

**Hydrogeologic Investigation of the Floridan  
Aquifer System  
Port Mayaca Site  
Martin County, Florida**

**Preliminary Report**

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## Executive Summary

The Comprehensive Everglades Restoration Plan (CERP) – jointly being conducted by the U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD) – is focused on storing available water currently lost to tide. The Aquifer Storage and Recovery (ASR) technology has been identified as a major storage option, particularly in the vicinity of Lake Okeechobee, where available water has been identified. The Lake Okeechobee ASR Pilot Project was designed to address some of the technical and regulatory uncertainties of storing treated surface water via ASR systems. Hydrogeologic testing of smaller diameter test/monitor wells was identified as one of the first tasks in evaluating ASR potential proximal to Lake Okeechobee.

The purpose of this project is to provide site-specific hydrogeologic on the Floridan Aquifer System (FAS) at three separate sites in support of the Lake Okeechobee ASR Pilot Project. Data collected from the testing and monitoring of these test wells will be instrumental in site selection for future ASR systems, inclusion in the proposed ASR regional study, development of a conceptual hydrogeologic model, and other future regional hydrogeologic and hydro-chemical assessments.

This report primarily describes the drilling, construction, and testing of the 12-inch diameter test/monitor well identified as MF-37 at the Port Mayaca Site. It summarizes and presents data obtained during drilling and testing operations and analyses conducted. Well MF-37 is the designation used by SFWMD to obtain a Martin County Health Department well construction permit (Permit Number 43-57-2928). The test/monitor well (MF-37) was constructed on SFWMD-owned right-of-way proximal to the SFWMD's S-153 water control structure on the L-65 Canal in the southeast quarter of Section 14 of Township 40 South, Range 37 East

The scope of the investigation consisted of constructing and testing a test/monitor well drilled to a total depth of 2,046 feet below pad level (bpl). If the Port Mayaca site is chosen as a site for an ASR system as part of the Lake Okeechobee ASR Pilot Project, well MF-37 will be modified to accommodate monitor zone(s) consistent with the future ASR well.

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

- Lithologic information and geophysical logs obtained from MF-37 indicate that soft non-indurated detrital clays, silts, sands and poorly indurated mudstones of the Hawthorn Group predominate from 146 to 755 feet bpl. These low permeable sediments act as confining units separating the Floridan Aquifer System (FAS) from the Surficial Aquifer System (SAS).
- The top of the FAS as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 755 feet bpl.

- Lithologic and geophysical logs, and packer test results, indicate moderate production capacity of the upper Floridan aquifer from 755 to 1,300 feet bpl.
- A productive horizon in the Middle Floridan aquifer from 1,487 to 1,570 feet bpl yielded a specific capacity of 106gpm/ft of drawdown.
- The production type logs (e.g. flow, temperature logs) indicates good production from flow zones between 1,490 and 1,600 feet bpl. Below 1,610 feet bpl, the productive capacity is limited (as indicated by the fluid-type logs) suggesting lower permeable – semi-confining units near the base of this productive horizon.
- Composite water quality sampling during straddle test and geophysical log data was used in tandem to identify the base of the USDW at approximately 1,740 feet bpl. Total dissolved solids concentrations below 1,860 feet bpl are similar in concentration to seawater.

## **Acknowledgements**

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The authors gratefully acknowledge the many people that aided in the successful completion of this project. We would like to thank the technical and professional staff of the South Florida Water Management District who reviewed the manuscript or lent technical expertise to the writing of the report. They include Mr. Peter Kwiatkowski, and Mr. John Lukasiewicz. We would also like to thank Electronic Support and Data Acquisition and Water Quality staff for the field support provided during construction and testing operations.

# **Introduction**

## **Background**

The Comprehensive Everglades Restoration Plan (CERP) – jointly being conducted by the U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD) – is focused on storing available water currently lost to tide. The Aquifer Storage and Recovery (ASR) technology has been identified as a major storage option, particularly in the vicinity of Lake Okeechobee, where available water has been identified. The Lake Okeechobee ASR Pilot Project was designed to address some of the technical and regulatory uncertainties of storing treated surface water via ASR systems. Hydrogeologic testing of smaller diameter test/monitor wells was identified as one of the first tasks in evaluating ASR potential proximal to Lake Okeechobee.

The purpose of this project is to provide site-specific hydrogeologic on the Floridan Aquifer System (FAS) at three separate sites in support of the Lake Okeechobee ASR Pilot Project. Data collected from the testing and monitoring of these test wells will be instrumental in site selection for future ASR systems, inclusion in the proposed ASR regional study, development of a conceptual hydrogeologic model, and other future regional hydrogeologic and hydro-chemical assessments.

## **Scope**

This report primarily describes the drilling, construction, and testing of a 12-inch diameter test/monitor well identified as (MF-37) at the Port Mayaca site. It summarizes and presents data obtained during drilling and testing operations and analyses conducted.

## **Project Description**

The Port Mayaca test site is located approximate 30 miles west of the Atlantic Ocean and approximately 1 mile east of the eastern boundary of Lake Okeechobee in unincorporated Martin County, Florida. The test/monitor well (MF-37) was constructed on a SFWMD-owned right-of-way proximal to the SFWMD's S-153 water control structure on the L-65 Canal in the southeast quarter of Section 14 of Township 40 South, Range 37 East (**Figure 1**).

The SFWMD issued a notice to proceed to Diversified Drilling Corp (DDC) on April 16, 2001 to drill and construct three 12-inch diameter test/monitor wells at separate locations proximal to Lake Okeechobee. On May 30 2001, construction began of the second test/monitor well identified as MF-37. Drilling, testing and construction of this well were completed on January 10, 2002.

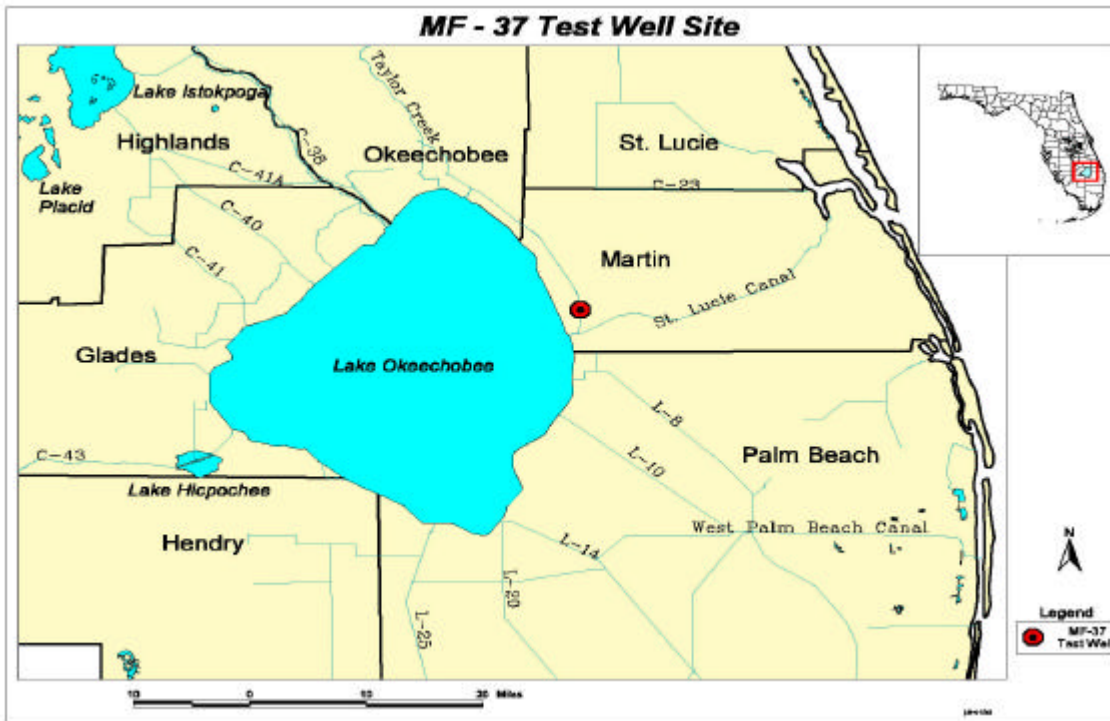


Figure 1. Project Location Map – MF-37

## Exploratory Drilling and Well Construction Test/Monitor Well (MF-37)

Diversified Drilling Corporation (DDC) began site preparation during mid-May, 2001. After minor clearing and rough grading of the site, the ground surface beneath the drill rig and settling tanks was lined with an impermeable high density polyethylene (HDPE) liner, which was covered with 10-inches of granular fill to protect the liner. A two-foot thick temporary drilling pad was then constructed using crushed limestone. An earthen berm two-feet in height above pad level surrounded the perimeter of the rig, and settling tanks. This earthen berm was constructed to contain drilling fluids and/or formation waters produced during well drilling, testing, and well construction activities (Figure 2).

