SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Hydrogeologic Investigation of the Floridan Aquifer System

C-23 CANAL SITE

Martin County, Florida

Technical Publication WS-24

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Executive Summary

Water supply plans developed for the Upper East Coast Planning Area (UEC) have identified the Floridan aquifer system (FAS) as a water supply alternative. Based on these plans, the South Florida Water Management District (SFWMD or District) initiated an exploratory well construction, aquifer testing, and long-term monitoring program in the UEC. This report documents the results of the investigation at a site adjacent to the C-23 Canal in north central Martin County.

The exploratory wells will supply information needed to characterize the water supply potential of the FAS and to develop groundwater flow models, which will support future planning and regulatory decisions for the UEC. The UEC includes Martin and St. Lucie counties and part of Okeechobee County. A combination of natural drainage basins and political boundaries define the extent of this planning area. The well site was selected to augment existing hydrogeologic data and to provide broad spatial coverage within the UEC.

The scope of the investigation involved drilling, constructing, and testing two FAS wells and one intermediate confining unit (ICU) monitor well. The SFWMD provided oversight and All Webb's Enterprises, Inc. (AWE) of Jupiter, Florida was responsible for drilling, construction, and testing services under SFWMD contracts CN-050199 and CN-060363.

The first FAS well, identified as MF-40, was a dual-zone monitor well drilled to a depth of 1,240 feet below land surface (bls). The contractor constructed a telescoping type well in various stages, completing it into two distinct hydrogeologic zones within the FAS. A second FAS well, a dual-zone test production well called MF-41, was constructed for aquifer testing of the two zones in the FAS monitor well (MF-40). MF-41 was located 288 feet west of MF-40. The ICU monitor well, MH-40, was built to evaluate leakance through this unit during aquifer testing.

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

- The top of the FAS, as described by the Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition (1986), was identified at a depth of approximately 730 feet bls.
- Water quality data from both monitor zones in MF-40 waters revealed ionic concentrations in excess of potable drinking water standards. Chloride concentrations were 1,300 and 1,200 milligram per liter (mg/L) for the upper and lower zones respectively.

- The petrophysical and rock geochemistry data matched well with the formation evaluation logs. This indicates that the logs alone are a good tool to determine lithologic characteristics in a borehole.
- Laboratory-determined intrinsic (matrix) permeability measurements ranged from too low to measure to 293 millidarcies for the core sections. These permeability values are very low and come from dolomitic sections in the Ocala Limestone and Avon Park Formation. The porosity of these sections ranged from 10 to 35.5 percent.
- Inorganic water chemistry data showed that sodium and chloride were the dominant ions in the groundwater. Under Frazee's (1982) classification, water from both monitor zones is classified as relic seawater.
- Noble gas data and radiocarbon dating of the water indicate water entered the aquifer approximately 36,000 years ago. The reported noble gas temperature suggests that the freshwater recharge occurred during the Wisconsin Glacial Episode, which started approximately 110,000 years before present and ended between 10,000 and 15,000 years before present.
- The inorganic chemistry, stable isotopes, and radiocarbon data summarized in this report suggest that the water in the lower monitor zone likely entered the aquifer as precipitation during the last glacial period and over time became mineralized and mixed with ocean water as sea levels rose at the end of the last ice age.
- The FAS monitor well (MF-40) has two productive horizons that are hydraulically connected. This conclusion was reached by observing the water level response from the aquifer tests and noting the similarity in response in both monitor zones when a separate production well was pumped.
- A productive horizon in the zone between 790 and 970 feet bls yielded a transmissivity value of 255,000 ft^2/day.
- A productive horizon in the zone between 1,100 and 1,200 feet bls yielded a transmissivity value of 1,107,000 ft^2/day.
- The average measured hydraulic heads for the monitoring intervals at this site over 3 days in October 2006 are as follows:
    - 23.39 feet above mean sea level for MH-40 (305–375 feet bls)
    - 47.01 feet above mean sea level for MF-40U (790–970 feet bls)
    - 48.61 feet above mean sea level for MF-40L (1,100–1,200 feet bls)

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1 Introduction

1.1 BACKGROUND

The Upper East Coast Planning Area (UEC) of the South Florida Water Management District (SFWMD or District) includes Martin and St. Lucie counties and a portion of Okeechobee County. A combination of natural drainage basins and political boundaries define the extent of this planning area. Water supply plans developed for the UEC identified the Floridan aquifer system (FAS) as a possible water supply alternative. Based on these plans, the District initiated a program of exploratory well construction, aquifer testing, and long-term water quality and hydraulic heads monitoring. These wells will supply information needed to characterize the water supply potential of the FAS and to develop a groundwater flow model, which will support future planning and regulatory decisions.

The C-23 Canal site in Martin County is the first to be completed under the exploratory well program recommended in the UEC Water Supply Plan (SFWMD 2004). The site is located in the northwest quadrant of Section 6 of Township 38 South, Range 39 East (**Figure 1**). A survey elevation on the northwest corner of MF-40 cement pad measured 33.39 feet relative to the National Geodetic Vertical Datum of 1929 (NGVD 1929).

1.2 PURPOSE

The purpose of this report is to document the hydrogeologic data collected during the well construction, aquifer testing, and monitoring program at the C-23 Canal site. The information includes a summary of: 1) well drilling and construction details; 2) lithostratigraphy and hydrogeology; 3) geophysical logging and rock chemistry; 4) water quality and productive capacity; 5) stable isotope, carbon-14, and noble gas data; 6) aquifer performance test data and analyses; and 7) short-term, project-specific hydraulic head data.

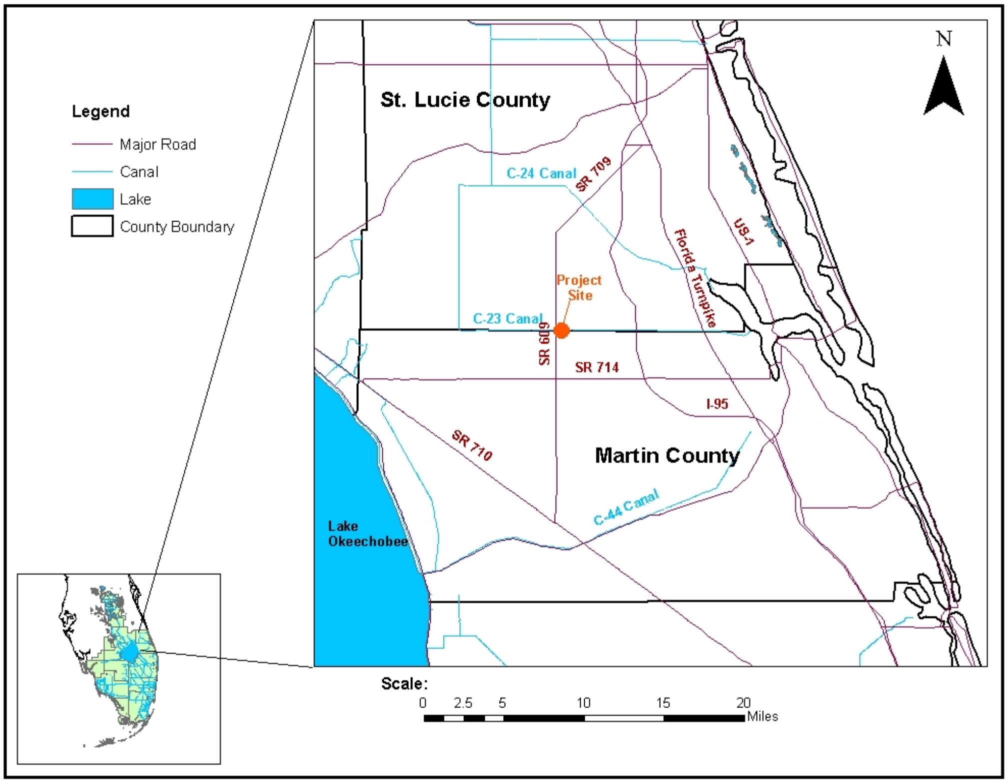

Figure 1. Project location map.

1.3 PROJECT DESCRIPTION

Preparation and equipment mobilization at the project site began May 23, 2005. The first well (MF-40), a telescoping style multi-zone monitor well, was drilled to a depth of 1,240 feet below land surface (bls) and completed in two distinct monitoring zones. The second well (MF-41), a dual-zone test-production well, was completed to 1,305 feet bls. The third well, an intermediate confining unit (ICU) monitor well (MH-40), was completed to 375 feet bls.

The SFWMD provided oversight and All Webb's Enterprises, Inc. (AWE) of Jupiter, Florida, was responsible for drilling, construction, and testing services associated with the two FAS wells and the ICU monitor well under SFWMD contracts CN-050199 and CN-060363. Well construction and testing were completed on December 18, 2006.

1.4 REGIONAL DESCRIPTION

The project site is near the northwest corner of the Allapattah Property in north central Martin County in the physiographic region known as the Eastern Valley, part of the Atlantic Coastal Lowlands (Cooke 1939). The surface elevation is about 30 feet NGVD in the study area.

Martin County encompasses about 570 square miles. The county is bounded by the Atlantic Ocean to the east, St. Lucie County to the north, Lake Okeechobee to the west, and Palm Beach County to the south. The area is a subtropical environment with long, hot, wet summers and mild, dry winters. The daily temperature averages 23.3 degrees Celsius (°C) with an average temperature range of 18.3 °C to 27.7 °C for the region. Seasonal variation in rainfall is pronounced; about 70 percent of the annual rainfall occurs during the 6-month wet season from May through October. Long-term records (1966–1995) indicate that average annual rainfall in Stuart, the major city in the county, is about 58 inches.

Well Screen Installation

2

Exploratory Drilling and Well Construction

The original scope of work for this project included the construction and testing of a tri-zone monitor well and a dual-zone production well. The SFWMD proposed that the tri-zone well would monitor portions of the Upper, Middle (Avon Park permeable zone), and Lower Floridan aquifers. However, District staff revised the well design during construction as a result of the borehole conditions encountered during drilling. AWE tried several times to advance the borehole below 1,240 feet without success. The friable and fractured nature of the formation kept collapsing into the borehole and prevented the drill bit from advancing. The SFWMD revised the design of the tri-zone monitor well to a dual-zone monitor well and a single-zone ICU monitor well. The two monitoring zones were completed in the Upper Floridan and the Avon Park permeable zone (APPZ). The ICU monitor well allowed the District to monitor water level changes in this zone during the aquifer performance tests (APTs) and determine leakance. The dual-zone production well (MF-41) stressed the two intervals in the Floridan aquifer corresponding to the dual-zone monitor well (MF-40). **Figure 2** shows the general layout of the wells at the C-23 Canal site.

During the drilling of these wells, the SFWMD and AWE collected cuttings every five feet or at noticeable formation changes. Three 10-foot long cores were collected during the construction of the dual-zone monitor well. The cores were analyzed for petrophysical and geochemical data and used to constrain geophysical log-derived porosity and permeability values. AWE collected one core in the Hawthorn sediments and two in the consolidated limestone of the Floridan aquifer. The core intervals are as follows: 631 to 641 feet bls, 855 to 865 feet bls, and 1,200 to 1,210 feet bls. AWE also ran a borehole deviation survey (sure shots) after every 60 feet of drilling to ensure that the borehole was straight and plumb.

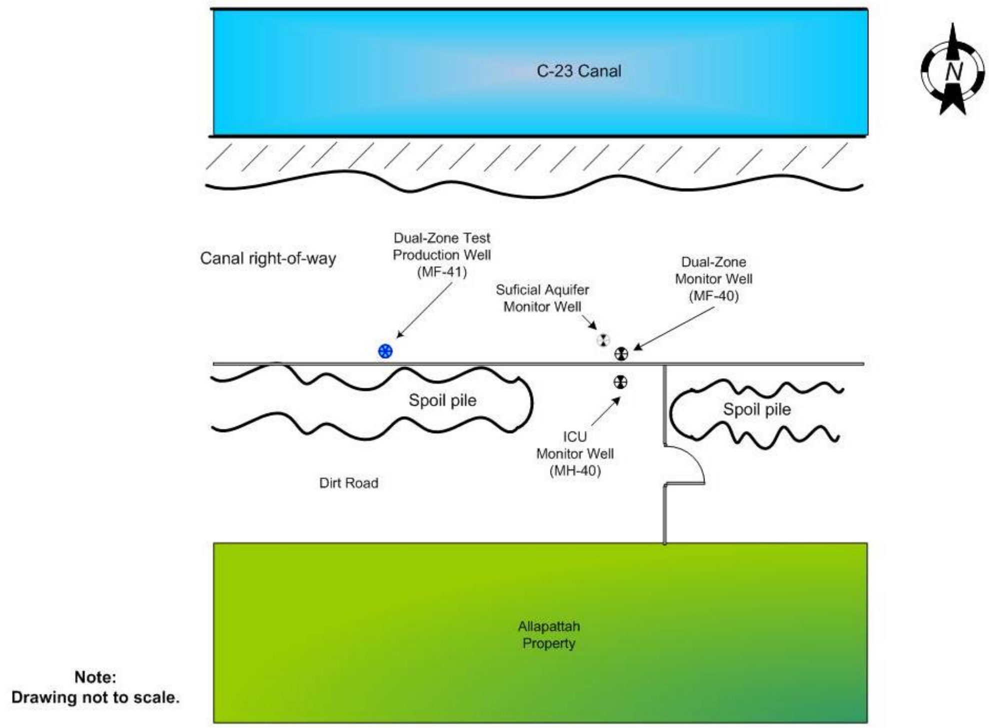

Figure 2. Diagram of the well locations at the C-23 Canal site.

2.1 DUAL-ZONE MONITOR WELL, MF-40

The District issued AWE a notice to proceed on May 23, 2005. After clearing and grading the site, AWE constructed a 2-foot thick drilling pad to support their rig and to contain drilling fluids and formation waters produced during well drilling, construction, and testing activities. The pad was lined with a 30-millimeter thick high-density polyethylene (HDPE) geomembrane. AWE secured the liner per the manufacturer's specifications within an anchor trench around the perimeter of the pad using a berm made of granular fill. An 8-inch layer of clean fine sand was placed above the liner. This sand did not contain any gravel size particles as they could puncture the HDPE liner. After adding this layer of fill, AWE compacted it to a density of at least 95 percent per the specifications listed in American Society of Testing and Materials (ASTM) D1557. Above the layer of sand, an additional 8-inch layer of crushed limerock was added and compacted to 95 percent per the specifications listed in ASTM D1557. The maximum particle size of this gravel was around 2 inches. The upper surface of the pad was slightly graded so any fluids on the pad would drain towards the sump, which was installed in the northwest corner of the drill pad. The sump's dimensions were 3-foot wide by 3-foot long by 3-foot deep. AWE then constructed a 2-foot high earthen wall around the perimeter of the drill pad. Dunkelberger Testing and Engineering, Inc. provided geotechnical services during the construction of the drilling pad. **Appendix A** includes a copy of the report they provided to AWE.

After setting and leveling the drilling rig in the pad, Quest Engineering Services and Testing, Inc. performed the hook load/weight capacity test as specified in the statement of work. The test required that the rig be able to handle a hook-load weight capacity 1.5 times the heaviest anticipated load. The rig passed the test and a copy of the certification report is included in **Appendix B**.

Mud-rotary and reverse-air techniques were used during drilling operations. Closed-circulation mud-rotary drilling was used to advance a nominal 10-inch diameter pilot hole from land surface to 1,060 feet bls. AWE used the reverse-air, open circulation method to drill the pilot hole from 1,060 to 1,240 feet bls.

The SFWMD used formation samples (well cuttings) and geophysical logs to determine setting depths for casings. Once the site geologist identified a suitable aquifer horizon for long-term monitoring, AWE reamed the pilot hole to the specified diameter and depth for the selected casing. Four concentric casings (30-, 24-, 18-, and 12-inch diameter) were used in the construction of the telescoping style monitor well (**Figure 3**).

