FLORIDAN AQUIFER SYSTEM
TEST WELL PROGRAM
L-30N CANAL, MIAMI-DADE, FLORIDA
Technical Publication WS-17

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EXECUTIVE SUMMARY

The Lower East Coast Planning Area (LECPA) of the South Florida Water Management District (SFWMD) includes all of Miami-Dade, Broward, and Palm Beach counties, most of Monroe, and the eastern portion of Hendry and Collier counties. Water supply plans developed for the LEC (SFWMD, 1993, 2000) have identified the Floridan aquifer system (FAS) as a possible water supply alternative and have recommended it be further explored and characterized. Based on these recommendations, the SFWMD initiated (in 1991) a program of exploratory well construction, aquifer testing, and long-term monitoring to provide data needed to assess and model the FAS underlying the area. This program will supply information needed to characterize the water supply potential of the FAS and for use in the development of ground water flow models that will support future planning and regulatory decisions.

Six test sites were completed in three counties and documented in the LECPA under this exploratory well program (CDM, 1993, Lukasiewicz, 2001a, 2001b, 2003, and Bennett, 2001a, 2001c). **Figure 1** shows the locations of all test sites constructed within the SFWMD under this program. The focus of this report (WS-17) is the Miami-Dade exploratory well site located on the L-30N canal right-of-way. This site was selected as the southern most site for the exploratory well program.

This report documents the construction and testing of three FAS wells located at the L-30N site. The wells were constructed on the L-30N canal's northeastern right-of-way which runs parallel to SR-997 (Krome Avenue) and approximately four miles southwest of US 27 (Okeechobee Road). Coordinates for the pilot well (DF-5) drilled at the site are as follows: Latitude 255435.8, Longitude 802805.9. This site was selected to augment data available from other wells and to provide broad, spatial coverage within the SFWMD's LEC Planning Area. The purpose of the drilling and testing program was to assess the subsurface hydrogeologic and water quality properties in the FAS and to evaluate the potential of this aquifer as a water supply resource.

The SFWMD provided oversight during all well drilling, construction and testing operations for the three FAS wells. RST, Partnership, Inc. (RST) of Ft. Myers, Florida, was selected as the drilling contractor under contract C-3229 in September 1992. RST was responsible for all drilling, well construction, and testing services associated with the three FAS wells.

The scope of the investigation consisted of constructing and testing three FAS wells for use in an aquifer performance test (APT) and long-term monitoring. The first "pilot" hole (DF-1) was drilled to a total depth of 2,745 feet below land surface (bls). This pilot hole was extensively tested and ultimately completed as a middle Floridan aquifer test production well. A second well (DF-2) was completed in the upper Floridan aquifer as a test production well. The third well was a tri-zone monitor well (DF-3, 4, 5), completed into the mid-Hawthorn (DF-3), upper Floridan (DF-4), and middle Floridan (DF-5) aquifers, respectively.

The main findings of the exploratory drilling and testing program at this site are as follows:

- Surficial sediments extended from land surface to a depth of approximately 200 feet bls and the Hawthorn Group (upper confining unit) was found to extend from 200 feet to approximately 1,135 feet bls. A piezometer (DF-3) was open-hole completed across the interval between 516 to 620 feet bls in what appeared to be a somewhat permeable limestone. It was later tested and found to have very low specific capacity (1.9 gpm/ft), characteristic of the semi-confining nature of the Arcadia Formation in this area.

- The top of the FAS at this site was identified as 1,135 feet bls which is within the basal Arcadia Formation, 57 feet above the top of the Avon Park Formation. The uppermost significant flow zones in the upper Floridan aquifer were seen on the temperature and flow logs at 1,166 feet bls and at 1,200 feet bls. An aquifer performance test (APT) was run across the open-hole interval between 1,140 to 1,230 feet bls. Analysis of the time-drawdown data from this APT resulted in a transmissivity (T) of 53,280 gallons per day per foot (gpd/ft) and a leakance value of $1.35e^{-2}$ gpd/ft. Water sampled from this interval contained a total dissolved solids concentration of 3,460 milligrams per liter (mg/L).

- Another significant flow zone was found between 1,730 and 1,770 feet bls on the temperature and flow logs in the middle Floridan aquifer. An APT conducted on the interval between 1,700 to 1,800 feet bls resulting in a transmissivity of 32,716 gpd/ft and a leakance value of $3.84e^{-4}$ gallons per day per cubic foot. Water collected from this zone had a total dissolved solids concentration of 3,450 mg/L.

- The base of the Underground Source of Drinking Water (USDW) is characterized by a total dissolved solids concentration equal to or greater than 10,000 mg/L. It was identified at 2,139 feet bls using geophysical logs and reverse-air water quality analyses.

- The unadjusted mean water levels measured in the upper and middle Floridan aquifers of the tri-zone monitor well (DF-3, 4) during the period from November 2001 to May 2003 were +51.79 and 51.42 feet above the National Geodetic Vertical Datum of 1929 (NGVD), respectively.

- Water levels in the upper and middle Floridan aquifers fluctuated approximately 1.5 feet during the two year period of record and showed no appreciable upward or downward trend.

ACKNOWLEDGEMENTS

Special recognition is extended to Mr. Milton Paul Switanek who provided much of the well site supervision during construction and testing of the wells. Milton also assisted with developing several of the graphics used in this report.

The author would also like to thank those who reviewed this manuscript both internal and external to the District. External reviewers included: Ron Reese of the United States Geological Survey, Rick Green of the Florida Geological Survey, and William Pitt, Sr. Professional Engineer, Miami-Dade Water and Sewer Department. Internal (District) reviewers included: Ed Rectenwald and Simon Sunderland. The author also thanks Ms. Sorrel Hoover of Orion Consulting for patience, perseverance and technical editing expertise throughout this report compilation process. Thanks are extended to each of these professionals for their unique contributions. This document is a much more useful and organized tool thanks to their contributions.

During the well construction and testing phases, Mr. Robert Tinsely was a source of reliable, invaluable guidance and expertise. At the time, Mr. Tinsely owned and operated RST Partnership, Inc (the drilling Contractor). At the time of this writing, he’s with All-Webb’s Enterprises of Ft. Pierce. His expertise in the business of deep well drilling, testing and construction served this project well and the author is grateful to have had the opportunity to benefit and learn from him in the field.

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INTRODUCTION

Background

The South Florida Water Management District's (SFWMD) Lower East Coast Planning Area (LECPA) covers approximately 1,200 miles and includes all of Palm Beach, Broward, and Miami-Dade counties, most of Monroe, and the eastern portion of Hendry and Collier counties. A combination of natural drainage basins and political boundaries define the extent of this planning area. Water supply plans developed for the LECPA identified the Floridan aquifer system (FAS) as a possible water supply alternative. Based on these plans, three Floridan aquifer wells were constructed under a SFWMD contract (C-3229) in north-central Miami-Dade County. The site is on the L-30N canal's north-eastern right-of-way (ROW) which runs parallel to State Road 997 (Krome Avenue) and approximately four miles southwest of US Highway 27 (Okeechobee Road). One of the three wells was completed as a tri-zone monitor well (DF-3, DF-4, and DF-5). The wells are in Section 26 of Township 43 South, Range 36 East, geographic coordinates at Latitude 25^{o}, 54 minutes 36 seconds and Longitude 80^{o} north, 28 minutes 07 seconds. **Figure 1** shows this site in relation to other SFWMD sites drilled south of Lake Okeechobee in the 1990s as part of a program to characterize the FAS in south Florida. Reference numbers of the completed summary documents (technical publication numbers) are also given on this figure. The location of the L-30N site is identified on the map with an arrow as "Study Area." The wells in **Figure 1** were constructed to obtain hydrogeologic and water quality data from the FAS within the SFWMD's Lower East Coast (LEC) and Lower West Coast (LWC) planning areas.

Purpose

The purpose of this report is to document the hydrogeologic data collected during the SFWMD-initiated FAS well drilling, aquifer testing, and monitoring project at the L-30N site. Information from this and the other exploratory drilling projects (see **Figure 1**) will be used to assist in the conceptual development and calibration of a regional ground water flow model simulating the FAS. Such a model will be developed by the SFWMD and U.S. Army Corp of Engineers as part of the Aquifer Storage and Recovery (ASR) Regional Floridan Aquifer Studies project for the Comprehensive Everglades Restoration Plan (CERP). Information provided in this report includes a summary of: 1) well drilling and construction details, 2) site geology, 3) hydrogeologic testing, 4) water quality and 5) water levels.

Project Overview

SFWMD staff prepared the well designs and technical specifications, and provided construction oversight of the drilling contractor. RST Partnership, Inc. (RST), of Fort Myers, Florida was selected as the drilling contractor to construct and test the wells. SFWMD contract C-3229 was executed in September 1992. The scope of work for C-3229 included drilling and testing three independent exploratory well sites, one was the L-30N site and the other two were on the C-13 canal ROW in Broward County and on the C-51 canal ROW in Palm Beach County. Notice to Proceed was issued for the L-30N site in July 1993. Two shallow wells were constructed first (L30SAS1, L30SAS2) at the north and south ends of the drill site. Water from these wells was sampled and tested regularly for specific conductance while drilling at the site to ensure drilling fluids did not contaminate the Surficial aquifer. Pilot hole DF-1 was drilled, tested, and completed as a middle Floridan aquifer production well between August and November 1993. This was followed by construction and testing of the tri-zone monitor well (DF-3, 4, and 5) between December 1993 and March 1994. The final upper Floridan test production well DF-2 was constructed between April and June 1994. The contract included drilling, packer testing, geophysical logging, construction and installation of associated wellhead piping and appurtenances for all wells. A separate work order was issued to run two aquifer performance tests (APTs) at the L-30N site; those tests were performed in December 1996.

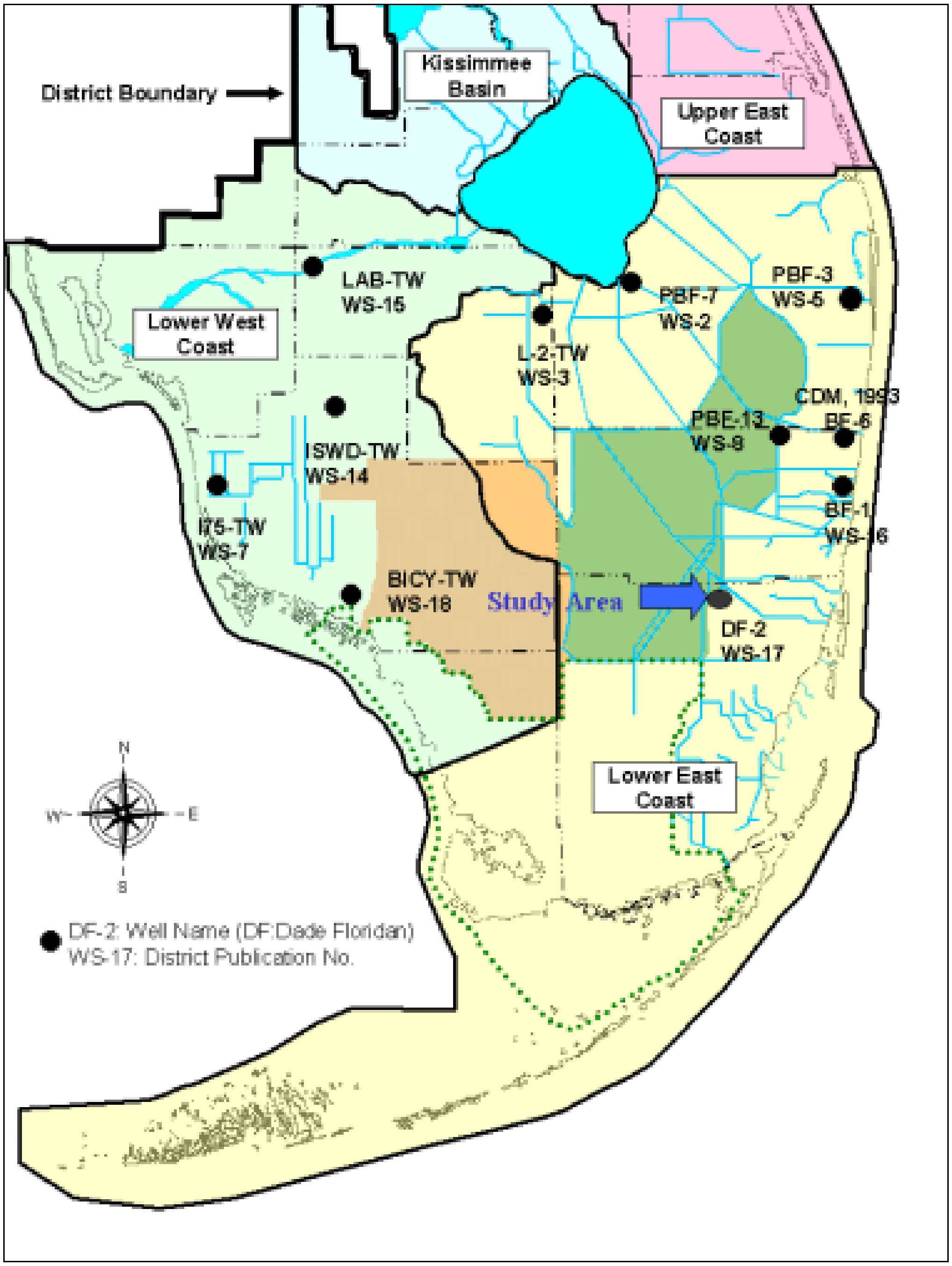

Figure 1. Location of SFWMD Exploratory Floridan Aquifer Wells Constructed and Tested in the 1990s South of Lake Okeechobee.

EXPLORATORY DRILLING AND WELL CONSTRUCTION

Three FAS wells were constructed on the eastern bank of the L-30N canal in north-central Miami-Dade County in late 1993 and 1994. The location of the wells are shown in **Figure 2**. The drilling schedule and well casing setting depths for each of the wells were designed to conform to site-specific hydrogeologic features. Data collected during construction and testing of the wells resulted in the interpretation of lithology, geophysical properties, water quality, water levels, transmissivity, storage and leakance coefficients corresponding to the producing zones within the FAS. The data were obtained from collection and description of drill cuttings, observations during pilot hole drilling, borehole geophysical logs, packer tests, and APTs.

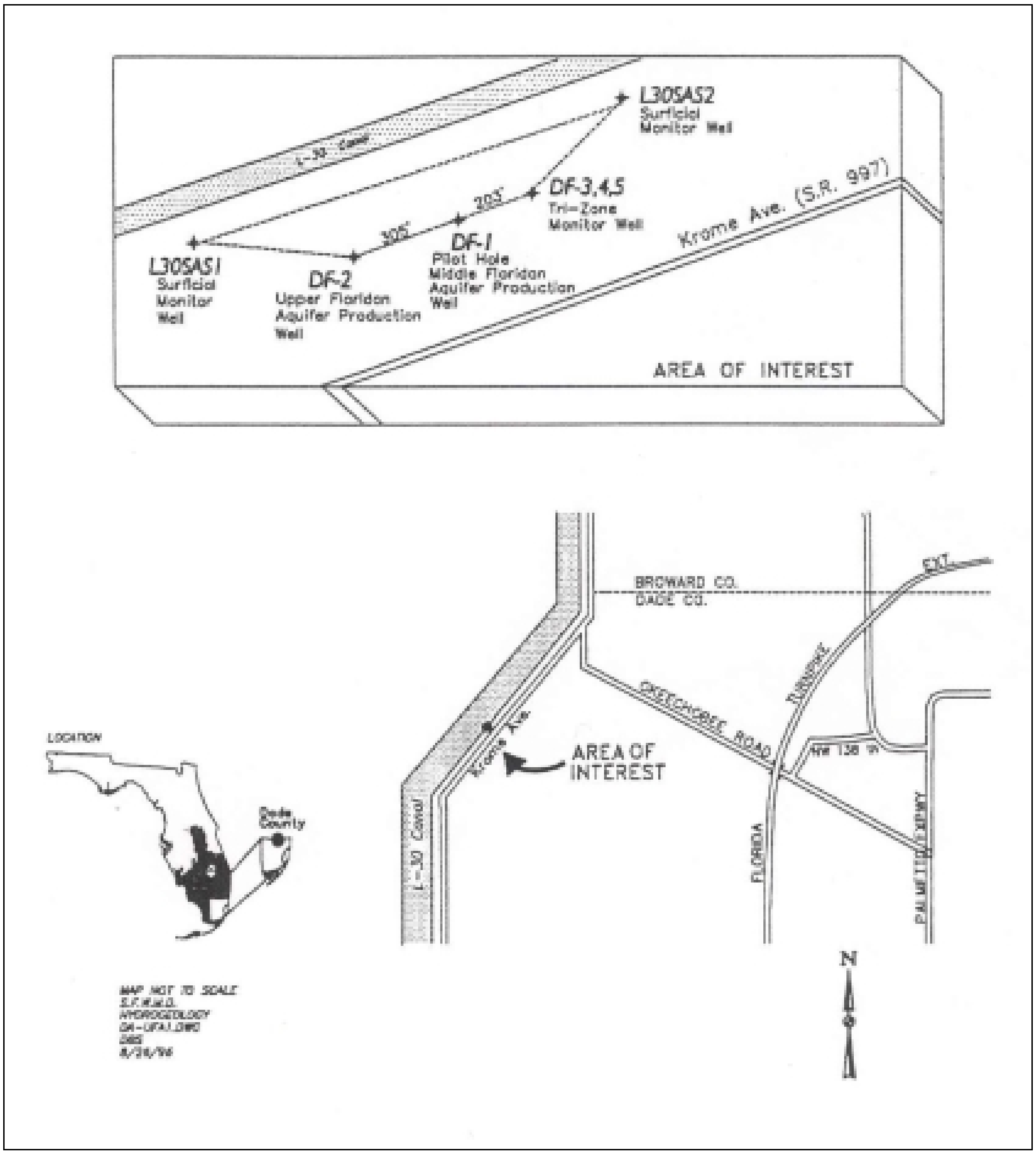

Figure 2. L-30N Site Location Map, Latitude 255436 Longitude 802806.

RST Partnership, Inc. was issued a Notice to Proceed under SFWMD contract C-3229 in July 1993 and began drilling in August with the rig positioned at well DF-1. DF-1, which stands for Dade-Floridan-1, is located on the north-east ROW of the L-30N canal between the water and Krome Avenue (SR-997). DF-1 served as the pilot hole, and ultimately the middle Floridan test production well at the site. It was drilled to a total depth of 2,745 feet below land surface (bls) and later back-plugged to a depth of 1,800 feet bls. Once completed, the rig moved 203 feet northeast to construct DF-3, 4, and 5, a tri-zone monitor well. Upon completion of the tri-zone well, the rig moved 305 feet southwest of DF-1 to drill DF-2, the uppermost Floridan production well. DF-2 was completed open-hole between 1,140 feet to 1,230 feet bls. The contractor demobilized from the site in July 1994. **Table 1** is a construction summary for each well on the site.

Well Name	Monitor Interval (feet bls)	Monitored Aquifer	Type Well	Completion Method
DF-1	1,700-1,800	middle Floridan	monitor	open hole
DF-2	1,140-1,230	upper Floridan	monitor	open hole
DF-3	516-620	mid-Hawthorne	monitor	annular zone
DF-4	1,140-1,230	upper Floridan	test production	annular zone
DF-5	1,700-1,800	middle Floridan	test production	open hole

Table 1. Well Construction Summary.

All wells were constructed using conventional closed-circulation mud rotary drilling through the Surficial aquifer and the upper confining unit, and reverse-air drilling through the FAS. All installed casings were made of steel and conformed to American Petroleum Institute (API) 5L or American Society of Testing Materials (ASTM) 53, Grade B standards. Casing centralizers were used for each string of steel casing. All cementing of casings conformed to State of Florida well drilling practices and to the American Water Well Association (AWWA) standards for deep wells (AWWA, A100-66).

SFWMD personnel supervised all drilling operations, casing installation and cementing, packer testing, water quality testing, geophysical logging, and APTs. Other technical support services were provided by Schlumberger (geophysical logging), Consolidated Hydro Technologies (geophysical logging), and Baker Corporation (packer testing).

The information collected during drilling of the pilot hole included lithology, water quality, static heads, transmissivity, storage coefficients, and vertical conductivity within the FAS. After construction, temporal water levels were recorded using a Campbell Scientific® (CR-10) recorder. The tri-zone monitor well has been incorporated into the SFWMD's regional monitor well network.

Drilling and Construction of DF-1

Construction of the exploratory FAS well DF-1 was initiated in August 1993 and completed in November 1993. Findings from this pilot hole were used to design the three remaining wells on the site. DF-1 was ultimately constructed as a middle Floridan aquifer test production well. The final well construction design is presented in **Figure 3.** DF-1 was drilled to a total depth of 2,745 feet bls. Geophysical logs, packer tests and lithologic cuttings were used to identify three production zones within the FAS. The reverse-air drilling method (with open circulation) was used to advance the borehole from 920 feet bls to total depth. Cuttings were collected and described at 10-foot intervals or at any significant change in lithology. The cuttings descriptions are provided in **Appendix A.** Water samples were collected and tested for specific conductance, chloride concentration and temperature during reverse-air drilling every 30 feet (end of drill rod) through the Floridan aquifer. Results are presented in the "***Hydrogeologic Testing***" section. A summary of the sequence of drilling, testing and casing runs is provided in the following sections.

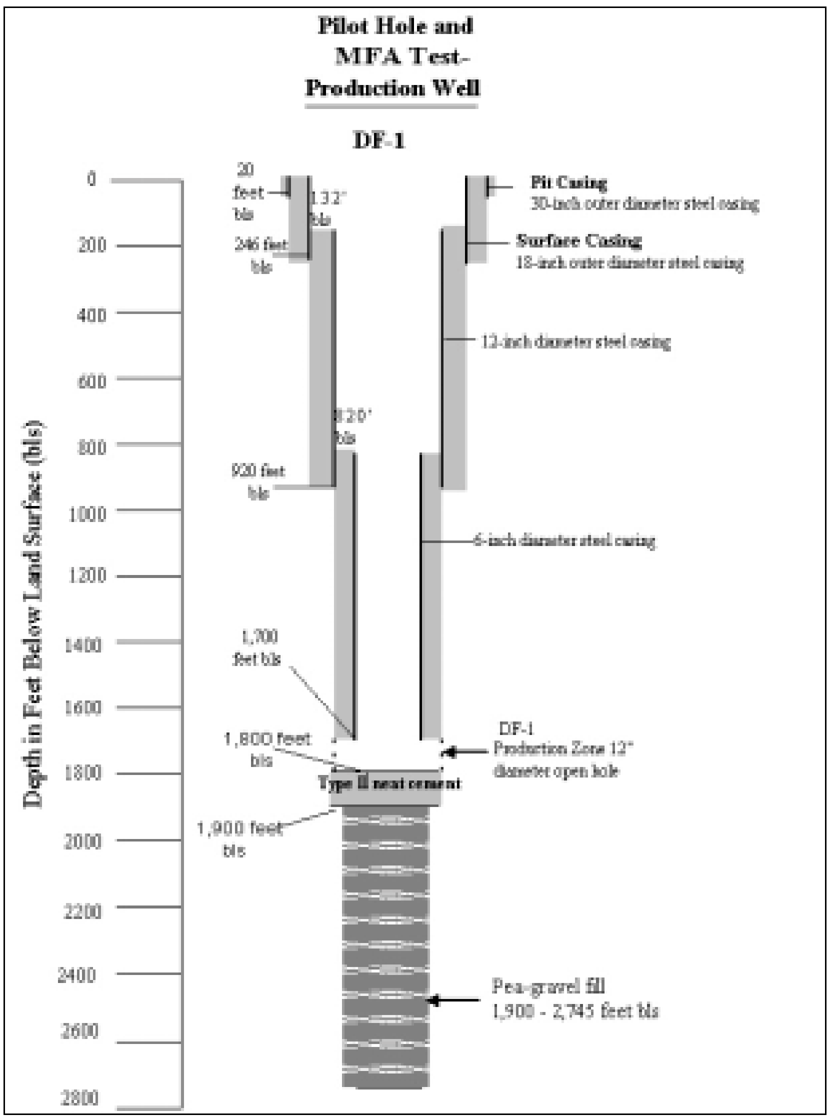

Figure 3. DF-1 Well Construction Diagram.

Steel Pit Casing

A pilot hole was advanced to a depth of 20 feet bls using a nominal 10-inch diameter bit by using the mud rotary method. This hole was then enlarged (reamed) using a nominal 36-inch diameter bit. Nominal 30-inch diameter steel pit casing was then installed from 0 to 20 feet bls. The annulus was pressure grouted to land surface using ASTM Type II neat cement. The purpose of the pit casing was to stabilize the ground beneath the drill rig during drilling operations. The SFWMD's on-site geologist collected cuttings in 10-foot intervals during drilling.

Surface Casing

A nominal 8-inch diameter drill bit then advanced the hole using the mud rotary method through the base of the Surficial aquifer system (SAS) and 46 feet into the upper confining unit to a depth of 246 feet bls. This pilot hole was then reamed using a nominal 22-inch diameter bit. A caliper log was used to calculate the volume of cement/grout required to fill the annular space. An 18-inch diameter steel casing was installed and the annulus pressure grouted to land surface using ASTM Type II neat cement. The purpose of this surface casing was to seal off the SAS and prevent inter-aquifer mixing while drilling through the deeper FAS.

Intermediate Casing

Following installation of the 18-inch diameter surface casing, mud rotary drilling using the nominal 8-inch diameter bit resumed to a depth of 950 feet bls (base of the upper confining unit and 185 feet above the top of the upper Floridan aquifer). Upon reaching 950 feet bls, drill pipe was removed from the borehole and geophysical logging performed. The interval between 246 to 920 feet bls was then reamed using a nominal 18-inch bit. A caliper log was run to verify borehole diameter for annular cement volume calculations prior to installing the 12-inch diameter steel casing from 132 to 920 feet bls.

A 12-inch diameter steel casing was then installed to a depth of 920 feet bls. The top of casing was not extended all the way up to land surface, but only to 132 feet bls. This was done to accommodate a larger diameter, high capacity pump, and to save on casing costs. To do this, the drill stem was used to hang the 12-inch diameter casing between 132 and 920 feet bls while ASTM Type II neat cement was pumped behind the 12-inch casing. The lowermost 400 feet of the annular space between casing and open-hole was pressure grouted using ASTM Type II neat cement. The remaining 388 feet of annular space was filled in stages with ASTM Type II neat cement. There was a minimum of eight hours setting time between each stage lift and then each lift was tagged using a 2-inch diameter steel tremmie pipe to ensure that the cement had risen and set as expected.

Pilot Hole Drilling and Testing

Once the intermediate casing was set, the drilling method was switched from closed circulation mud rotary to the open-circulation, reverse-air method. All cuttings were air-lifted over a shale shaker screen. Discharge water and the finer-grained cuttings were settled using a three-stage mud tank discharge system.

The pilot hole was advanced using a nominal 12-inch diameter bit and the reverse-air drilling method. Cuttings were collected every 10 feet and water samples every 30 feet during reverse-air drilling. Specific conductivity, temperature, and chloride concentration were measured in each of the water samples in the field**.** Reverse-air drilling continued to a total depth of 2,745 feet bls, which was 235 feet below the uppermost portion of the solutioned crystalline dolomites, marking the top of the lower Floridan aquifer (2,510 feet bls). The borehole was then air-developed until the discharge water was clear and free of particulates. The drill tools were then removed from the well and Schlumberger performed geophysical logging to a depth of 2,745 feet bls. The lithodensity, compensated neutron tool only got down to 1,950 feet bls due to an obstruction in the borehole. No readings from it were taken below this point. Geophysical and lithologic logs along with the site geologist's observations during drilling were reviewed and three intervals were selected to run packer tests. The "***Hydrogeologic Testing"*** chapter in this document summarizes the testing results at the site.

Production Casing

Once the packer tests were completed, the well was again air-developed until discharge waters were clear and free of particulates. Then the bottom 845 feet of the hole was backfilled with pea-sized gravel up to 1,900 feet bls. Type II neat cement was tremmie grouted above the gravel to form a 100 foot thick seal between 1,800 and 1,900 feet bls. After the grout cured, 100 feet of pea-sized gravel was tremmied into place above the cement seal to form a temporary seal across the open hole interval targeted by this well (1,700-1,800 feet bls). This temporary gravel provided a base for the final 880 feet of 6-inch diameter casing string to be lowered. Six-inch diameter casing was then installed, the base of which extended to 1,700 feet bls. The top of casing was extended to 820 feet bls, not to land surface to save on casing costs. To do this, the drill stem was used to hang a 980-foot long, 6-inch diameter casing string 820 feet bls. ASTM Type II neat cement was then pressure grouted into the annular space behind the 6-inch casing and was allowed to set for eight hours.