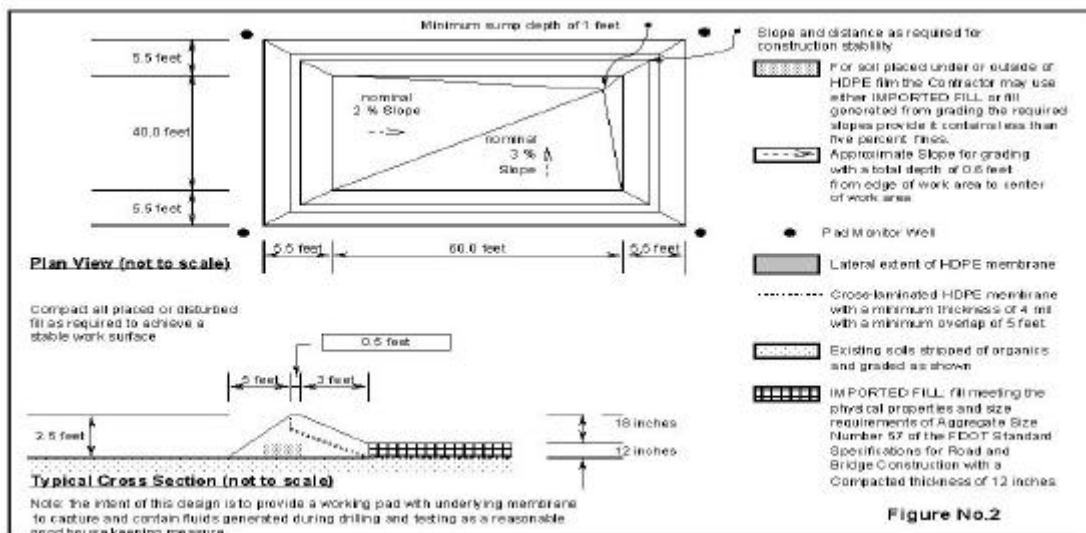


Figure 2. Well Pad Schematic

DDC installed four pad monitor wells at the corners of the temporary drilling pad prior to the start of drilling operations. SFWMD monitored the water quality of these wells on a weekly basis to ensure no releases of brackish water occurred during construction.

Lithologic (well cuttings), packer test, and borehole geophysical log data were used to determine the actual casing setting depths. The pilot hole was reamed to specified diameters and casing installed. Three concentric steel casings (24-, 18-, and 12-inch-diameter) were used in the construction of the Floridan aquifer test/monitor well (MF-37).

DDC initiated drilling activities for MF-37 on May 30, 2001. Drilling operations began by advancing a nominal 10-inch diameter pilot hole to a depth of 87 feet below pad level (bpl) via the mud rotary method. The nominal 10-inch diameter pilot hole was reamed to a depth of 80 feet bpl using a nominal 30-inch diameter staged reaming bit. In accordance with the well construction specifications, the reamed borehole was geophysically logged (caliper) to verify depths and to calculate cement volumes for subsequent cement grouting operations (**Appendix A-1**). On June 5, 2001, DDC installed the nominal 24-inch diameter, steel pit casing, (ASTM A53, Grade B, and 0.375-inch wall thickness) in the nominal 30-inch diameter borehole to a depth of 74 feet bpl. The annulus was pressure grouted to land surface using 165 cubic feet (ft<sup>3</sup>) of ASTM Type II, Portland cement (15.6 lbs./gal). A factory mill certificate for the 24-inch diameter steel pit casing is provided in **Appendix B**.

After installing the 24-inch diameter pit casing, DDC continued drilling the pilot hole with a nominal 8-inch diameter bit using the mud rotary method. On June 8, 2001, DDC advanced the pilot hole through the Pleistocene-Pliocene aged sediments and into the Hawthorn Group to a depth of 223 feet bpl. On June 13, 2001, MV Geophysical Surveys, Inc. of Ft. Myers, Florida, geophysically logged the pilot hole from 74 feet to 223 feet bpl without incident. The logging suite consisted of the following logs: 4-arm caliper, natural gamma ray, spontaneous potential (SP), borehole compensated sonic (BHC) and dual induction/laterolog combination. The individual log traces from geophysical log run no. 2 are presented in **Appendix A-2**.

Using well cuttings, and geophysical log data, the base of the Surficial Aquifer System (SAS) was identified at approximately 146 feet bpl where a greenish-gray phosphatic, silty clay unit was first encountered. In addition, the natural gamma log noted an increase in natural gamma ray emissions, which corresponded to the lower permeable silty, phosphatic clays, found at similar depth. On June 23, 2001, DCC reamed the nominal 8-inch diameter pilot hole to 175 feet bpl using a nominal 23-inch diameter staged bit reamer. The nominal 23-inch borehole was geophysically logged (caliper-natural gamma ray) to verify depths and to calculate cement volumes for subsequent grouting operations. The caliper log showed no unusual borehole conditions that would prohibit proper installation of the 18-inch diameter surface casing (**see Appendix A-3**). The Contractor then installed the 18-inch diameter, steel casing (ASTM A53, Grade B, and 0.375-inch wall thickness) in the nominal 23-inch diameter borehole to depth of 170 feet bpl. Once installed, the 24-inch diameter steel pipe was pressure grouted using 206 ft<sup>3</sup> of ASTM Type II cement. An additional 12 ft<sup>3</sup> of ASTM Type II cement was used to

bring cement levels in the annulus to surface, completing surface casing installation on June 25, 2001.

The purpose of the surface casing is to prevent unconsolidated surface sediments from collapsing into the drilled hole, to isolate the SAS from brackish water contamination, and to provide drill rig stability during continued drilling operations. A factory mill certificate for the 18-inch diameter surface casing is provided in **Appendix B**.

With the surface casing installed, DDC continued to advance the nominal 8-inch diameter pilot hole via the closed circulation mud-rotary drilling method. On July 5, 2001, DDC completed pilot hole drilling operations through the Miocene-aged Hawthorn unconsolidated to semi-consolidated sediments. Drilling operations continued through the Oligocene and upper Eocene-aged carbonates of the upper Floridan aquifer to a depth of 1,116 feet bpl. Several 4-inch diameter conventional cores were collected from carbonate section of the upper Floridan aquifer from the following depths intervals: 798 feet to 808 feet bpl, 931 feet to 951 feet, and 1,086 feet to 1,106 feet bpl. During coring operations, minimal lengths of core were retrieved to surface. A core recovery efficiency of 36 percent was obtained through this interval (798 to 1,106 feet bpl).

On July 24, 2001, Schlumberger Wireline Services conducted and completed geophysical logging operations within the nominal 8-inch diameter pilot hole from 170 feet to 1,116 feet bpl without incident. The geophysical logging suite which included both conventional and specialty logs are as follows: caliper, spontaneous potential, natural gamma ray spectrometry (NGS), high resolution array induction (AIT), dipole sonic imager (DSI), compensated density with photoelectric factor (PEF), compensated neutron, ultrasonic borehole imager (UBI), and fullbore formation micro-imager (FMI). A composite of the geophysical log traces that were exempt from post-processing from geophysical run no. 4 is provided in **Appendix A-4**.

Review of lithologic data (located in **Appendix C**) and geophysical logs (**Appendix A-4**) from the subject borehole indicates that the top of the FAS occurs at a depth of approximately 755 feet bpl. However, the final 12-inch steel production casing was set at a depth of 765 feet bpl for reasons listed below:

1. Seal off overlying clays of the Hawthorn Group and carbonate mud stringers and fine quartz and phosphatic sands within the lower portion of the Arcadia Formation
2. Facilitate reverse-air-drilling operations through the underlying permeable horizons of the FAS to the anticipated depth of 2,000 feet bpl.
3. Locate the casing in a competent, well-indurated rock unit to reduce undermining (erosion) at its base as a result of natural and induced high velocity upward flow.
4. Evaluate flow characteristics of the FAS within the anticipated open-hole interval of 765 to 2,000 feet bpl.
5. Avoid non-productive, phosphate-bearing silt/sand from approximately 700 feet to 765 feet bpl – as evidenced by the drill cuttings and peaks on the natural gamma ray log trace, which may pose impacts to FAS water quality and further drilling operations.

