Geraghty & Miller, Inc.

# INSTALLATION OF PRODUCTION WELL 2
# AT PORT LABELLE
# GLADES AND HENDRY COUNTIES, FLORIDA

June 1982

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## INTRODUCTION

By Contract 816, Addendum 19, General Development Utilities, Inc. (GDUI) authorized Geraghty & Miller, Inc. of West Palm Beach, Florida to proceed with the installation of a water-supply well in LaBelle, Florida. Installation of a back-up water-supply well at Port LaBelle had been required by the Florida DER (Department of Environmental Regulation), which was concerned that the capacity of the existing well and ground storage at LaBelle could not be relied upon. In May 1981, Geraghty & Miller Inc. proposed that a large-capacity well be installed; this well would serve as a back-up to the existing well and would serve as a primary supply well when the system is expanded to meet the future needs of this growing General Development community. The proposal was accepted in June 1981.

This report contains a description of previous water-supply development at LaBelle, information about local geologic conditions, construction details of PW 2 (Production Well 2), and the results and analyses of pumping tests. Local hydrologic conditions and their relevance to future water-system expansion are discussed. Information about design well capacity and predicted pumping levels are presented. Finally, recommendations for future testing and monitoring are made.

## CONCLUSIONS

1. Productive material beneath the water plant is nearly 100 feet thick, extending from 185 to 280 feet below land surface.

2. The estimated aquifer coefficients are:
   transmissivity: 240,000 gallons per day per foot
   storage coefficient: 0.0004

3. A hydrologic boundary is predicted to exist 1600 feet southwest of the water plant. The test data suggest that a second hydrologic boundary exists about 2 miles east or northeast of the test area.

4. Water from Production Well 2 is potable and suitable for use with conventional treatment.

5. As a back-up (or alternative) supply well, Production Well 2 will produce 350 gpm (gallons per minute) with a pumping level of 2.1 feet above sea level NGVD (National Geodetic Vertical Datum) during the dry season. At 500 gpm, the pumping level will be 1.1 feet below sea level.

6. The well is capable of producing 3 mgd (million gallons per day); assuming that similar wells will exist 1000 feet north and 1000 feet east of PW 2 and that the 3 wells will deliver 9 mgd during the dry season for 90 days, the pumping level of PW 2 is estimated at 73.7 feet below sea level.

7. Upconing of brackish Floridan aquifer water through the confining bed or lateral movement of brackish water from abandoned or improperly constructed artesian wells appear to pose the only threat to water quality in this aquifer near the water plant.

## RECOMMENDATIONS

1. The operation of a water-level recorder at the Jimmy Miller well should be continued by the U. S. Geological Survey or by GDUI.

2. The limits of the aquifer should be further defined by exploration and testing to determine if it is capable of supplying the future needs of Port LaBelle.

3. All existing wells in the vicinity of Port LaBelle should be inventoried; those tapping the Floridan aquifer should be systematically plugged.

4. Water-level and water-quality data from Production Wells 1 and 2 should be regularly collected by the plant operator and tabulated.

## HISTORY OF WATER-SUPPLY DEVELOPMENT AT PORT LABELLE

General Development began to explore the ground-water resources at Port LaBelle in 1971. Under Geraghty & Miller's direction, Test Well 71-1 was installed near the present golf course maintenance area to a depth of 142 feet below land surface. This well is often referred to as the Jimmy Miller Well. Geologic material (principally sand and shells) that appeared to be favorable for the installation of high-capacity wells was encountered from about 100 feet below land surface to the total drilled depth. A ten-foot-long well screen was installed in this well between 127 and 137 feet below land surface; the well was developed and a specific capacity of 47.7 gpm/ft (gallons per minute per foot of drawdown) was recorded in a one-hour test at 240 gpm. The well was left in place as a monitoring well at a potential future production well site.

In 1972, Geraghty & Miller, Inc. directed the installation of seven exploratory borings at widely separated locations in Port LaBelle. The first five borings (72-1 through 72-5) did not encounter material that could be considered to be highly productive, and they were abandoned by backfilling with drill cuttings and bentonite clay. Borings 72-6 and 72-7, located at the present water treatment plant site, encountered material between 200 and 300 feet below land surface that appeared to be favorable for the installation of high capacity wells. An eight-inch-diameter test-production well was installed at the location of Boring 72-6 and is designated as Production Well 1. An observation well was installed at Boring 72-7 and has remained as a permanent monitoring well (designated Well 72-7).

