Geraghty & Miller, Inc.

EXPLORATORY DRILLING AND TESTING AT THE RESERVE ST. LUCIE COUNTY, FLORIDA

August 1984

Prepared for:
Diversified Utility Services
5845 Margate Boulevard
Margate, Florida 33063

Prepared by:
Geraghty & Miller, Inc.
Ground-Water Consultants
2700 PGA Boulevard, Suite 104
Palm Beach Gardens, Florida 33410

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

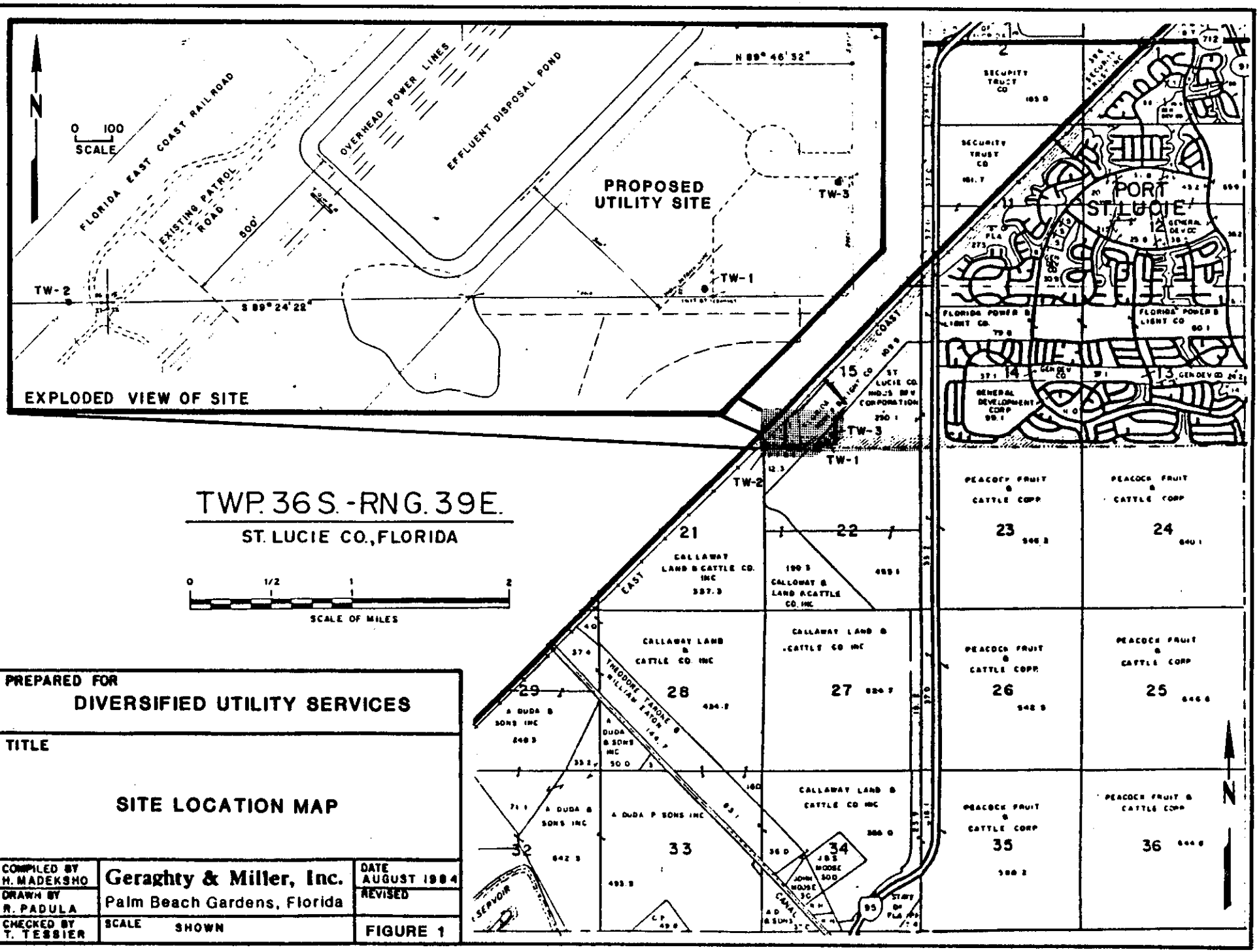
EXPLORATORY DRILLING AND TESTING AT THE RESERVE ST. LUCIE COUNTY, FLORIDA

INTRODUCTION

On June 1, 1984, Diversified Utility Services, of Margate, Florida authorized Geraghty & Miller, Inc. to provide hydrogeologic services in an exploratory program to develop a potable water supply for The Reserve, St. Lucie County, Florida. The Reserve is located west of Interstate 95 near Port St. Lucie and is bounded to the northwest by the Lake Harbour Branch of the Florida East Coast Railway. The property is owned by the Callaway Land and Cattle Company. A map showing the property location and wells is shown in Figure 1.

Drilling and testing services were provided by Persson Drilling Corporation of Fort Pierce, Florida. Water-sample analyses were performed by Environmental Services Laboratory of Riviera Beach, Florida. Both companies were contracted to Geraghty & Miller, Inc.

This report describes the drilling, testing and water sampling of three exploratory wells and water sampling of two existing wells on The Reserve property. Construction details, geologic logs and water-quality data of all the three new wells are included; water-quality data from the two existing wells are presented also. Pumping test data and interpretations are presented. Recommendations are made about the construction, location and yields of future production wells. The possibility of alternative sources of supply is discussed.


EXPLODED VIEW OF SITE
N
0 100
SCALE
FLORIDA EAST COAST RAILROAD
EXISTING PATROL ROAD
500'
OVERHEAD POWER LINES
EFFLUENT DISPOSAL POND
PROPOSED UTILITY SITE
TW-1
TW-2
TW-3
S 89° 24' 22"
N 89° 46' 32"
TWP. 36 S. - RNG. 39 E.
ST. LUCIE CO., FLORIDA
0 1/2 1 2
SCALE OF MILES
PORT ST. LUCIE
EAST COAST
CALLAWAY LAND & CATTLE CO. INC
PEACOCK FRUIT & CATTLE CORP
A DUDA & SONS INC
THEODORE TARONE & WILLIAM EATON
SECURITY TRUST CO
FLORIDA POWER & LIGHT CO
GENERAL DEVELOPMENT CORP
ST LUCIE CO. INDUS DEV CORPORATION
JBS MOOSE SOD
CANAL
RESERVOIR
PREPARED FOR
DIVERSIFIED UTILITY SERVICES
TITLE
SITE LOCATION MAP
COMPILED BY H. MADEKSHO
DRAWN BY R. PADULA
CHECKED BY T. TESSIER
Geraghty & Miller, Inc.
Palm Beach Gardens, Florida
SCALE SHOWN
DATE AUGUST 1984
REVISED
FIGURE 1

CONCLUSIONS

1. The most productive material in the shallow aquifer in the vicinity of the utility site at The Reserve occurs between about 30 and 80 feet below land surface.

2. The material is not suitable for open-hole completion; a properly designed screened well or gravel-packed well will be needed.

3. The productivity of the most favorable zone is low. Production wells should not be expected to produce more than 50 to 70 gpm (gallons per minute).

4. The water quality of the two best producing zones is potable and suitable for domestic use. Treatment will be necessary for public supply use.

5. More productive material may occur elsewhere in the shallow aquifer on The Reserve property or in areas east of the project.

6. The Floridan Aquifer is available for public water supply. This brackish supply will require desalination. A brine disposal method must be considered.

RECOMMENDATIONS

1. Future production wells at the sites of Test Wells 1, 2, and 3 should be constructed as 6-inch by 12-inch-diameter gravel-packed wells. The 6-inch-diameter steel casing should be attached to 6-inch-diameter wire-wound stainless steel screen and installed in a 12-inch-diameter hole. The gravel pack should surround the well screen.

2. Future exploration in the shallow aquifer should utilize surface resistivity and test drilling methods.

3. If the Floridan Aquifer is anticipated as a water source, brine disposal must be considered. A well is available on site for determining productivity and water quality of the Floridan Aquifer.