Therefore, on July 30, 2001, the nominal 8-inch diameter pilot hole was temporarily back-filled with 3/8-inch diameter crushed limestone gravel to approximately 700 feet bpl. DDC reamed the nominal 8-inch diameter pilot hole using a nominal 17-inch diameter staged bit reamer. During the course of over-drilling the pilot hole, the Contractor inadvertently drilled 30 feet past the designated depth of 770 feet bpl due to an incorrect drill rod tally. The Contractor began corrective measures by re-installing 3/8-inch diameter crushed limestone to 750 feet bpl, re-drilled the 17-inch diameter borehole to 780 feet bpl, installed 5 feet of silica sand, capped by a 5-foot thick bentonite seal. These measures limited cement filtrate from penetrating the more permeable crushed limestone material created during pressure-grouting operations. On August 14, 2001, DDC circulated and geophysically logged (caliper and natural gamma) the nominal 17-inch diameter borehole to its total depth without incident. The caliper log trace showed no unusual borehole conditions that would prohibit proper installation of the 12-inch diameter casing to 765 feet bpl (**caliper log trace provided in Appendix A-5**). The 12-inch diameter casing was installed (ASTM A53, Grade B, and 0.375-inch wall thickness) to a depth of 765 feet bpl. The factory mill certificate and the casing installation log for the 12-inch diameter casing are provided in **Appendix B**. Once the casing was installed to a depth of 765 feet bpl, it was rotated and reciprocated to discern if it was free within the borehole for subsequent cement grouting. The Contractor then circulated approximately 15,000 gallons of fluid through the annular space to displace the heavy drilling mud that was previously required for borehole stabilization. This post-conditioning water flush reduces the potential mixing of grout and drilling mud (of similar densities) during grouting operations, reducing the risk of mud channels (annular voids).

After the post-conditioning water flush, pressure-grouting operations began by installing tremie pipe (2.875-inch diameter) to 725 feet bpl. A volume of 445 ft<sup>3</sup> (350 bags @ 94lbs/bag) of ASTM C-150 Type II neat cement was then pumped during pressure grouting operations. A temperature/gamma survey was conducted 8 hours after cementing operations ceased. This survey was used to identify the top of the cement within the annulus as a result of pressure grouting. A significant shift in the temperature gradient log and corresponding deflection in the temperature differential log occurred at 50 feet bpl (see **Appendix A-6** for temperature-gamma log), which suggests that the top of the first stage is located at that depth. Steel tubing was then used to physically locate (hard tag) the cement level within the annulus. The physical tag indicated the cement level at 45 feet bpl, which was in close agreement to that suggested by the temperature log. An additional 35 ft<sup>3</sup> of ASTM Type II neat cement was pumped on August 15, 2001 via the tremie method causing cement returns at surface. Actual cement volumes pumped during casing installation were in close agreement to theoretical volumes (approximately 97 % of theoretical).

Once grouting operations were completed, the Contractor installed a well header on the 12-inch diameter steel casing as part of pressure testing operations. The wellhead was sealed at the surface via the temporary header to facilitate the test. Next, the well was filled with water and pressurized to approximately 50 pound per square inch (psi) using a high-pressure water pump. A preliminary 1-hour pressure test was conducted on August 17, 2001. During this test, internal casing pressures fell 8 psi - a 16 % reduction, which exceeded the test tolerance limit of +/- 5%. The Contractor then made appropriate

adjustments to the well head configuration isolating surface leaks observed during the preliminary pressure tests.

Once properly sealed, SFWMD notified FDEP of the scheduled pressure test date for the 12-inch diameter casing. The formal pressure test was conducted and successfully completed on August 21, 2001, however, a FDEP representative opted not to be present during the test. During the course of the 60 minute pressure test, the total pressure within the 12-inch diameter casing decreased 2-psi, representing a 4 % decline - within the test tolerance limit of +/- 5% (**Table 1.**)

<b>Table 1.</b>							
<b>Official Pressure Test on 12-inch Casing String</b>							
<b>MF-37</b>							
<b>Date</b>	<b>Time Hour</b>	<b>Elapsed Time (min)</b>	<b>Pressure Reading psi</b>	<b>Delta Pressure psi</b>	<b>Remarks</b>	<b>Recorded By</b>	
08/21/01	9:05	0	53.50	0.00	Start of Pressure Test	ER	
08/21/01	9:10	5	53.25	0.25		ER	
08/21/01	9:15	10	53.00	0.50		ER	
08/21/01	9:20	15	53.00	0.50		ER	
08/21/01	9:25	20	53.00	0.50		ER	
08/21/01	9:30	25	53.00	0.50		ER	
08/21/01	9:35	30	52.75	0.75		ER	
08/21/01	9:45	35	52.50	1.00		ER	
08/21/01	9:50	40	52.50	1.00		ER	
08/21/01	9:55	45	52.25	1.25		ER	
08/21/01	10:00	50	52.00	1.50		ER	
08/21/01	10:05	55	51.50	2.00		ER	
08/21/01	10:10	60	51.50	2.00		End of Pressure Test Total Pressure Change 2.00psi	ER

Recorded By: Ed Rectenwald, SFWMD  
Engineer of Record: Paul F. Linton SFWMD

On August 23, 2001, the Contractor drilled-out the cement-plug (a result of pressure grouting) at the base of the final casing string with a nominal 12-inch diameter bit. DDC tripped back in with a nominal 8-inch bit and began to drill-out the temporary backfill material (3/8-inch diameter crushed limestone) from the original pilot hole via the closed circulation, mud rotary technique. The pilot hole was re-drilled to its original total depth of 1,116 feet bpl on August 24, 2001.

On August 31, 2001, a conventional core was collected from 1,116 feet to 1,136 feet bpl but no core material was recovered at surface. On September 5, 2001, the Contractor resumed drilling the 8-inch diameter pilot hole via the mud rotary method. Mud rotary drilling continued through the Eocene aged carbonates to a depth of 1,500 feet bpl.

A cavernous dolostone unit was encountered at 1,500 feet bpl, which caused a loss of mud circulation and a 3-foot drop of the drill rod. The Contractor re-mixed and circulated approximately 10,000 gallons of drilling fluid in an effort to regain circulation; these efforts were unsuccessful. A decision was made to switch to the reverse-air drilling method to continue pilot-hole drilling to an anticipated depth of 2,000 feet bpl.

Consequently, the Contractor reconfigured the drilling equipment to accommodate reverse-air-drilling operations. SFWMD personnel installed water quality probes into the L-65 Canal equipped with sondes used to collect temperature, pH, specific conductance, dissolved oxygen, and turbidity data. These probes were deployed 100 meters upstream from the point of discharge (POD), 100 meters downstream from the POD, and 800 meters downstream from the POD. During reverse-air drilling operations, formation water was diverted through a series of 7,500-gallon settling tanks then discharged into the L-65 Canal via a 12-inch diameter PVC pipe equipped with a silt screen to minimize particulate matter being discharged. SFWMD personnel collected water quality data (3 times daily) from the L-65 Canal during discharges produced from the test/monitor well to comply with FDEP-issued National Pollutant Discharge Elimination System (NPDES) permit monitoring requirements.

On September 18, 2001, DDC began to drill a nominal 8-inch diameter pilot hole from 1,503 feet to 1,629 feet bpl via the reverse-air method. On September 22, 2001, a conventional core was cut from 1,629 feet to 1,637 feet bpl. However, only eight of the anticipated 20-foot section was cored because the core barrel (20 feet in length) plugged off at 1,637 feet bpl, which halted coring operations. The recovered length of core material was 7 feet (87% recovery efficiency). The Contractor continued reverse-air-drilling operations from 1,637 to 2,046 with a conventional obtained from 1,944 to 1,955 feet bpl – 9 feet of core recovered. On October 4, 2001, DDC completed drilling of the pilot-hole to a total depth of 2,046 feet bpl. Once the pilot hole was completed it was air developed and prepared for geophysical logging operations.

A bore hole video survey was initially run to evaluate borehole stability within the open section (765 to 2,046 feet bpl). On October 5, 2001, MV Geophysical Surveys, Inc completed an unobstructed video log to the full depth of the nominal 8-inch diameter pilot hole. The results of the video log indicated that the pilot hole was stable (e.g., no large rock fragments residing close to the borehole that would obstruct or cause the logging tool to become stuck downhole). As a result, MV Geophysical Surveys, Inc., geophysically logged the pilot hole from 765 feet to 2,046 feet bpl. The logging suite consisted of the following: x-y caliper, natural gamma ray, SP, BHC, and a dual and induction/laterolog combination. On October 8, 2001, MV Geophysical Surveys, Inc. performed static and dynamic production logging operations, which included a flowmeter, fluid resistivity, and high-resolution temperature logs. A composite of the geophysical logs ran by MV Geophysical Surveys, Inc including both the open hole and production type log traces is included in **Appendix A-7**.

Straddle-packer test intervals were selected using the information provided by analysis of the geophysical logs and lithologic data, and the first of six tests began on October 16, 2001. The purpose of these tests was to characterize the water quality and production capacities of specific intervals within the larger open hole interval (765 to 2,046 feet bpl). From a water resource perspective, intervals having total dissolved solids (TDS) concentration greater than 10,000 mg/L were not considered for further aquifer hydraulic characterization because they are not considered potential sources of drinking water as defined in Chapter 62-520 of the Florida Administrative Code. An “Underground Source

of Drinking Water” (USDW) is defined as an aquifer containing water with a TDS concentration of less than 10,000 milligrams per liter (mg/L).