Once lowered, the casing was grouted into place with multiple cement lifts. A minimum of eight hours setting time was provided between each stage lift. When cement had adequately set, a nominal 4-inch diameter bit drilled out the basal 100 feet of pea-sized gravel. With gravel removed, the well was then air-developed until discharge waters were clear and free of particulates. Each lift was tagged using a 2-inch diameter steel tremmie pipe to ensure that the cement had risen and set as expected.

Wellhead Installation

An 18-inch diameter wellhead was then installed on the well. It consisted of an iron body, bronze-mounted valve with flanged ends, solid wedge gate, and outside screw and yoke gate valve. The area around the wellhead was finished off with a 4-foot by 4-foot by 6-inch reinforced concrete pad surrounded by a locked chain link fence. This well was utilized as a test production well during APTs and is currently inactive. A recent photograph, given on **Figure 4,** shows the recently replaced wellhead.

Figure 4. DF-1 (Middle Floridan Aquifer Well), *Photograph taken November 2003

DF-2: Upper Floridan Aquifer Well

The construction of DF-2 took place between April and June 1994. A well construction diagram is given in **Figure 5.** This well was designed as a test production well that would pump the upper Floridan aquifer (between 1,140 to 1,230 feet bls) during a subsequent APT. Three concentric steel casings (30-, 14-, and 8-inch diameter) were used in the construction of this well. RST first installed a 30-inch diameter steel pit casing to 20 feet bls. Mud rotary drilling then advanced a 30-inch diameter borehole to 230 feet bls. Drill pipe was removed from the well and a caliper log was run to calculate cement volumes for grouting operations. After logging, a 14-inch diameter steel casing was installed from land surface to a depth of 230 feet bls. The casing was then pressure grouted using ASTM Type II neat cement until cement returns were seen at the surface.

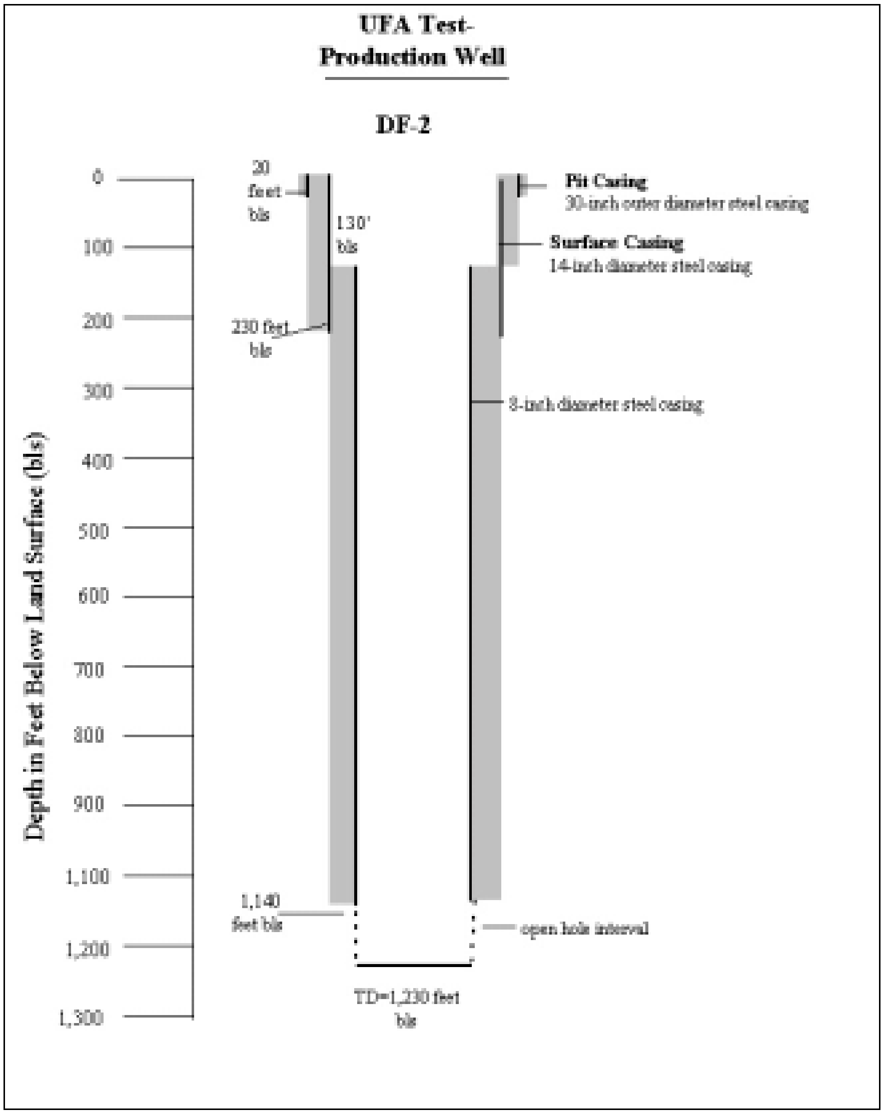

Figure 5. DF-2 Well Construction Diagram.

After setting the 14-inch diameter casing, a nominal 14-inch diameter drill bit advanced the borehole to the top of the upper Floridan aquifer production interval at 1,140 feet bls using the mud rotary method. A caliper log was then run before installing the 8-inch diameter steel casing. In order to save on casing costs and so the final well would accommodate a larger diameter and a high capacity pump, the upper portion of the 8-inch diameter casing was not extended to land surface. The drill stem was then used to lower the 8-inch casing into place from 130 to 1,140 feet bls. ASTM Type II neat cement was pressure grouted into the annular space behind the 8-inch casing and was allowed to set for 8 hours.

RST then cleared the borehole of mud and advanced the borehole with a nominal 8-inch diameter bit using the reverse-air method to a total depth of 1,230 feet bls. The well was then air-developed after drilling was complete until discharge waters were clear and free of particulates. RST completed construction of the well in June 1994.

Wellhead Installation

A 14-inch diameter wellhead was then installed on the well. It consisted of an iron body, bronze-mounted valve with flanged ends, solid wedge gate, and outside screw and yoke gate valve. The area around the wellhead was finished off with a 4-foot by 4-foot by 6-inch reinforced concrete pad surrounded by a locked chain link fence. This well was utilized as a test production well during an APT and is currently inactive. A recent photograph (see **Figure 6)** shows the recently replaced wellhead.

Figure 6. DF-2 (Upper Floridan Aquifer Well)

***Photograph taken November 2003**

DF-3,4,5: Tri-Zone Monitor Well

A tri-zone monitor well (DF-3, DF-4 and DF-5) was constructed between December 1993 and March 1994. A well construction diagram is given in **Figure 7.** This tri-zone monitor well was constructed for use in an APT and for long-term monitoring of three distinct hydrogeologic zones: the mid-Hawthorn interval (DF-3) between 516 and 620 feet bls, the upper Floridan aquifer (DF-4) between 1,140 to 1,230 feet bls, and the middle Floridan aquifer (DF-5), between 1,700 and 1,800 feet bls. The interval in the mid-Hawthorn between 516 to 620 feet bls was targeted with a piezometer because it appeared to be a somewhat permeable limestone. Permeability indicators included the loss of some drilling fluids while drilling through it and relatively pure limestone cuttings collected. This zone was later isolated and pumped, it yielded brackish water and had a low specific capacity of 1.9 gallons per minute per foot (gpm/ft).

Five concentric steel casings (30-, 18-, 12-, 6-, and 2-inch diameter) were used in the construction of this well. RST installed a 30-inch diameter pit casing to 20 feet bls and the annulus was grouted to land surface using ASTM Type II neat cement. Mud rotary drilling advanced a nominal 30-inch diameter borehole into the upper confining unit to 246 feet bls. A caliper log was then run to calculate the cement volume for grouting. Once completed, an 18-inch diameter steel casing was installed. The casing annulus was then pressure grouted using ASTM Type II neat cement from 246 feet bls to land surface.

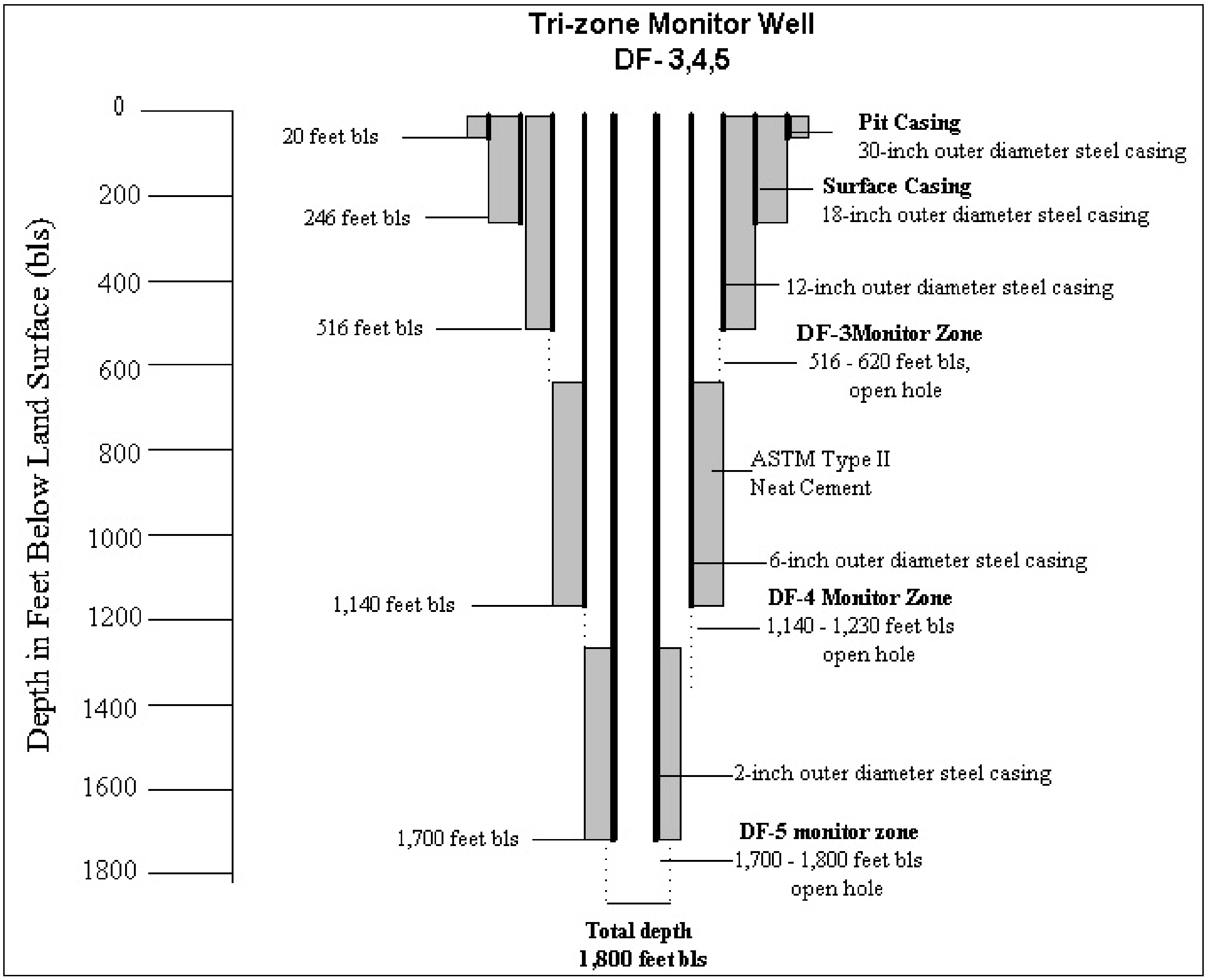

Figure 7. DF-3,4,5 Well Construction Diagram.

After setting the 18-inch diameter steel casing, a nominal 18-inch diameter bit advanced the borehole to the top of the Arcadia Formation (mid-Hawthorn) at 516 feet bls using the mud rotary method. A caliper log was then run prior to installation of 12-inch diameter steel casing from land surface to 516 feet bls and used to calculate the cement volume required to pressure-grout the casing in place. With a 12-inch diameter steel casing in place, a nominal 12-inch diameter bit advanced the borehole using the mud rotary method to the top of the upper Floridan aquifer production interval at 1,140 feet bls. A caliper log was run prior to installing a 6-inch diameter steel casing from 1,140 feet bls to land surface. ASTM Type II neat cement was then used to pressure and tremmie grout the annular space behind the 6-inch casing from 1,140 feet bls up to 620 feet bls. This resulted in an open-hole interval for monitoring between 516 to 620 feet bls.

With cement set, reverse-air drilling resumed using a 6-inch nominal bit to a depth of 1,800 feet bls. The drill bit was then extracted from the hole and a caliper log was run in the open-hole interval between 1,140 to 1,800 feet bls. The caliper was used to calculate the cement volume required to grout the casing in place. Grout was pumped through tremmie pipe with multiple lifts. The well was then air-developed thoroughly until discharge waters were clear and free of particulates. Then pea-size gravel was pumped through a tremmie pipe to fill the basal 100 feet of open-hole (1,700 – 1,800 feet bls). At this point, 2-inch diameter steel casing was set between land surface to 1,700 feet bls. ASTM Type II neat cement was then pressure grouted into the annular space behind the 2-inch casing between 1,700 to 1,230 feet bls. With 2-inch casing cemented in place, a 2-inch nominal bit was used to drill out the basal 100 feet of pea-gravel. At this point there was an open hole interval from 1,700 to 1,800 feet bls. The borehole was then air developed for several hours until all discharge water flowed clear. The 2-inch piezometer (DF-5) was completed in the middle Floridan aquifer.

Wellhead Installation

The Contractor installed three, 2-inch diameter, stainless steel extensions equipped with 2-inch inner diameter stainless steel ball valves to complete the wellhead for the tri-zone monitor well as shown on **Figure 8.** The completed telescoped-style well allows the SFWMD to monitor water levels and water quality in three distinct intervals. The uppermost monitor zone (DF-3) was constructed using a 12-inch diameter casing and completed with an open-hole interval between 516-620 feet bls in the mid-Hawthorn. The intermediate zone (DF-4) was constructed using 6-inch diameter casing and completed with an open-hole interval between 1,140 to 1,230 feet bls in the upper Floridan aquifer. The lowermost zone (DF-5) was constructed using 2-inch diameter casing and completed with an open-hole interval between 1,700 to 1,800 feet bls in the middle Floridan aquifer.

The Contractor developed the three monitor intervals by over-pumping and artesian flow techniques for several hours until discharge water flowed clear of particulates. The area around the wellhead was finished off with a 4-foot by 4-foot by 6-inch reinforced concrete pad and protected by a vandal proof bunker and chain link fence as seen in **Figure 9.** This well was utilized as a tri-zone monitor well during aquifer performance testing and subsequently added to the SFWMD's ground water monitoring well network in May 1995. In November 2001, because it was plugged off from the mid-Hawthorn and not functioning as designed, the uppermost piezometer (DF-3) was filled with cement. Further wellhead modifications are documented in the "***Water Levels"*** section in this report.

Figure 8. DF-3,4,5 Tri-Zone Wellhead.
***Photograph taken December 2001.**

Figure 9. DF-3,4,5 Tri-Zone Monitor Well Enclosure.
***Photograph taken August 2001.**

SITE GEOLOGY

Strata encountered during drilling of the pilot hole (DF-1) ranged in age from Holocene (most recent) to early Eocene (oldest). These lithostratigraphic units generally followed those recognized by Reese (1994), Fish (1988) and Reese and Cunningham (1999). The units, in descending order, are as follows: the undifferentiated Pleistocene series, the Ochopee Limestone (Pliocene), the Peace River (Pliocene-Miocene) and Arcadia Formations (Miocene-Oligocene), the Avon Park Formation (middle Eocene) and the Oldsmar Formation of early Eocene age. **Figure 10** presents a hydrostratigraphic summary of the site, including depths, lithostratigraphic unit, geologic age, and lithology. The stratigraphic interpretation was derived primarily from formation samples and geophysical logs collected in pilot hole DF-1. Cuttings were described twice, once by the SFWMD site geologist, then again by the Florida Geologic Survey (FGS), both sets of cuttings descriptions are provided in **Appendix A**. An electronic FGS version can be downloaded directly from FGS's Internet site at:

http://www.dep.state.fl.us/geology/gisdatamaps/litholog.htm.

Undifferentiated Pleistocene Series

From land surface to a depth of approximately 70 feet bls, the lithology consists primarily of white to tan and light orange oolitic limestone and sand of the undifferentiated Pleistocene series. The Pleistocene series consists of the Pamlico sand, Miami Limestone, the Anastasia Formation, and the Key Largo Formation (Fish, 1988). At 70 feet bls there was a noticeable change in lithology as the drill bit began to chatter and its penetration slowed. The lithology changed from a sandy, oolitic texture to a well indurated, harder limestone. From 70 to 200 feet bls, the lithology was primarily a mixed marine limestone, quartz sand, and sandy limestone. These deposits were identified as equivalents of the Pinecrest Sand and Ochopee Limestone members of the Pliocene Tamiami Formation.

Miocene

Hawthorn Group (Peace River and Arcadia Formations)

The Hawthorn Group, as defined by Scott (1988), is divided into two lithostratigraphic units. In descending order, they are the Peace River and Arcadia Formations. The Peace River Formation was defined as having a predominance of siliclastic material (Scott, 1988). At the L-30N project site, the Peace River Formation is a light olive gray, clay rich quartz sand, sandstone, and mudstone found between 200 to 500 feet bls. The Arcadia Formation was distinguishable at this site as a yellowish gray, low permeability calcilutite between 500 and 1,192 feet bls. The base of the Arcadia Formation is marked by a significant decrease of natural gamma emissions as evidenced on the gamma ray log in **Appendix B.** The top of the FAS was identified at 1,135 feet bls in the Arcadia Formation.

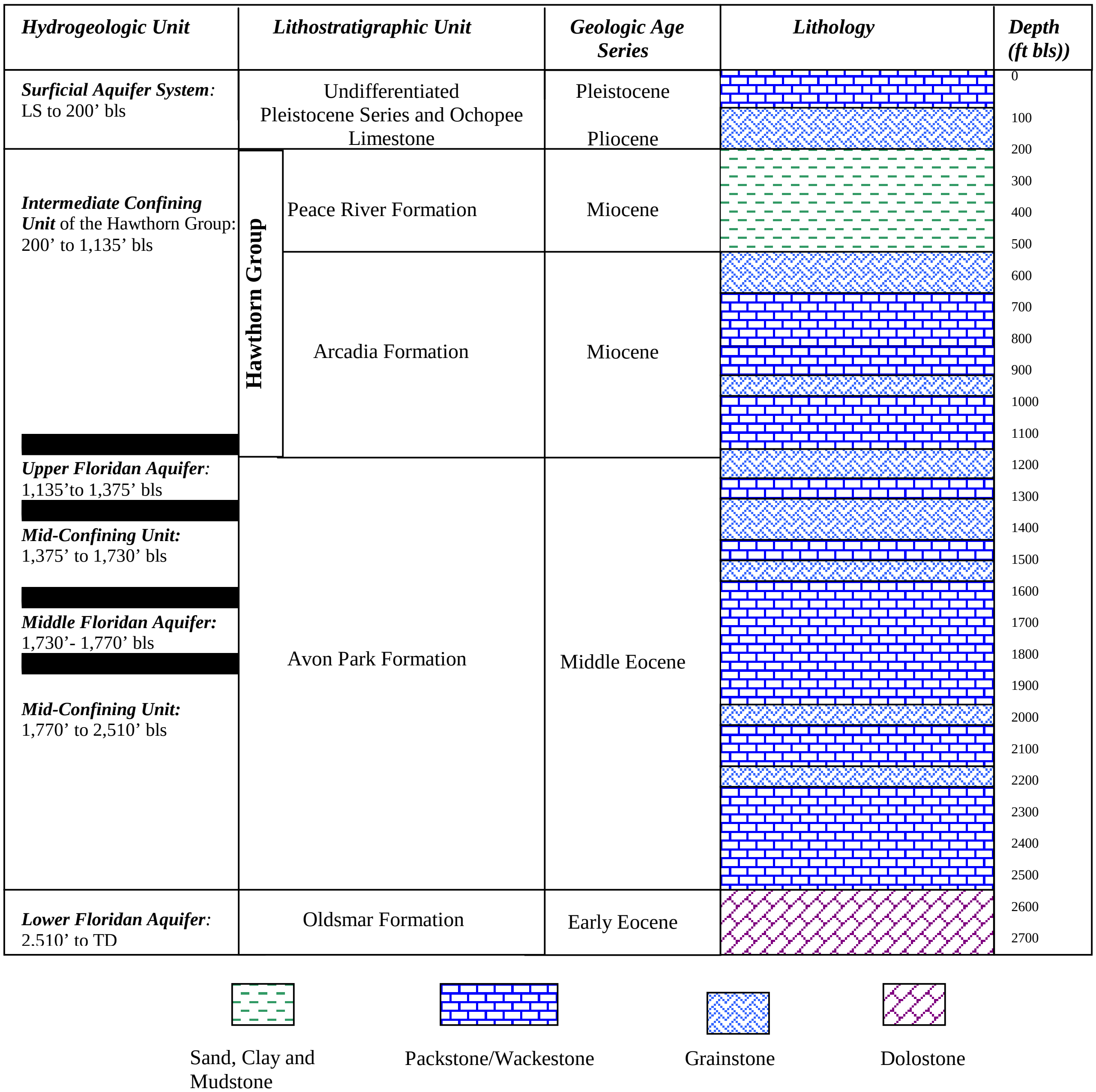

Figure 10. Hydrostratigraphic Summary Diagram.

Oligocene

Suwannee Limestone

The Suwannee Limestone (early Oligocene age) was not definitively identified at the site. It is generally described as white, tan, light brown, yellowish gray calcarenite (grainstone to packstone), with benthic foraminifera, crinoid stems, and mollusks as well as shell and phosphatic sand. The FGS cutting descriptions **(Appendix A)** make no mention of an occurrence of the Suwannee Limestone. This notable absence is probably based on an interpretation made using Scott's (1988) definition. Scott places the base of the Hawthorn Group at the base of the last occurrence of a sandy, variably phosphatic carbonate. Reese (review comments, March 2003) also places the phosphatic zone in the Hawthorn Group.

Upper Eocene

Ocala Limestone

The Ocala Limestone is not present in most of Miami-Dade and Broward counties (Miller, 1986) and was not present at the L-30N site. However, this geologic unit is present in western Broward, northernmost Monroe, northwestern Dade and Collier counties and reaches a thickness of 150 to 200 feet (Reese, 1994).

Middle Eocene

Avon Park Formation

The top of the Avon Park Formation was identified at 1,192 feet bls. The first occurrence of the benthic foraminifera *Dictyoconus sp*., an index fossil for the formation, was noted at 1,205 feet bls in the FGS cuttings descriptions (**Appendix A**). This along with faster drilling rates and abundant marine fossils provided evidence of an unconformity. The top of the rocks of Eocene age represent an unconformity in the study area. Generally this top can be readily determined using natural gamma ray geophysical logs and is closely associated with the top of the Floridan aquifer (Reese, 1994).

The Avon Park Formation is approximately 1,300 feet thick in the study area and is composed predominantly of micritic or chalky to fine-grained limestone with low permeability. This geologic unit is characterized as having relatively low natural radioactivity, generally less than 20 to 30 American Petroleum Institute (API) standard units on the natural gamma ray log. Total porosity can be as high as 50 percent at or near the top of the formation and gradually decreases with depth (Reese, 1994). The base of the Avon Park was identified in DF-1 as 2,510 feet bls.

Early Eocene

Oldsmar Formation

The top of the Oldsmar Formation is often difficult to identify because of a lack of diagnostic microfossils. It is predominantly comprised of micritic limestone in Broward County (Reese, 1994). The top of the Oldsmar in South Florida is often identified based on the presence of a hard, crystalline dolostone unit that generally occurs below a depth of 2,000 feet bls. This unit is identified on geophysical logs by increased gamma ray counts and higher resistivity values, both characteristics of dolomite. If these criteria are used, the Oldsmar could be identified at 2,510 feet bls at the site corresponding to the occurrence of a well indurated, crystalline dolostone.

SITE HYDROGEOLOGY

Two major aquifer systems underlie most of southeast Florida, the Surficial aquifer system (SAS) and Floridan aquifer system (FAS). The latter is the primary focus of this report and the field testing program. These aquifer systems are composed of multiple, discrete aquifers separated by low permeability "confining" units. **Figure 10** shows a generalized lithologic and hydrogeologic section underlying the L-30N site in northern Miami-Dade and southern Broward counties. **Figure 11** and **Figure 12** show the location of the L-30N site relative to nearby offset well sites in the area, as well as the cross-sectional line A-A'.

Surficial Aquifer System

The SAS extends from land surface to a depth of 200 feet bls at the site. It comprises all materials from the land surface to the top of the intermediate confining unit. These materials are primarily sandstone, sand, shell, clayey sand, and cavity-riddled limestone ranging in age from Pleistocene to Holocene. The top of the system may be considered to be land surface. Sediments of the SAS have a wide range of permeability, and locally may be divided into one or more aquifers separated by less permeable or semi-confining units. The Biscayne aquifer is the best known and contains the most permeable materials of the SAS. Another permeable unit, the gray limestone aquifer, can be found underlying the site. Reese and Cunningham (1999) mapped the top of this limestone at approximately 120 feet bls and interpolated it to be 50 feet thick at the L-30N site. The gray limestone thins to the east and ultimately pinches out near the Florida Turnpike. Since the focus of this exploratory drilling was the Floridan aquifer, the individual permeable portions of the SAS were not tested or identified in detail.

Intermediate Confining Unit

Below the SAS lies the intermediate confining unit, which was identified between 200 and 1,135 feet bls, and is 935 feet thick at the site. The intermediate confining unit varies in thickness from about 600 to 1,050 feet in Miami-Dade County (Reese, 1994). The geologic units of the intermediate confining unit generally include the Peace River and Arcadia Formations of the Hawthorn Group. The lithology of the intermediate confining unit is variable and includes clay, silt, fine sand, sandstone, siltstone, and limestone. A piezometer (DF-3) was open-hole completed across the interval between 516 to 620 feet bls in what appeared to be a somewhat permeable limestone. Permeability indicators included the loss of some drilling fluids while drilling, rapid drill bit penetration and relatively pure limestone in the return cuttings. This zone was later isolated, pumped and found to have very low specific capacity (1.9 gpm/ft), characteristic of the semi-confining nature of the Arcadia Formation in this area.

Floridan Aquifer System

The FAS is defined as a vertically continuous sequence of permeable carbonate rocks of Tertiary age that are hydraulically connected in varying degrees (Miller, 1986). It ranges in thickness from 2,500 to 3,000 feet in southeastern Florida. The top of the FAS was identified in the basal part of the Arcadia Formation at 1,135 feet bls based on the uppermost occurrence of flow into the borehole while drilling using the reverse-air method. The portion of the FAS drilled, tested, and described at the L-30N site includes permeable units of the basal Arcadia Formation, the Avon Park Formation and the Oldsmar Formation.