Production Well 1 was put into service and is the principal water source for Port LaBelle. Although the present pump capacity is 500 gpm, a pumping test performed on this well in 1973 indicated that, at this location, the aquifer is capable of yielding 1000 to 2000 gpm to properly constructed wells.

In 1980, additional exploratory drilling was accomplished to further define the trend of favorable material encountered in Wells 71-1, 72-7, and Production Well 1. The material was not encountered in borings one-half mile or more west of the water plant but was found in borings north and east of the plant. Water-producing material found at depths as shallow as 100 feet below land surface was shown to be hydraulically connected with the material tapped by

Production Well 1. A more detailed account of the 1980 exploratory program is found in the 1980 report to General Development, "Exploratory Drilling and Testing at Port LaBelle, Florida, February-May 1980" prepared by Geraghty & Miller, Inc.

## PRODUCTION-WELL CONSTRUCTION

Persson Drilling Corporation of Fort Pierce, Florida was contracted by Geraghty & Miller, Inc. to install Production Well 2 near the location of Well 72-7, 300 feet north of Production Well 1. Drilling began on October 8, 1981 and proceeded as follows:

1. Drilled 6-3/4-inch-diameter pilot hole by mud rotary method to 310 feet below land surface. Representative formation samples were obtained during drilling of the anticipated production zone and sieved by a well screen manufacturer. The screen size, screen length, and slot opening was selected by Geraghty & Miller, Inc., based on the results of sieve analysis that are shown in Appendix A.

2. Reamed the pilot hole to 20-inch-diameter to 220 feet below land surface.

3. Installed 14-inch-diameter steel casing to 220 feet below land surface; cemented annulus from bottom upward.

4. Drilled 13-inch-diameter hole by mud-rotary method to 290 feet below land surface.

5. Installed 60 feet of 12-inch-diameter, pipe size, 0.035-inch slot, wire-wound stainless steel well screen to 278 feet below land surface (58 feet exposed); riser pipe and packer assembly extended upward to 209 feet below land surface; installed 5 feet of 12-inch-diameter, closed bottom steel casing as sump to 283 feet below land surface.

6. Developed.

7. Tested.

8. Finished well head.

The Geraghty & Miller, Inc. hydrogeologist prepared a geologic log during the drilling of the pilot hole. It is shown in Appendix B. When the pilot hole was completed, the bore was geophysically logged. Gamma-ray, electric, and caliper logs are presented in Appendix C.

The geologic and geophysical logs provide much information about hydrogeologic conditions beneath the water plant. The geologic log shows that sand, limestone, and shell were penetrated to a depth of 63 feet below land surface. The same zone is evident as a unit of high electrical resistance to a depth of 54 feet on the electric log, and by an oversized hole to a depth of 59 feet on the caliper log. The gamma-ray log shows that this zone contains material with high natural gamma radiation, probably phosphate, to a depth of 70 feet.

Between 63 and 110 feet below land surface, clay is dominant in the geologic log. Sandy clay was found between 110 and 185 feet deep. The high clay content is apparent as moderate natural gamma radiation levels between depths of 70 and 130 feet in the gamma-ray log, and as low electrical resistance between 54 and 174 feet deep on the electric log. The caliper log shows that the hole diameter had reduced slightly between 59 and 135 feet below land surface. This is characteristic of plastic clay. The medium- to coarse-grained sand found between 185 and 280 feet is apparent by its low natural gamma radioactivity between 150 and 285 feet on the gamma-ray log, and by high electrical resistivity between 180 feet and 300 feet of depth on the electric log. Increasing clay content reported below 292 feet on the geologic log is also shown as high natural gamma activity below a depth of 290 feet in the gamma-ray log.

## PERFORMANCE AND INTERPRETATION OF PUMPING TESTS

Two types of pumping tests were performed on Production Well 2; a step-rate test and a constant-rate test. The step-rate test was performed for two principal purposes: (1) to establish a suitable rate for the longer constant-rate test, and (2) to determine well-loss and formation-loss factors that can be used to predict drawdown in the well at any specified pumping rate. The constant-rate test was conducted in order to determine aquifer coefficients, water level response, and water quality as a result of pumping stress.