TEST DRILLING AND WELL CONSTRUCTION

The three wells all were constructed similarly. A nominal six-inch-diameter exploratory hole was drilled by the mud-rotary method. Formation samples were collected and described after every five feet of drilling and at each formation change by a Geraghty & Miller hydrogeologist who was on site during the drilling, construction, and testing phases of the project. Following the completion of drilling to total depth, a suitable screen depth was selected on the basis of the formation samples. Well construction details are presented in Table 1. Two-inch-diameter PVC casing and machine-slotted Schedule 40 PVC well screen were installed to the selected depth. A type 6-20 silica gravel pack was then emplaced around the screen, filling the annulus to a depth approximately 10 feet above the top of the well screen. Well TW-1 (Test Well 1) had a total drilled depth of 100 feet and was screened from 40 to 80 feet below land surface; Well TW-2 was drilled to a total depth of 120 feet and screened from 50 to 90 feet; and Well TW-3 was drilled to a total depth of 140 feet and screened from 100 to 135 feet. After installing the gravel pack, the annulus between casing and borehole was backfilled to land surface with bentonite and drilled cuttings. Once the emplacement of the gravel envelope and backfilling was complete, the well was developed with compressed air until the water was free from turbidity. Each well was completed to two feet above land surface with galvanized steel casing attached three feet below ground level to the PVC casing. The well was completed with threaded cap; the casing was cemented in place with a two foot-square by four-inch thick pad. Completed wells were left in place to serve as future monitor wells for the water system.

TABLE 1

WELL CONSTRUCTION DETAILS OF
EXPLORATORY WELLS AT THE RESERVE,
ST. LUCIE COUNTY, FLORIDA

Well Number	Total Drilled Depth	Cased Depth	Screened Interval
TW-1	100	40	40 - 80
TW-2	120	50	50 - 90
TW-3	140	100	100 - 135

Note: All depths are in feet below land surface.

TW-1 is located close to the southern boundary of the utility site near the southeastern corner.

TW-2 is located in the southwest corner of Section 15, near the utility site, between the Florida East Coast Rail line and the Power Company easement.

TW-3 is located to the northeast of TW-1 on the eastern boundary of the utility site.

GEOLOGIC CONDITIONS

The geologic logs of the exploratory holes show that fine- to medium-grained quartz sands exist from the surface to about 20 feet below ground level. In two of the exploratory wells, Wells TW-1 and TW-2, a silty to clayey sand horizon was detected between about 2 and 6 feet below ground level. In the 20- to 35-foot interval, a sand and shell layer was present; it contained a small amount of light gray clay. Below this material in Well TW-1 to a depth of 77 feet, the drilling penetrated well-cemented shelly sandstone interbedded with some sand seams. The well screen in TW-1 was set in this material. In the two other wells, only unconsolidated shelly sand was penetrated in this interval; the shelly sand was screened in Well TW-2. From 80 to 100 feet, clayey sand with small quantities of shell fragments were encountered in all three exploratory wells.

Only Wells TW-2 and TW-3 penetrated deeper than 100 feet; Well TW-2 to 120 feet, and Well TW-3 to 140 feet. To the total depth in both wells, the drilling encountered a sand and shell formation interbedded with thin beds of moderately well-cemented limestone and traces of clay. This formation was screened in Well TW-3. Detailed lithologic logs of each well are found in Appendix A.

WELL TESTING

Following the completion of each well, including necessary development to remove mud and excess sand, each was pumped to determine its yield and to obtain a water sample from the screened zone. A vacuum gauge was placed at the suction side of the pump to provide a estimate of drawdown. Wells TW-1 and TW-2, screened in the shallower zone (above 100 feet), pumped considerably more water than the well which was screened in the lower zone (below 100 feet).

After 30 minutes of pumping, the pump was turned off and a quick-disconnect fitting was removed, allowing access to the well so that measurements of recovering water level could be made. Measurements were taken frequently for more than one hour using a steel tape, until the water level had returned to within one inch of static - the level before pumping began. A summary of the data obtained from the pump test are presented in Table 2. From the pump-test data, the apparent transmissivity, or rate of flow horizontally through the aquifer, was estimated. The transmissivity value obtained during these short tests is most reflective of the screened interval at the well, rather than the aquifer as a whole. A longer controlled test using observation wells for data collection would be necessary to determine aquifer transmissivity. The transmissivity of the two zones were very similar, but the interval screened in Well TW-3 from 100 to 135 feet produced very much less water than the interval screened in either Well TW-1 or TW-2.

From the geologic logs of the exploratory holes, at least three permeable zones are defined, each separated by a less permeable semi-confining layer. However, only in the two deeper permeable zones could public supply wells be constructed. The zone in which the screens of Wells TW-1 and TW-2 are set has a total thickness between 45 and 50 feet. This zone has a transmissivity of about 4200 gpd/ft (gallons per day per foot); it is confined above by 15 feet of a clayey material and below by approximately 20 feet of similar material.

Well TW-3 was screened in the zone below the second confining layer mentioned above in order to determine the potential yield of this zone, compared to the zone in which Wells TW-1 and TW-2 were screened. This zone is at least 30 feet thick. From data obtained from Well TW-3, the transmissivity of the zone is 3650 gpd/ft, which is in the same range as the transmissivity of the overlying zone. The volume of water pumped from Well TW-3 was much less than from either of the wells screened in the upper zone, however. The overlying permeable material encountered between 31 and 78 feet below land surface is similar to that encountered

TABLE 2

INFORMATION OBTAINED FROM PUMPING TESTS
AT THE RESERVE
ST. LUCIE COUNTY, FLORIDA

Well Number	Static Depth to Water (feet below land surface)	Pump Rate (gpm)	Apparent Transmissivity (gpd/ft)	Vacuum Gauge Reading (inches Hg)	Screened Zone (Depth)
TW-1	1.40	21	4200	26	40 - 80
TW-2	3.82	20	4300	21	50 - 90
TW-3	1.51	2.9	3650	17	100 - 135

between 37 and 80 feet in Well TW-2. It is assumed that if Well TW-3 was completed at shallower depth, it would have been as productive as Well TW-2.

WATER QUALITY

The quality of the two water-producing zones underlying The Reserve property was determined by collecting samples of water from each of the three exploratory wells and from each of the two wells already existing on the property. One of these wells is located at the construction trailer, and the second is a lake recharge well near the entrance of the property. These latter two wells are thought to be in the vicinity of 50 feet deep, so they probably tap the same zone as Wells TW-1 and TW-2.

At the time that the samples were collected from the three exploratory wells, field measurements of temperature, specific conductance, pH and chloride concentration were made. Specific conductance and temperature measurements were made of the two existing wells in the field when those water samples were collected. These data are presented in Table 3. Laboratory analysis was made for selected parameters that apply to secondary drinking water standards of the Florida Department of Environmental Regulation and those that affect treatability. The laboratory analyses are found in Appendix B.

The results of the chemical analyses from the laboratory show that, for the parameters tested, the water obtained from Wells TW-1 and TW-2 is adequate for public supply, if treated. Total dissolved solids, total alkalinity, hardness, color, and odor are typically high; the water is potable for domestic use. Treatment may be necessary for hardness, color and odor to provide an acceptable product. The other parameters tested were within public supply limits. The sample from Well TW-3, pumped from the lower zone, (between 100 and 135 feet) exceeded public supply limits for color. Hardness and odor may also require treatment.