DDC completed packer testing operations on November 13, 2001 (see the Packer Test Section of this report for a description of the methods and a summary of the results). The water quality data obtained from the straddle-packer tests were used in tandem with the geophysical logs to identify the base of the USDW at approximately 1,740 feet bpl. The production and water quality results for the various packer tests are presented in the next section.

Due to scheduling conflicts, Schlumberger Wireline Services were unable to provide specialty geophysical logging services at the MF-37 site until the first week of November 2001. On November 7, 2001, they conducted and completed geophysical logging operations within the nominal 8-inch diameter pilot hole from 765 feet to 2,046 feet bpl without incident. The geophysical logging suite included the following logs: caliper, spontaneous potential, natural gamma ray spectrometry (NGS), high resolution array induction (AIT), dipole sonic imager (DSI), compensated density with photoelectric effect (PEF), compensated neutron, ultrasonic borehole imager (UBI), and fullbore formation micro-imager (FMI). A composite of the geophysical log traces that were exempt from post-processing during geophysical log run no. 8 is provided in **Appendix A-8**.

Once hydraulic testing and geophysical logging operations were completed, DDC began to permanent back plug the bottom 363 feet of the nominal 8-inch diameter pilot hole. Back-plugging operations began on November 19, 2001 and completed on November 28, 2001. During back-plugging operations, the Contractor pumped 550 sacks (693 cubic feet) of Type II neat cement with 4 % (20-40 grade) quartz sand. This volume brought cement levels from the base of the pilot hole at 2,046 feet bpl to 1,683 feet bpl.

On January 3, 2002, the final stage of well construction began by DDC installing a semi-permanent inflatable packer at 1,500 feet bpl. The purpose of this packer is to isolate the saline waters below this depth, prohibiting inter-aquifer transfer and allow flexibility in the final design of this test/monitor well (e.g., single or dual zone monitor well). The current well completion for MF-37 is summarized below and illustrated in **Figure 3**:

- Permanent steel casing (12-inch diameter) set to 765 feet bpl,
- Open hole interval from 765 feet to 1,500 feet bpl,
- Long-term 7.0 inch diameter (Tam) inflatable packer set at 1,500 feet bpl,
- Open hole interval from 1,500 feet to 1,683 feet bpl,
- Nominal 8-inch diameter pilot hole, back plugged using neat cement and 4% 20-40 grade sand from 1,683 feet to 2,046 feet bpl.

The technical specifications for the semi-permanent inflatable packer are provided in **Appendix B**.

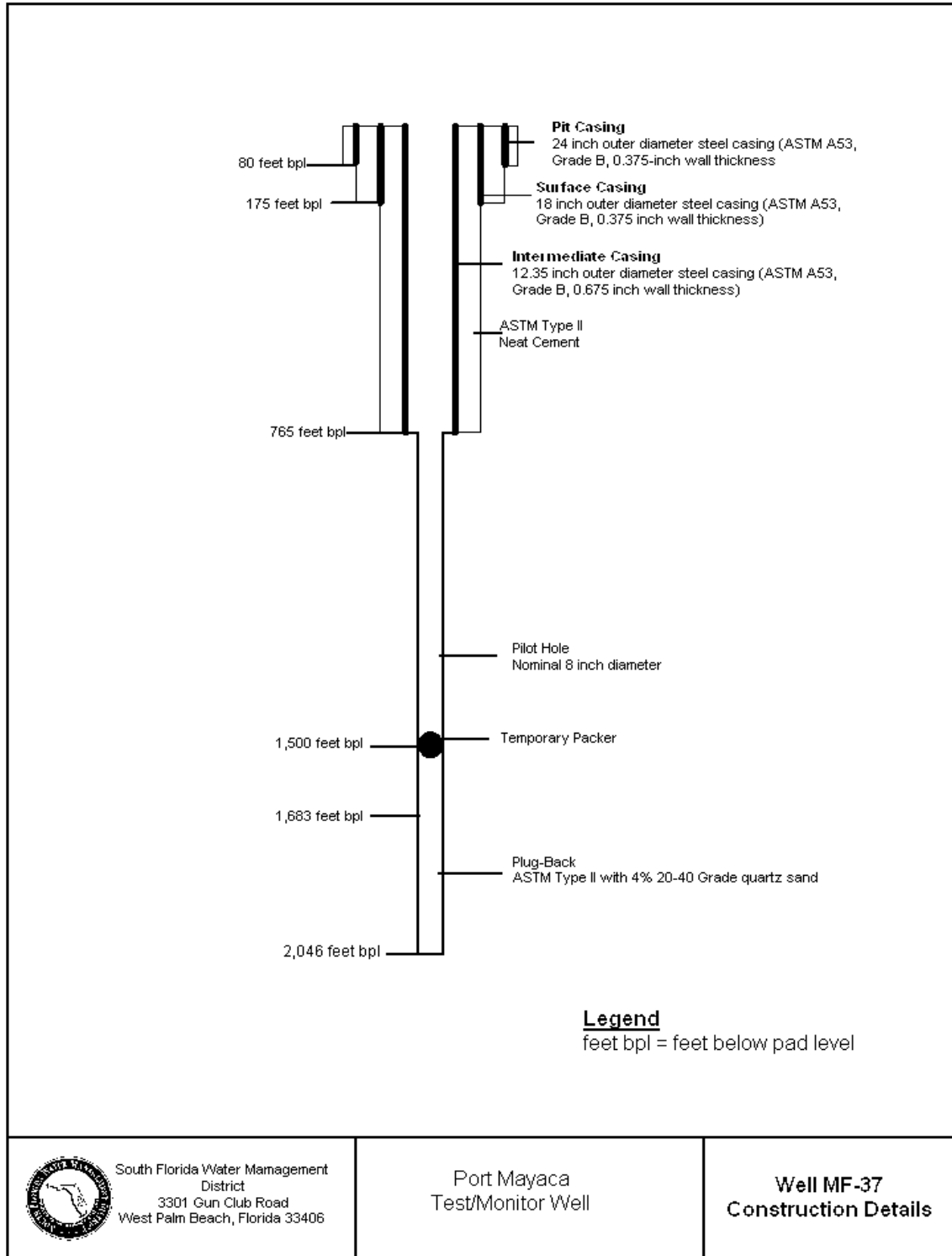
During the week of January 7-11, 2002, the Contractor installed a 12-inch diameter wellhead and 6-foot by 6-foot concrete pad with 4-foot high steel coroner posts

completing well construction activities at this site. Well construction and testing activities related to MF-37 are summarized in **Table 2**

