Geraghty & Miller, Inc.

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# GROUND-WATER RESOURCES EVALUATION
# GDC - MARTIN COUNTY
# WATER RESOURCES STUDY

MARTIN COUNTY, FLORIDA

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Prepared For:
General Development Corporation
1111 South Bayshore Drive
Miami, Florida
33131

Prepared By:
Geraghty & Miller, Inc.
Consulting Ground-Water Geologists and Hydrologists
1675 Palm Beach Lakes Blvd., Suite 403
West Palm Beach, Florida
33401

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# GDC - MARTIN COUNTY WATER RESOURCES STUDY
# MARTIN COUNTY, FLORIDA

## INTRODUCTION

In October, 1977, General Development Corporation (GDC) retained the services of Geraghty & Miller, Inc., (G&M) to evaluate the ground-water resources in a six-square-mile area in northern Martin County. The work was conducted under Contract #816, Addendum #6, between GDC and G&M.

At the same time, GDC contracted with the Layne-Atlantic Company of Orlando, Florida, to install a number of test wells on the tract to provide data for the study. Drilling began in November, 1977, and was completed in January, 1978. Drilling and testing was supervised by a Geraghty & Miller staff hydrogeologist.

## SITE DESCRIPTION

The GDC tract in Martin County is located north of State Road 714 and immediately west of Florida's Turnpike. The three-mile-long northern boundary is adjacent to Canal C-23. The location of the property is shown on Figure 1.

Generally, the property slopes from an elevation of +25 feet above mean sea level (MSL) in the west to +15 feet MSL in the east. The low relief is interrupted only by ditches draining what was once farm land, but is now used exclusively for grazing. Many permanent, shallow ponds exist in the western portion of the property. Temporary ponds exist in the eastern portion of the tract after heavy rains. The characteristic of standing water at the surface combined with numerous drainage and irrigation ditches make access difficult for drilling rigs and heavy equipment.

The tract was first visited in October, 1977, by representatives of Layne-Atlantic, GDC Engineering, and G&M. A total of eight test well locations were selected. Although some of the sites were rather difficult to reach in a four-wheel-drive vehicle, it was agreed by all parties present that minor site preparation work by GDC could make all sites accessible.

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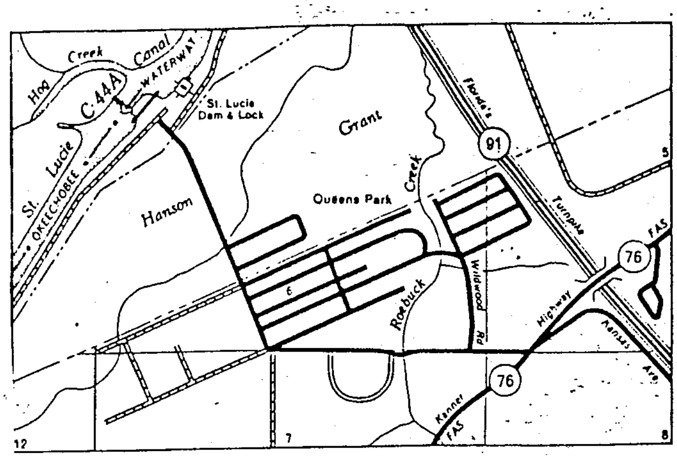
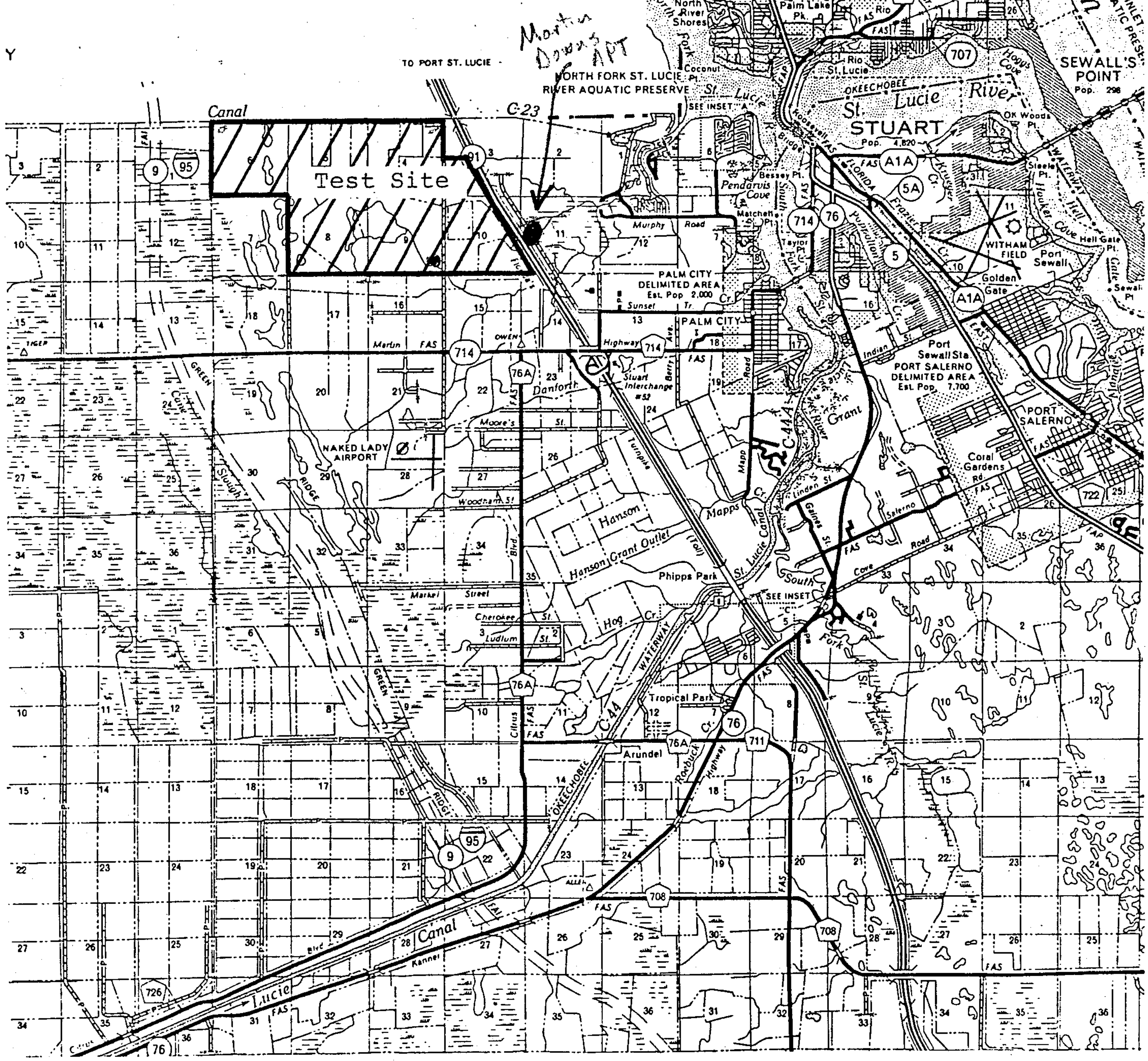
## FIGURE 1

Location of Test Site
GDC - Martin County Water
Resources Study
Martin Co., FL.