Step-Rate Test

Five pumping steps of approximately 30 minutes' duration were performed; each pumping step was followed by a 30-minute recovery period. The test is useful for predicting pumping levels at any rate and for comparing the efficiency of the well over time. The test data are shown in Table 1. To determine well-loss and formation-loss factors, a method proposed by Rorabaugh ("Graphical and Theoretical Analysis of Step-Drawdown Test of Artesian Well," American Society of Civil Engineers, December 1953) for step-rate test interpretation was used. First, the drawdown (s) between the start and end of each individual pumping step was determined. That value was divided by the pumping rate (Q) for that step. An assumed value for the formation-loss constant was subtracted from each s/Q value, and the logarithm of the calculated values were determined. These values were graphed against the logarithm of each pumping rate. A linear regression analysis of the data was performed, and a correlation coefficient was determined. By successive approximation, other values were assumed for the formation-loss constant, subtracted from the s/Q value, and the linear regression analysis performed again until a best-fit correlation coefficient was determined. An equation expressing drawdown after 30 minutes of pumping Production Well 2 at any constant rate is:

$$s = -0.033\ Q + 0.0258\ Q^{1.084}$$

This equation has a 98.85% correlation coefficient to the data.

The analysis could have been performed by calculating drawdowns at the end of each step as depth below the original static water level prior to the first pumping step. However, the suitability of the analysis and resulting equation lies in its ability to predict the drawdown after 30 minutes of pumping at any constant rate. The equation derived by this analysis is more suited to predicting the drawdown observed at the end of each step of the test, as well as the drawdown after 30 minutes of pumping in the constant-rate test. It is likely that, if the water level

Geraghty & Miller, Inc.

TABLE I

DATA COLLECTED DURING STEP-RATE
TEST OF PRODUCTION WELL 2
AT PORT LABELLE, FLORIDA
JANUARY 5, 1982

| Step | Pumping Rate (gallons per minute) | Static Depth to Water at Start of Pumping (feet below measuring point) | Depth to Water after 30 Minutes of Pumping (feet below measuring point) |
|---|---|---|---|
| 1 | 1823 | 9.36 | 37.24 |
| 2 | 1711 | 10.08 | 35.83 |
| 3 | 1500 | 10.40 | 32.24 |
| 4 | 1212 | 10.53 | 27.10 |
| 5 | 992 | 10.61 | 22.77 |

Note: Measuring point was 1.60 feet above land surface.

after each 30-minute recovery step were closer to the original static level, calculation of drawdown below the original static would have been more suitable for use.

Constant-Rate Test

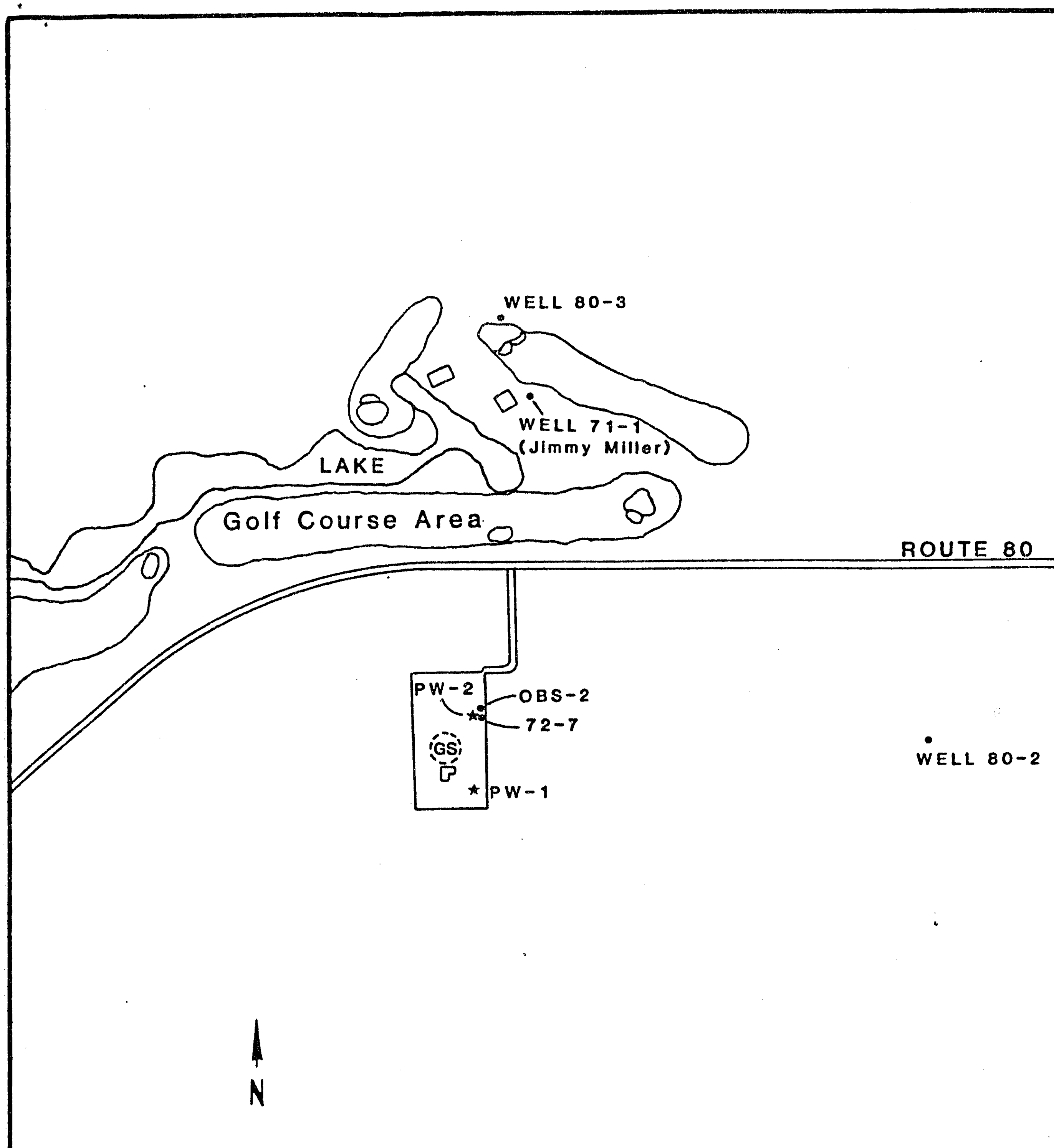
A constant-rate pumping test was begun on Production Well 2 on January 6, 1982 at 10:00 a.m. The test rate was 1669 gpm. Because Production Well 2 is located about 300 feet north of the Production Well 1, that well was turned off at 11:00 p.m. on January 5th so that the test results would not be affected by its use. It is possible to keep Production Well 1 off for several days at a time because the ground-storage tank at Port LaBelle contains much more water than is presently needed.