<b>Construction Progress Summary</b>	
<b>MF-37, St. Lucie Canal Site</b>	
<b>Date</b>	<b>Description of Activities</b>
04/16/01	Project Initiation (Notice to Proceed)
05/10/01	Site preparation and mobilization
06/01/01	Drilled a 9.875-inch pilot hole to 87 feet bpl.
06/05/01	Reamed pilot hole with a 30 inch diameter bit to 85 feet bpl.
06/05/01	Geophysically logged reamed pilot hole (Run No. 1)
06/05/01	Install pit casing (74 ft; 24-inch diameter steel)
06/08/01	Drilled a 7.875-inch diameter pilot hole to 223 feet bpl.
06/13/01	Geophysical logged pilot hole to 223 feet bpl (Run No. 2).
06/21/01	Reamed pilot hole with a 23 inch diameter bit to 175 feet bpl.
06/22/01	Geophysical logged reamed pilot hole (Run No.3)
06/22/01	Install surface casing (170 ft; 18-inch diameter steel)
07/05/01	Drilled a 7.875-inch diameter pilot hole to 778 feet bpl.
07/06/01	Cored from 778 to 798 feet bpl. (no recovery)
07/10/01	Cored from 798 to 808 feet bpl. (8 feet of recovery)
07/12/01	Drilled a 7.875-inch diameter pilot hole to 931 feet bpl.
07/16/01	Cored from 931 to 951 feet bpl. (10 feet of recovery)
07/17/01	Drilled a 7.875-inch diameter pilot hole to 1,086 feet bpl.
07/18/01	Cored from 1,086 to 1,106 feet bpl. (0% recovery)
07/23/01	Drilled a 7.875-inch diameter pilot hole to 1,116 feet bpl.
07/24/01	Schlumberger geophysically logged pilot hole to 1,116 feet bpl (Run No.4)
08/08/01	Reamed pilot hole with 17-inch diameter bit to 800 feet bpl.
08/09/01	Back fill pilot hole to 770 feet bpl with crushed limestone.
08/14/01	Geophysical logged reamed pilot hole to 770 feet bpl (Run No.5)
08/14/01	Installed 12-inch diameter steel casing to 765 feet bpl.
08/14/01	Pressure grouted using 340 sacks (94 lbs.) of neat cement.
08/15/01	Conducted temperature survey to verify top of cement at 45 feet bpl (Run No.6).
08/15/01	Second stage of grouting (25 sack of neat cement) completed to land surface.
08/21/01	Conducted 50-psi pressure test of 12-inch diameter casing.
08/22/01	Drilled out cement plug (as a result of pressure grouting) with 12-inch diameter bit.
08/23/01	Re-drilled a 7.875-inch diameter pilot hole to 1,116 feet bpl.
08/31/01	Cored from 1,116 to 1,136 feet bpl (0% Recovery)
09/05/01	Drilled a 7.875-inch diameter pilot hole to 1,362 feet bpl.
09/11/01	Cored from 1,362 to 1,382 feet bpl (9.5 feet of Recovery)
09/12/01	Drilled a 7.875-inch diameter pilot hole to 1,503 feet bpl (lost circulation at 1,500 feet bpl.)
09/13/01	Contractor switched to reverse air drilling method.
09/18/01	Drilled a 7.875-inch diameter pilot hole to 1,629 feet bpl.
09/22/01	Cored from 1,629 to 1,649 feet bpl (7 feet of Recovery)
10/01/01	Drilled a 7.875-inch diameter pilot hole to 1,942 feet bpl.
10/02/01	Cored from 1,942 to 1,962 feet bpl (2 feet of Recovery, bit plugged at 1,944 feet bpl.)
10/03/01	Cored from 1,944 to 1,964 feet bpl (9 feet of Recovery, bit plugged at 1,953 feet bpl.)
10/04/01	Drilled a 7.875-inch diameter pilot hole to 2,046 feet bpl.
10/05/01	Geophysical logged pilot hole to 2,046 feet bpl. (Run No. 7)
10/16/01	Packer test conducted on 1,993 to 2,046 feet bpl interval.
10/23/01	Packer test conducted on 1,782 to 1,850 feet bpl interval.
10/26/01	Packer test conducted on 1,496 to 1,543 feet bpl interval.
10/30/01	Packer test conducted on 1,610 to 1,657 feet bpl interval.
11/01/01	Packer test conducted on 1,241 to 1,288 feet bpl interval.
11/07/01	Schlumberger geophysical logged pilot hole to 2,046 feet bpl (Run No.8)
11/13/01	Packer test conducted on 765 to 900 feet bpl interval.
11/28/01	Back plugged nominal 8-inch diameter pilot hole to 1,683 feet bpl.
11/30/01	Demobilization
01/03/02	Set temporary packer at 1,500 ft. bpl.
01/31/02	Geophysical logged pilot hole 765 to 1,500 feet bpl (Run No.9)

**Table 2. Construction and Testing Activities Associated with MF-37**

After construction was completed, MF-37 was surveyed relative to permanent reference points by a Florida registered land surveyor, and located on a site plan map by latitude and longitude, and recorded in the public record (**Appendix E**).



**Figure 3. Well Completion Diagram, Test/Monitor Well (MF-37)**

## **Hydrogeologic Testing**

Specific information was collected during the drilling program to determine the lithologic, hydraulic and water quality characteristics of the FAS at the Port Mayaca site. These data were to be used in the preliminary design of the test/monitor. Once the specific ASR horizon is identified the test/monitor well be completed and used in a site-specific aquifer test. In addition, it will be incorporated into the SFWMD long-term FAS water level and quality-monitoring program.

### **Formation Sampling**

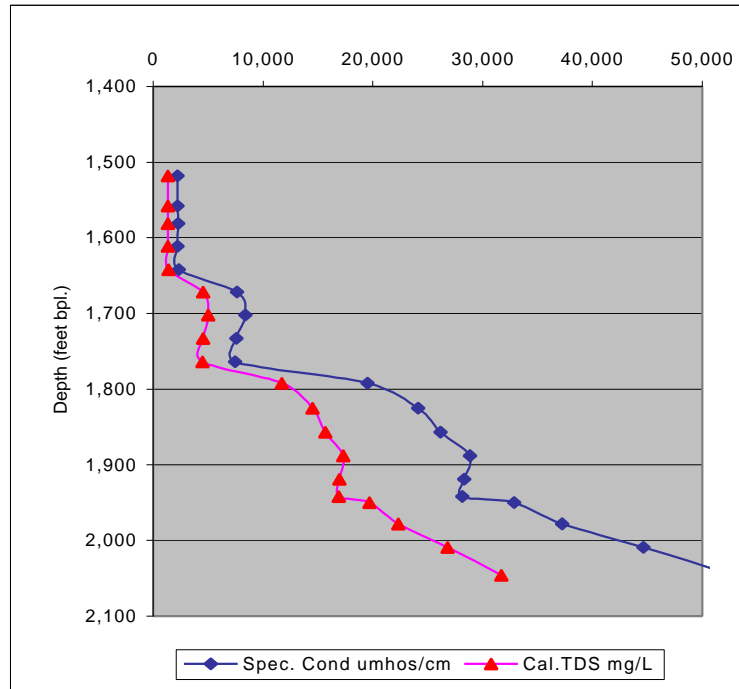
Geologic formation samples (well cuttings) were collected, washed and described (using the Dunham, 1962 classification scheme) on-site during the drilling of the pilot hole. Formation samples were collected and separated based on their dominant lithologic or textural characteristics, and to a lesser extent, color. If a massively bedded unit was encountered, composite samples were taken at a minimum of 5-foot intervals. The representative formation samples were sent to the Florida Geological Survey (FGS) for detail analysis and long term storage. The field lithologic descriptions for MF-37 are provided in **Appendix C**. During drilling of the test/monitor well, DDC Contractor obtained conventional cores using a 4-inch diameter, 20-foot long, diamond-tipped core barrel. Six rock cores of various lengths were recovered from the FAS between 778 and 1,964 feet bpl with core recoveries of 0 to 87 percent. The six (6) cores will be sent to Core Laboratories located in Midland, Texas to determine the following parameters: horizontal and vertical permeability, porosity, grain density, elastic, electric and acoustic properties, and lithologic character.

### **Formation Fluid Sampling**

During reverse-air drilling of the pilot hole, samples were taken from circulated return fluids (composite formation water) at 30-foot intervals (average length of drill rod) from 1,500 feet bpl to 2,046 feet bpl. A Hydrolab multi-parameter probe measured field parameters on each sample, which included temperature, specific conductance, and pH. **Figure 4** shows field determined specific conductance values and calculated total dissolved solids (TDS) concentrations (Hem, 1994) with respect to depth. Between 1,518 feet to 1,642 feet bpl, specific conductance values, and TDS concentrations averaged 2,235 micromhos per centimeter (umhos/cm) and 1,342 milligrams per liter (mg/L), respectively. Between 1,642 feet and 1,672 feet bpl, specific conductance readings increased rapidly to about 7,605 umhos/cm and with similar values continuing to a depth of 1,764 feet bpl. A second distinct change in specific conductance readings occurs between 1,764 feet and 1,792 feet bpl. Within this 30-foot interval, an increase in specific conductance of approximately 12,000 umhos/cm was noted, which transects the base of the USDW with a calculated TDS concentration of 12,100 mg/L at 1,792 feet bpl. Specific conductance values gradually increase to 28,865 umhos/cm at 1,888 feet bpl, remain constant over the next 90 feet, and then gradually increase to 52,828 umhos/cm at 2,046 feet bpl.

## Geophysical Logging

Geophysical logs were conducted in the pilot hole after each stage of drilling and before casing installation. These logs were conducted to provide a continuous record of the physical properties of the subsurface formations and their contained fluids. These logs were later used to assist in the interpretation of lithology, to provide estimates of permeability, porosity, bulk density, and resistivity of the aquifer, and to determine the salinity of the ground water (using Archie's equation, [Archie, 1942]). In addition, the extent and degree of confinement of specific intervals can be discerned from the



**Figure 4. Water Quality with Depth -- Reverse-air Returns**

individual logs. The geophysical logs also provided data to determine the desired casing setting depths on the test/monitor well. A CBL was conducted on the 12-diameter casing for MF-37 to assess the quality of grouting operations.

The geophysical logging contractor downloaded all geophysical log data directly from their onsite logging processor in log ASCII standard (LAS) version 1.2 or 2.0 format. The neutron and density porosity values determined calculated from geophysical log data during run no.4 and 8 were derived using a limestone matrix with a density of 2.71 grams per cubic centimeter ( $\text{gm}/\text{cm}^3$ ).