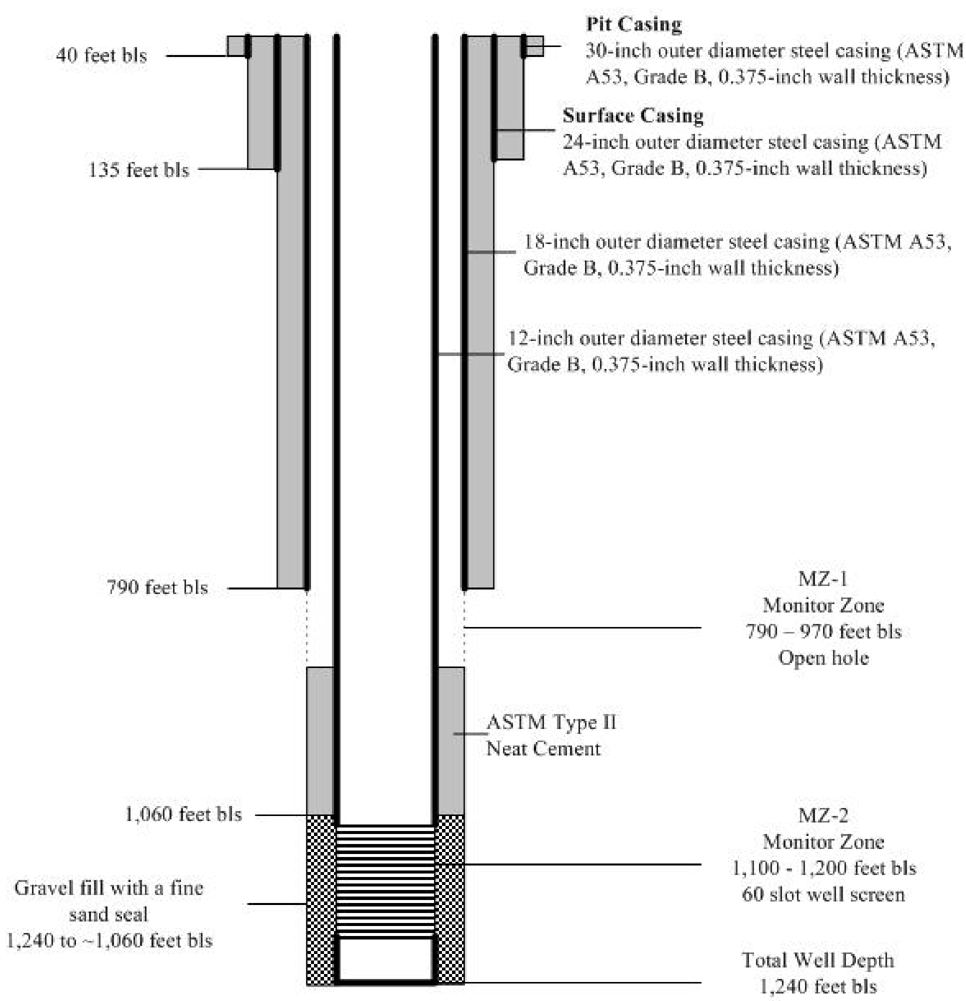

Figure 3. Dual-zone Floridan aquifer monitor well completion diagram (MF-40).

By July 6, 2005, AWE had installed the 30-inch diameter steel pit casing to 40 feet bls. AWE drilled a 36-inch diameter borehole using the mud-rotary method to this depth and installed the ASTM A53 Grade B steel casing in the borehole. The casing had a wall thickness of 0.375 inches. After installing a header, AWE used 86 cubic feet (ft^3) of ASTM Type II neat cement to pressure grout the 30-inch diameter steel casing from 40 feet bls to land surface.

By August 2005, AWE installed their electronic equipment to monitor drilling parameters and drilling fluid properties during the progression of work, as specified in the statement of work. The equipment measured weight on bit (WOB), drill string weight, rate of penetration (ROP), mud density (mud in–mud out), mud flow rates (flow in–flow out), mud resistivity, and mud pump pressure. AWE used a Yokogawa model DX100 recorder and retrieved these data weekly on 3.5-inch floppy disks. These data are currently kept at SFWMD headquarters in West Palm Beach, Florida.

On August 11, 2005, AWE began mud-rotary drilling through the pit casing down to 225 feet bls using a nominal 10-inch drill bit. After reaching 225 feet bls, the driller circulated drilling mud in the borehole to clean out drill cuttings in preparation for geophysical logging. After the drilling tools were removed from the borehole, MV Geophysical Surveys, Inc. ran 4-arm caliper and natural gamma geophysical logs. An in-depth discussion of the geophysical logging is presented in Section 5.1 and the logs are presented in **Appendix C**. The caliper log showed no unusual borehole conditions that would prohibit proper installation of the 24-inch diameter surface casing (ASTM A53, Grade B). AWE reamed the original borehole with a 30-inch drill bit to 135 feet bls. AWE then installed the 24-inch diameter casing at a depth of 135 feet bls, then pressure grouted it back to land surface using 239 ft^3 of ASTM Type II neat cement.

AWE installed a blow-off preventer on the 24-inch diameter casing to control potential artesian conditions while drilling through the ICU and FAS. Drilling by the mud-rotary method continued using a nominal 10-inch drill bit on August 16, 2005. The objective of this phase of the project was to drill as deep as possible into the Floridan aquifer using mud-rotary drilling before losing circulation. The scope of work for this project called for several specialty geophysical logs (formation evaluation logs) that are best run in a mud-drilled borehole. AWE first lost circulation at 905 feet bls, but were able to add sand to additional drilling mud to thicken it and try to seal off the lost circulation zone. They were unsuccessful at regaining circulation, even though they reduced weight on the drill bit, and had to add one sack of Baroid N Seal to the drilling mud to continue drilling to 1,060 feet bls, where mud circulation could not be regained. Between 905 and 1,060 feet bls, AWE lost approximately 50,000 gallons of drilling mud. After a delay due to Hurricane Katrina passing over south Florida, AWE circulated the nominal 10-inch diameter borehole to prepare it for geophysical logging. Schlumberger, an oil field services company, ran geophysical logs in the mud-filled pilot hole from the land surface to 1,060 feet bls on September 6, 2005.

The SFWMD reviewed the geophysical logs (**Appendix C**) and lithologic data (**Appendix D**), and identified the top of the FAS at a depth of approximately 730 feet bls. However, the 18-inch diameter casing was set at a depth of 790 feet bls to:

1. Seal off overlying silty clays of the Hawthorn Group, carbonate mud stringers, and fine quartz and phosphatic sands within the lower portion of the Arcadia Formation between 730 and 790 feet bls to avoid future drilling problems.
2. 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.
3. Facilitate reverse-air drilling operations through the underlying permeable horizons of the FAS to the anticipated total depth.

AWE installed a temporary cement plug in the nominal 10-inch diameter pilot hole at 820 feet bls. The cement plug provided a competent base for subsequent pressure grouting of the next casing string. AWE then reamed a nominal 23-inch diameter borehole to 790 feet bls via the mud-rotary method. A caliper log trace showed no unusual borehole conditions that would prohibit proper installation of the 18-inch diameter steel casing. AWE installed the 18-inch diameter steel casing (ASTM A53, Grade B) to a depth of 790 feet bls and pressure grouted the annular space using 343 ft^3 of ASTM Type II neat cement. Steel tubing was used to physically measure (hard tag) cement levels within the annulus. The physical hard tag indicated the cement level was 500 feet bls, which was in close agreement to calculated theoretical volumes using the caliper log data. AWE pumped an additional 591 ft^3 of ASTM Type II neat cement in one stage via the tremie method. This volume brought the cement level from 500 feet bls to land surface.

On September 27, 2005, the SFWMD oversaw a pressure test of the 18-inch diameter steel casing. AWE pressurized the well casing to 50.5 pounds per square inch (psi) with water. Pressure in the well casing was displayed on a 10-inch Wika pressure gauge (Model 342.1) and the District representative recorded the pressure every 5 minutes for 1 hour. The manufacturer calibrated the pressure gauge 1 month before AWE used it for this test. A copy of the calibration report is included in **Appendix E**. The well casing lost 2.0 psi over the course of the test, a 4 percent change in pressure that is within the 5 percent criterion for a successful test. **Table 1** summarizes the pressure test results.

Table 1. 18-inch steel casing pressure test results, MF-40.

Elapsed Time (minutes)	Gauge Pressure (psi)	Pressure Change (psi)	Pressure Change (%)
0	50.5	-	-
5	50.5	0.0	0.0
10	50.5	0.0	0.0
15	50.5	0.0	0.0
20	50.5	0.0	0.0
25	50.0	-0.5	-1.0
30	50.0	-0.5	-1.0
35	49.5	-1.0	-2.0
40	49.0	-1.5	-3.0
45	49.0	-1.5	-3.0
50	48.5	-2.0	-4.0
55	48.5	-2.0	-4.0
60	48.5	-2.0	-4.0

After setting the 18-inch diameter well casing, AWE switched the drilling system to reverse-air circulation. This method is well suited for highly permeable zones where mud circulation can be lost. Part of switching over to reverse-air circulation included the installation of a 12-inch diameter discharge pipe. The discharge pipe allowed water from the drilling operations to flow into the C-23 Canal. The District obtained a generic discharge permit from the Florida Department of Environmental Protection (FDEP) for this phase of the project. The permit allowed for the discharge of formation water into the C-23 Canal, provided the District monitor upstream and downstream water quality. To monitor, the District deployed two sensors into the C-23 Canal during the discharge of reverse-air water, one 500 yards upstream of the discharge point and another 800 yards downstream. In addition, AWE installed a water quality sensor at the discharge point. The discharge permit also required water quality analysis of the groundwater in the well before it could be released into the C-23 Canal. AWE collected a groundwater sample from the test well and sent it to Jupiter Environmental Laboratories (JEL) for analysis. According to the permit, JEL analyzed the sample for total organic carbon (TOC), pH, total recoverable mercury, total recoverable cadmium, total recoverable copper, total recoverable lead, total recoverable zinc, total recoverable chromium (hexavalent), benzene, and naphthalene. All of these constituents were below the limits specified in the permit. **Appendix F** includes a copy of the generic discharge permit and the analytical results.

AWE drilled through the cement plug at the base of the 18-inch diameter casing (a result of pressure grouting) using a nominal 17-inch diameter bit. They then reconfigured the drill bit assembly to a 10-inch diameter bit and continued to advance the pilot hole via the reverse-air method through the limestones and dolostones of the Floridan aquifer. Drilling went well from 1,062 to 1,200 feet bls, at which point the highly fractured nature of the rock formation led to problems. From October 17 to November 16, 2005, AWE only managed to drill 50 feet, from 1,200 to 1,240 feet bls, as large rock fragments continually clogged the reverse-air line and large quantities of cuttings were removed from the borehole. Rock cuttings also fell into the borehole onto the drill bit. The SFWMD and AWE agreed to drill the borehole with a nominal 17-inch diameter drill bit in an effort to prevent further cave-ins. AWE managed to drill to 1,100 feet bls with the nominal 17-inch bit before reverting to a nominal 10-inch bit due to the same problems with the borehole conditions. After re-entering the borehole with the nominal 10-inch bit, AWE continued drilling, but the borehole kept collapsing and drilling stopped at 1,240 feet bls. A caliper and video log showed four areas with large fractures and washouts between 904 and 1,240 feet bls. Some of the fractures had ledges where loose material hung precariously. The bottom 20 feet of the borehole was a highly fractured, cavernous dolomite. After several unsuccessful attempts to drill through this zone, the District decided to end drilling operations and complete the well as a dual-zone monitor well. Both parties agreed to set this second monitor zone as a screened section and fill the surrounding annular space with gravel. On December 14, 2005, AWE completed drilling operations to a depth of 1,240 feet bls.

Before setting the final casing string, AWE reverse-air developed the borehole and MV Geophysical ran production evaluation logs under static and artesian flow (dynamic) conditions. These production logs included flow meter, high-resolution temperature, and fluid resistivity logs. On October 14, 2005, AWE ran geophysical logs in the water-filled nominal 10-inch diameter pilot-hole from 790 to 1,240 feet bls.

AWE installed a 12-inch diameter steel casing and well screen (ASTM A53, Grade B) to a depth of 1,240 feet bls. The bottom 40 feet of the borehole (1,200–1,240 feet bls) consisted of solid steel casing. AWE welded 100 feet of steel well screen (ASTM A53, Grade B) with a 0.0060-inch slot size above the 40-foot section of steel casing. The remaining 1,100 feet of the well consisted of 12-inch diameter steel casing (ASTM A53, Grade B) to land surface. AWE then used the tremie method to add 56 cubic yards (1,512 ft^3) of $^3/_8$-inch limestone gravel to the annular space to fill the cavernous area at the base of the well and provide a filter pack around the well screen. The gravel was raised from 1,240 to 1,060 feet bls and capped with several feet of sand to prevent cement from seeping into the gravel and clogging the well screen. AWE then pumped 529 ft^3 of ASTM Type II neat cement via the tremie method into the borehole above the gravel to seal off the upper and lower monitoring intervals. Steel tubing was used to physically measure (hard tag) the cement level within the annulus. The physical hard tag indicated the cement level was at 970 feet bls, which was in close agreement to calculated theoretical volumes using the caliper log data. This was also the desired depth for the base of the first monitoring interval (790–970 feet bls).

On February 6, 2006, a District representative oversaw a pressure test of the 12-inch diameter steel casing. AWE installed a packer approximately 50 feet above the screened section and pressurized the well casing to 58.5 psi with water. Pressure in the well casing was displayed on a 10-inch Wika pressure gauge (Model 342.1) and the District representative recorded the well pressure every 5 minutes for 1 hour. The well casing lost 0.5 psi over the course of the test, a 0.9 percent change in pressure and within the 5 percent criterion for a successful test. The pressure test results are summarized in **Table 2**.

Table 2. 12-inch steel casing pressure test results, MF-40.

Elapsed Time (minutes)	Gauge Pressure (psi)	Pressure Change (psi)	Pressure Change (%)
0	58.50	-	-
5	58.50	0.00	0.00
10	58.50	0.00	0.00
15	58.50	0.00	0.00
20	58.50	0.00	0.00
25	58.25	-0.25	-0.40
30	58.25	-0.25	-0.40
35	58.25	-0.25	-0.40
40	58.25	-0.25	-0.40
45	58.25	-0.25	-0.40
50	58.25	-0.25	-0.40
55	58.00	-0.50	-0.90
60	58.00	-0.50	-0.90

To complete the well, AWE installed a 316 stainless steel (ASTM A790) wellhead on MF-40. An 18-inch stainless steel (ASTM A790) flange was installed 12 inches above the ground level. A 2-inch diameter stainless steel extension, equipped with a 2-inch inner diameter stainless steel ball valve, was installed in the flange, offset from center, to complete the wellhead for the Upper Floridan monitor zone (MF-40U). A 1-foot section of 12-inch stainless steel was installed in the center of the flange on the 18-inch diameter stainless steel. This section completed the lower monitor zone (MF-40L). The top of the 12-inch stainless steel section was finished with a flange. The top of the flange contained a 2-inch and a 4-inch diameter access port. AWE completed the 2-inch access port with a 50-psi pressure gauge and the 4-inch diameter port with a stainless steel ball valve and a threaded plug. The uppermost monitor zone (MF-40U) was constructed using an 18-inch diameter casing and completed with an annular zone from 790 to 970 feet bls. The lowermost monitor zone (MF-40L) was constructed using a

12-inch diameter well casing with a screened section from 1,100 to 1,200 feet bls The wellhead was centered in a 6-foot by 6-foot by 6-inch thick cement pad finished with a nonskid surface and a brass survey marker. The marker was located in the northwest corner of the pad and has an elevation of 33.39 feet NGVD. A Florida-licensed surveyor provided the elevation for the brass marker and a copy of the report is included in **Appendix G**. **Table 3** lists the monitor intervals and completion methods for the monitor wells.