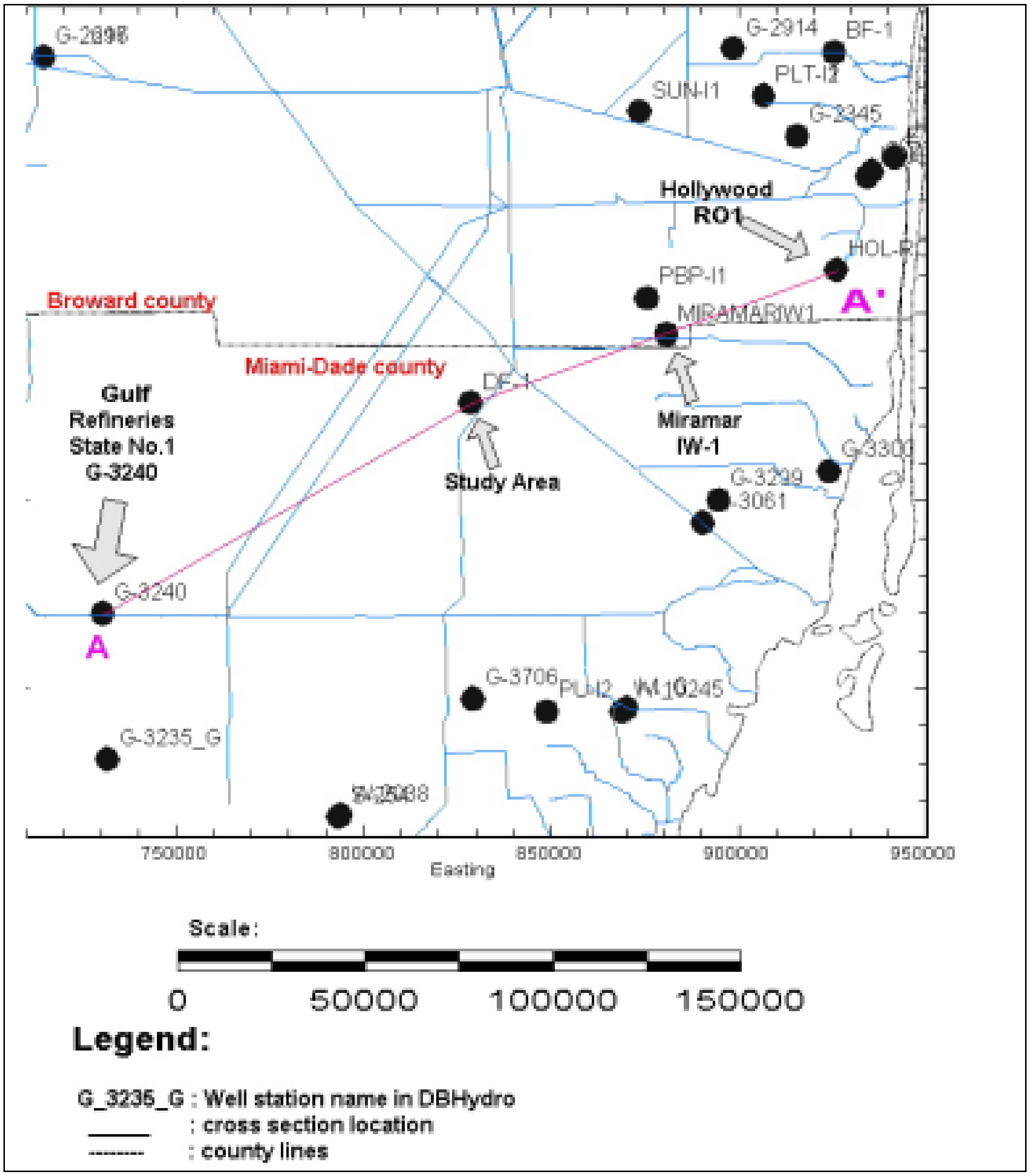

Figure 11: Location of L-30N Study Area Relative to Nearby Wells and Cross Sectional Line A-A'.

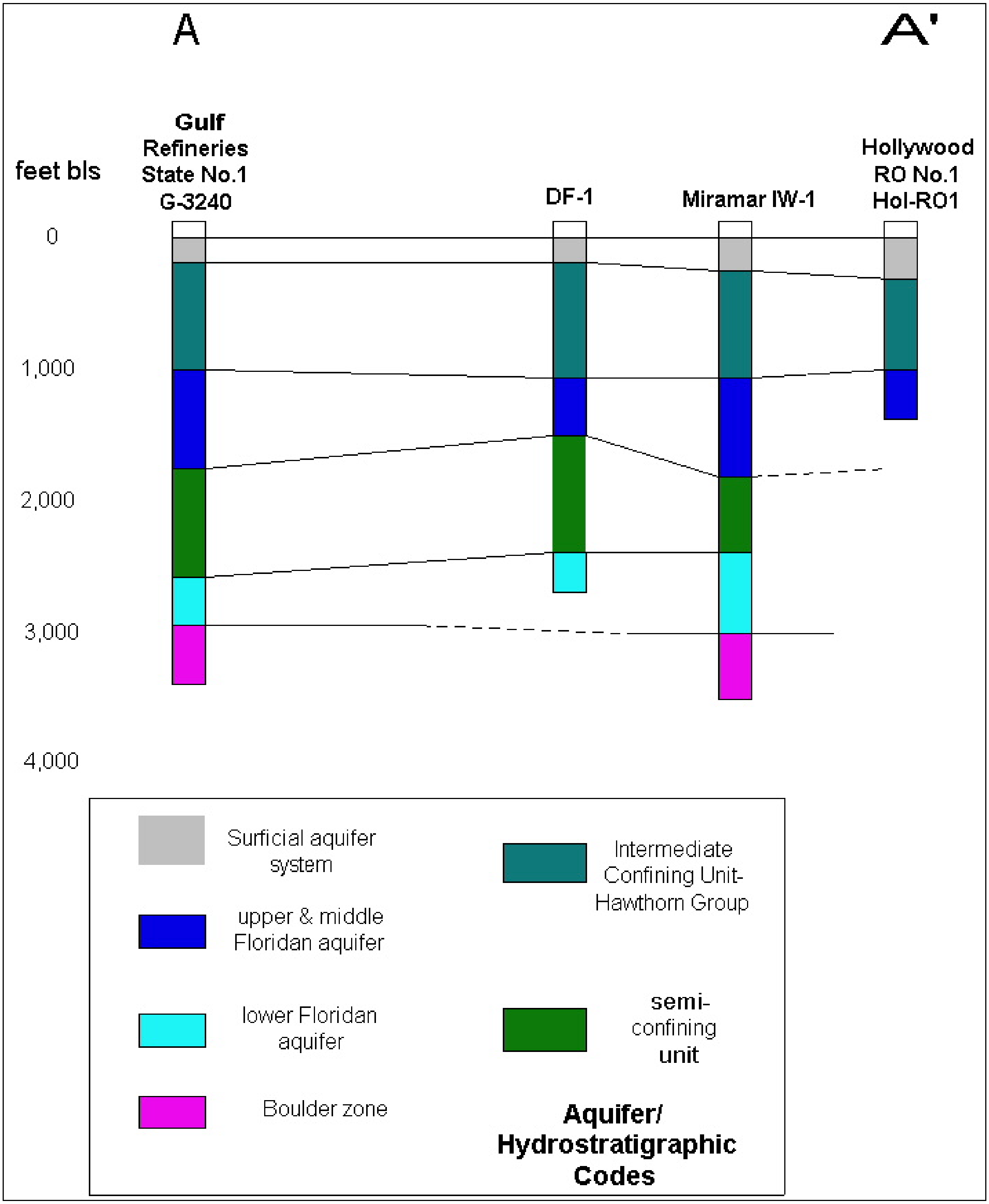

Figure 12. Hydrogeologic Cross Section.

The FAS can be divided into three hydrogeologic units: the upper Floridan aquifer, the middle semi-confining unit, and the lower Floridan aquifer (Reese, 1994). Discrete flow zones at the site were identified using information garnered from drilling characteristics, cuttings descriptions, geophysical logs (primarily flow meter, temperature, caliper, resistivity, and downhole video logs), packer tests, APTs, and water quality variations with depth. This combined information provided for a comprehensive picture of the system described below.

Upper Floridan Aquifer

The top of the FAS, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) coincides with the top of a vertically continuous, early Miocene to Oligocene-aged permeable carbonate sequence. The upper Floridan aquifer in south Florida consists of thin, high permeability water-bearing horizons interspersed with thick, low permeability units of early Miocene to middle-Eocene age sediments, including the basal Arcadia Formation, Suwannee and Ocala Limestones, and the Avon Park Formation.

The top of the FAS at this site was identified as 1,135 feet bls which is within the basal Arcadia Formation, 57 feet above the top of the Avon Park Formation. Two additional, much stronger flow zones were seen on the temperature and flow logs between 1,166 feet bls and at 1,200 feet bls. These two flow zones overlie the Avon Park Formation in the section and are characterized by grey and tan, crystalline and coarse grained limestone with abundant marine fossils (crinoids, gastropods, coral, shell molds).

The interval between 1,140 and 1,230 was pumped (APT No. 1) at a rate of 435 gallons per minute (gpm) resulting in a transmissivity of 53,280 gallons per day per foot (gpd/ft). The concentration of total dissolved solids in water recovered was 3,460 milligrams per liter (mg/L). Other evidence observed through these two flow zones included:

- Spinner (flow) log increased from 3.5 to 9 rotations per second (rps);
- a large temperature increase (1.5^{o} Fahrenheit (F)) on the temperature log;
- evidence of solution cavities on the borehole caliper log (1,100 to 1,200 feet bls);
- drill bit hopping and variable penetration rate between moderate to fast, and;
- artesian formation water flow into the borehole during reverse-air rotary drilling began slowly at 1,135 feet bls then picked up to 150 gpm at 1,230 feet bls.

Additional flow zones were identified between 1,300 and 1,370 feet bls in the upper Floridan aquifer. Flow was not particularly strong across these intervals and was only detected on the temperature log as a 0.2^{o} F increase each. Since flow zones appear somewhat randomly through this part of the Floridan aquifer and are not easily correlated (Reese, 1994), it is difficult to distinguish where the upper Floridan aquifer ends and where the middle confining unit begins. The base of the upper Floridan aquifer was identified at 1,370 feet bls at the site based on the flow logs which indicate flow stops entering the borehole below this point.

Middle Floridan Aquifer

The top and bottom of the middle Floridan aquifer was found at 1,730 and 1,770 feet bls, respectively. Here, the temperature climbed substantially, 1.1 ^{o} F on the log. Both a packer test and an APT were run across this flow zone and both provided evidence of moderate permeability and flow. The test results are summarized in the "***Hydrogeologic Testing"*** section of this report.

Middle Semi-Confining Unit

The middle semi-confining unit was identified between approximately 1,375 and 2,510 feet bls at the site. This interval is composed primarily of low permeability packstones and grainstones and sandwiches the middle Floridan aquifer. No other flow zones were identified below 1,800 feet bls in the semi-confining unit. The base of the Underground Source of Drinking Water (USDW) (10,000 mg/L total dissolved solids (TDS)) was found at 2,139 feet bls as seen on the dual-induction log in **Appendix B.**

Lower Floridan Aquifer

Reese (1994) used the occurrence of thick beds of crystalline dolomite as a marker for the top of the lower Floridan aquifer, which is placed in the Oldsmar Formation. This dolomite and the top of the lower Floridan aquifer were identified at 2,510 feet bls in the pilot hole. Between 2,510 and 2,640 feet bls, the bit penetrated alternating layers of crystalline dolomite and limestone (packstone). Some of the dolomite in this section exhibited solution features associated with flow zones. The lower Floridan aquifer was moderately permeable as evidenced by:

- The sonic and caliper logs showed small, abrupt increases in borehole diameter indicative of solution features. These increases occurred between 2,574 and 2,576 feet bls and 2,593 and 2,594 feet bls;
- conductivity of recovered reverse-air water quality samples increased from 13,300 to 30,900 millimhos (mmhos) as recorded in drill rod changes at 2,557 and 2,588 feet bls, respectively; and,
- a packer test pumped at a rate of 64 gpm between 2,565 and 2,640 feet bls resulted in a corrected specific capacity of 30.5 gpm/ft and TDS concentration of 34,200 mg/L.

Below 2,640 feet bls is predominantly limestone (packstone) with some dolostone to the total depth of the well. No additional flow zones were detected below 2,640 feet bls. Although the well terminated at 2,745 feet bls, the Oldsmar Formation probably extends down another 900 to 1,000 feet (Reese, 1994). The Boulder Zone (local name) contains massively bedded cavernous or fractured dolomite of high permeability and dense, recrystallized dolomite of low permeability. In nearby wells, the Boulder Zone occurs at the base of the Oldsmar Formation and was not penetrated at this site.

HYDROGEOLOGIC TESTING

The SFWMD collected information during the drilling and testing program to determine the lithologic, hydraulic, and water quality characteristics of the FAS at the site. The formation testing program included lithologic examination, observations while drilling, geophysical surveys, packer tests, APTs, water quality sampling, and water level measurements.

Formation Fluid Sampling

Water quality samples were collected while reverse-air drilling DF-1 through the FAS at approximately 30-foot intervals from 1,008 feet bls to the total depth of the pilot hole at 2,745 feet bls. A Hydrolab multi-parameter probe measured field parameters on each sample, which included temperature, specific conductance, and pH. A field titration method (Hach® Kit) measured field chloride concentrations. Where samples were brought back to the lab for analyses, SFWMD staff collected filtered and unfiltered water samples directly from the discharge point. Samples were then preserved and immediately placed on ice in a closed container and transported to the SFWMD's water quality laboratory. The samples were then analyzed for major ions using Environmental Protection Agency (EPA) and/or Standard Method Procedures (SFWMD, Comprehensive Quality Assurance Plan, 1995).

A graph of chloride concentrations and specific conductivity as a function of depth is presented on **Figure 13**. Results of the water quality analyses are listed in **Table 2**. Chloride concentrations from reverse-air samples collected at the top of the open-hole interval (between 978'-1,160' bls) had higher chloride concentrations than water sampled directly below it (4,280 mg/L vs 1,560 mg/L, respectively). Chloride concentrations remained relatively consistent (approximately 1,500 mg/L) between 1,195 to 2,100 feet bls. Between 2,100 and 2,340 feet bls, chloride concentrations increased gradually (from 1,550 to 2,058 mg/L). And between 2,371 and 2,557 feet bls chloride concentrations increased to approximately 5,000 mg/L before ultimately jumping to 15,000 and 20,000 mg/L at the bottom of the well (2,745 feet bls).

Geophysical Logging

Geophysical logging was conducted in the pilot hole after each stage of drilling and before reaming the boreholes for casing installations. The resulting logs provide a continuous record of the physical properties of the subsurface formations and their respective fluids. These logs were later used to assist in the identification of lithology and flow zones and to provide estimates of permeability, porosity, and bulk density of the Floridan aquifer. In addition, they were used to determine the resistivity profile of the formation water. The extent of confinement of discrete intervals can also be discerned from the individual logs. **Table 3** lists the formation evaluation logs, their physical characteristics, and properties measured.

Schlumberger was contracted to run the primary set of geophysical logs across the entire open-hole section of the FAS in DF-1. These were run directly after reverse-air drilling in a water filled borehole and included: caliper, natural gamma ray, spontaneous potential, dual induction, acoustilog, compensated neutron and density, flowmeter, temperature, and fluid resistivity logs. The lithodensity, compensated neutron logging tool only made it down to 1,950 feet bls where it encountered an obstacle in the hole, which it could not squeeze past. Geophysical log traces for several of the logging runs were digitized and are included as **Appendix B**. Original geophysical logs are archived at the SFWMD while the digital traces are available through the SFWMD's on-line corporate database (DBHydro) Browser at the following Internet address:

http://sonar.sfwmd.gov:7777/pls/dbhydro_pro_plsql/show_dbkey_info.main_page.

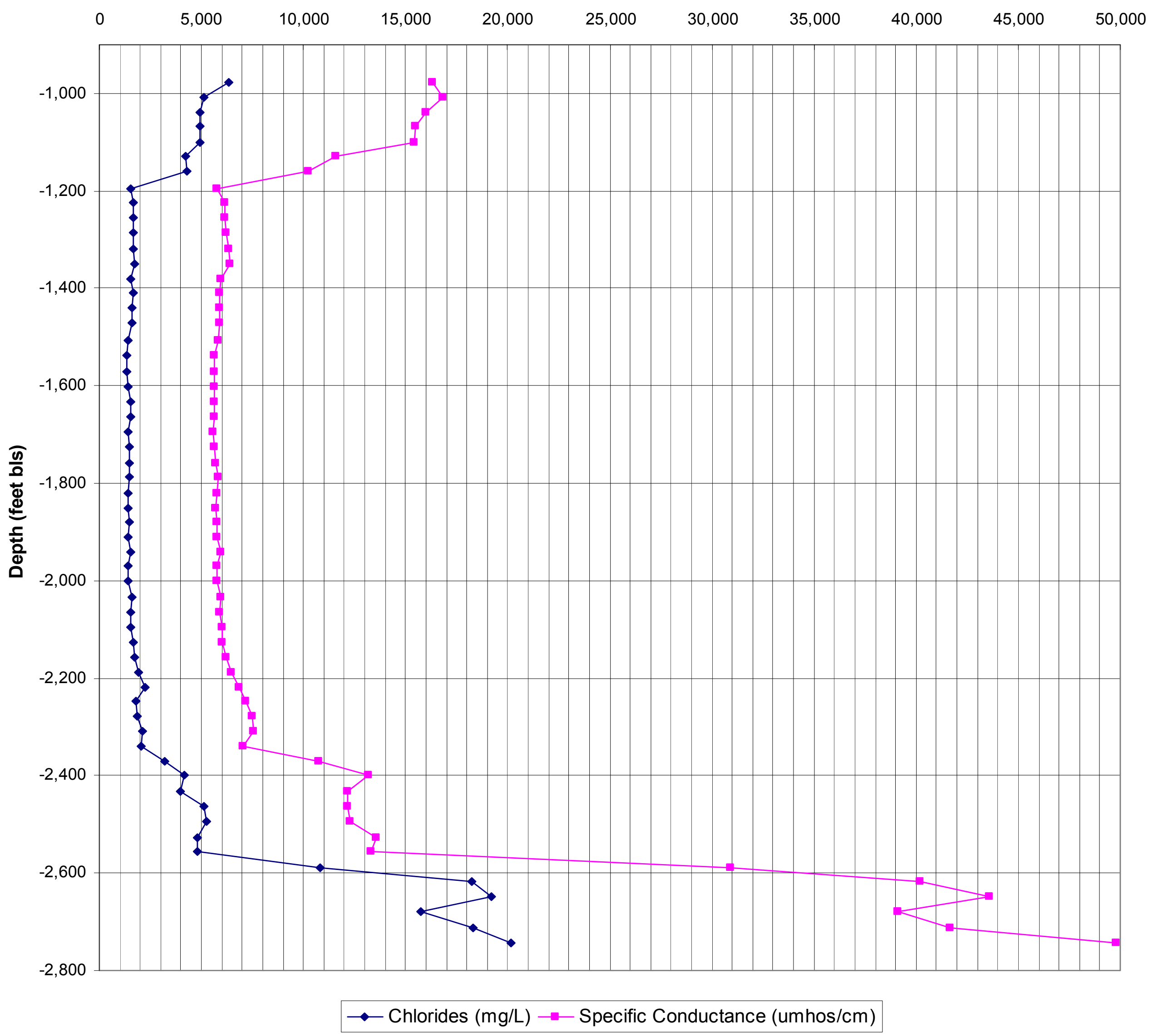

Figure 13. Reverse-Air Water Quality Profile DF-1.

Table 2. Reverse-Air Drilling Field Water Quality Results DF-1 (1 of 2)

Depth (feet bls)	Chlorides (mg/L)	Conductivity (umhos/cm)	Temp (C)
978	6320	16300	24.2
1008	5140	16820	23.7
1038	4920	16020	24.1
1068	No sample	15490	23.6
1100	No sample	15450	23.4
1130	4230	11570	23.9
1160	4280	10270	23.5
1195	1560	5760	23.4
1225	1676	6150	23.2
1255	1640	6170	23.3
1285	No sample	6210	23.4
1319	1690	6350	22.7
1350	No sample	6390	22.8
1380	1560	5960	22.9
1410	1680	5920	23.2
1440	1580	5900	23.0
1470	No sample	5890	22.7
1508	1432	5820	22.8
1538	1360	5630	23.9
1570	1360	5630	23.9
1602	1420	5630	23.3
1632	1542	5650	22.9
1663	No sample	5630	22.6
1695	1410	5600	22.7
1726	1445	5610	22.5
1758	No sample	5670	22.1
1788	No sample	5850	21.7
1820	1435	5750	22.7
1850	1380	5680	23.2
1880	1445	5730	23.1
1910	1435	5790	22.9
1940	1555	5930	22.1
1970	No sample	5770	22.3
2001	No sample	5760	22.1
2033	1576	5950	21.5
2065	1510	5910	21.5
2096	1550	6000	21.7
2127	1670	6020	22.5
2158	1710	6180	21.9
2188	1910	6460	22.9
2218	2214	6840	22.8
2248	1800	7150	22.2
2278	1832	7460	22.8
2309	2090	7530	22.0
2340	2058	7070	22.0
2371	3230	10750	21.8
2400	4191	13200	21.6
2433	4000	12160	21.8

Depth (feet bls)	Chlorides (mg/L)	Conductivity (umhos/cm)	Temp (C)
2464	5115	12170	21.9
2495	5265	12300	22.4
2527	4800	13570	21.2
2557	No sample	13300	21.2
2588	10820	30900	21.5
2618	18245	40200	21.7
2649	19175	43600	20.7
2680	15740	39100	20.6
2712	18285	41700	21.0
2743	20160	49800	21.0

Table 2. Reverse-Air Drilling Field Water Quality Results DF-1 (2 of 2)

Log Name	Log Type and units	Principal Application	Maximum Hole Size	Benefit to Ground Water Studies
4-arm Caliper	Mechanical (inches)	Determines borehole diameter and rugosity in two horizontal planes and used to correct other logs	22 inches	Used to correct flowmeter logs and aids in identifying suitable inflatable packer and casing placement depths
Natural Gamma Ray	Passive Nuclear reported in American Petroleum Institute Units (API)	Correlation, stratigraphic boundaries	24 inches	Correlation, used to estimate clay content
Dual Induction-Focused Log	Conductivity converted to resistivity. Bedding thickness resolution to 3 feet in smooth borehole values reported in ohm-meter (ohm-m)	Provides invasion profile and an accurate estimate of formation water resistivity (R_w)	20 inches	Water Quality - through R_w used in Archie Equation and provides estimates of permeability from invasion profile
Compensated Z-Density with Photoelectric Absorption Factor	Nuclear – Induced Radioactive – Pad mounted reports bulk density in grams per cubic centimeters (gm/cc) and porosity in porosity units (p.u)	Porosity analysis, bulk density and lithologic and fluid determination	14 inches; effected by rugged borehole	Porosity estimates and lithologic indicator – porosity may be used in Archie Equation.
Compensated Neutron	Nuclear – Induced Radioactive reports porosity in p.u.	Porosity analysis, and lithologic determination	14 inches; good in rough or washed out borehole	Porosity estimates and porosity may be used in Archie Equation.
Multipole Array Acoustilog[SM]	Acoustic Sonic Full wave form records the primary, secondary and tube wave velocities and reports these data in microseconds per foot (usec/ft)	Porosity and permeability analysis, dynamic and mechanical properties	15-inches; sensitive to washouts	Evaluates porosity and permeability plus rock mechanical properties aids in fracture and lithology estimates

Table 3. Formation Evaluation Logs.

Packer Tests

Methods

The following methods were used to conduct individual packer tests in pilot hole DF-1 and are standard operating procedures at the SFWMD.

- Using a 4.5" inner diameter (I.D.) drill stem, lower packer assembly to the interval selected for testing based on geophysical and lithologic data.
- Set and inflate packers and open the ports between the packers to the test interval.
- Install a submersible pump from a depth of 60 feet to 120 feet below the drill floor with a pumping capacity of 200 gpm.
- Install two 50-pounds per square inch (psi) pressure transducers inside the drill pipe and one 10-psig transducer in the annulus.
- Purge a minimum of three drill-stem volumes.
- Monitor pressure transducer readings and field water quality parameters (e.g., temperature, specific conductance, and pH) from the purged formation water until stable. The water quality parameters and transducer readings are used to determine the quality of isolation of the packed-off interval.
- Perform constant rate drawdown test and recovery test once the interval is effectively isolated and recording water levels.
- Collect formation water samples for laboratory water quality analyses per SFWMD's Quality Assurance, Quality Control (QA/QC) protocol.
- Reconfigure recorders to collect recovery data.
- Turn off pump.
- Record recovery data until water levels return to static conditions.

A hydrolab multi-parameter probe measured field parameters that included temperature, specific conductance, and pH on each sample. Chloride concentrations were determined using a field titration method (Hach® Kit).

Results

Packer tests were conducted during drilling operations to isolate two selected FAS zones in pilot well DF-1. One interval test without packers was performed between 516 and 730 feet bls in DF-3. The purpose of these tests was to gain water quality and production capacity data for discrete intervals. **Table 4** lists static water levels, total pumping time, and hydraulic results for each of the packer tests. **Table 5** lists the water quality parameters determined from analyses of samples taken during the packer tests. Friction loss was calculated using a 4.5-inch I.D. steel drill pipe.

Packer Test No	Interval (ft. bls)	Test Date	Thickness (Feet)	Static Water Level (ft LS)	Pumping Rate (gpm)	Actual/Corrected Drawdown (feet)	Corrected Spec. Cap. (gpm/ft)	Total Time Pumping (mins)	Friction Loss (ft)
1	2,565 - 2,640	10/12/93	75	-3.5	64	10.1 / 2.1	30.5	303	8
2	1,720 - 1,768	10/16/93	48	32.6	102	29.5 / 22.5	4.5	267	7
3*	516 - 730	3/21/94	214	-3.0	85	44.1 / 44.1	1.9	360	0

Table 4. Packer Pumping Test - Hydraulic Results.

Packer Test No	Interval (ft. bls)	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Alka A mg/L	Cl-(Lab) mg/L	SO4 mg/L	SIO2 mg/L	TDSFE mg/L	TDS mg/L	Specific Cond (field) umhos/cm
1	2,565 - 2,640	430.0	1,435.5	11,180	470.0	109.1	15,299.0	2,757.8	10.7	0.7	34,200	47,800
2	1,720 - 1,768	108.0	132.5	994	37.4	113.5	1,521.6	568.7	10.7	0.2	3,400	5,380
3	516 - 730	42.0	75.2	1,195	55.2	471.0	1,470.0	464.0	23.0	n/s	3,600	6,060

Table 5. Packer Pumping Tests - Water Quality Results.

Base of Underground Source of Drinking Water (USDW)

The base of the USDW is defined by the Florida Department of Environmental Protection as the depth to which water containing a TDS concentration of less than 10,000 mg/L extends. The TDS concentration in water sampled between 1,720 feet and 1,768 feet bls during Packer Test No. 2 was 3,400 mg/L, while Packer Test No. 1, sampled between 2,565 and 2,640 feet bls, had water with TDS concentration of 34,200 mg/L. The transition zone and the saltwater interface can be clearly seen on the dual induction log in **Appendix B** of pilot hole DF-1. The top of the sixty (60) foot thick transition zone can be seen at 2,078 feet bls on the dual-induction log where the deep resistivity curve drops from 10 ohm-meters to 6 ohm-meters. The top of seawater-like salinity, i.e. 35,000 mg/L TDS, is found at 2,138 feet bls where the deep induction resistivity curve first drops to 2-ohm-meters.

Packer Test No.1 (2,565 to 2,640 feet bls):

The purpose of this packer test was to determine the hydraulic properties and water quality characteristics of a productive interval within the lower Floridan aquifer. This test was conducted on October 12, 1993, when a dual packer assembly isolated an interval between 2,565 and 2,640 feet bls in pilot well DF-1. This interval was pumped for 303 minutes at an average discharge rate of 64 gpm. The static water level prior to pumping was measured as –3.5 feet relative to land surface. The measured drawdown while pumping was approximately 10 feet, approximately 8 feet of which was estimated to be friction loss. A friction loss corrected specific capacity of 30.5 gpm/ft was estimated**. Figure 14** is a semi-log plot of the time versus residual drawdown data collected during the recovery phase of the test. At the end of the recovery phase, the static water level rose to the initial height of –3.5 feet (below ground level). Shortly before the end of the drawdown phase, a composite water sample was taken from the discharge point and field water quality parameters measured. Chlorides and TDS concentrations in water sampled from the zone were 15,299 mg/L and 34,200 mg/L, respectively, as seen in **Table 5**.

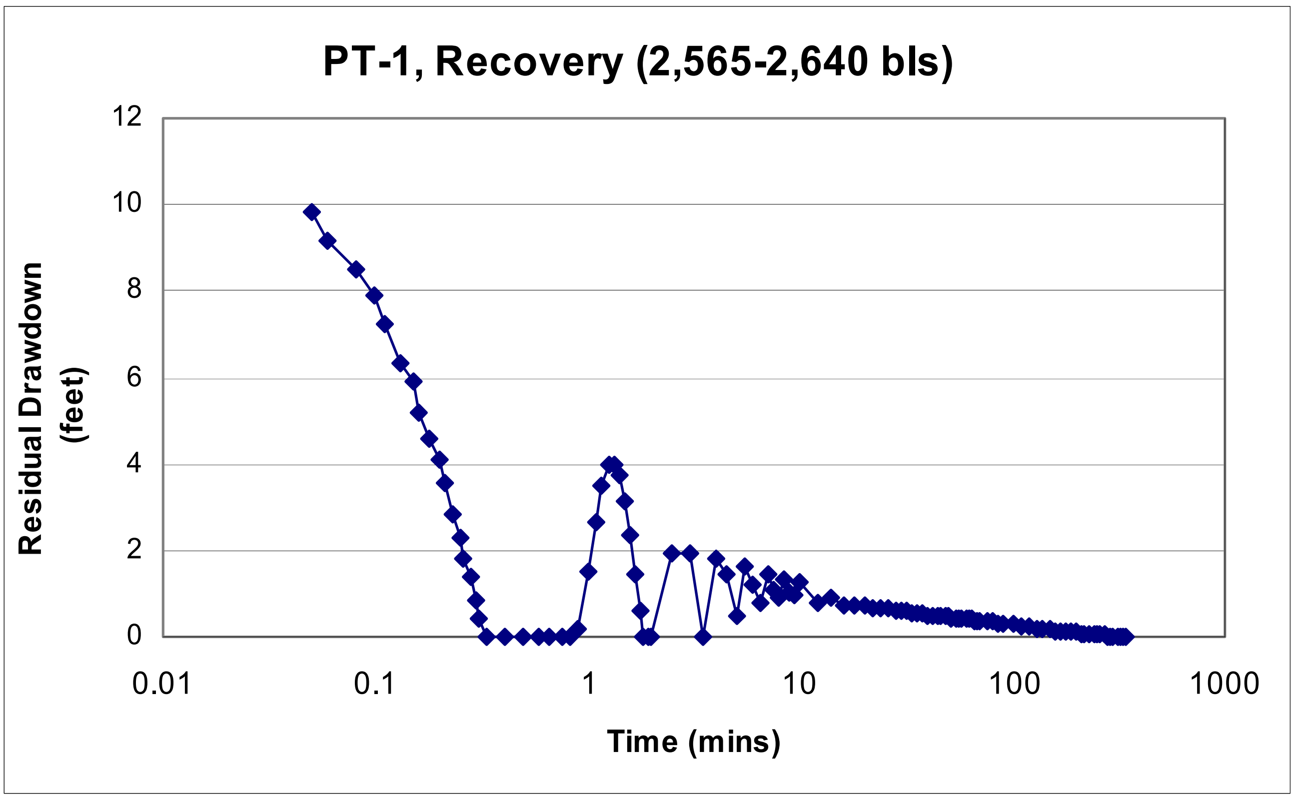

Figure 14. Packer Test 1, Recovery Data (2,565-2,640 feet bls).