The geophysical log traces from log runs no. 1 through 8 for well MF-37 are presented in Appendix A-1 through A-8. The original geophysical logs and video surveys are archived and available for review at SFWMD headquarters located in West Palm Beach, Florida. **Table 3** provides a summary of the geophysical logging operations conducted at this site.

Run #	Date	Logging Company	Logged Interval (ft.) bpl	Caliper	Natural Gamma	SP	DIL	Sonic	Flow-Meter	Temp	Fluid Res.	Video
1	06/05/01	MV-Geophysical	0-85	x	x							
2	06/13/01	MV-Geophysical	0-223	x	x	x	x	x				
3	06/24/01	MV-Geophysical	0-175	x	x							
5	08/14/01	MV-Geophysical	175-770	x	x							
6	08/15/01	MV-Geophysical	175-770		x					x		
7	10/5-8/01	MV-Geophysical	770-2046	x	x	x	x	x	x	x	x	x

Specialty logging operations conducted by Schlumberger Wireline Services are summarized in **Table 4**.

Run #	Date	Logging Company	Logged Interval (ft.) bpl	Natural Gamma Ray Spectrometry (NGS)	Array Induction Imager (AIT)	Compensated Density Neutron PEF	Dipole Sonic Imager (DSI)	Formation Micro Imager (FMI)	Ultrasonic Borehole Imager (UBI)
4	07/24/01	Schlumberger	175-1116	x	x	x	x	x	x
8	11/7/01	Schlumberger	765-2046	x	x	x	x	x	x

### Packer Tests

Six straddle-packer tests were conducted in the Floridan Aquifer System from 765 feet to 2,046 feet bpl at this site. The purpose of these tests was to gain water quality and production capacity data on discrete intervals (approximately 75 feet in length) and to establish the depth of the 10,000-mg/L TDS interface.

The procedures listed below were used to conduct individual packer tests in well MF-37 at the Port Mayaca site:

- 1) Lower packer assembly to the interval selected for testing based on geophysical logs and lithologic data.
- 2) Set and inflate packers and open the ports between the packers to the test interval.
- 3) Install a 15-horsepower submersible pump to depth of 60 to 120 feet below the drill floor with a pumping capacity of 30 to 300 gpm.
- 4) Install two 100-psig-pressure transducers inside the drill pipe and one 30-psig transducer in the annulus connected to a Hermit 3000 Data Logger to measure and record water-level changes during testing operations.
- 5) Purge a minimum of three drill-stem volumes.
- 6) Monitor pressure transducer readings and field parameters (e.g., temperature, specific conductance, and pH) from the purged formation water until stable. These parameters were used to determine the quality of isolation of the packed-off interval.
- 7) Perform constant rate drawdown and recovery, once the interval was effectively isolated.
- 8) Collect formation water samples for laboratory water quality analyses following the District's QA/QC sampling protocol.
- 9) Record recovery data until water levels return to static conditions.

Before ground water sampling, the packer intervals were purged until three borehole volumes were evacuated, or until field parameters of samples collected from the discharge port had stabilized. A limit of +/-5% variation in consecutive field parameter readings was used to determine chemical stability. Field parameters including temperature, specific conductance, and pH were determined on each sample using a Hydrolab multi-parameter probe. Chloride concentrations were also determined using a field titration method (Hach Kit). The flow of water from the discharge point was then adjusted to minimize the aeration and disturbance of the samples. Unfiltered and filtered samples were collected directly from the discharge point by SFWMD staff into a clean plastic bucket. Equipment blanks were obtained prior to sampling to qualify sampling procedures. Replicate samples were also collected from consecutive bailers in accordance with SFWMD Comprehensive Quality Assurance Plan (SFWMD, Comprehensive Quality Assurance Plan, 1999).

Once samples were collected, the bottles were preserved and immediately placed on ice in a closed container. The composite samples were submitted to the SFWMD Water Quality Laboratory and analyzed for major cation and anions using EPA and/or Standard Method procedures (SFWMD, Comprehensive Quality Assurance Plan, 1999). The analytical results for the samples obtaining during the six packer tests are reported in **Table 5**.

Identifier	Depth Interval (ft. bpl)	Sample Date	Cations				Anions				Field Parameters		
			Na <sup>+</sup> (mg/L)	K <sup>+</sup> (mg/L)	Ca <sup>2+</sup> (mg/L)	Mg <sup>2+</sup> (mg/L)	Cl <sup>-</sup> (mg/L)	Alka as CaCO <sub>3</sub> (mg/L)	SO <sub>4</sub> <sup>2-</sup> (mg/L)	TDS (mg/L)	Specific Conduct. (umhos/cm)	Temp ° C	pH (s.u.)
MF-37_PT6	765-900	11/13/01	385	13	103	77	731	121	285	1,759	3,057	27.03	7.54
MF-37_PT5	1241-1288	11/01/01	81	5	71	45	135	127	234	709	1,141	28.03	7.53
MF-37_PT3	1496-1543	10/26/01	905	25	179	132	1,867	119	384	3,775	6,516	27.92	7.69
MF-37_PT4	1613-1660	10/30/01	1,415	38	240	192	2,910	119	448	5,799	9,211	28.90	7.27
MF-37_PT2	1782-1850	10/23/01	5,423	128	741	670	10,538	104	1,362	20,803	31,823	29.67	7.20
MF-37_PT1	1993-2046	10/16/01	9,588	328	668	1,056	18,356	120	2,409	33,401	48,591	30.11	7.31

Friction loss coefficients were obtained from Appendix 17.A *Ground Water and Wells*, Driscoll, 1989) according to pipe diameter used during testing operations. This coefficient was then multiplied by the length of pipe to calculate the friction (head) losses as a result of induced flow up the drill pipe. These head losses were then used to correct the drawdown data for specific capacity determinations. The specific capacity (SC) was calculated using the following method:

$$\begin{aligned}
 SC &= Q / s \\
 Q &= \text{pumping rate in gpm as measured by an in-line flowmeter,} \\
 s &= \text{aquifer head loss in feet: Measured drawdown minus the pipe friction loss component.}
 \end{aligned}$$

Curve-matching techniques were not used to determine transmissivity values from the drawdown or recovery data collected from straddle packer tests because they generally

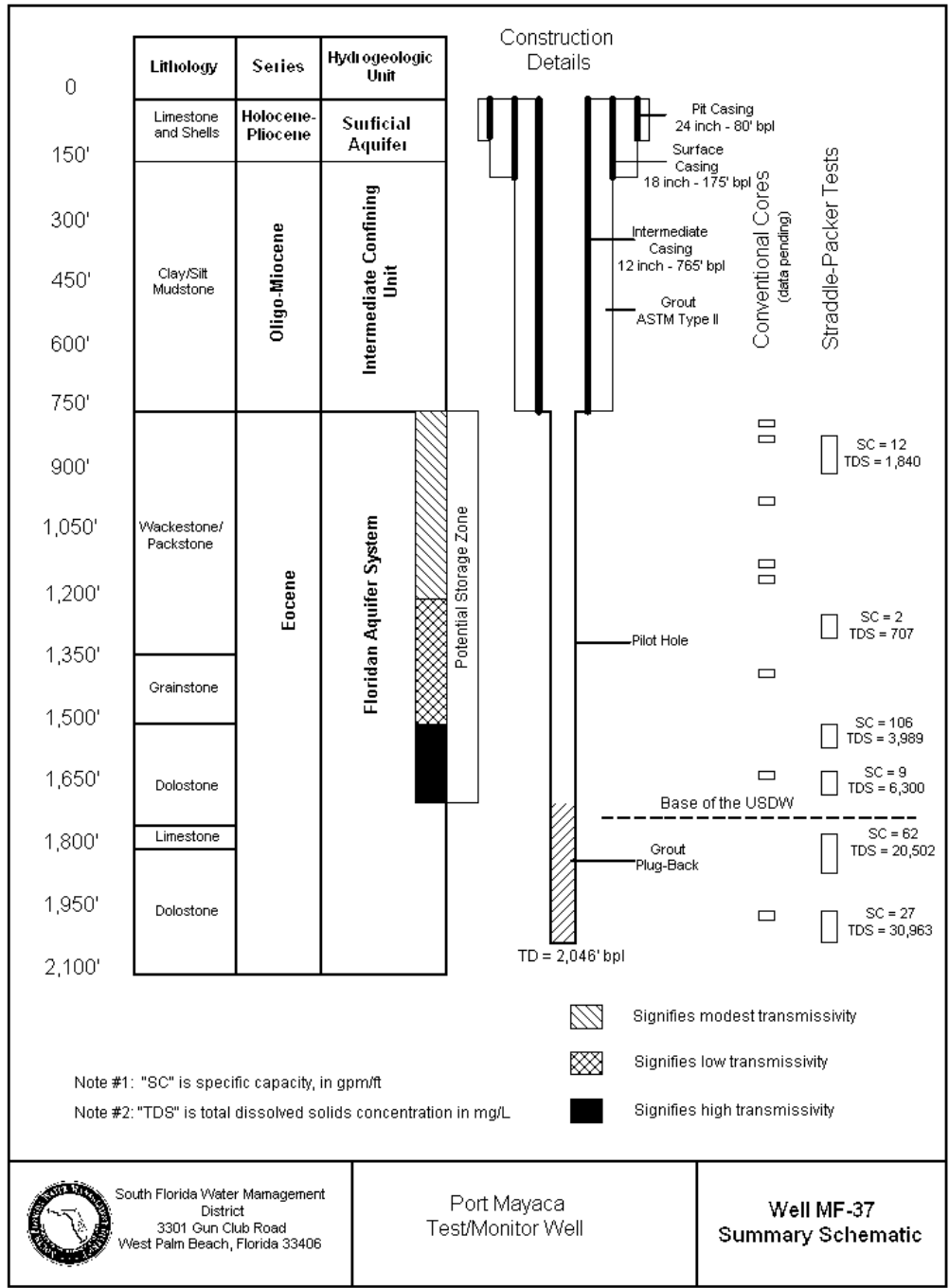
involve partial penetration, friction loss in small pipe, and short pumping period which violate the analytical method's basic assumptions. In addition, the productive nature of several of the tested intervals enabled them to respond almost instantaneously to the limited applied pumping stress which induced a pressure wave into the formation. The response to this pressure wave masks their true drawdown and recovery responses. The drawdown and recovery semi-log plots from the individual packer tests are provided in **Appendix D**. The production and static water level data from the individual packer tests are summarized in **Table 6**.

