-	1390.0	-	-	-	-	-	-	-	-
	06-27-77	-	-	-	-	-	-	880.0	-	-	-	-	-	-	-	-
	07-20-77	-	-	-	-	-	-	910.0	-	-	-	-	-	-	-	-
	09-19-77	-	-	-	-	-	-	1390.0	-	-	-	-	-	-	-	-
	11-01-77	-	-	-	-	-	-	1110.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	900.0	-	-	-	-	-	-	-	-
	01-19-78	-	-	-	-	-	-	1310.0	-	-	-	-	-	-	-	-
	02-15-78	-	-	-	-	-	-	1240.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	920.0	-	-	-	-	-	-	-	-
	05-03-78	-	-	-	-	-	-	1000.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	1090.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	1120.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	1120.0	-	-	-	-	-	-	-	-
	10-05-78	23.0	161	66.5	406	6.4	2980	880.0	90.0	2.64	7.6	201.0	0.0	0.10	0.17	1.5
	11-06-78	-	-	-	-	-	-	880.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	920.0	-	-	-	-	-	-	-	-
F134	04-30-75	-	-	-	-	-	-	1440.0	-	-	-	-	-	-	-	-
	09-26-75	-	-	-	-	-	-	1330.0	-	-	-	-	-	-	-	-
	12-03-75	-	-	-	-	-	-	1370.0	-	-	-	-	-	-	-	-
	01-14-76	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	03-03-76	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	04-19-76	-	-	-	-	-	-	1440.0	-	-	-	-	-	-	-	-
	05-31-76	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	06-14-76	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	08-23-76	-	-	-	-	-	-	1340.0	-	-	-	-	-	-	-	-
	09-27-76	-	-	-	-	-	-	1340.0	-	-	-	-	-	-	-	-
	01-11-77	-	-	-	-	-	-	1340.0	-	-	-	-	-	-	-	-
	07-20-77	-	-	-	-	-	-	1340.0	-	-	-	-	-	-	-	-
	09-19-77	-	-	-	-	-	-	1340.0	-	-	-	-	-	-	-	-
	11-01-77	-	-	-	-	-	-	1330.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	01-19-78	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	02-16-78	-	-	-	-	-	-	1380.0	-	-	-	-	-	-	-	-

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	03-14-78	-	-	-	-	-	-	1370.0	-	-	-	-	-	-	-	-
	04-25-78	-	-	-	-	-	-	1370.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	1370.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	1380.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	1350.0	-	-	-	-	-	-	-	-
	09-28-78	23.0	210	115.2	650	14.8	3200	1360.0	440.0	3.92	7.3	174.0	0.0	0.10	0.51	2.0
	11-06-78	-	-	-	-	-	-	1380.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	1380.0	-	-	-	-	-	-	-	-
F135	10-05-78	23.5	236	137.1	791	18.8	5900	1610.0	710.0	2.82	7.4	146.0	0.0	0.10	0.57	-
F138	09-28-78	23.0	256	140.9	882	21.4	3400	1740.0	795.0	1.90	7.4	125.0	0.0	0.10	0.92	5.0
F142	10-02-78	26.0	169	71.4	444	8.8	3700	1020.0	140.0	5.46	7.3	236.0	0.0	0.15	0.32	1.1
F158	01-11-79	23.0	165	140.0	800	14.7	4025	1596.0	420.0	2.84	7.3	171.0	0.0	0.63	0.28	4.6
F159	06-29-77	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
	07-22-77	-	-	-	-	-	-	76.0	-	-	-	-	-	-	-	-
	09-22-77	-	-	-	-	-	-	74.0	-	-	-	-	-	-	-	-
	11-02-77	-	-	-	-	-	-	71.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	76.0	-	-	-	-	-	-	-	-
	01-19-78	-	-	-	-	-	-	60.0	-	-	-	-	-	-	-	-
	02-20-78	-	-	-	-	-	-	75.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
	05-04-78	22.0	114	4.8	53	1.0	700	73.0	3.2	0.16	7.5	319.2	0.0	0.80	0.25	0.2
	06-05-78	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	80.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
	10-03-78	-	-	-	-	-	-	73.0	-	-	-	-	-	-	-	-
	11-07-78	-	-	-	-	-	-	85.0	-	-	-	-	-	-	-	-
	12-12-78	-	-	-	-	-	-	80.0	-	-	-	-	-	-	-	-
F160	10-03-78	23.5	118	78.3	215	8.7	2350	535.0	180.0	2.08	7.6	188.0	0.0	0.10	0.75	1.9
F162	10-05-78	26.0	208	146.7	763	8.9	6000	1800.0	103.0	3.76	7.3	179.5	0.0	0.20	0.52	2.3
F164	01-11-79	21.8	89	4.4	49	1.5	680	110.0	2.1	0.07	7.7	285.0	0.0	0.86	0.14	0.5
F165	01-10-79	22.3	96	82.3	187	8.3	1575	416.0	360.0	2.37	7.3	163.5	0.0	0.40	1.00	2.5
F166	09-28-78	23.5	256	144.3	1138	27.5	4300	2160.0	470.0	1.50	7.3	133.0	0.0	0.10	0.90	3.9

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
F167	05-03-78	21.5	122	3.1	28	1.0	750	56.0	0.0	0.10	7.3	313.1	0.0	3.70	0.20	0.2
F168	11-01-77	-	-	-	-	-	-	19.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	01-19-78	-	-	-	-	-	-	10.0	-	-	-	-	-	-	-	-
	02-18-78	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	03-18-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	05-03-78	22.0	124	2.1	10	1.0	650	21.0	0.0	0.12	7.3	318.2	0.0	4.31	0.16	0.2
	06-05-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	08-07-78	-	-	-	-	-	-	20.0	-	+	-	-	-	-	-	-
	10-05-78	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	11-06-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
F169	05-03-78	22.0	144	7.6	79	2.0	1100	200.0	0.0	0.30	7.3	298.0	0.0	0.40	0.18	0.3
F170	06-01-77	-	-	-	-	-	-	1260.0	-	-	-	-	-	-	-	-
	07-27-77	-	-	-	-	-	-	1240.0	-	-	-	-	-	-	-	-
	10-07-77	-	-	-	-	-	-	1270.0	-	-	-	-	-	-	-	-
	11-01-77	-	-	-	-	-	-	1240.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	1320.0	-	-	-	-	-	-	-	-
	01-19-78	-	-	-	-	-	-	1290.0	-	-	-	-	-	-	-	-
	02-16-78	-	-	-	-	-	-	1280.0	-	-	-	-	-	-	-	-
	03-22-78	-	-	-	-	-	-	1280.0	-	-	-	-	-	-	-	-
	05-04-78	-	-	-	-	-	-	1290.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	1270.0	-	-	-	-	-	-	-	-
	08-07-78	-	-	-	-	-	-	1300.0	-	-	-	-	-	-	-	-
	10-02-78	26.0	183	99.8	565	10.1	4525	1320.0	270.0	4.84	7.2	210.0	0.0	0.10	0.35	1.5
	11-07-78	-	-	-	-	-	-	1300.0	-	-	-	0.0	-	-	-	-
	12-05-78	-	-	-	-	-	-	1300.0	-	-	-	-	-	-	-	-
F171	09-28-78	23.0	98	6.7	71	2.0	1000	136.0	18.0	0.10	7.0	370.0	0.0	5.97	0.70	0.2
F174	01-31-78	-	-	-	-	-	-	166.0	-	-	-	-	-	-	-	-
	02-16-78	-	-	-	-	-	-	950.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	980.0	-	-	-	-	-	-	-	-
	05-04-78	25.0	176	74.0	460	11.0	3700	1040.0	141.0	2.68	-	212.1	0.0	-	0.45	1.3
	06-05-78	-	-	-	-	-	-	1100.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	1080.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	1100.0	-	-	-	-	-	-	-	-
	10-02-78	23.5	169	78.7	508	8.9	3850	1200.0	160.0	0.72	7.4	240.5	0.0	1.09	0.39	1.3
	11-07-78	-	-	-	-	-	-	1080.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	990.0	-	-	-	-	-	-	-	-
	01-08-79	23.0	145	88.2	570	10.0	3150	1230.0	170.0	0.72	7.7	230.0	0.0	0.35	0.36	2.6
F175	10-02-78	23.0	154	78.3	870	28.5	5500	1660.0	250.0	0.80	6.7	240.0	0.0	0.13	0.25	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	12-05-78	-	-	-	-	-	-	975.0	-	-	-	-	-	-	-	-
F176	05-11-78	21.5	136	51.0	270	6.0	2330	680.0	58.0	6.34	-	218.2	0.0	-	0.31	4.0
	07-12-78	-	-	-	-	-	-	750.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	580.0	-	-	-	-	-	-	-	-
	10-02-78	22.0	104	41.9	232	5.0	2050	555.0	45.0	6.42	7.2	255.0	0.0	0.10	0.33	4.0
	11-06-78	-	-	-	-	-	-	530.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	535.0	-	-	-	-	-	-	-	-
F177	05-11-78	-	-	-	-	-	-	88.0	-	-	-	-	-	-	-	-
	07-12-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	08-07-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	10-02-78	21.8	81	6.0	45	1.8	775	88.0	4.0	0.16	7.3	311.5	0.0	0.67	0.27	-
	11-06-78	-	-	-	-	-	-	95.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-
F178	07-12-78	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	09-28-78	22.0	93	9.0	50	2.4	1000	96.0	27.0	0.10	7.1	327.0	0.0	5.61	0.80	-
	11-06-78	-	-	-	-	-	-	110.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-
F181	06-15-78	-	-	-	-	-	-	145.0	-	-	-	-	-	-	-	-
	07-12-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	08-03-78	-	-	-	-	-	-	130.0	-	-	-	-	-	-	-	-
	09-08-78	-	-	-	-	-	-	135.0	-	-	-	-	-	-	-	-
	09-28-78	22.0	109	8.2	79	2.4	1100	173.0	15.0	0.12	6.9	445.0	0.0	15.85	0.06	-
	11-06-78	-	-	-	-	-	-	155.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	150.0	-	-	-	-	-	-	-	-
	01-08-79	22.5	126	6.7	64	2.0	980	128.0	5.2	0.12	7.2	411.0	0.0	14.20	0.10	0.5
F183	01-15-79	19.0	98	4.2	30	0.4	610	48.8	2.9	0.09	6.9	345.0	0.0	0.47	0.10	0.5
F184	01-15-79	17.5	85	20.4	71	2.3	730	156.0	2.2	1.46	7.2	284.0	0.0	0.22	0.15	0.5
F185	01-15-79	20.3	78	17.6	53	1.8	690	104.0	2.0	2.30	7.3	309.0	0.0	0.10	0.14	0.5
F186	01-11-79	22.5	88	16.8	66	2.0	850	152.0	3.0	1.57	7.1	271.0	0.0	0.13	0.10	0.5
F187	01-11-79	22.0	103	13.9	64	1.7	820	158.0	3.1	0.55	7.3	289.0	0.0	0.11	0.22	0.6
F188	01-15-79	20.3	176	155.0	855	23.8	4000	1595.0	850.0	2.06	7.5	116.5	0.0	0.10	0.75	8.7

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
F189	01-15-79	19.5	90	12.2	104	2.7	880	204.0	73.0	0.00	7.3	225.0	0.0	0.10	0.10	0.5
F190	01-16-79	21.5	100	20.6	145	3.6	1100	296.0	102.0	0.04	7.4	230.0	0.0	0.10	0.10	0.5
F192	01-16-79	23.5	166	155.0	875	24.2	4500	1762.0	820.0	0.02	7.4	126.0	0.0	0.97	0.42	6.8
F193	01-16-79	21.8	94	4.2	32	1.2	600	40.8	16.5	0.16	7.3	331.5	0.0	3.98	0.12	0.5
SJ115	01-10-79	24.8	145	120.0	190	10.0	2070	488.0	700.0	1.64	7.7	123.0	0.0	0.12	0.89	6.3
SJ117	09-20-78	25.0	199	118.6	260	9.3	2400	535.0	575.0	1.58	7.7	92.0	0.0	0.10	0.52	-
SJ200	09-19-78	24.0	216	131.8	363	9.3	3000	835.0	180.0	2.76	7.6	104.0	0.0	0.10	0.56	-
SJ263	09-01-75	-	-	-	-	-	-	400.0	-	-	-	-	-	-	-	-
	11-24-75	-	-	-	-	-	-	700.0	-	-	-	-	-	-	-	-
	01-13-76	-	-	-	-	-	-	820.0	-	-	-	-	-	-	-	-
	02-25-76	-	-	-	-	-	-	4480.0	-	-	-	-	-	-	-	-
	04-14-76	-	-	-	-	-	-	2150.0	-	-	-	-	-	-	-	-
	05-24-76	-	-	-	-	-	-	760.0	-	-	-	-	-	-	-	-
	08-05-76	-	-	-	-	-	-	620.0	-	-	-	-	-	-	-	-
	09-22-76	-	-	-	-	-	-	460.0	-	-	-	-	-	-	-	-
	01-10-77	-	-	-	-	-	-	520.0	-	-	-	-	-	-	-	-
	03-25-77	-	-	-	-	-	-	2280.0	-	-	-	-	-	-	-	-
	05-18-77	-	-	-	-	-	-	680.0	-	-	-	-	-	-	-	-
	07-18-77	-	-	-	-	-	-	1380.0	-	-	-	-	-	-	-	-
	06-27-77	-	-	-	-	-	-	1670.0	-	-	-	-	-	-	-	-
	09-20-77	-	-	-	-	-	-	1140.0	-	-	-	-	-	-	-	-
	11-07-77	-	-	-	-	-	-	3020.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	2660.0	-	-	-	-	-	-	-	-
	01-05-78	-	-	-	-	-	-	1670.0	-	-	-	-	-	-	-	-
	02-10-78	-	-	-	-	-	-	2800.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	1400.0	-	-	-	-	-	-	-	-
	04-24-78	-	-	-	-	-	-	3500.0	-	-	-	-	-	-	-	-
	06-13-78	-	-	-	-	-	-	1120.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	480.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	2620.0	-	-	-	-	-	-	-	-
	09-18-78	25.0	426	274.0	1630	30.4	7000	3340.0	565.0	2.48	7.9	107.0	0.0	0.33	0.57	6.1
	11-07-78	-	-	-	-	-	-	4440.0	-	-	-	-	-	-	-	-
	12-12-78	-	-	-	-	-	-	3840.0	-	-	-	-	-	-	-	-
SJ378	11-26-75	-	-	-	-	-	-	545.0	-	-	-	-	-	-	-	-
	01-13-76	-	-	-	-	-	-	710.0	-	-	-	-	-	-	-	-
	02-25-76	-	-	-	-	-	-	1240.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	04-14-76	-	-	-	-	-	-	1360.0	-	-	-	-	-	-	-	-
	05-19-76	-	-	-	-	-	-	1070.0	-	-	-	-	-	-	-	-
	08-05-76	-	-	-	-	-	-	740.0	-	-	-	-	-	-	-	-
	09-22-76	-	-	-	-	-	-	720.0	-	-	-	-	-	-	-	-
	01-11-77	-	-	-	-	-	-	760.0	-	-	-	-	-	-	-	-
	02-17-77	-	-	-	-	-	-	790.0	-	-	-	-	-	-	-	-
	03-07-77	-	-	-	-	-	-	960.0	-	-	-	-	-	-	-	-
	03-24-77	-	-	-	-	-	-	960.0	-	-	-	-	-	-	-	-
	05-18-77	-	-	-	-	-	-	700.0	-	-	-	-	-	-	-	-
	06-22-77	-	-	-	-	-	-	900.0	-	-	-	-	-	-	-	-
	07-18-77	-	-	-	-	-	-	850.0	-	-	-	-	-	-	-	-
	09-21-77	-	-	-	-	-	-	780.0	-	+	-	-	-	-	-	-
	11-07-77	-	-	-	-	-	-	790.0	-	-	-	-	-	-	-	-
	02-10-78	-	-	-	-	-	-	790.0	-	-	-	-	-	-	-	-
	04-24-78	-	-	-	-	-	-	930.0	-	-	-	-	-	-	-	-
	09-18-78	24.0	189	121.8	318	7.1	2900	800.0	655.0	1.70	7.8	104.0	0.0	0.12	0.58	4.5
SJ389	03-10-75	-	-	-	-	-	-	250.0	-	-	-	-	-	-	-	-
	07-02-75	-	-	-	-	-	-	136.0	-	-	-	-	-	-	-	-
	09-08-75	-	-	-	-	-	-	125.0	-	-	-	-	-	-	-	-
	05-25-76	-	-	-	-	-	-	220.0	-	-	-	-	-	-	-	-
	06-17-77	-	-	-	-	-	-	110.0	-	-	-	-	-	-	-	-
	07-19-77	-	-	-	-	-	-	236.0	-	-	-	-	-	-	-	-
	09-21-77	-	-	-	-	-	-	225.0	-	-	-	-	-	-	-	-
	11-07-77	-	-	-	-	-	-	225.0	-	-	-	-	-	-	-	-
	11-30-77	-	-	-	-	-	-	220.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	220.0	-	-	-	-	-	-	-	-
	02-07-78	-	-	-	-	-	-	240.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	230.0	-	-	-	-	-	-	-	-
	04-25-78	23.5	153	104.0	125	7.0	1990	230.0	688.0	1.56	7.7	108.1	0.0	0.10	0.62	3.9
	06-06-78	-	-	-	-	-	-	235.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	230.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	230.0	-	-	-	-	-	-	-	-
	09-20-78	-	-	-	-	-	-	240.0	-	-	-	-	-	-	-	-
	11-06-78	-	-	-	-	-	-	240.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	240.0	-	-	-	-	-	-	-	-
SJ412	03-10-75	-	-	-	-	-	-	88.0	-	-	-	-	-	-	-	-
	06-30-75	-	-	-	-	-	-	88.0	-	-	-	-	-	-	-	-
	09-18-75	-	-	-	-	-	-	89.0	-	-	-	-	-	-	-	-
	05-27-76	-	-	-	-	-	-	93.0	-	-	-	-	-	-	-	-
	05-19-77	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	07-20-77	-	-	-	-	-	-	92.0	-	-	-	-	-	-	-	-
	09-20-77	-	-	-	-	-	-	91.0	-	-	-	-	-	-	-	-
	11-04-77	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	80.0	-	-	-	-	-	-	-	-
	06-28-77	-	-	-	-	-	-	94.0	-	-	-	-	-	-	-	-
	02-13-78	-	-	-	-	-	-	92.0	-	-	-	-	-	-	-	-
	03-15-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	08-02-78	-	-	-	-	-	-	90.0	-	-	-	-	-	-	-	-
	09-26-78	25.0	57	43.6	48	3.9	900	89.0	260.0	3.68	7.7	143.5	0.0	0.10	0.92	2.5
	11-10-78	-	-	-	-	-	-	100.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	95.0	-	-	-	-	-	-	-	-
SJ413	09-21-78	23.0	60	49.8	44	4.4	1000	91.0	265.0	2.42	7.6	140.5	0.0	0.10	1.00	2.4
SJ414	04-27-78	23.0	83	50.0	38	3.0	950	74.0	296.0	1.96	7.3	103.8	0.0	0.10	1.07	2.3
SJ415	05-30-77	-	-	-	-	-	-	185.0	-	-	-	-	-	-	-	-
	06-28-77	-	-	-	-	-	-	139.0	-	-	-	-	-	-	-	-
	07-28-77	-	-	-	-	-	-	145.0	-	-	-	-	-	-	-	-
	09-26-77	-	-	-	-	-	-	198.0	-	-	-	-	-	-	-	-
	11-03-77	-	-	-	-	-	-	163.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	204.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	210.0	-	-	-	-	-	-	-	-
	02-09-78	-	-	-	-	-	-	220.0	-	-	-	-	-	-	-	-
	03-15-78	-	-	-	-	-	-	210.0	-	-	-	-	-	-	-	-
	04-26-78	23.0	105	55.0	80	5.0	1300	160.0	349.0	3.82	7.3	127.3	0.0	0.10	1.08	3.2
	06-06-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	130.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-
	09-20-78	-	-	-	-	-	-	131.0	-	-	-	-	-	-	-	-
	10-10-78	-	-	-	-	-	-	150.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
SJ416	04-27-78	22.5	71	33.0	37	3.0	800	68.0	206.0	3.80	7.4	143.9	0.0	0.10	1.05	1.6
SJ429	09-28-78	24.0	89	62.7	242	8.5	1800	520.0	315.0	3.30	7.6	143.5	0.0	0.10	1.03	3.2
SJ430	05-30-77	-	-	-	-	-	-	960.0	-	-	-	-	-	-	-	-
	06-30-77	-	-	-	-	-	-	830.0	-	-	-	-	-	-	-	-
	07-29-77	-	-	-	-	-	-	780.0	-	-	-	-	-	-	-	-
	09-26-77	-	-	-	-	-	-	770.0	-	-	-	-	-	-	-	-
	11-02-77	-	-	-	-	-	-	1235.0	-	-	-	-	-	-	-	-
	11-30-77	-	-	-	-	-	-	800.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	1790.0	-	-	-	-	-	-	-	-
	02-08-78	-	-	-	-	-	-	1900.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	1870.0	-	-	-	-	-	-	-	-
	04-26-78	-	-	-	-	-	-	1820.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	1660.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	1730.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	1740.0	-	-	-	-	-	-	-	-
	09-25-78	24.5	245	124.7	965	23.4	4000	1830.0	630.0	3.18	7.5	138.0	0.0	0.16	1.00	4.4
	11-06-78	-	-	-	-	-	-	1900.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	1780.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
SJ431	04-26-78	23.0	128	66.0	115	6.0	1625	230.0	430.0	2.04	7.3	114.1	0.0	0.10	1.10	3.3
SJ432	01-31-75	-	-	-	-	-	-	3380.0	-	-	-	-	-	-	-	-
	03-10-75	-	-	-	-	-	-	3410.0	-	-	-	-	-	-	-	-
	06-30-75	-	-	-	-	-	-	3350.0	-	-	-	-	-	-	-	-
	09-26-75	-	-	-	-	-	-	3260.0	-	-	-	-	-	-	-	-
	11-25-75	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	01-14-76	-	-	-	-	-	-	3220.0	-	-	-	-	-	-	-	-
	03-04-76	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	04-05-76	-	-	-	-	-	-	3460.0	-	-	-	-	-	-	-	-
	05-31-76	-	-	-	-	-	-	3400.0	-	-	-	-	-	-	-	-
	08-23-76	-	-	-	-	-	-	3100.0	-	-	-	-	-	-	-	-
	09-21-76	-	-	-	-	-	-	3300.0	-	-	-	-	-	-	-	-
	01-11-77	-	-	-	-	-	-	3300.0	-	-	-	-	-	-	-	-
	06-30-77	-	-	-	-	-	-	3360.0	-	-	-	-	-	-	-	-
	07-20-77	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	09-19-77	-	-	-	-	-	-	3310.0	-	-	-	-	-	-	-	-
	11-02-77	-	-	-	-	-	-	3310.0	-	-	-	-	-	-	-	-
	11-03-77	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	2910.0	-	-	-	-	-	-	-	-
	02-14-78	-	-	-	-	-	-	3360.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	3290.0	-	-	-	-	-	-	-	-
	04-25-78	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	3460.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	3340.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	09-25-78	25.5	328	230.0	1852	56.4	5900	3320.0	960.0	2.00	7.3	130.5	0.0	0.10	0.82	5.5
	11-06-78	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	3320.0	-	-	-	-	-	-	-	-
SJ433	01-14-75	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	03-10-75	-	-	-	-	-	-	138.0	-	-	-	-	-	-	-	-
	06-30-75	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	09-18-75	-	-	-	-	-	-	138.0	-	-	-	-	-	-	-	-
	05-27-76	-	-	-	-	-	-	146.0	-	-	-	-	-	-	-	-
	01-13-77	-	-	-	-	-	-	146.0	-	-	-	-	-	-	-	-
	03-30-77	-	-	-	-	-	-	130.0	-	-	-	-	-	-	-	-
	05-19-77	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	05-30-77	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	06-30-77	-	-	-	-	-	-	139.0	-	-	-	-	-	-	-	-
	07-19-77	-	-	-	-	-	-	141.0	-	-	-	-	-	-	-	-
	09-20-77	-	-	-	-	-	-	141.0	-	-	-	-	-	-	-	-
	11-04-77	-	-	-	-	-	-	142.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	142.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-
	02-10-78	-	-	-	-	-	-	142.0	-	-	-	-	-	-	-	-
	03-15-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	04-27-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	06-06-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	08-02-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	09-26-78	25.0	53	32.5	73	3.1	900	141.0	160.0	3.20	7.5	155.5	0.0	0.10	0.85	1.3
	11-10-78	-	-	-	-	-	-	145.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
SJ434	05-01-78	23.0	81	35.0	13	2.0	780	22.0	287.0	1.98	7.3	127.8	0.0	0.21	0.88	2.6
SJ438	04-27-78	22.0	72	33.0	62	3.0	930	119.0	180.0	2.20	7.5	147.0	0.0	0.34	0.96	1.4
SJ469	04-27-78	22.5	96	52.0	44	4.0	1020	78.0	376.0	2.22	7.5	127.3	0.0	0.10	1.00	2.1
SJ470	09-20-78	27.0	131	69.3	303	9.2	2100	610.0	360.0	2.28	7.6	145.0	0.0	0.10	0.88	3.2
SJ472	05-25-77	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	06-30-77	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	07-25-77	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	09-28-77	-	-	-	-	-	-	22.0	-	-	-	-	-	-	-	-
	11-04-77	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	12-01-77	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	02-10-78	-	-	-	-	-	-	14.0	-	-	-	-	-	-	-	-
	03-15-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	05-01-78	22.5	50	26.0	25	3.0	600	22.0	180.0	2.56	7.5	120.2	0.0	0.10	1.00	1.1
	06-06-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	10-09-78	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	11-10-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
	12-06-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
SJ473	05-01-78	22.5	59	29.0	14	2.0	620	23.0	180.0	2.60	7.5	129.3	0.0	0.10	0.88	1.0
SJ475	04-27-78	22.0	158	5.1	52	1.0	1000	138.0	1.6	0.28	7.4	334.3	0.0	4.70	0.19	0.3
SJ478	09-21-78	26.0	48	13.3	23	2.9	600	42.0	80.0	0.12	7.9	150.0	0.0	0.10	0.20	0.1
SJ479	09-28-78	22.0	50	1.5	13	0.4	450	24.0	0.0	0.44	7.3	182.0	0.0	0.23	0.10	0.1
SJ480	09-25-78	24.5	73	18.2	72	6.6	900	126.0	145.0	0.26	7.6	216.0	0.0	0.27	0.61	0.2
SJ481	09-27-78	22.5	98	11.9	138	2.1	1000	280.0	72.0	0.78	7.3	272.0	0.0	0.10	0.17	0.3
SJ482	05-31-77	-	-	-	-	-	-	1150.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	06-30-77	-	-	-	-	-	-	1180.0	-	-	-	-	-	-	-	-
	07-27-77	-	-	-	-	-	-	1180.0	-	-	-	-	-	-	-	-
	09-23-77	-	-	-	-	-	-	1130.0	-	-	-	-	-	-	-	-
	11-02-77	-	-	-	-	-	-	1140.0	-	-	-	-	-	-	-	-
	12-03-77	-	-	-	-	-	-	1160.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	1150.0	-	-	-	-	-	-	-	-
	02-14-78	-	-	-	-	-	-	1180.0	-	-	-	-	-	-	-	-
	03-14-78	-	-	-	-	-	-	1140.0	-	-	-	-	-	-	-	-
	04-25-78	-	-	-	-	-	-	1180.0	-	-	-	-	-	-	-	-
	06-05-78	-	-	-	-	-	-	1180.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	1190.0	-	-	-	-	-	-	-	-
	08-07-78	-	-	-	-	-	-	1170.0	-	-	-	-	-	-	-	-
	09-25-78	25.5	254	143.4	473	8.7	3250	1200.0	720.0	1.16	7.4	110.0	0.0	0.44	0.87	6.3
	11-06-78	-	-	-	-	-	-	1240.0	-	-	-	-	-	-	-	-
	12-05-78	-	-	-	-	-	-	1220.0	-	-	-	-	-	-	-	-
	01-08-79	-	-	-	-	-	-	1226.0	-	-	-	-	-	-	-	-
SJ483	09-25-78	23.5	91	28.1	243	8.3	1700	510.0	95.0	0.18	7.2	232.0	5.0	2.67	0.39	0.2
SJ484	09-25-78	24.0	80	66.0	65	5.3	1100	148.0	390.0	1.92	7.6	120.0	0.0	0.10	1.17	3.0
SJ485	10-11-77	-	-	-	-	-	-	148.0	-	-	-	-	-	-	-	-
	11-02-77	-	-	-	-	-	-	149.0	-	-	-	-	-	-	-	-
	11-30-77	-	-	-	-	-	-	156.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	150.0	-	-	-	-	-	-	-	-
	02-07-78	-	-	-	-	-	-	152.0	-	-	-	-	-	-	-	-
	03-15-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	04-26-78	24.0	14	10.5	200	16.0	1190	148.0	48.0	0.20	-	325.2	0.3	0.10	1.12	0.0
	06-06-78	-	-	-	-	-	-	140.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	09-25-78	24.0	5	7.4	241	13.8	1100	170.0	77.0	0.36	8.3	344.0	12.0	0.10	1.22	0.0
	11-06-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	190.0	-	-	-	-	-	-	-	-
SJ486	04-26-78	23.0	119	16.6	44	2.0	920	71.0	121.0	0.06	7.2	244.0	0.0	3.40	0.34	0.5
SJ487	05-02-78	25.5	63	34.0	13	2.0	695	24.0	173.0	1.98	7.5	128.3	0.0	0.10	0.99	1.3
SJ488	09-21-78	25.0	66	12.5	34	11.5	780	60.0	38.0	0.36	7.4	248.0	0.0	1.94	1.28	0.1
SJ489	10-09-78	23.0	77	10.4	32	3.3	700	55.0	32.0	2.34	6.8	292.5	0.0	0.10	0.13	0.1
SJ490	09-26-78	27.0	97	4.1	54	1.2	800	141.0	3.5	0.14	7.1	283.5	0.0	8.48	0.19	0.7