INSET "C"
T39S-R40E, R41E

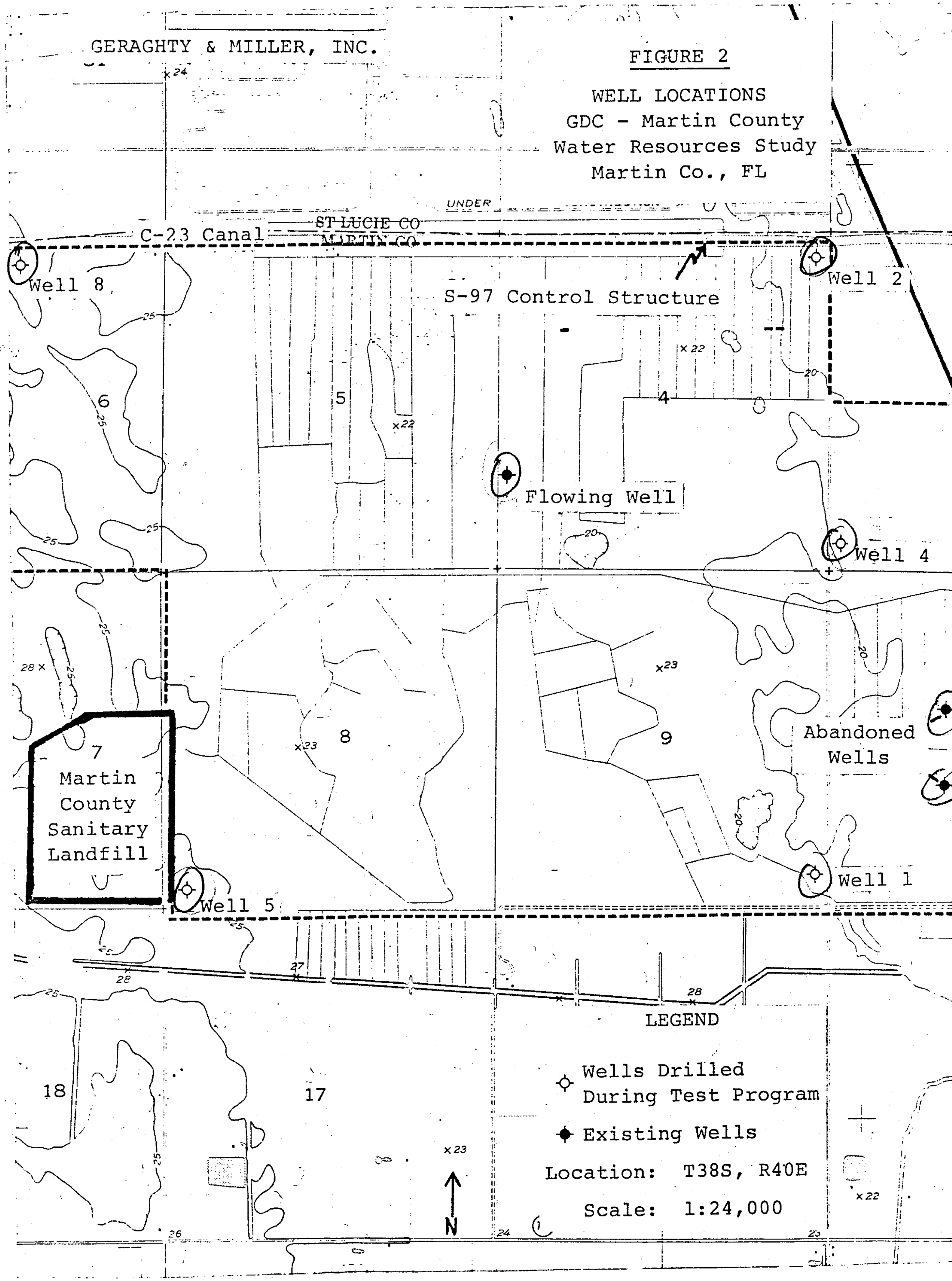


It later turned out that accessibility would remain a problem because of unseasonably heavy rains.

The eight sites originally selected were in the eastern half of the property. The western portion was largely ignored because of major access problems. However, because GDC desired information about the western portion, some of the well locations originally planned were moved to the west. The well locations are shown on Figure 2. Well numbers shown at the five sites which were drilled correspond to those assigned prior to the start of drilling.

## SUMMARY

The program to evaluate the ground-water resources of a six-square-mile tract in northern Martin County for General Development Corporation started in October, 1977. Test drilling began in November, 1977. Five test wells were completed by the cable-tool method. The six-inch-diameter wells were finished to various depths and equipped with 30-slot (0.030-inch) screens. After development by surging, four of the five wells were tested. In one of the wells, two different screen zones were tested. After testing, all casings and screens were removed and the


GERAGHTY & MILLER, INC.
FIGURE 2
WELL LOCATIONS
GDC - Martin County
Water Resources Study
Martin Co., FL
UNDER
C-23 Canal
ST LUCIE CO
MARTIN CO
Well 8
Well 2
S-97 Control Structure
Flowing Well
Well 4
Abandoned Wells
Well 1
Well 5
Martin County Sanitary Landfill
6
5
4
7
8
9
18
17
LEGEND
Wells Drilled During Test Program
Existing Wells
Location: T38S, R40E
Scale: 1:24,000
N

unconsolidated materials permitted to collapse, filling the holes.

From the land surface, a sequence of sand and shell beds more than 100 feet thick is extensive over much of Martin County (Pamlico sand and Anastasia Formation). These sand and shell beds comprise the shallow aquifer in Martin County. Beneath the sand and shells, an extensive sequence of marl and clays (Caloosahatchee Marl, Tamiami and Hawthorn Formations), hundreds of feet thick, separate the aquifer from the underlying sequence of sandy and crystalline limestone and dolomite comprising the Floridan aquifer in Martin County.

Based on the geologic logs of the test wells, the shallow aquifer at the site is 130 to 160 feet thick and is underlain by clay. Within the aquifer, potential water-bearing zones occur at varying depths throughout the property.

