**Stemle, Andersen & Associates, Inc.**

ENVIRONMENTAL & HYDROLOGIC CONSULTANTS

# FLORIDAN AQUIFER WELLFIELD DEEPENING
# PRELIMINARY HYDROGEOLOGIC REPORT

## FOR THE TOWN OF JUPITER WATER SYSTEM
## JUPITER, FLORIDA

prepared for:

Hutcheon Engineers Division of
Kimley-Horn and Associates, Inc.
4431 Embarcadero Drive
West Palm Beach, Florida 33407

December, 1994

prepared by:
Stemle, Andersen & Associates, Inc.
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Project Number
94-1001

12/7/94

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December 7, 1994

Mr. John Potts, P.E.
Hutcheon Engineers
4431 Embarcadero Drive
West Palm Beach, Florida 33407

**RE: Town of Jupiter Water System**
**Hydrogeologic Report for the**
**Floridan Wellfield Deepening Project**

Dear John:

It is our pleasure to forward with this letter, four copies of the Preliminary Hydrogeologic Report for the Floridan wellfield deepening project. The report ties in the new data from the construction of wells RO-5, RO-6 and RO-7 with the existing Town of Jupiter and Encon hydrogeologic information. I believe that the report sheds light on some nagging questions about the water quality in the floridan aquifer and I hope the Town will find the answers enlightening.

Thank you for your input and assistance providing background information and for graciously allowing me to use some of Kimley-Horn's resources. If you or the Town have any questions please don't hesitate to call me.

Sincerely,
**Stemle, Andersen & Associates, Inc.**

James L. Andersen, P.G.
Principal Hydrogeologist

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## 1.0 INTRODUCTION

This report presents a summary of the relevant geologic and hydrologic data pertaining to the Town of Jupiter Floridan Aquifer wellfields, Jupiter, Florida. Its purpose is to evaluate the feasibility of deepening the eastern wellfield (RO-1, RO-2, RO-3 and RO-4) to the depths penetrated in the new western wellfield (RO-5, RO-6 and RO-7) to take advantage of the higher productivity and better water quality present deeper in the Floridan Aquifer System. The locations of the wells are shown on the site plan, Figure 1.

## 2.0 HYDROGEOLOGY

To evaluate the hydrogeology underlying the project site area, the following consultant reports were reviewed: ViroGroup 1994 (construction of RO-5, RO-6 and RO-7); Geraghty & Miller, 1994 (construction of monitor well #1 at ENCON); Missimer & Associates 1992 (Future Water Supply Study); Geraghty & Miller, 1990 (construction of RO-4); Geraghty & Miller, 1990 (construction of RO-2 and RO-3). Additionally, data from South Florida Water Management District and US Geological Survey publications were also of use. A list of referenced publications is included in Section 5.0.

To provide background, a general discussion of the Floridan Aquifer System (FAS) hydrogeology beneath the site is given and the following section discusses the hydrogeologic relationships between the eastern and western Floridan wellfields. With the understanding that the geology of Florida is much like a "layer cake" with relatively continuous horizontal beds of sedimentary rock, correlation between wells would seem very strait forward. However, geologic formations can vary greatly in character within a small area, as do the interpretations by various geologists. Fortunately with the use of geophysical methods, characteristics of the rock not readily apparent to the geologist's eye, can be evaluated with less bias. Because each borehole has a distinct geophysical signature, geophysical logs are a useful tool in correlation.

### 2.1 Regional Geology

Sediments of the Surfical Aquifer, an important water resource to the Jupiter area, are not relevant to this report and are not discussed. Underlying the surficial sediments is the intermediate confining unit which separates and confines the Surfical Aquifer from the Floridan Aquifer System. The confining unit is continuous beneath the site and consists of the relatively impermeable

calcareous clays and silts of the Miocene aged Hawthorn Group. The predominantly clayey upper section of the of the unit is known as the Peace River Formation and where present, clays and limestones that underlie the Peace River are of the Arcadia Formation.