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
SJ491	09-21-78	23.5	103	5.5	32	1.8	800	65.0	6.0	0.64	7.2	375.5	0.0	1.08	0.12	0.3
SJ492	04-26-78	19.0	147	62.0	86	8.0	1400	174.0	523.0	0.08	7.4	139.4	0.0	0.25	1.00	2.4
SJ493	09-20-78	23.0	98	3.3	32	0.9	750	47.0	0.0	0.24	7.1	368.0	0.0	1.09	0.10	0.2
SJ494	09-27-78	21.0	95	3.2	30	0.6	800	56.0	0.0	0.42	7.0	364.0	0.0	0.61	0.06	0.2
SJ495	04-25-78	21.5	152	17.2	112	5.0	1250	270.0	58.0	0.54	7.3	269.7	0.0	1.54	0.42	1.4
SJ496	04-25-78	22.0	127	6.7	22	1.0	790	61.0	0.5	0.06	7.2	342.4	0.0	0.41	0.32	0.1
SJ497	09-26-78	23.0	65	3.9	38	2.2	550	51.0	0.0	0.10	7.4	272.5	0.0	0.49	0.26	0.1
SJ498	02-24-78	-	-	-	-	-	-	42.0	-	-	-	-	-	-	-	-
	04-26-78	21.5	122	8.1	25	2.0	750	42.0	0.0	0.08	7.2	352.5	0.0	0.10	0.37	0.1
	06-07-78	-	-	-	-	-	-	40.0	-	-	-	-	-	-	-	-
	07-11-78	-	-	-	-	-	-	40.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	40.0	-	-	-	-	-	-	-	-
	09-27-78	-	-	-	-	-	-	41.0	-	-	-	-	-	-	-	-
	11-06-78	-	-	-	-	-	-	45.0	-	-	-	-	-	-	-	-
	12-11-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
SJ499	05-15-78	21.0	47	2.5	20	1.0	350	38.0	10.0	0.28	6.9	124.2	0.0	1.11	0.04	1.0
	07-12-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	08-07-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	09-27-78	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	11-06-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
	12-12-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
SJ501	10-10-78	24.0	53	34.1	64	3.4	950	125.0	180.0	2.48	7.3	154.0	0.0	0.10	0.92	-
SJ502	10-10-78	25.0	33	29.0	27	3.7	650	21.0	185.0	2.48	7.6	140.0	0.0	0.10	1.10	-
SJ503	07-05-78	-	-	-	-	-	-	60.0	-	-	-	-	-	-	-	-
	07-07-78	-	-	-	-	-	-	60.0	-	-	-	-	-	-	-	-
	10-10-78	22.0	95	4.8	34	1.3	830	60.0	0.0	0.28	7.0	388.0	0.0	2.12	0.07	0.5
	11-10-78	-	-	-	-	-	-	65.0	-	-	-	-	-	-	-	-
	12-12-78	-	-	-	-	-	-	70.0	-	-	-	-	-	-	-	-
	01-04-79	-	-	-	-	-	-	56.0	-	-	-	-	-	-	-	-
SJ504	06-27-78	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	07-07-78	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-
	10-10-78	21.0	105	7.5	62	2.0	1100	122.0	0.0	0.22	6.9	419.0	0.0	3.95	0.08	0.5
	11-10-78	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-
	12-12-78	-	-	-	-	-	-	130.0	-	-	-	-	-	-	-	-
	01-04-79	-	-	-	-	-	-	116.0	-	-	-	-	-	-	-	-
D1	05-02-78	23.0	51	20.0	11	1.0	440	8.0	74.0	3.20	7.3	148.5	0.0	0.10	0.66	0.0
D2	10-09-78	21.5	47	9.0	17	2.0	430	27.0	2.0	1.32	7.4	226.0	0.0	0.10	0.58	0.0
D3	05-01-78	22.5	90	7.8	13	1.0	495	24.0	0.2	0.20	7.5	266.6	0.0	0.00	0.62	0.0
D5	05-02-78	21.5	36	4.1	7	1.0	240	15.0	0.2	0.08	7.6	118.0	0.0	0.10	0.18	0.0
D6	09-22-78	24.0	34	20.6	16	1.7	600	22.0	72.0	3.88	7.6	165.0	0.0	0.10	0.57	0.0
D7	10-09-78	22.0	63	6.9	19	2.2	480	26.0	0.0	0.28	7.3	256.0	0.0	0.10	0.66	0.0
D9	10-06-78	22.5	23	1.4	8	0.6	248	15.0	9.0	0.18	6.5	99.2	0.0	2.25	0.07	-
	11-09-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
	12-13-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
D10	10-06-78	21.1	20	3.0	8	0.5	250	15.0	2.0	0.12	7.8	89.0	0.0	0.10	0.11	-
	11-09-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	12-13-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
D11	09-22-78	24.5	34	15.6	38	4.6	600	38.0	18.0	0.48	7.9	206.5	0.0	0.65	0.54	0.5
	11-17-78	-	-	-	-	-	-	34.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	45.0	-	-	-	-	-	-	-	-
	01-04-79	22.5	26	11.8	33	4.6	318	17.5	2.0	-	8.2	159.5	18.0	0.24	0.70	0.5
D12	09-22-78	25.5	8	24.3	956	40.4	2900	1060.0	170.0	21.52	8.2	658.0	0.0	0.10	1.62	0.5
	11-17-78	-	-	-	-	-	-	1120.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	1045.0	-	-	-	-	-	-	-	-
	01-04-79	22.0	7	23.6	895	45.9	3120	960.0	75.0	-	8.2	604.0	21.0	0.10	2.10	0.5
D13	09-22-78	26.5	166	222.0	2356	82.4	7600	4300.0	420.0	10.68	7.6	278.0	0.0	0.19	0.38	2.5
	11-17-78	-	-	-	-	-	-	4400.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	4420.0	-	-	-	-	-	-	-	-
	01-04-79	21.5	155	325.0	3125	106.0	11500	5830.0	670.0	-	7.5	271.0	0.0	0.27	0.30	2.5
D14	09-29-78	21.5	4	1.2	12	0.7	150	10.0	9.0	0.38	5.7	19.7	0.0	0.36	0.06	0.5

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	11-08-78	-	-	-	-	-	-	15.0	-	-	-	-	-	-	-	-
	12-06-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
	01-03-79	-	-	-	-	-	-	4.5	-	-	-	-	-	-	-	-
D16	01-18-79	21.5	43	22.1	13	1.9	350	21.0	85.0	12.97	7.7	154.0	0.0	0.10	0.42	1.2
D17	01-18-79	24.5	53	34.4	52	2.6	730	106.0	175.0	3.09	7.4	151.0	0.0	0.10	0.69	0.8
D18	01-18-79	26.5	61	40.3	73	2.8	950	174.0	200.0	2.61	7.5	147.5	0.0	0.10	0.46	1.1
D19	01-18-79	26.0	52	36.8	60	2.6	830	131.0	200.0	2.61	7.4	146.5	0.0	0.25	0.40	0.9
D20	01-17-79	26.8	58	33.2	31	2.3	750	93.0	188.0	1.70	7.8	136.0	0.0	0.14	0.44	3.1
D21	01-17-79	24.0	46	28.0	11	1.6	435	17.6	180.0	2.21	7.6	139.0	0.0	0.10	0.58	1.6
D164	06-22-77	-	-	-	-	-	-	150.0	-	-	-	-	-	-	-	-
	07-26-77	-	-	-	-	-	-	161.0	-	-	-	-	-	-	-	-
	09-30-77	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	11-10-77	-	-	-	-	-	-	161.0	-	-	-	-	-	-	-	-
	11-29-77	-	-	-	-	-	-	163.0	-	-	-	-	-	-	-	-
	01-12-78	-	-	-	-	-	-	197.0	-	-	-	-	-	-	-	-
	02-22-78	-	-	-	-	-	-	165.0	-	-	-	-	-	-	-	-
	03-16-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	05-02-78	25.5	79	37.0	70	3.0	1100	162.0	194.0	2.36	7.3	156.6	0.0	0.10	0.63	0.3
	06-08-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	07-13-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	08-09-78	-	-	-	-	-	-	160.0	-	-	-	-	-	-	-	-
	09-29-78	-	-	-	-	-	-	166.0	-	-	-	-	-	-	-	-
	11-09-78	-	-	-	-	-	-	180.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	175.0	-	-	-	-	-	-	-	-
	01-04-79	-	-	-	-	-	-	155.2	-	-	-	-	-	-	-	-
D245	10-31-77	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	11-29-77	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	01-18-78	-	-	-	-	-	-	33.0	-	-	-	-	-	-	-	-
	02-21-78	-	-	-	-	-	-	22.0	-	-	-	-	-	-	-	-
	03-16-78	-	-	-	-	-	-	33.5	-	-	-	-	-	-	-	-
	05-02-78	-	-	-	-	-	-	21.0	-	-	-	-	-	-	-	-
	06-08-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	07-13-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
	08-09-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	10-09-78	21.0	73	1.7	15	0.5	490	24.0	0.0	0.12	6.6	282.0	0.0	1.04	0.28	0.1
	11-10-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	12-06-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
D247	10-04-78	23.5	4	1.7	9	1.1	108	13.0	0.0	0.10	7.8	41.0	0.0	0.10	0.07	-
D424	05-24-77	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	06-27-77	-	-	-	-	-	-	19.0	-	-	-	-	-	-	-	-
	07-25-77	-	-	-	-	-	-	19.0	-	-	-	-	-	-	-	-
	09-30-77	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	10-31-77	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-	-
	11-29-77	-	-	-	-	-	-	22.0	-	-	-	-	-	-	-	-
	01-13-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
	02-22-78	-	-	-	-	-	-	8.0	-	-	-	-	-	-	-	-
	03-16-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	05-02-78	22.5	61	21.0	11	1.0	550	8.0	137.0	2.34	7.4	161.6	0.0	0.27	0.71	0.7
	06-08-78	-	-	-	-	-	-	15.0	-	-	-	-	-	-	-	-
	07-13-78	-	-	-	-	-	-	15.0	-	-	-	-	-	-	-	-
	08-09-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	10-06-78	-	-	-	-	-	-	23.0	-	-	-	-	-	-	-	-
	11-09-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	12-13-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
N1	05-08-78	22.0	32	2.0	7	1.0	223	17.0	1.0	0.12	7.8	102.0	0.0	0.00	0.16	0.0
N2	10-04-78	25.5	30	7.2	26	4.2	435	53.0	37.5	0.06	7.8	106.0	0.0	0.10	0.56	0.0
N3	06-13-77	-	-	-	-	-	-	450.0	-	-	-	-	-	-	-	-
	09-22-77	-	-	-	-	-	-	240.0	-	-	-	-	-	-	-	-
	10-24-77	-	-	-	-	-	-	40.0	-	-	-	-	-	-	-	-
	05-08-78	22.0	68	33.0	18	2.0	690	34.0	202.0	2.16	7.4	169.7	0.0	0.10	0.63	0.5
	06-08-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
	07-13-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	10-04-78	-	-	-	-	-	-	35.0	-	-	-	-	-	-	-	-
	11-08-78	-	-	-	-	-	-	40.0	-	-	-	-	-	-	-	-
N5	10-04-78	23.5	38	28.7	18	1.9	610	28.0	125.0	1.76	7.7	159.0	0.0	0.18	0.62	0.0
N6	11-08-77	-	-	-	-	-	-	15.0	-	-	-	-	-	-	-	-
	01-12-78	-	-	-	-	-	-	24.0	-	-	-	-	-	-	-	-
	02-23-78	-	-	-	-	-	-	16.0	-	-	-	-	-	-	-	-
	03-16-78	-	-	-	-	-	-	24.0	-	-	-	-	-	-	-	-
	05-08-78	-	-	-	-	-	-	16.0	-	-	-	-	-	-	-	-
	06-08-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	08-09-78	-	-	-	-	-	-	10.0	-	-	-	-	-	-	-	-
	10-04-78	21.0	30	4.3	8	0.8	245	17.0	3.0	0.12	7.5	126.0	0.0	0.33	0.15	0.0
	11-08-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
	12-06-78	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-
N16	05-08-78	24.0	59	9.7	16	1.0	450	40.0	10.0	0.02	7.6	185.8	0.0	0.53	0.14	0.0
N18	09-29-78	-	-	-	-	-	-	330.0	-	-	-	-	-	-	-	-
	11-09-78	-	-	-	-	-	-	350.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	430.0	-	-	-	-	-	-	-	-
	01-03-79	17.0	47	35.2	305	27.1	1400	340.0	67.0	0.68	7.5	478.0	0.0	0.55	0.93	0.5
N19	09-29-78	-	-	-	-	-	-	470.0	-	-	-	-	-	-	-	-
	11-09-78	-	-	-	-	-	-	560.0	-	-	-	-	-	-	-	-
	12-07-78	-	-	-	-	-	-	550.0	-	-	-	-	-	-	-	-
	01-03-79	19.0	23	49.9	338	34.0	1600	461.0	3.3	9.84	7.6	421.0	0.0	0.10	0.37	0.5
N20	09-29-78	-	-	-	-	-	-	17.0	-	-	-	-	-	-	-	-
	11-08-78	-	-	-	-	-	-	20.0	-	-	-	-	-	-	-	-
	12-06-78	-	-	-	-	-	-	30.0	-	-	-	-	-	-	-	-
	01-03-79	17.5	60	10.6	11	1.1	352	10.3	4.1	0.06	7.7	269.0	0.0	1.17	0.16	0.5
P57	09-18-78	25.0	295	153.9	630	7.2	3800	1290.0	720.0	2.38	7.5	101.5	0.0	0.12	0.44	-
P77	09-18-78	24.0	70	45.5	174	5.4	1500	370.0	300.0	4.52	7.7	113.0	0.0	0.10	0.30	-
P87	09-18-78	28.5	244	124.7	888	15.3	4700	1950.0	560.0	4.22	7.5	114.0	0.0	0.17	0.32	-
P100	09-18-78	23.5	102	48.7	172	5.4	1600	375.0	245.0	4.70	7.7	115.0	0.0	0.10	0.29	2.1
P189	06-17-77	-	-	-	-	-	-	730.0	-	-	-	-	-	-	-	-
	07-18-77	-	-	-	-	-	-	730.0	-	-	-	-	-	-	-	-
	09-23-77	-	-	-	-	-	-	720.0	-	-	-	-	-	-	-	-
	11-07-77	-	-	-	-	-	-	735.0	-	-	-	-	-	-	-	-
	11-28-77	-	-	-	-	-	-	740.0	-	-	-	-	-	-	-	-
	01-05-78	-	-	-	-	-	-	720.0	-	-	-	-	-	-	-	-
	02-07-78	-	-	-	-	-	-	745.0	-	-	-	-	-	-	-	-
	03-21-78	-	-	-	-	-	-	740.0	-	-	-	-	-	-	-	-
	04-25-78	-	-	-	-	-	-	750.0	-	-	-	-	-	-	-	-
	06-06-78	-	-	-	-	-	-	755.0	-	-	-	-	-	-	-	-
	07-10-78	-	-	-	-	-	-	740.0	-	-	-	-	-	-	-	-
	08-02-78	-	-	-	-	-	-	740.0	-	-	-	-	-	-	-	-
	09-18-78	23.5	221	130.6	330	6.8	2800	745.0	955.0	3.36	7.7	96.0	0.0	0.38	0.38	6.0
ATO	01-22-79	22.0	388	1285.0	11450	416.0	22000	19350.0	2250.0	0.00	8.1	85.0	26.0	0.22	0.72	3.6

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
G040	08-24-76	23.0	120	5.2	33	1.2	675	55.0	5.0	-	-	366.0	0.0	-	0.10	0.7
G042	08-24-76	25.0	130	2.9	24	1.4	700	34.0	60.0	-	-	326.0	0.0	-	0.20	0.7
G044	05-02-77	21.2	67	33.0	55	3.1	852	112.5	99.0	-	7.9	201.0	0.0	-	-	2.9
G045	05-11-77	25.0	95	41.0	15	3.2	775	22.0	310.0	-	7.4	108.0	0.0	-	-	5.0
G046	05-05-77	23.5	86	35.0	15	2.9	785	22.0	270.0	-	-	101.0	0.0	-	-	4.6
G047	05-03-77	22.0	68	45.0	15	3.1	775	22.0	270.0	-	7.8	97.0	0.0	-	-	4.7
G048	05-03-77	22.6	50	30.0	27	3.7	605	22.0	120.0	-	7.5	190.0	0.0	-	-	2.4
G049	05-06-77	23.0	56	37.0	15	3.2	660	20.0	160.0	-	-	163.0	0.0	-	-	4.8
G050	05-05-77	23.0	67	36.0	17	3.1	680	20.0	110.0	-	-	260.0	0.0	-	-	3.2
G051	05-06-77	23.0	54	44.0	15	3.4	745	22.0	250.0	-	-	75.0	0.0	-	-	5.1
G052	05-05-77	22.0	72	34.0	15	2.8	670	18.0	300.0	-	-	22.0	0.0	-	-	4.3
G053	05-05-77	23.0	56	32.0	17	3.5	622	22.0	120.0	-	-	191.0	0.0	-	-	3.1
G054	05-06-77	22.0	86	42.0	16	3.3	850	27.5	320.0	-	-	66.0	0.0	-	-	5.8
G055	05-05-77	23.0	53	32.0	17	3.3	510	18.0	160.0	-	-	138.0	0.0	-	-	3.8
G057	05-05-77	23.5	75	38.0	16	3.2	725	16.0	260.0	-	-	109.0	0.0	-	-	4.6
G058	05-10-77	22.0	91	3.6	10	1.3	502	13.4	3.8	-	-	296.0	0.0	-	-	0.1
G059	05-10-77	24.0	72	36.0	15	3.0	685	19.4	240.0	-	-	106.0	0.0	-	-	4.2
G060	05-11-77	29.0	63	32.0	21	2.4	630	34.0	98.0	-	7.6	229.0	0.0	-	-	2.8

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
G061	05-02-77	23.5	65	33.0	16	3.0	652	22.0	140.0	-	-	195.0	0.0	-	-	5.7
G062	05-02-77	24.5	61	31.0	20	3.2	645	16.0	140.0	-	-	194.0	0.0	-	-	2.9
G063	05-10-77	24.0	25	2.7	8	1.0	166	8.0	2.0	-	-	97.0	0.0	-	-	0.1
G065	05-10-77	28.0	66	29.0	13	2.5	600	20.0	96.0	-	-	229.0	0.0	-	-	3.4
G066	05-03-77	23.0	64	35.0	14	2.6	630	16.0	160.0	-	-	181.0	0.0	-	-	2.5
G067	05-11-77	30.5	78	33.0	18	2.7	742	65.0	130.0	-	-	178.0	0.0	-	-	3.7
G068	05-05-77	22.0	110	3.9	16	0.9	620	26.0	2.1	-	-	351.0	0.0	-	-	0.6
G069	09-14-77	23.0	71	33.0	13	2.6	640	16.0	190.0	-	-	151.0	0.0	0.03	-	2.9
G070	05-13-75	-	64	38.0	14	2.9	637	14.0	180.0	-	8.4	152.0	2.0	0.03	0.80	2.1
G071	05-06-77	28.5	77	31.0	36	2.6	800	103.0	110.0	-	7.4	173.0	0.0	-	-	2.9
G072	05-05-77	26.5	65	27.0	15	2.3	590	28.0	110.0	-	7.4	189.0	0.0	-	-	2.8
G073	05-10-77	23.0	85	4.2	12	1.2	491	16.0	10.0	-	-	273.0	0.0	-	-	0.3
G074	09-13-77	-	67	27.0	11	2.1	-	16.0	140.0	-	7.4	167.0	0.0	0.06	0.50	3.1
G075	09-14-77	-	230	60.0	110	5.9	-	190.0	270.0	-	7.2	633.0	0.0	0.80	1.10	7.0
G077	09-12-77	29.0	69	28.0	10	2.2	549	17.0	160.0	-	-	148.0	0.0	-	-	3.7
G078	05-13-75	-	62	37.0	12	2.3	627	14.0	170.0	-	8.3	160.0	0.0	0.01	0.80	1.2
G079	05-03-77	23.0	72	32.0	15	2.7	643	14.0	125.0	-	-	241.0	0.0	-	-	2.4
G080	09-12-77	28.0	73	28.0	21	1.9	626	52.0	120.0	-	-	180.0	0.0	-	-	2.1

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
G081	05-04-77	28.5	75	31.0	35	2.3	774	90.0	110.0	-	7.0	186.0	0.0	-	-	2.7
G082	05-13-75	-	61	36.0	12	2.4	627	17.0	170.0	-	8.3	153.0	0.0	0.04	0.80	2.0
G083	09-13-77	28.0	67	26.0	20	2.0	610	48.0	110.0	-	7.4	168.0	0.0	-	-	2.3
G084	05-05-77	28.0	60	24.0	13	1.9	480	16.0	95.0	-	7.5	192.0	0.0	-	-	2.1
G085	05-04-77	22.0	5	2.1	6	0.6	75	9.5	1.8	-	-	25.0	0.0	-	-	0.0
G086	09-14-77	22.5	67	25.0	13	2.1	564	22.0	120.0	-	-	177.0	0.0	-	-	2.2
G087	05-03-77	22.0	59	21.0	14	2.4	535	19.0	88.0	-	-	181.0	0.0	-	-	2.1
G089	05-04-77	27.0	93	37.0	73	2.6	1080	200.0	110.0	-	7.1	183.0	0.0	-	-	2.4
G090	05-02-77	21.5	50	24.0	15	1.8	465	20.0	70.0	-	-	192.0	0.0	-	-	0.0
G091	05-02-77	27.5	78	40.0	70	3.0	1150	160.0	160.0	-	-	150.0	0.0	-	-	1.4
G092	09-15-77	22.0	54	24.0	14	1.7	545	20.6	78.0	-	-	190.0	0.0	-	-	0.6
G093	05-03-77	23.0	23	24.0	12	1.7	340	17.0	35.0	-	8.3	151.0	0.0	-	-	0.7
G094	05-03-77	23.0	21	9.7	8	1.1	225	15.0	1.5	-	6.9	110.0	0.0	-	-	0.1
G095	04-04-78	22.8	56	30.0	17	2.2	587	26.0	120.0	-	7.3	190.0	0.0	0.00	0.50	0.6
G096	09-07-77	-	58	30.0	16	2.0	588	26.0	120.0	-	-	176.0	0.0	0.06	-	0.5
G097	04-04-78	23.0	53	31.0	18	2.3	614	27.0	130.0	-	7.4	190.0	0.0	0.01	0.60	0.6
G098	04-10-78	21.7	58	29.0	17	2.0	582	25.0	120.0	-	7.2	190.0	0.0	0.02	0.50	0.5
G099	04-04-78	22.8	57	30.0	19	2.3	608	30.0	130.0	-	7.2	190.0	0.0	0.01	0.60	0.6

TABLE A-2 CONTD.