Testing of the wells drilled during this study indicated that wells yielding 100 to 200 gallons per minute (gpm) could be constructed nearly anywhere on the site. Wells yielding 300 gpm or more could be found in the eastern portion of the property. The average aquifer transmissivity is calculated to be 22,000 gallons per day per foot (gpd/ft).

The aquifer receives recharge principally from precipitation falling directly on the land surface. Much ponding and standing water at the land surface indicates losses due to evapotranspiration are high. In the vicinity of Canal C-23, hydraulic connection exists between the canal and the adjacent aquifer. Depending upon relative water levels, the canal may provide additional recharge to the aquifer or receive discharge from it.

As judged from the wells tested, the water quality generally is good. However, contamination threats exist from abandoned, flowing, and improperly plugged wells tapping the deeper, Floridan aquifer, which produces brackish water. This water may recharge the water-table aquifer directly where it spills onto the land surface or by leaks from corroded or improperly seated casings, or by infiltration from canals and ditches carrying poor-quality water. Seasonally, the chloride concentration of the water in Canal C-23 may rise to 500 mg/l (milligrams per liter). This water might infiltrate the aquifer and move toward pumping wells located adjacent to C-23.

## DRILLING AND TESTING PROGRAM

Prior to commencement of drilling, available data from the files of the South Florida Water Management District (SFWMD) were reviewed. Ground-water reports which G&M had prepared for GDC in neighboring St. Lucie County were reviewed, as was the Florida Report of Investigations No. 23 (Lichtler, 1960).

Very little information is available about shallow ground-water conditions in this portion of Martin County. Because the area is largely rural and undeveloped, well construction has been limited to shallow domestic wells and deeper (900 feet and more) flowing wells producing brackish water for irrigation.

The eight wells to be constructed during this program were originally intended to be 100 feet deep. Based upon data collected and evaluated prior to drilling, but after the program started, it was discovered that the shallow aquifer occurred to a greater depth than 100 feet in this area. Therefore, the program was modified and several of the test wells were drilled to greater depths, reaching the underlying clay. The additional cost of the program incurred because of the extra footage drilled was reduced by not drilling wells at several of the more inaccessible well locations.

Five wells were completed by the cable-tool method. Ten-inch-diameter casing was driven to the total depth of the hole. Samples of the drilled material were collected and described. In each completed well, one or more zones suitable for testing were selected. Twenty feet of wire-wound, 0.030-inch-slot well screen was attached to six-inch-diameter casing and lowered inside the ten-inch casing to the desired zone. The ten-inch casing was pulled up until a suitable length of screen was exposed to the water-bearing material. The well was then developed and tested.

A summary of the construction data of the test wells is presented in Table 1. The geologic logs of the completed wells are given in Appendix 1. Formation samples from the test wells have been forwarded to GDC for future reference. It should be noted that Well 3, one mile east of Well 1, was drilled to 60 feet and abandoned. Shortly after drilling started, heavy rainfall made the access road impassable and equipment to repair the roads was not available. Consequently, the hole was not completed and no samples were collected.

Each of the five completed test wells was developed after the screen was set to remove fine-grained material from the

TABLE 1

Construction Data on Test Wells
GDC - Martin County Water Resources Study

| Well # | Total Depth Drilled (Feet) | Screened Interval Tested (Feet)[a)] | Duration of Development (Hours) | Duration of Pumping (Hours) |
|---|---|---|---|---|
| 1 | 100 | 83 to 98 | 10 | 3 |
| 2 [b)] | 152 | 45 to 63<br>105 to 125 | 16<br>40½ | 1<br>2 |
| 3 [c)] | 60 | -- | -- | - |
| 4 | 125 | 95 to 107 | 21 | 2 |
| 5 | 156 | 72 to 92 | 22 | 1 |
| 8 | 134 | 83 to 103 | 8 | 4 |

a) Screen length was 20 feet. The full length was not always exposed.

b) Two zones were tested in this well.

c) Abandoned

aquifer adjacent to the screen so that the well's efficiency is increased. For these test wells, development was accomplished by surging. Four of the completed wells were developed successfully and deemed suitable for test pumping. However, extended development of Well 5 with the screen exposed from 72 to 92 feet was not successful as there was no reduction in the large quantity of fine sand present in the discharge water during development. Therefore, Well 5 was not tested.

At each of the four wells tested, the water level in the well was allowed to stabilize before the test began. A constant-rate drawdown and recovery test was conducted. The pumping rate was held constant, and drawdowns were measured in the pumping well. Discharge was into the nearest surface-water body. The test was continued until little or no change in drawdown occurred over successive increments of time. At this point, the pump was turned off and measurements of the rate of recovery of the water level in the well were made. Following each test, casings and screen were removed from the hole and the hole was backfilled. A summary of the test data is shown in Table 2.

As part of the test program, sieve analyses were performed on selected samples from potentially productive zones in the

## TABLE 2

Summary of Pumping Test Data
GDC - Martin County Water Resources Study

| Well No. | Zone Screened (Feet) | Static Water Level (Feet Below Casing) | Total Drawdown (Feet) | Pumping Rate (gpm) | Test Duration (minutes) | Estimated Production Well Yield (gpm) |
|---|---|---|---|---|---|---|
| 1 | 83 - 98 | 5.98 | 13.25 | 128 | 30 | 200 - 300 |
| 2 | 45 - 63 | 10.34 | 13.49 | 41 | 30 | < 100 |
| | 105 - 125 | 8.72 | 13.35 | 77 | 92 | 200 - 300 |
| 4 | 95 - 107 | 6.45 | 19.07 | 160 | 100 | 200 - 300 |
| 8 | 83 - 103 | 3.52 | 23.97 | 73.3 | 25 | 100 - 200 |

N All tests were conducted until the rate of water-level decline slowed and approached stabilization test wells. The results of these analyses are given in the Table in Appendix 2.

## GEOLOGY

### General

The Pamlico sand is the uppermost geologic unit in Martin County. This fine-grained, clean sand is rarely more than a few feet thick in the county, but is important because recharge from rainfall can pass easily through the sand and enter the underlying beds. The Pamlico sand lies unconformably on the Anastasia Formation.

The Anastasia Formation is extensive throughout Martin County. It varies widely in composition, ranging from sand, shell beds, to friable sandstone and limestone. Shells seem to predominate in the eastern portion of the county, while sand layers predominate to the west. The formation is generally more than 100 feet thick in eastern Martin County, and it thins considerably to the west. It disappears west of Martin County, where it is replaced in the sequence by the Fort Thompson Formation. The Anastasia Formation unconformably overlies the older rock units below it -- the Caloosahatchee Marl, and the Tamiami and Hawthorn Formations.