Table 3. Completion intervals for the monitored zones at the MF-40 site.

Identifier	Monitor Interval (feet, bls)	Completion Method	Aquifer
MH-40	305—375	Screened	intermediate confining unit
MF-40U	790—970	Annular zone	Upper Floridan
MF-40L	1,100—1,200	Screened	Avon Park permeable zone

AWE developed the two monitor intervals via over-pumping and artesian flow techniques until the sediment concentration of the produced formation waters was 5 mg/L or less (using an Imhoff cone). AWE then constructed a 5-foot by 5-foot reinforced concrete pad at the surface of the MF-40 monitor wellhead and placed traffic bumpers at its corners. AWE completed well construction operations related to MF-40 on April 25, 2006. **Figure 4** is a photograph of the completed wellhead for MF-40U and MF-40L.

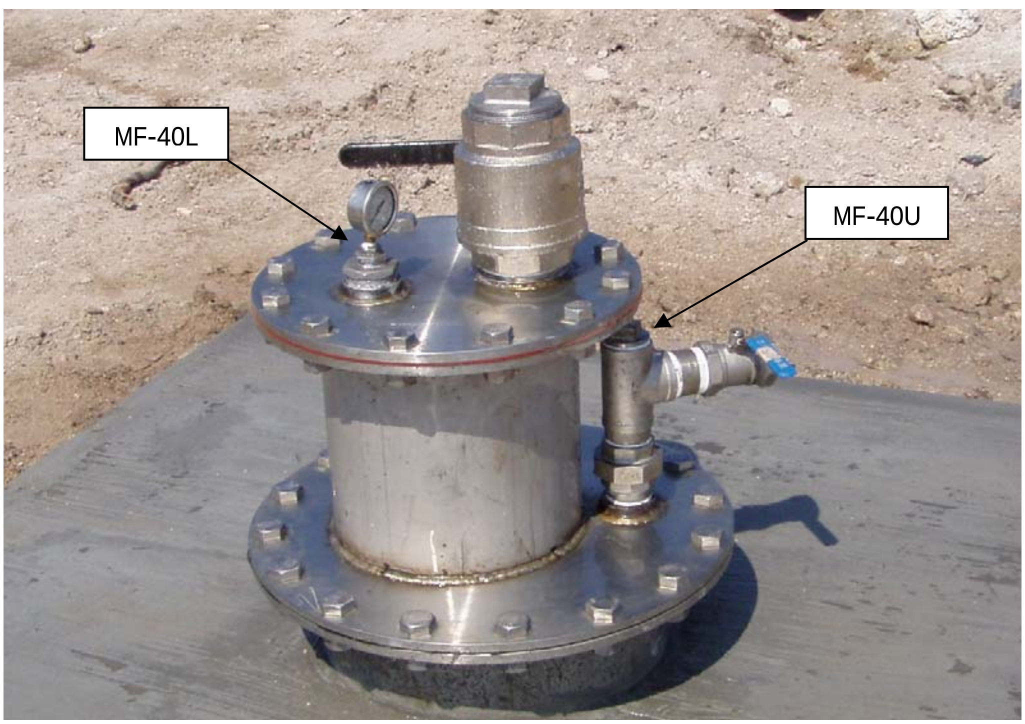

Figure 4. Photograph of MF-40 wellhead.

2.2 DUAL-ZONE TEST PRODUCTION WELL, MF-41

The site for the test production well (MF-41) is approximately 288 feet west of the dual-zone monitor well (MF-40). The intended use of this well was to pump water for aquifer performance testing from the two zones that correspond with the intervals in MF-40.

AWE cleared and rough graded the location of the test production well to build a 60-foot by 40-foot temporary drilling pad. The purpose of the temporary drilling pad was to contain drilling fluids and formation waters produced during well drilling, testing, and well construction activities. The drilling pad consisted of 2 feet of crushed limestone lined with an HDPE membrane. AWE then moved the drill rig and supporting equipment onto the well pad and configured the equipment to begin construction of the dual-zone test production well. Once AWE moved their equipment, they constructed an earthen wall 2 feet high around the perimeter of the drilling pad that surrounded the rig and settling tanks. **Figure 5** is a completion diagram of well MF-41.

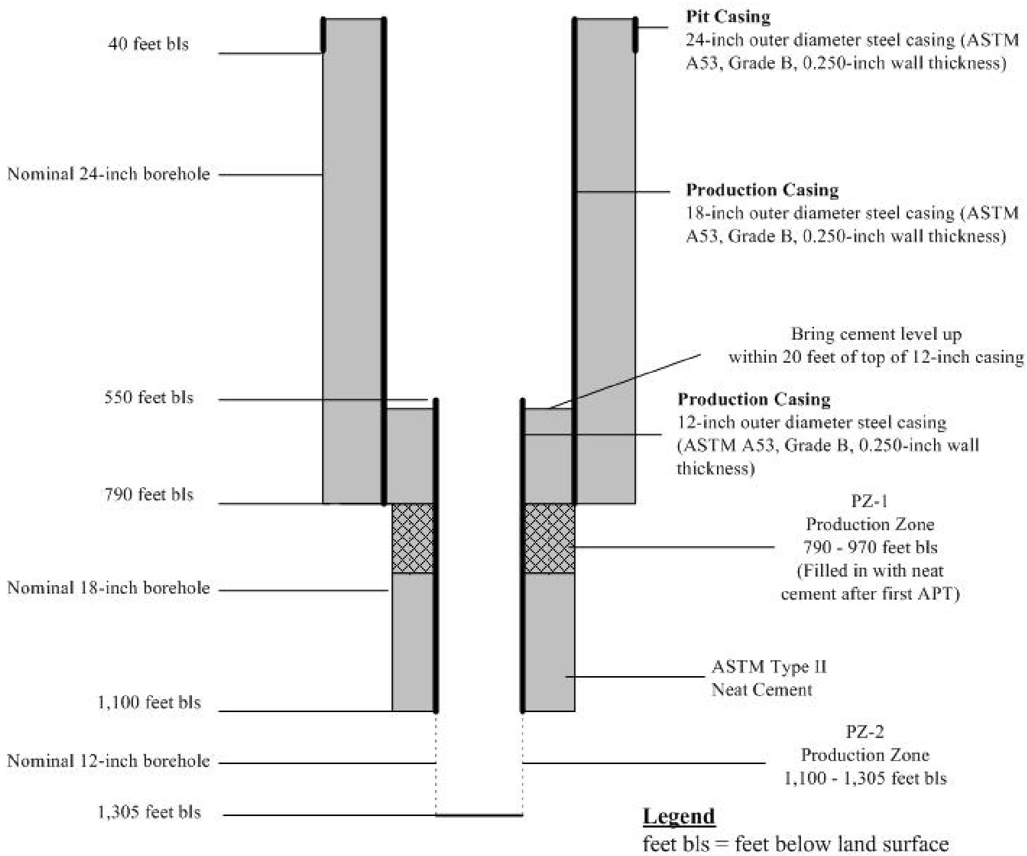

Figure 5. Dual-zone FAS test production well completion diagram (MF-41).

The SFWMD designed the dual-zone test-production well using three concentric steel casings (24-, 18-, and 12-inch diameter). AWE installed a 24-inch diameter pit casing to 40 feet bls. Once completed, AWE advanced a nominal 23-inch diameter borehole via the mud-rotary method to depth of 790 feet bls. On September 30, 2006, AWE ran a caliper log in the nominal 23-inch diameter borehole to evaluate stability and to calculate cement volumes for grouting operations. AWE then installed the first production casing, which consisted of 18-inch diameter steel pipe (ASTM A53, Grade B, and 0.25-inch wall thickness) to 790 feet bls. This casing was pressure-grouted using 1,086 ft^3 of ASTM Type II neat cement. Steel tubing was then used to physically measure (hard tag) the cement level within the annulus on October 1, 2006, and then pump additional neat cement to the land surface via the tremie method.

On October 7, 2006, AWE began to drill through the cement plug at the base of the 18-inch diameter casing (a result of pressure grouting) using a nominal 18-inch diameter bit by reverse-air circulation. AWE continued to advance the nominal 18-inch diameter borehole using the reverse-air method to 970 feet bls. At this depth, AWE developed the production interval via the reverse-air method and removed the drill bit assembly to prepare for the first aquifer performance test (APT). AWE ran geophysical logs in the well on October 12, 2006 in the open hole section of the well from 790 to 970 feet bls. On October 16, 2006, after conducting a step-drawdown test, the first APT was conducted (see Section 5.5 for details and results).

After successfully completing the first APT, AWE advanced the borehole via the reverse-air drilling method using a nominal 18-inch diameter bit to 1,100 feet bls. AWE ran a caliper log to evaluate borehole diameter variability and to calculate cement volumes for subsequent grouting of the 12-inch diameter steel casing. The second stage of well construction consisted of AWE installing 12-inch diameter steel casing (ASTM A53, Grade B, and 0.25-inch wall thickness) to 1,100 feet bls and suspending it with "J" hooks inside the 18-inch casing. The second production casing was tremie grouted to 570 feet bls using 1,404 ft^3 of ASTM Type II neat cement. The top of the 12-inch diameter steel casing was 550 feet bls. AWE completed its installation on October 27, 2006.

On November 7, 2006, AWE entered the 12-inch diameter casing using a nominal 12-inch diameter bit and advanced a nominal 12-inch diameter borehole using the reverse-air method to 1,240 feet bls. After attaining this depth, AWE developed the production interval using the reverse-air method and removed the drill bit assembly to prepare for the second APT. Initial testing of this zone while setting the pump showed that it would not yield a significant quantity of water for the second APT. The SFWMD issued a change order to AWE authorizing them to continue drilling and complete the well at 1,305 feet bls. AWE reached 1,305 feet bls and performed geophysical logging in the well on November 21, 2006 in the open hole section of the well from 1,100 to 1,305 feet bls. The geophysical logging is summarized in Section 5.1 of this report. The second

APT, scheduled for November 28, 2006, had to be rescheduled as the pump failed and AWE had to order a new one. On December 13, 2006, the second APT was conducted on the interval from 1,100 to 1,305 feet bls (see Section 5.5 for details and results).

AWE installed a standard 18-inch diameter wellhead, which consisted of a steel body, bronze-mounted valves with flanged ends, solid wedge gate, and outside screw and yoke gate valves with a 12-inch diameter side-discharge port. AWE then constructed a 5-foot by 5-foot reinforced concrete pad at the surface to complete the construction of the test-production well (**Figure 6**).

Figure 6. Photograph of MF-41 wellhead.

2.3 INTERMEDIATE CONFINING UNIT MONITOR WELL, MH-40

AWE constructed a single-zone monitor well (MH-40) into the Arcadia Formation after completing the dual-zone Floridan aquifer monitor well (MF-40). The purpose of this well was to monitor water levels in the ICU sediments during the APTs and help calculate leakance from this unit into the FAS. MH-40 is approximately 10 feet south of MF-40. AWE began construction of the ICU monitor well on January 14, 2006. **Figure 7** is a completion diagram of MH-40.

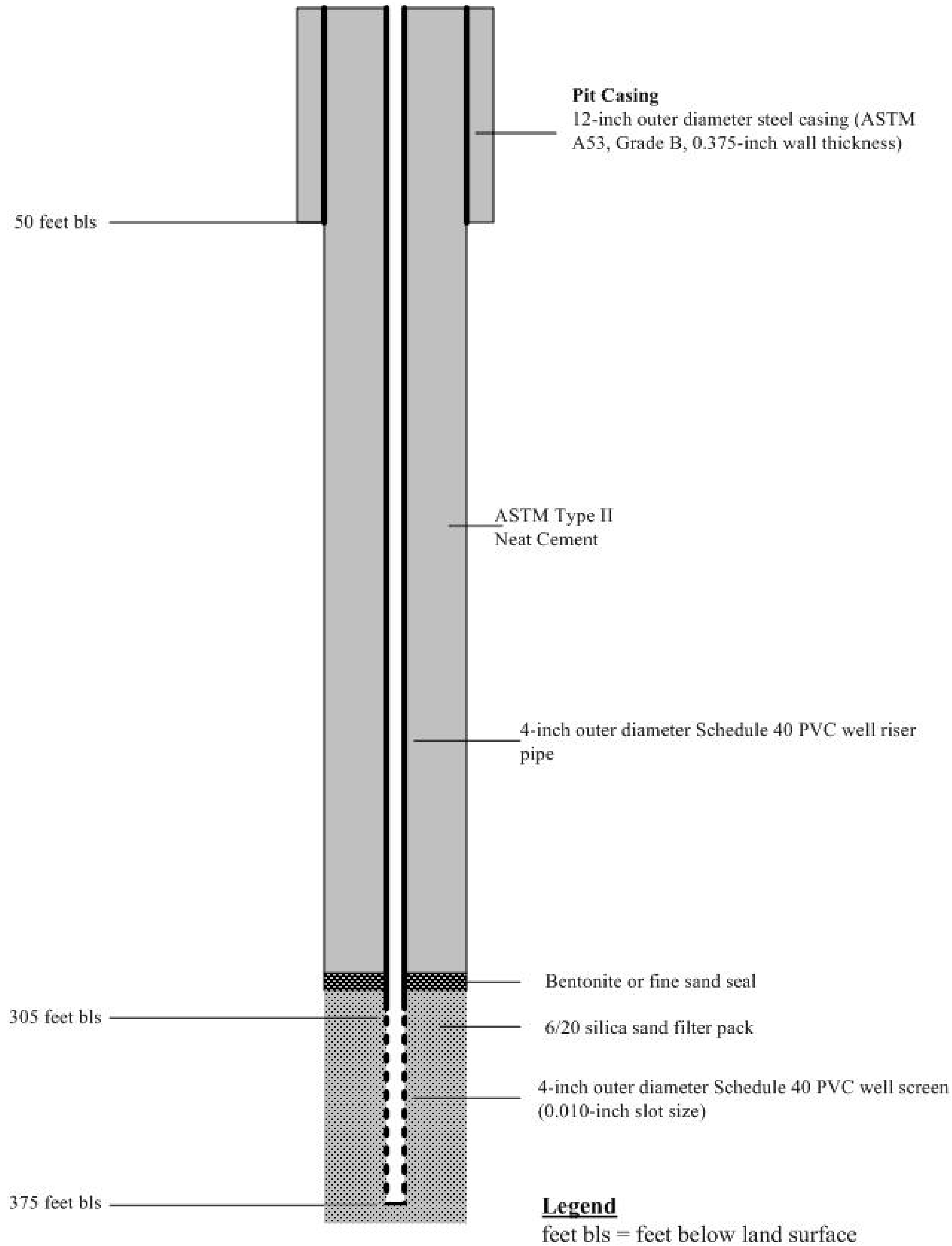

Figure 7. Intermediate confining unit monitor well completion diagram (MH-40).

AWE drilled an 18-inch diameter borehole to 50 feet bls and installed a 12-inch diameter ASTM A53 Grade B steel casing in the borehole. The casing had a wall thickness of 0.375 inches. AWE installed a header and used 50 ft^3 of ASTM Type II neat cement to pressure grout the 12-inch diameter ASTM A53 Grade B steel casing from 50 feet bls to land surface.