WELL NO	DATE COLL	TEMP	CA	MG	NA	K	SPEC COND	CL	SO4	S	PH	HCO3	CO3	FE	F	SR
G100	04-05-78	23.0	60	34.0	23	2.3	663	23.0	140.0	-	7.4	200.0	0.0	0.00	0.60	0.7
G101	04-11-78	22.5	62	33.0	21	2.6	611	30.0	140.0	-	7.3	200.0	0.0	0.00	0.60	0.7
G102	09-07-77	-	62	37.0	18	2.1	660	30.0	140.0	-	-	196.0	0.0	0.08	-	0.7
G103	04-12-78	25.0	65	47.0	97	3.9	1160	200.0	160.0	-	7.7	170.0	0.0	0.01	0.60	0.9
G104	04-05-78	24.5	61	34.0	23	2.5	680	18.0	150.0	-	7.2	200.0	0.0	0.00	0.60	0.7
G105	04-06-78	24.0	67	41.0	68	3.4	986	140.0	170.0	-	7.2	200.0	0.0	0.01	0.60	0.8
G106	04-05-78	23.2	77	40.0	51	3.0	965	94.0	160.0	-	7.2	210.0	0.0	0.00	0.50	0.8
G107	04-06-78	24.8	64	35.0	27	2.6	736	19.0	160.0	-	7.2	210.0	0.0	0.00	0.50	0.7
G108	04-10-78	22.3	65	35.0	21	2.5	702	12.0	160.0	-	7.3	210.0	0.0	0.01	0.50	0.6
G109	04-06-78	27.5	93	52.0	67	3.4	1170	129.0	240.0	-	7.4	200.0	0.0	0.00	0.50	0.9
G110	04-05-78	22.6	53	32.0	37	7.7	705	5.2	160.0	-	7.3	220.0	0.0	0.02	0.60	0.0
G111	04-07-78	25.0	69	37.0	25	27.0	743	44.0	180.0	-	7.3	200.0	0.0	0.01	0.50	0.8
G112	04-07-78	25.0	70	37.0	23	2.7	733	32.0	180.0	-	7.2	200.0	0.0	0.01	0.50	0.8
G113	04-07-78	25.5	71	38.0	36	3.0	844	38.0	190.0	-	7.1	200.0	0.0	0.00	0.50	0.8
G114	10-04-77	-	74	37.0	22	2.2	-	31.0	160.0	-	-	216.0	0.0	0.03	0.50	0.7
G115	05-03-77	23.5	41	29.0	18	2.0	415	8.0	92.0	-	-	191.0	0.0	-	-	0.5

APPENDIX B

CLIMATIC DATA FROM PROJECT STATIONS

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1								3.05			0.16	0.50
2						0.30		2.05				
3							0.10	0.02			0.07	
4					0.70	0.70	0.42				0.12	
5						0.30	0.30	0.15				0.15
6						0.26	0.70	0.04				0.02
7						0.02	0.02					
8						0.44	0.58					
9						0.48			1.05			
10					0.80	0.08			0.60	0.05		0.04
11						0.36			0.02	2.00		
12						0.03		0.90				0.80
13							0.05	0.20		0.22		
14						0.07	0.86				0.07	
15							0.02	0.12				
16						0.01	0.22					
17					0.70	0.08	0.74					
18							0.74					
19					0.02		0.82			0.48		
20												
21										0.42		
22									0.05			
23						1.70						
24									0.03			
25									1.05			1.00
26							0.03					
27									0.70			
28							0.91		1.20			
29										0.48		0.76
30							1.30			1.40		0.02
31							0.08			1.90		
MONTHLY TOTAL					2.22	4.83	7.89	6.53	4.70	6.95	0.42	3.29
CUMULATIVE						7.05	14.94	21.47	26.17	33.12	33.54	36.83

FIGURE B1. -- Bulow Plantation Ruins Daily Precipitation, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1												
2					1.85							
3												
4												
5												
6		0.16	0.92		0.92							
7					0.07							
8					0.90							
9					1.75							
10					2.50							
11			0.42		1.25							
12	3.05		1.00		0.18							
13	0.40				0.04							
14												
15												
16												
17												
18		0.24										
19		0.05										
20												
21	0.66				0.01							
22												
23												
24	1.50		0.15									
25				1.75	1.50							
26		0.14		0.12								
27	0.36											
28												
29												
30	0.50											
31					0.50							
MONTHLY TOTAL	6.47	0.59	2.49	1.87	11.47							
CUMULATIVE		7.06	9.55	11.42	22.89							

FIGURE B1. -- Bulow Plantation Ruins Daily Precipitation, 1979

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1						0.90		3.50		0.03		
2						0.40		1.29				0.50
3						0.60	0.10	1.64				
4						0.30	0.42					
5							0.30		0.40			0.30
6						0.64	0.70		0.20			
7						0.22	0.02					
8						0.46	0.58					
9						0.12						
10						0.38			0.02			0.20
11									0.40	0.70		
12									0.15			0.60
13							0.06			0.62		
14							0.86	1.25			0.35	
15							0.02					
16						0.10	0.22					
17					0.05		0.74					
18							0.74					
19							0.82					
20										0.15		
21												0.05
22												
23									0.05	0.15		
24												
25									1.15			
26							0.03		0.03			1.00
27									0.10			
28							0.91					1.25
29										1.60		0.90
30							1.30		1.75			0.10
31					0.60		0.08			0.45		
MONTHLY TOTAL					0.65	4.12	7.90	7.68	4.25	3.70	0.35	4.90
CUMULATIVE						4.77	12.67	20.35	24.60	28.30	28.65	33.55

FIGURE B2. -- Faver Dykes State Park Daily Precipitation, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1					0.02							
2	0.80				0.04							
3												
4												
5												
6		0.25	0.90	0.60								
7		0.52	1.00		0.08							
8	0.05	0.04			1.25							
9					1.50							
10				0.40	1.25							
11			0.09	0.12	0.86							
12	2.25				0.15							
13	0.42											
14				0.32	0.20							
15												
16												
17												
18		0.50										
19		0.06										
20												
21	1.38				0.01							
22		0.03			0.03							
23												
24	1.20	1.35	0.05									
25		0.40		1.50	0.10							
26				0.06								
27	0.55											
28	0.05											
29												
30												
31	0.54				0.27							
MONTHLY TOTAL	7.24	3.15	2.04	3.00	5.76							
CUMULATIVE		10.39	12.43	15.43	21.19							

FIGURE B2. -- Faver Dykes State Park Daily Precipitation, 1979

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1					0.04	0.36	0.06	1.26				0.06
2					0.13	0.06						
3					0.26	0.52	0.07		0.60		0.12	
4					0.70	0.38	0.30		1.75			0.07
5						1.35	0.17					0.05
6							0.10	0.14				
7					0.04	0.14	0.45					
8					0.16	0.26	0.36					0.10
9					0.15	0.14	0.05					
10						0.66			0.26	1.17		
11						0.03	0.66	0.36				0.64
12										0.92		
13				0.50			3.50	0.35		0.11	0.17	
14							0.36		0.06			
15							0.30		0.42			
16						0.15	0.28					
17												
18				1.27			1.30		0.09	0.20		
19				0.17			0.17					
20												
21											0.04	0.04
22						0.75	0.05					
23									0.41			
24								0.11	3.45			0.65
25									0.05			
26									0.12			
27							0.68		4.15			1.50
28							0.48			0.28		0.80
29							0.38		0.18	0.06		0.15
30							0.30			1.17	0.50	
31					0.21		1.65					
MONTHLY TOTAL				1.94	1.69	4.80	11.67	2.22	11.54	3.91	0.83	4.06
CUMULATIVE					3.63	8.43	20.10	22.32	33.86	37.77	38.60	42.66

FIGURE B3. -- Washington Oaks State Gardens Daily Precipitation, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1					0.07							
2	0.42											
3						2.30						
4												
5		0.28	1.25	0.58		0.36						
6		0.41	0.74		0.16							
7	0.05	0.16			0.12							
8					1.60							
9				0.46	1.70							
10				0.12	1.62							
11	2.70		0.11		1.75							
12	0.76				0.04							
13				0.36								
14					0.15							
15												
16												
17		0.50										
18		0.11										
19												
20	0.64											
21		0.06										
22												
23	1.30		0.08									
24		1.42		1.76	0.07							
25		0.50		0.56								
26	0.46											
27	0.14											
28												
29												
30	0.54				0.30							
31												
MONTHLY TOTAL	7.01	3.44	2.18	3.84	7.58							
CUMULATIVE		10.45	12.63	16.47	24.05							

FIGURE B3. -- Washington Oaks State Gardens Daily Precipitation, 1979

DAY	APRIL		MAY		JUNE		JULY	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
1			29.96	30.04	30.08	30.14	29.92	29.98
2			29.98	30.09	30.03	30.07	30.00	30.08
3			30.06	30.10	29.98	30.03	29.98	30.06
4			30.01	30.07	29.85	29.96	29.96	30.02
5			29.95	29.98	29.86	29.90	29.98	30.16
6			29.89	29.93	29.80	29.87	30.08	30.19
7			29.88	29.96	29.81	29.94	30.10	30.16
8			29.92	29.98	29.91	30.03	30.00	30.12
9			29.93	30.01	30.04	30.10	29.91	29.98
10			29.91	29.99	30.00	30.04	29.90	29.96
11			29.96	30.07	29.81	29.92	29.92	30.06
12			29.94	30.02	29.98	30.06	30.06	30.13
13			29.96	30.04	30.02	30.09		
14			29.94	30.00	30.02	30.12		
15			29.94	30.01	29.98	30.02		
16			29.96	30.05	29.88	29.98		
17			30.03	30.15	29.94	30.06		
18			30.08	30.14	30.00	30.13		
19			30.02	30.05	30.06	30.14		
20			29.95	30.01	30.10	30.14		
21			29.91	29.99	30.12	30.20		
22			29.93	30.05	30.15	30.21		
23			30.01	30.07	30.01	30.06		
24			29.95	29.99	30.08	30.14		
25			29.77	29.94	30.08	30.14		
26	29.69	30.76	29.96	30.06	30.05	30.12		
27	29.75	29.85	29.99	30.14	30.05	30.14		
28	29.87	29.97	30.02	30.08	30.12	30.16		
29	29.96	30.04	29.98	30.00	30.07	30.13		
30	29.93	30.03	29.92	30.05	29.90	30.06		
31			29.98	30.14				
MONTHLY HIGH		Inc.		30.15		30.21		Inc.
MONTHLY LOW	Inc.		29.88		29.80		Inc.	

FIGURE B4. -- Barometric Pressure at Washington Oaks Barrier Island Monitor Site, April to July 1979

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1						0.05						
2						0.07						
3												
4		0.02				0.79						
5			0.03	0.78								
6		0.52	0.68	0.75	1.00							
7		0.56	0.42		0.19							
8	0.33		0.06		1.57							
9			0.02	0.25	0.86							
10				0.03	0.82							
11			0.11		0.75							
12	1.10		0.04		0.73	1.05						
13	0.94				0.82							
14				0.22	0.64	0.03						
15					0.15	1.05						
16						1.75						
17												
18		0.22										
19		0.10										
20	1.80	0.02										
21		0.01										
22		0.01										
23		0.23				0.65						
24	0.90	0.02	T		0.02							
25		3.00		0.80	0.56							
26		0.17		0.25	0.02	2.10						
27	0.51	0.02										
28	0.02			0.28								
29												
30												
31	0.31											
MONTHLY TOTAL	5.91	4.90	1.36	3.36	8.13	7.54						
CUMULATIVE		10.81	12.17	15.53	23.66	31.20						

FIGURE B5. -- Little Talbot Island State Park Daily Precipitation, 1979

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1		0.30				0.10	0.50	2.40				0.20
2	0.70	0.50	1.20			1.20		1.10				
3	0.10	0.10	1.20		0.10		1.50	0.70	0.10			
4					0.80	0.20	0.40		0.20			
5						0.50	1.00	0.10	0.20			0.10
6						0.30	2.50		0.60			
7						0.30	0.80					
8	1.00	2.80	0.40			0.30	0.70					
9			0.30		0.40	0.50		0.10				
10					0.40	0.10		0.20	0.10	1.70		
11						0.30		0.30	0.20			0.10
12						0.10	0.20	0.60				
13	1.20							0.20				
14						0.10	0.05	1.80				
15		0.30	0.20				0.80					
16		0.48	0.50				1.10					
17	0.10	0.80		0.10			0.20					
18		0.50		2.20			0.25	0.30				
19	1.00	0.45					0.15			0.20		
20		0.15					0.20					
21			0.20			0.20						0.10
22												
23								0.40	0.20			
24						0.50		0.10	0.10			0.50
25	0.10		0.10				0.20					
26							0.25	0.30				
27							0.40		0.20			1.20
28		1.05					0.90					0.50
29							0.70			1.00		
30						1.70	1.00			0.70		
31							1.50	0.20		0.70	1.25	
MONTHLY TOTAL	4.20	7.43	4.10	2.30	1.70	6.40	15.30	8.80	1.90	4.30	1.25	2.70
CUMULATIVE		11.63	15.73	18.03	19.73	26.13	41.43	50.23	52.13	56.43	57.68	60.38

FIGURE B6. -- Deleon Springs Forestry Tower Daily Precipitation, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	0.27	0.01	0.44			0.22		1.75		.04		.70
2		0.38	0.01		0.30	0.28		1.15				.04
3	0.02	0.50	1.55		0.16	0.34						
4		0.10	0.64		0.36	0.70			T		.09	
5			0.02		1.10	0.38	0.08		.24		.01	.06
6						1.00		0.05	.26			
7												
8						0.18		0.08				
9	0.82	2.05	0.38			0.90	0.34					
10		0.05	0.19		0.10	0.24			.05			.16
11						0.82			.18	.54		.02
12						0.02	1.00	0.32				.7
13	0.04							0.10		.10		
14	0.70		T	0.52			2.52	0.18		.42	.14	
15							0.30	0.02	.02	.04		
16		0.31				0.01	0.50					
17		0.24			0.08		0.08					
18	0.10	0.84					0.14					
19	0.02	0.18		1.08			0.66			.15		
20	1.40			0.81			0.30					
21		0.03		0.03								.02
22												
23						0.18				.06		
24									.48			
25									1.51			.68
26	0.10								.04	.20		
27	0.02								.04			
28							0.62		1.47			1.30
29							0.22		.06	3.00		.74
30							0.80		.34	.09		.02
31							1.30			.09		.06
MONTHLY TOTAL	3.49	4.69	3.23	2.44	2.10	5.27	8.86	3.65	4.69	4.73	.24	4.50
CUMULATIVE		8.18	11.41	13.85	15.95	21.22	30.08	33.73	38.42	43.15	43.39	47.89

FIGURE B7. -- Marineland Daily Precipitation, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1												
2												
3	.90											
4												
5												
6		1.8	1.15	.56								
7	.01	.44	1.0	.08	.2							
8		.08	.1		1.85							
9					2.35							
10				.22	1.30							
11			.12	.10	1.40							
12	2.35		.03		.10							
13	.60											
14	.04			.30	.08							
15				.06								
16												
17												
18		.54										
19		.06										
20												
21	1.06											
22	.04	.2										
23												
24	1.2		.06									
25		1.08		1.0	.09							
26		.52		.34								
27	.54	.02		.06								
28	.10											
29												
30												
31	.60				.38							
MONTHLY TOTAL	7.44	4.74	2.46	2.72	7.75							
CUMULATIVE		8.18	10.64	13.36	21.11							

FIGURE B7. -- Marineland Daily Precipitation, 1979

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	30.04	30.25	29.95	30.18	29.78	29.98	29.98	30.02	30.06	29.96	30.15	29.98
2	30.09	30.10	30.08	30.20	29.84	30.04	29.95	30.02	30.06	30.08	30.12	30.16
3	30.24	30.18	29.62	30.30	29.86	29.99	29.92	30.06	29.98	29.99	30.00	30.16
4		30.31	29.90	30.32	29.54	29.98	29.95	30.08	29.92	29.98	29.98	29.96
5	30.28	30.19	30.27	30.18	29.94	30.01	29.98	30.06	29.93	30.02	30.10	29.90
6	30.10	30.07	30.25	30.20	30.12	30.03	30.02	30.12	29.94	29.92	30.12	30.12
7	30.16	30.18	30.16	30.15	30.08	30.04	30.06	30.16	29.98	30.02	29.98	30.23
8	29.88	30.05	30.01	30.14	30.00	30.00	30.06	30.12	29.98	30.02	29.94	30.18
9	30.11	20.87	29.84	30.04	30.00	30.00	30.08	30.10	30.00	30.17	30.02	29.92
10	30.32	29.99	29.82	30.00	30.09	30.08	30.08	30.09	30.04	29.98	30.12	30.26
11	30.39	30.08	30.08	29.96	30.10	30.10	30.02	30.06	29.93	29.96	30.22	30.27
12	30.14	30.09	30.06	29.97	30.16	30.08	30.04	30.08	29.94	29.98	30.17	30.32
13	29.76	29.88	30.12	29.86	29.92	30.00	30.08	30.08	30.00	30.02	30.12	30.32
14	29.88	29.94	29.92	30.08	29.82	30.06	30.08	30.14	30.09	29.98	30.19	30.24
15	30.25	30.14	29.98	30.09	29.72	30.14	29.99	30.16	30.00	30.13	30.17	30.24
16	30.31	29.98	29.92	30.03	29.84	30.20	29.89	30.14	29.98	30.08	30.18	30.23
17	29.98	30.12	30.28	30.08	29.94	30.24	29.91	30.07	30.06	30.12	30.16	30.28
18	30.12	29.84	30.48	29.97	30.09	30.18	30.08	30.05	30.13	30.25	30.19	30.32
19	29.82	30.08	30.44	29.84	30.08	30.08	30.08	30.10	30.14	30.14	30.19	30.12
20	29.93	30.08	30.33	29.87	30.08	30.08	30.11	30.10	30.04	30.04	30.22	30.02
21	30.24	30.04	30.15	29.88	30.04	30.06	30.12	30.10	30.04	30.12	30.16	29.86
22	30.32	30.20	30.04	30.08	30.03	30.04	30.15	30.08	30.12	30.14	30.15	30.09
23	30.36	30.11	30.04	30.07	30.06	30.03	30.18	30.08	30.10	30.10	30.12	30.08
24	30.12	30.12	30.04	29.99	30.02	29.98	30.19	30.09	30.03	29.94	30.04	29.72
25	29.66	30.12	30.02	29.86	30.00	29.99	30.12	30.08	29.98	30.02	30.06	30.04
26	29.94	30.10	29.88	29.66	30.04	30.06	30.03	30.04	30.01	30.01	30.05	30.08
27	30.24	30.16	29.93	29.90	30.02	30.12	30.02	30.06	29.98	30.01	29.99	30.18
28	30.20	30.04	30.08	30.03	30.01	30.04	30.07	30.02	30.00	30.04	30.16	30.11
29	30.24		30.10	30.02	30.00	30.04	30.07	30.07	30.02	30.06	30.12	30.19
30	30.32		30.10	29.96	29.98	29.99	30.06	30.07	30.02	30.16	30.02	30.31
31	30.26		30.18		29.99		30.07	30.06		30.18		30.29

FIGURE B8. -- Marineland Barometric Pressure Daily Readings, 1978

DAY	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	30.16	30.16	30.16	30.15	30.02							
2	29.94	30.26	30.24	30.11	30.08							
3	30.60	30.21	30.16	30.07	30.10							
4	30.60	30.12	30.08	29.98	30.06							
5	30.50	30.14	30.11	30.05	29.94							
6	30.31	30.00	30.04	30.24	29.95							
7	30.10	29.84	29.94	30.28	30.00							
8	30.05	30.16	29.87	30.12	29.98							
9	30.36	30.08	30.22	29.84	29.96							
10	30.34	30.36	30.16	30.00	30.00							
11	30.20	30.38	30.12	30.11	29.98							
12	29.92	30.28	30.27	30.08	30.01							
13	29.82	30.18	30.28	29.94	30.02							
14	29.95	30.22	30.12	29.94	30.01							
15	30.46	30.14	30.28	29.98	30.06							
16	30.44	30.08	30.44	30.08	30.12							
17	30.34	30.20	30.46	30.15	30.15							
18	30.16	30.19	30.28	30.14	30.14							
19	30.14	30.36	30.15	30.16	30.03							
20	29.78	30.04	30.04	30.16	29.98							
21	29.59	30.26	30.02	30.18	29.98							
22	30.06	30.26	30.06	30.24	30.06							
23	29.99	30.18	29.86	30.19	30.06							
24	NR	30.04	29.66	30.08	29.90							
25	30.03	29.84	29.77	29.78	29.86							
26	29.92	29.96	30.10	29.75	30.02							
27	29.74	30.08	30.29	29.84	30.09							
28	29.84	30.14	30.38	29.92	30.03							
29	30.02		30.39	30.04	29.98							
30	30.06		30.33	30.02	30.03							
31	29.86		30.28		30.13							

FIGURE B8. -- Marineland Barometric Pressure Daily Readings, 1979

APPENDIX C

DRILLERS' LOGS AND A LISTING OF AVAILABLE GEOPHYSICAL LOGS FOR PROJECT SITES AND/OR GEOPHYSICAL LOGS FROM WELLS WITHIN OR IN THE VICINITY OF PROJECT BOUNDARIES USED TO DESCRIBE THE GEOLOGY