It was intended to pump Production Well 2 for one or more days. However, the diesel power unit failed after 21 hours and 15 minutes of pumping. Because it was determined that data collected to that time were sufficient for interpretation, the test was not restarted. After 4 hours of recovery, however, the well was repumped for one hour at the test rate in order to obtain a water sample.

The test layout is shown in Figure 1. Five observation wells were available for collection of water-level data during the test; water-level data were collected from the pumped well also. Dimensions of the wells are shown in Table 2. Test data are presented in Appendix D.

The Jimmy Miller Well had been screened at a much shallower depth than Production Wells 1 or 2. However, water-level records obtained from the U. S. Geological Survey (which operated a water-level recorder on this well for several years) indicated that the Jimmy Miller Well responded to pumpage from Production Well 1. It was concluded that the two screened zones were hydraulically connected. Data collected from this test confirmed that the screened zone in the Jimmy Miller Well was connected with Production Well 2 also.

Data from all wells were graphed on semilogarithmic graph paper. Data from the Jimmy Miller Well (71-1), and Wells 80-2 and 80-3 were graphed on double logarithmic graph paper. Data from Production Well 2, and Wells 71-1, 80-2, and 80-3 suggested that water levels were influenced by a hydrologic barrier boundary in the area. The test data were




PREPARED FOR

GENERAL DEVELOPMENT UTILITIES, INC.

TITLE

LOCATIONS OF PRODUCTION AND MONITORING WELLS

Near GDUI - Port LaBelle Water Plant

| | | |
|---|---|---|
| COMPILED BY T.L. Tessler | Geraghty & Miller, Inc. | DATE March 1982 |
| DRAWN BY P.Q. Smith | West Palm Beach, Florida | REVISED |
| CHECKED BY T.L. Tessler | SCALE 1 inch = 600 feet | FIGURE 1 |