TABLE 3

WATER-QUALITY DATA COLLECTED AND ANALYZED IN THE FIELD AT THE RESERVE ST. LUCIE COUNTY, FLORIDA

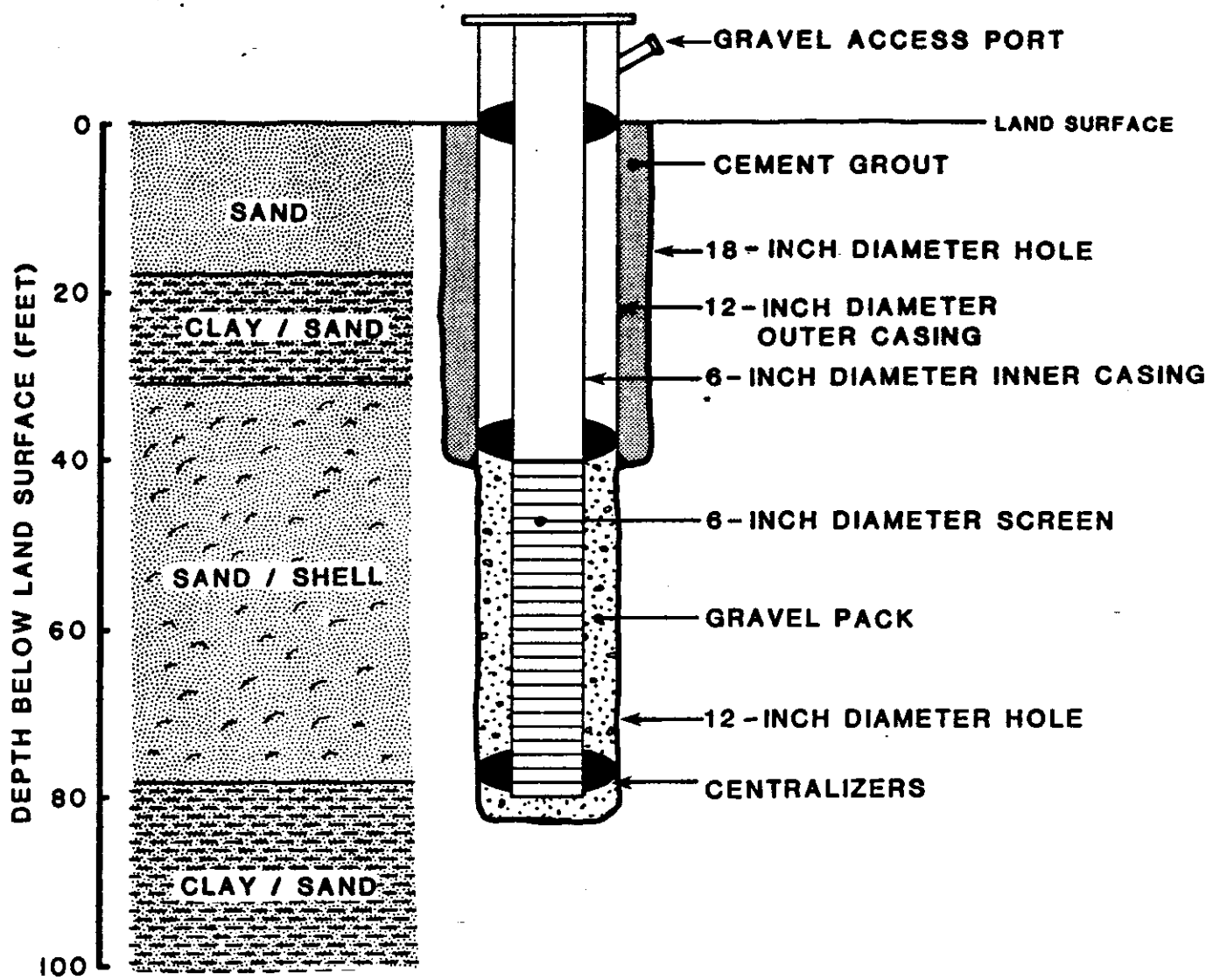
Well	pH	Specific Conductance (umhos/cm)	Temperature (Degree F)	Chloride Concentration (mg/l as Cl)
TW-1	6.85	610	74	38
TW-2	6.95	610	74	38
TW-3	7.25	610	72	38
Trailer Well	-	510	75	-
Lake Recharge Well	-	460	74	-

The water quality of the Trailer well and the Lake Recharge well show noticeable differences when compared with the water quality from the three exploratory wells. These two wells, located to the south of the exploratory wells, have high iron concentrations and exceed potable standards for color. They also have a lower pH value than the exploratory wells. The lower pH coupled with much lower values for Alkalinity indicate that there may be higher concentrations of carbon dioxide in these two wells than in the exploratory wells.

FUTURE PRODUCTION WELLS

The best material to tap for water supply is between 30 feet and 80 feet. This is the upper of the two water-producing zones tested; the two zones were selected as the only two that had any likelihood of producing water, based on information gathered during the drilling of the exploratory holes. Subsequent testing has shown that although both zones had transmissivity values in the same numerical range and similar water quality, the upper zone from 30 to 80 feet was the only zone that produced signficant quantities of water. Although supply wells could be constructed in the lower zone also, it probably would be difficult to develop high yields due to the semi-consolidated nature of the formation.

Because the material in the 30- to 80-foot zone is largely unconsolidated, it will not be possible to complete production wells as open-hole wells (that is with an open borehole below the casing). Because of the fine-grained nature of the material, it is recommended that production wells be constructed with well screens and gravel packs. This will allow the well screens to be sized much larger than the formation material to maximize the open intake area of the well. Screen slot size and gravel-pack size should be selected as appropriate to the formation. A 6-inch-diameter gravel-packed, wire-wound, stainless steel well screen attached to 6-inch-diameter steel casing and set in a 12-inch-diameter hole should adequately provide production. A typical production well design is shown on Figure 2.



PREPARED FOR

DIVERSIFIED UTILITY SERVICES

TITLE

RECOMMENDED DESIGN
PRODUCTION WELLS
THE RESERVE
ST. LUCIE COUNTY, FLORIDA

COMPILED BY H. MADEKSHO	Geraghty & Miller, Inc.	DATE AUGUST 1984
DRAWN BY R. PADULA	Palm Beach Gardens, Florida	REVISED
CHECKED BY T. TESSIER	SCALE SHOWN	FIGURE 2

The capacity of individual production wells can be estimated based on the transmissivity value obtained during testing and assumptions made about other characteristics of the flow system. It appears from the testing that the effective transmissivity in the production zone can be expected to be about 4000 gpd/ft. It also appears that the overlying and underlying layers, containing significant clay, will act as leaky confining beds when the production zone is pumped. This means that the ground-water system will be recharged by rainfall and surface water which will move primarily downward through the surficial sands and confining clay and into the production zone, then laterally toward the nearest well.