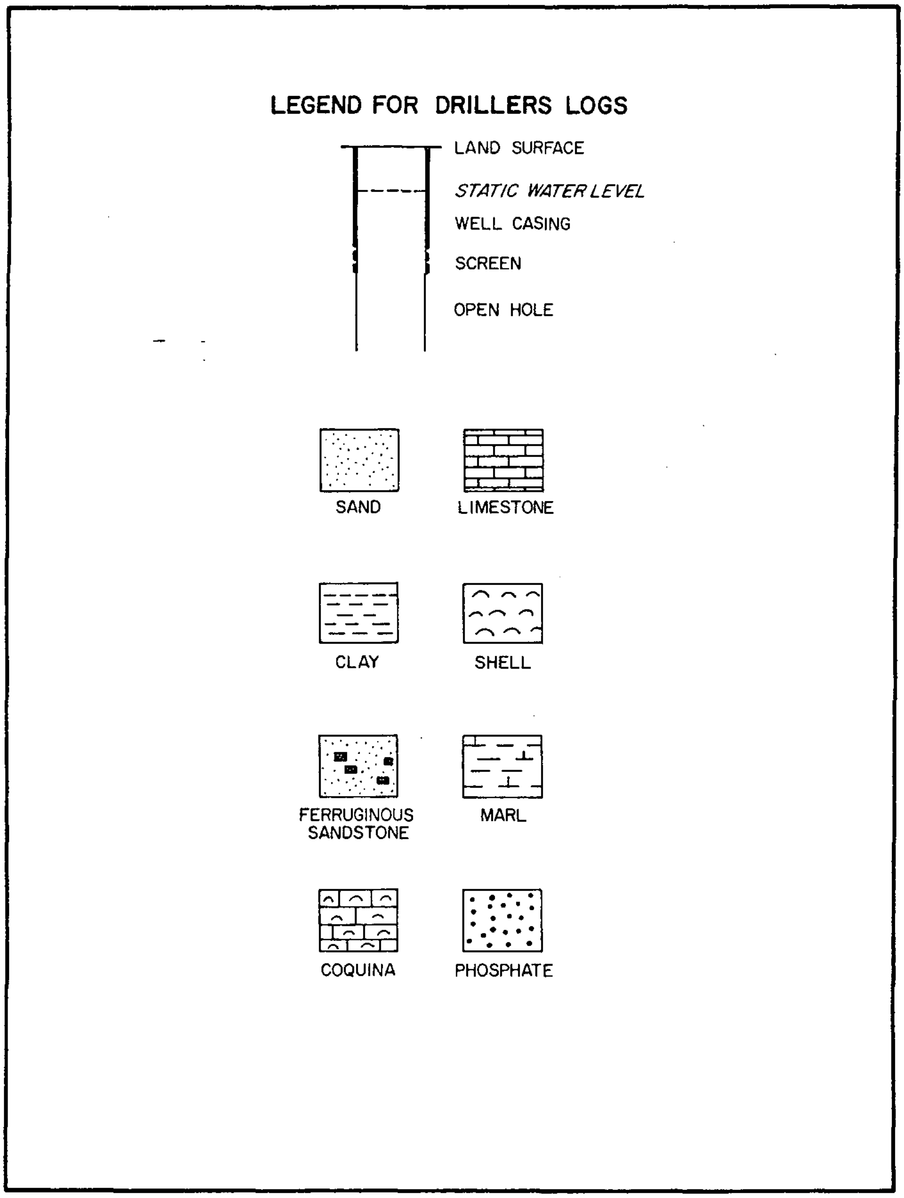

FIGURE C1-1. -- Legend for Drillers' Logs

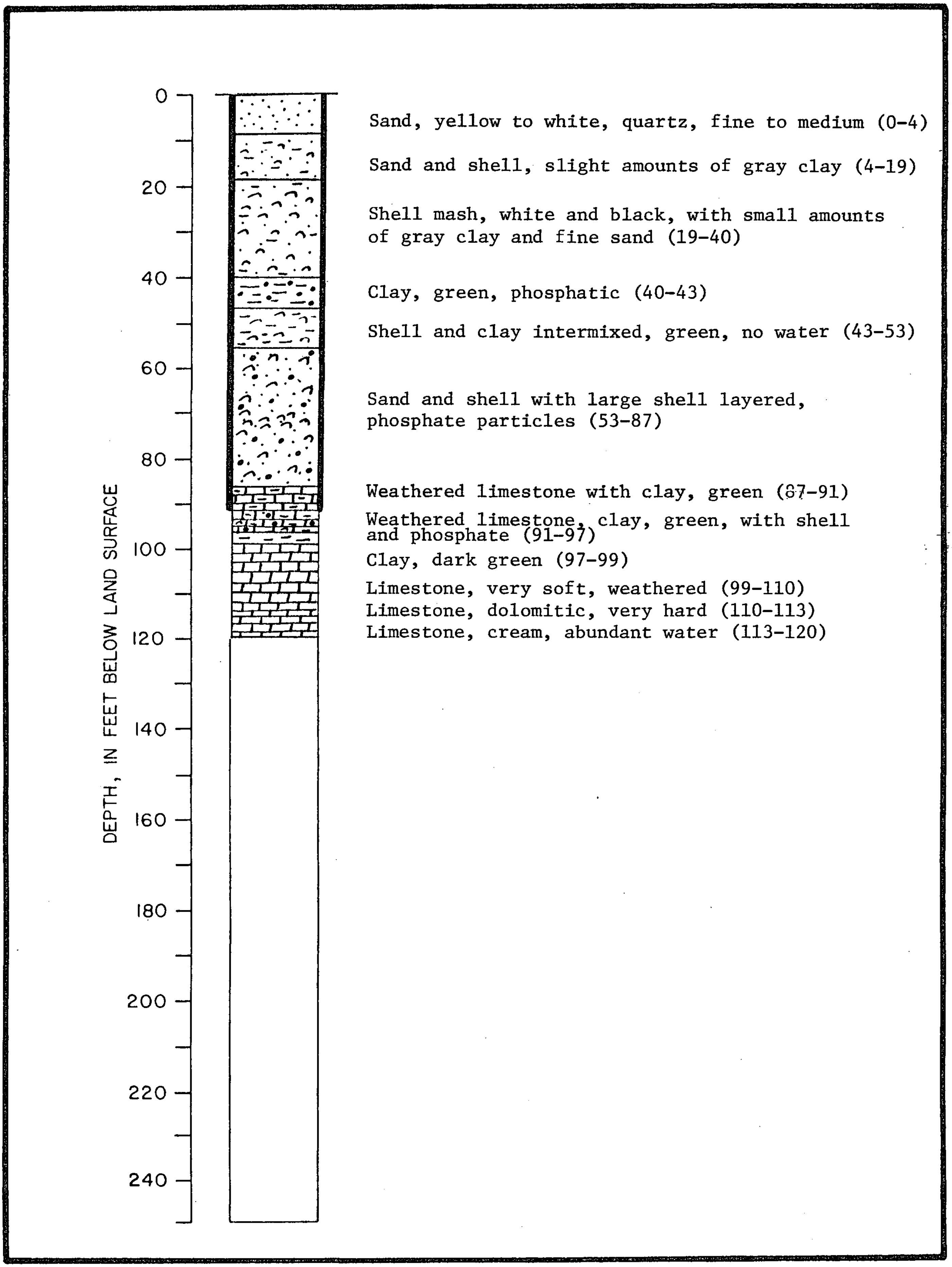

FIGURE C1-2. -- Test Well F-176 at Bulow Ruins

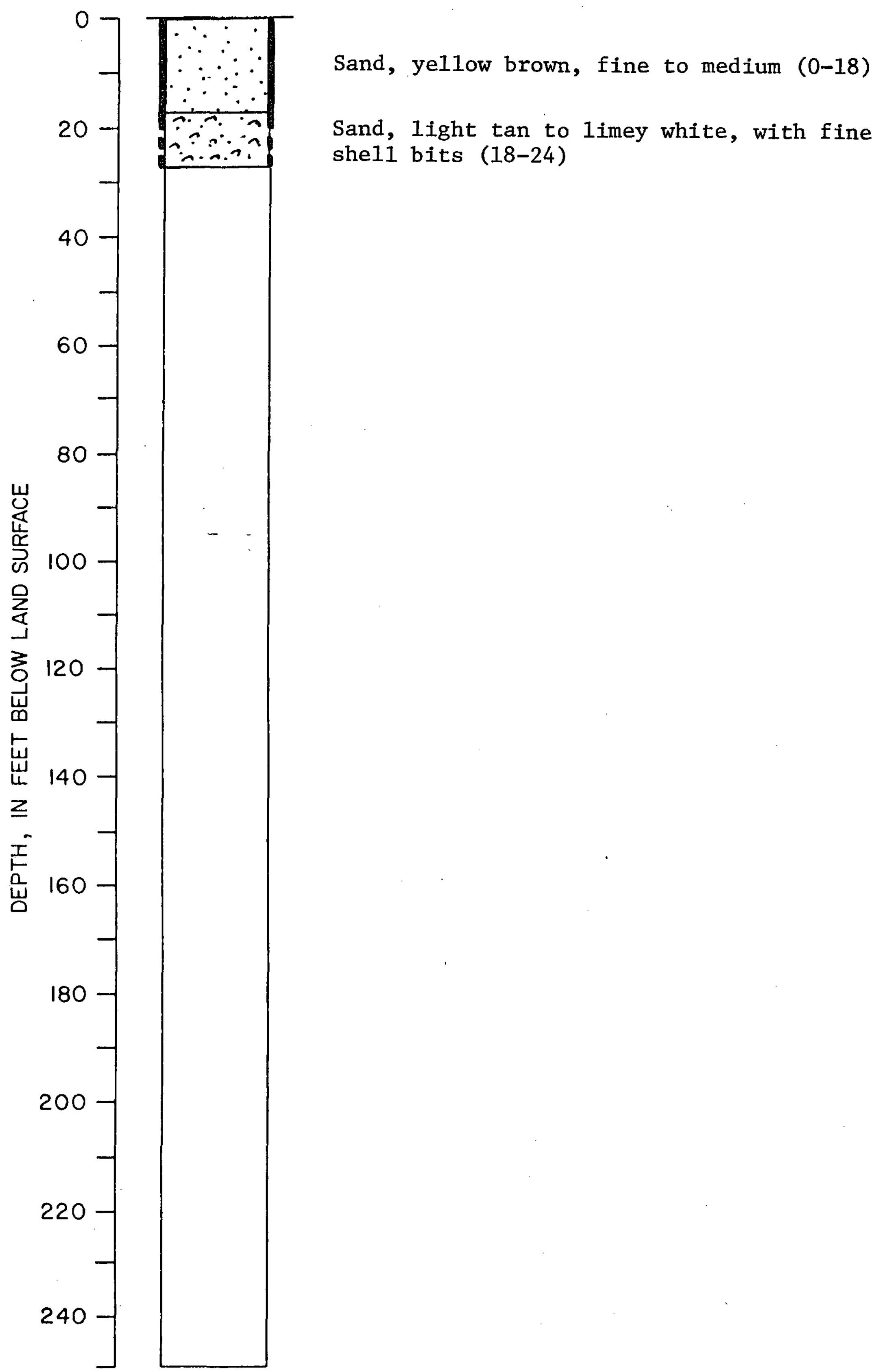

FIGURE C1-3. -- Test Well F-178 at Washington Oaks State Gardens

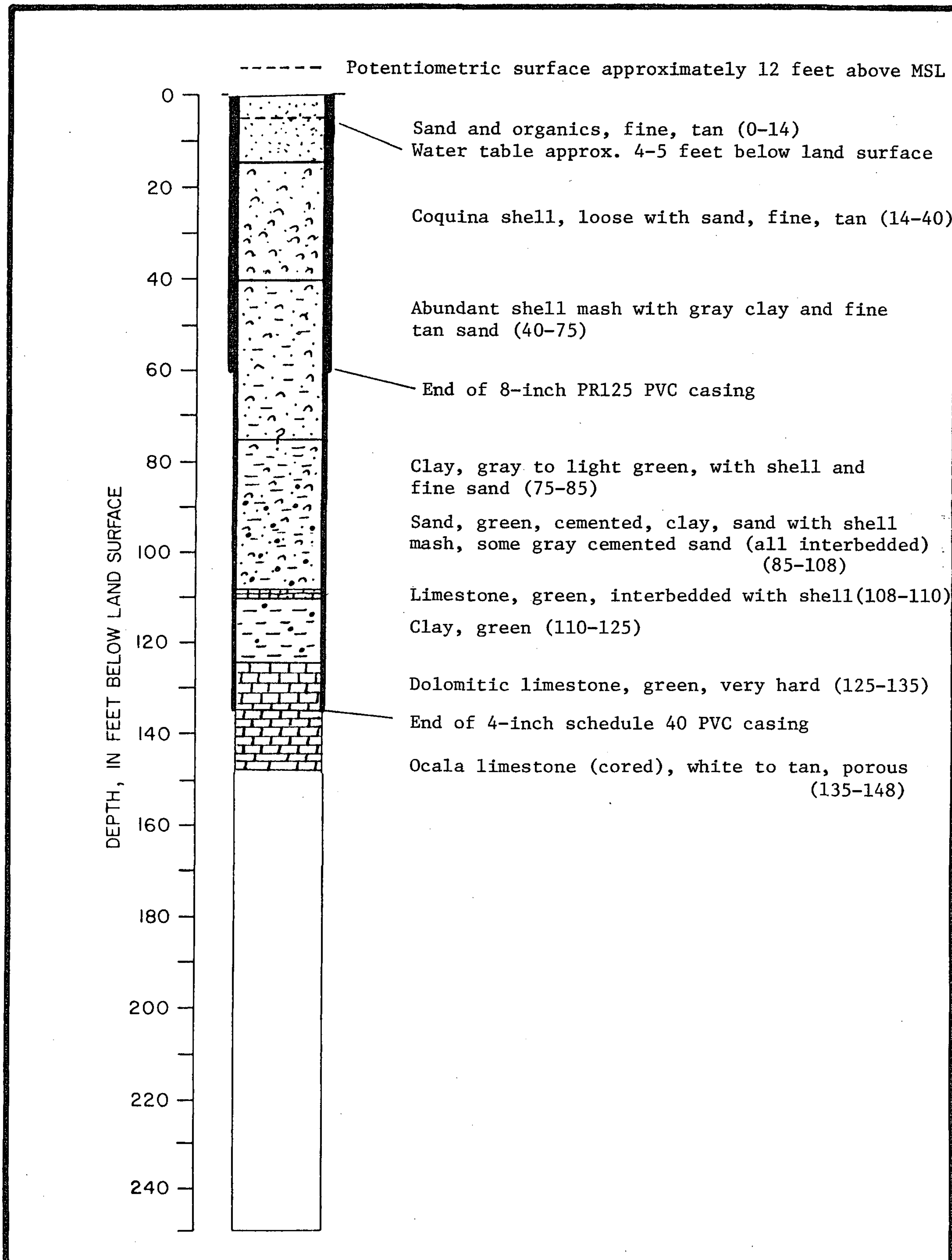

FIGURE C1-4. -- Test Well F-200 at Washington Oaks State Gardens

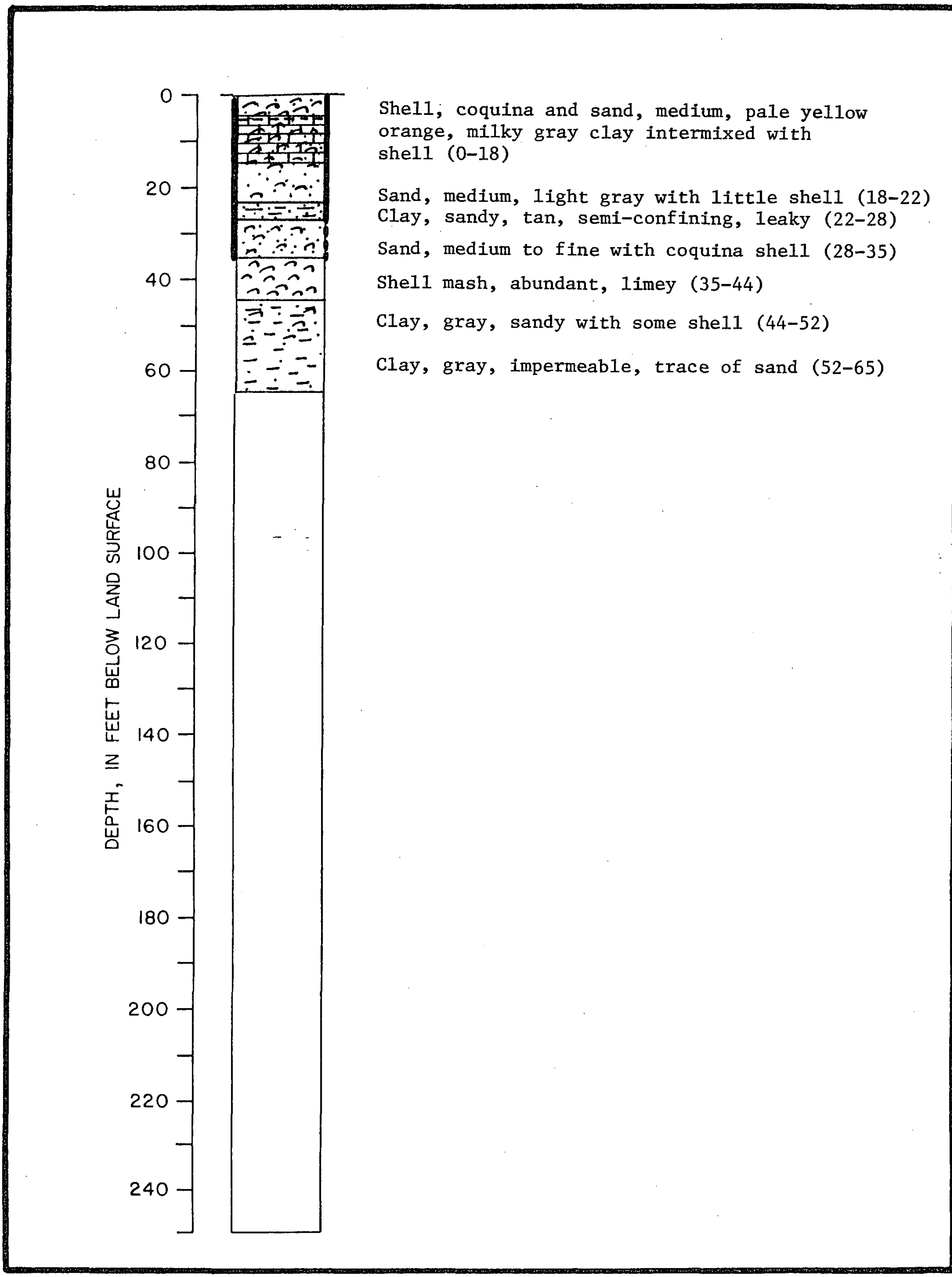

FIGURE C1-5. -- Test Well F-181 at Washington Oaks State Gardens

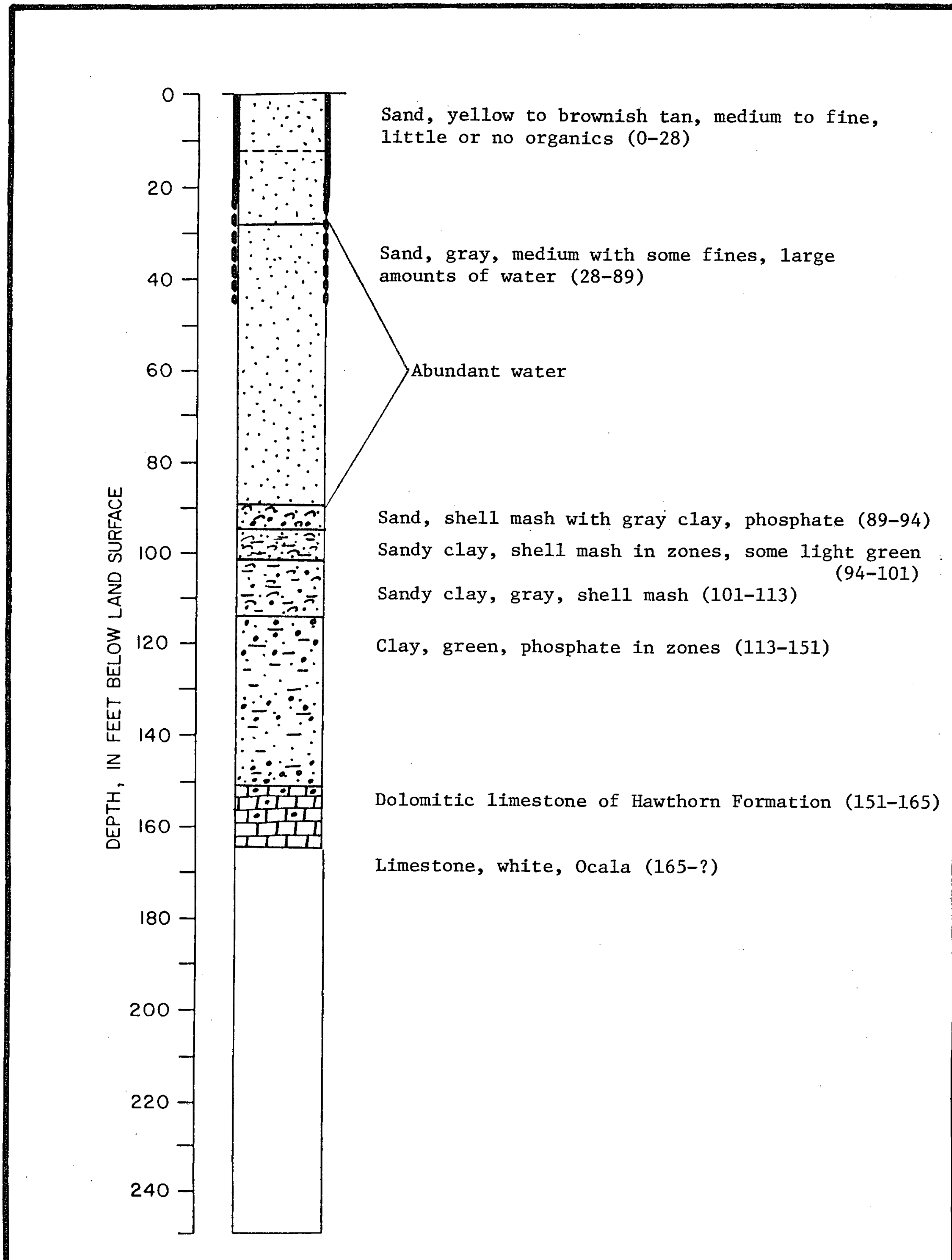

FIGURE C1-6. -- Test Well SJ-499 and DNR Core Hole at Faver Dykes State Park

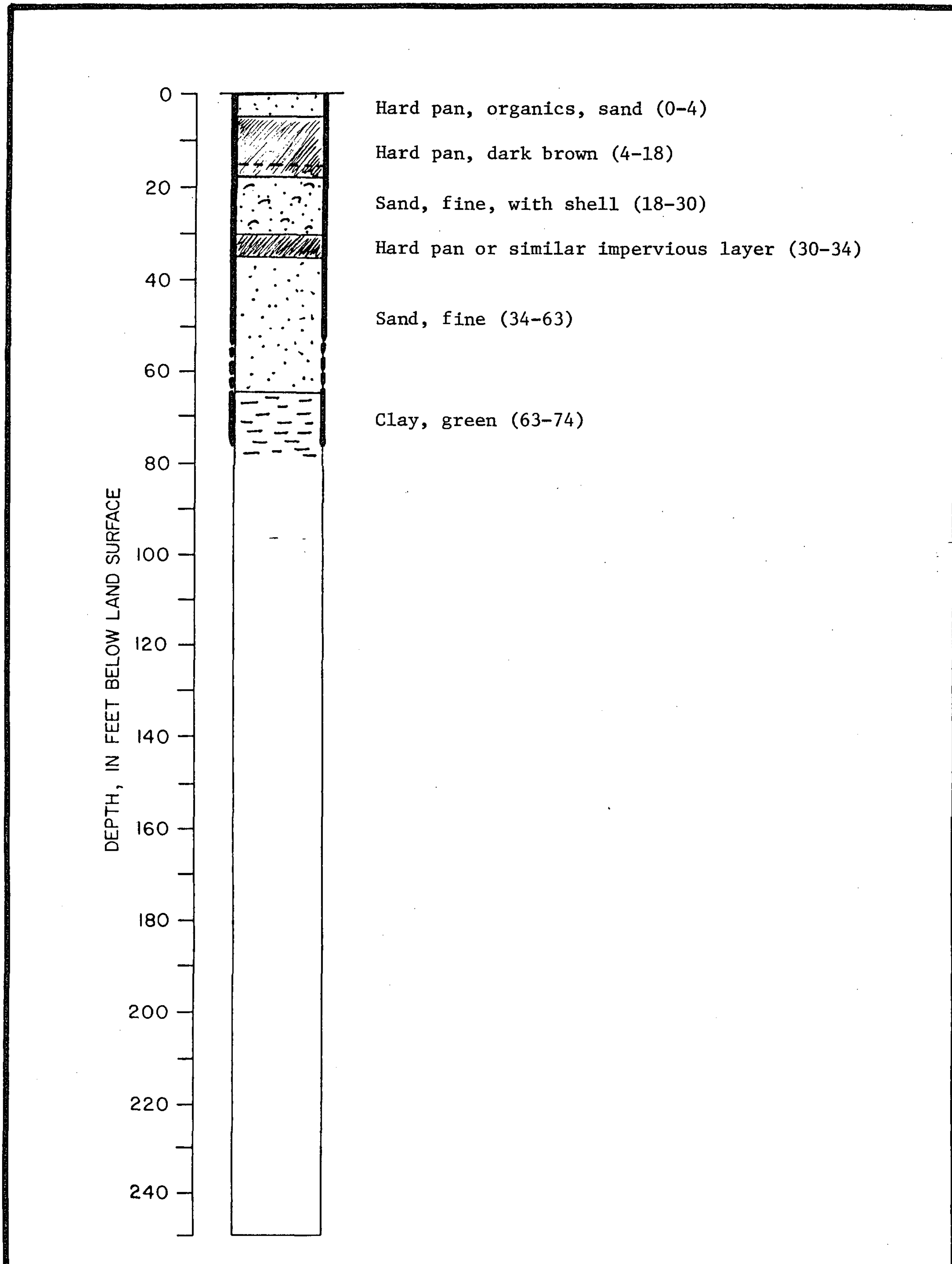

FIGURE C1-7. -- Test Well SJ-500 at Durbin Tower

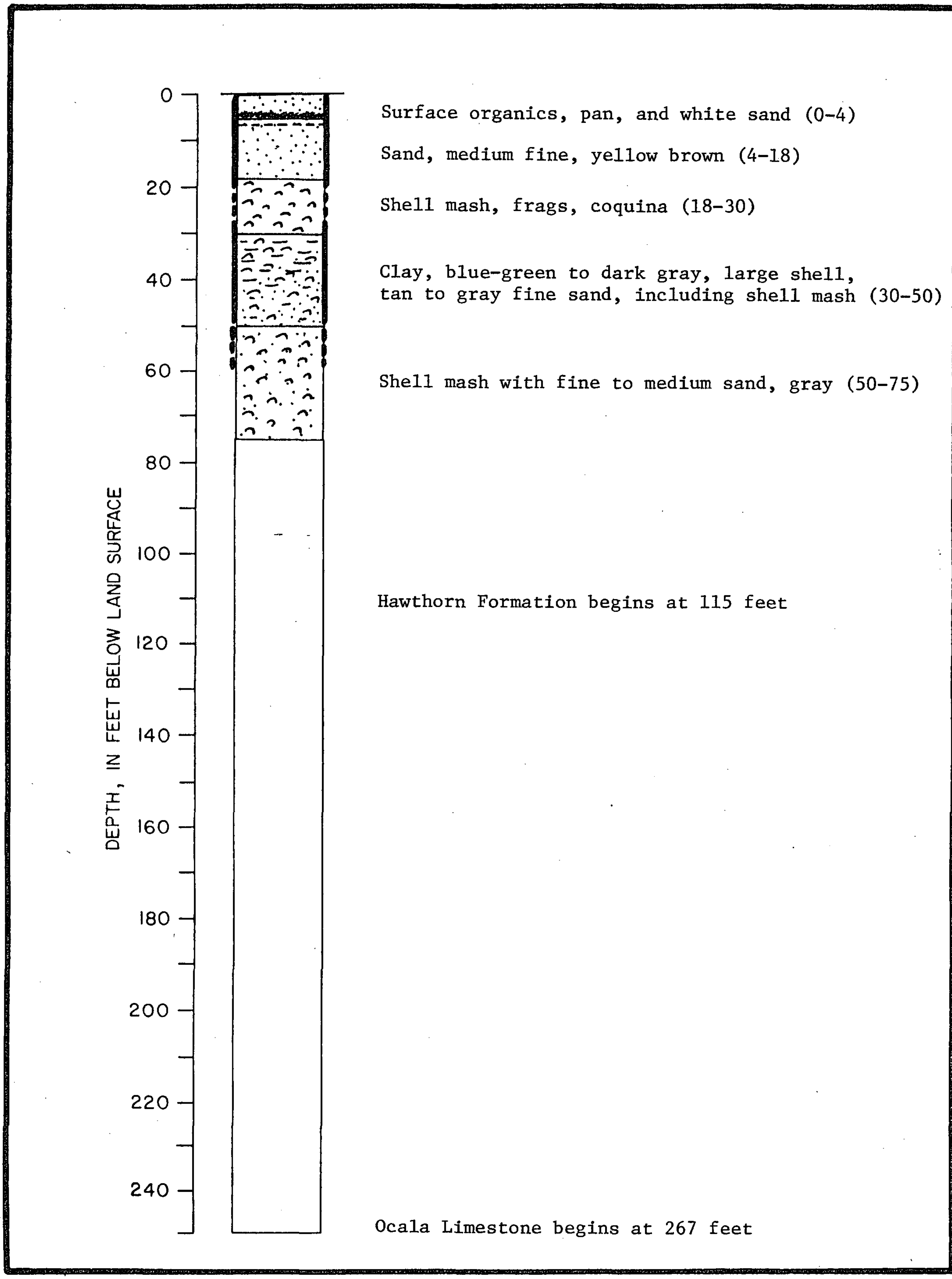

FIGURE C1-8. -- Test Wells SJ-503, 504, and SJB at Guana Wildlife Management Area