TABLE 2

DIMENSIONS OF WELLS MEASURED
DURING CONSTANT-RATE PUMPING
TEST OF PRODUCTION WELL 2
AT PORT LABELLE, FLORIDA
January 6, 1982

| Well Number | Screened Interval (feet below land surface) | Distance to Pumped Well (feet) |
|---|---|---|
| P W 1 | 220 - 278 | 0.5 |
| 80-2 | 110 - 200 | 1860 |
| 80-3 | 110 - 200 | 1650 |
| 72-7 (OBS 1) | 273 - 276 | 14 |
| OBS-2 | 115 - 135 | 34 |
| 71-1 (Jimmy Miller) | 127 - 137 | 1350 |

interpreted based on the assumed presence of such a boundary. In fact, data from Well 80-2 suggested that a second barrier boundary had influenced water levels in that well. It was assumed also that the producing zone responds as an artesian aquifer with no source of recharge. The results of analysis are presented in Table 3. The results listed on the table are shown as being either "drawdown early" or "drawdown late". The former refers to analyses being performed on the data collected prior to the effect of the hydrologic boundary; the latter refers to analyses performed on data collected after the effect of the boundary. The term t/t' refers to the analysis of the recovery data. Based on this tabulation, the aquifer transmissivity is estimated as 240,000 gpd/ft., and the storage coefficient is estimated as 0.0004.

The assumption of no recharge to the aquifer is probably not strictly true. Observation Well OBS-2 was screened in clayey sediments above the water-producing zone tapped by Production Well 2. As shown in Appendix D, the water level in this well rose by nearly 0.1 feet initially in response to pumping. After about 2 hours, the water level declined at a slow but steady rate. This type of water-level response is observed commonly in leaky confining beds adjacent to artesian aquifers. Because data from the wells screened in the producing zone showed no sign of stabilization (leakage) within the test period, it is assumed that the previous method of analysis remained valid for the test period. The effect of leakage will be small in a short-term test, but will be greater under long-term stress.

The location of a hydrologic boundary west of the water plant site was estimated based on image-well theory as presented by Walton ("Groundwater Resource Evaluation", McGraw-Hill, 1970) and by Ferris and others ("Theory of Aquifer Tests", U.S. Geological Survey Water-Supply Paper 1536-E, 1962). The presence of such a boundary had been suspected based on previous geologic evidence. Based on image-well theory, the boundary is located approximately 1600 feet southwest of the water plant.

The presence of the boundary is significant because it shows that the aquifer tapped by General Development Utilities, Inc. is limited in extent. The productivity of wells located close to such a boundary is somewhat limited because, instead of being able to draw water radially for 360 degrees, they are limited to that water available within only about a 180-degree arc.

# TABLE 3

## RESULTS OF ANALYSES OF DATA FROM PUMPING TEST OF PRODUCTION WELL 2 AT PORT LABELLE, FLORIDA January 6, 1982

| Well Number | Data Interpreted | Method of Interpretation | Transmissivity (gpd/ft) | Storage Coefficient (dimensionless) | Distance to Image Well (feet) |
|---|---|---|---|---|---|
| 81-1 | Drawdown (early) | Jacob Mod. | 262,200 | ND | ND |
| | Drawdown (late) | Jacob Mod. | 119,100 | ND | ND |
| | Recovery (t/t') | Jacob Mod. | 224,800 | ND | ND |
| 71-1 | Drawdown (early) | Walton | 245,200 | 0.00036 | 3870 |
| | Drawdown (late) | Jacob Mod. | 128,800 | 0.00047 | ND |
| | Drawdown | Stallman | Same as Walton | Same as Walton | 4050 |
| 72-7 | Drawdown | Jacob Mod. | 129,600 | ND | ND |
| 80-2 | Drawdown (early) | Stallman | Same as Walton | Same as Walton | 4650 |
| | Drawdown (early) | Walton | 298,900 | 0.00030 | → 4650 (Image 1) |
| | Drawdown (early) | Walton | 298,900 | 0.00030 | → 10400 (Image 2) |
| | Drawdown (late) | Jacob Mod. | 128,100 | 0.00036 | ND |
| 80-3 | Drawdown (early) | Walton | 239,100 | 0.00043 | 4410 |
| | Drawdown (early) | Stallman | Same as Walton | Same as Walton | 4130 |
| | Drawdown (late) | Jacob Mod. | 128,800 | 0.00043 | ND |

Notes:

ND means "not determined".
Jacob Mod. means Jacob's modification of Theis equation.
Image 1 and Image 2 refer to the first and second suspected boundaries as shown in the data.

The presence of a hydrologic boundary to the southwest suggests that the aquifer presently tapped by GDUI is a linear feature trending northwest to southeast. A similar hydrologic boundary may be expected east or northeast of the test area. Although there is not yet any geologic evidence to verify its presence, the data collected from Monitoring Well 80-2 during the test suggests that the boundary is about 2 miles away. This will have to be confirmed by future drilling and testing.