The sediments of the FAS underlie the intermediate confining unit. The lithologies are predominantly composed of interbedded limestone and dolomite. Six primary rock units comprise the upper and middle Floridan Aquifer System. From approximately 1000 feet beneath the site, in descending order are the Suwannee Limestone (Oligocene age); Ocala Group, Avon Park Limestone, Lake City Limestone, Oldsmar Limestone (Eocene age); and upper part of the Cedar Keys Limestone (Paleocene age). Within the aquifer system multiple good water producing zones (flow zones) exist which are semi-confined from each other by lower permeability strata.

### 2.2 Site Hydrogeologic Interpretations

Even though the eastern and western wellfields both are completed in the FAS, the two wellfields draw water from two essentially separate aquifers. To illustrate this, a cross section of the hydro-stratigraphic units penetrated by the wells is provided as Figure 2 (for the location of the wells see Figure 1). Also shown on Figure 2 are selected groundwater chloride data collected during the course of well construction and testing of the west wellfield (RO-5, RO-6, and RO-7) in 1994; and during testing of the east wellfield (RO-1 through RO-4) in 1992, (M&A 1992).

Using existing geophysical logs, primarily gamma, each well was plotted showing the depths of various geophysical correlation points which were found to be continuous in many, if not all of the wells. The points were then connected with lines to illustrate the geologic structure in cross section. From the geophysical

correlation lines, a fold or anticline is apparent with the axis of the fold near RO-7. The uppermost line (GP-1) represents the base of the Miocene aged Hawthorn Group, and the next underlying line (GP-2) represents the top of the Eocene aged Ocala Group. Using these formation contacts, the recorded depths were contoured and are shown on Figures 3 and 4, respectively. The contour maps illustrate the beds' dipping southwest and east of the anticline's axis (the axis is parallel to an imaginary strait line drawn between well RO-7 and the ENCON well site). Additionally, the axis of the anticline is gently dipping to the southeast.

The third geophysical correlation line (GP-3) corresponds to the top of the production zone in the western wellfield. The depth of this interval ranged from 1470 feet below land surface (bls) in RO-5 to 1340 feet bls in RO-7. With the exception of RO-6, the top of the production zone was consistently 355 feet below the top of the Ocala Group (GP-2) in the west wellfield and the ENCON monitor well. In RO-6 the distance was estimated to be 345 feet. Using this correlation, the top of the west wellfield production zone ranges between 1440 feet and 1600 feet bls at the east wellfield. These depths are illustrated on the cross section in relation to the existing open intervals. Table 1 summarizes the available well construction and geologic correlation data as well as the anticipated depths for well deepening at the east wellfield.

### 2.3 Static Heads in the FAS

To date, no concurrent set of static water levels has been collected from all the Town of Jupiter production and monitor wells penetrating the Floridan Aquifer System. However, based on available well construction data, there are considerable static head differences between the mid-FAS and upper-FAS. In 1990, during the construction of RO-2, RO-3 and RO-4 (Geraghty & Miller 1990, 1990), the static heads were reported to range from 27.50 to 29.75 feet above

land surface (which ranged from 12.2 feet to 14.4 feet above NGVD). As a result, the static heads in the upper FAS in wells RO-2, RO-3 and RO-4 ranged from approximately + 42.7 feet NGVD to 47.2 feet NGVD. Based on the construction and testing data from RO-5, RO-6, RO-7 and DZMW (ViroGroup, 1994), the static heads in the mid-FAS are estimated to range from + 48.2 feet NGVD to + 50.0 feet NGVD. At the same time the static head in the upper-FAS in the DZMW was estimated to be + 43.5 feet NGVD. (References to NGVD from wells RO-5, RO-6, RO-7 and DZMW are based on land surface elevations during well construction.) Although some differences in heads are expected due to water quality related density differences, the flow zone in the mid-FAS has static heads approximately 5 feet higher than that of the upper-FAS.