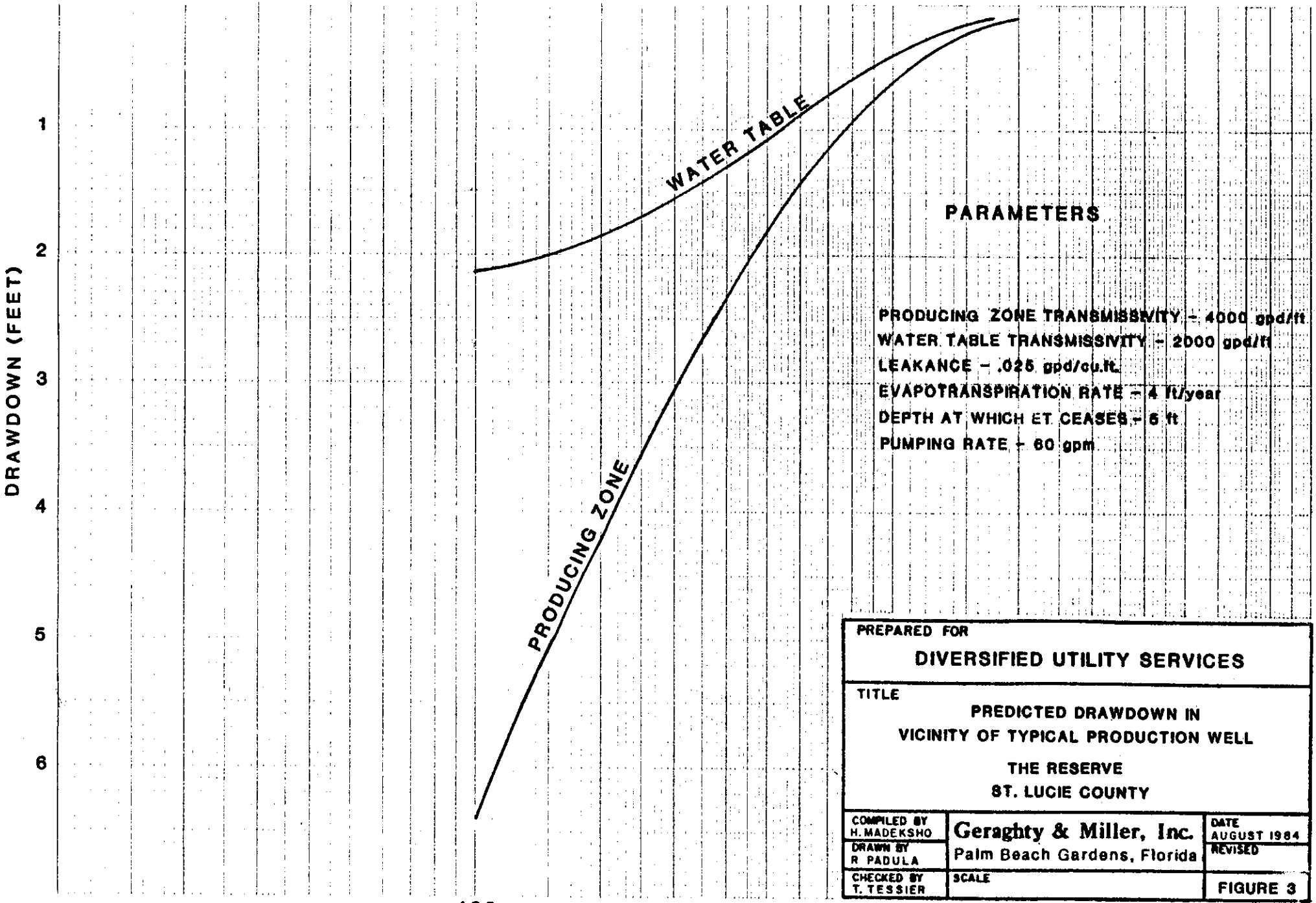
With this type of hydrogeologic system, the aquifer responds as a leaky artesian one. The cone of depression that develops as drawdown around individual wells will expand laterally until enough recharge is intercepted and water levels stabilize.

An available equation indicates that the theoretical specific capacity (yield per foot of drawdown) in a screened well could be as high as 2.2 gpm/ft (gallons per minute per foot of drawdown) if the transmissivity is 4000 gpd/ft, as described by N. T. Sheahan (1965). This, however, is an optimum value. Geraghty & Miller's experiences in this area are that production wells rarely can be developed to their theoretical specific capacity. Reasonably, a specific capacity in the range of 1.5 to 2 gpd/ft can be expected. To achieve maximum yield from individual wells, a well screen should be set in the lower portion of homogeneous material. Assuming that the top of the well screens in The Reserve production wells is set at 40 feet below land surface and that the local water level seasonally declines to about 5 feet below, 35 feet drawdown will be available to production wells and the yields of individual wells could be in the range of 50 (35 x 1.5) to 70 (35 x 2) gpm.

Interference effects that develop when the cone of depression (drawdown) from a pumping well influences water levels at another pumping well will

reduce the available drawdown and potential well yield. Therefore, it is important that adequate spacing be provided between production wells.

Although all the parameters necessary to predict interference effects at The Reserve have not been developed, they can be estimated from the geologic and test data. A coupled aquifer model, in which it is assumed that recharge to the ground-water system is derived from salvaged evapotranspiration at the water table, represents a conservative means of determining drawdown and interference effects near pumping wells. Assuming that evapotranspiration takes place at its potential evapotranspiration rate (PET) only while the water table is within 5 feet of land surface (regional data indicate that this is a reasonable depth), that the transmissivity of the production zone is 4000 gpd/ft, that the transmissivity of the water table is 2000 gpd/ft (reasonable for the local shallow sediments), and that the average vertical permeability of the material overlying the producing zone is about 1 percent of the water-table permeability, the drawdown around a well pumping at 60 gpm will be as shown in Figure 3. It can be seen that beyond about 800 feet from the pumping well, the drawdown in the producing zone is less than one foot. As long as wells are not clustered in a single well-field area, an 800-foot spacing should be adequate. This means that, if two adjacent wells are pumping, one well will cause about one foot of drawdown in the other, and reduce the yield of the other well by 1.5 to 2 gpm. If three wells are each located 800 feet apart in a line, the effect is additive. The outer wells can each cause one foot of drawdown at the center well, thus reducing that well's yield by 3 to 4 gpm. If wells are located closer together, the effect increases. For example, a 450-foot spacing will result in an interference drawdown of about 2 feet from each well. Then, the center well will incur 4 feet of total interference resulting in a decline in yield of 6 to 8 gpm.


DRAWDOWN (FEET)
1
2
3
4
5
6
WATER TABLE
PRODUCING ZONE
100
1000
DISTANCE FROM
MPED WELL (FEET)
PARAMETERS
PRODUCING ZONE TRANSMISSIVITY = 4000 gpd/ft
WATER TABLE TRANSMISSIVITY = 2000 gpd/ft
LEAKANCE = .025 gpd/cu.ft.
EVAPOTRANSPIRATION RATE = 4 ft/year
DEPTH AT WHICH ET CEASES = 5 ft
PUMPING RATE = 60 gpm
PREPARED FOR
DIVERSIFIED UTILITY SERVICES
TITLE
PREDICTED DRAWDOWN IN
VICINITY OF TYPICAL PRODUCTION WELL
THE RESERVE
ST. LUCIE COUNTY
COMPILED BY
H. MADEKSHO
DRAWN BY
R PADULA
CHECKED BY
T. TESSIER
Geraghty & Miller, Inc.
Palm Beach Gardens, Florida
SCALE
DATE
AUGUST 1984
REVISED
FIGURE 3

ALTERNATIVES TO INCREASE SUPPLY

Shallow Aquifer

It is possible that more productive water-bearing formations occur within the shallow aquifer elsewhere in the area. Trends of small but very productive shell deposits will be and have been tapped in the Port St. Lucie area by General Development Utilities. However, these deposits appeared less frequently and were generally less productive west of Florida's Turnpike in Port St. Lucie.

To search for more productive well sites at The Reserve, two exploration techniques are recommended. First, a rapid geophysical method used in the oil and mineral industry, surface resistivity, could be used to identify areas of material with high electrical resistivity properties. High electrical resistivity generally relates to areas of more permeable material and to those that contain better quality water. A Geraghty & Miller crew could test three to four selected potential sites per day in an effort to find areas with higher resistivity than the first three well sites, using these sites for data control. When higher resistivity sites are identified by this method, a test well could be drilled to establish production. The two techniques, surface resistivity and test well drilling, are employed together because, although resistivity is a rapid, cost-effective means of exploration, it is not measuring the parameter of water production. It is measuring electrical resistivity which may relate to production. Test drilling is needed to confirm production.