The water sample obtained from Production Well 2 was analyzed by Orlando Laboratories, Inc., of Orlando, Florida for constituents regulated by the Florida DER and for those that affect treatability. Results are shown in Appendix E. The water was typically hard, and high in bicarbonates. Sulfate and chloride concentrations were low, as were iron, and nitrate.

## ESTIMATED CAPACITY AND PREDICTED IMPACT OF THE USE OF PRODUCTION WELL 2

The pumping test results and geologic conditions indicate that the aquifer is limited in its westward extent. A pump capacity and design pumping level have been estimated for this well by assuming that this well and two additional wells will be in service delivering a total of 9 mgd for 90 days. The additional wells are assumed for planning purposes to be 1000 feet north and 1000 feet east of the water plant. Production Well 1 will be a back-up well only at that time.

The new well can deliver 3 mgd (2082 gpm) with a pumping level referenced to mean sea level as shown below:

| | |
|---|---|
| Estimated land surface elevation: | +18.0 feet m.s.l. |
| January 1982 static depth to water: | - 6.9 feet |
| Seasonal fluctuation: | -3.0 feet |
| Interference from hypothetical wells 1000 feet north and east pumping 3 mgd each: | -40.2 feet |

| | |
|---|---|
| Self-induced drawdown from pumping this well at 3 mgd: | -41.6 feet |
| Estimated pumping level: | -73.7 feet m.s.l. |

Although short-term pumping tests at LaBelle have not shown any stabilization effects, water-level stabilization is likely to occur as a result of long-term pumping. Therefore, this is the maximum water level which is likely to occur under the assumed conditions.

If GDUI chooses, a lower capacity pump could be installed in the new well temporarily so that it could serve as a back-up well only. A 350-gpm capacity pump could be installed with a pumping level of +2.1 feet m.s.l.; a 500-gpm capacity pump could be installed with a pumping level of -1.1 feet m.s.l. The much larger permanent pump could then be installed when demand warrants.

Because of the absence of potential sources of contamination near the land surface, and because of the presence of extensive clay that serves as the upper confining bed overlying this aquifer, water from the Floridan aquifer appears to be the only threat to the water quality of Production Well 2. The Floridan aquifer poses a potential threat via two mechanisms.

The first threat is from upconing, that is from potential movement of water from the Floridan aquifer upward beneath major pumping centers. The depth to the top of the Floridan aquifer, the water quality at that depth, and the hydrogeologic conditions existing between it and the bottom of Production Wells 1 and 2 are presently unknown. The Floridan aquifer top is assumed to occur between 300 and 400 feet below land surface in the Port LaBelle area and to contain water of much higher salinity under greater hydraulic pressure. A confining bed is assumed to restrict the natural upward movement of this water.

The pilot hole of Production Well 2 was drilled into clayey material at 310 feet below land surface without encountering the Floridan aquifer. The clayey sediments may represent the upper section of the suspected confining bed. Although the water quality in Production Well 1 has remained stable throughout its operation, it is recommended that one monitoring well be drilled into the Floridan aquifer in the near future, prior to the development of larger quantities of water, so that its relationship to the aquifer tapped by GDUI can be determined.

A second threat to water quality is by lateral movement of Floridan aquifer water from abandoned wells tapping the aquifer in the area. Because of its high salinity, Floridan aquifer water is corrosive and tends to corrode steel or iron casing. Because of its higher natural hydraulic head, Floridan aquifer water tends to displace water under lower hydraulic pressure. Therefore, where abandoned wells tapping the aquifer are allowed to flow, are capped or improperly plugged, corrosion of the well casing can allow water to move into shallow aquifers and migrate toward production wells. Apparently, this occurred at one time in the town of LaBelle and resulted in the deterioration of water quality in the town's supply wells. So that this does not occur in Port LaBelle, all existing wells should be inventoried and those tapping the Floridan aquifer should be systematically plugged according to regulations.

## FUTURE TESTING AND MONITORING

The collection of additional information will be useful in protecting the productivity and water quality from GDUI's withdrawal. Further, when the water system is expanded, certain additional data will be required by the South Florida Water Management District before a new water-use permit can be issued.

The USGS (U. S. Geological Survey) has operated a water-level recorder on the Jimmy Miller Well for the past five years. This should be continued, and data should be provided to GDUI. If the USGS elects to discontinue this monitoring, then GDUI should continue it. If the Jimmy Miller Well is placed in production or a new production well is installed nearby, the recorder should be placed at another location. A continuous water-level record will help document water-level response as a result of increasing withdrawals.