**Table 6. Packer Test Specific Capacity Data**

Test Name	Interval Tested (ft.)	Pump Rate (gpm)	Total Volume Pumped (gals.)	Initial Head (ft/H <sub>2</sub> O)	Final Head (ft/H <sub>2</sub> O)	Total Drawdown (ft)	Total Friction Loss (ft.)	Corrected Drawdown (ft.)	Specific Capacity (gpm/ft)
MF37 PT6	765-900	210	43064	98.84	98.76	8260	6440	1820	11.5
MF37 PT5	1241-1288	107	22221	81.93	81.79	7954	3153	4801	22
MF37 PT3	1496-1543	170	16434	100.16	100.24	9523	9363	160	106.2
MF37 PT4	1610-1657	123	23845	89.95	90.12	6924	5567	1357	9.1
MF37 PT2	1782-1850	129	33067	82.49	82.18	6371	6162	209	61.7
MF37 PT1	1992-2046	155	33300	77.36	77.42	7742	71.72	5.70	27.2

# Hydrogeologic Framework

Two major aquifer systems underlie this site - the Surficial Aquifer System (SAS), the Intermediate Confining Unit, and the Floridan Aquifer System (FAS) with the FAS being the focus of this test well program. These aquifer systems are composed of multiple, discrete aquifers separated by low permeable “confining” units that occur throughout this Tertiary/Quaternary aged sequence. **Figure 5** shows a hydrogeologic section underlying the Port Mayaca site.



**Figure 5. Hydrogeologic Section for the Port Mayaca Site**

### **Surficial Aquifer System**

The SAS extends from land surface (top of the water table) to a depth of 146 feet bpl. It consists of Holocene and Pliocene-Pleistocene aged sediments. The undifferentiated Holocene sediments occur from land surface to a depth of 10 feet bpl, and consist of unconsolidated orange to light gray, very fine to coarse grained quartz sands and shell fragments within a calcilutite matrix. The sediments from 10 feet to 146 feet in depth are composed primarily of yellowish gray, moderately indurated limestone with intermittent shell beds - 5 to 10 feet thick. Low permeable, arenaceous calcilutite at 146 feet bpl forms the base of the SAS at this site. A significant increase in the natural gamma ray activity below a depth 170 feet bpl suggests an increase in clay content and phosphate percentages with emissions above 30 American Petroleum Institute (API) units.

### **Intermediate Confining Unit**

Below the SAS lies the Intermediate Confining Unit, which extends from 146 to 755 feet bpl at this location. The Peace River and Arcadia Formations of the Miocene-Pliocene aged Hawthorn Group (Scott, 1989) act as confining units separating the FAS from the SAS. Lithologic information obtained from drill cuttings from MF-37 indicate that the Hawthorn Group sediments consist predominately of soft non-indurated detrital clays, silts and poorly to moderately indurated mudstones/wackestone with minor amounts of sand and shell material (see lithologic descriptions in **Appendix C**).

The signature of the photoelectric absorption index (PEFZ) log indicates a clayey silt to fine sand unit with a minor carbonate component (interpreted to be the Peace River Formation) that extends from 146 to 430 feet bpl with average values of 2 barnes per electron (b/e). The bulk density and the derived porosity logs suggest that this unit to be composed of low density, high porosity sediments (average of 48 porosity units). The irregular shape of the caliper log and borehole diameters exceeding bit size (nominal 8-inch) indicates that this interval is poorly indurated. Qualitatively, the resistivity profile of the induction log suggests shallow mud invasion occurred during drilling whereby the medium resistivity curve (AHT30) reads near the deep curve (AHT90).

A change in lithology occurs below 430 feet bpl-identified by an increase in bulk density readings and natural gamma radiation with a corresponding decrease in derived porosity and sonic transit times (Arcadia Formation?). The Photoelectric (PEFZ) log values within this interval range between three and four indicating a carbonate lithology including a minor silt/sand component (Hallenburg, 1998). The natural gamma log below 430 feet bpl produces thin, intermittent, gamma radiation peaks, associated primarily with intervals of significant phosphate sand/silt content.

The lithology from 655 feet to 755 feet bpl is primarily a moderately indurated packstone unit with 30 to 40 % clay, silt, and phosphatic sands. This interval is noted by a positive shift in resistivity, photoelectric and bulk density values with a corresponding reduction in derived porosity. These low permeable units form the lower boundary of the Intermediate Confining Unit.

### **Floridan Aquifer System**

The FAS consists of a series of Tertiary-age limestones and dolostones. The system includes permeable sediments of the lower Arcadia Formation, Suwannee Limestone,

Ocala Limestone, Avon Park Formation, and the Oldsmar Formation. The Paleocene-age Cedar Keys Formation with evaporitic gypsum and anhydrite forms the lower boundary of the FAS (Miller, 1986).

### **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 permeable carbonate sequence. The upper Floridan aquifer (UFA) consists of thin, high permeable water bearing horizons interspersed within thick, low permeable units of early Miocene to middle-Eocene aged sediments, including the Suwannee Limestone, Ocala Limestone, and the Avon Park Formation. At this site, the top of the FAS occurs at a depth of 755 feet bpl, which coincides with the basal Hawthorn Unit (Reese, 2000), part of the of the Arcadia Formation.

The Arcadia Formation from 755 to 788 feet bpl is composed primarily of moderately indurated packstone and grainstones containing approximately 5-10% shell fragments and 5-7% phosphatic sands and silts. The induction, bulk density, neutron-density porosity and caliper logs all indicate a competent, low porosity unit at 755 feet that continues to 788 feet bpl. The resistivity values increase from 12 to 40 ohm-meter (ohm-m). The bulk density increase with a corresponding decrease in porosity and the caliper log shows a relatively gauged borehole (i.e. similar to the diameter of the drill bit).

The sharp formation contact between the Miocene-aged Arcadia Formation (Hawthorn Group) and the underlying Oligocene-aged Suwannee Limestone at a depth of 788 feet bpl is identified by a change in lithology from a dark gray, well-indurated wackestone to a yellowish-gray packstone, which continues to 825 feet bpl. This discontinuity at 788 feet bpl is evidenced by a significant attenuation of the natural gamma activity, decrease in the formation resistivity and bulk density, with a corresponding increase in porosity (based on the derived density-neutron porosity data).

A slight change in lithology from a yellowish-gray, wackestone to light orange-gray, friable, moderately indurated wackestone-packstone identifies the upper boundary of the Ocala Limestone at a depth of 825 feet bpl. This formation boundary coincides with a slight attenuation of natural gamma activity, a slight increase in sonic travel times, a spiked signature of the resistivity log trace and enlarged borehole (see geophysical log traces from run no. 4 in **Appendix A-4**)

Generally, two predominant permeable zones exist within the UFA with the uppermost typically lies between 700 and 1,300 feet bpl. The most transmissive part usually occurs near the top, coincident with an unconformity at the top of the Oligocene or Eocene aged formations (Miller, 1986). Well cuttings and production type geophysical logs suggest that neither of these productive horizons exist within the upper Floridan aquifer at this site resulting in limited productive capacities. A slight deflection in the temperature differential log trace at 825 feet bpl suggests the presence of a minor flow zone. However, a specific capacity test on an interval from 765 to 900 feet bpl, which straddled the Suwannee-Ocala formation contact, yielded only 12 gallons per minute per foot (gpm/ft) of drawdown when pumped at a rate of 210 gpm. Brown, (1980) noted similar production potential of the UFA along the eastern boundary of Lake Okeechobee in

Martin County. Within this area, transmissivity values ranged between 25,000 to 50,000gpm/ft.