AWE then used mud-rotary drilling with a nominal 10-inch bit to penetrate the cement plug at the bottom of the pit casing and reach a depth of 375 feet bls. AWE then circulated drilling mud in the borehole to clean out drill cuttings and ensure it would not collapse during installation of the well. On January 18, 2006, AWE installed the 4-inch diameter Schedule 40 polyvinyl chloride (PVC) well. The well consisted of 70 feet of 0.010-inch slotted screen from 305 to 375 feet bls and 300 feet of solid Schedule 40 PVC from 305 feet bls to land surface. All well casings and screen joints used threaded connections and manufacturer-supplied "O" rings.

AWE placed a 6/20 silica sand filter pack, using the tremie method, in the annular space around the screened interval of the well. The filter pack extended 10 feet above the top of the screened interval before well development. The filter pack extended from 375 to 295 feet bls. The additional filter pack around the well screen was required because the sand settles during well development. Developing the well before sealing the remaining annular space with cement allowed AWE to add sand to the filter pack to account for any subsidence during this process. According to standard well design practices, a suitable filter pack passes 10 percent of its material through a well screen during development (Driscoll 1986), hence the subsidence in the level of the filter pack. After AWE developed the well, they measured where the top of the filter pack was and added additional sand to raise the level of the filter pack up to 10 feet above the top of the well screen. AWE placed 5 feet of bentonite pellets above the filter pack using the tremie method. After placing the pellets in the well, they hydrated them to provide a seal between the filter pack and the cement grout. The remaining annular space above the bentonite seal was filled with neat cement by the tremie method from 295 feet to land surface. After allowing the cement to cure, AWE developed the well by overpumping with a centrifugal pump.

AWE installed a 316 stainless steel (ASTM A790) wellhead on the monitor well. A 4-inch stainless steel (ASTM A790) flanged section of pipe was installed 12-inches above the ground level. A 4-inch diameter stainless steel "T" extension, equipped with 4-inch diameter stainless steel gate valve extends above the flange. The top of the "T" is capped with another flange with a 2-inch access port sealed with a threaded plug. The wellhead is centered in a 4-foot by 4-foot by 6-inch thick cement pad finished with a nonskid surface.

3
Stratigraphic Framework

The SFWMD collected geologic formation samples (well cuttings) from the pilot hole during drilling operations for the dual-zone monitor well (MF-40) and separated them based on their dominant lithologic or textural characteristics, and, to a lesser extent, color. Formation samples were washed and shipped to the Florida Geological Survey (FGS) for analysis and long-term storage. **Appendix D** contains a copy of the FGS detailed lithologic description for the pilot-hole/monitor well MF-40 (reference no. W-18726). An electronic version of the lithologic description is available from the FGS (http://www.dep.state.fl.us/geology/gisdatamaps/litholog.htm).

3.1 HOLOCENE, PLEISTOCENE, AND PLIOCENE SERIES

Sediments of the Holocene, Pleistocene, and Pliocene series occur from the land surface to a depth of 145 feet bls at this site. These sediments consist of poorly to well-indurated wackestones, sand, and unconsolidated shell beds with 20 to 25 percent sand content. The poorly indurated fine-to-coarse grain sands from 0 to 30 feet bls represent the Holocene-aged Pamlico Sands (Parker *et al.* 1955). The light-gray wackestone that occurs from 30 to 40 feet bls is indicative of the Pleistocene-aged Fort Thompson Formation. Between 40 to 60 feet bls, the Fort Thompson Formation consists of fine-to-medium grain quartz sand with a calcilutite matrix. Beneath these sands, interbedded shell beds and limestones of the Pleistocene-aged Fort Thompson Formation lie from 60 to 145 feet bls.

3.2 MIOCENE SERIES

3.2.1 Hawthorn Group

The Hawthorn Group is composed of a heterogeneous mixture of silt, clay, calcareous clay, dolosilt, quartz sand, phosphate, limestone, and dolomite. The Hawthorn Group is divided into two lithostratigraphic units. The upper unit, the Peace River Formation, is composed of predominantly siliciclastic material. The lower unit, the Arcadia Formation, is composed principally of carbonates (Scott 1988). A major regional disconformity separates these two units (Scott 1988; Missimer 1997 and 2002). The contact between these two units can often be identified by the occurrence of a bed of coarse to pebble-size quartz sand and phosphatic sand and gravel. If present, this unit produces a distinctive response ("peak") on the natural gamma ray log. The contact was found between 410 and 415 feet bls in the borehole for MF-40.

3.2.2 Peace River Formation

The top of the Peace River Formation is recognized as the first appearance of olive-gray to yellowish-gray, poorly indurated clayey sands and a silt unit with a minor phosphate component. The sands are fine, sub-angular to sub-rounded grains with low permeability. The poorly indurated silts occur at a depth of 145 feet bls at this site. The Peace River Formation is approximately 265 feet thick at this site and extends to a depth of 410 feet bls.

3.2.3 Arcadia Formation

Generally, the Arcadia Formation is separated from the Peace River Formation by a change from predominately siliciclastic to mixed siliciclastic-carbonate sediments. At this site, a distinctive lithologic break occurs at 410 feet bls, where dark gray phosphatic sand with a gravel component is encountered. This lithologic unit is noted on the geophysical logs by relatively high gamma-ray emissions and higher log-derived density/neutron porosity values. This layer is only 5 feet thick and below it, a yellowish-gray, poorly indurated wackestone and packstone with phosphatic sand and gravel extends to a depth of 631 feet bls. A grayish olive-green clay is present from 631 to 641 feet bls. Between 641 and 735 feet bls, the lithology returns to a light olive-gray to yellowish-gray, poorly indurated wackestone with phosphatic sand and gravel.

The lithology between 735 feet bls and 765 feet bls shifts to a grayish-brown to yellowish-gray dolostone that is well-indurated, very fine-grained, and contains phosphate sand and gravel. This interval is marked by higher formation resistivity and bulk density readings, and decreased sonic transit times on the geophysical log runs. This unit correlates with the "marker unit" in the basal Hawthorn Group identified by Reese (2004). Reese found this marker unit to be laterally continuous throughout much of Martin County. This lowermost section of the Arcadia Formation is identified by an increase in formation resistivity, bulk density values, and natural gamma ray activity.

3.3 OLIGOCENE SERIES

3.3.1 Suwannee Limestone

The Suwannee Limestone consists predominantly of packstone and grainstone units with a minor silt/sand component (Scott 1988). The District and the FGS did not find any rocks or fossils from this formation in the drill cuttings, indicating that this unit did not occur at the site. This unit is typically not present as a continuous sequence across eastern peninsular Florida. The general thought is that it may have eroded away (Miller 1986).

3.4 EOCENE SERIES

3.4.1 Ocala Limestone

The upper Eocene-aged Ocala Limestone is at a depth of 765 feet bls below this site. The lithologic character of the upper portion of the Ocala Limestone consists of a well-indurated, yellow-gray to light orange-gray wackestone and minor amounts of dolomite. The first occurrence of the diagnostic microfossil *Lepidocycina ocalana* (primarily a biostratigraphic designation, as noted by Applin & Applin [1944]) is a key identifier of this formation. A dolostone layer occurs from 857 to 865 feet bls. This layer is light orange and well indurated with varying degrees of porosity (intercrystalline to vugular). The bottom of the Ocala Limestone occurs at 890 feet bls.

3.4.2 Avon Park Formation

The FGS, using lithologic samples from this site, identified the top of the middle Eocene-aged Avon Park Formation at a depth of 890 feet bls. At this depth, the lithology changes to a very light orange to grayish-brown packstone with some dolostone. In addition, this formation boundary coincides with a change in the fossil assemblage, higher formation resistivity, and an increase in natural gamma activity. The first occurrence of *Dictyoconus americanus*, a diagnostic microfossil used extensively as a bio-stratigraphic indicator for the Avon Park Formation, occurs at 905 feet bls, 15 feet below the identified top of the formation. This formation is present to the base of the borehole at 1,240 feet bls. It consists predominantly of well-indurated, tan to yellowish-gray packstone and wackestone to 1,100 feet bls. Below this depth, the formation consists predominantly of dark yellow-brown to very light orange well-indurated dolostone, as indicated by the increased spikes on the resistivity logs.

Hawthorn Core

4

Hydrogeologic Framework

Two major aquifer systems underlie this site, the surficial aquifer system (SAS) 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 permeable zones separated by low permeability "confining" units that occur throughout this Tertiary/Quaternary-aged sequence. **Figure 8** shows a generalized hydrogeologic section underlying Martin County.

Series		Geologic Unit		Hydrogeologic Unit		Approximate Thickness (feet)
HOLOCENE		PAMLICO SAND		SURFICIAL AQUIFER SYSTEM		50 - 250
PLEISTOCENE		ANASTASIA FORMATION				
		FT. THOMPSON FORMATION				
PLIOCENE		TAMIAMI FORMATION				
MIOCENE AND LATE OLIGOCENE		HAWTHORN GROUP	PEACE RIVER FORMATION	INTERMEDIATE CONFINING UNIT		250 - 750
			ARCADIA FORMATION			
EARLY OLIGOCENE		BASAL HAWTHORN/ SUWANNEE UNIT		FLORIDAN AQUIFER SYSTEM	UPPER FLORIDAN AQUIFER	300 - 500
EOCENE	LATE	OCALA LIMESTONE				
	MIDDLE	AVON PARK FORMATION			MIDDLE CONFINING UNIT	200 - 400
					LOWER FLORIDAN AQUIFER	2,000
	EARLY	OLDSMAR FORMATION			BOULDER ZONE	300 - 500
PALEOCENE		CEDAR KEYS FORMATION				
				SUB-FLORIDAN CONFINING UNIT		~1,500

Figure 8. Generalized hydrogeologic section of Martin County (Source: Reese 2004).

4.1 SURFICIAL AQUIFER SYSTEM

At this location, the SAS consists of the Holocene-aged Pamlico Sands and the Pleistocene-aged Fort Thompson Formation (Reese 2004). The sediments in these formations include quartz sand, silts, clays, shell beds, coquina, calcareous sandstone, and sandy, shelly limestone. The base of the SAS is defined where the sediments grade into the clayey sands and clay of the Hawthorn Group. Lithologic and geologic logs place the base of the SAS at 145 feet bls at the site. The top of the SAS is considered the water table, which occurs at approximately 20 feet bls at this location. Recharge to the SAS comes from precipitation and the adjacent C-23 Canal when water levels in the canal are higher than in the aquifer.

4.2 INTERMEDIATE CONFINING UNIT

The intermediate confining unit (ICU) is below the SAS and extends from 145 to 730 feet bls at this site. The sediments of this unit separate the FAS from the SAS. The Hawthorn Group sediments consist of unconsolidated shell beds, soft non-indurated clay, silt and quartz-phosphatic sand units, and poorly to moderately indurated mudstones/wackestones of the Peace River and Arcadia formations. The base of the ICU occurs where the lithology changes to a grayish-brown dolostone that is shown by a spike in formation resistivity on the dual-induction log. The SFWMD monitor well into the ICU (MH-40) has a screened interval from 305 to 375 feet bls, which crosses both lithologic units. The water level in MH-40 is approximately 10.5 feet bls, about 135 feet above the top of the unit.

4.3 FLORIDAN AQUIFER SYSTEM

The FAS consists of a series of Tertiary-aged limestone and dolostone units. The system includes permeable sediments of the Lower Arcadia Formation, the Ocala Limestone, and the Avon Park Formation. The early Eocene Oldsmar Formation and the Paleocene Age Cedar Keys Formation occur below the Avon Park Formation. However, this investigation did not encounter these units. The Cedar Keys Formation, with evaporitic gypsum and anhydrite, forms the lower boundary of the FAS (Miller 1986). The potentiometric surface of the Upper Floridan aquifer is approximately 47 feet NGVD at this site. Present-day recharge to the aquifer occurs to the northwest of the study area in central Florida around the ridges and uplands that dominate the area.

4.3.1 Upper Floridan Aquifer

The top of the FAS, as described by the Southeastern Geological Society Ad Hoc 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 water-bearing horizons with high permeability interspersed within thick units of late- to middle-Eocene Age sediments with low permeability, including the basal Arcadia Formation, Ocala Limestone, and the Avon Park Formation. At this site, the top of the FAS occurs at a depth of 730 feet bls, which coincides with the lower portion of the Arcadia Formation (basal Hawthorn unit, Reese 2004). The higher permeability units occur due to solution features and fractures in the rock or along bedding planes. The lower permeability sections relate to the primary, or intergranular permeability, of the rock formations.

The most transmissive part of this upper zone usually occurs near the top, coincident with zones of dissolution in association with unconformities of the Oligocene- or Eocene-aged formations (Miller 1986). The first transmissive horizon in the FAS at the MF-40 site occurs from 730 to 760 feet bls, and includes the basal Arcadia Formation. This productive unit is composed of grayish-brown to light olive-gray, well-indurated dolostone. The second transmissive horizon occurs from 905 to 955 feet bls, and consists of a well-indurated wackestone of varying color. The driller's log noted major drilling fluid losses starting at 905 feet bls, which is indicative of a porous/permeable horizon. The flowmeter log indicated that the majority of the water production within this interval is found at 905 feet bls with another discrete flow zone from 916 to 926 feet bls. The geophysical logs for the test production well (MF-41) showed less fracturing than MF-40. The fractures that did occur in MF-41 were neither as deep nor as wide as those seen in MF-40. The SFWMD selected the depth interval of 790 to 970 feet bls for long-term monitoring and hydraulic testing based on moderate to good water production potential and similar water characteristics. Formation water samples obtained from this completed monitor zone (790 to 970 feet bls) yielded chloride and total dissolved solids (TDS) concentrations of 1,300 and 2,400 mg/L, respectively.

4.3.2 Middle Floridan Confining Unit and Avon Park Permeable Zone

Below the productive horizons of the UFA, there appears to be a somewhat low permeability, inter-aquifer semi-confining carbonate unit that extends from 970 to 1,100 feet bls in MF-40 and from 970 to 1,240 feet bls in MF-41. This unit occurs within the Avon Park Formation. It consists predominately of a well-indurated dolostone interbedded with well-indurated wackestone and packstone layers. The well-indurated dolostone is not as predominant in MF-41. 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 log traces for MF-40 indicate no significant productive horizons, as seen by smooth temperature and flowmeter log traces (after correcting for borehole diameter), which support the confining nature of this interval. However, the caliper log run through this interval showed five fracture zones and the subsequent APTs indicate that there is good hydraulic connection between the Upper Floridan and the Avon Park permeable zone (APPZ) below this semi-confining unit. It was unclear from the lithology and the geophysical logs that the APPZ was present in MF-41. While the caliper log showed a washout area between 1,100 and 1,200 feet bls, there was no evidence of production horizons.

The Avon Park Formation began at 890 feet bls at this site. The borehole for MF-40 was still in this formation when drilling terminated at 1,240 feet bls. The Avon Park Formation consists of a low-permeability, well-indurated dolostone unit. The caliper log for MF-40 showed a large cavity from 1,120 to 1,150 feet bls and a borehole video survey showed the formation to be highly fractured. Formation samples do not show evidence of large-scale secondary porosity development, and the temperature and flowmeter logs indicate limited water production, which supports the overall confining nature of this interval. Due to the cavernous nature of the lower section of the MF-40 borehole and the propensity for material to collapse around the drill bit, the SFWMD decided to screen this lower monitoring section of the borehole. The MF-41 borehole through the Avon Park Formation was different. There were no cavernous sections, only the aforementioned washout area indicating relatively softer material.

4.3.3 Lower Floridan Aquifer

The Lower Floridan aquifer occurs deeper than the 1,240 feet bls reached in this investigation.

5
Hydrogeologic Testing

The SFWMD collected information during the drilling program to determine the lithologic, hydraulic, and water-quality characteristics of the Floridan aquifer system at this site. These data helped complete the final design of both the monitor and test-production wells for use in site-specific aquifer tests, and a long-term water level and water-quality monitoring program.