Packer Test No. 2 (1,720 – 1,768 feet bls):

Packer Test No. 2 was conducted on October 16, 1993 when a dual packer assembly was lowered and isolated an interval between 1,720 and 1,768 feet bls in pilot well DF-1. This interval was pumped for 267 minutes at an average discharge rate of 102 gpm. The static water level prior to pumping was measured as 32.6 feet relative to land surface. The measured drawdown while pumping was approximately 29.5 feet, 7 feet of that was calculated as friction loss. A friction loss corrected specific capacity of 4.5 gpm/ft was calculated. **Figure 15** is a semi-log plot of the time versus residual drawdown data collected during the recovery phase of the test. Chloride and TDS concentrations in water sampled from the zone were 1,522 mg/L and 3,400 mg/L, respectively, as seen in **Table 5**.

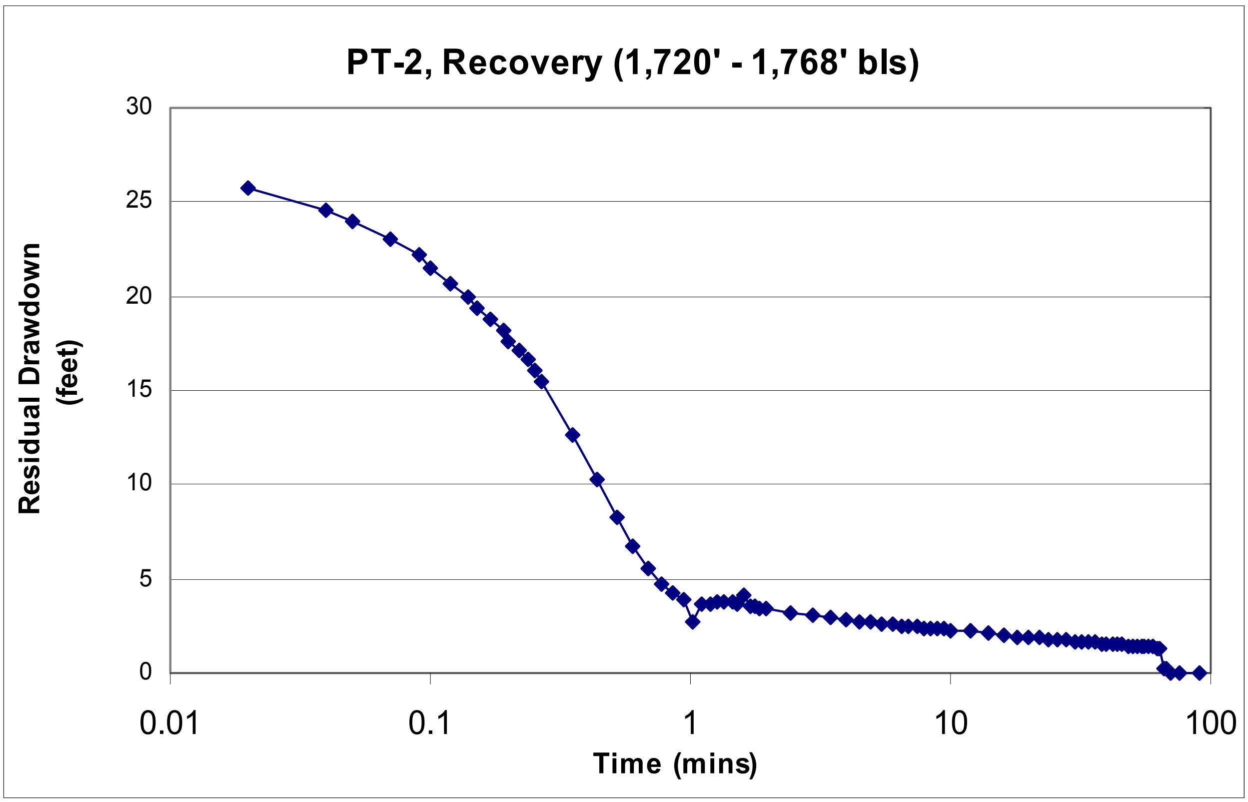

Figure 15. Packer Test 2, Recovery Data (1,720-1,768 feet bls).

Interval Test No. 3 (516 – 730 feet bls):

Interval Test No. 3 was conducted on March 21, 1994 and isolated the interval between 516 and 730 feet bls in well DF-3. This interval was tested after significant mud loss was experienced while drilling through it with the mud rotary method. No packers were used during this test, rather a 12-inch diameter open borehole was tested directly under the 12-inch casing. The test was conducted by pumping this interval for 360 minutes at a rate of 85 gpm. The static water level was measured at -3.0 feet relative to ground level at the site. The drawdown was 44.1 feet and the specific capacity calculated as 1.9 gpm/ft. **Figure 16** is a semi-log plot of the time versus residual drawdown data collected during the recovery phase of the test. Chlorides and TDS concentrations in water sampled from the zone were 1,470 mg/L and 3,600 mg/L, respectively (see **Table 5**).

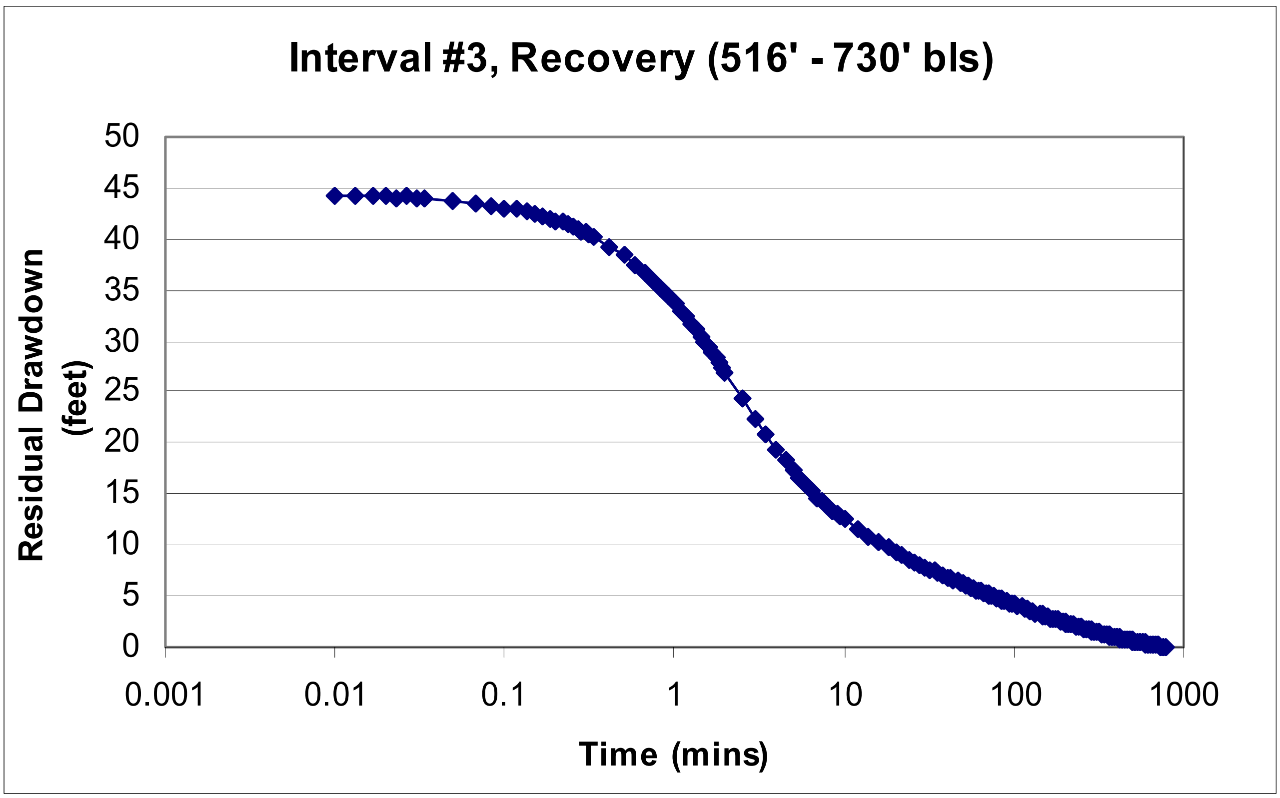

Figure 16. Interval Test 3, Recovery Data (516-730 feet bls).

Aquifer Performance Testing

Two APTs were conducted at the site to evaluate subsurface hydraulics and water quality characteristics within the FAS. The results of these tests include the interval tested, static water level, drawdown, discharge rate (Q), transmissivity (T), storage coefficient, and analytical methods are listed in **Table 6**. A 10-inch diameter submersible pump was installed in the test-production wells with the pumping bowl set approximately 100 feet bls. A 12-inch manometer (circular orifice weir) with a 6-inch orifice plate was used to measure the discharge rate during APT-1, whereas a 6-inch circular orifice weir with a 3-inch orifice plate was used to measure the discharge rate during APT-2. In both cases, the manometer was verified with an in-line flowmeter. Pressure transducers were installed on/in the test-production wells, all monitor wells, and the end of the manometer tube during the tests and connected to a datalogger during the drawdown and recovery periods for both APTs. Further details on both tests are summarized below.

APT No.	Well	Interval (ft. bls)	T (gpd/ft)	Avg. Pumping Rate (gpm)	Pumping Time (hrs)	Spec Cap (gpm/ft)	Storativity	Leakance (Gal/day/ft^3)	Analysis Method	Q (avg) (gals/min)	Drawdown (feet)	TDS (mg/L)	Static WL (ft LS)
1	DF-2	1,140-1,230	53,280	435	67	140	1.30E-03	1.35E-02	Moench (Case 1) (1985)	435	3.1	3,460	38.9
2	DF-1	1,700-1,800	32,716	100	38	32	9.03E-05	3.84E-04	Hantush-Jacob (1955)	103	3.2	3,450	37.7

Table 6. Aquifer Performance Test Results.

Water Quality Results

Both production wells (DF-1 and DF-2) were sampled after a minimum of eight-hours pumping to ensure ambient formation water was being obtained. Those samples were submitted to the SFWMD's laboratory for major cation/anion analyses. **Table 7** summarizes the analytical results.

APT No.	Date	Ca mg/L	Mg mg/L	Na mg/L	K mg/L	Alka/50 meq/l	Cl- mg/L	SO4 mg/L	mg/LACO CACO	SIO2 mg/L	Tot Dis Iron ug/L	TDS mg/L	Sp. Cond Umhos/Cm	Temp °C	pH Units
1	12/06/96	103	125	939	39.7	115.7	1648.1	513.5	772	11.9	10.8	3460	5900	23.8	7.2
2	12/12/96	109	127	955	42.0	116.7	1612.7	534.2	795	10.4	103.0	3450	5790	22.2	7.6

Table 7. Water Quality Data from APTs.

Aquifer Performance Test No. 1 – DF-2 the Pumping Well

SFWMD conducted the first of two APTs from December 5-9, 1996. APT-1 was conducted in the open-hole interval between 1,140 to 1,230 feet bls in the upper Floridan aquifer within the upper Avon Park Formation and basal Arcadia Formation. The static water level in DF-2, the pumping well, was measured to be 38.9 feet aboveground level prior to starting the test. The drawdown phase consisted of pumping well DF-2 for 67 hours at a discharge rate that ranged between 420 to 510 gpm, but held relatively constant at 435 gpm. Water levels in all other wells on site were monitored while pumping DF-2. Aquifer parameters were computed from time-drawdown data collected during pumping from tri-zone monitoring well DF-4 which is located 508 feet from DF-2 and completed in the same zone in the upper Floridan aquifer. **Figure 17** illustrates the configuration of the tri-zone monitor well and test-production well used in the first APT.

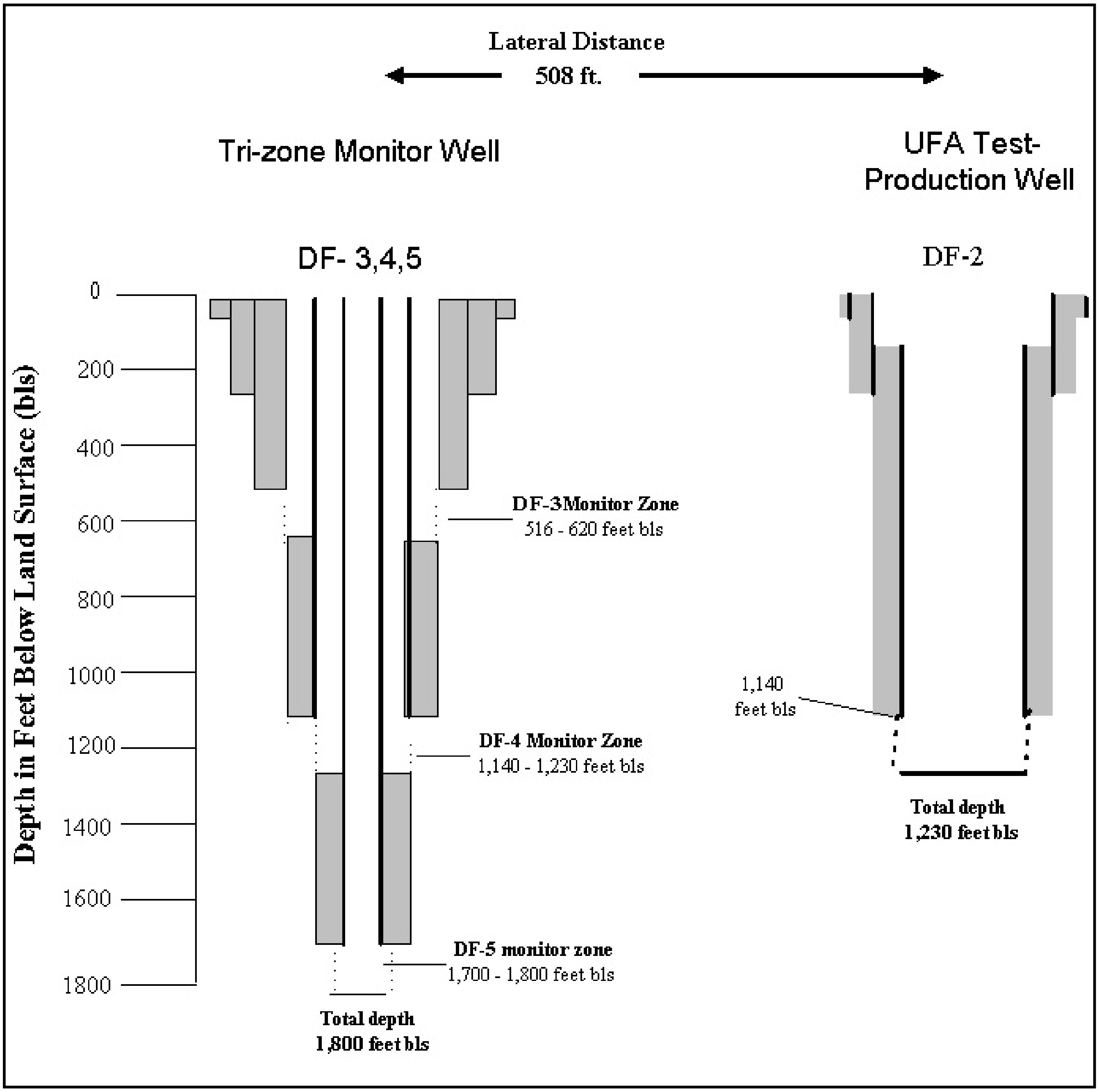

Figure 17. Well Configuration-APT-1.

Figure 18 illustrates water levels observed during the drawdown phase of the APT in monitor wells completed in the upper and middle Floridan aquifers (DF-4 and DF-5, respectively) and in the mid-Hawthorn (DF-3). The manometer measured pumping rate and is also illustrated on this figure. Water levels in the upper Floridan monitor well (DF-4) decreased approximately 3 feet after one day of pumping while, at the same time, those in the middle flow aquifer (DF-5) decreased 0.6 feet and levels in the mid-Hawthorn decreased only 0.03 feet. These results indicated that the semi-confining interval between the upper and middle Floridan aquifers is “leaky-confining,” whereas the interval between the upper Floridan and mid-Hawthorn is substantially more confining. A leaky aquifer is one that loses or gains water through a semi-confining unit or aquitard.

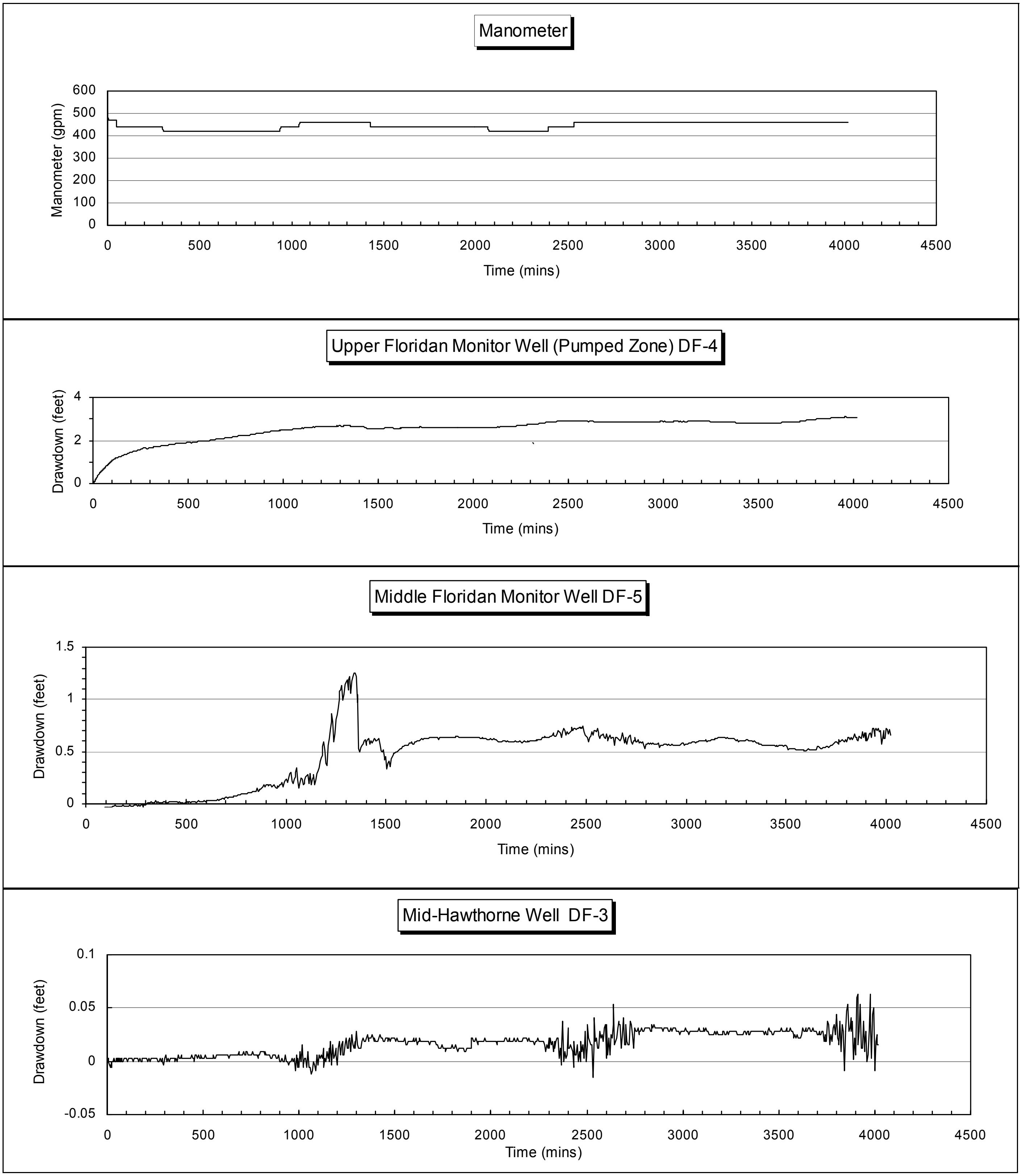

Figure 18. APT-1, Water Level Responses in all Monitor Wells to Pumping DF-2 (Upper Floridan Flow Zone).

Before pumping stopped, SFWMD staff reconfigured the dataloggers to record recovery data. The submersible pump was then shut off on December 8, 1996 and water levels allowed to recover to static condition. The recovery phase of the APT continued for 22 hours, ending December 9. **Figure 19** is a time-drawdown plot of the recovery data for each of the three monitor wells (DF-3,4,5). It is interesting to note that water levels recovered back to zero drawdown in DF-4, but not in DF-3 or DF-5. Electronic copies of the original drawdown and recovery data for the APT are archived and available for review at the SFWMD's headquarters in West Palm Beach, Florida.

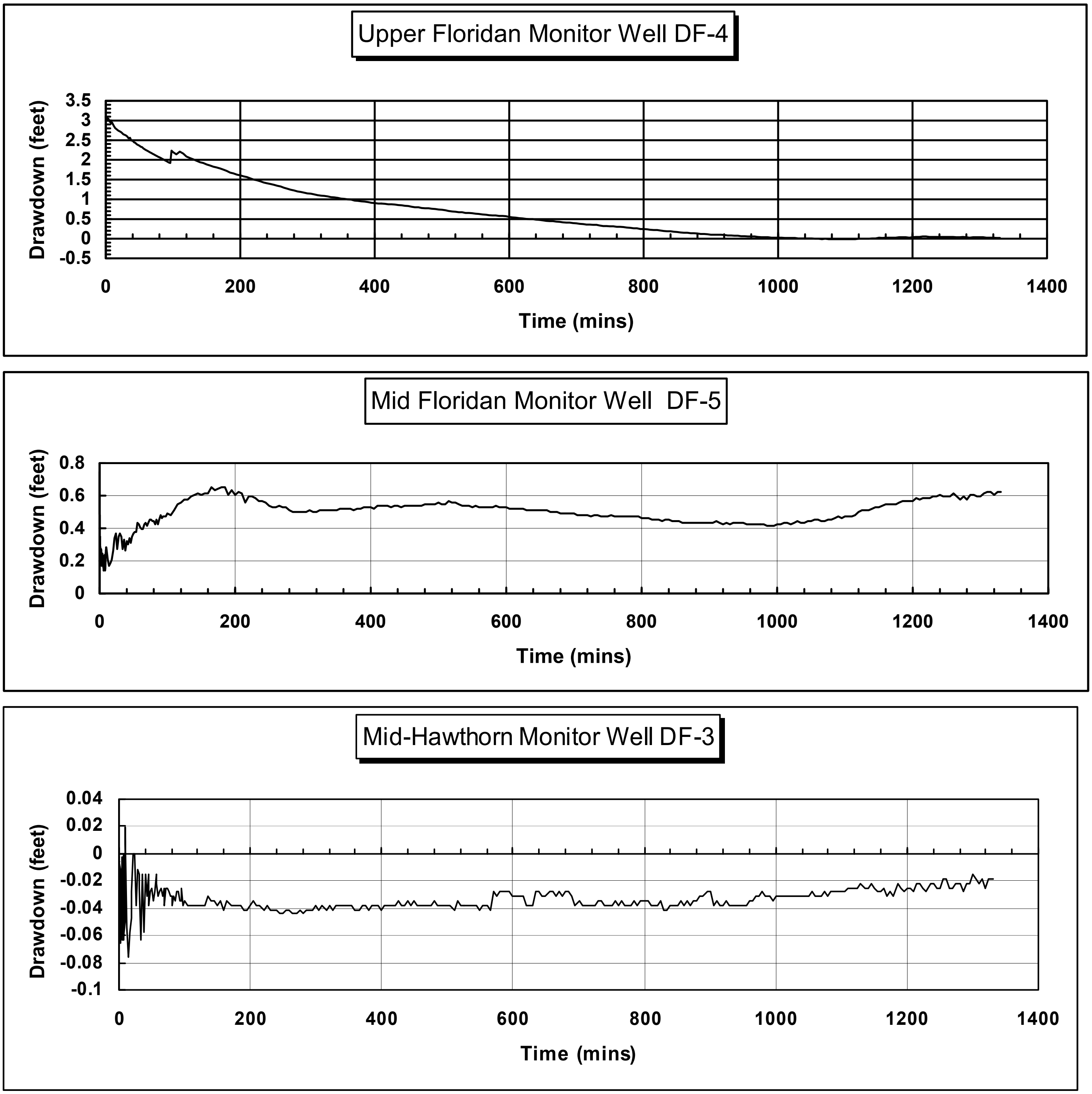

Figure 19. APT-1-Recovery, Linear Plot of Time Drawdown During Recovery Phase (Upper Flow Zone).

Figure 20 is a log/log, time drawdown plot for monitor well DF-4 during APT-1. The shape of the drawdown curve indicates a leaky aquifer. The lithologic and geophysical data indicates that the under- and overlying units are composed of porous sediments that have the potential to provide water from storage to the pumping well. Based on the relative changes in water levels (in proximal monitor wells) within each of the layers above and below the pumped zone (see **Figure 18**), the leakance appears to originate from below.

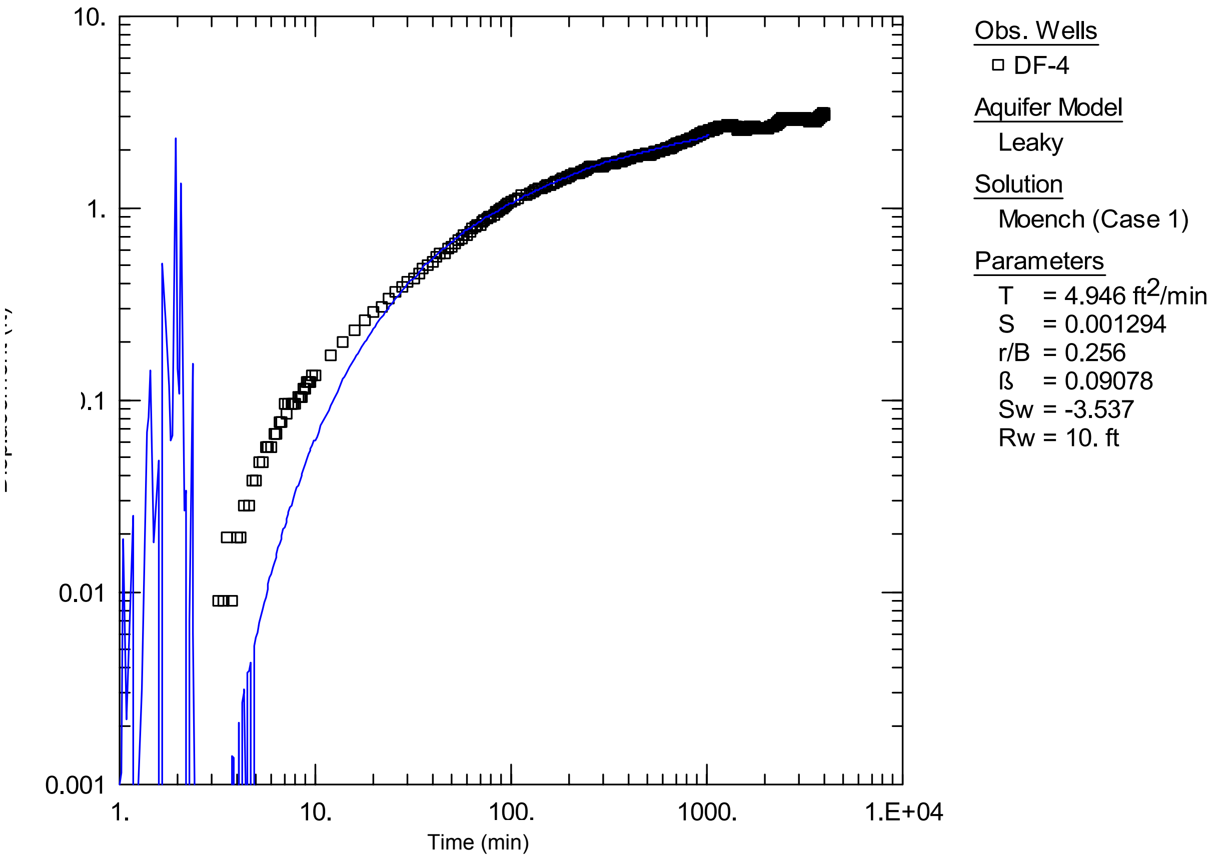

Figure 20. APT-1, Log/Log Plot of Drawdown vs. Time for Monitor Well DF-4 (Upper Flow Zone)- Moench (Case 1) Solution.