## 3.0 WATER QUALITY

To illustrate water quality at various locations across the site, selected dissolved chloride data are plotted on Figure 2. Chloride measurements collected during construction of the western wellfield and the ENCON monitor well are shown with respect to the sample collection depths (ViroGroup, 1994). The ENCON monitor well was installed to monitor water quality within the FAS below the base of the underground source of drinking water (USDW) as defined by the Florida Department of Environmental Protection (FDEP). Only selected data, representing trends, are illustrated. The open hole interval water sample in the ENCON well was analyzed as part of the well completion (G&M, 1994). Data collected at the well head of RO-1, RO-2, RO-3 and RO-4 are shown as rounded averages based on wellfield operations.

Upon reviewing Figure 2, several trends are evident:

1) A zone of better quality water exists just below the GP-3 correlation line and is apparently continuous beneath the western 2/3 of the wellfield area. The eastern wellfield does not penetrate this zone. It should be present beneath the eastern wellfield, however it dips steeply to the east with an estimated bottom depth of 1800 feet below land surface at RO-4. It is unknown if the GP-3 correlation zone (mid FAS flow zone) continues to dip steeply to the east beyond RO-4 and/or if water quality deteriorates significantly in that direction.
2) Water quality in the FAS improves in the vicinity of RO-7 and the ENCON MW. This area corresponds to the axis of the anticline (the highest elevation of the FAS beneath the area). Of the eastern wellfield, wells RO-2 and RO-3 are nearest to the axis of the anticline and produce consistently better water quality than from wells RO-1 and RO-4.

3) A relationship exists between permeability and water quality. Chloride concentrations are often lower in the more permeable zones, and higher in intervals of low permeability. The eastern wellfield producing zone (the upper FAS) has much higher permeability than that of the same zone in wells RO-5 and RO-6. During drilling of RO-5 and RO-6, chloride concentrations in the upper FAS ranged from 3360 mg/l to 4590 mg/l and maximum recorded formation flow rates were less than 200 gpm. Well RO-7 exhibited flow rates estimated greater than 1000 gpm in this interval and chloride concentrations ranged from 1970 mg/l to 2500 mg/l. This high permeability zone in RO-7, from 1110 feet bls, (and it's water quality), correlate to the flow zone reported by Geraghty & Miller (G&M 1990) that was encountered from 1200 feet in RO-3, below 1270 feet in RO-2 and below 1340 feet in RO-1 (RO-4 was not deep enough to encounter this flow zone). The reported permeability of the mid FAS production zone in western wellfield (wells RO-5, RO-6 and RO-7) was three to more than ten times greater than reported in upper FAS tapped by the eastern wellfield. Chloride concentrations of water samples collected at the wellheads of RO-5, RO-6 and RO-7 ranged from 1350 mg/l to 1980 mg/l.

4) The apparent base of the USDW in the FAS may not follow the stratigraphic features beneath the site, given the respective depths where water quality degradation was encountered in RO-5 and at ENCON. Either the base of the USDW is deeper than 1900 feet bls at RO-5 or locally the freshening trend apparent in the upper FAS in the vicinity of RO-7 may also occur with depth. Two data points are not sufficient to properly evaluate this situation.

From these conclusions, the better water quality found in areas of the eastern wellfield may be attributable to: **i)** Areas of better hydraulic connection that exist between the mid FAS and the upper FAS located along the RO-7 anticline

northward. The higher heads in the mid FAS would recharge the upper FAS through the better connected zones or by upward leakage through semi-confining layers. This is apparent because ambient water quality in the upper FAS is better near the anticline and degrades with distance away from it. or **ii)** Selected higher permeability zones within the FAS are better connected to their respective upgradient recharge source (in central Florida). This is apparently true in the mid FAS where the zone appears to be regionally extensive. or **iii)** Good water quality in the upper FAS is a result of the aquifer storage and recovery (ASR) testing that was conducted at the SFWMD C-18 canal water control structure years ago. Based on the new findings, it is unlikely that the results of the ASR test is currently a major factor governing water quality.