5.1 GEOPHYSICAL LOGGING

A geophysical log of each pilot hole was made to determine intervals for casing installations and to evaluate borehole characteristics, such as depths of various water production horizons and casing setting points. The resulting logs provide a continuous record of the physical properties of the subsurface formations and their respective fluids. These logs assist District hydrogeologists with the interpretation of lithology; with providing estimates of permeability, porosity, bulk density, and resistivity of the aquifer; and with determining the salinity profile of the groundwater using the Archie Equation (Archie 1942). The extent of confinement of discrete intervals can also be determined from the individual logs. **Table 4** lists the formation evaluation logs conducted by Schlumberger in MF-40, their physical characteristics, and properties measured.

After completing a suite of logs, each geophysical logging contractor downloaded the data directly from the onsite logging processor onto compact disks (CDs) using log ASCII standard (LAS) version 2.0 format. Video logging surveys of the borehole were delivered to the District on VHS cassette. **Appendix C** contains the geophysical log traces from the various log runs at the C-23 site. The original geophysical logs and video surveys from this project are archived and available for review at the SFWMD headquarters in West Palm Beach, Florida. **Table 5** is a summary of the geophysical logging program conducted in both MF-40 and MF-41.

Table 4. Formation evaluation logs.

Log Name	Log Type	Principal Application	Maximum Hole Size	Benefit to Groundwater 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 interpret flowmeter logs and aids in identifying suitable inflatable packer and casing placement zones
Gamma Ray (GR)	Natural Radioactive Nuclear reported in American Petroleum Institute (API) Units	Correlation, stratigraphic boundaries	24 inches	Correlation, used to estimate shale and clay volume
Elemental Capture Spectroscopy (ECS)	Nuclear – Natural Gamma Emissions of the 254 Mineral spectrum reported in API units	Correlation, mineral identification – silicon (Si), iron (Fe), calcium (Ca), sulfur (S), titanium (Ti), gadolinium (Gd), chlorine (Cl), barium (Ba), and hydrogen (H)	20 inches	Correlation, defines clay type and aids in mineral identification and permeability estimated based on lithology
Array Induction Imager Tool (AIT-H)	Conductivity converted to Resistivity. Bedding resolution to 2 feet in smooth borehole values reported in ohmmeter (ohm-m)	Provides invasion profile and accurate water resistivity (Rw) determination	20 inches	Water quality – determination of R_w via Archie Equation, and provides estimates of permeability from invasion profile
Dipole Shear Sonic Imager (DSI)	Compressional and shear Δt wave forms	Porosity estimation, lithology and clay identification. Stonely wave measurement for fracture evaluation	21 inches	Stonely wave measurement aids in lithology and fracture identification.
Compensated Z-Density with Photoelectric Absorption	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 affected by rugose borehole	Porosity estimates and lithologic indicator – porosity may be used in Archie Equation.
Compensated Neutron (CN)	Nuclear – Induced Radioactive reports porosity in porosity units (p.u)	Porosity analysis, and lithologic determination	14 inches good in rough or washed out borehole	Porosity estimates, porosity may be used in Archie Equation.
Natural Gamma Ray Spectrometry Tool (NGS)	Natural gamma ray emissions using five window spectroscopy	Measures potassium (K), thorium (Th), and uranium (U) content of sediments	No limit	Determines clay type and depositional facies determination
Fullbore Formation MicroImager (FMI)	Electrical borehole image from 192 microresistivity measurements	Identifies structural and sedimentary features	21 inches	Determination of carbonate texture and secondary porosity features.

Table 5. Summary of the geophysical logging, MF-40 and MF-41.

Well	Run #	Date	Logging Company	Logged Interval (feet bls)	Caliper	Natural Gamma	Dual Induction/ Sonic	Formation Evaluation Logs (see Table 2)	Flow Meter	Temperature	Fluid Resistivity	Video
MF-40	1	08/11/05	MV Geophysical	0—225	X	X	X					
	2	09/06/05	Schlumberger	120—1,050	X	X	X	X				
	3	10/05/05	MV Geophysical	790—1,240	X	X			X	X	X	X
MF-41	1	10/12/06	All Webb Enterprises	790—970	X	X			X	X	X	X
	2	11/21/06	All Webb Enterprises	1,080—1,305	X	X			X	X	X	X

AWE contracted Schlumberger to run the formation evaluation logs presented in **Table 4**. These logs were performed in a water-based, mud-filled borehole so they only include the first 1,050 feet of the monitor well borehole. Schlumberger ran the formation evaluation logs on September 6, 2005. Most of the formation evaluation logs correlated well with the lithologic description from the well cuttings. The only tool that provided questionable readings was the fullbore formation microimager (FMI). This tool did not seem to pick up some of the fractures in the formation, especially around 900 to 910 feet bls, that were seen on the video and caliper logs. The FMI tool is capable of detecting small fractures filled with conductive fluids. Sand and mud polymers were used when AWE first lost circulation to thicken the drilling mud to help advance the borehole. Thus, the lack of fracture detection by the FMI tool may be due to sand and mud polymers filling the fractures.

The SFWMD used the geophysical log data to identify water quality changes (specifically TDS concentration) within the FAS. In previous investigations, this analysis assisted in determining the depth of the base of the underground source of drinking water (USDW) where TDS concentrations are less than 10,000 mg/L. However, as this drilling program did not reach the USDW base, the data show how the water quality varies with depth.

To develop a salinity profile of the FAS, the District used the "Archie Equation." Archie (1942) discovered that the resistivity of a water-saturated rock (R_o) varies by a constant value as the resistivity of the formation water (R_w) changes. He qualified the relationship as:

$$R_o = F * R_w \qquad \textbf{Equation 1}$$

Where:

R_o = the resistivity in ohmmeters of the 100% water-saturated formation.

F = the formation factor, a proportionality constant.

R_w = the resistivity in ohmmeters of the water saturating the formation.

Archie derived the equation by saturating core samples of different porosities (10 to 50 percent) with water of various salinities (1,000–20,000 mg/L) then measuring R_o. He found that the equation was valid for the entire range of porosity and salinity. Archie also observed that R_o, and consequently F, decreased as porosity increased and inferred that F was a function of porosity and derived an empirical relationship between the two as:

$F = 1/\phi^m$ **Equation 2**

Where:

F = formation factor

ϕ = porosity in decimal form

m = cementation factor

A subsequent investigation by Winsauer *et al.* (1952) led to the addition of the variable "a" in the numerator:

$F = a/\phi^m$ **Equation 3**

Where:

a = tortuosity factor

Chombart (1960) noted that "m" generally had values of 1.8 to 2.0 for chalky limestone and 2.1 to 2.6 for vugular carbonates, while "a" ranged between 0.85 and 1.3 for carbonates.

Therefore, to determine the resistivity of the formation water, the Archie equation can be rearranged as $R_w = R_o/F$. The deep induction resistivity log values, corrected to standard temperature (25 °C), were substituted for R_o and the formation factor (F) was determined using the empirical relationship of $F = a/\phi^m$ (with a = 1, m = 1.95 and ϕ = sonic derived porosity values [Wyllie *et al.* 1956]). The resulting resistivity values (R_w in ohm-m) were converted to specific conductance by taking the inverse of R_o ($1/R_o$) then multiplying by 10,000 to produce values in micromhos per centimeter. The SFWMD translated the calculated specific conductance values to TDS using a two-step approach (Reese 1994) and water quality correlation data for the Upper East Coast (Reese 2004). **Figure 9** shows the calculated formation water TDS log compared to measured TDS concentrations of water samples collected from each monitor zone on June 7, 2007. The base of the USDW was not identified in this investigation. However, at a location 3 miles to the north of this site, the City of Port St. Lucie encountered the USDW base at approximately 1,690 feet bls.

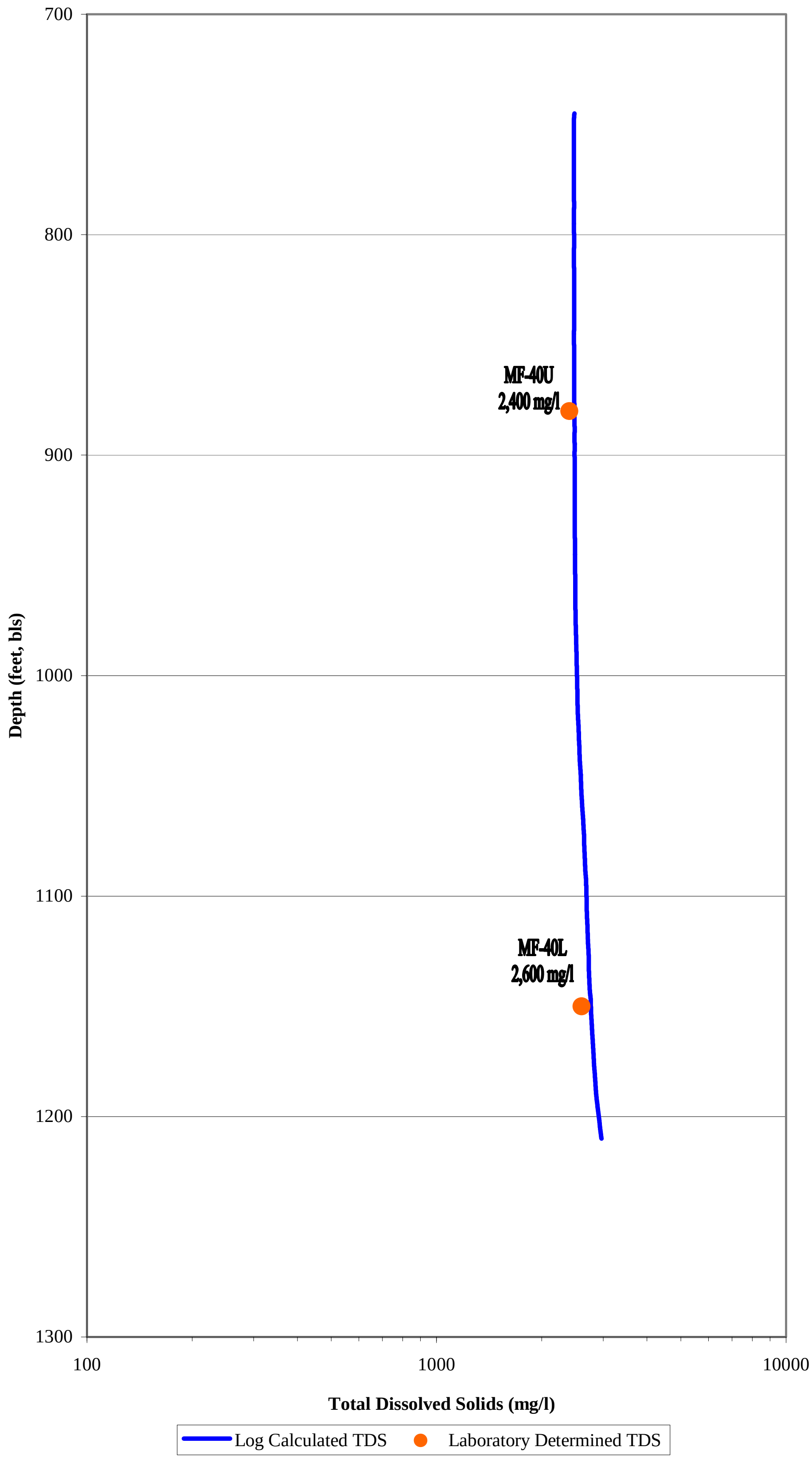

Figure 9. Calculated vs. laboratory TDS of the formation water.

5.2 PETROPHYSICAL AND PETROLOGIC DATA

During construction of MF-40, AWE collected three 10-foot cores from different depth intervals as shown in **Table 6**. The purpose of the coring program was to constrain log-derived porosity and permeability values from a carbonate aquifer with laboratory-determined values. AWE collected the cores from intervals specified by the District using a 4-inch diameter, 10-foot long, diamond-tipped core barrel.

Table 6. Core collection depths and formations, MF-40.

Core Number	Depth Interval (feet, bls)	Collection Date	General Lithology	Depositional Environment	Porosity	Intrinsic Permeability (md)	Formation
1	631—641	08/18/05	Dark green clay	NA	NA	NA	Arcadia Formation
2	855—865	08/24/05	Light brown packstone	Marine	35.3%	293	Ocala Limestone
3	1,200—1,210	10/06/05	Light gray-tan dolomite	Marine	7.1%	<5	Avon Park Formation

NA – Sample not analyzed. Only samples from the Floridan aquifer were used.
md – Millidarcies.

The SFWMD sent the full-diameter cores to the FGS to determine matrix permeability, porosity, and lithologic character. The District identified various intervals from the total core footage for detailed analyses. The FGS cleaned and dried the selected core samples using a convection oven to remove residual fluid. The FGS the used thin sections and standard petrographic techniques, such as staining and impregnation, to determine the lithology, rock fabric, grain types, biotic constituents, sedimentary structures, pore types, and diagenetic alteration. The rock fabric description followed Dunham's (1962) descriptions with slight modifications. Samples with no dolomite rhombohedrons were classed as limestone. Samples with dolomite rhombohedrons fell into the following classifications: trace to 50 percent dolomite – dolomitic limestone; 50 to 90 percent dolomite – limey dolostones; and greater than 90 percent dolomite – dolostones. The classification of pore type in each sample followed Choquette and Pray (1970). Before cutting each thin section, the FGS impregnated each sample with a blue-dyed epoxy to highlight the difference between the sample matrix and the pore space. This dye filled voids in the samples and appeared blue in each thin section. The impregnation process included immersing each sample in the liquid epoxy, drawing a vacuum for 5 minutes, applying a pressure of 2,000 psi for 8 hours, and then curing in an oven.

The FGS measured the porosity of each sample using a bulk-density technique. The process involved weighing each sample, wrapping it in parafilm wax, and weighing it again. By placing the wrapped sample in a beaker of water, the FGS measured the displacement, which equals the bulk volume of the sample. The porosity was calculated from the bulk volume and the mass of the sample using the rock density (2.71 grams per cubic centimeter [gm/cm^3] for pure limestone and adjusted based on mineral content) and the wax density (0.74 gm/cm^3).

The intrinsic (matrix) permeability testing required each sample to be at least 1 inch thick and 2 inches wide. The matrix permeability was measured by minipermeametry (Goggin 1993; Sutherland *et al.* 1993; Hurst and Goggin 1995). Gas was then injected into the samples at a pressure of 13.8 psi (measured by pressure transducer) and an electronic mass flow meter measured the gas flow rates through the core samples. To calculate the matrix permeability, the FGS converted the measured gas flow rates from the minipermeameter to equivalent liquid permeabilites using an empirical correlation between flow rates and Klinkenberg permeabilities (Klinkenberg 1941) of a suite of standards. The standards were cylindrical sandstone core plugs determined by a Core Laboratories, Inc. PDPK-200 instrument, which is a pressure-decay gas permeameter. One should note that the fine scale of this investigation does not reflect the contribution of vugs, molds, fractures, or cavernous porosity greater than the minipermeameter tip's diameter (3 millimeters).

The core sample from 863 to 864 feet bls in the Ocala Limestone is classified as a sucrosic dolostone with traces of pyrite. The formation evaluation logs match well with this lithologic description. The porosity and intrinsic permeability are 35.5 percent and 293 millidarcies (md), respectively. The porosity of this sample is very heterogeneous with high permeability patches occurring where the dolomite crystals are not interlocking and have a high intercrystal porosity. Generally, the texture of the sample is sucrosic. Lower porosity occurs where the dolomite rhombohedrons are more numerous and form tighter interlocking masses, reducing the porosity and ultimately the intrinsic permeability. Some pyrite is present in the pore space indicating it formed after dolomitization. The original depositional fabric of the rock is difficult to determine, but the presence of molds and bioturbation indicates a diverse biota in a marine environment.