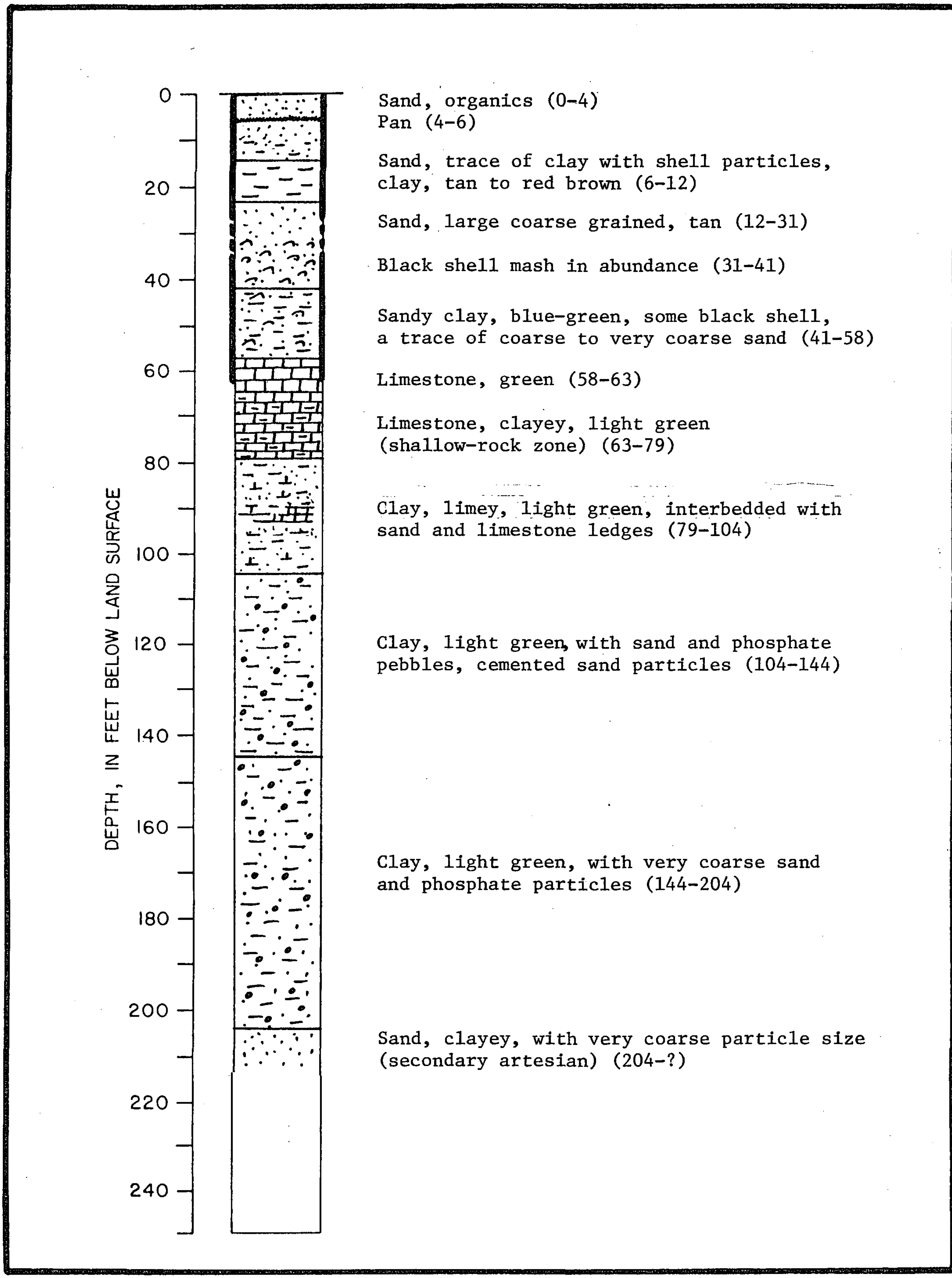

FIGURE C1-9. -- Test Wells D-9 and D-10 at Ft. Caroline National Monument

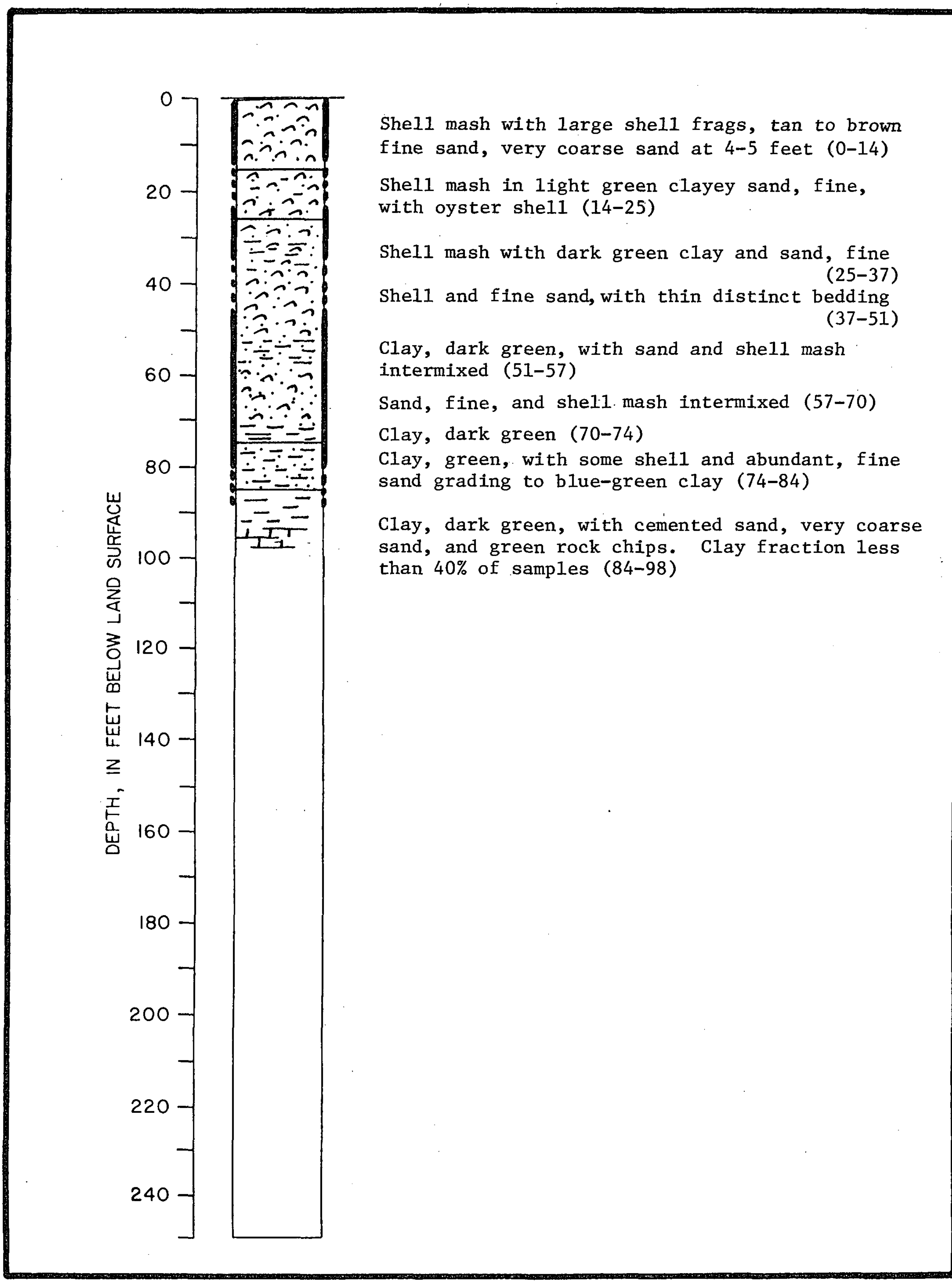

FIGURE C1-10. -- Test Wells D-11, D-12, and 13 at Little Talbot Island

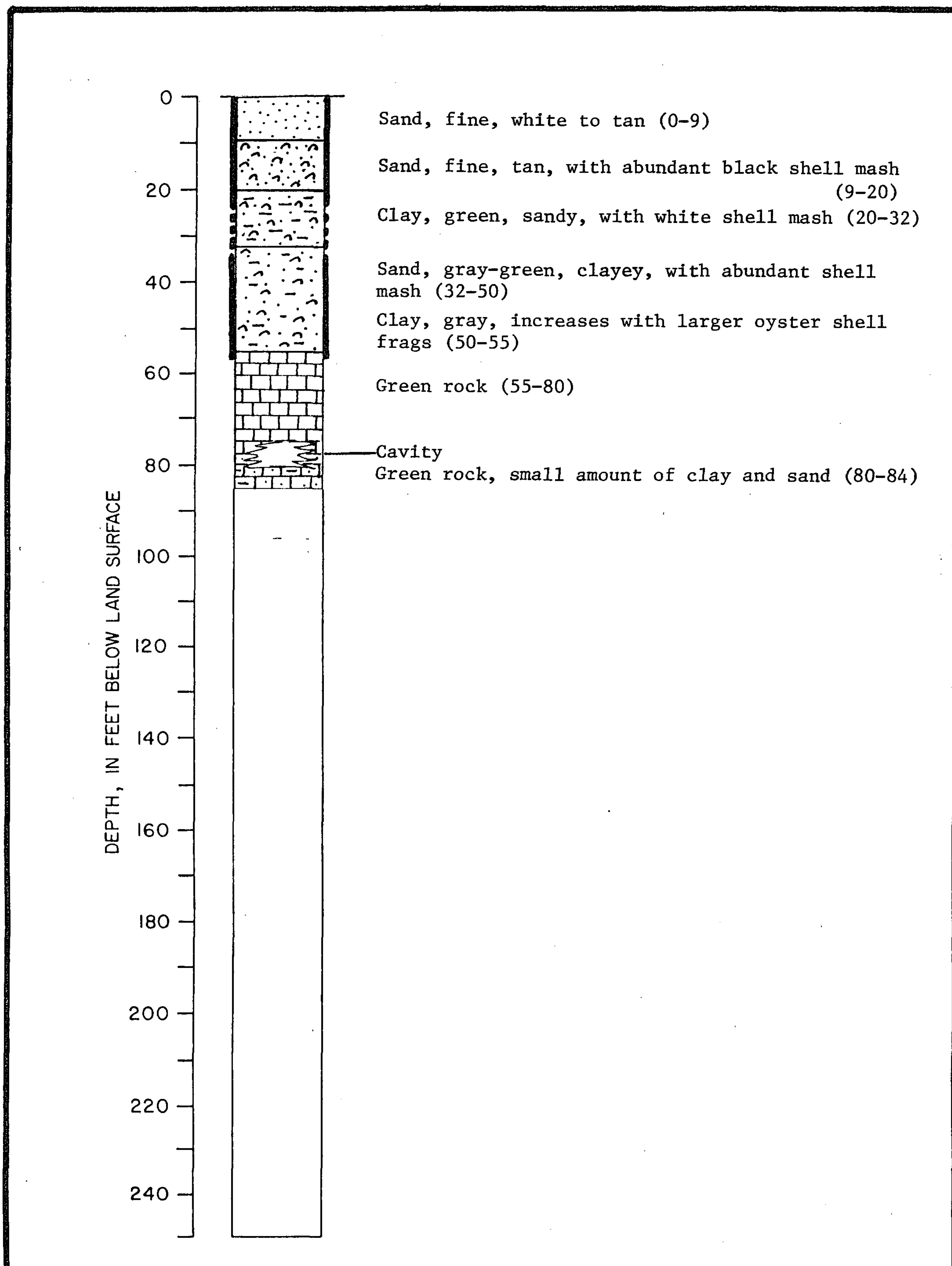

FIGURE C1-11. -- Test Wells N-18 and N-19 at Ft. Clinch State Park

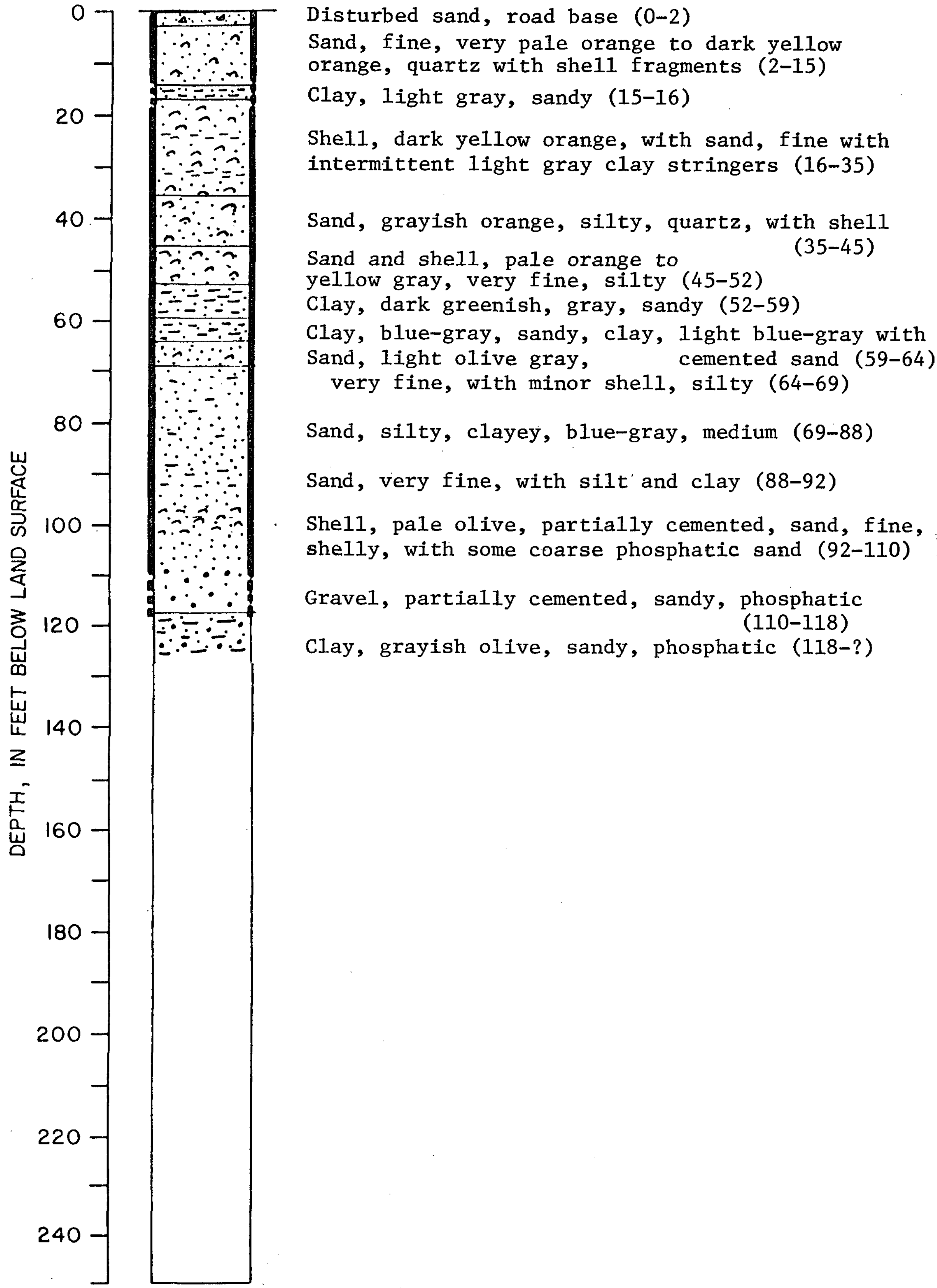

FIGURE C1-12. -- Test Wells F-174 and 175 at Flagler Beach State Park

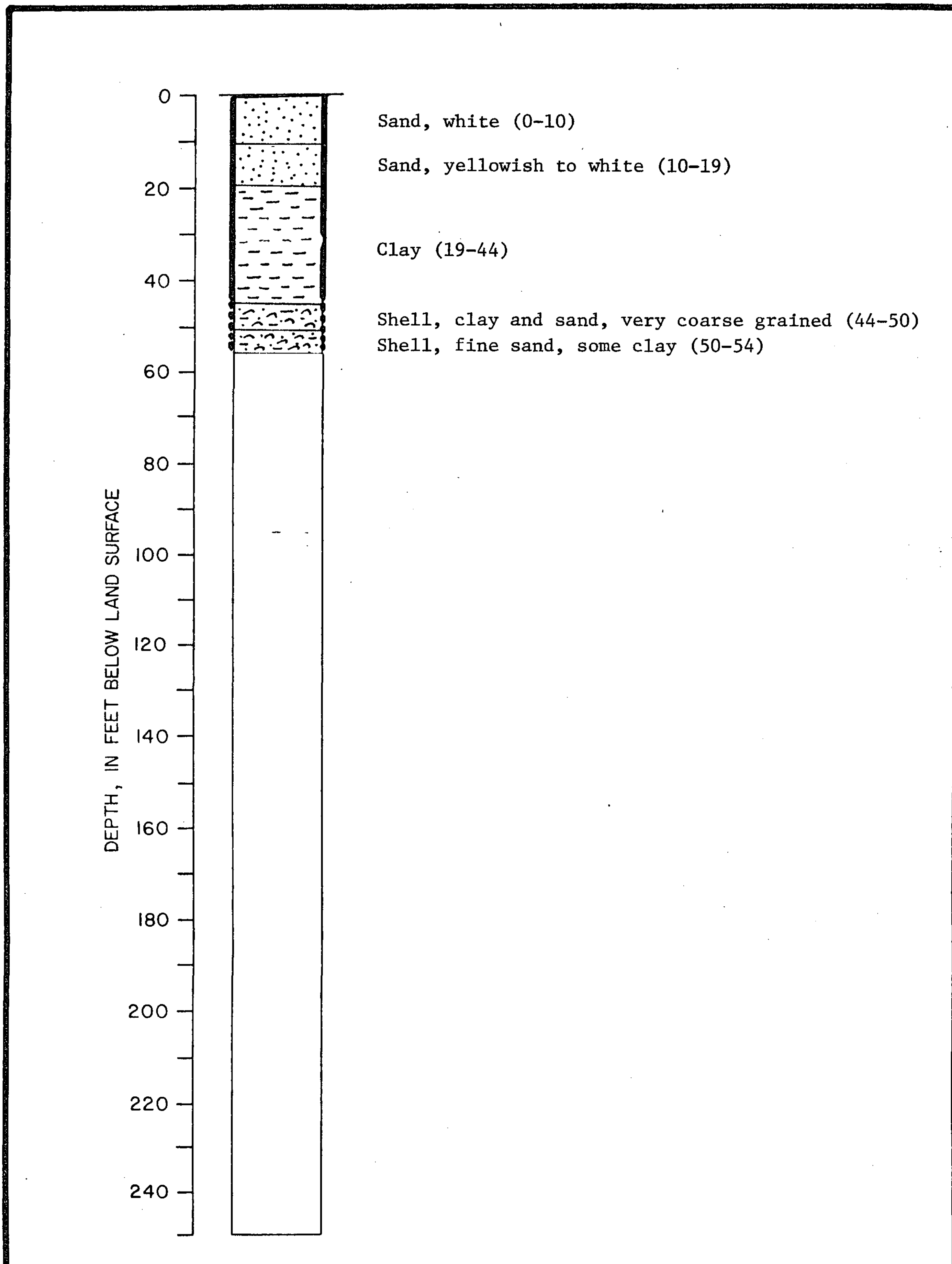

FIGURE C1-13. -- Test Well N-20 at Yulee Forestry Tower

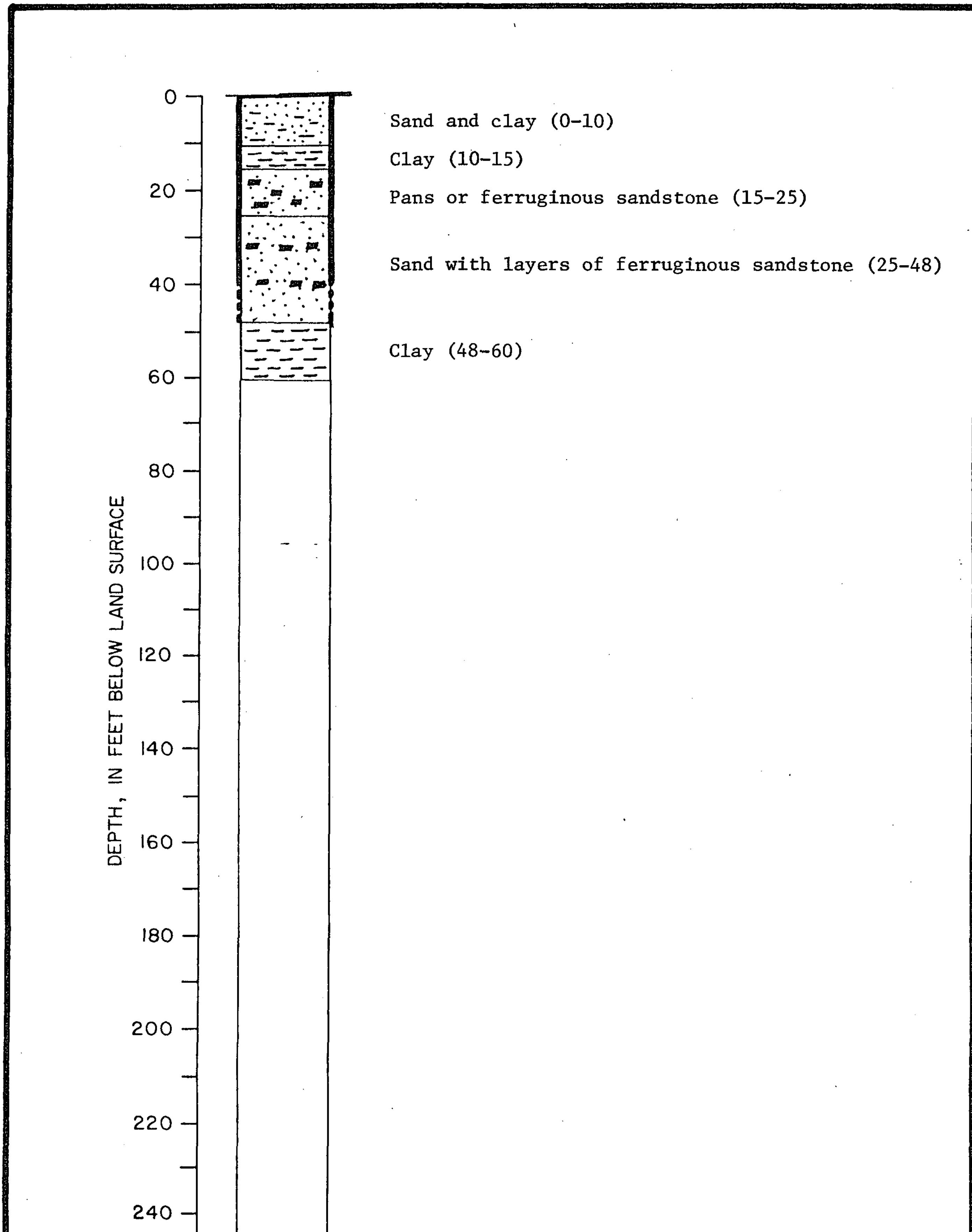

FIGURE C1-14. -- Test Well D-14 at Tisonia Forestry Tower

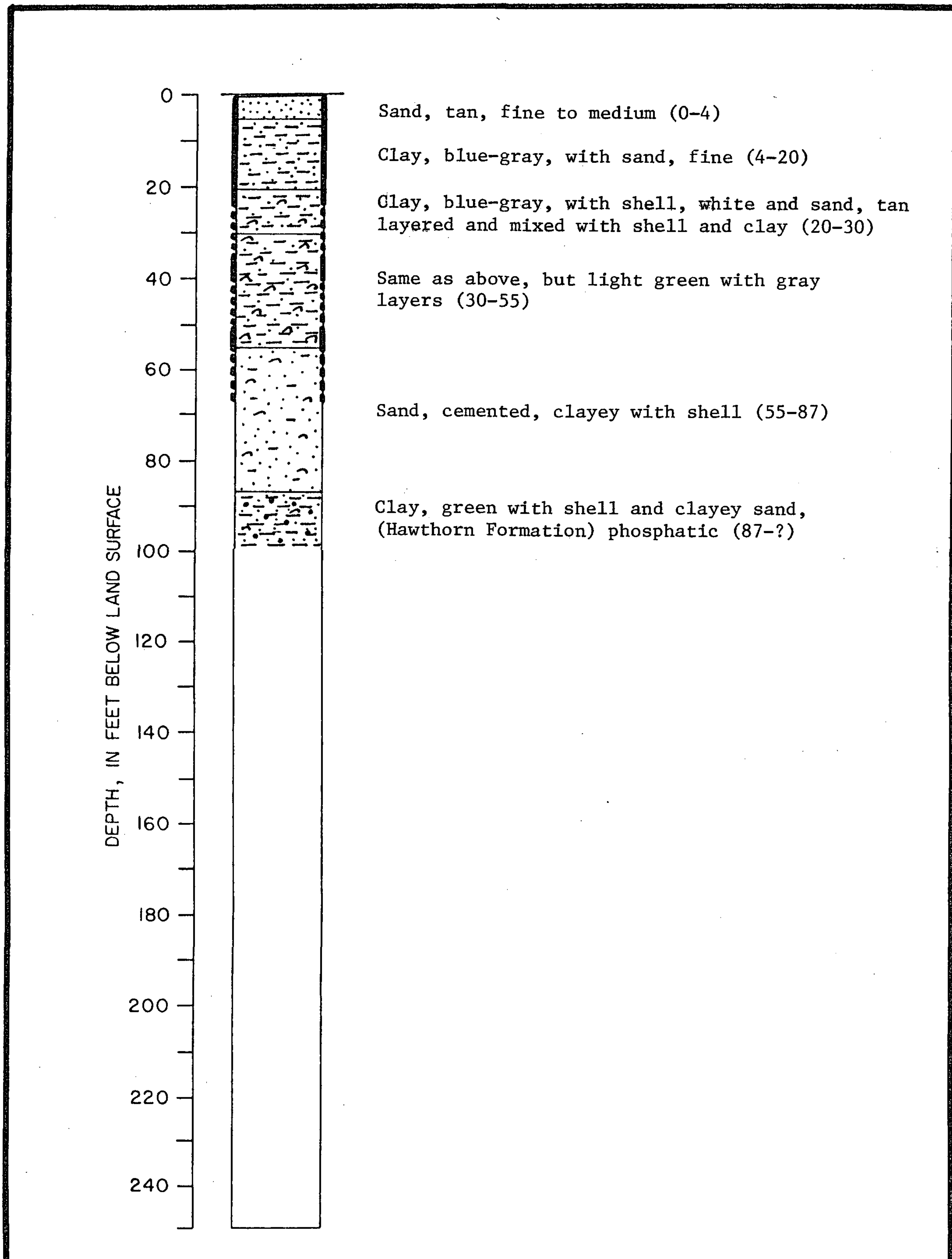

FIGURE C1-15. -- Generalized Picture of Five Test Holes at Mayport Naval Base

TABLE C2-1. -- Geophysical Logs Used for Fence Diagram

WELL OR COUNTY NO.	LOCATION DATA		WELL DATA			BOTTOM HOLE SAMPLE		TOP OF FORMATIONS (DEPTH IN FEET BELOW MSL)				LAND SURFACE
	LATITUDE (°,',")	LONGITUDE (°,',")	TDL (FEET)	TDC (FEET)	DIAM. (IN.)	DEPTH (FEET BELOW MSL)	Cl⁻ (mg/L)	HAWTHORN	OCALA	AVON PARK	LAKE CITY	ALTITUDE (FT. ABOVE MSL)
F-174	292603	810624	118	110	2	-	-	110	120	-	-	5
F-135	293402	811110	146	101	5	130	1830	103	144	-	-	0
F-173	294002	811252	300	155	4	284	3530	38	157	-	-	6
SJ-482	294300	811417	458	155	4	436	1170	102	162	436	-	6
SJ-430	294924	811616	233	188	4	-	-	29	214	-	-	13
PS1	295047	811603	233	77	6	0	80	42	157	-	-	10
SJ-484	295200	811623	370	149	4	350	110	32	173	-	-	10
953-117-1	2953--	8117--	330	-	4	-	-	134	182	-	-	6
955-117-2	2955--	8117--	291	177	4	-	-	165	175	-	-	10
SJ-B	300203	812027	433	319	3	0	110	107	259	-	-	8
Dee Dot	301327	812657	1014	315	8	Surface	20	77	358	606	665	16
AB1	302058	812442	1009	393	18	-	-	84	384	645	725	10
D-164*	302537	812531	618	448	8	-	-	100	446	-	-	12
CCA9	304044	812702	1050	547	26	1040	89	48	501	887	-	32
N-11	304113	812720	1253	536	20	1250	470	70	538	1071	-	41
N-3	304208	812710	707	554	3	689	450	85	519	-	-	11
				68	5							
F-66	292523	812347	198	95	6	-	-	40	76	158	-	21

TABLE C2-1. (CONTINUED)

WELL OR COUNTY NO.	LOCATION DATA		WELL DATA			BOTTOM HOLE SAMPLE		TOP OF FORMATIONS (DEPTH IN FEET BELOW MSL)				LAND SURFACE
	LATITUDE (°,',")	LONGITUDE (°,',")	TDL (FEET)	TDC (FEET)	DIAM. (IN.)	DEPTH (FEET BELOW MSL)	Cl^- (mg/L)	HAWTHORN	OCALA	AVON PARK	LAKE CITY	ALTITUDE (FT. ABOVE MSL)
WT	293716	812926	412	96	6	-	-	39	144	269	-	21
SJ-378	293943	812842	291	114	4	-	-	40	155	-	-	14
SJ-263	294120	812920	540	117	6	350	2580	39	180	301	-	12
SJ-CAP	294947	813022	526	152	8	Surface	600	90	246	405	-	20
MCF1	295817	813046	385	167	6	370	22	57	227	-	-	20
HGM1*	301512	813311	1237	537	18	-	-	62	494	724	768	64
5L	302031	813922	1321	493	12	1300	23	51	492	736	768	17
F-176	292603	810825	120	91	4	-	-	80	106	-	-	7
PS2	292648	811206	169	115	6	165	60	86.5	88.5	-	-	27.5
F-126	292647	811820	157	122	6	-	-	7	104	-	-	13
F-158	293314	811324	284	183	6	242	1540	85	114	-	-	28
F-164	293313	811352	94	94+	6	60	150	-	-	-	-	30
F-161	293256	811720	141	125	6	101	320	75	87	-	-	34
F-160	293504	811837	200	120	8	158	730	82	117	-	-	37
F-165	293529	811917	140	125	4	88	170	82	-	-	-	36
SJ-115	293729	812214	613	145	6	-	-	44	105	243	463	39
SJ-389	294612	812534	301	105	4	-	-	45	123	-	-	33
D-424	302305	812941	705	427	6	686	25	76	414	690	-	12

TABLE C2-1. (CONTINUED)

WELL OR COUNTY NO.	LOCATION DATA		WELL DATA			BOTTOM HOLE SAMPLE		TOP OF FORMATIONS (DEPTH IN FEET BELOW MSL)				LAND SURFACE
	LATITUDE (°,',")	LONGITUDE (°,',")	TDL (FEET)	TDC (FEET)	DIAM. (IN.)	DEPTH (FEET BELOW MSL)	Cl^- (mg/L)	HAWTHORN	OCALA	AVON PARK	LAKE CITY	ALTITUDE (FT. ABOVE MSL)
D-10	302301	812950	204	62	4	–	–	47	–	–	–	15
OPS2	302342	813152	1213	519	18	Surface	60	157	500	770	845	9

* Suwannee limestone found based on geophysical records at D-164 (431-446 feet below MSL) and HGM1 (474-494).

APPENDIX D

PRINTOUT OF FACTOR ANALYSIS RUN

APPENDIX D. PRINTOUT OF FACTOR ANALYSIS RUN

OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
F66**FL	349.0000	290.0000	227.0000	246.0000	-44.0000	87.0000	218.0000	188.0000	252.0000	83.0000	-44.0000	44.0000
F101*FL	347.0000	290.0000	228.0000	235.0000	-47.0000	86.0000	221.0000	187.0000	249.0000	87.0000	-100.0000	53.0000
F126*FL	347.0000	294.0000	230.0000	195.0000	-77.0000	88.0000	221.0000	182.0000	261.0000	81.0000	-100.0000	42.0000
F134*FL	351.0000	313.0000	224.0000	264.0000	-29.0000	86.0000	232.0000	206.0000	281.0000	117.0000	-100.0000	59.0000
F135*FL	377.0000	321.0000	216.0000	285.0000	-24.0000	87.0000	237.0000	214.0000	290.0000	127.0000	-100.0000	30.0000
F139*FL	353.0000	324.0000	210.0000	290.0000	-4.0000	87.0000	241.0000	215.0000	295.0000	133.0000	-100.0000	28.0000
F142*FL	357.0000	301.0000	237.0000	215.0000	-49.0000	86.0000	223.0000	185.0000	265.0000	95.0000	-82.0000	74.0000
F158*FL	360.0000	320.0000	223.0000	262.0000	-55.0000	87.0000	222.0000	215.0000	290.0000	117.0000	-20.0000	45.0000
F160*FL	337.0000	273.0000	227.0000	226.0000	-12.0000	88.0000	207.0000	189.0000	233.0000	94.0000	-100.0000	32.0000
F162*FL	378.0000	326.0000	225.0000	201.0000	-28.0000	86.0000	232.0000	217.0000	288.0000	95.0000	-70.0000	58.0000
F165*FL	320.0000	262.0000	221.0000	256.0000	0.0000	86.0000	199.0000	192.0000	227.0000	92.0000	-40.0000	37.0000
F166*FL	363.0000	333.0000	212.0000	267.0000	-5.0000	86.0000	241.0000	216.0000	306.0000	144.0000	-100.0000	18.0000
F170*FL	366.0000	312.0000	232.0000	243.0000	-46.0000	86.0000	226.0000	200.0000	275.0000	100.0000	-100.0000	68.0000
F176*FL	331.0000	274.0000	241.0000	165.0000	-48.0000	86.0000	202.0000	162.0000	237.0000	70.0000	-100.0000	81.0000
F184*FL	286.0000	219.0000	245.0000	34.0000	-82.0000	86.0000	193.0000	131.0000	186.0000	36.0000	-66.0000	16.0000
F185*FL	284.0000	202.0000	249.0000	30.0000	-85.0000	86.0000	190.0000	125.0000	173.0000	26.0000	-100.0000	36.0000
F186*FL	293.0000	218.0000	243.0000	48.0000	-100.0000	85.0000	195.0000	123.0000	182.0000	30.0000	-89.0000	20.0000
F187*FL	291.0000	220.0000	246.0000	49.0000	-66.0000	86.0000	201.0000	114.0000	181.0000	23.0000	-96.0000	-26.0000
F188*FL	360.0000	320.0000	207.0000	293.0000	-12.0000	88.0000	225.0000	219.0000	293.0000	138.0000	-100.0000	31.0000
SJ115FL	332.0000	269.0000	209.0000	285.0000	-5.0000	89.0000	216.0000	208.0000	228.0000	100.0000	-92.0000	21.0000
SJ117FL	338.0000	273.0000	196.0000	276.0000	-28.0000	89.0000	230.0000	207.0000	242.0000	97.0000	-100.0000	20.0000
SJ200FL	348.0000	292.0000	202.0000	226.0000	-25.0000	88.0000	234.0000	212.0000	256.0000	97.0000	-100.0000	30.0000
SJ263FL	385.0000	352.0000	203.0000	275.0000	-24.0000	90.0000	263.0000	244.0000	321.0000	148.0000	-48.0000	39.0000