In summary, items i) and ii) may both be correct. Zones of good water quality in the FAS are the result of fresh water flushing. The former notion that elevated chloride concentrations are the result of salt water intrusion is overstated. A lack of "the flushing out" of connate water is a more likely cause of the high chlorides found in the upper FAS.

## 4.0 WELL DEEPENING CONSTRUCTION

We recommend proceeding with deepening the eastern wellfield, excluding RO-1, on a well by well basis. The project should be bid on one well only with change orders for up to two additional wells at the same unit costs. The bid will be on a unit price basis for all commonly required items; and that all bid items may not be required.

The first well to be deepened should be RO-3. Given the lower specific capacity of the well (16.1 gpm/ft, pumping 1300 gpm), casing off the existing open interval may not be required. The recommended total drilling depth is 1655 feet bls, as given on Table 1. The actual total depth will be based on water quality and flow data collected during drilling, geophysical logging and lithologic sample collection. Geophysical logging should include a flow test to evaluate the water contributions from the mid and upper intervals of the FAS. After completion of the testing it will be determined if installation of a liner (or other actions) will be required. Following completion of construction and well development, a step drawdown test will be conducted to evaluate specific capacity. During construction and testing, a formation water disposal system will be needed with the capability to handle average steady flow rates of 200 to 400 gpm during drilling. During development and step drawdown testing steady flows up to 3000 gpm, with short term peak flows up to 4000 gpm can be anticipated.

After the successful completion of well RO-3, deepening can commence on the next well. Because of the higher specific capacity and moderately good water quality in well RO-2, a liner may be necessary to receive the full benefit of the deepening. As in RO-3, the liner option will be evaluated at the conclusion of construction and testing of RO-2.

It should be noted that if the liner option is likely in well RO-2, then well RO-4 should be considered first because of the historical well construction and water quality problems. Additionally, the deepening in RO-4 will provide deeper water quality information at the eastern edge of the wellfield. Based on correlation data the deepening will penetrate to 1800 feet bls.

## 5.0 REFERENCES


Geraghty & Miller, Inc., 1990. Construction and Testing of Flordian Aquifer Wells RO-2 and RO-3 for the Town of Jupiter, Jupiter Florida. Consultants Report.

Geraghty & Miller, Inc., 1990. Construction and Testing of Floridan Aquifer Well RO-4 for the Town of Jupiter, Jupiter Florida. Consultants Report.

Geraghty & Miller, Inc., 1994. Construction and Testing of Deep Monitor Well #1, Loxahatchee River Environmental Control District Wastewater Treatment Plant, Jupiter Florida. Consultants Report, p. 4-6.

Lukasiewicz, J., 1992. A Three-Dimensional Finite Difference Ground Water Flow Model of the Floridan Aquifer System in Martin, St. Lucie and Eastern Okeechobee Counties, Florida. South Florida Water Management District Technical Publication 92-03.

Meyer, F.W., 1985. Hydrogeology, Groundwater Movement, and Subsurface Storage in the Floridan Aquifer System in Southern Florida. U.S. Geological Survey Professional Paper 1403-G.

Missimer & Associates, Inc., 1992. Town of Jupiter Future Water Supply Study Phase III; Floridan Aquifer Performance Test, Solute Transport Modeling and Impact Analysis, p. 15-19.