The core sample from 1,201–1,202 feet bls in the Avon Park Formation is classified as a dolostone with traces of pyrite. The formation logs were not run to this depth. The porosity of this sample is 7.1 percent, while the intrinsic permeability was too low to measure (less than 5 md). This sample did have centimeter-scale alterations of horizontally bioturbated dolomite with wispy (irregular) laminated dolomite. The dolomite rhombohedrons are clear and large in the bioturbated sections and small and cloudy (with inclusions) in the wispy laminated sections. The wispy laminated sections also contain pyrite and are indicative of a wackestone during deposition. It is difficult to determine the original depositional fabric of the bioturbated sections, but they were more than likely a wackestone as well.

5.2.1 Rock Geochemistry

The FGS ran five samples from the three cores to determine the rock chemical composition and mineralogy. **Table 7** presents the depth intervals and formations for each sample.

Table 7. Rock geochemistry sample intervals, MF-40.

Sample Number	Sample Interval (feet, bls)	Collection Date	Formation
1	637—638	08/18/05	Arcadia Formation
2	857—858	08/24/05	Ocala Limestone
3	861—862	08/25/05	Ocala Limestone
4	863—864	08/25/05	Ocala Limestone
5	1,201—1,202	10/06/05	Avon Park Formation

X-ray diffraction and geochemical analysis on the samples revealed that the main mineral in the sample from the Arcadia Formation was smectite with high silica content. The geochemical analysis report (Arthur *et al.* 2007) described the lithology of the Arcadia Formation core section as a quartz-bearing, dolomitic claystone. The dominant minerals in the two lower core sections of the Ocala Limestone (Samples 3 and 4 in **Table 7**) varied; calcite was predominant in the 861–862 foot bls sample, while dolomite was predominant in the 863–864 foot bls sample. The lithology of the upper core section is a limestone, while the lower section is a dolostone. The dominant mineral in the sections of the Avon Park Formation (Sample 5 in **Table 7**) was dolomite and the lithology of the section is a dolostone. The FGS cutting descriptions and the formation evaluation logs confirm the results of the geochemical analysis.

5.3 INORGANIC CHEMISTRY

A SFWMD contractor collected water samples from both zones in MF-40 on June 6, 2007 and September 6, 2007. They sent the samples to a state-certified laboratory for analysis of major cations and anions using U.S. Environmental Protection Agency (EPA) and/or standard method procedures (SFWMD 1995). The September 6, 2007 data were plotted on a Piper trilinear diagram (Piper 1944) (**Figure 10**) indicating that sodium and chloride are the dominant ions and that the concentrations of dissolved constituents were very similar for both intervals in MF-40. The inorganic data suggest seawater as a dominant source.

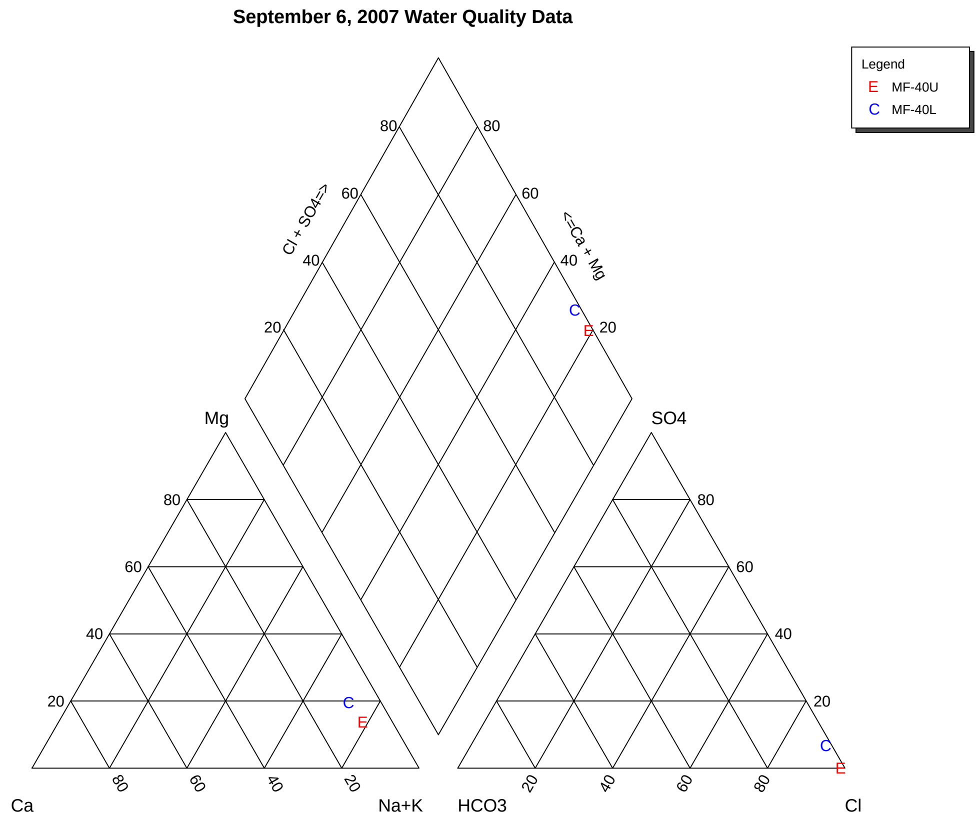

Figure 10. Piper trilinear diagram for MF-40.

Frazee (1982) developed a method of determining the origin of water plotted on a Piper trilinear diagram using an overlay pattern. The original pattern development using the Piper trilinear diagram began with a coastal study during the 1970s along the northeast coast of Florida. Frazee developed the initial patterns in areas of known water types and supported his conclusions with a detailed statistical analysis. The patterns were adjusted slightly over time as more data became available. The patterns work very well for the Floridan aquifer, the focus of the study (Frazee 1982). The Frazee overlay patterns, when placed on **Figure 10**, show that the groundwater in both MF-40U and MF-40L is relic seawater. Frazee (1982) describes relict seawater as unflushed water consisting of sodium and chloride, with chloride concentrations approaching the levels of brine. **Figure 11** shows how the MF-40 water quality data relate to the Frazee overlay.

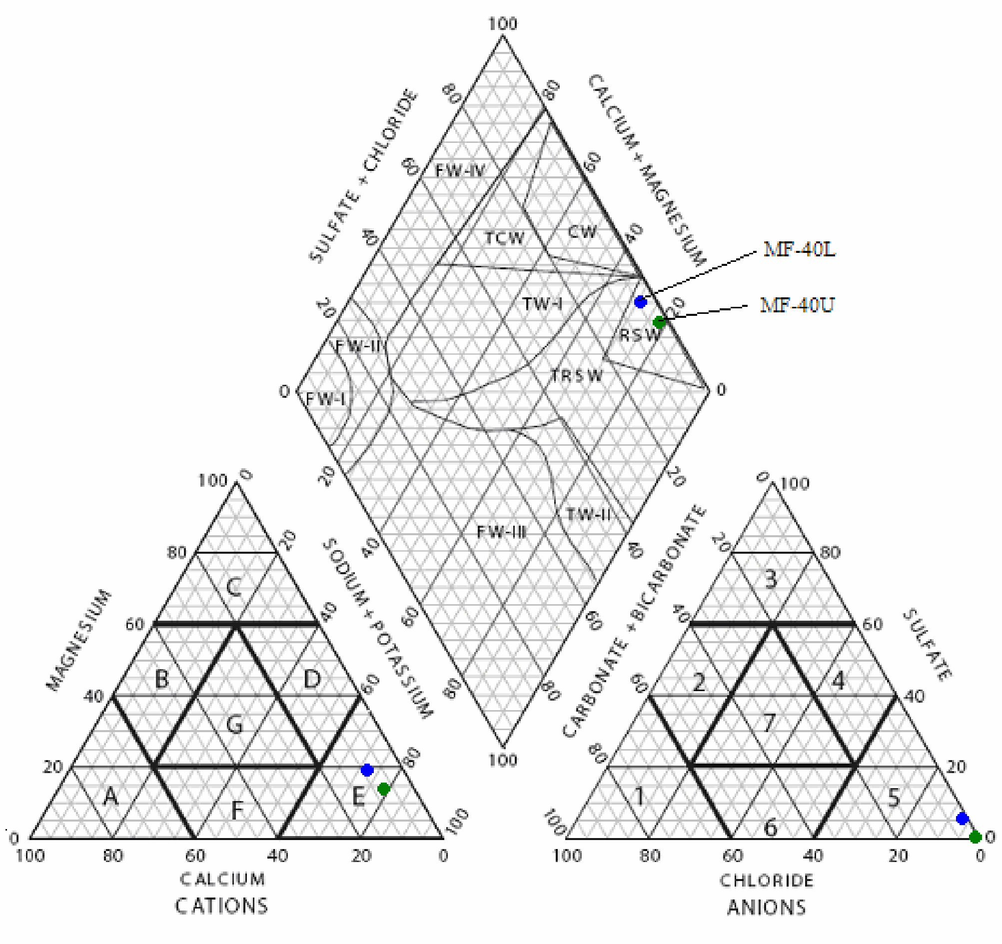

Figure 11. Classification of MF-40 groundwater.

Table 8 provides a brief description of the different water types determined by Frazee as shown in **Figure 11**.

Stiff (1951) developed a graphical method to compare water quality samples. This technique uses four parallel horizontal axes extending beyond zero, which is the single vertical axis. Milliequivalents of each cation are plotted to the left of the vertical axis and milliequivalents of each anion are plotted to the right. The first step to create the diagram is to plot the points for each constituent based on their respective milliequivalent value. After plotting the points, a series of lines connecting them reveal a distinct polygonal shape. These patterns show water composition similarities and differences. **Figure 12** is a Stiff plot for the September 6, 2007 water quality samples. The plots show that both zones of the well have similar water quality, with the sample from MF-40L containing sulfate. The presence of sulfate in this monitor zone is due to natural groundwater mixing with relict seawater (O'Reilly *et al.* 2002).

Table 8. Description of Frazee water types.

Abbreviation	Description	Characteristics
FW-I	Fresh Recharge Water – Type I	Rapid infiltration through sands, high calcium bicarbonate ($CaHCO_3$).
FW-II	Fresh Recharge Water – Type II	Infiltration through sands and clay lenses, $CaHCO_3$ with sodium (Na), sulfate (SO_4), and chloride (Cl).
FW-III	Fresh Recharge Water – Type III	Infiltration through clay-silt esturine depositional environment, high sodium bicarbonate ($NaHCO_3$).
FW-IV	Fresh Recharge Water – Type IV	Fresh water, low calcium (Ca), magnesium (Mg), SO_4, and Cl.
TW-I	Transitional Water – Type I	Seawater begins to dominate source water, Cl begins to dominate bicarbonate (HCO_3) with increasing sodium chloride (NaCl) percentage.
TW-II	Transitional Water – Type II	Transitional water with source water still dominant, bicarbonate (HCO_4) – sulfate (SO_4) mixing zone with increasing Cl.
TCW	Transitional Connate Water	Connate water dominates source water, SO_4 begins to dominate HCO_3 with increasing CL.
TRSW	Transitional Seawater	Transitional water with seawater dominating source water.
CW	Connate Water	Highly mineralized fresh water with high TDS and calcium sulfate ($CaSO_4$) dominance.
RSW	Relict Seawater	Unflushed seawater with NaCl

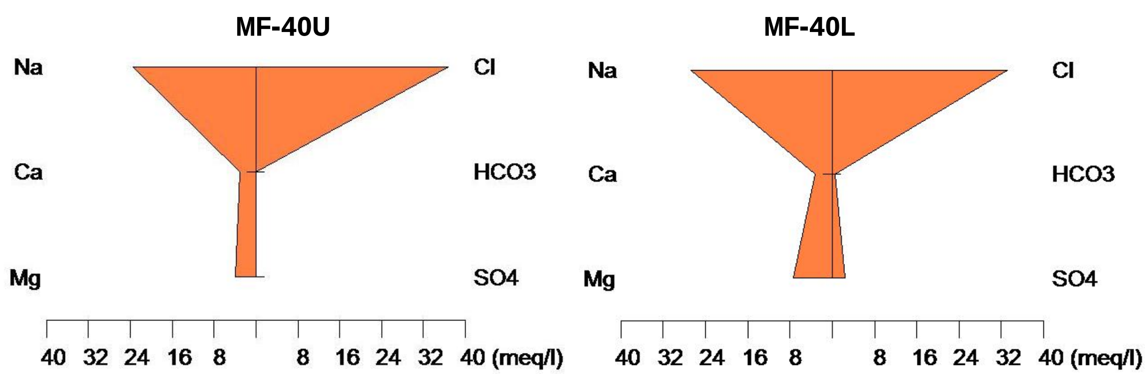

Figure 12. Stiff plots for the September 6, 2007 water quality data.

Pie diagrams for the water quality data from both monitor zones also compare the water quality data (Hem 1985). The radii of each circle represent the total ionic concentration of each sample, the more mineralized the water, the larger the radius when compared to fresh water. The sections in each circle are the percent millequivalent of each ion divided by the total millequivalent value for the sample. **Figure 13** is a pie chart plot for the September 6, 2007 sample from both monitor zones of MF-40. The pie charts show that sodium and chloride are the dominant ions in both monitor zones, confirming the nature of the water as seawater. The main difference between the two samples is that the lower zone contains sulfate and more magnesium due to the presence of dolomite in the aquifer across the monitored interval.

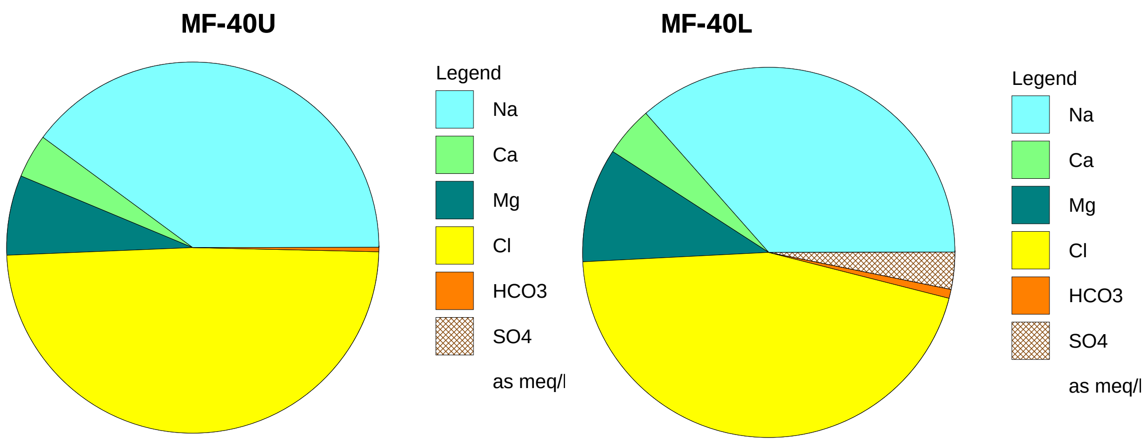

Figure 13. Pie charts for the September 6, 2007 water quality data.

The major anion and cation data from the June 6 and September 6, 2007 sampling events are provided in **Table 9**.

Table 9. Major anion and cation data for MF-40U and MF-40L.