SJ378FL	346.0000	290.0000	202.0000	282.0000	-24.0000	89.0000	228.0000	209.0000	250.0000	85.0000	-92.0000	23.0000
SJ389FL	330.0000	236.0000	203.0000	284.0000	-21.0000	89.0000	218.0000	202.0000	210.0000	85.0000	-100.0000	19.0000

OBSERVATION MATRIX

WELL # AND AQ	SP.COND. FE	CL S	HCO3+CO3	SO4	F	PH	CA	MG	NA	K
SJ412FL	295.0000	195.0000	216.0000	241.0000	-4.0000	89.0000	176.0000	164.0000	168.0000	60.0000
	-100.0000	57.0000								
SJ413FL	300.0000	196.0000	215.0000	242.0000	0.0000	88.0000	178.0000	170.0000	165.0000	64.0000
	-100.0000	38.0000								
SJ414FL	298.0000	187.0000	202.0000	247.0000	3.0000	86.0000	192.0000	170.0000	158.0000	48.0000
	-100.0000	29.0000								
SJ415FL	311.0000	220.0000	210.0000	254.0000	3.0000	86.0000	202.0000	174.0000	190.0000	70.0000
	-100.0000	58.0000								
SJ416FL	290.0000	183.0000	216.0000	231.0000	2.0000	87.0000	185.0000	152.0000	157.0000	48.0000
	-100.0000	58.0000								
SJ429FL	326.0000	272.0000	216.0000	250.0000	1.0000	88.0000	195.0000	180.0000	238.0000	93.0000
	-100.0000	52.0000								
SJ430FL	360.0000	326.0000	214.0000	280.0000	0.0000	88.0000	239.0000	210.0000	298.0000	137.0000
	-80.0000	50.0000								
SJ431FL	321.0000	236.0000	206.0000	263.0000	4.0000	86.0000	211.0000	182.0000	206.0000	78.0000
	-100.0000	31.0000								
SJ432FL	377.0000	352.0000	212.0000	298.0000	-9.0000	86.0000	252.0000	236.0000	327.0000	175.0000
	-100.0000	30.0000								
SJ433FL	295.0000	215.0000	219.0000	220.0000	-7.0000	88.0000	173.0000	151.0000	187.0000	50.0000
	-100.0000	51.0000								
SJ434FL	289.0000	134.0000	211.0000	246.0000	-6.0000	86.0000	191.0000	154.0000	111.0000	30.0000
	-68.0000	30.0000								
SJ438FL	297.0000	208.0000	217.0000	226.0000	-2.0000	88.0000	186.0000	152.0000	179.0000	48.0000
	-47.0000	34.0000								
SJ469FL	301.0000	189.0000	210.0000	258.0000	0.0000	88.0000	198.0000	172.0000	164.0000	60.0000
	-100.0000	35.0000								
SJ470FL	332.0000	279.0000	216.0000	256.0000	-6.0000	88.0000	212.0000	184.0000	248.0000	96.0000
	-100.0000	36.0000								
SJ472FL	278.0000	134.0000	208.0000	226.0000	0.0000	88.0000	170.0000	141.0000	140.0000	48.0000
	-100.0000	41.0000								
SJ473FL	279.0000	136.0000	211.0000	226.0000	-6.0000	88.0000	177.0000	146.0000	115.0000	30.0000
	-100.0000	41.0000								
SJ482FL	351.0000	308.0000	204.0000	286.0000	-6.0000	87.0000	240.0000	216.0000	268.0000	94.0000
	-36.0000	6.0000								
SJ484FL	304.0000	217.0000	208.0000	259.0000	7.0000	88.0000	191.0000	182.0000	182.0000	72.0000
	-100.0000	28.0000								
SJ497FL	284.0000	138.0000	211.0000	224.0000	0.0000	88.0000	180.0000	153.0000	111.0000	30.0000
	-100.0000	30.0000								
SJ501FL	298.0000	210.0000	219.0000	226.0000	-4.0000	86.0000	173.0000	153.0000	181.0000	54.0000
	-100.0000	39.0000								
SJ502FL	281.0000	132.0000	215.0000	227.0000	4.0000	88.0000	153.0000	146.0000	145.0000	57.0000
	-100.0000	39.0000								
D1***FL	264.0000	90.0000	217.0000	187.0000	-18.0000	86.0000	171.0000	130.0000	104.0000	0.0000
	-100.0000	51.0000								
D6***FL	278.0000	134.0000	222.0000	186.0000	-24.0000	88.0000	153.0000	131.0000	121.0000	24.0000
	-100.0000	59.0000								
D16**FL	254.0000	132.0000	219.0000	193.0000	-38.0000	89.0000	164.0000	134.0000	114.0000	28.0000
	-100.0000	111.0000								
D17**FL	286.0000	203.0000	218.0000	224.0000	-16.0000	87.0000	172.0000	154.0000	172.0000	41.0000
	-100.0000	49.0000								
D18**FL	298.0000	224.0000	217.0000	230.0000	-34.0000	88.0000	179.0000	161.0000	187.0000	45.0000
	-100.0000	42.0000								

OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
D19**FL	292.0000	212.0000	217.0000	230.0000	-40.0000	87.0000	172.0000	157.0000	178.0000	41.0000	-60.0000	42.0000
D20**FL	288.0000	197.0000	213.0000	227.0000	-36.0000	89.0000	177.0000	152.0000	150.0000	36.0000	-85.0000	23.0000
D21**FL	264.0000	125.0000	214.0000	226.0000	-24.0000	88.0000	166.0000	145.0000	108.0000	20.0000	-100.0000	34.0000
D164*FL	304.0000	221.0000	219.0000	229.0000	-20.0000	87.0000	190.0000	157.0000	185.0000	48.0000	-100.0000	37.0000
D424*FL	274.0000	90.0000	221.0000	214.0000	-15.0000	87.0000	179.0000	132.0000	104.0000	0.0000	-57.0000	37.0000
N3***FL	284.0000	153.0000	223.0000	231.0000	-20.0000	87.0000	183.0000	152.0000	126.0000	30.0000	-100.0000	33.0000
N5***FL	279.0000	145.0000	220.0000	210.0000	-21.0000	89.0000	158.0000	146.0000	126.0000	28.0000	-74.0000	25.0000
P57**FL	358.0000	311.0000	201.0000	286.0000	-36.0000	88.0000	247.0000	219.0000	280.0000	86.0000	-92.0000	30.0000
P77**FL	318.0000	257.0000	205.0000	248.0000	-52.0000	89.0000	185.0000	166.0000	224.0000	73.0000	-100.0000	66.0000
P87**FL	367.0000	329.0000	206.0000	275.0000	-49.0000	88.0000	239.0000	210.0000	295.0000	118.0000	-77.0000	60.0000
P100*FL	320.0000	257.0000	206.0000	239.0000	-54.0000	89.0000	201.0000	169.0000	224.0000	73.0000	-100.0000	67.0000
P189*FL	345.0000	287.0000	198.0000	298.0000	-42.0000	89.0000	234.0000	212.0000	252.0000	83.0000	-42.0000	53.0000
AT0**O	434.0000	429.0000	205.0000	335.0000	-14.0000	91.0000	259.0000	311.0000	406.0000	262.0000	-66.0000	0.0000
F159*A	285.0000	186.0000	250.0000	51.0000	-60.0000	88.0000	206.0000	68.0000	172.0000	0.0000	-10.0000	-80.0000
F164*S	283.0000	204.0000	245.0000	32.0000	-85.0000	89.0000	195.0000	64.0000	170.0000	18.0000	-7.0000	-115.0000
F167*S	288.0000	175.0000	250.0000	0.0000	-70.0000	86.0000	209.0000	49.0000	145.0000	0.0000	57.0000	-100.0000
F168*S	281.0000	132.0000	250.0000	0.0000	-80.0000	87.0000	209.0000	32.0000	100.0000	0.0000	63.0000	-92.0000
F169*A	304.0000	230.0000	247.0000	0.0000	-74.0000	87.0000	216.0000	88.0000	190.0000	30.0000	-40.0000	-52.0000
F171*S	300.0000	213.0000	257.0000	126.0000	-15.0000	85.0000	199.0000	83.0000	186.0000	31.0000	78.0000	-100.0000
F174*A	359.0000	308.0000	238.0000	220.0000	-41.0000	87.0000	223.0000	190.0000	271.0000	95.0000	4.0000	-14.0000
F175*S	374.0000	322.0000	238.0000	240.0000	-60.0000	83.0000	219.0000	189.0000	294.0000	146.0000	-89.0000	0.0000
F177*S	289.0000	194.0000	249.0000	60.0000	-57.0000	86.0000	191.0000	78.0000	166.0000	25.0000	-17.0000	-80.0000
F178*S	300.0000	198.0000	251.0000	143.0000	-10.0000	85.0000	197.0000	95.0000	170.0000	38.0000	75.0000	-100.0000
F181*S	299.0000	211.0000	261.0000	72.0000	-100.0000	86.0000	210.0000	83.0000	181.0000	30.0000	115.0000	-92.0000
F183*A	279.0000	169.0000	254.0000	46.0000	-100.0000	84.0000	199.0000	62.0000	148.0000	-40.0000	-33.0000	-105.0000
F189*S	294.0000	231.0000	235.0000	186.0000	-100.0000	86.0000	196.0000	109.0000	202.0000	43.0000	-100.0000	0.0000

OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
F190*S	304.0000	247.0000	236.0000	201.0000	-100.0000	87.0000	200.0000	131.0000	216.0000	56.0000	-100.0000	-140.0000
F192*S	365.0000	325.0000	210.0000	291.0000	-38.0000	87.0000	222.0000	219.0000	294.0000	138.0000	-1.0000	-170.0000
F193*S	278.0000	161.0000	252.0000	122.0000	-92.0000	86.0000	198.0000	62.0000	151.0000	8.0000	60.0000	-80.0000
SJ475S	300.0000	214.0000	252.0000	20.0000	-72.0000	87.0000	220.0000	71.0000	172.0000	0.0000	67.0000	-55.0000
SJ478S	278.0000	162.0000	218.0000	190.0000	-70.0000	90.0000	169.0000	112.0000	137.0000	46.0000	-100.0000	-92.0000
SJ479S	265.0000	138.0000	226.0000	0.0000	-100.0000	86.0000	170.0000	18.0000	114.0000	-39.0000	-64.0000	-36.0000
SJ480S	295.0000	210.0000	233.0000	216.0000	-21.0000	88.0000	187.0000	126.0000	186.0000	82.0000	-57.0000	-59.0000
SJ481S	300.0000	245.0000	243.0000	186.0000	-77.0000	86.0000	199.0000	108.0000	214.0000	32.0000	-100.0000	-11.0000
SJ483S	323.0000	271.0000	237.0000	198.0000	-41.0000	86.0000	196.0000	145.0000	239.0000	92.0000	43.0000	-74.0000
SJ485S	304.0000	223.0000	255.0000	189.0000	9.0000	92.0000	71.0000	87.0000	238.0000	114.0000	-100.0000	-44.0000
SJ486S	296.0000	185.0000	239.0000	208.0000	-47.0000	86.0000	208.0000	122.0000	164.0000	30.0000	53.0000	-122.0000
SJ488S	289.0000	178.0000	239.0000	158.0000	11.0000	87.0000	182.0000	110.0000	154.0000	106.0000	29.0000	-44.0000
SJ489S	285.0000	174.0000	247.0000	151.0000	-89.0000	83.0000	189.0000	102.0000	151.0000	52.0000	-100.0000	37.0000
SJ490S	290.0000	215.0000	245.0000	54.0000	-72.0000	85.0000	199.0000	61.0000	173.0000	8.0000	93.0000	-85.0000
SJ491S	290.0000	181.0000	257.0000	78.0000	-92.0000	86.0000	201.0000	74.0000	151.0000	25.0000	3.0000	-19.0000
SJ492S	315.0000	224.0000	214.0000	272.0000	0.0000	87.0000	217.0000	179.0000	193.0000	90.0000	-60.0000	-110.0000
SJ493S	288.0000	167.0000	257.0000	0.0000	-100.0000	85.0000	199.0000	52.0000	151.0000	-2.0000	4.0000	-62.0000
SJ494S	290.0000	175.0000	256.0000	0.0000	-122.0000	85.0000	198.0000	51.0000	149.0000	-19.0000	-21.0000	-38.0000
SJ495A	310.0000	243.0000	243.0000	176.0000	-38.0000	87.0000	218.0000	124.0000	205.0000	70.0000	19.0000	-27.0000
SJ496S	290.0000	179.0000	253.0000	-30.0000	-49.0000	86.0000	210.0000	83.0000	134.0000	0.0000	-39.0000	-122.0000
SJ497A	274.0000	171.0000	244.0000	0.0000	-59.0000	87.0000	182.0000	59.0000	159.0000	35.0000	-31.0000	-100.0000
SJ498A	288.0000	162.0000	255.0000	0.0000	-43.0000	86.0000	209.0000	91.0000	140.0000	30.0000	-100.0000	-110.0000
SJ499S	254.0000	158.0000	209.0000	100.0000	-140.0000	84.0000	167.0000	40.0000	130.0000	0.0000	5.0000	-55.0000
SJ503S	292.0000	178.0000	259.0000	0.0000	-115.0000	85.0000	198.0000	68.0000	154.0000	10.0000	33.0000	-55.0000
SJ504S	304.0000	209.0000	262.0000	0.0000	-110.0000	84.0000	202.0000	88.0000	180.0000	30.0000	60.0000	-66.0000
D2***A	263.0000	143.0000	235.0000	30.0000	-24.0000	87.0000	168.0000	95.0000	125.0000	31.0000	-100.0000	12.0000

OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
D3***A	269.0000	138.0000	243.0000	-70.0000	-21.0000	88.0000	195.0000	89.0000	111.0000	0.0000	0.0000	-70.0000
D5***A	238.0000	118.0000	207.0000	-70.0000	-74.0000	88.0000	156.0000	61.0000	85.0000	0.0000	-100.0000	-110.0000
D7***A	268.0000	141.0000	241.0000	0.0000	-18.0000	86.0000	180.0000	84.0000	129.0000	34.0000	-100.0000	-55.0000
D9***S	239.0000	118.0000	200.0000	95.0000	-115.0000	82.0000	137.0000	15.0000	92.0000	-19.0000	35.0000	-74.0000
D10**A	240.0000	118.0000	195.0000	30.0000	-96.0000	89.0000	131.0000	48.0000	93.0000	-27.0000	-100.0000	-92.0000
D11**S	278.0000	158.0000	231.0000	126.0000	-27.0000	90.0000	154.0000	119.0000	158.0000	66.0000	-19.0000	-32.0000
D12**S	346.0000	303.0000	282.0000	223.0000	21.0000	91.0000	90.0000	139.0000	298.0000	161.0000	-100.0000	133.0000
D13**S	388.0000	363.0000	244.0000	262.0000	-42.0000	88.0000	222.0000	235.0000	337.0000	192.0000	-72.0000	103.0000
D14**S	218.0000	100.0000	129.0000	95.0000	-122.0000	76.0000	66.0000	8.0000	110.0000	-15.0000	-44.0000	-42.0000
D245*S	269.0000	138.0000	245.0000	0.0000	-55.0000	82.0000	187.0000	23.0000	118.0000	-30.0000	2.0000	-92.0000
D247*S	203.0000	111.0000	161.0000	0.0000	-115.0000	89.0000	68.0000	23.0000	98.0000	4.0000	-100.0000	-100.0000
N1***A	235.0000	123.0000	201.0000	0.0000	-80.0000	89.0000	151.0000	30.0000	85.0000	0.0000	0.0000	-92.0000
N2***S	264.0000	172.0000	203.0000	157.0000	-25.0000	89.0000	149.0000	86.0000	142.0000	62.0000	-100.0000	-122.0000
N6***S	239.0000	123.0000	210.0000	48.0000	-82.0000	88.0000	148.0000	63.0000	95.0000	-10.0000	-48.0000	-92.0000
N16**S	265.0000	160.0000	227.0000	100.0000	-85.0000	88.0000	177.0000	99.0000	120.0000	0.0000	-28.0000	-170.0000
N18**S	315.0000	253.0000	268.0000	183.0000	-3.0000	88.0000	167.0000	155.0000	248.0000	143.0000	-26.0000	-17.0000
N19**A	320.0000	266.0000	262.0000	52.0000	-43.0000	88.0000	137.0000	170.0000	253.0000	153.0000	-100.0000	99.0000
N20**S	255.0000	101.0000	243.0000	61.0000	-80.0000	89.0000	178.0000	103.0000	107.0000	4.0000	7.0000	-122.0000

MEANS

305.09912	217.37189	226.01651	166.64462	-42.34711	87.02478	193.04956	137.23965
191.01651	57.33057	-57.22314	-8.87603				

STANDARD DEVIATIONS

39.46483	71.39922	22.09370	104.24765	37.32744	1.98100	34.71907	60.90566
66.82927	52.64285	55.64831	67.21233				

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
F66**FL	1.1124	1.0172	0.0445	0.7612	-0.0443	-0.0125	0.7186	0.8334	0.9125	0.4876	0.2376	0.7867

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
F101*FL	1.0617	1.0172	0.0898	0.6557	-0.1247	-0.5173	0.8050	0.8170	0.8676	0.5636	-0.7687	0.9206
F126*FL	1.0617	1.0732	0.1803	0.2720	-0.9283	0.4923	0.8050	0.7349	1.0472	0.4496	-0.7687	0.7569
F134*FL	1.1631	1.3393	-0.0913	0.9339	0.3576	-0.5173	1.1219	1.1290	1.3465	1.1335	-0.7687	1.0099
F135*FL	1.8219	1.4514	-0.4534	1.1353	0.4915	-0.0125	1.2659	1.2603	1.4811	1.3234	-0.7687	0.5784
F138*FL	1.2138	1.4934	-0.7249	1.1833	1.0273	-0.0125	1.3811	1.2767	1.5560	1.4374	-0.7687	0.5486
F142*FL	1.3151	1.1713	0.4971	0.4639	-0.1782	-0.5173	0.8627	0.7842	1.1071	0.7156	-0.4452	1.2330
F158*FL	1.3911	1.4374	-0.1365	0.9147	-0.3390	-0.0125	0.8338	1.2767	1.4811	1.1335	0.6689	0.8016
F160*FL	0.8083	0.7791	0.0445	0.5694	0.8130	0.4923	0.4018	0.8498	0.6282	0.6966	-0.7687	0.6082
F162*FL	1.8472	1.5214	-0.0460	0.3296	0.3844	-0.5173	1.1219	1.3096	1.4512	0.7156	-0.2296	0.9950
F165*FL	0.3776	0.6251	-0.2271	0.8571	1.1345	-0.5173	0.1714	0.8991	0.5384	0.6586	0.3095	0.6826
F166*FL	1.4672	1.6195	-0.6344	0.9627	1.0005	-0.5173	1.3811	1.2932	1.7206	1.6464	-0.7687	0.3999
F170*FL	1.5432	1.3253	0.2708	0.7324	-0.0979	-0.5173	0.9491	1.0305	1.2567	0.8105	-0.7687	1.1438
F176*FL	0.6563	0.7931	0.6782	-0.0158	-0.1514	-0.5173	0.2578	0.4065	0.6881	0.2407	-0.7687	1.3372
F184*FL	-0.4840	0.0228	0.8592	-1.2724	-1.0623	-0.5173	-0.0014	-0.1024	-0.0751	-0.4052	-0.1577	0.3701
F185*FL	-0.5346	-0.2153	1.0403	-1.3108	-1.1427	-0.5173	-0.0878	-0.2010	-0.2696	-0.5952	-0.7687	0.6677
F186*FL	-0.3066	0.0088	0.7687	-1.1381	-1.5445	-1.0221	0.0562	-0.2338	-0.1349	-0.5192	-0.5710	0.4296
F187*FL	-0.3573	0.0368	0.9045	-1.1285	-0.6337	-0.5173	0.2290	-0.3816	-0.1499	-0.6521	-0.6968	-0.2548
F188*FL	1.3911	1.4374	-0.8607	1.2121	0.8130	0.4923	0.9203	1.3424	1.5260	1.5324	-0.7687	0.5933
SJ115FL	0.6816	0.7231	-0.7702	1.1353	1.0005	0.9971	0.6610	1.1618	0.5534	0.8105	-0.6249	0.4445
SJ117FL	0.8337	0.7791	-1.3586	1.0490	0.3844	0.9971	1.0643	1.1454	0.7629	0.7536	-0.7687	0.4296
SJ200FL	1.0871	1.0452	-1.0870	0.5694	0.4647	0.4923	1.1795	1.2275	0.9724	0.7536	-0.7687	0.5784
SJ263FL	2.0246	1.8856	-1.0418	1.0394	0.4915	1.5019	2.0148	1.7529	1.9450	1.7224	0.1657	0.7123
SJ378FL	1.0364	1.0172	-1.0870	1.1066	0.4915	0.9971	1.0067	1.1782	0.8826	0.5256	-0.6249	0.4743
SJ389FL	0.6310	0.2609	-1.0418	1.1257	0.5719	0.9971	0.7186	1.0633	0.2841	0.5256	-0.7687	0.4147
SJ412FL	-0.2559	-0.3133	-0.4534	0.7133	1.0273	0.9971	-0.4911	0.4394	-0.3444	0.0507	-0.7687	0.9801
SJ413FL	-0.1292	-0.2993	-0.4986	0.7228	1.1345	0.4923	-0.4335	0.5379	-0.3893	0.1267	-0.7687	0.6974

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
SJ414FL	-0.1799	-0.4254	-1.0870	0.7708	1.2148	-0.5173	-0.0302	0.5379	-0.4940	-0.1772	-0.7687	0.5635
SJ415FL	0.1495	0.0368	-0.7249	0.8380	1.2148	-0.5173	0.2578	0.6036	-0.0152	0.2407	-0.7687	0.9950
SJ416FL	-0.3826	-0.4814	-0.4534	0.6173	1.1881	-0.0125	-0.2318	0.2423	-0.5090	-0.1772	-0.7687	0.9950
SJ429FL	0.5296	0.7651	-0.4534	0.7996	1.1613	0.4923	0.0562	0.7021	0.7030	0.6776	-0.7687	0.9057
SJ430FL	1.3911	1.5214	-0.5439	1.0874	1.1345	0.4923	1.3235	1.1946	1.6008	1.5134	-0.4093	0.8760
SJ431FL	0.4029	0.2609	-0.9060	0.9243	1.2416	-0.5173	0.5170	0.7349	0.2242	0.3926	-0.7687	0.5933
SJ432FL	1.8219	1.8856	-0.6344	1.2600	0.8934	-0.5173	1.6979	1.6215	2.0348	2.2352	-0.7687	0.5784
SJ433FL	-0.2559	-0.0332	-0.3176	0.5118	0.9469	0.4923	-0.5775	0.2259	-0.0601	-0.1393	-0.7687	0.8908
SJ434FL	-0.4079	-1.1677	-0.6797	0.7612	0.9737	-0.5173	-0.0590	0.2752	-1.1973	-0.5192	-0.1937	0.5784
SJ438FL	-0.2052	-0.1313	-0.4081	0.5694	1.0809	0.4923	-0.2030	0.2423	-0.1798	-0.1772	0.1837	0.6379
SJ469FL	-0.1039	-0.3974	-0.7249	0.8763	1.1345	0.4923	0.1426	0.5707	-0.4043	0.0507	-0.7687	0.6528
SJ470FL	0.6816	0.8631	-0.4534	0.8571	0.9737	0.4923	0.5458	0.7678	0.8527	0.7346	-0.7687	0.6677
SJ472FL	-0.6867	-1.1677	-0.8155	0.5694	1.1345	0.4923	-0.6639	0.0617	-0.7634	-0.1772	-0.7687	0.7421
SJ473FL	-0.6613	-1.1397	-0.6797	0.5694	0.9737	0.4923	-0.4623	0.1438	-1.1375	-0.5192	-0.7687	0.7421
SJ482FL	1.1631	1.2693	-0.9965	1.1449	0.9737	-0.0125	1.3523	1.2932	1.1519	0.6966	0.3814	0.2213
SJ484FL	-0.0279	-0.0052	-0.8155	0.8859	1.3220	0.4923	-0.0590	0.7349	-0.1349	0.2787	-0.7687	0.5486
SJ487FL	-0.5346	-1.1117	-0.6797	0.5502	1.1345	0.4923	-0.3759	0.2588	-1.1973	-0.5192	-0.7687	0.5784
SJ501FL	-0.1799	-0.1032	-0.3176	0.5694	1.0273	-0.5173	-0.5775	0.2588	-0.1499	-0.0633	-0.7687	0.7123
SJ502FL	-0.6106	-1.1957	-0.4986	0.5790	1.2416	0.4923	-1.1535	0.1438	-0.6886	-0.0063	-0.7487	0.7123
D1***FL	-1.0414	-1.7839	-0.4081	0.1953	0.6523	-0.5173	-0.6351	-0.1189	-1.3021	-1.0890	-0.7687	0.8908
D6***FL	-0.6867	-1.1677	-0.1818	0.1857	0.4915	0.4923	-1.1535	-0.1024	-1.0477	-0.6331	-0.7487	1.0099
D16**FL	-1.2948	-1.1957	-0.3176	0.2528	0.1165	0.9971	-0.8367	-0.0532	-1.1524	-0.5572	-0.7487	1.7835
D17**FL	-0.4840	-0.2013	-0.3628	0.5502	0.7058	-0.0125	-0.6063	0.2752	-0.2846	-0.3102	-0.7687	0.8611
D18**FL	-0.1799	0.0928	-0.4081	0.6077	0.2236	0.4923	-0.4047	0.3901	-0.0601	-0.2342	-0.7687	0.7569
D19**FL	-0.3319	-0.0752	-0.4081	0.6077	0.0629	-0.0125	-0.6063	0.3244	-0.1948	-0.3102	-0.0499	0.7569
D20**FL	-0.4333	-0.2853	-0.5892	0.5790	0.1700	0.9971	-0.4623	0.2423	-0.6138	-0.4052	-0.4992	0.4743

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
D21**FL	-1.0414	-1.2937	-0.5439	0.5694	0.4915	0.4923	-0.7791	0.1274	-1.2422	-0.7091	-0.7687	0.6379
D164*FL	-0.0279	0.0508	-0.3176	0.5981	0.5987	-0.0125	-0.0878	0.3244	-0.0900	-0.1772	-0.7687	0.6826
D424*FL	-0.7880	-1.7839	-0.2271	0.4543	0.7326	-0.0125	-0.4047	-0.0860	-1.3021	-1.0890	0.0040	0.6826
N3***FL	-0.5346	-0.9016	-0.1365	0.6173	0.5987	-0.0125	-0.2895	0.2423	-0.9729	-0.5192	-0.7687	0.6230
N5***FL	-0.6613	-1.0136	-0.2723	0.4159	0.5719	0.9971	-1.0095	0.1438	-0.9729	-0.5572	-0.3015	0.5040
P57**FL	1.3405	1.3113	-1.1323	1.1449	0.1700	0.4923	1.5539	1.3424	1.3315	0.5446	-0.6249	0.5784
P77**FL	0.3269	0.5550	-0.9512	0.7804	-0.2586	0.9971	-0.2318	0.4722	0.4935	0.2977	-0.7687	1.1140
P87**FL	1.5685	1.5634	-0.9060	1.0394	-0.1782	0.4923	1.3235	1.1946	1.5560	1.1525	-0.3554	1.0248
P100*FL	0.3776	0.5550	-0.9060	0.6941	-0.3122	0.9971	0.2290	0.5215	0.4935	0.2977	-0.7687	1.1289
P189*FL	1.0110	0.9752	-1.2681	1.2600	0.0093	0.9971	1.1795	1.2275	0.9125	0.4876	0.2736	0.9206
AT0**0	3.2662	2.9640	-0.9512	1.6150	0.7594	2.0067	1.8995	2.8529	3.2169	3.8879	-0.1577	0.1321
F159*A	-0.5093	-0.4394	1.0855	-1.1093	-0.4729	0.4923	0.3730	-1.1368	-0.2846	-1.0890	0.8486	-1.0582
F164*S	-0.5600	-0.1873	0.8592	-1.2916	-1.1427	0.9971	0.0562	-1.2025	-0.3145	-0.7471	0.9025	-1.5789
F167*S	-0.4333	-0.5935	1.0855	-1.5985	-0.7408	-0.5173	0.4594	-1.4488	-0.6886	-1.0890	2.0526	-1.3558
F168*S	-0.6106	-1.1957	1.0855	-1.5985	-1.0087	-0.0125	0.4594	-1.7279	-1.3619	-1.0890	2.1604	-1.2367
F169*A	-0.0279	0.1769	0.9498	-1.5985	-0.8480	-0.0125	0.6610	-0.8085	-0.0152	-0.5192	0.3095	-0.6416
F171*S	-0.1292	-0.0612	1.4024	-0.3899	0.7326	-1.0221	0.1714	-0.8906	-0.0751	-0.5002	2.4300	-1.3558
F174*A	1.3658	1.2693	0.5424	0.5118	0.0361	-0.0125	0.8627	0.8663	1.1968	0.7156	1.1002	-0.0762
F175*S	1.7459	1.4654	0.5424	0.7037	-0.4729	-2.0317	0.7474	0.8498	1.5410	1.6844	-0.5710	0.1321
F177*S	-0.4079	-0.3273	1.0403	-1.0230	-0.3925	-0.5173	-0.0590	-0.9726	-0.3743	-0.6141	0.7228	-1.0582
F178*S	-0.1292	-0.2713	1.1308	-0.2268	0.8666	-1.0221	0.1138	-0.6935	-0.3145	-0.3672	2.3760	-1.3558
F181*S	-0.1545	-0.0892	1.5834	-0.9079	-1.5445	-0.5173	0.4882	-0.8906	-0.1499	-0.5192	3.0948	-1.2367
F183*A	-0.6613	-0.6775	1.2666	-1.1573	-1.5445	-1.5269	0.1714	-1.2353	-0.6437	-1.8489	0.4353	-1.4302
F189*S	-0.2812	0.1909	0.4066	0.1857	-1.5445	-0.5173	0.0850	-0.4637	0.1644	-0.2722	-0.7687	0.1321
F190*S	-0.0279	0.4150	0.4519	0.3296	-1.5445	-0.0125	0.2002	-0.1024	0.3738	-0.0253	-0.7687	-1.9509
F192*S	1.5178	1.5074	-0.7249	1.1929	0.1165	-0.0125	0.8338	1.3424	1.5410	1.5324	1.0103	-2.3972

APPENDIX D CONTD.