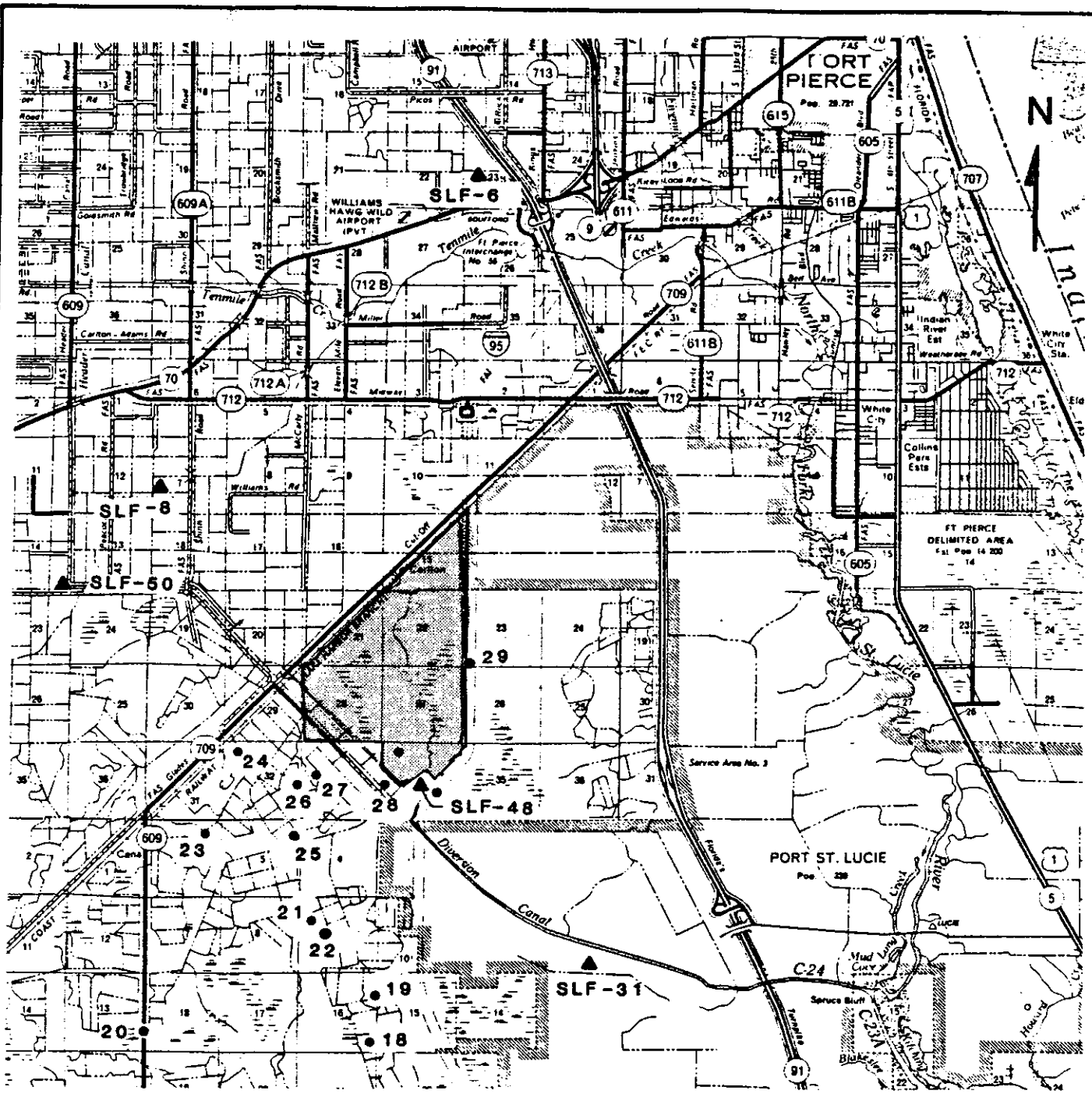
Alternatively, production from properties east of The Reserve is worthy of investigation. Although little is known about the Peacock Ranch, test wells drilled on General Development property in Sharrett Ranch, north of Peacock Ranch, were more productive than test wells at The Reserve. Surface resistivity and test drilling are recommended exploratory techniques for the Peacock Ranch site also.

Floridan Aquifer

The Floridan Aquifer offers a highly productive source of brackish water. The top of the aquifer is marked by the occurrence of limestone at a depth of about 350 to 500 feet below land surface at The Reserve. A search of the available published data revealed that a number of wells which tap the Floridan Aquifer exist near The Reserve. No information has been discovered about the wells located on the property, but another well, SLF-48 (used in the South Florida Water Management District's monitoring network) provides useful information. It is located adjacent to Callaway Land and Cattle Company property on an unincluded parcel of land in Section 34, Township 36S, Range 39E, north of canal C-24. Other wells for which information exists located within a radius of about four miles of the subject property are: 16 Floridan wells on property owned by A. Duda and Sons, to the southwest of The Reserve mostly on the south side of C-24; Well SLF-31, to the southeast, also south of C-24, on property owned by General Development Corporation (information on this well exists on record, but it has recently been plugged); Well SLF-6 to the north of the GO Team Industrial Park; Well SLF-8 to the northwest of The Reserve, and Well SLF-50 located just to the west of SLF-8. These wells are all located on Figure 4.

Well SLF-50 is a well recently investigated in a SFWMD (South Florida Water Management District) project. There is considerable detailed information on this well, especially on tested characteristics of the aquifer. Well SLF-48 is of interest also, because of its close proximity to the subject property. These two wells, and the three other wells in the SFWMD monitoring system which provide useful data in determining the character of the Floridan Aquifer at The Reserve, are listed in Table 4, together with the construction details of the wells and a summary of the information available. Some information exists on the Duda Wells, but their depths are unknown.

Geologic Conditions. - The suite of rocks described as the Floridan Aquifer consist of a thick sequence of interbedded limestones and



LEGEND

▲ FLORIDAN WELLS IN SFWMD MONITORING NETWORK

● FLORIDAN WELLS ON WHICH ONLY CASING DIAMETER AND LOCATION INFORMATION IS AVAILABLE

☐ PROPERTY OWNED BY CALLAWAY LAND AND CATTLE COMPANY KNOWN AS THE RESERVE

0 2
SCALE MILES

PREPARED FOR
DIVERSIFIED UTILITY SERVICES

TITLE
LOCATION OF WELLS TAPPING FLORIDAN AQUIFER IN THE VICINITY OF THE RESERVE, ST. LUCIE COUNTY

COMPILED BY H. MADEKSHO	Geraghty & Miller, Inc.	DATE AUGUST 1984
DRAWN BY Y. DIMICK	Palm Beach Gardens, Florida	REVISED
CHECKED BY T. TESSIER	SCALE AS SHOWN	FIGURE 4

TABLE 4

SUMMARY OF INFORMATION ON WELLS TAPPING THE FLORIDAN AQUIFER IN THE VICINITY OF THE RESERVE, ST. LUCIE COUNTY, FLORIDA

	Well Number				
	SLF-6	SLF-8	SLF-31	SLF-48	SLF-50
Well Depth (ft)	596	944	1008	800	1000*
Casing Depth (ft)	142	448	818	320	600
Casing diameter (inches)	3	6	3.5	?	6
Geophysical logs available	Yes	No	Yes	Yes	Yes
Lithologic log	No	No	No	No	Yes
Top of Floridan (ft. below land surface)	340 ±	?	400 ±	350 ±	600 ±

* Cemented up to 775 feet

dolomites which are supposed to extend to a depth of about 3000 feet. The top of the Floridan Aquifer is characterized by a sharp, high intensity "kick" on natural gamma ray geophysical logs. The rock corresponding to this "kick" has been described as a tan to white, sandy, fossiliferous, limestone containing silt-sized phosphorite. From geophysical logs, a number of production zones can be identified; at least three within 300 feet of the top of the Floridan Aquifer. Information obtained from water-quality data compared with open borehole depths delineate three zones where the water quality changes. These zones do not coincide with individual water-producing zones identified from geophysical logs; instead the zones described by the water-quality parameters are a composite of a number of small contributing water-producing zones.

From the information obtained on the Floridan wells in the vicinity of The Reserve, it appears that the top of the Floridan Aquifer is about 350 feet below land surface in the southern part of the property, dipping southward. Maps compiled by the SFWMD of the UECPA (Upper East Coast Planning Area - which consists of Martin and St. Lucie Counties and part of Okeechobee County) agree with this.