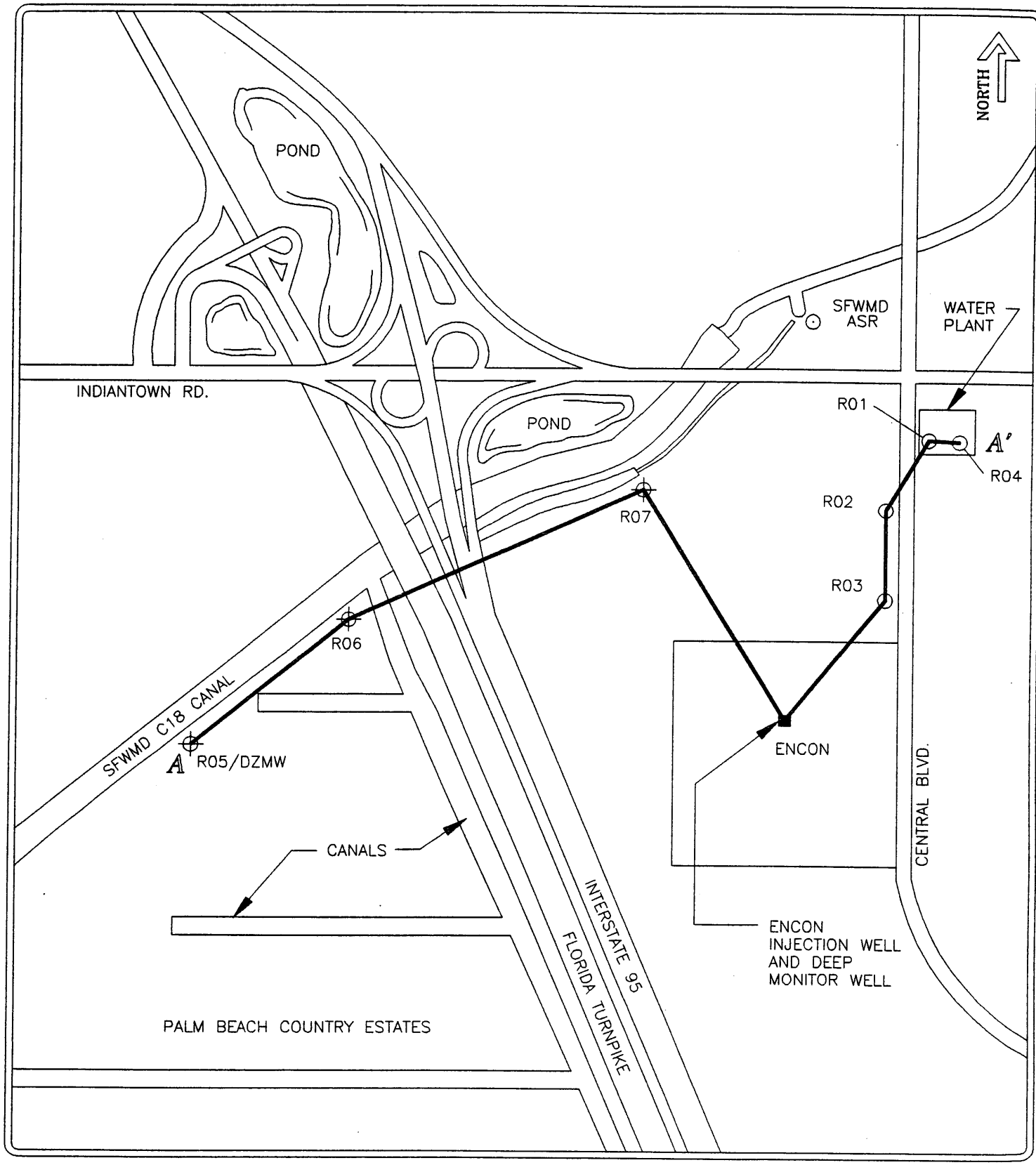
Mooney, R.T. 1980. Stratigraphy of the Floridan Aquifer System East and Northeast of Lake Okeechobee, Florida. S.F.W.M.D., Technical Publication #80-9.

Shine, M.J., D.G.J. Padgett, W.M. Barfknecht. 1989. Groundwater Resource Assessment of Eastern Palm Beach County, Florida. South Florida Water Management District Technical Publication 89-4.