The Caloosahatchee Marl, composed mostly of sand and shells, has not been identified as extensive in Martin County. Where it occurs, it may be tentatively identified with the lower part of the Anastasia Formation which stratigraphically overlies it, or with stratigraphically underlying Tamiami and Hawthorn Formations.

In Martin County, the distinction between the Tamiami Formation and the underlying Hawthorn Formation is based upon the examination of fossils. Generally, the two formations are classified together as Hawthorn, a 350- to 550-foot-thick unit of green to white, phosphatic clay with silt and sand. The Tamiami and Hawthorn Formations form the confining unit between the shallow, non-artesian water-bearing units and the deeper, artesian units (Floridan aquifer).

Below the Hawthorn Formation, a thick sequence of limestone formations extend down 12,000 feet to the igneous and metamorphic basement rocks. Rocks of the upper portion of this sequence form the Floridan aquifer.

<u>GDC Tract</u>

The test wells in this program penetrated as much as 150 feet of unconsolidated materials of varying permeability (See

Appendix 1 for geologic logs). The materials were similar in each hole -- layers of sand interbedded with layers of shells -- but individual units are not continuous over the area. For example, a thick shell bed encountered between 60 and 85 feet deep in Well 4 is not present at this depth in Wells 1 or 2 located one mile south and north of Well 4, respectively. Likewise, a shell bed that extended from 52 to 62 feet in Well 2 was similar to one that occurred from 28 to 58 feet in Well 1, but did not appear in Well 4.

The lack of areally extensive beds coarse enough to be screened is not surprising. During drilling at North and South Port St. Lucie, areally extensive geologic units were not encountered. After much drilling in St. Lucie County, it was concluded at that time that broad bands of favorable and unfavorable materials exist, and in general they parallel the present-day coastline. The favorable trends, in which yields of 100 to 200 gallons per minute are obtained, range from a few hundred to several thousand feet wide (see "Test and Production Well Drilling During 1973 at South Port St. Lucie, North Port St. Lucie, and Port Malabar, Florida, General Development Utilities" prepared by Geraghty & Miller, Inc., January 1974).

Favorable and unfavorable trends (for water-supply development) may exist in Martin County also. The five wells drilled on the GDC tract can hardly be considered to provide positive proof. However, the productive sand and shells present at the site of Well 4 may hint at this trend. Elsewhere in Martin County, insufficient logging and testing of wells has been undertaken.

A clay unit corresponding to the Hawthorn Formation was encountered in each of the three deeper wells (Wells 2, 5, and 8). This layer was found at somewhat different depths in each well. Published data indicate the clay occurs 150 feet below land surface at a point one mile south of the GDC tract. In Well 2, clay was penetrated at 150 feet. In Well 5, it was encountered at 156 feet. In contrast, the clay was encountered at 128 feet in Well 8.

From drilled wells elsewhere in Martin County, layers of sandstone and limestone have been reported. At the GDC tract, partially cemented sand was penetrated in some zones. Layers or lenses of this material were most commonly encountered in the depth interval from 50 to 100 feet below land surface. Samples could be crumbled by hand and are not very competent.

Further, because the casing was driven to depth without any unusual resistance, it is concluded that continuous cemented sand layers do not exist beneath the site.

## HYDROGEOLOGY

The shallow aquifer is the major source of fresh water in Martin County. Water occurs under water-table conditions in the aquifer. Since the permeable Pamlico sand and Anastasia Formation extend over the whole surface of the county, recharge to the shallow aquifer is derived principally from local precipitation. Secondly, recharge comes from the many irrigation ditches and drainage canals which cross the area. The aquifer discharges to nearby wells, to canals and natural surface-water bodies, and to the atmosphere by evapotranspiration.

The clays of the Hawthorn Formation effectively confine and isolate the water-table aquifer from the artesian Floridan aquifer. As reported in the literature and by the USGS, clay is first encountered at around 150 feet, although well reports have been filed in which the clay was first reported at a depth of 230 feet. Where wells have been drilled into permeable zones just above clay layers at 200 feet or more, the increase in available drawdown over most wells in the area has permitted the development of wells with greater than normal yields. This phenomenon has given rise to the myth of a "Super Well" in St. Lucie County very close to the GDC tract. The data indicate that the "Super Well" is merely a well that has penetrated a thicker sequence of sand and shells, has a deeper screen setting and, therefore, possesses a greater than normal available drawdown than wells in the rest of the area. In the test wells at the GDC tract, no highly permeable material was encountered below a depth of approximately 125 feet.

The Floridan aquifer beneath the Hawthorn Formation is artesian. Wells drilled into the Floridan aquifer flow (except on the Atlantic Coastal Ridge). Since they flow, while wells screened in the water-table aquifer do not, the hydraulic head in the Floridan aquifer is greater than that in the water-table aquifer.

Because ground water in the Floridan aquifer exists under greater head than the shallow aquifer and the quality of the Floridan aquifer water is inferior to that of the shallow aquifer, the Floridan aquifer poses a threat to the shallow aquifer because of the potential for upward migration of brackish water.

The confining bed between the aquifers is naturally thick and areally extensive. Thus, there is little, if any, chance for the natural upward migration of brackish water. The threat is in the presence of the many wells which have been drilled into the Floridan aquifer to provide irrigation water in the area. Where these wells are permitted to flow at the land surface, they discharge water onto the ground where it can seep into the shallow aquifer. Even when these flows are shut off by a cap or valve, leaky, short, or poorly seated casings can allow the brackish water to contaminate the shallow aquifer.

## RESULTS OF DRILLING AND TESTING

Because the goal of the program was to attempt to delineate potential areas for future ground-water development, no observation wells were drilled in this investigation. Each of the drilled wells was used to sample the material beneath the site and to obtain a general idea of potential and aquifer characteristics by performing brief pumping tests. After tests at each location, the hole was backfilled with impermeable materials and the casings and well screen were removed. Detailed information on aquifer characteristics, sustained yields, and impacts would require a much more extensive and costly study than the one recently completed. A study of this type would, and should, be performed as the initial step in a large-scale ground-water development.

Constant-rate drawdown and recovery tests were conducted on Wells 1, 4, and 8. Two tests were conducted on separate screen zones in Well 2. Ideally, these tests could have been conducted for several days, and water levels could have been measured in one or more observation wells to properly establish aquifer characteristics. Because of the very general nature of this test program and its goals, and the economic and time constraints, the use of brief tests employing no observation wells was selected over a more idealized, costly method of testing.