Three analytical pump test methods were considered when evaluating the data: Moench (1985), Hantush-Jacob (1955), and Neuman Witherspoon (1969). Each relies on assumptions that could apply toward the actual conditions at the site (for the interval tested). **Table 8** lists the underlying unique set of assumptions for each method.

Method of Analysis	Solution Assumptions
Moench (Case 1, 1985)	Type curve solution, leaky confined, with storage in aquitard and variable rate and wellbore storage. Case 1: constant head aquitard boundary condition.
Hantush-Jacob (1955)	Type curve solution, leaky confined, with storage in aquitard and variable rate and partial penetration.
Neuman-Witherspoon (1969)	Type curve solution, leaky confined, 2-aquifer system, with storage in aquitard and variable rate.

Table 8. APT 1 Assumptions Used in the Various Solution Methods.

These three type curve methods were used to analyze the APT-1 time-drawdown data and are displayed in **Appendix C**. This exercise yielded three sets of aquifer parameters which are listed in **Table 9.**

APT No.	Interval (ft. bls)	T (gpd/ft)	Storativity	Leakance (Gal/day/ft^3)	Analysis Method	r/B	Radius
1	1,140-1,230	53,280	1.30E-03	1.35E-02	Moench (Case 1, 1985)	0.256	508 ft
1	1,140-1,230	65,443	1.62E-03	7.68E-03	Hantush-Jacob (1955)	0.174	508 ft
1	1,140-1,230	54,391	1.32E-03	1.28E-02	Neuman-Witherspoon (1969)	0.247	508 ft

Table 9. APT 1 Solutions to Various Methods of Analysis.

The Moench type curve method was ultimately chosen here. Moench (1985) derived an analytical solution for modeling cones of depression in response to pumping a large diameter well that assumes well bore storage in a leaky confined aquifer and storage in the aquitard(s) as well as wellbore skin effects. This method also builds on several previously established analytical solutions, such as Hantush (1960), Popadopulos and Cooper (1967), and Argarwal, et al (1970). The assumptions built into the Moench analytical method appears to best reflect the site specific conditions and was, therefore, used to generate the type curve overlay seen in blue on **Figure 20.** The results of this solution yielded a transmissivity of 53,280 gpd/ft, a storage coefficient of 0.0013, and an r/B value of 0.256. The dimensionless parameter r/B characterizes the leakage across the aquitard to the pumped aquifer. This value was used to calculate the leakance parameter of 1.35E-02 gal/day/ft^3 (Walton, 1960).

Aquifer Performance Test No. 2 – DF-1 the Pumping Well

The SFWMD conducted a second APT using DF-1 as the pumping well to determine hydraulic characteristics of the middle Floridan aquifer from 1,700-1,800 feet bls within the Avon Park Formation on December 12, 1996.

The static water level in the DF-5 was found to be 37.7 feet above land surface prior to pumping. The drawdown phase consisted of pumping well DF-1 for 38 hours at a discharge rate that gradually increased from 76 to 115 gpm, but held relatively constant and averaged 100 gpm. Water levels in all other wells on site were monitored while pumping DF-1. Aquifer parameters were computed from time-drawdown data collected from tri-zone monitoring well DF-5 located 203 feet northeast of DF-1 and completed in the same interval. **Figure 21** illustrates the configuration of the tri-zone monitor well and test-production well used in this second APT.

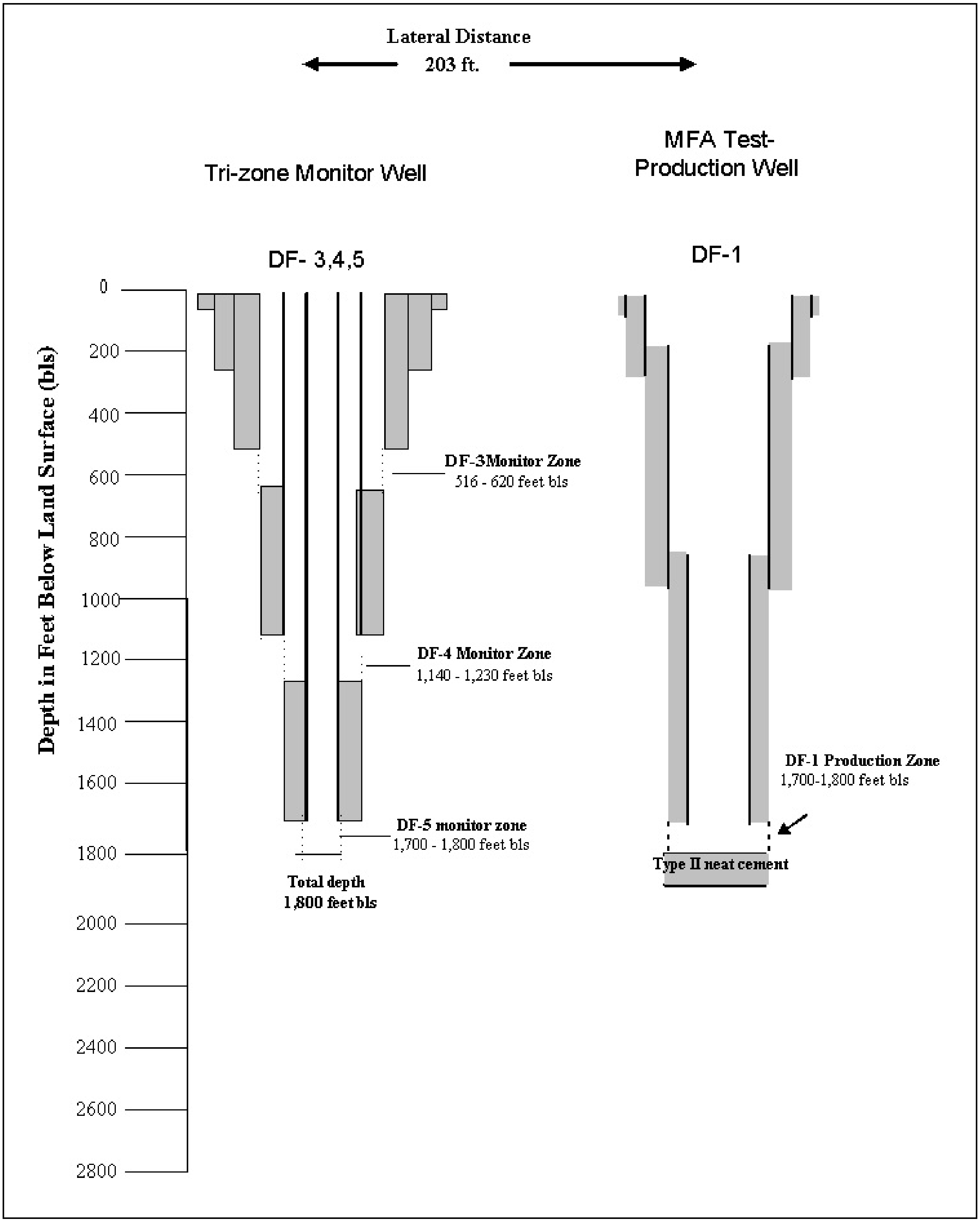

Figure 21. Well Configuration- APT-2.

Figure 22 illustrates water levels in each of the monitored Floridan aquifers in response to pumping the middle Floridan aquifer (DF-1). Also included in this figure is the manometer-measured pumping rate. Water levels in the middle Floridan monitor well (DF-5) decreased approximately 3 feet after one day of pumping while, at the same time, those in the upper Floridan aquifer (DF-4) decreased 1.0 foot and levels in the mid-Hawthorn (DF-3) did not respond at all. These results again indicate that the semi-confining interval between the middle and upper Floridan aquifers is "leaky-confining," whereas the interval between the middle Floridan and mid-Hawthorn is completely confined.

Before pumping stopped, SFWMD staff reconfigured the dataloggers to record the recovery data. The submersible pump was then shut off on December 14, 1996 and water levels were allowed to recover to static condition. The recovery phase of the APT continued for 6 hours. **Figure 23** is a time-drawdown plot of the recovery data for each of the three monitor wells (DF-3, 4, 5). It is interesting to note that water levels recovered back to zero drawdown in DF-5, but in the 6.6 hours of recovery, only recovered half way back to static in DF-4. Levels in DF-3 were again unresponsive. Electronic copies of the original drawdown and recovery data for the APT are archived and available for review at the SFWMD's headquarters in West Palm Beach, Florida.

Figure 24 is a log/log, time drawdown plot for monitor well DF-5 during APT-2. The shape of the drawdown curve indicates a leaky aquifer. The lithologic and geophysical data indicates that the under- and overlying units are composed of porous sediments that have the potential to provide water from storage to the pumping well. Based on the relative changes in water levels (in proximal monitor wells) within each of the layers above and below the pumped zone (see **Figure 22**), the leakance appears to originate from above.

As with APT-1, three analytical pump test methods were considered when evaluating the data: Moench (1985), Hantush-Jacob (1955), and Neuman Witherspoon (1969). Each assumes hydrogeologic conditions that could apply toward the actual conditions at the site (for the interval tested). **Table 8** lists the underlying unique set of assumptions for each method.

These three type curve methods were fit to the APT-2 time-drawdown data and are displayed in **Appendix C**. This exercise yielded three sets of aquifer parameters which are listed in **Table 10.**

APT No.	Interval (ft. bls)	T (gpd/ft)	Storativity	Leakance (Gal/day/ft^3)	Analysis Method	r/B	Radius
2	1,700-1,800	50,060	5.26E-06	4.00E-09	Moench (Case 1, 1985)	5.71E-05	203 ft
2	1,700-1,800	32,716	9.03E-05	3.84E-04	Hantush-Jacob (1960)	2.20E-02	203 ft
2	1,700-1,800	24,723	9.77E-05	2.00E-09	Neuman-Witherspoon (1969)	5.75E-05	203 ft

Table 10. APT-2 Solutions to Various Methods of Analysis.

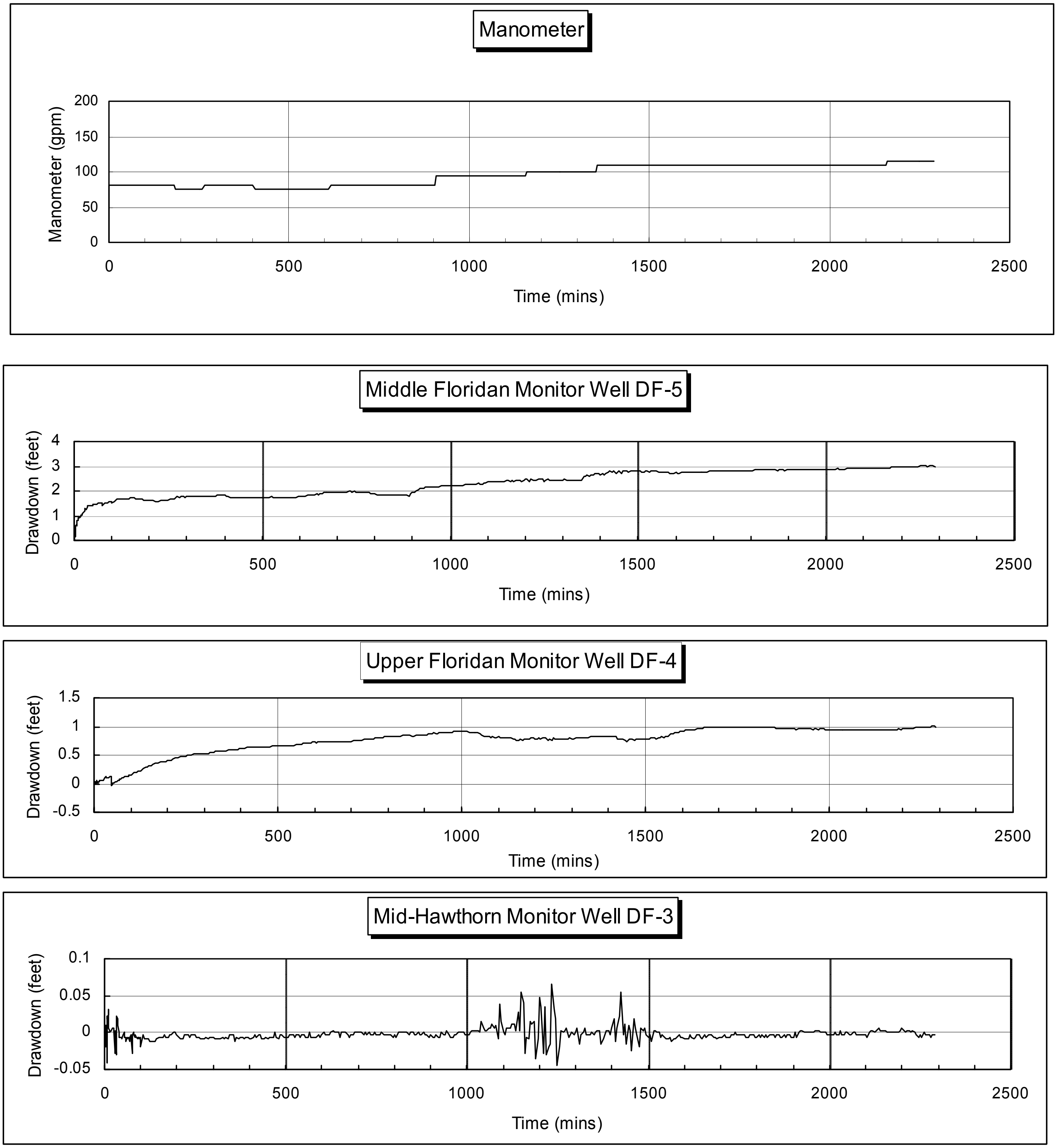

Figure 22. APT-2, Drawdown, Water Level Responses in All Monitor Wells to Pumping DF-1 (Middle Floridan Aquifer Flow Zone).

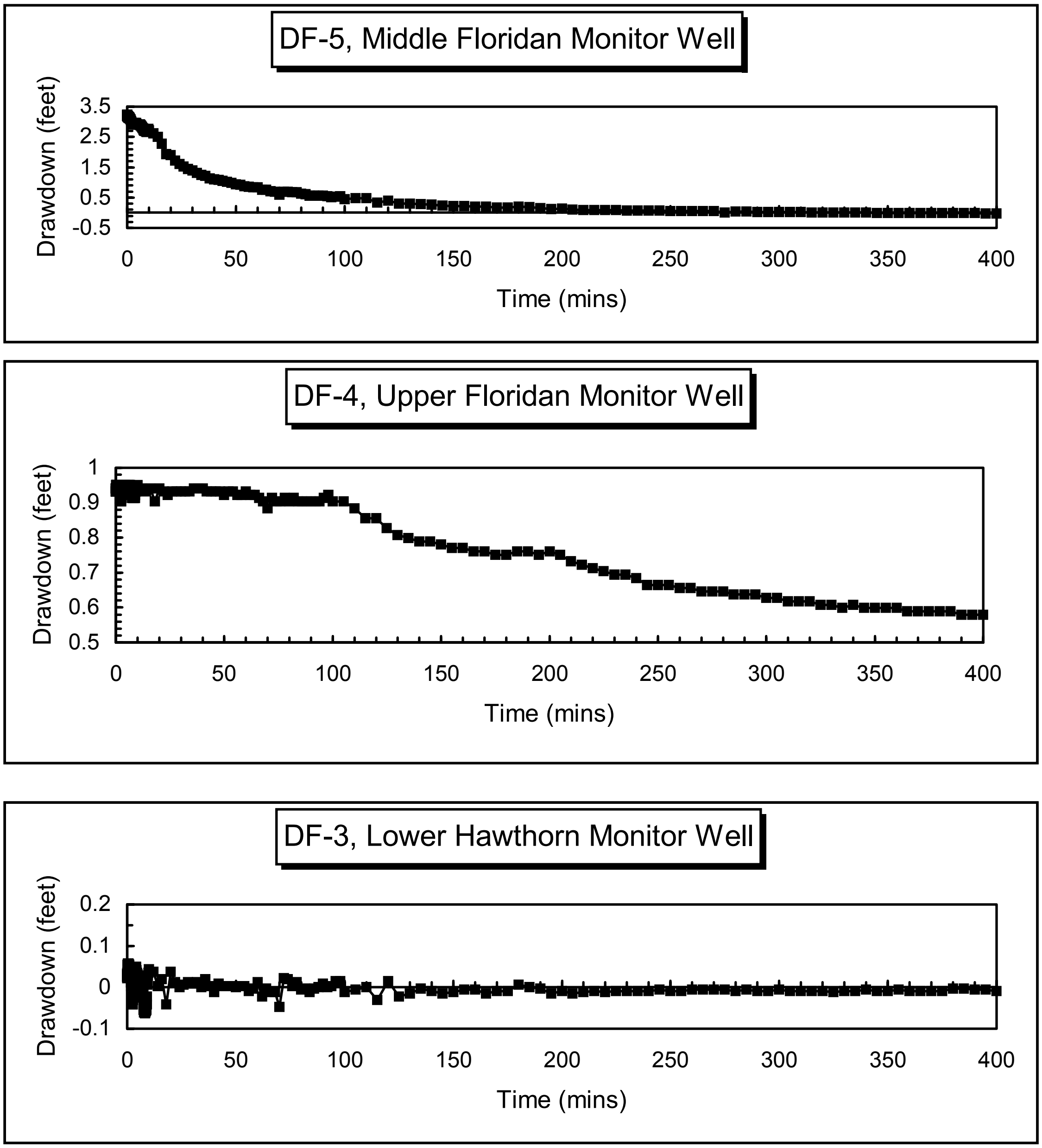

Figure 23. APT-2 Recovery, Linear Plot of Time Drawdown During Recovery Phase (Middle Floridan Aquifer Flow Zone).

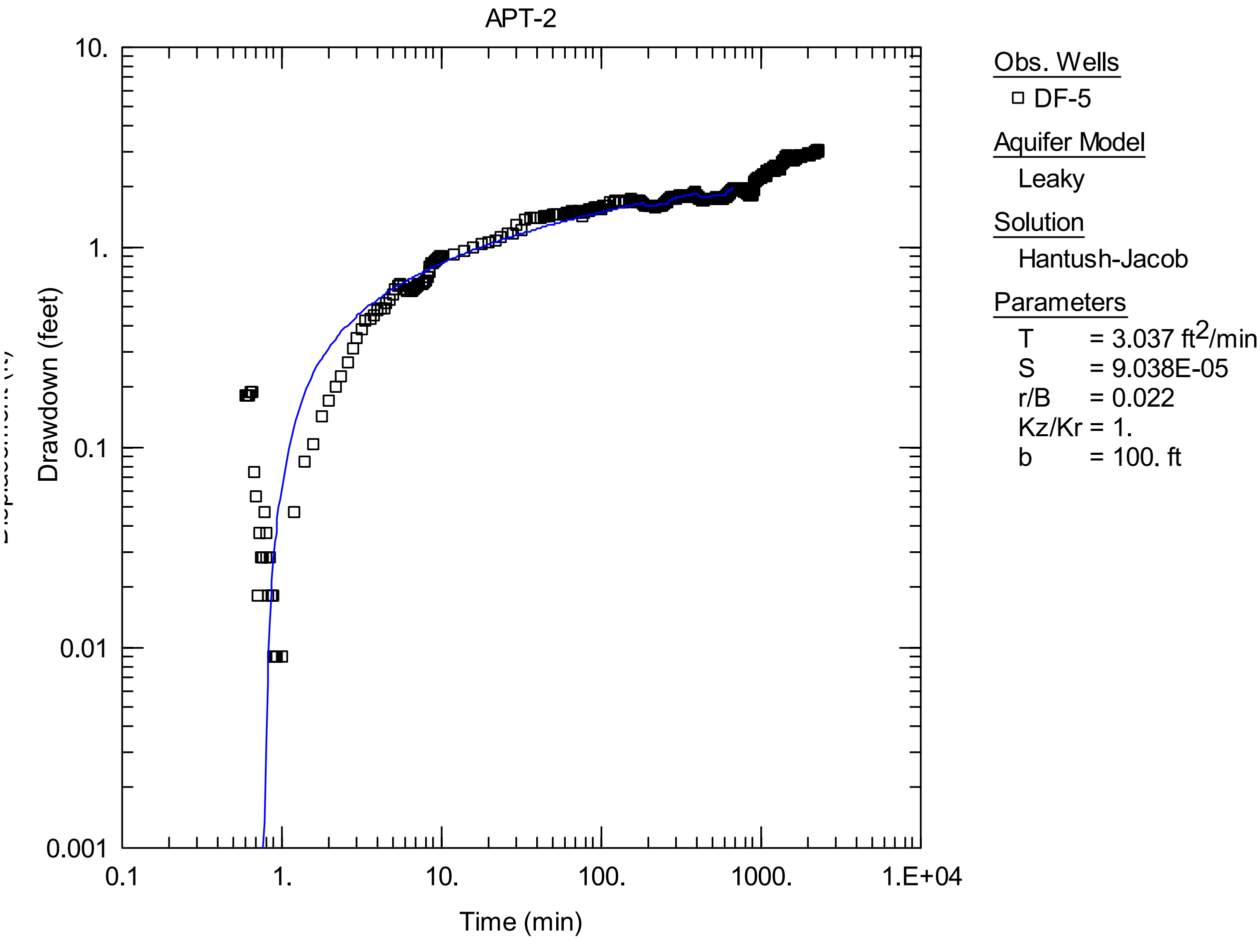

Figure 24. APT-2, Log/log Plot of Drawdown vs. Time and the Hantush-Jacob Solution (1955) for Monitor Well DF-5 (Middle Floridan).

The Hantush-Jacob (1955) type curve method was ultimately selected to analyze APT-2 and used to generate the type curve overlay seen in blue on **Figure 24.** Hantush-Jacob (1955) was used because both the Moench (1985) and Neuman-Witherspoon (1969) methods seemed to underestimate the r/B parameter (10E-5) used to compute leakance. **Figure 22** clearly illustrated leakance between the upper and middle Floridan aquifers. The results of this Hantush-Jacob (1955) solution yielded a transmissivity of 32,716 gpd/ft, a storage coefficient of 9.03E-5, and an r/B value of 0.022. The dimensionless parameter r/B characterizes the leakage across the aquitard to the pumped aquifer. This value was used to calculate the leakance parameter of 3.84E-04 gal/day/ft^3 (Walton, 1960).

Figure 25 summarizes most of the pertinent hydraulic characteristics of the FAS at the site including: depths to flow zones, packer test depths and results, APT depths, final monitor intervals and water quality characteristics, etc.

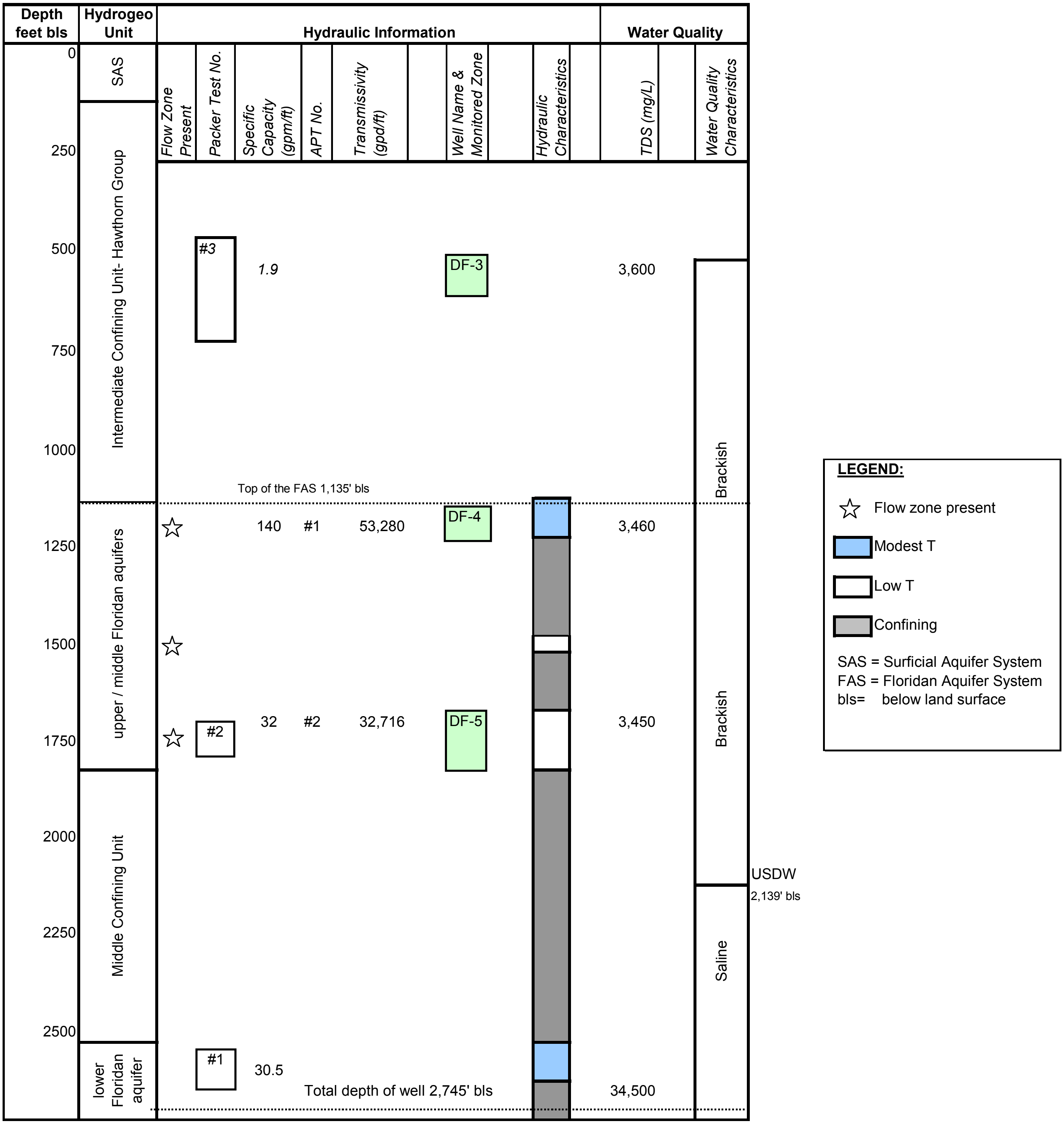

Figure 25. Summary of Hydraulic Findings at the L-30N Site.

WATER LEVELS

SFWMD staff collected monthly water levels from wells DF-3, DF-4, and DF-5 manually from May 1995 to December 1998 by measuring pressure at the wellhead monthly with a transducer. Upon inspection of that period of record, it became evident that water levels in DF-3 were unresponsive (plotted as a straight line hydrograph) and DF-4 and DF-5 were erratic and therefore, suspect. Although levels in DF-3 are not shown, those for DF-4 and DF-5 are plotted in **Figure 26**. These levels are referenced to NGVD 1929 using the measuring point datums as shown in **Table 11**. Levels in DF-5 were consistently lower than those in DF-4 and from May 1995 to May 2003, fluctuated 5 feet between 47 and 52 feet National Geodetic Vertical Datum (NGVD, 1929). Staff discontinued monitoring this site from December 1998 to April 2000 since it was determined that the previous data were erratic, possibly due to pressure leaks in the wellhead. Monthly measurements resumed from April 2000 through September 2000. Then, from October 2000 through November 2001, water level monitoring ceased while the wellheads were repaired. During repairs, DF-3 (lower Hawthorn piezometer) was permanently capped by filling it with cement. The wellheads and pads were replaced for DF-4 and DF-5 due to the leaks. Once the wellheads were replaced, a Campbell Scientific® (CR-10) datalogger was installed on December 2001 and pressure transducers were fitted to each of the two piezometers. The datalogger was programmed to record levels every 15-minutes in both DF-4 and DF-5.