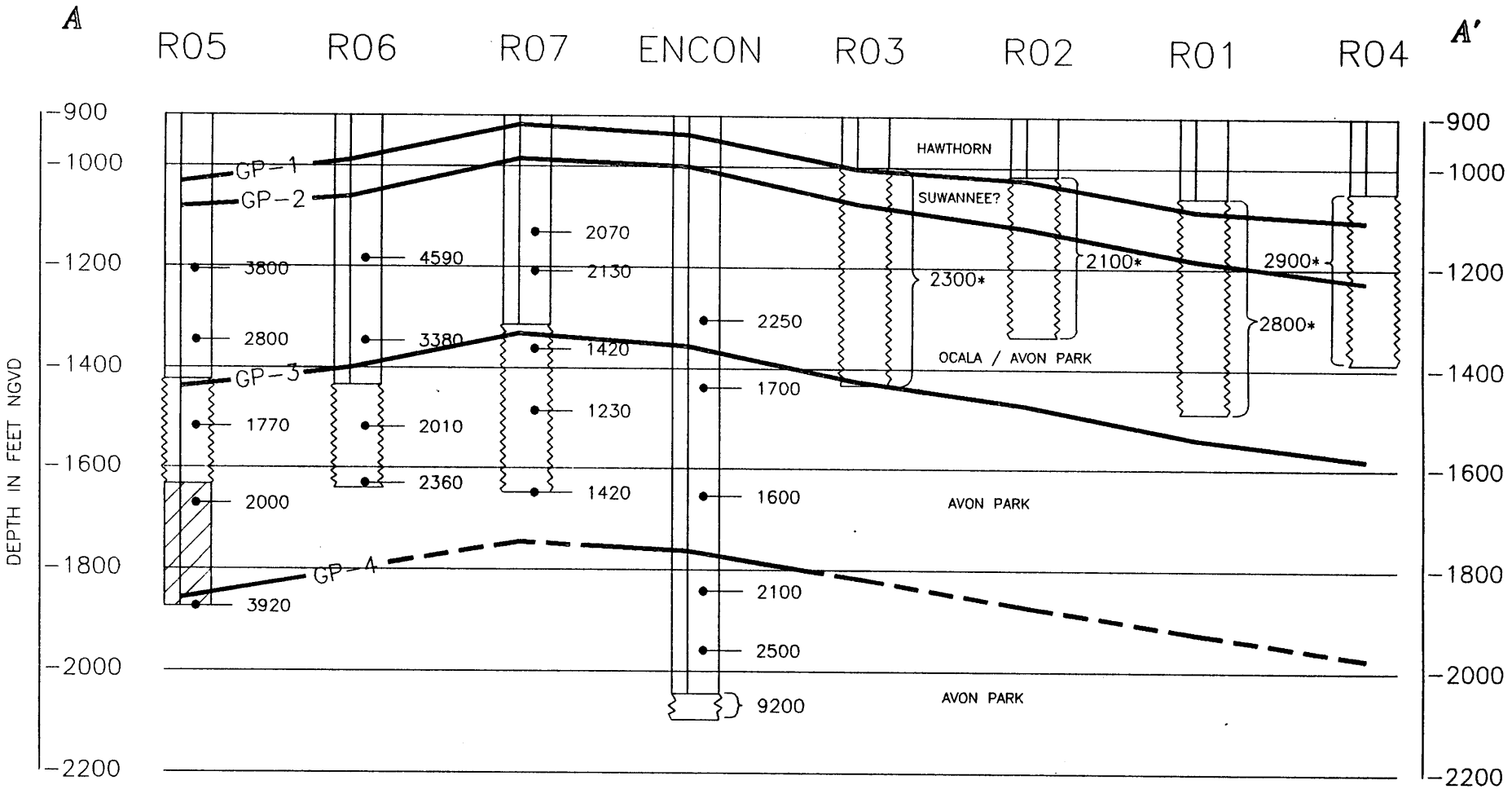
ViroGroup, Inc., 1994. Floridan Aquifer Wellfield Expansion Completion Report of Wells RO-5, RO-6, RO-7 and the Dual Zone Monitor Well at Site RO-5, for the Town of Jupiter Water System, Jupiter Florida. Consultants Report.