The future water needs of Port LaBelle should be defined, and the aquifer should be further explored to determine if it can support the planned withdrawal. Exploratory drilling, geophysical surveys, and additional well testing are recommended. If it is determined that this aquifer cannot support the planned diversion, investigation of another aquifer or alternative water source should be pursued.

The relationship between the tapped aquifer and the Floridan aquifer should be determined by installing a Floridan aquifer monitoring well. Further, the following water-quality parameters should be determined for that well, and the same parameters should be monitored annually during the dry season from the production well that imposes the greatest stress on the aquifer - field pH, total dissolved solids, sodium, potassium, calcium, magnesium, chloride, sulfate, and total alkalinity.

Relative to the present two production wells, water samples should be obtained quarterly and analyzed for specific conductance, total dissolved solids, chlorides, and sulfates. Pumping rate, and static and pumping water levels should be measured in each production well annually (or semi-annually as usage increases) during short-term (one-half hour) pumping tests. These tests can be conducted by the operator. Data should be recorded and tabulated, and kept as a permanent record. Comparison of these data will aid water managers in determining when the wells need redevelopment or the pumps need service.

## ACKNOWLEDGEMENTS

The cooperation of the U. S. Geological Survey in operating the water-level recorder on the Jimmy Miller Well is appreciated. We appreciate the assistance provided by Ralph Goodwin (GDUI-LaBelle) and all of the employees of GDUI-Miami.

Respectfully submitted,
GERAGHTY & MILLER, INC.

Thomas L. Tessier

Thomas L. Tessier
Senior Scientist

June 24, 1982

# APPENDIX B

Geologic Log of
Production Well 2
General Development Utilities, Inc.
Port LaBelle, Florida

# GEOLOGIC LOG OF PRODUCTION WELL 2 PORT LABELLE

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| SANDS - Sand, 95%, light brown to cream, fine to medium grained, angular, clear, quartz; trace of organics. | 0- 6 | 6 |
| LIMESTONE AND SAND - Limestone, 85%, off-white, fine to medium grained, calcareous; Sand, 15%, incalcareous matrix. | 6- 7 | 1 |
| LIMESTONE AND SAND - Limestone, 75%, off-white, medium to fine grained, biomicrite, poor induration; Sand, 25%, fine to medium grained, round, quartz. | 7- 15 | 8 |
| LIMESTONE AND SAND - Limestone, 80%, light gray, medium to fine grained, biomicrite, poor induration; trace of loose shells; Sand, 20%, fine to medium grained, round to sub-round, quartz. | 15- 20 | 5 |
| LIMESTONE AND SHELLS - Limestone, 60%, light gray, fine to medium grained, biomicrite, poor induration; Shells, 35%, loose shells and shell fragments, coarse to medium grained, angular, calcareous; Sand, 5%, very fine to fine grained, round. | 20- 25 | 5 |
| SHELLS AND SHELL FRAGMENTS - Shell Fragments, 95%, off-white, granule to sand sized, calcareous; trace sand, fine to very fine grained, quartz. | 25- 30 | 5 |

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| SHELLS AND SHELL FRAGMENTS - Shells and Shell Fragments, 90%, off-white, granule to fine grained size, calcareous; Limestone, 5%, fine to medium grained, intraclast micrite; Sand, 5%, fine to medium grained, quartz. | 30- 35 | 5 |
| SHELLS, SHELL FRAGMENTS, AND LIMESTONE - Shells and shell fragments, 70%, light gray, granule-sized to fine-grained, calcareous; Limestone, 30%, fine to very fine grained, intraclast micrite, very soft, poor induration. | 35- 40 | 5 |
| LIMESTONE AND SHELL FRAGMENTS - Limestone, 70%, light gray, medium to fine grained, very hard, intraclast micrite, dolomitic; Shells and Shell Fragments, 30%, medium grained to granule sized, angular, calcareous. | 40- 43 | 3 |
| LIMESTONE AND SHELL FRAGMENTS - Limestone, 70%, dark gray, medium to fine grained, intraclast micrite, poor induration, soft; Shells and Shell Fragments, 30%, medium to coarse grained, loose, calcareous. | 43- 63 | 20 |
| LIMESTONE AND CLAY - Limestone, 50%, medium to fine grained, intraclast micrite, poor induration, soft; trace loose shells and shell fragments; Clay, 30%, green-gray, soft, pliable, silty to sandy. | 63- 85 | 22 |