Interpretation of the test data was based on the modified non-equilibrium formula for the drawdown portion of the tests (Jacob, 1950) and the recovery formula (Theis, 1935) for the recovery portions. The lengths of tests varied between 25 and 100 minutes for the drawdown portions and between 6 and 42 minutes for the recovery portions. A summary of the test data was shown on Table 2. In interpreting the tests, the effects of aquifer dewatering were disregarded because observed drawdowns were a small percentage of the aquifer thickness. In addition, during such comparatively short tests, the aquifer responds as an artesian system. On a long-term basis, the shallow aquifer probably will respond as a water-table system. Geologic data do not indicate the presence of any well-defined confining beds overlying the zones screened in the test wells. Differences between horizontal and vertical permeability may result in the system behaving as an artesian system, but in the absence of detailed data, it is best to assume the aquifer will respond as a water-table system on a long-term basis.

Evaluation of pumping and recovery data from the various tests showed reasonably close agreement, with the exception of the pumping data from Wells 4 and 8, which give anomalously high values. These are believed to be due to the influence of gravity drainage (water-table system) or leakage through a confining bed (artesian system). In either case, these values are far too large considering the nature of the material comprising the aquifer and, therefore, are not considered as representative. Calculated values of aquifer transmissivity based on the data from each well tested is shown in Table 3.

TABLE 3

Calculated Values of Aquifer Transmissivity
in the Vicinity of Test Wells
GDC - Martin County Water Resources Study

| Well # | Zone Screened (Feet) | Transmissivity From Drawdown Data (gpd/ft) | Transmissivity From Recovery Data (gpd/ft) |
|---|---|---|---|
| 1 | 83 - 98 | 15,000 | 24,000 |
| 2 | 45 - 63 | 27,000 | 15,000 |
| | 105 - 125 | 18,000 | 24,000 |
| 4 | 95 - 107 | 170,000 a) | 33,000 |
| 8 | 83 - 103 | 77,000 a) | 13,000 |
| | Average | 20,000 | 22,000 |

a) Invalid, water levels influenced by gravity drainage or leakance

Because only a pumped well was used for testing, the storage coefficient of the shallow aquifer could not be calculated. Observation wells must be used to determine this parameter. Based upon past experience, a storage coefficient of from 0.1 to 0.01 is assumed to be reasonable for the type of water-bearing materials found on the property.

The results of the program indicate that ground water can be developed nearly anywhere on the GDC property. Properly constructed production wells could be expected to yield 100 to 200 gpm. At the sites of Wells 1, 2, and 4, it is estimated that yields of 200 to 300 gpm could be obtained from wells tapping the zone in the depth interval between 85 and 125 feet below land surface. These wells are located in a north-south line extending the length of the eastern portion of the property from Canal C-23 to the southern boundary, indicating the presence of a potentially productive trend similar to those that have been discovered during other investigations at GDC communities in eastern coastal Florida.

The data indicate that the capability of the aquifer to produce water appears to diminish to the west. Only two widely spaced wells were installed on the western portion of the property. Data from these may not be indicative of conditions all over the western portion of the property. However, much of this part of the tract is low and flooded, and considerable effort would be required to provide suitable access.

The principal source of aquifer recharge is precipitation. Considerable standing water exists at the land surface at the tract during most of the year. Some permanent ponds exist in closed depressions. Many temporary ponds are formed after heavy rains. These and the presence of large marshy areas indicate that the annual water losses due to evapotranspiration (ET) are high and form a large percentage of the precipitation. It is estimated that approximately 12 to 13 inches of the average annual precipitation reaches the water-table aquifer as recharge (3.4 to 3.7 million gallons per day). This is equivalent to 1.25 to 1.35 billion gallons per year for the six square miles of property in Martin County. Assuming the aquifer behaves as a water-table system on the long-term, the drawdown of the water table resulting from a large-scale ground-water diversion would result in a reduction in the natural loss due to ET. In effect, this reduction becomes salvaged water, and is a quantity which can be used in addition to the so-called "water crop" for the property. Thus, the true quantity of water available for development is greater than the average recharge.

The gate on the control structure (S-97) on Canal C-23 (see Figure 2) was kept closed during the drilling program; no release of water occurred. As a result, the canal water-level west of the structure was considerably higher than to the east. Because the water-table aquifer is hydraulically connected with the canal, the ground-water system in the vicinity of the canal reflects the presence of the structure; the shallow aquifer receives water from Canal C-23 on the western end of the property and discharges to C-23 on the eastern end. The shallow depth to water in Well 8 as compared to the relatively greater depth to water in Well 2 would seem to support this assumption. Because of a hydraulic interconnection with the aquifer, the canal may provide additional recharge to wells located close to it in the areas west of Control Structure S-97. The influence of the canal on quality and quantity would have to be determined if supply wells are close to it.

## WATER QUALITY

Water samples were obtained from each well during the pumping tests. In addition, Well 5 was sampled during development. Analyses were performed for a selected number of constituents -- temperature, specific conductance, chloride, total hardness, and sulfate. The results are shown in Table 4.

Ground water at the tract appears to be of generally good quality. Sulfate and chloride concentrations are low, and the hardness is rather high; no significant quality changes occurred during the tests except possibly in the two tests of Well 2 where the chloride concentration rose slightly during the testing of the shallow zone, and specific conductance rose slightly during the testing of the deeper zone. The changes are believed to be due to normal variations in the analytical technique and are not significant.

The relatively higher concentration of chloride in Well 8 may be significant. Well 8 is located within a few hundred feet of C-23 on the upstream side of the S-97 structure. When Well 8 was tested on January 19, 1978, the structure was closed, and the water behind it very nearly overfilled the canal. The high water level in the canal was reflected in the static water level in Well 8, estimated at 1.5 feet below land surface.

The high static water level in Well 8 indicates that hydraulic connection exists between the canal and the well. Further, SFWMD records indicate that when the structure remains closed

TABLE 4

Water Quality from Test Wells
GDC - Martin County Water Resources Study

| Well # | Sampled During Test | Temperature (°F) | Specific Conductance (µmhos/cm) | Total Hardness (grains/gallon) | Chloride (mg/l) | Sulfate (mg/l) |
|---|---|---|---|---|---|---|
| 1 | Early | 75 | 660 | 11 | 68 | 60 |
| 2[a)] | Early | -- | 600 | 10 | 61 | <50 |
| | Late | -- | 600 | 11 | 68 | <50 |
| 2[b)] * | Early | 76 | 610 | 13 | 59 | <50 |
| | Late | 75 | 690 | 14 | 59 | <50 |
| 4 | Early | 75 | 500 | 15 | 53 | Ø |
| | Late | 75 | 500 | 14 | 53 | Ø |
| 5 | -- | 78 | 650 | 6 | 61 | No Test |
| 8 | Early | -- | 650 | 7 | 91 | <50 |
| | Late | -- | 650 | 12 | 91 | <50 |

a) 45- to 63-foot zone

b) 105- to 125-foot zone

* Canal C-23 sampled downstream from S-97 adjacent to Well 2 during this test. Specific Conductance 675 µmhos/cm; Temperature 68°F

during the dry season, chloride concentration in C-23 water may reach 500 mg/l. It is probable that the high chloride concentration in the water from Well 8 is related to the infiltration of water from the canal.