Well	Sample Date	Na (mg/L)	K (mg/L)	Ca (mg/L)	Mg (mg/L)	Cl (mg/L)	HCO3 (mg/L)	CO3 (mg/L)	SO4 (mg/L)	TDS (mg/L)	pH	Spec Cond. (υs/cm)	Temp (°C)
MF-40U	06/06/07	540	16	61	48	1,300	6	6	<1.7	2,400	9.1	4,184	29.2
	09/06/07	647	18	54	60	1,225	16	16	<0.1	2,384	9.1	-	28.8
MF-40L	06/06/07	560	-	110	85	1,200	130	130	200	2,600	7.7	4,589	30.8
	09/06/07	616	18	64	89	1,176	34	34	114	2,409	8.8	-	30.3

mg/L – milligrams per liter
υs/cm – microsiemens per centimeter
°C – degrees Celsius

5.4 STABLE ISOTOPE, RADIOCARBON, AND NOBLE GASES

Stable isotope data complement inorganic geochemistry and physical hydrogeologic investigations. Hydrogeologists often use geochemical data to estimate groundwater ages and to help discern circulation patterns within a hydrologic system. A multi-tracer approach using inorganic constituents, stable isotopes, radiocarbon dating, and noble gases can be successfully applied to understanding complicated hydrologic systems with travel times measured in thousands of years (Bottomley *et al.* 1984; Clark *et al.* 1997 and 1998; Stute *et al.* 1995). The chemical composition of groundwater reflects both the sources of water and processes that modify the inorganic and isotopic compositions as it moves along its flow path. Each source and process leaves a distinctive geochemical "signature" on the water. If water from an interval produces a particular isotopic signature, it can identify and map the lateral extent of horizons within the Floridan aquifer. Radiocarbon dating often complements the stable isotope data and can help estimate regional flow velocities (Hanshaw *et al.* 1964). Noble gas paleo-thermometry has become an acceptable method for determining continental temperatures of past climates based on the temperature dependence of the solubility of noble gases in groundwater. This method can help to determine the paleo-temperatures of water entering the Floridan aquifer (Stute *et al.* 1995; Clark *et al.* 1997), thus providing constraints to the determined radiocarbon ages.

5.4.1 Stable Isotopes

A SFWMD contractor collected water samples from both the upper and lower zones of MF-40 on June 6, 2007 and sent them to the University of California, Santa Barbara (UCSB) for analysis. The analytical services included the determination of the stable isotope compositions for oxygen-18 ($\delta^{18}O$), deuterium (δD), and carbon-13 ($\delta^{13}C$).

Oxygen-18 values were determined by CO_2 equilibration using standard procedures outlined by Epstein and Mayeda (1953) and Drimmie and Heemskerk (1993). Hydrogen isotope compositions were determined using the methods of Coleman *et al.* (1982) and Drimmie *et al.* (1990). The results are presented as per mil (‰) derivations from a water standard using the δ-notation (delta):

$$\delta_{x} = \delta_{x-\mathrm{std}} = \left(\frac{R_x}{R_{Standard}} - 1\right) \text{ x } 1{,}000 \qquad \textbf{Equation 4}$$

where R_x is the isotope ratio of the sample (e.g., $^2H/^1H$) and $R_{Standard}$ is the isotopic standard. The standard related to deuterium and ^{18}O is standard mean ocean water (SMOW). The reproducibility for $\delta^{18}O$ and δD were ± 0.05‰ and ±0.5‰, respectively.

Water samples received by UCSB for $\delta^{13}C$ determinations were acidified under vacuum with phosphoric acid. The released CO_2 produced from dissolved inorganic carbon in the sample was then purified using cold distillation and analyzed by a mass spectrometry (Drimmie *et al.* 1990). These results were then compared to a carbon standard. The carbon standard is the isotope ratio derived from CO_2 liberated from beleminites of the Cretaceous-aged Pee Dee Formation of South Carolina. The results are presented as per mil (‰) derivations with respect to the standard using the δ-notation (delta):

$$\delta^{13}C\ (‰,\ PDB) = \left(\frac{{}^{13}C/{}^{12}C_{sample}}{{}^{13}C/{}^{12}C_{Standard}} - 1 \right) \times 1{,}000 \qquad \textbf{Equation 5}$$

5.4.2 Radiocarbon Age Dating

An accelerator mass spectrometer was used to determine radiocarbon age, delta ^{14}C, and percent modern carbon (pmC). The ^{14}C activities or pmC values are absolute percent of modern carbon, relative to the National Bureau of Standards (NBS) oxalic acid standard corrected for decay since 1950. The activity of "modern carbon" is 95 percent of the ^{14}C in the 1950 NBS oxalic acid standard, which is close to the activity of 1890 wood produced in a fossil-fuel free environment (Clark and Fritz 1997). Del ^{14}C is the relative difference between the absolute standard activity and the sample activity as calculated by:

$$\text{Del } ^{14}C = (A_s/A_{abs} - 1) \times 1{,}000 \qquad \textbf{Equation 6}$$

In Equation 6, A_s is the activity of the sample and A_{abs} is the activity of the standard. The modern activity of ^{14}C is set as 13.56 decays-per-minute per gram of carbon. The "zero year" for this activity is 1950 AD (pre-thermonuclear testing) with an activity of 100 pmC. The conventional radiocarbon age (^{14}C Age) is determined in the following manner:

$$T = -8033 \ln (A_{sn}/A_{on}) \qquad \textbf{Equation 7}$$

In Equation 7, A_{sn} is the normalized sample activity and A_{on} is the normalized oxalic acid activity (count rate). T is the calculated time that elapsed represented by the difference in activities between the standard and sample. Time (T) however, is not the actual date of recharge because ^{14}C is either removed or added as the water moves through the system. To calculate time since recharge, Equation 9 is modified to:

$$t = -8267 \ln (A_t/A_o) \qquad \textbf{Equation 8}$$

In Equation 8, t is the time since recharge, A_t is the current ^{14}C activity of the sample and A_o is the initial ^{14}C activity. Calculating time since recharge requires the current ^{14}C activity of the sample, which is measured, and the initial activity (A_o), which must be estimated.

Table 10 summarizes the stable isotope and radiocarbon results for MF-40. Tritium was detected in the sample from MF-40U and thus, the ^{14}C pmC reading is inaccurate. The half-life of tritium is very short and it is only used to date "modern" groundwater because the source of tritium in groundwater is fallout from thermonuclear bomb testing between 1951 and 1976, with the peak occurring in 1963, so (Clark and Fritz 1997). The presence of tritium in the sample from MF-40U indicates that the sample was contaminated during collection. Possible sources of tritium include luminescent dials of wristwatches and modern waters used during well construction. However, it appears that the rest of the data are acceptable.

Table 10. Stable isotope and radiocarbon age dating results for MF-40.

Well	Date Sampled	TDS (mg/L)	Seawater (%)	^{14}C (pmC)	^{14}C error	d13C (‰)	d18O (‰)	d18O reservoir	dD (‰)
MF-40U	06/06/07	2,400	4%	18.4	0.06	-4.5	-1.61	-2.61	-5.1
MF-40L	06/06/07	2,600	-3%	1.3	0.04	-4.3	-1.63	-2.63	-4.7

mg/L – milligrams per liter
% - percent
pmC – percent modern carbon
$^0/_{00}$ – per mil

5.4.3 Dissolved Noble Gases

Noble gas samples were collected from the upper and lower monitor zones of MF-40. UCSB personnel collected these samples in 15-milliliter copper tubes connected to a peristaltic pump and regulator, which reduced aeration of the sample. Once the copper tubing was flushed with formation water at high pressure, it was sealed at each end with steel pinch-off clamps. The noble gas concentrations, including helium (He), neon (Ne), argon (Ar), krypton (Kr), and xenon (Xe), were determined on a MAP 215-50 noble gas mass spectrometer using the method outlined by Stute *et al.* (1995). The system was calibrated using known quantities of air and water standards. Absolute noble gas concentrations were determined with a precision of +/- 1 percent for Ar and Xe and +/- 2 percent for He, Ne, and Kr. As water recharges and flows downgradient within the aquifer, there is no longer exchange with other fluid phases and the heavier noble gas concentrations remain unchanged, making them suitable for paleoclimate studies. Helium concentrations in groundwater change due to radioactive decay of uranium/thorium nuclides within the aquifer (Bottomley *et al.* 1984; Torgersen and Ivey 1985) Helium concentrations increase with time and vary between aquifers, making it useful as an approximate chronometer (Clark

2002). **Table 11** contains the noble gas data and calculated paleo-temperatures of the groundwater samples. There was an error in analyzing the samples from MF-40U and much of the noble gas data were not calculated.

Table 11. Dissolved noble gas data for MF-40.

Well	Date Sampled	Tng (°C)	Tng Error	Fit	Excess He	He (cc stp/g)	Ne (cc stp/g)	Ar (cc stp/g)	Kr (cc stp/g)	Xe (cc stp/g)
MF-40U	06/06/07	lost	lost	lost	lost	7.096E-06	-	-	-	-
MF-40L	06/06/07	18.6787	0.5013	TAF-1: good	1.12E-07	1.812E-07	2.740E-07	3.748E-04	7.823E-08	1.048E-08

5.4.4 Discussion

Precipitation, or meteoric water, contains very little dissolved constituents and the oxygen and hydrogen isotope composition of worldwide rainfall falls along the documented global meteoric water line (GMWL, Craig 1961). The isotope results from MF-40U and MF-40L are very similar. However, because of the presence of tritium in the sample from MF-40U, this evaluation did not include those data. The stable isotope results from MF-40L indicate that waters in this production interval are depleted in both ^{18}O and D in comparison to SMOW, where $\delta^{18}O$ = 0‰ and δD = 0‰. **Figure 14** shows the isotopic composition of water in MF-40L deviates slightly from the GMWL and mean isotopic composition of recent Everglades rainfall ($\delta^{18}O$ = -2.2‰; δD = -7.6‰, Meyers *et. al.* 1993). Stable isotope results from other wells in the same aquifer interval at other locations in south Florida produce similar results and plot in the same region near the GMWL. The occurrence of $\delta^{18}O$ and δD values near the GWML suggest that these waters are likely meteoric in origin and modified by evaporation prior to infiltration. This contrasts with the Piper trilinear diagram in **Figure 10**, which shows the water as relic seawater. By combining the results from the isotope and inorganic chemistry data, one can conclude that the water class is connate water (Frazee 1982). Perhaps the water entered the system as rainfall and over time, as it remained in the aquifer, it became highly mineralized and mixed with ocean water as sea levels rose after the last glacial period.

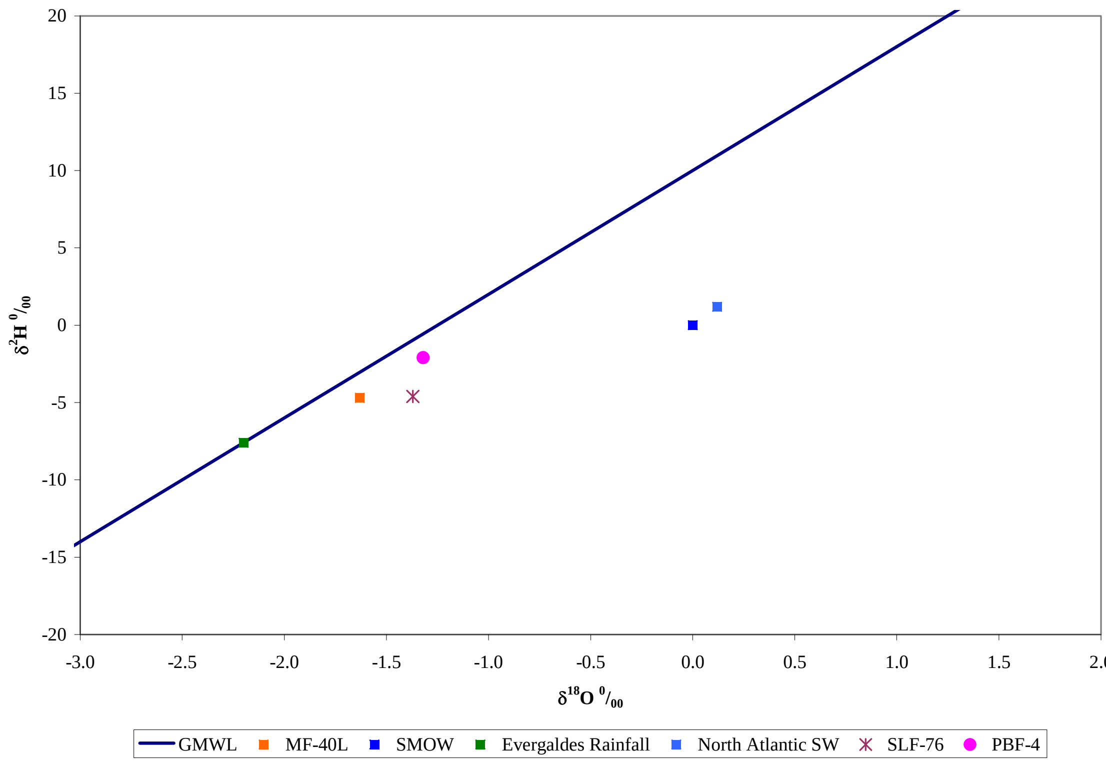

Figure 14. Isotopic data related to the global meteoric water line.

The ^{14}C activity in pmC of the groundwater samples from MF-40L was 1.3. The uncorrected radiocarbon age of the water is 36,000 years before present (bp) (from Equation 8). Based on a conversation with Dr. Jordan Clark of UCSB (2008), the District did not apply any of the various age corrections to the ^{14}C data as they yield varying ages and are not very accurate for carbonate aquifers. The uncorrected radiocarbon ages suggest that recharge to the hydrologic system from 1,100 to 1,200 feet in depth occurred during the late Pleistocene Epoch. The noble gas data support this assertion. Noble gas temperatures from MF-40L suggest the temperature at recharge was 19.7 degrees Celsius (°C), about 4 °C cooler than the present-day south Florida mean annual air temperature of 23.6 °C. The reported noble gas temperature suggests that freshwater recharge occurred during the Wisconsin Glacial Episode, which started approximately 110,000 years before the present (bp) and ended between 10,000 and 15,000 years bp (Clark 2002).

5.5 AQUIFER PERFORMANCE TESTING

The SFWMD installed three wells at this project site; one test production well (MF-41) and one multi-zone monitor well (MF-40) and one intermediate confining unit (ICU) monitor well (MH-40). The distance between the two wells is 288 feet in an east-west direction as seen in **Figure 15.** During the two APTs, an In-Situ, Inc. Hermit 3000 data logger and In-Situ, Inc. PXD-261 pressure transducers collected water level data during the drawdown and recovery phases of each test. Before each test, the District collected background water level data and ran a specific capacity test. Background water level data are useful to correct for extreme barometric pressure fluctuations. The specific capacity tests allowed the SFWMD to determine the optimal discharge rate for the APT.

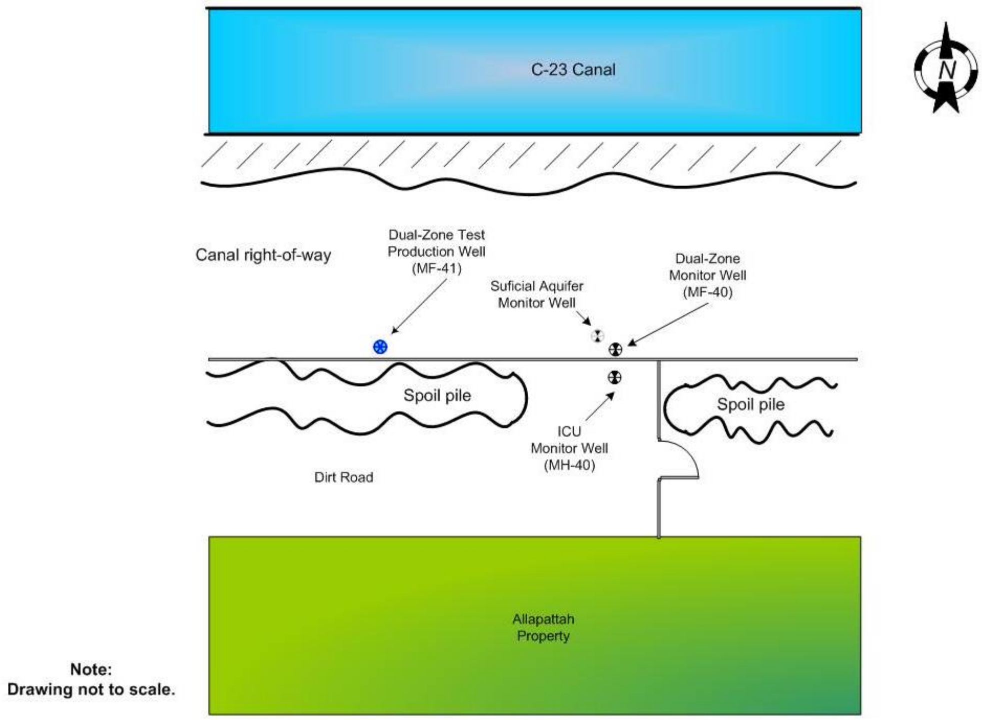

Figure 15. Layout of monitor and production wells at the C-23 site.