Hydrogeologic Conditions. - Well SLF-50 provides much detailed information on the characteristics of the different zones comprising the Floridan Aquifer. The SFWMD conducted pumping tests of the production zones of this well (Wedderburn, Knapp 1983). Six-inch-diameter PVC casing was set to a depth of 600 feet below land surface. This coincides with the top of the Floridan Aquifer. Below this, a nominal 5-inch-diameter hole was drilled with stage breaks at 627 feet, 747 feet, and 870 feet below land surface. Pump tests were conducted at each depth. The results were calculated values of relative transmissivity which are summarized in Table 5, along with other information from the pumping tests. Transmissivities increased with the depth of penetration of the aquifer. A corrected flowmeter log was utilized to determine the percentage contribution of water flow into the completed borehole from the respective zones. The corrected flowmeter

TABLE 5

REPRODUCTION OF DATA FROM PUMPING TESTS CONDUCTED BY SOUTH FLORIDA WATER MANAGEMENT DISTRICT ON WELL SLF-50

TABLE 1. SUMMARY OF PUMPING TEST DATA AND RESULTS

DATE OF TEST	DURATION OF PUMPING (HRS)	WELL DEPTH (FT) PUMPED WELL	WELL DEPTH (FT) OBS. WELLS	CASING DEPTH(FT) PUMPED WELL	CASING DEPTH(FT) OBS. WELL	PUMPING RATE (GPM)	MAXIMUM DRAWDOWN (FT) PUMPED	MAXIMUM DRAWDOWN (FT) OBS.	TRANSMISS. (GPD/FT)	STORAGE COEFFICIENT	LEAKAGE K'/m' (DAY^{-1})	REMARKS
1-5-82 to 1-6-82	2	627 (SLF-50)	893 (SLF-49)	600	560	55	35.73	ND	9,428*	-	-	Recovery data-pumped well Jacob semi-log analysis
1-19-82 to 1-21-82	46.25	747 (SLF-50)	893 (SLF-49)	600	560	396	32.69	ND	65,340*	-	-	Recovery data-pumped well Jacob semi-log analysis
2-2-82	6	870 (SLF-50)	893 (SLF-49)	600	560	450	29.0	ND	88,000*	-	-	Recovery data-pumped well Jacob semi-log analysis
2-9-82 to 2-10-82	24.15	1000 (SLF-50)	893 (SLF-49)	600	560	580	30.93	ND	107,077*	-	-	Recovery data-pumped well Jacob semi-log analysis
8-24-82 to 8-27-82	72	775 (SLF-51)	1) 775 (SLF-50) 2) 893 (SLF-49)	600	1) 600 2) 560	388	35.35	1) 2.37 2) ND	a) <u>44,233</u>** b) <u>48,080</u>** c) <u>43,416</u>**	a) $\underline{1.64X10^{-4}}$ b) $\underline{2.67X10^{-4}}$ c) $\underline{1.65X10^{-4}}$	a) <u>.0432</u> b) <u>.0470</u>	a) Drawdown data-obs. well #1, Hantush/Jacob b) Recovery data-obs. well #1, Hantush/Jacob type curve analysis c) Drawdown data-obs. well #1, Hantush inflection point analysis

*Preliminary tests to determine relative transmissivity with depth. Values do not reflect true transmissivity since the effects of leakance are ignored.
**Values underlined reflect true aquifer characteristics of injection horizon.

Reference: Wedderburn, Knapp, 1983.

log showed that the 600- to 627-foot interval contributed 29 percent of the total flow from the well; the 600- to 747-foot interval contributed 40 percent of the total flow, and below 750 feet to 1000 feet, the contribution of individual zones did not exceed 10 percent. It appears that the most productive zone in this well was between 600 and 747 feet. The zone was subsequently pump tested for 72 hours. Analysis of the data from the pumping well and one observation well resulted in a transmissivity of between 43,000 and 48,000 gpd/ft (gallons per day per foot) depending on the method of analysis.

No flowmeter log was conducted on the well closest to The Reserve, Well SLF-48, but a differential temperature log was obtained. A differential temperature log traces the temperature changes in the borehole, and it can be expected that where there is significantly more inflow into the borehole the temperature will be lower. The log of Well SLF-48 showed no significant changes in temperature over the length of the open borehole, so it can be assumed that the flow of water into the well from the formation is fairly uniform.

Two other wells for which geophysical logs were conducted were Wells SLF-6 and SLF-31. No flowmeter logs are available for these wells; however, differential temperature logs do exist for both wells. The logs of the two wells are essentially similar. The log of Well SLF-6 shows no significant temperature gradient until a depth of about 530 feet. From 530 feet to the bottom of the borehole at 600 feet, the temperature gradient increases uniformly. The top of the Floridan Aquifer in this well is estimated as 340 feet below land surface. Well SLF-31 shows very little change in temperature gradient until about 920 feet. The top of the Floridan Aquifer in SLF-31 is estimated at 400 feet and the borehole is cased to 818 feet. It would appear that in the vicinity of The Reserve, there are no significant contributing production zones, but that the contribution of the formation is fairly uniform over the entire length of the open borehole. The limiting factors determining how much water can be pumped from the Floridan Aquifer in this area will be the length of the open borehole selected

and the transmissivity of the material encountered. The length of the borehole primarily will depend on the water quality, which is known to deteriorate with depth.

Water Quality. - Selected water-quality information exists on the five wells monitored by the SFWMD. The water samples obtained from all these wells are composite samples, so it is difficult to define a water-quality "type" for a specific water-producing zone. However, it is possible to generalize about the quality of composite samples from wells drilled to similar depths.

The Floridan Aquifer, in general, has higher total dissolved solids (TDS) than the shallow aquifer. Chloride (Cl) is the dominant anion (negatively charged ion) and sodium (Na), calcium (Ca), and magnesium (Mg) are the major cations (positively charged ions). The high sodium and chloride concentrations are due to the presence of highly mineralized water trapped in the sediments during an earlier geologic period; it is not due to direct saltwater intrusion from the Atlantic Ocean.

The five SFWMD monitoring network wells can be divided into three groups—wells with open boreholes to 600 feet, to 800 feet, and to 1000 feet. Those wells with open boreholes to 600 feet fit into a median range of quality for most of the measured parameters. Only one well of the five fits into this group; it is Well SLF-6. Wells with open boreholes to 800 feet, of which there are two in this group of five, SLF-48 and SLF-50, have the lowest values for TDS, sodium, potassium, calcium, magnesium, chloride, sulfate, specific conductance, and dissolved iron. Wells with open boreholes to 1000 feet have the highest values of the above mentioned chemical parameters. Table 6 summarizes the water-quality information available on the five Floridan wells and Table 7 shows the range of water quality of each of the three depth ranges, according to the data available on the five SFWMD wells.

TABLE 6

WATER QUALITY DATA OBTAINED FROM PUBLISHED INFORMATION FOR FIVE FLORIDAN WELLS IN VICINITY OF THE RESERVE, ST. LUCIE COUNTY, FLORIDA

	Well Number				
	SLF-6	SLF-8	SLF-31	SLF-48	SLF-50
Date water sample collected	9/14/83	5/8/79	5/9/79	9/21/83	10/14/82
Average temperature (°C)	28.3	29.1	27.7	26(79F)	-
pH	-	7.60	7.40	8.15	7.72
TDS (mg/l)	1946	3357	2090	1284	1436
Cl (mg/l)	800.5	1489.2	970	493.4	673.6
Na (mg/l)	492.8	850.9	580	250.8	323.6
K (mg/l)	16.4	18.22	20	10.16	11.33
Ca (mg/l)	112.0	226.04	110	42.20	86.30
Mg (mg/l)	94.96	142.46	100	56.48	63.70
SO_4 (mg/l)	239.5	336.9	180	97.3	161.3
Fe, diss. (mg/l)	0.04	0.13	0.15	0.03	0.08
Alkalinity (meq/l)	2.72	2.25	-	2.34	2.59
Specific Conductance (umhos/cm)	3375	5460	3670	-	2270
Laboratory Conductivity (umhos/cm)	3650	4200	-	1750	2450

TABLE 7

RANGE IN QUALITY OF FIVE
WATER SAMPLES FROM FLORIDAN WELLS NEAR THE RESERVE,
ST. LUCIE COUNTY, FLORIDA

Chemical Parameter	Open Borehole to less than 600 feet	Open Borehole to less than 800 feet	Open Borehole to less than 1000 feet
TDS (mg/l)	1900 ±	1200 - 1500	2000 - 3500
Cl (mg/l)	800 ±	400 - 700	970 - 1500
Na (mg/l)	490 ±	250 - 350	500 - 800
K (mg/l)	16 ±	10 - 11.5	18 - 20
Ca (mg/l)	112	42 - 87	110 - 226
Mg (mg/l)	95 ±	50 - 70	100 - 150
SO_4 (mg/l)	240 ±	97 - 170	180 - 340
Fe, diss. (mg/l)	0.04	0.03 - 0.08	0.13 - 0.15
Alkalinity (meq/l)	2.72	2.30 - 2.60	2.25
Specific Conductance (umhos/cm)	3300 ±	2270	3600 - 5500 ±
Laboratory Conductivity (umhos/cm)	3600 ±	1700 - 2500	4200
pH	-	7.70 - 8.15	7.40 - 7.60
Number of Wells from which samples obtained	1	2	2

NOTE: These are approximate values only, based on one sample for each of the five wells.