Canal C-23 represents an interesting water-management problem. C-23 is used to drain the land adjacent to it. During certain peak rainfall periods in the wet season, water from Lake Okeechobee is also released to C-23 in order to control the lake level. Conversely, during the dry season, the flood control structure (S-97) on C-23 is closed to aid in maintaining the level in Lake Okeechobee.

The quality of water in C-23 remains inferior to that in the shallow aquifer throughout the year. Even during the wet season when water is released from Lake Okeechobee, the chloride concentration in canal water is higher than that in the water-table aquifer.

Four sources contribute to the flow in Canal C-23. Throughout the year, runoff from precipitation drains into the canal and eastward to the St. Lucie River. During the wet season, when Lake Okeechobee and its surrounding wetlands become overfilled, additional water may be released from the lake through the canal.

A third source of flow is ground-water underflow from the shallow aquifer that drains into the canal when canal water levels are lower than the head in the aquifer. A fourth source is irrigation tail water.

Ground water is used for irrigation throughout the area. Although the water-table aquifer may provide some of this water, the Floridan aquifer is the principal source, primarily because of its capability to yield considerable water by natural flow, eliminating the need for pumps. Although the water may be described as brackish (chloride concentration generally in excess of 1000 mg/l), the irrigated crops are not seriously damaged. As a result of this practice, large volumes of irrigation waste water are discharged to canals like C-23. A common practice is to allow artesian wells to flow continuously, even during the wet season or after the fields are no longer farmed. It is this practice which results in chloride concentrations of 500 mg/l and more in C-23 during the dry winter months (John Lutz, SFWMD, personal communication). The annual range in chloride concentration in water from C-23 is 100 to 500 mg/l.

The GDC tract was once extensively used for growing tomatoes. Although a crop is no longer harvested, at least four flowing artesian wells have been reported on the property in Sections 4, 5, 8, and 9. One flowing well in Section 4 (Figure 2) was producing water with a specific conductance of 3,800 μmhos/cm and a chloride concentration of 1,300 mg/l on October 25, 1977. This water spilled into a drainage ditch which discharges southward off the property.

Obviously, four wells flowing brackish water could affect the development of a potable water supply, particularly because they are located in the area with the greatest potential for future development. Additionally, any abandoned artesian wells which were improperly plugged or capped but never plugged could contaminate the shallow aquifer. The flowing wells should be plugged, and every effort should be made to locate and plug any other abandoned wells on the GDC tract.

## WATER SUPPLY DEVELOPMENT

It is evident from the geologic test data that considerable water is available for development on the GDC tract. Wells capable of yielding 100 to 200 gpm of good-quality water could be constructed nearly anywhere on the property. The best potential appears to be on the eastern portion of the site, where wells yielding 300 gpm, possibly more, could be developed.

Permanent production wells should be gravel packed because intermixed layers of shells and sand constitute potential screen zones. A gravel-pack design would facilitate development, produce an efficient well, and add to the life of the well, based on experience at the other GDC communities on the east coast.

Development of ground water should naturally begin in those areas of maximum potential in the eastern portion of the property. Initial development could start at the sites of Wells 1 and 4 where production wells could be installed. Their depths should be approximately 120 feet deep. An 8-inch by 16-inch gravel pack design is recommended. Preferably, the cable-tool method should be employed for construction, although the rotary method could be used providing the contractor can demonstrate his expertise in well development techniques. Screen length and slot size and the gravel-packing material should be selected on the basis of sieve analysis of the cuttings. A five-foot blank plugged at the bottom should be placed at the bottom of the well screen to serve as a sump.

Extensive ground-water development of this tract would require careful well-field design to minimize the potential for the infiltration of poor-quality water from C-23 to the shallow aquifer. Detailed testing would be needed to evaluate the influence of the canal. For this reason, initial development should begin on the eastern portion of the property in the general area of Wells 1 and 4.

A potential source of contamination from landfill leachate is located near the property. The Martin County Sanitary Landfill is situated just outside the property boundary west of Well 5. The limited data collected from Well 5 do not indicate the presence of contamination. However, sustained pumping from a well located near the Well 5 area could result in contamination. Although the landfill is designated as a sanitary landfill, pollution has occurred when such sites have not been specifically designed to eliminate the migration of leachate into ground water. Apparently the landfill has been in operation for a number of years and it is unlikely that a system to prevent leachate from entering the shallow aquifer is in use.

## CONCLUSIONS

1. As it now exists, the GDC tract in Martin County has only limited access for drilling and testing. Especially during and after rainy periods, considerable site preparation is necessary.

2. Productive zones in sand and shell beds capable of yielding 100 to 200 gpm to properly constructed wells exist at varying depths nearly everywhere on the site.

3. The data indicate yields of 300 gpm and more could be obtained from properly designed wells at locations on the eastern part of the property.

4. The top of the clays and marls that underlie the water-table aquifer and separate it from the deeper Floridan aquifer occurs at about 150 feet below land surface. The upper surface is undulating, however. Where deep pockets occur in this surface, the water-table aquifer may extend to depths of 200 feet or more below land surface. Wells encountering productive zones in these pockets are reported to have very high yields (500 gpm or more) due to the increased available drawdown associated with the greater depth. No deep pockets were encountered during drilling at the GDC tract, however.

5. Water quality in the shallow aquifer at the Martin County site generally is good. The deeper Floridan aquifer produces brackish water not suitable for potable supply without

treatment to reduce the salt and total dissolved solids concentrations.

6. The Hawthorn and Tamiami Formations which confine the Floridan aquifer are thick and extensive. They effectively prevent the migration of brackish water upward into the water-table aquifer.

7. Abandoned flowing and improperly plugged wells penetrating the Floridan aquifer are presently actively contaminating the shallow aquifer on the property.

8. Poor-quality irrigation waste water discharging via ditches to Canal C-23 causes the chloride concentrations of the canal water to rise to as much as 500 mg/l in the canal during the dry season. The quality of water from wells on the GDC tract adjacent to C-23 and west of the S-97 control structure may be affected by canal quality fluctuations.