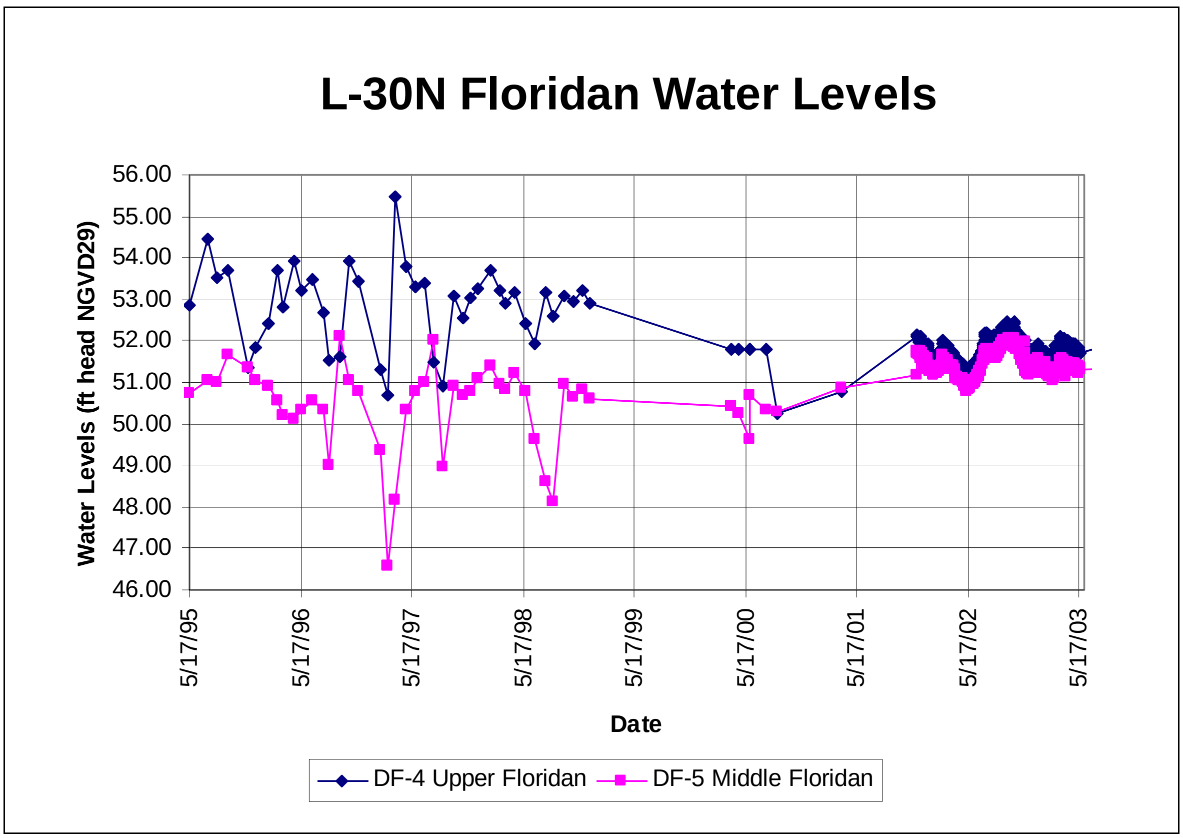

Figure 26. Hydrographs for DF-4 and DF-5 between May 1995 to May 2003.

In November 2002, the wellhead was again modified by installing ports to obtain water quality samples. Each time the wellhead was modified, the measuring point and reference elevations also changed. These elevation changes are important to know when referencing water levels to the NGVD datum over the period of record. The elevations are listed in **Table 11** along with the chronology of water level recordings at the site.

Well	Monitoring Period	Measurement Frequency	NGVD 29 *BM	NGVD 29 **MP	NGVD 29 ***Reference	Comments
DF-4	May 1995 to Dec 1998	Monthly	9.55	4.24	13.79	Monthly pressure readings
DF-5	""		9.55	3.33	12.88	""
DF-4	Dec 1998 to Apr 2000	None	9.55	4.24	13.79	Wellheads leaky, levels suspect
DF-5	""	""	9.55	3.33	12.88	""
DF-4	Apr 2000 to Sep 2000	Monthly	9.55	4.24	13.79	Monthly levels resume, no repairs to wellhead
DF-5	""	""	9.55	3.33	12.88	""
DF-4	Oct 2000 to Nov 2001	None	9.55	4.24	13.79	Recorders installed, DF-3 plugged
DF-5		""	9.55	3.33	12.88	""
DF-4	Nov 2001 to Nov 2002	Recorder, 15 min	9.55	4.614	14.164	Wellheads repaired, MP elevation change
DF-5	Nov 2001 to Nov 2002	""	9.55	3.644	13.194	""
DF-4	Nov 2002 to Present	Recorder, 15 min	9.55	5.264	14.814	Wellhead sampling ports on, MP elevation change
DF-5	Nov 2002 to Present	""	9.55	4.324	13.874	

*BM: Bench mark elevation (NGVD 29)
**MP: Measuring point elevation (NGVD 29)
***Reference: reference elevation (NGVD 29)

Table 11. Reference Elevations (NGVD 1929) for Period of Record.

Figure 27 displays the hydrographs of DF-4 and DF-5 over the period of record between November 2001 to May 2003. This period of record includes only water levels collected by the recorders. All water level data are currently stored in the SFWMD's database (DBHydro). Prior to storing these high frequency levels, daily averages were computed. Minimum, maximum and average levels in both the upper and middle Floridan aquifers over this period of record were computed and are listed in **Table 12.** Average water levels in the upper Floridan aquifer (DF-4) are 0.37 feet higher than those in the middle Floridan aquifer (DF-5).

Aquifer	Average Water Level (feet NGVD 1929)	Min Water Level (feet NGVD 1929)	Max Water Level (feet NGVD 1929)
upper Floridan	51.79	50.79	52.46
middle Floridan	51.42	50.79	52.06

Table 12. Summary of Water Levels Between November 2001 to May 2003.

Water levels in both the upper and middle Floridan aquifer fluctuated approximately 1.5 feet within a range between 50.79 to 52.46 feet, NGVD. Fluctuations during the two year period of record are attributed to seasonal variations, lowest in the dry and highest in the wet season.

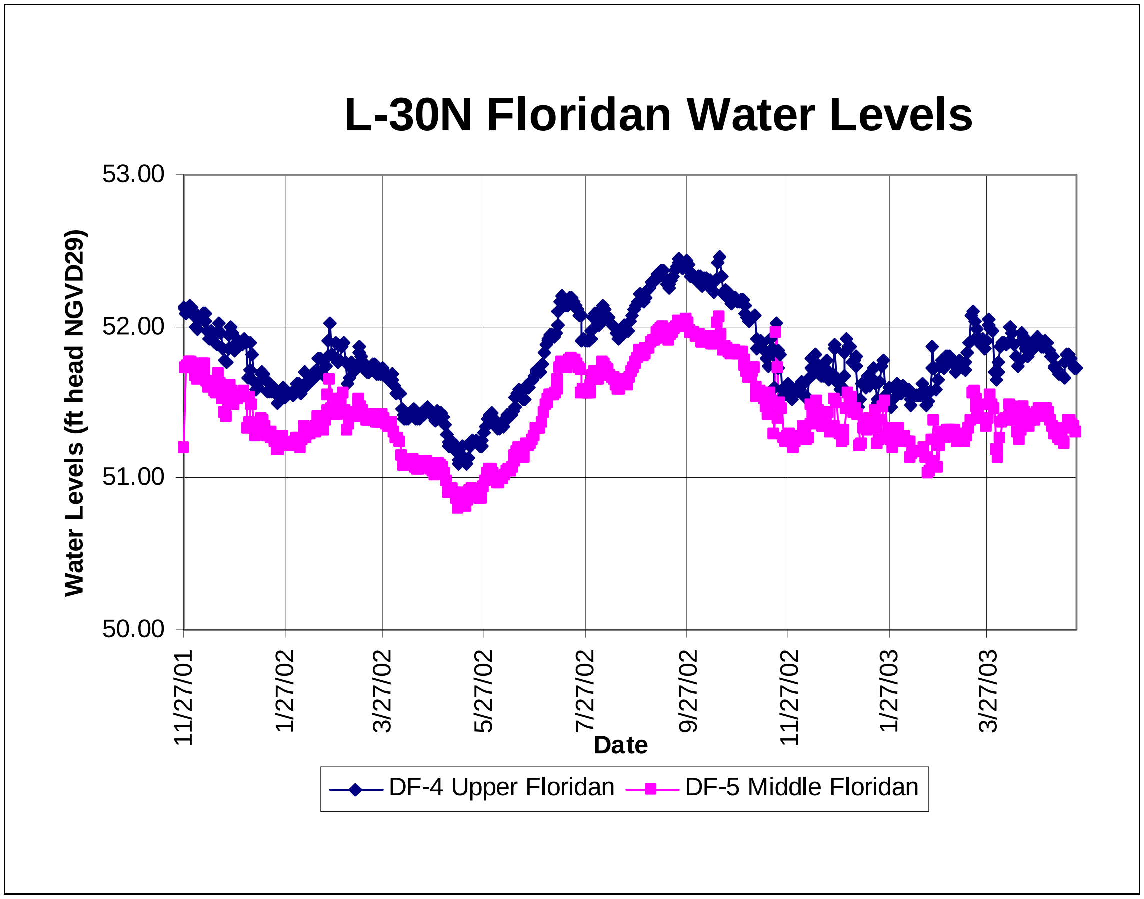

Figure 27. Hydrographs for DF-4 and DF-5 between November 2001 to May 2003.

SUMMARY

Three new Floridan aquifer wells were constructed in north-central Miami-Dade County on the eastern right-of-way of the L-30N canal. These wells were constructed to obtain hydrogeologic and water quality data from the FAS. The pilot hole (DF-1) was drilled the deepest (2,745 feet bls) and was the most extensively tested among the three wells.

The principal findings of the exploratory drilling and testing program are as follows:

- The SAS extends from land surface to a depth of approximately 200 feet bls.
- The Hawthorn Group (upper confining unit) was found to extend from 200 to approximately 1,135 feet bls. An interval between 516 to 620 feet bls appeared to be a somewhat permeable limestone. Permeability indicators included the loss of some drilling fluids while drilling, rapid drill bit penetration and relatively pure limestone nature of the return cuttings. This zone was later isolated, pumped and found to have very low specific capacity (1.9 gpm/ft), characteristic of the semi-confining nature of the Arcadia Formation in this area.
- The top of the FAS was identified at a depth of approximately 1,135 feet bls.
- Two flow zones were found between 1,166 and 1,200 feet bls directly overlying the top of the Avon Park Formation. An APT performed on the open-hole interval between 1,140 and 1,230 feet bls yielded a transmissivity of 53,280 gpd/ft, leakance was $1.35e^{-2}$ gpd/ft^3 and total dissolved solids concentration was 3,460 mg/L.
- Another significant flow zone was found between 1,730 and 1,770 feet bls. An APT was performed across the open hole interval between 1,700 to 1,800 feet bls. Test results yielded a transmissivity of 32,716 gpd/ft, leakance was $3.84e^{-4}$ gpd/ft^3 and the TDS concentration was 3,450 mg/L.
- The base of the USDW (TDS > 10,000 mg/L) was found at 2,139 feet bls.
- Three packer tests were conducted. The three intervals tested were between 516-730, 1,720-1,768 and 2,565-2,640 feet bls. Corrected specific capacities were determined in each as 1.9, 4.5 and 30.5 gpm/ft, respectively. Total dissolved solids concentrations in each zone were 3,600, 3,400 and 34,200 mg/L, respectively.
- Average water levels (uncorrected for salinity) in the upper and middle Floridan aquifers (DF-4 and DF-5) measured between November 2001 and May 2003 were approximately +51.79 and +51.42 feet above the NGVD 1929, respectively. Water levels fluctuated approximately 1.5 feet over the period of record.

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APPENDICES

Appendix A – Lithologic Descriptions

Florida Geologic Survey Descriptions

Pilot Hole DF-1

CUTTING DESCRIPTIONS BY FGS FOR PILOT HOLE DF-1

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LITHOLOGIC WELL LOG PRINTOUT                      SOURCE - FGS

WELL NUMBER:   W-17089                            COUNTY -   DADE
TOTAL DEPTH:    2743  FT.                         LOCATION:  T.52S R.39E S.19
338 SAMPLES FROM 0 TO 2743 FT.                               LAT = 25D 54M 06S
                                                             LON = 80D 28M 33S
COMPLETION DATE: 10/  /93                         ELEVATION: 15 FT
OTHER TYPES OF LOGS AVAILABLE - NONE

OWNER/DRILLER:SOUTH FLORIDA WATER MANAGEMENT DISTRICT/RST PARTNERSHIP

WORKED BY:__LI LI (06/01/94)
WELL NAME IS DF-2
SFWMD ID# FOR CUTTINGS IS 025-2, AT 5--10 FT. INTERVAL.
SFWMD GEOPHYSICAL LOG # 0250000012.
WELL IS LOCATED IN THE NE 1/4, SW 1/4, SEC 19, T52S, R39E.
PENNSUCO 7.5' QUADRANGLE, DADE COUNTY.
PLANAR X=672310; PLANAR Y=570270.
THE OKEECHOBEE FORMATION IS PROPOSED FOR THE PLIO-PLEISTOCENE INTERVAL
(SCOTT, 1992, P. 23, FLORIDA GEOLOGICAL SURVEY SPECIAL PUBLICATION 36).

    0.    -  210.   121PCPC   PLIOCENE-PLEISTOCENE
  210.    - 1235.   122HTRN   HAWTHORN GROUP
 1235.    - 2743.   124AVPK   AVON PARK FM.
   40.    -   45.   000NOSM   NO SAMPLES
  270.    -  280.   000NOSM   NO SAMPLES
  775.    -  785.   000NOSM   NO SAMPLES
 1195.    - 1205.   000NOSM   NO SAMPLES

    0  -   30   PACKSTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY
                15% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
                LOW PERMEABILITY
                GRAIN TYPE: BIOGENIC, CRYSTALS, PELLET
                70% ALLOCHEMICAL CONSTITUENTS
                GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
                MODERATE INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
                ACCESSORY MINERALS: SHELL-05%, QUARTZ SAND-05%
                FOSSILS: MOLLUSKS

   30  -   33   WACKESTONE; WHITE TO LIGHT GRAY
                15% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
                LOW PERMEABILITY
                GRAIN TYPE: SKELETAL, SKELTAL CAST, CRYSTALS
                30% ALLOCHEMICAL CONSTITUENTS
                GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL
                MODERATE INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX
                ACCESSORY MINERALS: QUARTZ SAND-05%
                FOSSILS: MOLLUSKS, FOSSIL MOLDS
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 33  -   40   WACKESTONE; VERY LIGHT ORANGE
              15% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
              LOW PERMEABILITY
              GRAIN TYPE: CRYSTALS, BIOGENIC, SKELTAL CAST
              40% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
              MODERATE INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              ACCESSORY MINERALS: QUARTZ SAND-10%
              FOSSILS: MOLLUSKS, FOSSIL MOLDS

 40  -   45   NO SAMPLES

 45  -   65   PACKSTONE; VERY LIGHT ORANGE
              15% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
              LOW PERMEABILITY
              GRAIN TYPE: CRYSTALS, BIOGENIC, SKELTAL CAST
              70% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
              MODERATE INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              ACCESSORY MINERALS: QUARTZ SAND-10%
              FOSSILS: MOLLUSKS, FOSSIL MOLDS

 65  -   70   SHELL BED; WHITE TO VERY LIGHT GRAY
              30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
              UNCONSOLIDATED
              ACCESSORY MINERALS: LIMESTONE-20%, QUARTZ SAND-10%
              FOSSILS: MOLLUSKS, BRYOZOA, SPICULES
              ACCESSORY LIMESTONE IS LIGHT GRAY COLOR, WELL INDURATED
              FOSSILIFEROUS PACKSTONE. WHITE CALCITE CEMENTED QUARTZ
              SANDSTONE FRAGMENTS WERE NOTED.

 70  -   75   GRAINSTONE; VERY LIGHT GRAY TO VERY LIGHT ORANGE
              25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
              GRAIN TYPE: BIOGENIC, SKELETAL
              90% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
              MODERATE INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
              ACCESSORY MINERALS: SHELL-20%, QUARTZ SAND-05%
              FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
              MOST LOOSE MOLLUSK FRAGMENTS MAY BE CAVINGS.

 75  -   95   GRAINSTONE; LIGHT GRAY
              25% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
              POSSIBLY HIGH PERMEABILITY
              GRAIN TYPE: BIOGENIC, SKELETAL
              95% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
              MODERATE INDURATION
              CEMENT TYPE(S): SPARRY CALCITE CEMENT
              ACCESSORY MINERALS: QUARTZ SAND-05%
              FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

 95  -  100   GRAINSTONE; VERY LIGHT GRAY TO VERY LIGHT ORANGE
              25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
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                 GRAIN TYPE: BIOGENIC, SKELETAL
                 90% ALLOCHEMICAL CONSTITUENTS
                 GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
                 MODERATE INDURATION
                 CEMENT TYPE(S): SPARRY CALCITE CEMENT
                 ACCESSORY MINERALS: CALCILUTITE-20%, QUARTZ SAND-05%
                 FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
                 20% OF THE SAMPLE ARE FRAGMENTS OF WHITE POORLY INDURATED
                 CHALKY WACKSTONE AND MUDSTONE.

  100  -  117    GRAINSTONE; VERY LIGHT ORANGE TO LIGHT GRAY
                 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                 GRAIN TYPE: BIOGENIC, SKELETAL
                 90% ALLOCHEMICAL CONSTITUENTS
                 GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
                 POOR INDURATION
                 CEMENT TYPE(S): CALCILUTITE MATRIX
                 ACCESSORY MINERALS: LIMESTONE-30%, QUARTZ SAND-10%
                 PHOSPHATIC GRAVEL-  %
                 FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
                 ACCESSORY LIMESTONE ARE LIGHT GRAY, SPARRY CALCITE CEMENTED
                 SANDY LIMESTONE.

  117  -  120    PACKSTONE; VERY LIGHT ORANGE
                 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                 GRAIN TYPE: BIOGENIC, SKELETAL
                 80% ALLOCHEMICAL CONSTITUENTS
                 GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL
                 MODERATE INDURATION
                 CEMENT TYPE(S): CALCILUTITE MATRIX
                 ACCESSORY MINERALS: QUARTZ SAND-20%
                 FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

  120  -  125    GRAINSTONE; YELLOWISH GRAY
                 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                 GRAIN TYPE: BIOGENIC, SKELETAL
                 90% ALLOCHEMICAL CONSTITUENTS
                 GRAIN SIZE: GRAVEL; RANGE: MEDIUM TO GRAVEL
                 POOR INDURATION
                 CEMENT TYPE(S): CALCILUTITE MATRIX
                 ACCESSORY MINERALS: QUARTZ SAND-10%
                 FOSSILS: MOLLUSKS, ECHINOID

  125  -  145    PACKSTONE; YELLOWISH GRAY
                 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                 GRAIN TYPE: BIOGENIC, SKELETAL
                 90% ALLOCHEMICAL CONSTITUENTS
                 GRAIN SIZE: GRAVEL; RANGE: FINE TO GRAVEL
                 MODERATE INDURATION
                 CEMENT TYPE(S): CALCILUTITE MATRIX
                 ACCESSORY MINERALS: QUARTZ SAND-40%, PHOSPHATIC SAND-  %
                 FOSSILS: MOLLUSKS, ECHINOID
                 SANDY LIMESTONE. 30-40%FINE TO MEDIUM, SUBROUNDED, WELL
                 SORTED QUARTZ SAND CEMENTED BY CALCILUTITE MATRIX.
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145 - 147 GRAINSTONE; WHITE TO YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELTAL CAST, CRYSTALS
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT
ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND- %
OTHER FEATURES: LOW RECRYSTALLIZATION
FOSSILS: MOLLUSKS, FOSSIL MOLDS

147 - 150 GRAINSTONE; WHITE TO YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, PHOSPHATIC SAND- %
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

150 - 155 GRAINSTONE; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, SKELTAL CAST
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: QUARTZ SAND-15%
OTHER FEATURES: LOW RECRYSTALLIZATION
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, FOSSIL MOLDS

155 - 176 PACKSTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CRYSTALS
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: QUARTZ SAND-30%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

176 - 180 GRAINSTONE; WHITE TO YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-20%, PHOSPHATIC SAND- %
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
50% MOLLUSK FRAGMENTS AND 50% CALCAREOUS SANDSTONE (OR
SANDY LIMESTONE ?).

180 - 198 MUDSTONE; WHITE
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELTAL CAST
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-05%
OTHER FEATURES: CHALKY
FOSSILS: MOLLUSKS

198 - 210 SAND; LIGHT OLIVE GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-10%, LIMESTONE-10%
CALCILUTITE-10%, PHOSPHATIC SAND-03%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
TOP OF HAWTHORN FORMATION.

210 - 225 SAND; OLIVE GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-15%, CALCILUTITE-10%
PHOSPHATIC SAND-05%, LIMESTONE-03%
FOSSILS: MOLLUSKS

225 - 235 SAND; LIGHT OLIVE GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-10%, CALCILUTITE-10%, SHELL-10%
PHOSPHATIC SAND-03%
FOSSILS: MOLLUSKS

235 - 265 MUDSTONE; VERY LIGHT GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS; 10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-20%, QUARTZ SAND-10%
FOSSILS: MOLLUSKS
LIGHT GRAY MARL, MIXTURE OF 60-70% CALCILUTITE, 20-30% CLAY
AND 10% QUARTZ SAND.

```
265  -  270   MUDSTONE; VERY LIGHT GRAY TO LIGHT OLIVE GRAY
               15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
               GRAIN TYPE: CRYSTALS; 10% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: VERY FINE; POOR INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: CLAY-30%, QUARTZ SAND-20%
               PHOSPHATIC SAND-01%
               FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA
               SAMPLE IS MIXTURE OF 50-60% LIGHT GRAY MARL DESCRIBED ABOVE
               AND 40-50% OLIVE GRAY HAWTHORN FM. LOOSELY INDURATED VERY
               FINE SAND.

270  -  280   NO SAMPLES

280  -  301   SAND; LIGHT OLIVE GRAY TO VERY LIGHT GRAY
               20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
               ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
               POOR INDURATION
               CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
               ACCESSORY MINERALS: CLAY-20%, CALCILUTITE-20%
               PHOSPHATIC SAND-02%, MICA-  %
               FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA
               SIMLAR ROCK AS IN ABOVE INTERVAL, A MIXTURE OF OLIVE GRAY
               SAND AND LIGHT GRAY MARL. PERCENTAGE OF MARL DECREASES
               DOWNSECTION.

301  -  391   SAND; OLIVE GRAY
               20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
               ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
               POOR INDURATION
               CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
               ACCESSORY MINERALS: CLAY-20%, CALCILUTITE-10%
               PHOSPHATIC SAND-03%
               FOSSILS: FOSSIL FRAGMENTS

391  -  400   SAND; LIGHT OLIVE GRAY
               20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
               ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
               POOR INDURATION
               CEMENT TYPE(S): CLAY MATRIX
               ACCESSORY MINERALS: CLAY-20%, PHOSPHATIC SAND-02%
               FOSSILS: BENTHIC FORAMINIFERA

400  -  430   SAND; OLIVE GRAY
               20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
               ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
               POOR INDURATION
               CEMENT TYPE(S): CLAY MATRIX, CALCILUTITE MATRIX
               ACCESSORY MINERALS: CLAY-20%, CALCILUTITE-10%
               PHOSPHATIC SAND-02%, MICA-  %
               FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS
```

430 - 435 GRAINSTONE; LIGHT OLIVE GRAY TO OLIVE GRAY
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
ACCESSORY MINERALS: QUARTZ SAND-20%, CLAY-10%
CALCILUTITE-10%
FOSSILS: BRYOZOA, BENTHIC FORAMINIFERA, MOLLUSKS, CORAL
SAMPLE IS A MIXTURE OF 20-30% HAWTHORN FM. FINE SAND AND
70-80% LIGHT OLIVE GRAY, VERY COARSE, HIGHLY POROUS
BRYOZOAN FRAGMENTS (POSSIBLE PARTIALLY DISSOLVED MOLLUSK
FRAGMENTS), AND SMALL CORALS.

435 - 460 PACKSTONE; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-30%, QUARTZ SAND-05%
CLAY-05%, PHOSPHATIC SAND-01%
FOSSILS: MOLLUSKS, BRYOZOA

460 - 470 PACKSTONE; YELLOWISH GRAY
30% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, SKELTAL CAST
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-30%, DOLOMITE- %
FOSSILS: MOLLUSKS, BRYOZOA
GASTROPOD CASTS ARE VERY COMMON. THEY ARE MAINLY CALCITE
CRYSTALS. SOME ARE POSSIBLE DOLOMITE CRYSTALS.

470 - 483 WACKESTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELTAL CAST
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, PHOSPHATIC GRAVEL-01%
FOSSILS: MOLLUSKS, SPICULES

483 - 500	PACKSTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC, SKELTAL CAST 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND-01% FOSSILS: MOLLUSKS, BRYOZOA 20% COARSER GRAIN MOLLUSK AND BRYOZOAN FRAGMENTS.
500 - 580	GRAINSTONE; YELLOWISH GRAY 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND-01% FOSSILS: MOLLUSKS, BRYOZOA, FOSSIL MOLDS 30-40% MOLLUSK & BRYOZOAN FRAGMENTS. DECREASE TO 20% DOWNSECTION.
580 - 625	GRAINSTONE; YELLOWISH GRAY 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC, SKELTAL CAST 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: QUARTZ SAND-03%, PHOSPHATIC SAND- % OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: MOLLUSKS, FOSSIL MOLDS
625 - 630	PACKSTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC, SKELTAL CAST 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND- % FOSSILS: MOLLUSKS, FOSSIL MOLDS
630 - 645	GRAINSTONE; YELLOWISH GRAY 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-01%, QUARTZ SAND- % FOSSILS: MOLLUSKS, FOSSIL MOLDS

645 - 670 PACKSTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, SPICULES

670 - 710 PACKSTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND- %
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA

710 - 720 WACKESTONE; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY
FOSSILS: MOLLUSKS, BRYOZOA

720 - 740 PACKSTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA, SPICULES

740 - 775 WACKESTONE; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC; 30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA

775 - 785 NO SAMPLES

785 - 795 PACKSTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA, SPICULES

795 - 820	GRAINSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: FINE TO GRAVEL; POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS, SPICULES
820 - 830	PACKSTONE; VERY LIGHT ORANGE 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS
830 - 850	WACKESTONE; VERY LIGHT ORANGE 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC; 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS
850 - 870	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC GRAVEL- % FOSSILS: MOLLUSKS
870 - 888	WACKESTONE; VERY LIGHT ORANGE 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC GRAVEL- % FOSSILS: MOLLUSKS
888 - 925	GRAINSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS, SPICULES

925 - 950 GRAINSTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC, SKELTAL CAST
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA, SPICULES

950 - 973 GRAINSTONE; PINKISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC; 95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA, ECHINOID

973 - 975 PACKSTONE; PINKISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC; 75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA

975 - 978 GRAINSTONE; PINKISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC; 90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA

978 - 990 GRAINSTONE; PINKISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, CRYSTALS
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA, ECHINOID

990 - 995 GRAINSTONE; PINKISH GRAY
30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC; 95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA

995 - 1000 GRAINSTONE; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, CRYSTALS
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND- %
FOSSILS: MOLLUSKS, ECHINOID

1000 - 1020 PACKSTONE; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

1020 - 1038 WACKESTONE; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC; 30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

1038 - 1055 WACKESTONE; LIGHT OLIVE GRAY TO OLIVE GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, CRYSTALS
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
ACCESSORY MINERALS: CLAY-30%
FOSSILS: MOLLUSKS

1055 - 1068 WACKESTONE; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

1068 - 1075 GRAINSTONE; YELLOWISH GRAY
30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, BRYOZOA

1075	- 1095	WACKESTONE; YELLOWISH GRAY 10% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC; 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC GRAVEL- % FOSSILS: MOLLUSKS
1095	- 1100	PACKSTONE; PINKISH GRAY 20% POROSITY: INTERGRANULAR, PIN POINT VUGS POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELTAL CAST 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND- %, QUARTZ SAND- % FOSSILS: MOLLUSKS, FOSSIL MOLDS
1100	- 1125	PACKSTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, PIN POINT VUGS POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELTAL CAST, CRYSTALS 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-15%, QUARTZ SAND-10% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: MOLLUSKS, FOSSIL MOLDS QUARTZ AND PHOSPHATE SANDS CEMENTED BY CALCILUTITE AND AS FILLINGS OF MOLLUSK CASTS.
1125	- 1130	WACKESTONE; YELLOWISH GRAY 20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELTAL CAST 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-05%, QUARTZ SAND-05% OTHER FEATURES: MEDIUM RECRYSTALLIZATION FOSSILS: MOLLUSKS, FOSSIL MOLDS
1130	- 1135	WACKESTONE; LIGHT OLIVE GRAY 20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: SKELTAL CAST, BIOGENIC 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-20%, QUARTZ SAND-10% OTHER FEATURES: MEDIUM RECRYSTALLIZATION FOSSILS: MOLLUSKS, FOSSIL MOLDS

1135 - 1150 WACKESTONE; YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELTAL CAST, BIOGENIC
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-05%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: MOLLUSKS, FOSSIL MOLDS

1150 - 1155 PACKSTONE; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELTAL CAST, BIOGENIC
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%
FOSSILS: MOLLUSKS

1155 - 1170 PACKSTONE; YELLOWISH GRAY TO VERY LIGHT GRAY
25% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELTAL CAST, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: COARSE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND- %
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: MOLLUSKS, FOSSIL MOLDS

1170 - 1195 GRAINSTONE; YELLOWISH GRAY TO VERY LIGHT GRAY
25% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELTAL CAST, PELLET
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRAVEL; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC SAND-02%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: MOLLUSKS, SPICULES, FOSSIL MOLDS

1195 - 1205 NO SAMPLES

1205 - 1235	GRAINSTONE; PINKISH GRAY 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, CONES, CORAL, ECHINOID DICTYOCONUS cookei & americanus. TOP OF AVON PARK FORMATION.
1235 - 1255	GRAINSTONE; PINKISH GRAY 25% POROSITY: INTERGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET, CRYSTALS 95% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): SPARRY CALCITE CEMENT OTHER FEATURES: MEDIUM RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
1255 - 1330	PACKSTONE; GRAYISH BROWN 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 85% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
1330 - 1370	GRAINSTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRANULE; RANGE: FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
1370 - 1430	GRAINSTONE; GRAYISH ORANGE PINK TO VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID

1430 - 1490	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
1490 - 1575	GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS, ECHINOID AVON PARK FORMATION INDEX FOSSILES WERE OBSERVED: LITUONELLAM sp., DICTUOCONUS americanus, CRIBROBULIMINA sp.
1575 - 1610	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES, ECHINOID FOSSIL MOLDS
1610 - 1695	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES, ECHINOID
1695 - 1710	WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL GOOD INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

1710	- 1740	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 25% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS
1740	- 1770	WACKESTONE; VERY LIGHT ORANGE 10% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: PELLET; 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO COARSE GOOD INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
1770	- 1790	PACKSTONE; YELLOWISH GRAY 25% POROSITY: INTERGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
1790	- 1830	GRAINSTONE; GRAYISH ORANGE PINK TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES
1830	- 1860	PACKSTONE; VERY LIGHT ORANGE 15% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 80% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS
1860	- 1870	GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, PELLET 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-10% FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

1870 - 1920 GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

1920 - 1930 PACKSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

1930 - 1980 GRAINSTONE; GRAYISH BROWN
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

1980 - 1990 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES

1990 - 2020 GRAINSTONE; GRAYISH BROWN
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO GRAVEL; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

2020 - 2040 PACKSTONE; GRAYISH BROWN TO VERY LIGHT GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS
20% OF THE SAMPLE ARE FRAGMENTS OF LIGHT GRAY, WELL
INDURATED MUDSTONE.