Using desalination techniques, the Floridan Aquifer could provide potable water at The Reserve. The most popular desalination technique for brackish water is reverse osmosis. Regional maps indicate that the TDS (total dissolved solids) concentration in the upper Floridan Aquifer is about 1200 to 1500 mg/l in this area and that the chloride concentration is about 400 to 700 mg/l. Assuming that reverse osmosis will produce a brine reject stream that is 20 percent of the raw water input, a mass-balance analysis indicates that 100 gallons of feed water containing a TDS concentration of 1500 mg/l and a chloride concentration of 700 mg/l will produce 80 gallons of water with a TDS concentration of 300 mg/l and a chloride concentration of 150 mg/l and 20 gallons of reject brine with a TDS concentration of 6300 mg/l and a chloride concentration of 2900 mg/l. The brine is too concentrated to be disposed of on the surface. Discharge to saline water or an injection well probably would be necessary. A well exists on the project site at which productivity and water quality could be tested. Geophysical logging and flow testing should be performed to confirm local conditions.

CLOSING COMMENTS

Production wells tapping the shallow aquifer near the utility site at The Reserve are capable of producing small volumes of potable water for domestic use. The water can be treated for public supply use. The property and adjacent properties could be explored in an effort to identify well sites with greater yields. The Floridan Aquifer represents an alternative source.

We appreciate the cooperation of personnel connected with The Reserve, particularly John Holcomb for his help in locating and clearing well sites. We would like to thank James Harrison of Diversified Utility Services for his guidance in this program.

Respectfully submitted,
GERAGHTY & MILLER, INC.

Helen V. Madeksho
Scientist

Thomas L. Tessier
Associate

August 1984

REFERENCES CITED

South Florida Water Management District 1979 (Brown, Reece). Map Series No. 1. Florida Aquifer System Upper East Coast Planning Area.

South Florida Water Management District 1980 (Reece, Brown, Hynes). Hydrogeologic Data Collected from the Upper East Coast Planning Area.

South Florida Water Management District. 1983 (Wedderburn, Knapp). Field Investigation into the Feasibility of Storing Freshwater in Saline Portions of the Floridan Aquifer System, St. Lucie County, Florida.

APPENDIX A

Geologic Logs of Exploratory Holes

GEOLOGIC LOG
OF
TEST WELL 1
ST. LUCIE COUNTY, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, light brownish gray to brownish gray, quartz, very fine- to medium-grained, sub-rounded to sub-angular.	0 - 2	2
SILTY SAND - Sand, 70%, very light gray, quartz, fine-grained, sub-rounded to sub-angular; Silt, 30%, dusky yellowish brown.	2 - 3	1
SANDY CLAY - Clay, 60%, dark greenish gray, plastic; Sand, 40%, light brownish gray, quartz, fine-grained, sub-rounded to sub-angular.	3 - 6	3
SAND - Sand, 100%, grayish brown, quartz, fine- to medium-grained, sub-rounded to sub-angular.	6 - 18	12
CLAYEY SHELLY SAND - Sand, 50%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Shell, 40%, bleached to grayish yellow, small to medium fragments and whole shells; Clay, 10%, medium light gray, plastic.	18 - 34	16
SHELLY SANDSTONE AND SAND - Sand, 50%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Sandstone, 50%, light olive gray, very fine-grained, well cemented, shelly.	34 - 77	43
SHELLY CLAYEY SAND - Sand, 50%, light brownish gray, very fine-grained, sub-rounded to sub-angular; Clay, 35%, medium light gray, plastic; Shell, 15%, bleached to grayish yellow, small fragments.	77 - 100	23+
	TOTAL DEPTH	100

Geraghty & Miller, Inc.

GEOLOGIC LOG
OF
TEST WELL 2
ST. LUCIE COUNTY, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, very light gray and frosted, quartz, fine- to medium-grained, sub-rounded to sub-angular.	0 - 2	2
SILTY SAND - Sand, 60%, very light gray, quartz, fine- to medium-grained, sub-rounded to sub-angular; Silt, 40%, dusky yellowish brown.	2 - 5	3
SAND - Sand, 100%, grayish brown, quartz, fine- to medium-grained, sub-rounded to sub-angular.	5 - 18	13
CLAYEY SHELLY SAND - Sand, 55%, light brownish gray to brownish gray, quartz, very fine to fine-grained, sub-rounded to sub-angular; Shell, 35%, bleached to grayish yellow, small to medium-sized fragments and whole shells; Clay, 10%, dark greenish gray, plastic.	18 - 37	19
SHELLY SAND - Sand, 60%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Shell, 40%, bleached to grayish yellow, small fragments to whole shells.	37 - 80	43
CLAYEY SHELLY SAND - Sand, 40%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Shell, 30%, bleached to grayish yellow, small to moderately large fragments and whole shell; Clay, 30%, medium light gray, plastic.	80 - 100	20

SANDY SHELL AND LIMESTONE - Shell, 50%, bleached to grayish yellow, small to medium-sized fragments and whole shell; Sand, 35%, light brownish gray, quartz, fine-grained, sub-rounded to sub-angular; Limestone, 15%, light olive gray to dark gray, very fine-grained, moderately well cemented; Clay, trace, medium light gray plastic.	100 - 120	20+
	TOTAL DEPTH	120

GEOLOGIC LOG
OF
TEST WELL 3
ST. LUCIE COUNTY, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, light brownish gray to brownish gray, quartz, very fine- to medium-grained, sub-rounded to sub-angular.	0 - 22	22
CLAYEY SHELLY SAND - Sand, 60%, light brownish gray to brownish gray, quartz, very fine- to fine-grained, sub-rounded to sub-angular; Shell, 30%, medium-sized fragments and whole shells; Clay, 10%, dark greenish gray, plastic.	22 - 31	9
SHELLY SAND - Sand, 60%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Shell, 40%, bleached to grayish yellow, small to moderately large-sized fragments and whole shells.	31 - 78	47
CLAYEY SHELLY SAND - Sand, 40%, light brownish gray, quartz, very fine-grained, sub-rounded to sub-angular; Shell, 30%, bleached to grayish yellow, small to moderately large fragments and whole shell; Clay, 30%, medium light gray, plastic.	78 - 110	32
SANDY SHELL AND LIMESTONE - Shell, 60%, bleached to grayish yellow, small to medium-sized fragments and whole shell; Sand, 25%, light brownish gray, quartz, fine-grained, sub-rounded to sub-angular; Limestone, 15%, light olive gray to dark gray, very fine-grained, moderately well cemented.	110 - 140	30+
	TOTAL DEPTH	140

APPENDIX B

Water-Quality Analyses

Environmental Services of South Florida, Inc.

P.O. Box 10003 • Riviera Beach, Florida 33404 • (305) 848-7805

DHRS LAB #86117

LABORATORY ANALYSIS — WATER / WASTEWATER / SOIL / FOOD

CONSULTING — INDUSTRIAL / AGRICULTURAL / DOMESTIC

Geraghty & Miller, Inc. - TW-1

WATER ANALYSIS REPORT

Sample ~~collected~~ submitted by H. Madeksho on 7-20-84 at _____

Temperature at time of collection (180°)	°C	Carbon Dioxide, CO_2	mg/l
Total Dissolved Solids	403 mg/l	Hydroxide as $CaCO_3$	mg/l
Total Hardness as $CaCO_3$	324 mg/l	Carbonate as $CaCO_3$	mg/l
Total Alkalinity as $CaCO_3$	310 mg/l	Bicarbonate as $CaCO_3$	mg/l
Non-Carbonate Hardness	mg/l	Bacteria, Total Coliform	/100 ml
Bicarbonate, HCO_3	mg/l	Arsenic, As	mg/l
Iron, Fe	0.09 mg/l	Barium, Ba	mg/l
Sulfate, SO_4	mg/l	Copper, Cu	mg/l
Chloride, Cl	31 mg/l	Cadmium, Cd	mg/l
Calcium, Ca	mg/l	Chromium, Cr^{+6}	mg/l
Magnesium, Mg	mg/l	Cyanide	mg/l
Fluoride, F	mg/l	Lead, Pb	mg/l
Hydrogen Sulfide, H_2S	0.08 mg/l	Manganese, Mn	mg/l
pH	6.8	Mercury, Hg	mg/l
pHs		Nitrate, as N	mg/l
Stability Index		Phenols	mg/l
Saturation Index		Selenium, Se	mg/l
MBAS	mg/l	Silver, Ag	mg/l
T Odor	3	Sodium, Na	mg/l
Color, APHA	10	Turbidity, NTU	
Residual Chlorine: Free Available		Zinc, Zn	mg/l
Combined Available			

Specific Conductance at 26.6°C 720 μmhos

Samples were not collected by Environmental Services personnel and results represent samples as received by Environmental Services.