9. Considerable fine-grained material and shells are present in the aquifer. Production wells will require properly sized artificial gravel packs to achieve the most efficient installation.

10. The Martin County Sanitary Landfill near the southwestern corner of the GDC property is a potential source of contamination from leachate.

Respectfully submitted,
GERAGHTY & MILLER, INC.

Thomas L. Tessier

Thomas L. Tessier

Vincent P. Amy

Vincent P. Amy

Date: March 8, 1978

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1. LICHTLER, W. F., "Geology and Ground-Water Resources of Martin County, Florida," Florida Geological Survey, Report of Investigations No. 23, 1960

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# APPENDIX 1

## GEOLOGIC LOGS OF TEST WELLS
## INSTALLED NOVEMBER 1977 - JANUARY 1978

## GENERAL DEVELOPMENT CORPORATION
## MARTIN COUNTY WATER RESOURCES STUDY

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources
DATE: 11/9/77 SHEET: 1 OF 1

LOCATION: Palm City Quadrangle, Martin County, FL.
DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 1
DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: J. Wheatley
SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| No sample recovered | 0 - 23 | 23 |
| Medium- to fine-grained, light brown quartz SAND, with a few shell fragments | 23 - 28 | 5 |
| SAND as above with 50% shell fragments | 28 - 33 | 5 |
| Fine-grained, blue-gray quartz SAND, with 40%-60% shell fragments | 33 - 47 | 14 |
| Fine-grained, blue-gray quartz SAND with 30% shell fragments | 47 - 58 | 11 |
| Medium-grained, gray quartz SAND (little water during bailing) | 58 - 66 | 8 |
| Coarse-grained, partially cemented quartz SAND, with some shell fragments | 66 - 75 | 9 |
| Fine-grained, light tan to gray SAND, with trace shells (heaving sand) | 75 - 83 | 8 |
| Fine- to coarse-grained, blue-gray, partially cemented SAND, with 20% shell fragments (heaving sand) | 83 - 88 | 5 |
| Medium-grained SAND, with some fine sand and shell fragments | 88 - | 12+ |
| TOTAL DEPTH | 100 | |
| Screen zone tested, 83 to 98 feet | | |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources

DATE: 12/1/77 SHEET: 1 OF 2

LOCATION: Palm City Quadrangle Martin County, FL

DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 2

DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: G. M. Witt

SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| No sample recovered | 0 - 25 | 25 |
| Brown SILT, brown clay matrix, with fine quartz sand, organics, and shells | 25 - 35 | 10 |
| Calcareous SHELLS (60%), fragmented, with fine- to medium-grained quartz sand | 35 - 40 | 5 |
| Fine- to medium-grained, tan to gray quartz SAND, subangular to subrounded, with 15% shell fragments and some silt | 40 - 45 | 5 |
| Very fine- to medium-grained, gray quartz SAND, subrounded, with 10% shell fragments, some silt | 45 - 52 | 7 |
| Fine to coarse, white to tan SHELLS (50%), fragmented, with 50% very fine- to fine-grained gray sand and silt | 52 - 57 | 5 |
| White to tan to gray SHELLS (75%), fragmented, with fine-grained light gray quartz sand, subangular to round | 57 - 63 | 6 |
| Fine- to medium-grained, partially cemented, gray calcareous SAND, subangular to round, with 25% shell fragments | 63 - 68 | 5 |
| Fine- to coarse-grained, partially cemented, gray calcareous SAND, subangular to angular, with shell fragments (less than 25%) | 68 - 75 | 7 |
| Very fine- to coarse-grained, gray SAND, subangular to subrounded, with some shell fragments | 75 - 81 | 6 |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources    DATE: 12/1/77    SHEET: 2 OF 2

LOCATION: Palm City Quadrangle Martin County, FL    DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 2    DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: G. M. Witt    SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Very fine- to medium-grained, partially cemented, gray SAND with shell fragments (15% - 20%) | 81 - 104 | 23 |
| Very fine- to fine-grained, partially cemented, light gray calcareous SAND, subangular to subrounded, with silt and trace shells | 104 - 115 | 11 |
| Gray to tan to white SHELLS (70% - 80%), fragmented with very fine- to medium-grained gray sand and silt | 115 - 125 | 10 |
| Very fine- to fine-grained, gray calcareous SAND, with some shell fragments and silt | 125 - 150 | 25 |
| Gray to green CLAY with silt | 150 - | 2+ |
| TOTAL DEPTH | 152 | |
| Screen zones tested, 45 to 63 feet and 105 to 125 feet | | |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources DATE: 12/14/77 SHEET: 1 OF 2

LOCATION: Palm City Quadrangle Martin County, FL DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 4 DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: G. M. Witt SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Very fine brown SAND, with silt, clayey, organics and shell fragments | 0 - 20 | 20 |
| Fine- to coarse-grained light gray SAND, with shell fragments (20% - 30%) | 20 - 30 | 10 |
| Fine- to medium-grained, light gray SAND, with trace of shell fragments (less than 5%) | 30 - 40 | 10 |
| Fine- to medium-grained, gray SAND, silty | 40 - 45 | 5 |
| Medium-grained gray SAND, with shell fragments (5% - 10%) | 45 - 50 | 5 |
| Very fine- to medium-grained, partially cemented gray SAND with silt and shell fragments (20%) | 50 - 55 | 5 |
| Very fine- to fine-grained, light gray SAND, with trace shell fragments, silty | 55 - 60 | 5 |
| Large, white to tan to gray SHELLS and shell fragments (70% - 90%), often partially cemented, with very fine- to medium-grained light gray silty sand, often partially cemented | 60 - 85 | 25 |
| Very fine- to fine-grained, light gray, silty SAND, with shell fragments (10%), clayey | 85 - 95 | 10 |
| Large, gray to tan SHELLS and shell fragments, often partially cemented with fine-grained gray sand | 95 - 100 | 5 |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources  DATE: 12/14/77  SHEET: 2 OF 2

LOCATION: Palm City Quadrangle, Martin County, FL  DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 4  DRILLING METHOD: Cable Tool

SAMPLE ESCRIBED BY: G. M. Witt  SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Fine- to coarse-grained, light gray SAND, with shell fragments and some coquina. | 100 - 110 | 10 |
| Very fine- to medium-grained, light gray SAND, clayey, with shell fragments (less than 10%) | 110 - | 15+ |
| TOTAL DEPTH | 125 | |
| Screen zone tested, 95 to 107 feet | | |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources DATE: 1/2/78 SHEET: 1 OF 2