2040 - 2140 PACKSTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

2140 - 2160 WACKESTONE; VERY LIGHT ORANGE
10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET; 30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, MILIOLIDS

2160 - 2218 GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2218 - 2270 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES, ECHINOID

2270 - 2310 WACKESTONE; VERY LIGHT ORANGE
10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2310 - 2330 PACKSTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2330 - 2340 WACKESTONE; WHITE TO PINKISH GRAY
10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC; 30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY
FOSSILS: BENTHIC FORAMINIFERA, CONES

2340 - 2440 PACKSTONE; PINKISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2440 - 2495 GRAINSTONE; PINKISH GRAY TO YELLOWISH GRAY
20% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: PELLET, BIOGENIC
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2495 - 2526 PACKSTONE; PINKISH GRAY TO LIGHT GRAY
15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
GRAINSTONE MIXED WITH 20-30% LIGHT GRAY, WELL INDURATED
MUDSTONE. DOLOMITE CRYSTALS ARE EUHEDRAL.

2526 - 2556 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, PELLET
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-50%
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
40-50% OF THE SAMPLE IS FINE TO MEDIUM GRAIN EUHEDRAL
DOLOMITE CRYSTALS.

2556 - 2565	WACKESTONE; VERY LIGHT ORANGE 10% POROSITY: INTERGRANULAR, LOW PERMEABILITY GRAIN TYPE: PELLET; 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05% OTHER FEATURES: CHALKY FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS
2565 - 2585	DOLOSTONE; DARK YELLOWISH BROWN 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; ANHEDRAL GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-05%
2585 - 2588	DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN 05% POROSITY: LOW PERMEABILITY; 90-100% ALTERED; ANHEDRAL GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2588 - 2618	DOLOSTONE; DARK YELLOWISH BROWN 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; SUBHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2618 - 2625	WACKESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN 10% POROSITY: INTERGRANULAR, INTERCRYSTALLINE LOW PERMEABILITY GRAIN TYPE: PELLET, BIOGENIC 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-25% FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
2625 - 2649	DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN 10% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY 90-100% ALTERED; SUBHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-05% FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS

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2649  - 2675   PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
               POSSIBLY HIGH PERMEABILITY
               GRAIN TYPE: PELLET, BIOGENIC
               80% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
               POOR INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-30%
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2675  - 2680   DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
               POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; EUHEDRAL
               GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
               GOOD INDURATION
               CEMENT TYPE(S): DOLOMITE CEMENT
               ACCESSORY MINERALS: LIMESTONE-30%
               OTHER FEATURES: CALCAREOUS
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS

2680  - 2690   GRAINSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
               20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
               POSSIBLY HIGH PERMEABILITY
               GRAIN TYPE: BIOGENIC, PELLET
               90% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-20%
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2690  - 2720   DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
               POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; EUHEDRAL
               GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
               GOOD INDURATION
               CEMENT TYPE(S): DOLOMITE CEMENT
               ACCESSORY MINERALS: LIMESTONE-20%
               OTHER FEATURES: CALCAREOUS
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2720  - 2730   PACKSTONE; VERY LIGHT ORANGE
               15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
               GRAIN TYPE: BIOGENIC, PELLET
               70% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-05%
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES
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2730  - 2743   PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               15% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
               LOW PERMEABILITY
               GRAIN TYPE: PELLET, BIOGENIC
               70% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-40%
               FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, CONES

2743  TOTAL DEPTH

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Appendix A

Site Geologist's Lithologic Descriptions

Pilot Hole DF-1

Feet BLS (SFWMD)	DF-1 Cutting Descriptions from Site Geologist
0-20	Pit casing: Driller reported loss circulation in top 20’ during pit casing installation.
20-22	80% L.S., gray, poorly ind., sparry, 20% shells, mollusks, tan, fragments, v. fine (smooth) TR peat, dark, root debris.
22-25	As above.
25-30	90% L.S., intergranular ∅, poor to fairly ind., L. gray to white, sparry (glistens), some quartz replacement, 70% shells, tan. TR peat.
	SECURE DRILLING LOSS CIRCULATION AT 28’
30-33	60% cement, 40% L.S., olive green to gray, angular, fine-grain, mod. Sorted, somewhat consolidated due to cement silts.
33-35	90% L.S., light gray to white, angular, fine grain, well sorted, low perm due to some siltstones, no visible ∅, some shell molds. 10% gray siltstones (may be coagulated drillers mod) TR. Mollusk, sparry, replaced by quartz.
35-40	95% L.S., light gray to pale orange, angular, moldic, secondary solning (sparry), oolitic, mod to well sorted, good ∅. 5% siltstone, gray, fine to silty grn, somewhat plastic texture. TR orange tevebra’s.
40-45	98% L.S., oolitic, light gray to yellow, med grn, angular to subrounded, moldic, quartzitic shell molds, (binsparite) molds display prismatic xtals under 10x. 2% shells.
45-50	98% L.S., pale orange, moldic, fine to med grn, soln, sparry, vuggy, good ∅, good perm.
50-55	98% L.S., oolitic, subrounded to slightly angular, light gray to white, biosparite, (mollusk sparry with quartz luster), moldic, med grn, good ∅, well sorted.

	2% siltstone, oval, platy, smooth texture, jewel like (shiny), v. fine grn, mood ind, approx. 4mm in length.
55-62	95% L.S., light gray to white, oolitic shell molds, (sparry), good ∅, good perm., well sorted, well ind., coarse grn. 5% shells replaced by prismatic xtals (quartz), pale orange to orange TR splinters “Hard drilling” Secure need to mix mud, loss circulation.
62-65	80% shells, fragmented, mollusk, pale orange to orange, mod ∅. 20% L.S., light gray to dark, moldic, mod. ind., sparry, (quartic replacement), angular, no visible ∅, 1-3mm, well sorted. TR gray siltstones.
65-70	90% mollusk and coral stems, well preserved, pale orange to yellow, pelecypods, (pectins), cockles, thorny cockles, snails. 10% L.S., oolitic, well ind. Gray, interparticle cementation, moldic, low to mod perm, mod ∅, med grn, “fast drilling”.
70-75	95% L.S., dark gray, well indurated, angular, platy, no visible ∅, cemented phosphorite grns (heavy minerals), well sorted, some sparry molds. 5% shells, corals, buttercup lucines, (terebras) augers.
75-80	As above.
80-85	80% L.S., dark gray, oolitic, rounded, interparticle cementation of phosphorites (heavy minerals) and coarse grains of allochews(oolites). 10% L.S., olive green to gray, phosphorite specs, rounded, mod. ind., mod. sorted, low to med perm. 10% shells, corals, forams (splinters), white to pale orange.
85-90	80% L.S., dark gray, cemented siltstones or phosphorite (dark blk)?, subrounded to angular, cemented particles of shells intergranular ∅, good perm. 5% siltstones, dark oval, platy, smooth, mod. indurated (jewelstone like). 5% shell frags, orange. 5% quartzose grains, 3-5mm, oval, transparent. “Hard Drilling”

90-95	As above.
95-100	80% L.S., gray, well ind., (heavy minerals), phosphorite specs, intergranular ∅, angular. 10% L.S., olive green, rounded, heavy minerals, phosphorite, mod. to poorly ind., oolitic, sandy grain, low to mod. perm. 10% shells, pale orange.
100-105	70% sandstone, olive green, phosphaltic (or laden with heavy minerals), silty grn, v. poorly ind., low perm. 10% L.S., gray, well ind., heavy minerals, cemented, may be above or overlying formation. 10% siltstone, oval, platy, black, smooth, no ∅.
105-110	As above.
110-117	60% S.S., silty, olive grn, heavy mineral specs (dark blk 1-2mm), 40% silty, plastic clay, poor (low) perm.
117-120	30% clayey s. sandstone, green, phosphatic, low perm, 30% L.S., gray, well indurated, subrounded, cemented heavy minerals (blk specs), no visible ∅, TR intrgrnlr ∅, low perm. 30% shells, fragments, pale orange to white. 5% siltstone, black as above.
120-125	50% green phosphatic clay, low perm, no ∅. 50% shells, purple and yellow.
125-130	60% green silty sandstone, laden with heavy minerals, fine grain to silty, no ∅, low perm, rounded. 40% shells.
130-135	80% sandstone, green, (phosphatic or other dark heavy minerals?), cemented grains, med to well indurated, silty grn. Reaction with HCl (limy) S.S. 20% shell matrix, pectins, splinters (pinnicles)
135-140	95% cemented green, phosphatic limy S.S., some quartz replacement (quartzose) 5% shells, hard, fragmented.
140-145	50% L.S., gray, angular, well indurated, chips. 40% quartzose sandstone replace by quartz. 10% green phosphatic silty clay patties.

145-147	80% L.S. light gray, rounded, intergranular ∅, well ind., some vugs, med coarse grain. 10% S.S. green, cemented with quartz (quartzose) 5% shells 5% clays.
147-150	90% L.S., light gray, subrounded, cemented quartz grns., med to well ind., dark phosphorite specs cemented interparticle cementation, moldic, coarse grn., fair ∅ 5% shells, tan to pale, pelecypods, buttercups. 5% silty muds, low perm.
150-155	90% L.S. as above, coarse grn., l. gray. 5% shell frags with cement phosphatic limy. TR silts.
155-165	95% L.S., gray, cemented phosphorite (dark specs), bioclast cemented, mod. ind., sandy grn when grinded, subrounded to round, some moldic ∅, some vugs, med to coarse grn., well sorted, some soln with replacement of quartz, good perm. 5% cemented limy phosphatic shells, pale to light gray, good perm.
165-170	90% L.S., olive green to gray, phosphatic specs, coarse grn, some cemented shell molds, intergranular ∅, well indurated, some quartz replacement. 75% shells, as above with some pink in color (TR) 3% siltstones, black, platy, smooth, fissile. TR dark and white coral stems, septa exposed. TR forams, splinters.
170-176	85% S.S., olive grn color, silty grn, phosphorite specs, somewhat consolidated, low to fair perm., no visible ∅, holds water in hand, no perculation. 5% quartzose grns, transparent, oval, smooth. 5% shells and coral stems, white to orange. TR siltstone, TR silts muddy.
176-180	98% shell frags in light olive grn matrix, shells are pale to yellow, somewhat consolidated, fair to good perm. 2% silty sandstones, round 1-3mm
180-198	70% shells as above. 30% clay stones, gray, nodular, 2-3 inch girth, hard, golf ball size.
198-207	99% dark green, plastic, phosphatic clay. “Hawthorne”

	1% shells
207-210	As above.
210-215	As above.
215-220	As above.
220-225	As above.
225-230	As above.
230-237	As above.
237-240	Cement plug and olive green clay.
240-245	50% clay; silty, green, phosphatic. 50% claystone; gray, angular, mod. ind.
245-250	100% claystones; gray, silty, blocky, angular, ultrafine grn, consolidated, mod. ind., hard to break apart.
250-255	80% claystones; gray, angular, mod. ind., ultrafine grn, no ∅. 10% claystones; green, phosphatic, soft, pliable. 10% clay; soupy, green phosphatic matrix.
255-260	Same as above, TR: shell frag.
260-269	Same as above, 1-2% shell frags.
269-275	50% gray, siltstone, poor to mod ind. Ultrafine silty grn, platy. 50% green plastic, phosphatic soupy clay, “washe”
275-280	50% gray siltstone as above 50% clay, soupy, plastic, phosphatic green mixture. “Recovery difficult; cuttings are washing out”
280-285	100% clay, green, phosphatic
285-301	100% clay, green, phosphatic
301-362	Same clay; green phosphatic, soupy.
362-391	100% clay; green, adhesive, phosphatic, dense, plastic.
391-395	99% clay; green, phosphatic, well consolidated. TR white fragmented shells.

395-400	98% clay; green, phosphatic as above. 1% claystones; gray, angular, silty, blocky. TR siltstone; blk, platy, angular.
400-410	100% clay; green, phosphatic, silty, plastic, adhesive.
410-421	98% clay; phosphatic, silty, plastic. 2% silty claystone; large block of gray silty clay.
421-430	98% clay, green, phosphatic, silty. 2% claystone; silty, angular, small chips. TR shell frag
430-435	75% L.S., chips, olive greenish gray, poorly ind. Intergranular ∅, some shells cemented, “marly” 20% S.S.; olive grn, silty, limy, clayey, ultra-fine grn. 10% clay matrix
435-440	50% S.S.; calcareous exterior, poorly ind., stained olive greenish gray. 10% shells; coral stems, “shark teeth” 40% clay; green phosphatic, “no perm”
440-445	60% clay; muddy color, phosphatic 20% siltstone; platy, poorly ind, no ∅, dark gray. 20% S.S.; calcareous, limestone cemented grns, no visible ∅, “no perm” TR: shell, coral stems, “echinolormata stem” foram, cones.
445-451	85% clay; muddy, light green, phosphatic 10% claystone; gray, silty, some nodular and some platy. 10% crinoid stems, coral stems, shell frag.
451-460	80% clay; muddy, light green, phosphatic 10% shells; white frag. 10% L.S.; oolitic, light grn to gray, intergranular ∅, poor ind., rounded, cemented oolites. 10% claystones; gray platy. TR broken crinoidal stems.
460-470	60% clay; muddy tan to gray color, “no perm” holds water. 20% coral; stems, fragments, white, some splinters. 10% S.S.; calcareous, silty, ultra-fine grn, light gray. 10% coal or siltstone; cherty, well ind., angular

	hard, looks like "coal blocks"
470-483	60% clay; muddy gray, phosphatic 10% L.S.; oolitic, mod to well ind., rounded, stained olive green. 10% shells; fragmented, white. 10% claystone; gray, phosphatic, platy. 5% siltstone; coal like, black, fissile, smooth exterior, well ind. TR crinoid stem.
483-487	70% S.S.; tan, calcareous, cemented, fine grn, poor ind. 20% L.S.; gray, fine grn, platy, angular chips, mod to well ind., no visible ∅, smooth texture. 10% corals.
487-490	50% Clay; muddy tan. 40% S.S.; light gray, coarse to med grn, poorly ind. 10% claystone; gray, range 3-6mm, rounded.
490-500	90% sandstone; light gray to mud color, ultra-fine grn, fairly consolidated, low to med perm., phosphate cemented specs. 5% shell frags, white to v. light gray 5% claystones; gray. TR Siltstone, black oval.
500-513	95% L.S.; sandy, poorly ind., light gray. 5% shells; "mud loss"
513-515	90% L.S.; sandy, coarse grn, poorly sorted (diff sizes) rounded cemented grns, poorly ind., olive gray. 10% shells; tan to l. gray. TR silts, gray, platy.
515-520	90% L.S.; olive gray, phosphatic, sandy, cemented calcareous grn, coarse, subrounded, fairly consolidated, good perm, sparry, no visible ∅. May be intergranular ∅. 10% splinters, shell frags, tan to orange. TR siltstones, blk, angular, fissile, smooth coal like.
520-525	Same as above.
525-530	90% L.S., olive gray, phosphatic, sandy, cemented calcareous grn, fairly consoled, poorly sorted, low perm (holds water after rinsing in sifter) poorly ind, coarse grn, cemented shell frags, sparry, gritty looking.

	10% same.
530-544	95% L.S.; sandy, phosphatic, olive gray to mud color, coarse grn, cemented calcite, sparry, uniform, well sorted, no visible ∅, "med perm" 5% shell frags; with some quartz replacement, "white to orange"
544-547	90% L.S.; sandy, "marl" as above. 5% shell; fragmented, cemented sandy phosphate. 1% claystone; gray, silty. 1% coral; orange, stems, splinters TR spirals, TR chalk
547-550	85% L.S., sandy, marly, chalky residue 10% white chalk, "marl" TR leps, cherty, L.S., angular, hard, cryphortalline, "bit chatter", "moderate perm."
550-555	70% L.S.; sandy, cemented calcareous grns, sparry coarse grn, poorly ind. Well sorted, (all grns are uniform size), intergranular ∅, some gray corals cemented to L.S. grns. 20% chalk; white, clayey, slimy, no ∅, write with it. "marl". 10% shells; coral stems, white to orange and fragments. "Holds water fair to mod. ∅"
555-560	Same as above. TR blk siltstones, oval, hard.
560-565	60% L.S.; sandy, olive grn to gray, phosphatic specs, poorly ind, coarse grn, rounded, well sorted, intergranular ∅. 20% shell; frag, white to orange, some replacement of quartz. 10% L.S.; chalky, white, hard, leaves white residue, angular, phosphate specs. 5% claystones, silty, gray. TR splinters
565-570	60%(?) S.S.; sandy, olive grn, cemented calcareous grn, phosphatic, poorly ind., well sorted, intergranular ∅. 10% L.S.; white, phosphatic, sandy grn, well indurated, angular, poorly sorted, some dark gray cemented shells, intergranular ∅. 30% shells; tan. Orange, platy or flat like, coral stems. "silty residue" all fine grn.
570-575	Same as above.

575-580 85% L.S.; sandy, calcareous, coarse grn, cemented allochems, phosphate specs, intergranular ∅, heavy, “fairly good perm”
10% shell frag, light gray to off-white.
5% gray claystones, oblong, “marl”

580-585 75% L.S.; sandy as above.
20% shells; some calcite or quartz replacement
10% L.S.; darker gray, sandy phosphatic, no visible ∅, mod to well ind.

585-590 75% L.S.; sandy, rounded, olive green to l. gray, phosphatic, mod ind, no visible ∅.
10% L.S.; sparry, may be calcitic or quartz,
15% shell; fragmented.
TR white chalk; clayey

590-595 80% L.S.; sandy, phosphatic, l. olive grn, poorly ind., coarse grn, intergranular ∅, heavy (holds water), silty residue, “low perm”
10% L.S.; gray, sandy, hard, coarse grn, sparry, soln’d.
10% shells; l. gray to orange to pale.
TR silts.

595-607 Same as above.

670-610 75% sandy, poorly ind., pale gray phosphatic L.S., coarse grn, “cemented calcareous sands”, no visible ∅, may be intergranular due to cementation of shell bits.
10% gray sandy calcareous stone, poorly ind, F-M grn, floury ultra-fine, heavy, low perm.
10% pale orange shell frags.
5% wht L.S. chips, sandy grain
1% silty gray claystones.

Lost 4000 gallons of mud in this section.
Fair to med perm. 25% loss.

610-615 As above, “marl”

615-620 75% sandy, olive gray dull, phosphatic L.S., med to coarse grn, poor to med ind., no visible ∅, some micritic, weathered, poorly sorted, harder grains are bigger.
10% dark gray, calcareous phosphatic sands
10% tan to l. gray shells
TR silty residue orange quartz shells.

620-630 80% L.S.; sandy as above.

	10% chert: L.S., dark gray, angular, micritic, no visible ∅.
630-638	80% L.S.; sandy, light gray, phosphatic, mod-ind cemented grains, intergranular ∅. 10% sands; gray, calcareous, poorly ind, M-C grn, flourly when crumbled. 10% quartz; pale orange replaced shell frags. TR claystones; dark gray silty.
638-640	95% L.S.; sandy, calcareous, olive light grn to light gray, phosphatic, poor to mod. ind., coarse grn, cemented allochems. (phos. Specs and shell frag), poorly sorted, “mod. perm” 5% pale to light gray, shell frags. TR siltstones, fissile, dark gray to black. Mud loss 638-700’, 2000 gallons.
640-645	90% L.S.; calcareous, sandy as above 5% L.S.; dark gray, sandy, calcareous, phosphatic, poor to mod., ind., cemented allochems, coarse grn, intergranular ∅, poorly sorted, rounded. 2% clay; phosphatic, nodular, pale TR chalk; white.
645-655	80% L.S.; sandy, calcareous, phosphatic, poorly sorted 10% clay; olive green 10% shells; fragmented and poorly sorted. “Low to no perm.”
655-665	60% L.S.; sandy, light gray, phosphatic, calcareous, poorly ind., coarse grn, intergranular ∅.
665-670	60% L.S.; sandy, light gray, phosphatic, calcareous as above. 30% clay; slightly olive grn, to l. gray, as above. 2% claystone; silty, dark grn to gray 2% L.S.; chips, hard, light gray to pale tan. 1% shells; frag., pale to light gray, poorly sorted, “no perm.”, holds a lot of water.
670-675	80% L.S..; sandy, light gray to olive, oolitic calcareous, poor to mod. ind., weathered, pitting ∅ and cemented allochems, fairly consolidated, coarse grn. 10% L.S. chips, light gray to pale brown, hard angular chips, sparry, no visible ∅. 10% clay, silty.

	TR gray bores. "Bone Valley"
675-685	90% L.S.; sandy, light gray to brown, phosphatic, calcareous, weathered, soln'd, cemented dark elongated fragments, platy, slight pitting ∅, mod ind. Coarse grn. 5% L.S. chips, sparry, dark gray, mod. ind.
685-695	90% L.S. sandy, light gray to tan, phosphatic, calcareous, weathered, med-coarse grn, poorly ind., subrounded flat (platy) 5% mollusk shells 5% clay, silty residue.
695-701	90% L.S.; sandy, light gray to tan, phosphatic, poorly ind., may be intergranular ∅, (due to cementation of phosphatic and mollusks particles), med-coarse grn, weathered, flat and rounded edges. 2% L.S.; tan to gray, chips, well ind., angular, moldic, sparry, hard. 2% clay: silty, green, phosphatic. 2% Coral: stems, cemented. 4% shells: frags, orange to plae
701-705	95% L.S.; sandy, phosphatic, light olive gray, coarse grn, subrounded, well sorted, no visible ∅, (may have some intergranular ∅ due to cemented particulates). 2% L.S.' sparry, ships, angular, well indurated, no visible ∅. 2% Cynoids stems, pale to slightly orange.
705-710	80% L.S.; sandy, phosphatic, olive gray, med-F grn, silty, platy (flat x-sec), rounded at edges, no ∅. 10% L.S.; gray, micritic, moldic ∅, sparry 10% Shells; replaced by quartz, sparry, "good perm."
710-720	Same as above, more siltiness.
720-725	90% L.S.; olive gray, phosphatic, med-coarse grn, sandy texture, poorly ind., no visible ∅, weathered. 5% L.S.; sparry, white. 5% Crinoids; stems, pale, smooth texture
725-732	Same as above.
732-735	80% L.S.; olive gray, small amount of phosphates, gritty, sandy/silty grn, poorly ind., no visible ∅, subangular.

	20% L.S.; crystalline inside, cemented exterior, sandy/gritty grn, olive gray to sparry inside (transparent).
735-740	85% L.S.; olive gray, trace phosphate, poorly ind., silty gritty grn, no ∅. 10% Shells; olive gray, soln'd, crystalline inside. 5% L.S.; pale, well ind., angular, no ∅, hard 5% clay
740-750	80% Clay; silty, phosphatic, plastic, well consolidated. 20% L.S.; gritty, olive gray, poorly ind., "no perm"
750-755	85% Clay; silty, phosphatic, as above. 15% L.S.; silty grn, ultrafine, some phosphatic specs, no ∅, poorly ind.
755-762	Same as above.
762-765	85% Clay; silty, phosphatic, plastic, well consolidated, adhesive, light gray to olive light green. 10% L.S.; silty grn, ultra-fine, phosphates particulates.
765-770	90% Clay; silty, phosphatic, adhesive, plastic, light gray to olive. 10% L.S.; cemented, gritty, phosphatic, poorly ind., no ∅, silty grn. TR Shells; white, hard, soln'd.
770-775	Same as above.
775-785	80% Clay; silty as above. 15% L.S.; gritty, cemented. 5% Siltstones; black, fissile, angular, (looks like phosphate nodules) TR Shells; white, well ind., "low perm."
785-793	70% Clay; silty, phosphate, not as abundant. 10% L.S.; gritty, phosphatic, poorly ind., no ∅, weathered. 10% Shells; pale to white, hard 5% Siltstones; angular, well ind., black
793-795	L.S.; tan-olive green, m-f grained, silty, some shells, phosphatic (TR), low perm, TR clay.
795-800	L.S.; as above, less silt, no clay, granular,

	shell frags, gastropods, TR phosphate, “fair perm”
800-810	L.S.; tan as above, phosphatic Clay; slightly plastic, v. silty, shells, “low perm.”
810-825	L.S.; silt; clay; tan-olive grn as above, low plasticity, shells and TR phosphate, “no perm”
825-830	L.S.; silty with some clay; tan-gray, olive (TR) phosphate, shells, “low perm”
830-856	Clay; calcareous with some L.S., shells, blk fish teeth, phosphate specks and nodules, increasing phosphate with depth, “no perm”
856-870	Clay with limestones as above.
870-888	L.S.; silty with clay; tan-olive grn, fairly plastic, v. phosphatic, TR shells, “v. low perm”
888-895	70% L.S.; pale, well ind., chips, well sorted angular, no visible ∅. 20% Shells; pale to orange, fragmented, poorly sorted. 10% Clay, olive green, phosphatic TR Blk, siltstones.
895-900	65% L.S.; pale to white, well ind., angular chips, no visible ∅, smooth texture, v. fine grain, well sorted, 1-4mm. 20% Shells pale to orange, fragmented, poorly sorted. 10% Phosphate; blk, oval, rounded, nod-ind. 10% Clay; light-grn to gray, phosphatic
900-905	60% L.S.; white, angular, smooth texture, some sparry, well ind., larger fragments 3-8mm, well sorted. 25% Shells; tan to pale gray, fragmented, poorly sorted. 5% Phosphate nodules, oval, smooth, blk. 5% Chalk; clayey, white, slimy 5% Clay; phosphatic, light olive grn.
905-910	Same as above.
910-919	80% L.S.; white to orange, angular, well ind., poorly sorted, smooth, fine grn. 5% L.S.; gray, moldic, large, well ind., worm burrows, some cemented white L.S. 5% Phosphate module, blk oval, elongated, smooth texture.