Michael A. Fuder

Environmental Services of South Florida, Inc.

P.O. Box 10003 • Riviera Beach, Florida 33404 • (305) 848-7805

DHRS LAB #86117

LABORATORY ANALYSIS **CONSULTING**

WATER / WASTEWATER / SOIL / FOOD INDUSTRIAL / AGRICULTURAL / DOMESTIC

Geraghty & Miller, Inc. - TW-2

WATER ANALYSIS REPORT

Sample submitted by H. Madeksho on 7-20-84 at _____

Temperature at time of collection _____ °C (180°)

Total Dissolved Solids	370 mg/l	Carbon Dioxide, CO_2	_____ mg/l
Total Hardness as $CaCO_3$	316 mg/l	Hydroxide as $CaCO_3$	_____ mg/l
Total Alkalinity as $CaCO_3$	294 mg/l	Carbonate as $CaCO_3$	_____ mg/l
Non-Carbonate Hardness	_____ mg/l	Bicarbonate as $CaCO_3$	_____ mg/l
Bicarbonate, HCO_3	_____ mg/l	Bacteria, Total Coliform	_____ /100 ml
Iron, Fe	0.14 mg/l	Arsenic, As	_____ mg/l
Sulfate, SO_4	_____ mg/l	Barium, Ba	_____ mg/l
Chloride, Cl	31 mg/l	Copper, Cu	_____ mg/l
Calcium, Ca	_____ mg/l	Cadmium, Cd	_____ mg/l
Magnesium, Mg	_____ mg/l	Chromium, Cr^{+6}	_____ mg/l
Fluoride, F	_____ mg/l	Cyanide	_____ mg/l
Hydrogen Sulfide, H_2S	0.06 mg/l	Lead, Pb	_____ mg/l
pH	7.0	Manganese, Mn	_____ mg/l
pHs	_____	Mercury, Hg	_____ mg/l
Stability Index	_____	Nitrate, as N	_____ mg/l
Saturation Index	_____	Phenols	_____ mg/l
MBAS	_____ mg/l	Selenium, Se	_____ mg/l
T Odor	1	Silver, Ag	_____ mg/l
Color, APHA	15	Sodium, Na	_____ mg/l
		Turbidity, NTU	_____
Residual Chlorine: Free Available	_____	Zinc, Zn	_____ mg/l
Combined Available	_____		

Specific Conductance at 26.6°C 710 μmhos

Samples were not collected by Environmental Services personnel and results represent samples as received by Environmental Services.

Michael A. Fertig

Environmental Services of South Florida, Inc.

P.O. Box 10003 • Riviera Beach, Florida 33404 • (305) 848-7805

DHRS LAB #86117

LABORATORY ANALYSIS — WATER / WASTEWATER / SOIL / FOOD

CONSULTING — INDUSTRIAL / AGRICULTURAL / DOMESTIC

Geraghty & Miller, Inc. - TW-3

WATER ANALYSIS REPORT

Sample ~~collected~~ submitted by H. Madeksho on 7-20-84 at

Temperature at time of collection (180°)	°C	Carbon Dioxide, CO_2	mg/l
Total Dissolved Solids	411 mg/l	Hydroxide as $CaCO_3$	mg/l
Total Hardness as $CaCO_3$	262 mg/l	Carbonate as $CaCO_3$	mg/l
Total Alkalinity as $CaCO_3$	288 mg/l	Bicarbonate as $CaCO_3$	mg/l
Non-Carbonate Hardness	mg/l	Bacteria, Total Coliform	/100 ml
Bicarbonate, HCO_3	mg/l	Arsenic, As	mg/l
Iron, Fe	0.09 mg/l	Barium, Ba	mg/l
Sulfate, SO_4	mg/l	Copper, Cu	mg/l
Chloride, Cl	37 mg/l	Cadmium, Cd	mg/l
Calcium, Ca	mg/l	Chromium, Cr^{+6}	mg/l
Magnesium, Mg	mg/l	Cyanide	mg/l
Fluoride, F	mg/l	Lead, Pb	mg/l
Hydrogen Sulfide, H_2S	0.08 mg/l	Manganese, Mn	mg/l
pH	7.2	Mercury, Hg	mg/l
pHs		Nitrate, as N	mg/l
Stability Index		Phenols	mg/l
Saturation Index		Selenium, Se	mg/l
MBAS	mg/l	Silver, Ag	mg/l
T Odor	3	Sodium, Na	mg/l
Color, APHA	25	Turbidity, NTU	
		Zinc, Zn	mg/l
Residual Chlorine: Free Available			
Combined Available			

Specific Conductance at 26.6°C 720 μmhos

Samples were not collected by Environmental Services personnel and results represent samples as received by Environmental Services

Environmental Services of South Florida, Inc.
P.O. Box 10003 • Riviera Beach, Florida 33404 • (305) 848-7805

DHR 5117

LABORATORY ANALYSIS
WATER / WASTEWATER / SOIL / FOOD

CONSULTING
INDUSTRIAL / AGRICULTURAL / DOMES

Geraghty & Miller, Inc. - Lake Recharge Well

WATER ANALYSIS REPORT

Sample ~~collected~~ submitted by H. Madeksho on 7-16-84 at _____

Temperature at time of collection _____ °C (180°)

Total Dissolved Solids 241 mg/l

Total Hardness as $CaCO_3$ 161 mg/l

Total Alkalinity as $CaCO_3$ 152 mg/l

Non-Carbonate Hardness _____ mg/l

Bicarbonate, HCO_3 _____ mg/l

Iron, Fe 20.9 mg/l

Sulfate, SO_4 _____ mg/l

Chloride, Cl 25 mg/l

Calcium, Ca _____ mg/l

Magnesium, Mg _____ mg/l

Fluoride, F _____ mg/l

Hydrogen Sulfide, H_2S 0.08 mg/l

pH 6.5

pHs _____

Stability Index _____

Saturation Index _____

MBAS _____ mg/l

T Odor 2

Color, APHA 90

Residual Chlorine:
Free Available _____
Combined Available _____

Carbon Dioxide, CO_2 _____ mg/l

Hydroxide as $CaCO_3$ _____ mg/l

Carbonate as $CaCO_3$ _____ mg/l

Bicarbonate as $CaCO_3$ _____ mg/l

Bacteria, Total Coliform _____ /100 ml

Arsenic, As _____ mg/l

Barium, Ba _____ mg/l

Copper, Cu _____ mg/l

Cadmium, Cd _____ mg/l

Chromium, Cr^{+6} _____ mg/l

Cyanide _____ mg/l

Lead, Pb _____ mg/l

Manganese, Mn _____ mg/l

Mercury, Hg _____ mg/l

Nitrate, as N _____ mg/l

Phenols _____ mg/l

Selenium, Se _____ mg/l

Silver, Ag _____ mg/l

Sodium, Na _____ mg/l

Turbidity, NTU _____

Zinc, Zn _____ mg/l

Specific Conductance at 26.0°C 382 μmhos

Samples were not collected by Environmental Services personnel and results represent samples as received by Environmental Services.

Michael A. Fuster