LOCATION: Palm City Quadrangle Martin County, FL DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 5 DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: J. Wheatley SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| No sample recovered | 0 - 15 | 15 |
| Fine- to medium-grained, colorless quartz SAND, with brown organics | 15 - 20 | 5 |
| Fine- to medium-grained, colorless quartz SAND with some organics and trace shell fragments | 20 - 25 | 5 |
| Fine- to medium-grained, tan to colorless quartz SAND with shell fragments (5%) | 25 - 30 | 5 |
| Fine- to medium-grained, gray to colorless, partially cemented quartz SAND with partially cemented shell fragments (15% - 20%) | 30 - 42 | 12 |
| Very fine- to fine-grained, gray to colorless quartz SAND with shell fragments (less than 10%) | 42 - 65 | 23 |
| Fine- to medium-grained, gray quartz SAND with tan to white to gray shell fragments (30%) | 65 - 75 | 10 |
| Very fine- to fine-grained, gray quartz SAND with shell fragments (less than 10%) | 75 - 85 | 10 |
| White to tan to gray SHELLS and coarse shell fragments (70%) with fine-grained gray sand, partially cemented | 85 - 95 | 10 |
| Fine-grained gray SAND with shell fragments (less than 10%) | 95 - 111 | 16 |
| White to tan to gray SHELL fragments (greater than 60%) with fine gray sand | 111 - 118 | 7 |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources DATE: 1/2/78 SHEET: 2 OF 2

LOCATION: Palm City Quadrangle Martin County, FL DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 5 DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: J. Wheatley SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Fine-grained gray SAND with shell fragments (10% or less) | 118 - 156 | 38 |
| CLAY | 156 - | + |
| TOTAL DEPTH | 156 | |
| Screen zone tested, 72 to 92 feet | | |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources DATE: 1/11/78 SHEET: 1 OF 2

LOCATION: Palm City Quadrangle Martin County, FL DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 8 DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: E. W. Pearce SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Medium- to coarse-grained, brown quartz SAND, subangular to rounded | 0 - 10 | 10 |
| Medium- to coarse-grained, gray quartz SAND, subangular to rounded, with medium to coarse shell fragments (10%) | 10 - 20 | 10 |
| No sample recovered | 20 - 25 | 5 |
| Coarse SHELLS with fine shell fragments and fine quartz sand | 25 - 30 | 5 |
| Very coarse SHELLS with medium-grained clear quartz sand (trace coarse) and fine shell fragments | 30 - 35 | 5 |
| Fine- to medium-grained, brown to gray SAND, trace of coarse sand, with shell fragments (less than 5%) and trace phosphatic sand grains | 35 - 50 | 15 |
| Fine-grained, gray to brown quartz SAND with coarse shell fragments (20% - 40%) | 50 - 65 | 15 |
| Fine-grained gray quartz SAND, subangular to angular with shell fragments (15% to 20%) | 65 - 82 | 17 |
| Coarse SHELLS, with fine quartz sand and shell fragments, partially cemented, clayey | 82 - 103 | 21 |
| Fine-grained quartz SAND with fine shell fragments | 103 - 113 | 10 |
| Fine to medium SHELLS and shell fragments (80%), with fine- to medium-grained colorless quartz sand, partially cemented | 113 - 128 | 15 |

Geraghty & Miller, Inc.

# WELL LOG

PROJECT: GDC - Martin County Water Resources DATE: 1/11/78 SHEET: 2 OF 2

LOCATION: Palm City Quadrangle Martin County, FL DRILLING CONTRACTOR: Layne-Atlantic

WELL NUMBER: 8 DRILLING METHOD: Cable Tool

SAMPLE DESCRIBED BY: E. W. Pearce SAMPLING METHOD: Bailing

| SAMPLE DESCRIPTION | Depth Interval (Feet) | Thickness (Feet) |
|---|---|---|
| Fine-grained, colorless quartz SAND with fine shell fragments and gray to green clay | 128 - | 6+ |
| TOTAL DEPTH | 134 | |
| Screen zone tested, 83 to 103 feet | | |

# APPENDIX 2

## SUMMARY OF SIEVE ANALYSES OF SELECTED SAMPLES FROM THE TEST WELLS

GENERAL DEVELOPMENT CORPORATION
MARTIN COUNTY WATER RESOURCES STUDY

## APPENDIX 2

### Summary of Sieve Analyses
### GDC - Martin County Water Resources Study

| Well No. | Interval (Feet) | Effective Grain Size (Inches) | Sieve Size Retaining 40% of Material (Inches) | Uniformity Coefficient |
|---|---|---|---|---|
| 1 | 83 - 88 | 0.004 | 0.038 | 9.5 |
| | 88 - 91 | 0.006 | 0.021 | 3.7 |
| | 91 - 100 | 0.007 | 0.027 | 3.9 |
| 2 | 45 - 52 | 0.002 | 0.067 | 36.5 |
| | 52 - 57 | 0.004 | 0.040 | 10.0 |
| | 57 - 63 | 0.005 | 0.054 | 11.0 |
| | 104 - 110 | 0.004 | 0.012 | 3.0 |
| | 110 - 115 | 0.003 | 0.011 | 3.7 |
| | 115 - 120 | 0.010 | Not Calculated | |
| | 120 - 125 | 0.017 | Not Calculated | |
| | 125 - 130 | 0.005 | 0.017 | 3.4 |
| | 130 - 135 | 0.005 | 0.009 | 1.8 |
| | 135 - 140 | 0.004 | 0.008 | 2.0 |
| | 140 - 145 | 0.004 | 0.008 | 2.0 |
| | 145 - 150 | 0.004 | 0.009 | 2.3 |
| 4 | 95 - 100 | 0.018 | Not Calculated | |
| | 100 - 105 | 0.006 | 0.038 | 6.3 |
| | 105 - 110 | 0.006 | 0.025 | 4.2 |
| 5 | 85 - 90 | 0.009 | Not Calculated | |
| | 90 - 95 | 0.007 | 0.056 | 8.0 |
| | 131 - 137 | 0.007 | 0.023 | 3.3 |
| | 137 - 141 | 0.007 | 0.017 | 2.4 |
| 8 | 80 - 85 | 0.003 | 0.010 | 3.3 |
| | 85 - 90 | 0.002 | 0.070 | 35.0 |
| | 90 - 95 | 0.002 | 0.013 | 6.5 |
| | 95 - 103 | 0.003 | Not Calculated | |

Note: Samples marked as not calculated contained a considerable volume of coarse material which could not be separated with the set of sieves available.