	10% Silts, "low to med perm."
919-925	70% L.S.; light gray to white, well ind., crytortalline, smooth texture, fine grn, angular, poorly sorted. 10% L.S.; gray, sandy, poorly ind., subrounded, cemented sandy L.S. granules (white) 10% Shells; fragmented, poorly sorted, pale to orange TR L.S.; sandy, olive-grn 10% Siltstones; black platy, fissile
925-930	80% L.S.; white to light gray, angular, well indurated, micritic well sorted, solnd, rough texture, f-grn. 15% L.S.; gray, soln'd, calcitic veins, rough texture, med-coarse grn, subrounded, hard 5% Siltstones; blk, platy, "coal like", laminated, poorly ind., fine to ultra-fine grn. TR calcite minerals; angular, transparent, orange and tan.
930-935	50% L.S.; white as above. 40% L.S.; gray, soln'd, moldic and calcified, rounded, well ind., cemented grns attached to exterior surface. 10% Shells molds, white calcified TR Siltstones as above TR L.S.; sandy grn, poorly to mod. ind., rounded
935-940	70% L.S.; gray to l. gray, mod ind., moldic, some sparriness, poorly sorted. 30% L.S.; tan to white, angular, med-fine grn, well ind., some pitting ∅, soln'd. TR Siltstones; platy, blk, soft, "good perm"
940-945	Same as above.
945-950	80% L.S.; white, angular chips, well sorted, smooth text, well ind. 20% L.S.; gray, micritic, calcitic, veins, soln'd, weathered rough texture, mod to well ind. TR tan to orange calcite minerals, angular, transparent.
920-950	This portion of hole first cut prior to Top FAS casing run.
950-960	Limestone; white, crystalline, forams (disk shaped, large), trace phosphate, 10% cement grout
960-965	Limestone; tan-cream, crystalline with some

	granular. Low-no silt content; shell molds, disk shaped forams, hard.
965-970	Limestone; fine-med. granular, silty with chalk, shell frags, no perm, trace phosphate. fining upward.
970-973	Limestone; Limestone: tan-lt cream, 50% crystalline, platy, mod. hard, shell molds, coral molds, crinoid stems. 50% granular, fine grained, tr silt. Fair porosity: intergranular.
973-978	Limestone; tan-wht cream, v.silty, some clay, tr. phosphate, low-no perm.
978-983	Limestone; white and lt. grey, 50% crystalline, 50% granular, shell molds, moderately indurated, shark teeth, crinoid stems, low silt content.
983-985	Limestone; grey and white, fine-med. grained, shell molds, mod.-poorly indurated. 10% silt, tr. crinoid stems, tr. shark teeth, oolites, no chalk, mod. intergranular perm.
985-990	Limestone; tan-cream and tan-white, granular, poorly to mod. indurated shell molds, forams, crinoid stems, trace calcite replacement.
990-1000	Limestone, calcareous silt and clay; lt-med grey, white-tan and cream, some platy well indurated with shell molds. Clay: grey, phosphatic, low-mod. plasticity, no perm.
1000-1020	Clay and Silt; grey, med plasticity, phosphatic, tr. limestone, tr shark teeth.
1025-1030	Clay; 80% as above, Limestone; 20%, prob. interbedded, white, difficult to distinguish characteristics since its buried in clay matrix.
1030-1038	Clay; grey, med plasticity, phosphatic.
1038-1045	Clay; grey as above; 95%, Limestone; 5%; white.
1045-1055	Clay; green (like Hawthorne): 85%, Limestone:15%; white.
1055-1068	Clay; green, as above
1068-1075	Limestone; grey, 80%; crystalline, shell molds Clay and silt; 20%, grey as above.
1075-1095	Clay; grey as above; 90%, Limestone; 5%, as above.

1095-1100	Limestone; grey and tan, granular, forams, shells, crinoids, poorly indurated, low silt, mod perm.
1100-1105	Limestone; 80% grey crystalline and 20% tan granular, mod. indurated, tr silt, clay, forams.
1105-1110;	Limestone; grey and some tan, crystalline, hard, shell molds (aqtuapectin), potential moldic porosity, no silt.

1110-1115	Limestone; tan granular with some crystalline, black peppered color: phosphate; well indurated, silt, shell molds, crinoids, coral stems.
1115-1120	Limestone; grey with light black peppering; mod. crystalline, 20% tan, granular, mod indurated.
1120-1125	Limestone; tan and some lt. grey, tan and grey mottled, granular and crystalline (interbedded), shell molds, tr. worm burrows, fair intergranular porosity.
1125-1130	Limestone; grey and dark tan, gravelly texture, granular with some crystalline, shell molds, fair perm as above.
1130-1135	Limestone; dark grey and peppered black (phosphate) and tan, gravelly, well indurated and crystalline, trace black platy shale or coal, crinoids, gastropods, shell molds, low perm.
1135-1145	Limestone; grey, crystalline, hard, shell molds.
1145-1163	Limestone; grey and tan, crystalline and granular as above, shell molds, corals, crinoids, oysters, etc. intervals of biohash, worm burrows, molds, etc. aquapectin molds, no vis. porosity.
1163-1170	Limestone; grey and tan, crystalline, trace calcite, probable solutioning, shell molds, gastropod molds, NOTE: flow at discharge pipe increased significantly.
1170-1175	Limestone; tan-cream, crystalline with v.f. grained granular, shell molds, crinoids, etc.
1175-1185	Limestone; grey, mostly crystalline with some granular, well indurated, fossils as above.
1185-1195	Limestone; white, crystalline. 10% grey crystalline, v.hard, dense, worm burrows, poss. pinhole por., some solutioning, 50% well indurated granular, some v.f. grained silt. Discharge at pipe increased significantly.
1195-1205	Limestone; white, v.well indurated oolitic and crystalline, shell molds, moldic and intergranular por., white silt in discharge: v.f. grained ooloitic sand and silt.

1205-1225 Limestone; white-light tan, f.g. granular, moderately indurated, some crystalline, dictyoconus and buttons, trace coral stems, large portion of discharge is vf grained oolitic ooze and sand, discharge milky white.

1225-1255 Limestone; white-lt. tan as above, f.g. granular, mod.-poorly indurated, buttons, cones, spherical small round forams, lots of oolitic ooze.

1255-1360 Limestone; pale orange, f.g., poorly indurated, buttons, cones, forams, sand dollars, high silt and oolitic f.-m. grained calcareous sand.

1360-1370 Limestone; 80% lt. grey-white, calcarenite as above, 20% tan calcarenite as above, decreasing cones.

1370-1430 Limestone; tan-cream calcarenite, abundant silt

1430-1440 Limestone; 80% as above, 20% cryptocrystalline, cream color, hard, angular, no vis. por..

1440-1610 Limestone; tan and grey calcarenite, v.f.g. as above, lots of silt.

1610-1620 Limestone; 80% tan-cream calcilutite as above, 20% tan-cream, cryptocrystalline, v.hard, conchoidal fracturing, tr. grey limestone, cryptocrystalline, pinhole por., no calcite.

1620-1650 Limestone; tan-cream calcarenite, abundant silt

1650-1663 Limestone; 70% as above, 30% well indurated and crystalline, tan-white, no evident por., crinoids, cones.

1663-1695 Limestone; tan-cream, calcarenite, f-m grained, silty, low-no perm, cones, tr. hard crystalline limestone as above.

1695-1715 Limestone; tan-cream, 50% calcarenite as above, 50% well indurated poss crystalline limestone; tan-grey, hard, no apparent por., high silt content.

1715-1726 Limestone; tan-wht calcarenite, tr. chalk, 10% well indurated limestone as above, poss pinhole por..

1726-1740 Limestone; 90% tan w/some grey, calcarenite, silty., 10% black and grey mottled, hard limestone, well indurated, no vis. por.

1740-1758	Limestone; tan-wht., alternating beds of calcarenite grainstone and well indurated crystalline limestone, tr. chalk, silty.
1758-1765	Limestone; white; 60% well indurated and crystalline, 40% grainstone calcarenite, f-m grained, tr. chalk.
1765-1770	Limestone; white and grey and tan, 40% crystalline as above, 40% calcarenite, 20% grey clay; mod. plasticity.
1770-1780	Limestone; 80% grey and white, well indurated, crytalline, no vis. por., hard, angular, tr. chalk, 20% wht-grey calcarenite.
1780-1785	Limestone; 40% tan and grey well indurated, crystalline as above, 60% calcarenite, tan and grey as above.
1785-1790	Limestone; 90% wht-tan, poorly indurated grainstone, cones, buttons, 10% wht-tan well indurated crystalline, no vis. por.
1790-1805	Limestone; tan-cream, poorly indurated, calcarenite, v.silty and sandy, abundant cones and forams, tr. wht chalk.
1805-1810	Limestone; tan and dk. 50% tan calcarentie as above, 20% grey-black, well indurated crystalline, gravel like, 30% dk. grey sand and silt size carbonate grains
1810-1918	Limestone; tan-cream calcarenite and calcareous silty sand, abundant cones and buttons.
1918-1920	Limestone; crystalline, hard, dk. grey and blk. mottled with cream, some fossils, platy, no apparent por., cones.
1920-2020	Limestone; tan-cream calcarenite, calcareous silt and sand, abundant cones and buttons.
2020-2064	Limestone; 70% tan calcarenite as above., 30% dk. grey and black crystalline, platy, hard, no apparent por., angular, lots of silt and sand size calcareous fines.
2064-2195	Limestone; tan-cream calcarenite, calcareous silt and sand, cones, forams, low-no perm.
2195-2200	Limestone; grey and tan, calcarenite and calcareous silt and sand as above

2200-2218	Limestone; tan and cream, calcarenite and calcarous silt and sand.
2218-2230	Limestone; tan with some grey, 80% calcarenite and calcareous silt and sand as above, 15% well indurated , tan, crystalline, no vis. por., low-no perm, angular, trace black platy lignite or coal, tr. cones.
2230-2250	Limestone; 70% calcarenite as above, 30% crystalline-well indurated as above., tr. cones and siltstone, abundant calc. silt and sand as above.
2250-2278	Limestone; 90% tan calcarenite, 10% tan and grey well indurated limestone, tr. cones.
2278-2309	Limestone; 80% tan calcarenite, abundant silt, 10% wht.-tan well ind. as above, 10% tan-grey siltstone, abundant calc. silt and sand as above.
2309-2320	Limestone; tan-white, 70% calcarenite and silt and sand as above, 30% well indurated tan crystalline , angular, hard, no vis. por..
2320-2340	Limestone; tan-lt. brown, 50% well indurated crypto crystaline as above, 20% tan siltstone, 30% tan calcarenite as above., cones, calc. silt and sand.
2340-2495	Limestone; calcilutite with trace siltstone as above, calc. sand and silt.
2495-2520	Limestone; 50% tan, sandy/ silty calc. grainstone Dolomite; trace grey to dark grey, crystalline, well ind., angular, no vis. por..
2515-2526	Limestone; 65% as above tan-grey, Dolomite; 45%, greenish-grey, mottled, crypto-crytalline, well ind., angular, no vis. por..
2526-2530	Limestone; 50% grey-white calcarenite, poorly sorted, abundant calc. silt and sand. Dolomite; 50% brown, sucrosic, almost granular, med coarse grained, v.well indurated.
2530-2557	Limestone; grey-white calcarenite, f-m grained, poorly sorted, abund. calc silt and sand. 30% dolomite as above, brown and dk. grey.
2557-2565	Limestone; 95%, tan-lt. grey, calcarenite, f-m grained, poorly sorted, silty and sandy calc., 5% plastic chalk.

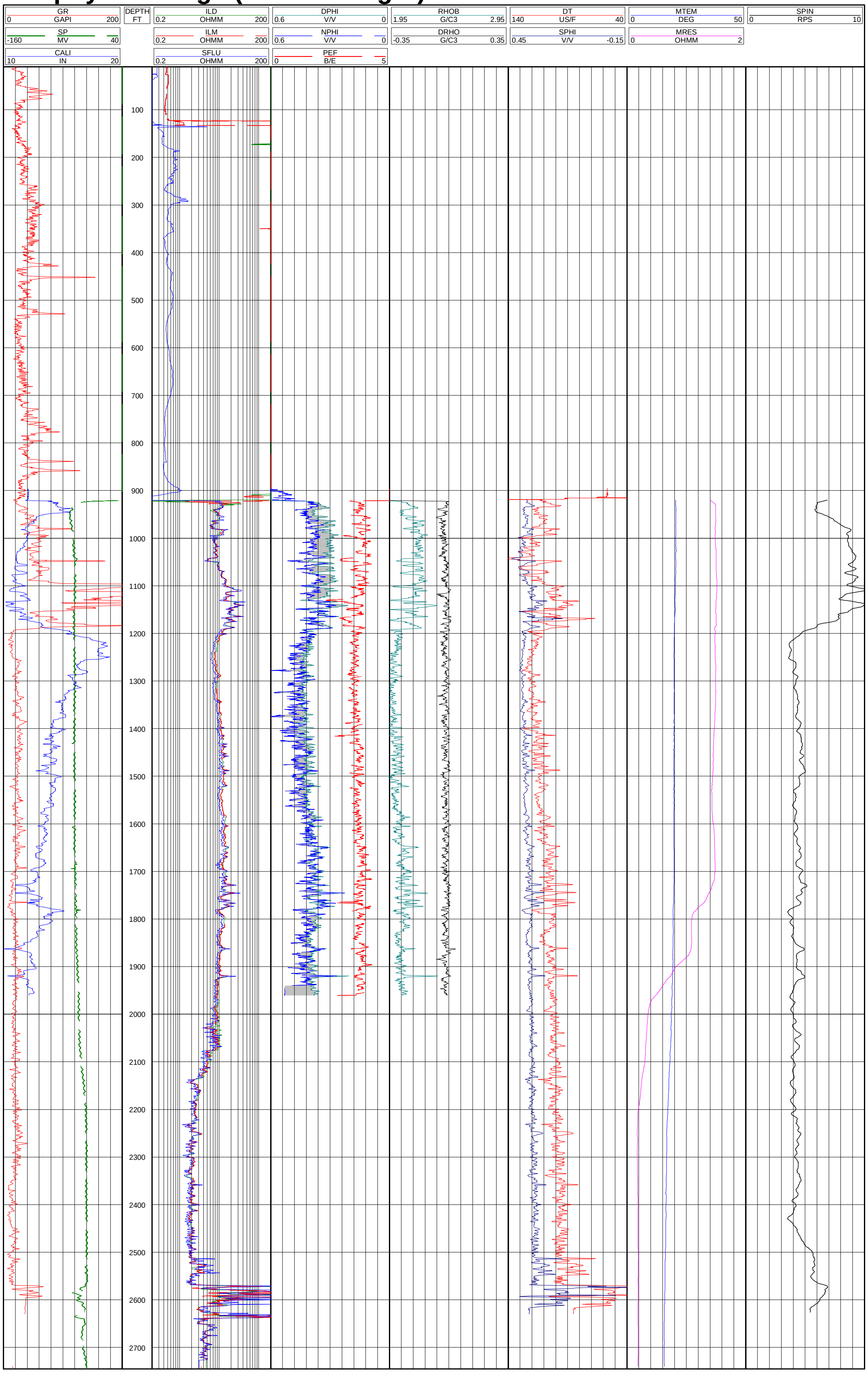
2565-2575	Dolomite; 50%, bacon brown, crystalline, angular, no vis. por., platy and sucrosic., Limestone; 50% as above.
2575-2580	Dolomite; 80% brown, crystalline, angular, hard, no vis. por., 20% Limestone, tan as above.
2580-2595	Dolomite 90%+, brown-black, crystalline, angular, some sucrosic, rest no vis. por.10% Limestone; white, calcarenite, poorly indurated.
2595-2605	Dolomite: 90%, solutioned, poorly indurated course crystalline, sucrosic, some pinhole por., brown-grey, 10% Limestone, white as above.
2605-2610	Dolomite; sucrosic and vugular, brown-grey and black, crystalline. 10% Limestone, white-tan, calcarenite, poorly indurated, intergran. por., f-m grained as above.
2610-2618	Dolomite; brown-tannish gray, soloutioned, pinhole por., 20% Limestone as above.
2618-2625	Limestone; white-lt.gray, poorly indurated, sand/silty, med.grained, marly, poss. phosphate. 10% Dolomite as above.
2625-2630	Dolomite; 80%, brown, some solutioned por., crystal graines, cryptocrystalline, Limestone; 20%, white as above.
2630-2640	Dolomite; 80%, black, no vis por., crystalline, angular.
2640-2695	Dolomite; Beige-lt.grey, no vis. por., angular., trace limestone as above.
2695-2649	Dolomite; 60%, brown-grey black, mottled, some solutioning, 40% Limestone; white, gritty, poorly indurated, intergran. por., chalky residue.
2649-2665	Limetsone; 90%, tan-brown calcarenite, poorly ind., intergran. por., 5% Dolomite; brown as above, 5% chalk; white, clayey.
2665-2675	Limestone; 80%, tan-brown, weathered and solutioned, gritty, sandy, poorly ind., f-m grained. 20% Dolomite chips; brown, crystalline, no vis. por..
2675-2680	Limestone; tan, mod to well ind., chalky, dolomitized nucleus, exterior cemented calc. sands.

2680-2690	Silt; 70%, white, fine grained, 30% Limestone; intergranular por., white-tan, grainy, poorly ind.
2690-2700	Dolomite crystals; sucrosic, mod. indurated, tan-lt. brown, course grained, 40% Limestone; tan, poorly ind., no vis. por., trace echinoderm.
2700-2712	Dolomite; 50%, l.brown, sucrosic por., calcite crystals, poorly ind., coarse grained., 10% Dolomite; white-tan, well ind., angular, 30% Limestone; tan as abobe.
2712-2730	Limestone; 80%, tan, mod.ind., f-m grained, fossilized, weathered, poorly sorted. 5% Lignite, coal, black, fissile, platy, laminar. %5 Echinoids and forams, fossilized, white.
2730-2743	Limestone; 80%, tan calcilutite, poorly ind., silt and sand size, Dolomite; 20%, brown sucrosic, granular, poor-mod. ind., poss. por. and perm. forams abundant.
2743:	TD9/30/9312:01 PM

Appendix B

Geophysical Logs

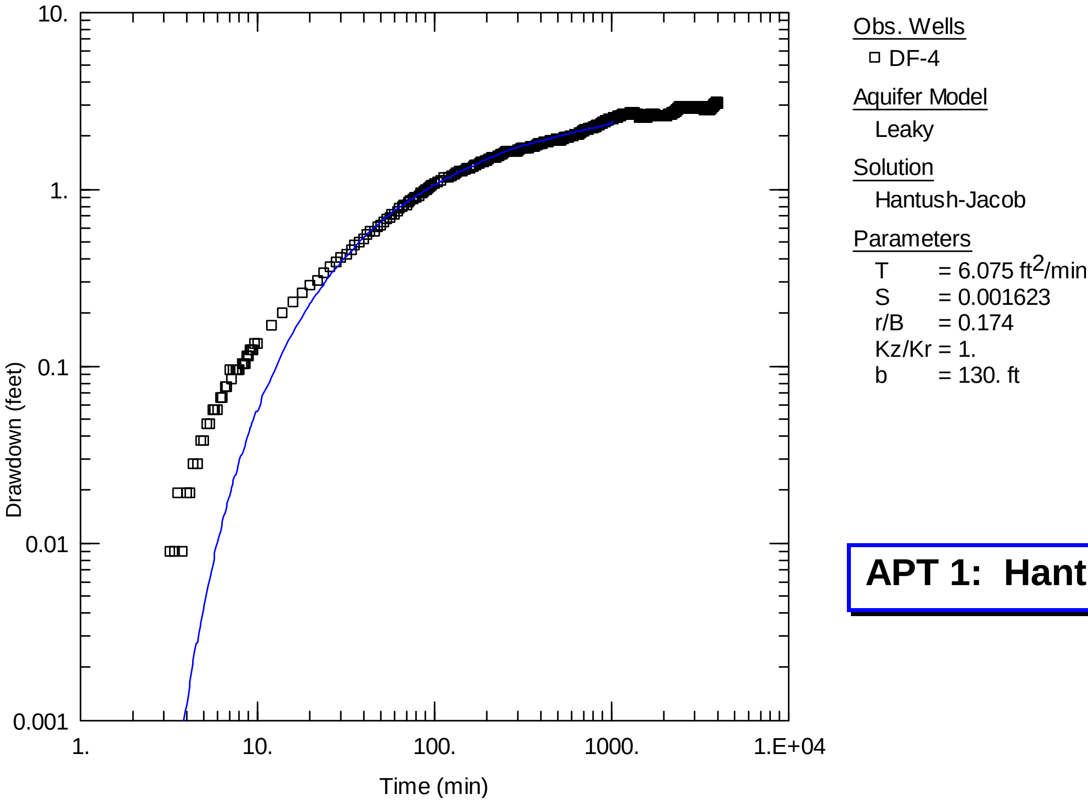
Geophysical Logs (Schlumberger) from Pilot Well DF-1



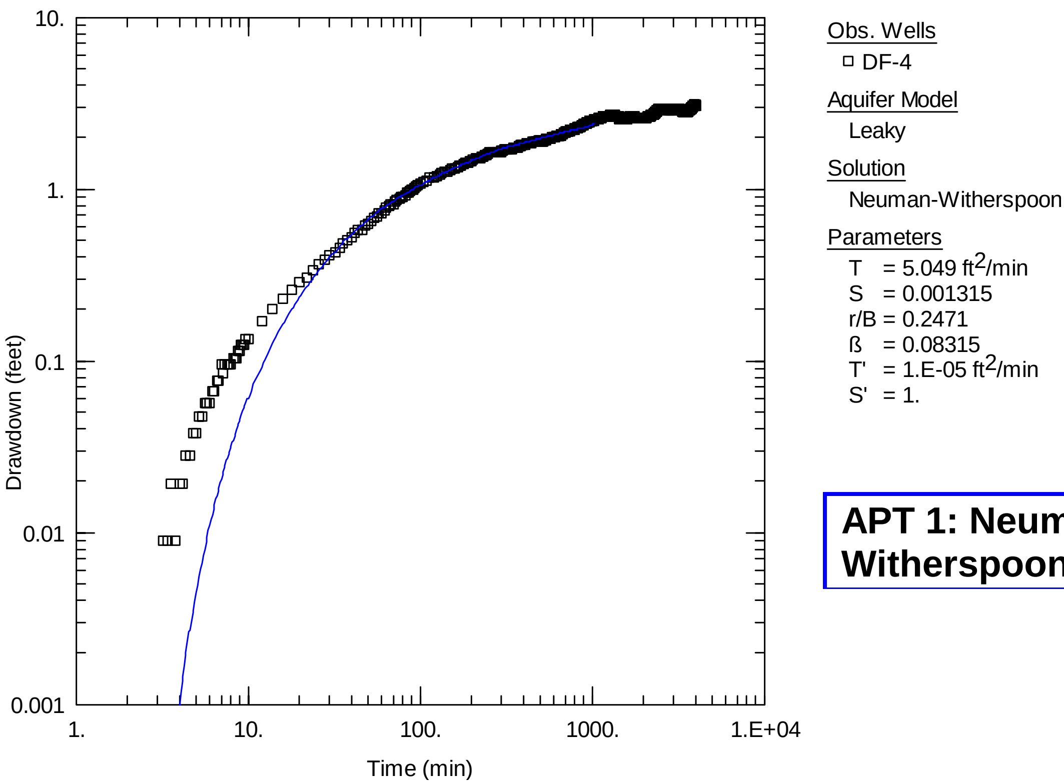
Appendix C

Aquifer Performance Test Analyses

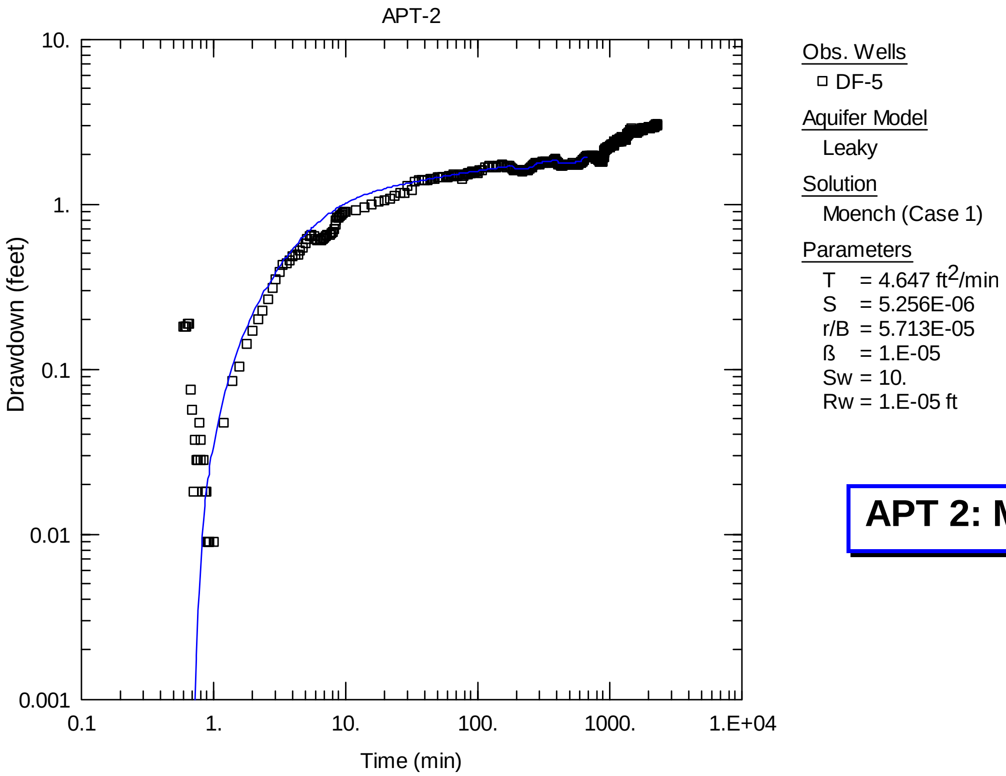
Type Curve Matching



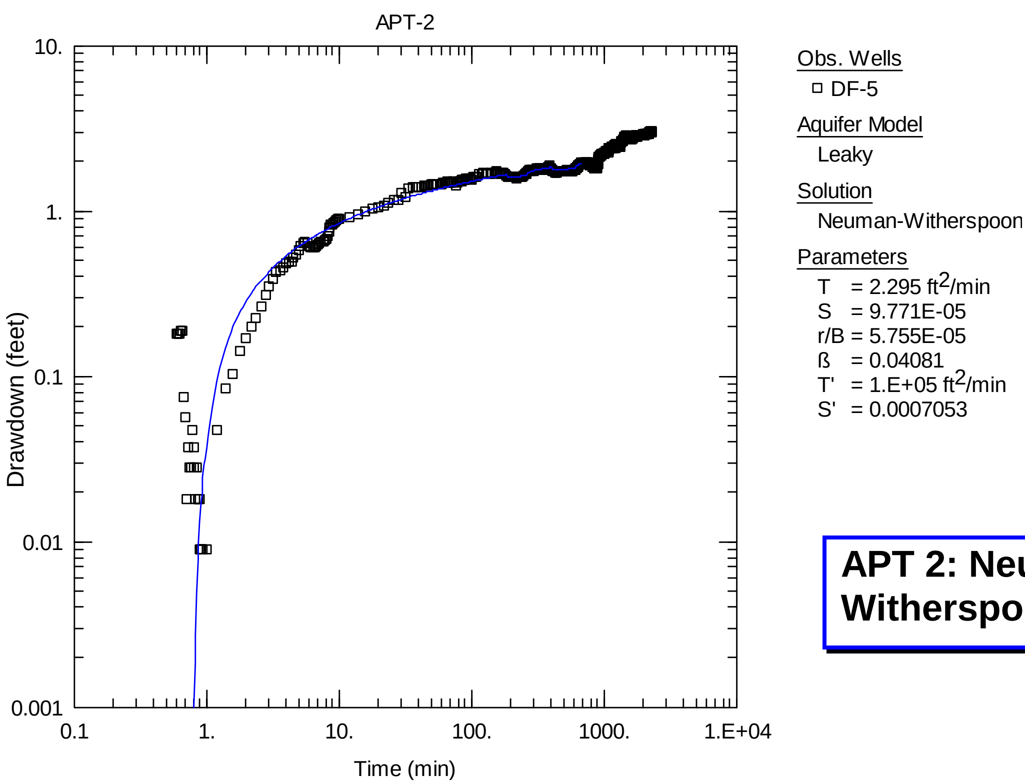
APT 1: Hantush Jacob



APT 1: Neuman - Witherspoon, 1969



APT 2: Moench



APT 2: Neuman-Witherspoon, 1969