# APPENDIX A

FIGURES




| | | | |
|---|---|---|---|
| LEGEND: ⊕ NEW WELL LOCATION; ⊙ EXISTING WELL LOCATION | SCALE 1" = 1600' | STEMLE, ANDERSEN & ASSOCIATES | |
| PREPARED FOR: TOWN OF JUPITER WATER SYSTEM, HUTCHEON ENGINEERS | | DATE DRAWN: 12-6-94 | |
| FIGURE TITLE: SITE PLAN SHOWING LOCATION OF HYDRO-STRATIGRAPHIC CROSS SECTION | PROJECT NUMBER: 94-1001 | FIGURE NUMBER: 1 | |




UNITS ARE IN CHLORIDE CONCENTRATION IN MG/L OF GROUNDWATER SAMPLES COLLECTED FROM DEPTHS SHOWN.

(* ESTIMATED AVERAGE)

LEGEND: GP-1 GEOPHYSICAL CORRELATION POINT; WELL CASING; OPEN HOLE; GROUT

HORIZ. SCALE N.T.S.

STEMLE, ANDERSEN & ASSOCIATES

PREPARED FOR: TOWN OF JUPITER WATER SYSTEM, HUTCHEON ENGINEERS

DATE DRAWN: 12-6-94

FIGURE TITLE: WEST - EAST HYDROSTRATIGRAPHIC CROSS SECTION A - A'

PROJECT NUMBER: 94-1001

FIGURE NUMBER: 2

# APPENDIX B

TABLES

## TABLE 1

## WELL DEEPENING PROJECT DATA SUMMARY

### TOWN OF JUPITER WATER SYSTEM
### FLORIDAN AQUIFER WELLFIELD

| WELL NO. | WELL ELEV. (ft ngvd) | WELL DATA | | GEOLOGIC DATA | | | PROJECTED DEPTHS FOR WELL DEEPENING | |
|---|---|---|---|---|---|---|---|---|
| | | CASING DEPTH (ft bls) | TOTAL WELL DEPTH (ft bls) | BASE OF HAWTHORN GR. (ft bls) | TOP OF OCALA GR. (ft bls) | DEPTH TO TOP OF MFA PRODUCTION ZONE (ft) * | TOP OF MFA PRODUCTION ZONE (ft bls) | TOTAL DRILLING DEPTH (ft bls) |
| RO-1 | + 12.6 | 1073 | 1500 | 1100 | 1200 | NA | 1555 | 1755 |
| RO-2 | + 14.4 | 1032 | 1350 | 1040 | 1135 | NA | 1490 | 1690 |
| RO-3 | + 13.6 | 1017 | 1455 | 1020 | 1085 | NA | 1440 | 1655 |
| RO-4 | + 12.2 | 1065 | 1373 | 1130 | 1245 | NA | 1600 | 1800 |
| RO-5 | + 24.0 | 1451 | 1665 | 1055 | 1110 | 355 | --- | --- |
| RO-6 | + 23.5 | 1465 | 1660 | 1010 | 1080 | 345 | --- | --- |
| RO-7 | + 17.0 | 1330 | 1663 | 925 | 1000 | 355 | --- | --- |
| ENCON MW | + 18.0 | 2062 | 2107 | 955 | 1025 | 355 | --- | --- |

bls - below land surface GR. - Group MFA - mid floridan aquifer

Geologic data references are based on gamma log correlation points.

* - Depth to top of mid-floridan production zone from the referenced correlation point at the top of the Ocala Group.