Based on lithologic and geophysical log data, the Ocala Limestone was separated into three distinct units. The upper portion of the Ocala occurs from 825 feet to 890 feet bpl and consists of low to moderated permeability, orangish-gray moderately indurated wackestones, and packstones, inter-bedded with light-gray micrite. The middle portion occurs from 890 feet to 1,003, and consists of moderately to well-indurated wackestones and packstones. This unit was evident on the geophysical logs by a positive shift in the resistivity and bulk density log values and a decrease in sonic transit times and borehole diameter (as compared to above and below) and lower density-neutron porosity values (**Appendix A-8**). The lower portion consists of white to light gray friable wackestones and packstones present from 1,003 feet to 1,186 feet bpl. There was little evidence of significant water production discerned during drilling operations or from the lithologic and geophysical log data over the lower portion of Ocala Limestone at this site.

### **Middle Floridan Confining Unit**

The lithologic character of the upper portion of the Avon Park is generally very similar in lithologic character to the lower Ocala Limestone. The top of the Avon Park formation was tentitively identified at depth of 1,186 feet bpl based on a lithologic change from a white to light-gray friable packstone to a dolomitic mudstone/wackestone. In addition this lithologic change is evident in the geophysical log data by a slight increase in natural gamma activity, distinctive photoelectric log signature, and a general decrease in sonic transit times, bulk density and porosity values (**Appendix A-8**). The lower Ocala Limestone and upper Avon Park Formation from 1,003 to 1,487 feet bpl form an inter-aquifer confining unit within the FAS at this site. This interval consists of low permeable mudstones and wackestones. A packer test in the upper Avon Park Formation (1,241 to 1,288 feet bpl) yielded a specific capacity of two gpm/ft. Formation samples from this interval do not show evidence of large-scale secondary porosity development (e.g., good pinhole, or moldic porosity). In addition, the production type geophysical logs traces (e.g., temperature and flowmeter logs) indicate no significant productive horizons, as seen by smooth log traces in both the temperature and flowmeter logs which supports the confining nature of this interval.

### **Middle Floridan Aquifer**

Permeable intervals have been documented within the Avon Park Formation, ranging in depth from 1,400 to 1,600 feet bpl (Miller, 1986). At this site, well-indurated crystalline dolostones inter-bedded with moderate to well indurated packstone to grainstone units occur from 1,487 feet to 1,790 feet bpl. The dolostone units are cryptocrystalline to surcosic in nature with the limestone units showing evidence of varying degrees of pinhole and moldic porosity development. A cavernous dolostone unit was encountered at 1,500 feet bpl, which caused a loss of mud circulation and a 3-foot drop of the drill rod. The Contractor re-mixed and circulated approximately 10,000 gallons of drilling fluid in an effort to regain circulation; these efforts were unsuccessful. During reverse air drilling, the majority of the natural artesian flow is produced from below this depth, supported by the flowmeter data. A specific capacity test on an interval from 1,496 to 1,543 feet bpl, which straddled the cavernous dolostone unit, yielded 106 gpm/ft of drawdown. Water quality analysis of samples taken during this test yielded chloride and

TDS concentrations of 1,867 mg/L and 3,775 mg/L, respectively. A second specific capacity test was conducted within a crystalline dolostone unit from 1,613 to 1,660 feet bpl. The result from this test identified this dolostone unit as being relatively non-productive, producing nine gpm/ft of drawdown with a measured TDS concentration of 5,800 mg/L.

Miller (1986) observed that portions of the lower Avon Park Formation are fine-grained and have low permeability, thereby acting as inter-aquifer confining units within the FAS. At this site, an inter-aquifer confining unit composed of well-indurated, mudstone to packstone units with intermittent brown to gray dolostone occurs in the subsurface from 1,660 to 1,795 feet bpl.

### **Lower Floridan Aquifer**

A significant lithologic change from limestone to predominately well-indurated crystalline dolostones occurs below 1,795 feet bpl. These dolostones are moderately to highly permeable, fractured, and cavernous that occur interspersed within less permeable dolostone and limestone units. This change in lithology is noted by the caliper log measuring a relatively gauged borehole - similar to drill bit diameter, an increase in resistivity, and a decrease in sonic travel times. In addition, the photoelectric log produces values of 3 b/e, and derived neutron porosity readings are approximately 6 porosity units (p.u) greater than those of the density porosity log, both of which are indicative of dolostones (see **Appendix A-8**).

A well-defined flow zone from 1,790 to 1,805 feet bpl near the top of this dolostone sequence was noted during reverse-air drilling by a significant increase in water production. Deflections in the temperature and dynamic flowmeter log traces and information from the borehole video log confirmed its productive nature log (see **Appendix A-7**). Straddle Packer Test No. 2 (1,782 to 1,850 feet bpl) was conducted to isolate this flow zone. This flow zone generated a specific capacity of 62 gpm/ft of drawdown stressed at 129 gpm but produced saline waters with a laboratory determined TDS concentration of 20,502 mg/L.

Based on information provided by Meyers (1989) and Reese (2000), the interval from 1,795 to 2,046 feet bpl was identified as the upper dolostone unit of the lower Floridan aquifer. The pilot hole extends into the upper dolostone units of the lower Floridan to a total depth of 2,046 feet bpl.

The top of the Oldsmar Formation is often difficult to identify because of a lack of diagnostic microfossils, which are generally obliterated by diagenetic effects or a lithologic character similar to the overlying Avon Park Formation. The top of the Oldsmar in south Florida is often identified based on the presence of a dolostone unit that occurs below a depth of 2,000 feet bpl. This unit is discerned on geophysical logs by increased gamma ray counts and resistivity values and decreased sonic travel times. If these criteria are used, the Oldsmar Formation could be identified at 1,795 feet bpl which corresponds to the occurrence of a well indurated, crystalline (euhedral to subhedral) dolostone. Based on lithologic criteria defined by Miller (1986), the lack of a glauconite marker bed used by Duncan et al., (1994), and the absence of Early Eocene index fossils

such as Helicostegina gyralis (Chen, 1965), the Oldsmar Formation was not encountered at this site.

## **Summary**

A 12.75-inch outer diameter test/monitor well was successfully constructed and tested in accordance with the SFWMD technical specifications at the Port Mayaca site.

Lithologic information and geophysical logs obtained from MF-37 indicates that soft non-indurated detrital clays, silts and poorly indurated mudstones of the Hawthorn Group predominate from 175 to 755 feet bpl. These low permeable sediments act as confining units separating the Floridan Aquifer System (FAS) from the Surficial Aquifer System (SAS).

The top of the FAS, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 755 feet bpl.

Lithologic and geophysical logs, packer test results, and specific capacity, results indicate moderate production capacity of the upper Floridan aquifer from 755 to 1,003 feet bpl.

A productive horizon in the Middle Floridan aquifer from 1,487 to 1,570 feet bpl yielded a specific capacity of 106gpm/ft of drawdown.

The production type logs (e.g. flow, temperature logs) indicates good production from flow zones between 1,490 and 1,600 feet bpl. Below 1,610 feet bpl, the productive capacity is limited (as indicated by the fluid-type logs) suggesting lower permeable – semi-confining units near the base of this productive horizon.

Composite water quality sampling during straddle test and geophysical log data was used in tandem to identify the base of the USDW at approximately 1,740 feet bpl. Total dissolved solids concentrations below 1,860 feet bpl are similar in concentration to seawater.

## **Conclusions**

1. Potential ASR zones generally exists from the top of the Floridan Aquifer System (765 feet bpl) to the base of the USDW (1,740 feet bpl) at the MF-37 site.
2. Additional production-type geophysical logging (i.e., flowmeter, temperature, fluid resistivity) should be conducted from the base of casing (765 feet bpl) down to the temporary packer (1,500 feet bpl) to more fully evaluate the upper and middle portions of the FAS for ASR potential. This approach will ensure that the highly productive zones below 1,500 feet bpl will not overwhelm the less overlying permeable zones during testing so that a better evaluation of this interval for ASR potential can be obtained.

3. Following the recommended flow logging, an evaluation should be conducted if acidization or additional specific capacity testing of MF-37 is warranted to further evaluate ASR potential.
4. If the Port Mayaca site is chosen as a site for an ASR system as part of the Lake Okeechobee ASR Pilot Project, MF-37 will need to be modified to accommodate monitor zone(s) consistent with the future ASR well.

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