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| CLAY - Clay, gray-green silty to very fine sand, soft, pliable | 85- 90 | 5 |
| CLAY AND SHELLS - Clay, 80%, gray-green silty, sandy, soft, pliable; Shell Fragments, 20%. | 90-110 | 20 |
| CLAY AND SAND - Sand, 60%, medium to very fine grained, clear sub-round, quartz; Sand, 20%, fine to medium grained, subround to round; Clay, 20%, gray-green, soft, pliable, silty. | 110-125 | 15 |
| CLAY AND SAND - Clay, 90%, gray-green, soft, pliable. | 125-126 | 1 |
| CLAY AND SAND - Sand, 80%, medium to fine grained, subround, quartz; Clay, 20%, gray-green, soft, pliable, silty; trace phosphate sand. | 126-130 | 4 |
| SAND AND CLAY - Sand, 75%, medium to fine grained, subround, quartz; Clay, 20%, gray-green, soft, pliable, silty; trace phosphate sand. | 130-135 | 5 |
| SAND AND CLAY - Sand, 95%, medium to fine grained, subround, quartz; Clay, 5%, gray-green, soft, pliable, silty; trace phosphate. | 135-140 | 5 |
| SAND AND CLAY - Sand, 95%, medium to fine grained, subround, quartz; Clay, 5%, gray-green, soft, pliable, silty; trace of calcareous shell fragments. | 140-170 | 30 |
| SAND AND CLAY - Sand, 85%, medium to coarse grained, subround to round; quartz. | 170-185 | 15 |

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| SAND - Sand, 100%, medium to coarse grained, subround to round, quartz; trace shell fragments. | 185-190 | 5 |
| SAND - Sand, 60%, medium to coarse grained, round to subround, quartz; Phosphatic sand; 10%, round to subround; Shell Fragments, 20%, coarse grained. | 190-200 | 10 |
| SAND - Sand, 95%, medium grained, round, grains, frosted, quartz; Sand, 3%, medium grained, round, phosphate; Sand and Shell Fragments, 2%, angular, calcareous. | 200-205 | 5 |
| SAND - Sand, 70%, medium to coarse grained, round, spherical, quartz; Sand, 20%, fine to medium grained, round, quartz; Sand, 7%, medium grained, angular, calcareous; Sand, 3%, medium grained, round, phosphatic. | 205-210 | 5 |
| SAND - Sand, 75%, coarse to medium grained, round, spherical, quartz; Sand, 15%, fine grained, round, quartz; Sand, 8%, medium to coarse grained, angular, calcareous; Phosphatic Sand, 2%. | 210-215 | 5 |
| SAND - Sand, 60%, medium grained, round, quartz; Sand, 10%, coarse grained, round, quartz; Sand, 20%, fine grained, round, quartz; Sand, 10%, coarse to fine grained, shell fragments, angular, calcareous. | 215-220 | 5 |

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| SAND - Sand, 40%, coarse grained, round, quartz; Sand, 20%, medium to fine grained, round, quartz; Sand, 20%, coarse to fine grained, angular, calcareous. | 220-225 | 5 |
| SAND - Sand, 45%, coarse grained, round, frosted, quartz; Sand, 45%, medium grained, round, frosted, quartz; Sand, 10%, coarse to medium, angular, calcareous. | 225-235 | 10 |
| SAND - Sand, 60%, coarse grained, round, frosted, quartz; Sand, 20%, medium to coarse grained, round, quartz; Sand, 15%, coarse to medium, angular, calcareous; Sand, 5%, medium grained, round, phosphate. | 235-245 | 10 |
| SAND - Sand, 45%, coarse to granular grained, rounded, frosted, quartz; Sand, 35%, coarse to granular grained, angular, calcareous; Sand, 20%, medium grained, round, quartz. | 245-250 | 5 |
| SAND - Sand, 50%, coarse pebbles to medium grained, round quartz; Sand, 20%, medium grained, round quartz; Sand, 20%, granular to medium grained, calcareous; Sand, 10%, medium grained phosphatic. | 250-255 | 5 |
| SAND - Sand, 85%, medium grained to coarse grained, round, quartz; Sand, 10%, medium grained, angular, calcareous; Sand, 5%, medium grained, round, phosphate. | 255-280 | 25 |

| Sample Description | Depth Interval (feet) | Thickness (feet) |
|---|---|---|
| SAND - Sand, 85%, medium to fine grained, round, quartz; Sand, 10%, medium grained, angular, calcareous. | 280-292 | 12 |
| CLAY - Clay, soft, pliable, silty to sandy; very fine sand. Amount of sand decreases with depth. | 292-310 | 18 |