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
F193*S	-0.6867	-0.7895	1.1761	-0.4283	-1.3302	-0.5173	0.1426	-1.2353	-0.5988	-0.9371	2.1065	-1.0582
SJ475S	-0.1292	-0.0472	1.1761	-1.4067	-0.7944	-0.0125	0.7762	-1.0876	-0.2846	-1.0890	2.2323	-0.6862
SJ478S	-0.6867	-0.7755	-0.3628	0.2240	-0.7408	1.5019	-0.6927	-0.4144	-0.8083	-0.2152	-0.7687	-1.2367
SJ479S	-1.0161	-1.1117	-0.0007	-1.5985	-1.5445	-0.5173	-0.6639	-1.9578	-1.1524	-1.8299	-0.1218	-0.4036
SJ480S	-0.2559	-0.1032	0.3161	0.4734	0.5719	0.4923	-0.1742	-0.1845	-0.0751	0.4686	0.0040	-0.7458
SJ481S	-0.1292	0.3870	0.7687	0.1857	-0.9283	-0.5173	0.1714	-0.4801	0.3439	-0.4812	-0.7687	-0.0316
SJ483S	0.4536	0.7511	0.4971	0.3008	0.0361	-0.5173	0.0850	0.1274	0.7180	0.6586	1.8010	-0.9689
SJ485S	-0.0279	0.0788	1.3118	0.2144	1.3756	2.5115	-3.5153	-0.8249	0.7030	1.0765	-0.7687	-0.5226
SJ486S	-0.2306	-0.4534	0.5877	0.3967	-0.1247	-0.5173	0.4306	-0.2502	-0.4043	-0.5192	1.9807	-1.6831
SJ488S	-0.4079	-0.5514	0.5877	-0.0829	1.4292	-0.0125	-0.3183	-0.4472	-0.5539	0.9245	1.5494	-0.5226
SJ489S	-0.5093	-0.6075	0.9498	-0.1501	-1.2498	-2.0317	-0.1166	-0.5786	-0.5988	-0.1013	-0.7687	0.6826
SJ490S	-0.3826	-0.0332	0.8592	-1.0805	-0.7944	-1.0221	0.1714	-1.2518	-0.2696	-0.9371	2.6995	-1.1326
SJ491S	-0.3826	-0.5094	1.4024	-0.8503	-1.3302	-0.5173	0.2290	-1.0383	-0.5988	-0.6141	1.0822	-0.1506
SJ492S	0.2509	0.0928	-0.5439	1.0106	1.1345	-0.0125	0.6898	0.6857	0.0297	0.6206	-0.0499	-1.5045
SJ493S	-0.4333	-0.7055	1.4024	-1.5985	-1.5445	-1.0221	0.1714	-1.3995	-0.5988	-1.1270	1.1002	-0.7904
SJ494S	-0.3826	-0.5935	1.3571	-1.5985	-2.1339	-1.0221	0.1426	-1.4160	-0.6287	-1.4500	0.6509	-0.4333
SJ495A	0.1242	0.3589	0.7687	0.0897	0.1165	-0.0125	0.7186	-0.2174	0.2092	0.2407	1.3697	-0.2697
SJ496S	-0.3826	-0.5374	1.2213	-1.8863	-0.1782	-0.5173	0.4882	-0.8906	-0.8532	-1.0890	0.3275	-1.6831
SJ497A	-0.7880	-0.6495	0.8140	-1.5985	-0.4461	-0.0125	-0.3183	-1.2846	-0.4791	-0.4242	0.4712	-1.3558
SJ498A	-0.4333	-0.7755	1.3118	-1.5985	-0.0175	-0.5173	0.4594	-0.7592	-0.7634	-0.5192	-0.7687	-1.5045
SJ499S	-1.2948	-0.8315	-0.7702	-0.6393	-2.6161	-1.5269	-0.7503	-1.5966	-0.9130	-1.0890	1.1181	-0.6862
SJ503S	-0.3319	-0.5514	1.4929	-1.5985	-1.9464	-1.0221	0.1426	-1.1368	-0.5539	-0.8991	1.6213	-0.6862
SJ504S	-0.0279	-0.1173	1.6287	-1.5985	-1.8124	-1.5269	0.2578	-0.8085	-0.1648	-0.5192	2.1065	-0.8499
D2***A	-1.0668	-1.0416	0.4066	-1.3108	0.4915	-0.0125	-0.7215	-0.6935	-0.9878	-0.5002	-0.7687	0.3106
D3***A	-0.9147	-1.1117	0.7687	-2.2700	0.5719	0.4923	0.0562	-0.7920	-1.1973	-1.0890	1.0283	-0.9094
D5***A	-1.7002	-1.3918	-0.8607	-2.2700	-0.8480	0.4923	-1.0671	-1.2518	-1.5864	-1.0890	-0.7687	-1.5045

STANDARDIZED OBSERVATION MATRIX

WELL # AND AQ	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
D7***A	-0.9401	-1.0696	0.6782	-1.5985	0.6523	-0.5173	-0.3759	-0.8741	-0.9280	-0.4432	-0.7687	-0.6862
D9***S	-1.6749	-1.3918	-1.1776	-0.6873	-1.9464	-2.5365	-1.6144	-2.0070	-1.4816	-1.4500	1.6572	-0.9689
D10**A	-1.6495	-1.3918	-1.4039	-1.3108	-1.4374	0.9971	-1.7872	-1.4652	-1.4667	-1.6019	-0.7687	-1.2367
D11**S	-0.6867	-0.8315	0.2256	-0.3899	0.4111	1.5019	-1.1247	-0.2995	-0.4940	0.1647	0.6869	-0.3440
D12**S	1.0364	1.1993	2.5339	0.5406	1.6971	2.0067	-2.9681	0.0289	1.6008	1.9693	-0.7687	2.1109
D13**S	2.1006	2.0396	0.8140	0.9147	0.0093	0.4923	0.8338	1.6051	2.1844	2.5582	-0.2655	1.6645
D14**S	-2.2070	-1.6439	-4.3911	-0.6873	-2.1339	-5.5653	-3.6594	-2.1220	-1.2123	-1.3740	0.2376	-0.4928
D245*S	-0.9147	-1.1117	0.8592	-1.5985	-0.3390	-2.5365	-0.1742	-1.8757	-1.0926	-1.6589	1.0642	-1.2367
D247*S	-2.5871	-1.4898	-2.9428	-1.5985	-1.9464	0.9971	-3.6018	-1.8757	-1.3919	-1.0131	-0.7687	-1.3558
N1***A	-1.7762	-1.3217	-1.1323	-1.5985	-1.0087	0.9971	-1.2111	-1.7608	-1.5864	-1.0890	1.0283	-1.2367
N2***S	-1.0414	-0.6355	-1.0418	-0.0925	0.4647	0.9971	-1.2687	-0.8413	-0.7335	0.0887	-0.7687	-1.6831
N6***S	-1.6749	-1.3217	-0.7249	-1.1381	-1.0623	0.4923	-1.2975	-1.2189	-1.4367	-1.2790	0.1657	-1.2367
N16**S	-1.0161	-0.8035	0.0445	-0.6393	-1.1427	0.4923	-0.4623	-0.6279	-1.0627	-1.0890	0.5251	-2.3972
N18**S	0.2509	0.4990	1.9002	0.1569	1.0541	0.4923	-0.7503	0.2916	0.8527	1.6274	0.5611	-0.1209
N19**A	0.3776	0.6811	1.6287	-1.0997	-0.0175	0.4923	-1.6144	0.5379	0.9275	1.8173	-0.7687	1.6050
N20**S	-1.2695	-1.6299	0.7687	-1.0134	-1.0087	0.9971	-0.4335	-0.5622	-1.2572	-1.0131	1.1541	-1.6831

CORRELATION COEFFICIENT MATRIX

	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
SP.COND.	1.00000	0.95388	0.02799	0.65016	0.38301	0.19343	0.73363	0.84442	0.95432	0.86081	-0.16923	0.44670
CL	0.95388	1.00000	-0.00518	0.59207	0.27613	0.17951	0.65769	0.78372	0.98574	0.85982	-0.17217	0.39473
HCO3+CO3	0.02799	-0.00518	1.00000	-0.44626	-0.17921	-0.06265	0.10580	-0.28490	-0.00307	-0.09761	0.42625	-0.21061
SO4	0.65016	0.59207	-0.44626	1.00000	0.64951	0.29704	0.35174	0.85790	0.61405	0.70084	-0.44613	0.60645
F	0.38301	0.27613	-0.17921	0.64951	1.00000	0.42779	0.14103	0.62461	0.31061	0.53334	-0.39013	0.48136
PH	0.19343	0.17951	-0.06265	0.29704	0.42779	1.00000	-0.00184	0.36587	0.19141	0.34696	-0.30814	0.18949
CA	0.73363	0.65769	0.10580	0.35174	0.14103	-0.00184	1.00000	0.58350	0.60055	0.42188	0.08610	0.13771

CORRELATION COEFFICIENT MATRIX

	SP.COND.	CL	HCO3+CO3	SO4	F	PH	CA	MG	NA	K	FE	S
MG	0.84442	0.78372	-0.28490	0.85790	0.62461	0.36587	0.58350	1.00000	0.79058	0.83835	-0.47296	0.64245
NA	0.95432	0.98574	-0.00307	0.61405	0.31061	0.19141	0.60055	0.79058	1.00000	0.89720	-0.19220	0.41823
K	0.86081	0.85982	-0.09761	0.70084	0.53334	0.34696	0.42188	0.83835	0.89720	1.00000	-0.31420	0.47345
FE	-0.16923	-0.17217	0.42625	-0.44613	-0.39013	-0.30814	0.08610	-0.47296	-0.19220	-0.31420	1.00000	-0.59808
S	0.44670	0.39473	-0.21061	0.60645	0.48136	0.18949	0.13771	0.64245	0.41823	0.47345	-0.59808	1.00000

EIGENVALUES

6.37629	2.12958	1.02174

CUMULATIVE PERCENTAGE OF EIGENVALUES

0.53136	0.70882	0.79397

EIGENVECTORS

VECTOR 1	0.36297	0.34923	-0.08197	0.33288	0.24032	0.14397	0.23174	0.38226	0.35388	0.36134	-0.17431	0.25350
VECTOR 2	0.25298	0.26635	0.41824	-0.20213	-0.29182	-0.23597	0.38120	-0.06326	0.24175	0.06433	0.46812	-0.27821
VECTOR 3	-0.02020	-0.05999	0.54259	-0.13500	0.33040	0.71951	-0.13050	-0.03827	-0.03557	0.11033	0.10672	-0.11476

FACTOR MATRIX (3 FACTORS)

	I	II	III
SP.COND.	0.91655	0.36918	-0.02041
CL	0.88184	0.38868	-0.06064
HCO3+CO3	-0.20700	0.61034	0.54846
SO4	0.84057	-0.29496	-0.13646
F	0.60685	-0.42586	0.33397
PH	0.36353	-0.34435	0.72729
CA	0.58518	0.55628	-0.13191
MG	0.96525	-0.09231	-0.03868
NA	0.89360	0.35278	-0.03595
K	0.91243	0.09388	0.11152
FE	-0.44015	0.68314	0.10788
S	0.64013	-0.40599	-0.11600

ITERATION CYCLE	VARIANCES
0	0.178034
1	0.359631
2	0.362376
3	0.362400
4	0.362400
5	0.362400
6	0.362400
7	0.362400

ROTATED FACTOR MATRIX (3 FACTORS)

	I	II	III
SPCOND.	0.96984	-0.10642	0.15764
CL	0.95498	-0.09827	0.10363
HCO3+CO3	0.09073	0.82700	0.15496
SO4	0.56759	-0.63576	0.29300
F	0.25305	-0.39672	0.66312
PH	0.05032	-0.03339	0.88093
CA	0.80043	0.11245	-0.12632
MG	0.76952	-0.48355	0.34019
NA	0.94344	-0.11742	0.14284
K	0.80767	-0.24429	0.37651
FE	-0.02225	0.75014	-0.32991
S	0.33787	-0.62708	0.28402

CHECK ON COMMUNALITIES

VARIABLE	ORIGINAL	FINAL	DIFFERENCE
SP.COND.	0.97676	0.97676	0.00000
CL	0.93239	0.93239	0.00000
HCO3+CO3	0.71617	0.71617	0.00000
SO4	0.81219	0.81219	0.00000
F	0.66115	0.66115	0.00000
PH	0.77968	0.77968	0.00000
CA	0.66929	0.66929	0.00000
MG	0.94172	0.94172	0.00000
NA	0.92427	0.92427	0.00000
K	0.85377	0.85377	0.00000
FE	0.67205	0.67204	0.00000
S	0.58805	0.58805	0.00000

INVERTED CORRELATION COEFFICIENT MATRIX

31.478	-1.523	-2.140	-1.104	-0.936	0.391	-6.751	-4.753	-18.177	-1.486	-1.160	-1.286
-1.523	52.291	1.441	1.291	1.043	-1.128	-4.642	-0.479	-51.082	3.690	0.265	-0.027
-2.140	1.441	2.104	1.297	-0.494	-0.331	-0.300	1.700	-0.857	-0.128	-0.423	-0.538
-1.104	1.291	1.297	5.651	-1.011	0.273	1.156	-4.543	-1.320	0.850	-0.681	-0.233
-0.936	1.043	-0.494	-1.011	2.810	-0.269	0.228	-1.269	2.097	-1.718	-0.004	-0.069
0.391	-1.128	-0.331	0.273	-0.269	1.506	0.545	-1.455	1.343	-0.340	0.175	0.443
-6.751	-4.642	-0.300	1.156	0.228	0.545	5.744	-4.663	6.854	3.159	-0.629	1.341
-4.753	-0.479	1.700	-4.543	-1.269	-1.455	-4.663	18.560	2.423	-4.936	2.086	-2.392
-18.177	-51.082	-0.857	-1.320	2.097	1.343	6.854	2.423	72.592	-11.255	0.300	0.317
-1.486	3.690	-0.128	0.850	-1.718	-0.340	3.159	-4.936	-11.255	11.742	-0.276	1.274
-1.160	0.265	-0.423	-0.681	-0.004	0.175	-0.629	2.086	0.300	-0.276	2.283	0.824
-1.286	-0.027	-0.538	-0.233	-0.069	0.443	1.341	-2.392	0.317	1.274	0.824	2.671

TRANSPOSE ROTATED FACTOR MATRIX

0.96900	0.95500	0.09000	0.56700	0.25300	0.05000	0.80000	0.76900	0.94300	0.80700	-0.02200	0.33700
-0.10600	-0.09800	0.82700	-0.63500	-0.39600	-0.03300	0.11200	-0.48300	-0.11700	-0.24400	0.75000	-0.62700
0.15700	0.10300	0.15500	0.29300	0.66300	0.88000	-0.12600	0.34000	0.14200	0.37600	-0.32900	0.28400

TRANSPOSE * INVERSE

0.208	0.242	0.070	0.051	-0.057	-0.112	0.226	0.112	0.193	0.132	0.101	-0.005
0.067	0.036	0.505	-0.228	-0.021	0.222	0.090	-0.110	0.064	0.026	0.325	-0.244
-0.035	-0.092	0.332	-0.014	0.387	0.689	-0.175	0.036	-0.035	0.131	-0.058	0.017

FACTOR SCORES

WELL # AND AQ	I	II	III
F66**FL	1.039	-0.113	-0.218
F101*FL	1.004	-0.530	-0.522
F126*FL	0.949	-0.096	-0.135
F134*FL	1.351	-0.658	-0.418
F135*FL	1.536	-0.612	-0.182
F138*FL	1.431	-0.787	-0.056
F142*FL	1.223	-0.200	-0.441
F158*FL	1.525	-0.047	-0.407
F160*FL	0.605	-0.330	0.645
F162*FL	1.548	-0.291	-0.508
F165*FL	0.609	-0.499	-0.012
F166*FL	1.629	-0.731	-0.382
F170*FL	1.357	-0.447	-0.493
F176*FL	0.625	-0.240	-0.241
F184*FL	-0.079	0.454	-0.488
F185*FL	-0.288	0.259	-0.401
F186*FL	-0.031	0.151	-1.062
F187*FL	-0.141	0.461	-0.374
F188*FL	1.312	-0.795	0.259
SJ115FL	0.580	-0.699	0.769
SJ117FL	0.722	-0.944	0.248
SJ200FL	0.961	-0.806	-0.028
SJ263FL	1.928	-0.199	0.490
SJ378FL	0.836	-0.771	0.319
SJ389FL	0.360	-0.892	0.524
SJ412FL	-0.498	-0.822	1.143
SJ413FL	-0.394	-0.889	0.816
SJ414FL	-0.334	-1.377	-0.140
SJ415FL	0.092	-1.216	-0.077
SJ416FL	-0.492	-1.017	0.455
SJ429FL	0.417	-0.743	0.677
SJ430FL	1.451	-0.506	0.386
SJ431FL	0.331	-1.177	-0.194
SJ432FL	2.034	-0.779	-0.439
SJ433FL	-0.383	-0.756	0.757
SJ434FL	-0.678	-1.050	-0.079
SJ438FL	-0.252	-0.425	0.660
SJ469FL	-0.300	-0.984	0.637
SJ470FL	0.641	-0.633	0.504
SJ472FL	-0.968	-1.094	0.810
SJ473FL	-1.000	-1.043	0.725
SJ482FL	1.285	-0.522	-0.293
SJ484FL	-0.150	-1.005	0.701
SJ487FL	-0.955	-1.002	0.769

FACTOR SCORES

WELL # AND AQ	I	II	III
SJ501FL	-0.276	-0.957	0.108
SJ502FL	-1.007	-0.971	1.064
D1***FL	-1.280	-1.135	0.028
D6***FL	-1.152	-0.794	0.811
D16**FL	-1.263	-0.971	0.965
D17**FL	-0.469	-0.936	0.317
D18**FL	-0.252	-0.772	0.393
D19**FL	-0.275	-0.684	-0.010
D20**FL	-0.594	-0.647	0.685
D21**FL	-1.197	-1.008	0.643
D164*FL	-0.123	-0.782	0.169
D424*FL	-1.127	-0.657	0.367
N3***FL	-0.715	-0.823	0.351
N5***FL	-1.031	-0.507	1.097
P57**FL	1.274	-0.842	-0.307
P77**FL	0.130	-0.944	0.341
P87**FL	1.493	-0.668	-0.298
P100*FL	0.252	-0.865	0.255
P189*FL	0.977	-0.697	-0.004
ATO**D	3.010	-0.013	1.129
F159*A	-0.371	1.516	0.284
F164*S	-0.396	1.705	0.366
F167*S	-0.260	1.888	-0.583
F168*S	-0.635	1.966	-0.268
F169*A	0.093	1.254	-0.255
F171*S	0.220	1.759	-0.229
F174*A	1.383	0.744	-0.119
F175*S	1.771	-0.259	-1.506
F177*S	-0.260	1.167	-0.256
F178*S	0.126	1.518	-0.204
F181*S	0.389	2.336	-0.783
F183*A	-0.429	1.080	-1.471
F189*S	0.056	-0.151	-0.855
F190*S	0.267	0.474	-0.542
F192*S	1.637	0.492	-0.462
F193*S	-0.267	1.559	-0.689
SJ475S	0.103	1.954	-0.345
SJ478S	-0.929	0.019	0.850
SJ479S	-1.259	0.267	-0.947
SJ480S	-0.128	0.323	0.752
SJ481S	0.151	0.091	-0.572
SJ483S	0.828	1.003	-0.337
SJ485S	-0.928	0.868	3.426
SJ486S	0.100	1.143	-0.447
SJ488S	-0.209	0.875	0.887
SJ489S	-0.196	-0.371	-1.429
SJ490S	0.079	1.708	-1.059
SJ491S	-0.165	1.240	-0.536
SJ492S	0.347	-0.155	0.181
SJ493S	-0.309	1.475	-1.018
SJ494S	-0.345	1.228	-1.278
SJ495A	0.515	1.002	0.060

FACTOR SCORES

WELL # AND AQ	I	II	III
SJ496S	-0.408	1.466	-0.208
SJ497A	-0.628	1.261	0.119
SJ498A	-0.476	1.035	0.051
SJ499S	-0.789	-0.092	-2.302
SJ503S	-0.107	1.663	-1.147
SJ504S	0.357	1.859	-1.451
D2***A	-1.115	-0.008	0.588
D3***A	-0.951	1.445	0.767
D5***A	-1.774	0.075	0.018
D7***A	-0.962	0.386	0.316
D9***S	-1.302	-0.404	-2.735
D10**A	-2.008	-0.402	-0.006
D11**S	-0.830	0.662	1.553
D12**S	0.202	0.797	3.528
D13**S	2.070	0.138	0.553
D14**S	-1.908	-3.471	-5.475
D245*S	-0.742	0.866	-1.735
D247*S	-2.683	-1.238	-0.293
N1***A	-1.715	0.459	0.108
N2***S	-1.166	-0.291	0.862
N6***S	-1.624	0.113	-0.081
N16**S	-0.884	0.891	-0.088
N18**S	0.498	1.255	1.611
N19**A	0.276	0.493	1.392
N20**S	-1.122	1.419	0.632

ABBREVIATIONS AND UNITS

WELL # = WELL NUMBER F = FLAGLER COUNTY
SJ = ST. JOHNS COUNTY
D = DUVAL COUNTY
N = NASSAU COUNTY
P = PUTNAM COUNTY
ATO = SEA WATER
AQ = AQUIFER FL = FLORIDAN
O = SEA WATER SAMPLE
S = SHALLOW
A = SECONDARY ARTESIAN
SP.COND. = SPECIFIC CONDUCTIVITY IN MICROMHOS/CENTIMETER

CL = CHLORIDE IN MG/L
HCO3+CO3 = BICARBONATE PLUS CARBONATE IN MG/L
SO4 = SULFATE IN MG/L
F = FLUORIDE IN MG/L
PH = STANDARD UNITS
CA = CALCIUM IN MG/L
MG = MAGNESIUM IN MG/L
NA = SODIUM IN MG/L
K = POTASSIUM IN MG/L
FE = IRON IN MG/L
S = SULFIDE IN MG/L

NOTES:
1) OBSERVATION MATRIX IS THE LOG10 TRANSFORMATION OF THE ACTUAL DATA.
2) DECIMALS IN THE OBSERVATION MATRIX ARE SHIFTED TWO PLACES TO THE RIGHT.

APPENDIX E

DOCUMENTATION OF SAFE YIELD CRITERIA FOR FLORIDAN AQUIFER

SIMPSON METHOD

(Safe Yield Approximations)

E-1.1 Basis for Use

1. Pumping trough in a coastal aquifer
2. An extension of Darcy's Law
3. Lateral flow to the coast
4. Interface at or near shoreline for basin south of 1 and 2

E-1.2 Calculation of Safe Yield

$$KA = Q/h/L \tag{1}$$

KA takes into account permeability coefficient and cross-sectional area. Other terms are defined as follows:

Q = Available recharge (ft^3/s)

h = Difference in elevation of potentiometric surface from recharge area to center line of trough, in feet

L = Distance from recharge area to center line of trough, in feet

KA term is inserted in the following safe yield equation:

$$Sy = KA \frac{h}{L} \tag{2}$$

where

Sy = Safe yield

h = Difference in potentiometric surface from recharge area to sea level, in feet

L = Distance from recharge area to the coast (hypothesized interface point), in feet

E-1.3 Best References

Simpson, T. R., 1946, Saline Basin Investigation: Calif. Div. of Water Res. Bull. 52, 230 p.

______________, 1946, see also Bull. 52A; Bull. 52A, Supplements 1-7; Bull. 52B; Bull. 53.

Todd, D. K., 1960, Ground Water Hydrology: John Wiley and Sons, Inc., New York, 336 p., pp. 208-211.

CRITERIA FOR SAFE YIELD APPROXIMATIONS FOR BASINS 1 AND 2

E-2.1 Basin 1 (Fernandina Cone Area)

Minimal Safe Yield Criteria

1. Available recharge estimated to be 81 Mgal/d.

2. Subtract maintenance flow to retard or stabilize interface movement.

3. Interface at shoreline or at edge of cone estimated to be five miles offshore. Interface considered to be 250 mg/L chloride isochlor.

4. Induced flow not considered due to the location of interface.

5. Leakage through confining beds insignificant

Probable Safe Yield Criteria

1. Available recharge estimated to be 81 Mgal/d.

2. Interface with sea water at or approaching continental slope 74 miles offshore hypothesized to be Floridan aquifer discharge point. Interface considered to be 250 mg/L chloride isochlor located east of cone influence at or near five miles.

3. Induced flow from east side of cone estimated to be 10-24 Mgal/d.

4. Induced recharge from Georgia north of cone and seaward, unknown but may be significant. The Georgia industrial pumpage (46 Mgal/d) may be supplied from this flow and not from Basin 1 recharge.

5. Ground water flow passing cone adequate to maintain or significantly retard inward movement of interface.

6. Leakage through confining beds insignificant.

7. Confining layer of dolomitic limestone at 1,250 feet impermeable.

Maximum Demand Level Criteria

1. Future deterioration of source aquifer with interface shift into cone.

2. Available recharge 81 Mgal/d.

3. Interface 74 miles offshore.

4. Induced flow 10-24 Mgal/d within five-mile cone limit.

5. Ground water in storage removed as cone expands beyond five-mile limitation addressed in 4.

6. Induced flow due to change in Basin configuration (Georgia available recharge) north of cone.

7. Leakage downward insignificant and upconing insignificant due to hypothesized impermeable boundary at 1,250 feet.

E-2.2 Basin 2 (Jacksonville Cone Area

Minimal Safe Yield Criteria

1. Available recharge 159 Mgal/d.

2. Interface (250 Mg/L Cl^-) at shoreline or within five miles of shoreline.

3. Induced flow to cone not considered due to undetermined confining conditions (faults, inconsistent zones of impermeable dolomite at 2,045 feet).

4. Downward leakage undetermined.

5. Recharge east of cone on Central Park Ridge not considered due to its importance as a fresh water barrier seaward of the cone.

Probable Safe Yield Criteria

1. Available recharge 159 Mgal/d.

2. Interface at or approaching point 74 miles offshore hypothesized to be the discharge point of the Floridan aquifer. 250 Mg/L isochlor considered to be closer to shoreline.

3. Induced flow to cone unknown at present, but considered a major element in the total available for safe yield. Estimates may be as high as 130 Mgal/d.

4. Downward leakage considered a minor element. Upward flow due to poorly constructed wells may be a negative element until increased well yields reverse potentiometric-water table head differential. An increase of up to 30 Mgal/d would remain available in storage for use by Jacksonville area cones.

5. Recharge east of cone could increase available recharge as cone expands, but the fresh water buffer would disappear. The buffer may supply critical recharge to coastal barrier island supplies.

6. Interface sustaining flow element hypothesized to be approximately 9 Mgal/d.

NOTE: Corps of Engineers (1979) report indicated a 274.6 Mgal/d safe yield figure for Duval County and a total demand of 384.7 Mgal/d in the year 2030. The 110.1 Mgal/d excess would come from alternate sources (surface water or de-salting).

Maximum Demand Level Criteria

1. Future deterioration of source with interface shift inland.

2. Available recharge 159 Mgal/d.

3. Induced flow from storage significantly higher than element 3 of Probable Safe Yield Criteria.

4. Salt water/fresh water interface at or approaching 74 miles offshore.

5. Leakage through Cedar Keys limestone confining beds with potential upconing of higher salinity connate water. Occurrence of leakage along fault lines postulated to be the route of intrusion.

6. Eventual conversion to alternate sources as considered in Corps of Engineers (1979) report.

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