For each APT, a PXD-261 pressure transducer was set in the production well, each zone of the dual-zone monitor well (MF-40U and MF-40L), the ICU monitor well (MH-40), a surficial aquifer monitor well, and the manometer on the discharge line. The District programmed the data logger to record water level data on a logarithmic scale so the instrument collected numerous data points rapidly for the first 10 minutes of the test when drawdown occurred quickly. After 10 minutes, the data logger collected data every minute.

The discharge line from the test production well consisted of 12-inch diameter pipe with an 8-inch diameter orifice plate. This configuration allowed the SFWMD to determine the discharge rate during the APTs from the manometer connected near the end of the discharge line. The manometer had a double-end fitting allowing the connection of a pressure transducer and a manometer tube adjacent to a measuring stick. The SFMWD collected discharge readings using a PXD-261 pressure transducer and verified them with manual readings on the manometer tube. A calibrated in-line flow meter verified the manometer readings.

5.5.1 Aquifer Performance Test No. 1

The SFWMD conducted the first of two APTs on October 16, 2006. This test aimed to determine the hydraulic properties of the monitor interval from 790 to 970 feet bls in the UFA, covering the Ocala Limestone and Upper Avon Park Formation. The principal factors of aquifer performance, such as transmissivity and storage coefficients, were calculated from the drawdown and recovery data obtained from the dual-zone monitor well, with the upper zone completed in the same interval (MF-40U) as the pumped horizon. Monitoring the zones above and below the tested interval can determine the leakance of the semi-pervious layers.

AWE set a turbine pump in test production well MF-41. The drawdown phase consisted of pumping the well at a constant rate of 2,000 gallons per minute (gpm) and lasted for 24 hours. The water levels in the observation wells stabilized with approximately 90 feet of drawdown in MF-41. A 24-hour recovery period with no pumping followed the drawdown phase and water levels were allowed to return to static condition. **Figure 16** shows the configuration of the monitor and test-production wells used in the first APT.

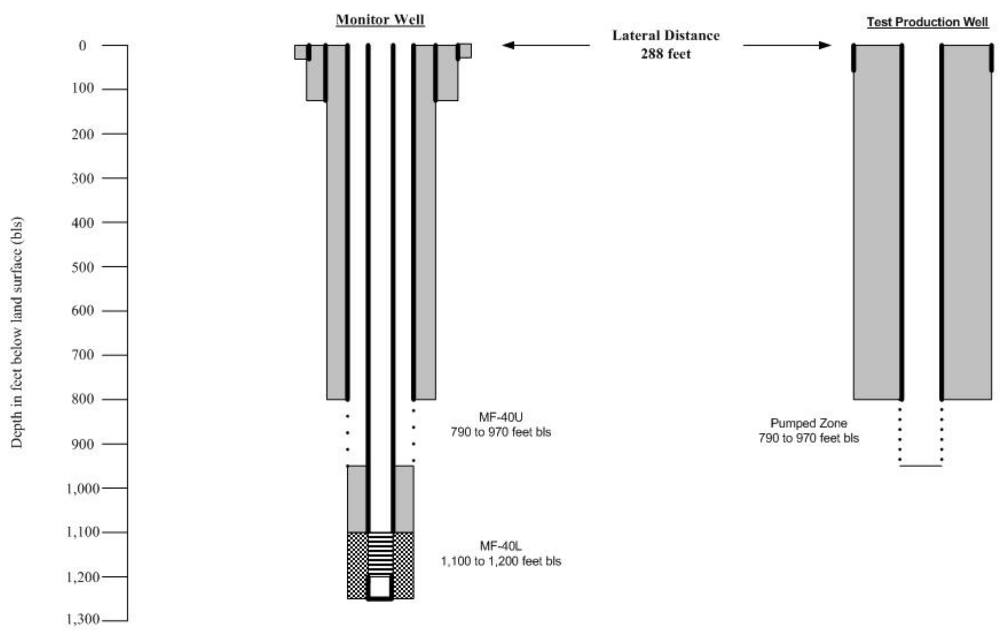

Figure 16. Cross-section of first aquifer performance test.

Figure 17 is a time-series plot of the drawdown data for the production well (MF-41) and discharge rates (manometer readings) during the pumping phase of the APT. Maximum drawdown in MF-41 was 90 feet with flow rates varying about 5 percent during the test.

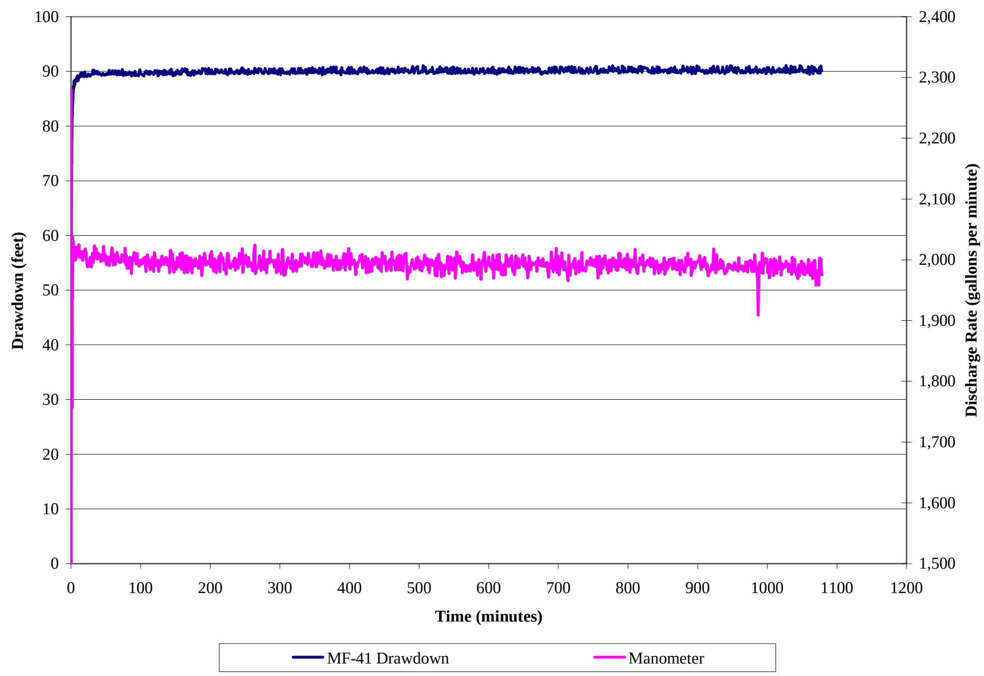

Figure 17. Time-series plot of drawdown data in MF-41 and discharge rate data from orifice weir.

Water-level changes during the drawdown phase for MF-40U (790–970 feet bls) and MF-40L (1,100–1,200 feet bls) showed similar responses to the pumping, indicating a high degree of interconnection between these two monitor zones. **Figure 18** is a log-log plot of the drawdown data in both zones of MF-40.

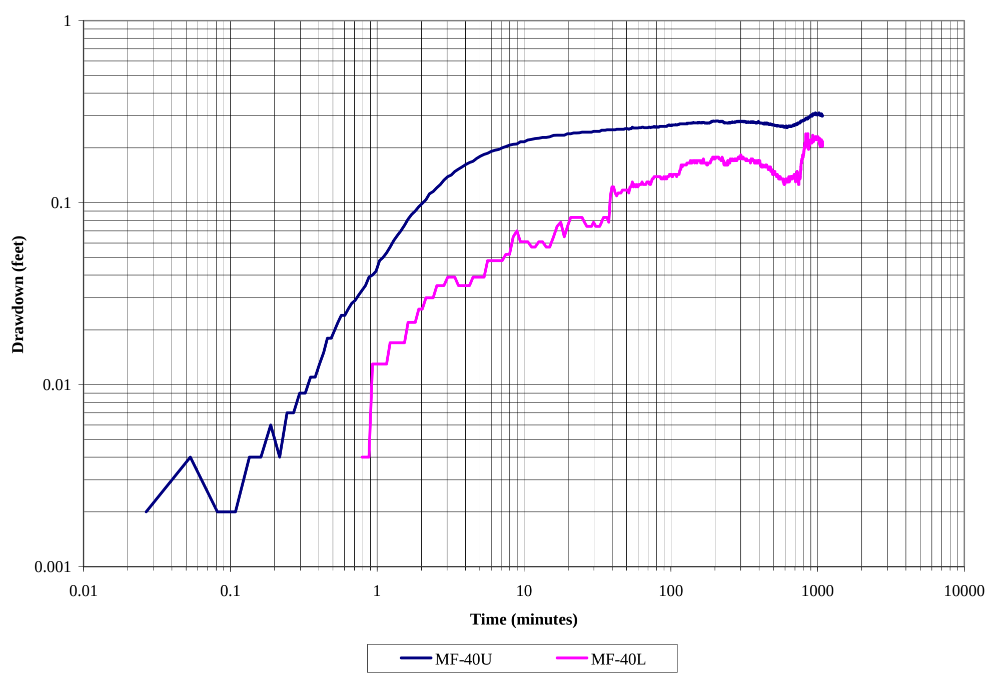

Figure 18. Log-log plot of the drawdown data in MF-40U and MF-40L.

Before the pumping phase of the first APT concluded, the District reconfigured the various data loggers to record the recovery data in both the test production well and the monitor wells. After AWE stopped the pump, they manually closed the discharge port from MF-41 allowing the water levels to recover to static conditions. The recovery phase of the APT continued for 24 hours, ending on October 17, 2006. Electronic copies of the original drawdown, recovery, and orifice weir (flow rate) data for the APT are archived and available for review at the SFWMD headquarters in West Palm Beach, Florida.

The SFWMD applied various analytical models to the drawdown data collected during the APT to determine the hydraulic properties of the aquifer and aquitard(s) at this site. The analytical methods included both confined and semi-confined "leaky" solutions. The confined transient analytical solutions include the Theis (1935) non-equilibrium method and the Cooper-Jacob (1946) approximation. The semi-confined "leaky" analytical models include the Hantush-Jacob (1955), Hantush (1960), and Moench (1985). The methods referenced are based on various assumptions and interested readers should refer to the original articles for further details. Analyses of the water level recovery data produced similar hydraulic results. In general, drawdown data from a single observation well (for recovery data) only provide an estimate of aquifer and confining unit properties because many of these type of curves are similar in shape to one another and do not necessarily provide a unique match to a given data set.

Figure 19 is a log-log plot of drawdown versus time for the MF-40U. The Upper Floridan aquifer is a leaky-type aquifer as indicated by the drawdown curve for the well falling below the Theis curve (orange line in **Figure 19**). A leaky (semi-confined) aquifer is one that loses or gains water (depending on the pressure gradients) through a semi-confining unit. If a semi-confining unit is composed of a thick layer of unconsolidated or poorly indurated high porosity sediments, it may provide water to the pumped interval.

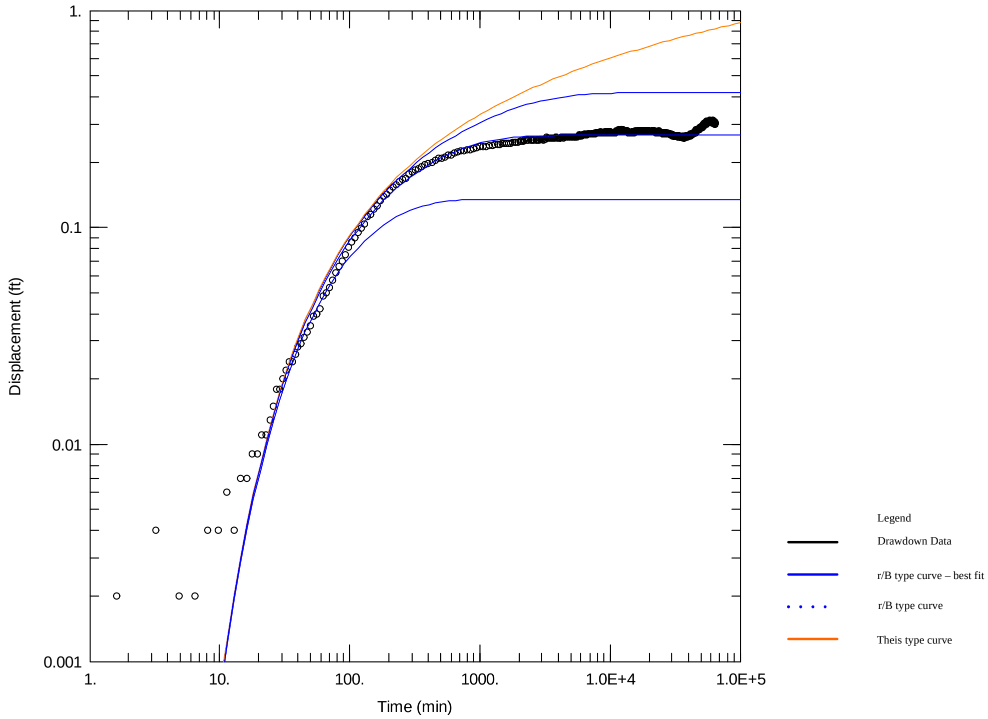

Figure 19. Log-log plot of drawdown data for MF-40U using the Hantush and Jacob (1955) solution.

Hantush and Jacob (1955) derived an analytical solution for predicting water level displacements in response to pumping a well that either fully or partially penetrates a leaky-confined aquifer. Other solutions used were Moench (1985), Papadopulos and Cooper (1967), and Hantush (1960). Based on the assumptions of Hantush and Jacob (1955) and the site-specific hydrogeologic data collected during drilling and aquifer testing, this analytical model appears to best represent the conditions present at this site. This solution yielded a transmissivity value of 255,359 square feet per day (ft^2/day), storage coefficient of 0.0047, and an r/B value of 0.4. The dimensionless parameter r/B characterizes the leakance across the semi-confining unit(s) to the pumped aquifer. As the deeper Floridan aquifer system (FAS) monitor well responded to pumping MF-41, while the ICU well did not, the leakance direction was assumed to be from the lower to the upper monitor zone. To calculate the leakage coefficient one needs to determine the vertical hydraulic conductivity (K') through the semi-confining layer (Equation 9).

$$B = \sqrt{\frac{Tb'}{K'}}$$ **Equation 9**

Where:

B = Leakage factor calculated from r/B = 0.4

T = Transmissivity of the tested aquifer (ft^2/day)

b' = Thickness of the semi-confining bed

K' = Vertical hydraulic conductivity of the semi-confining bed

Equation 9 is rearranged as follows (Equation 10) to calculate K':

$$K' = \frac{Tb'}{B^2}$$ **Equation 10**

The vertical hydraulic conductivity calculated from the APT data was 64 ft/day. K' was calculated using Equation 10 and the transmissivity value determined from the Hantush (1960) Equation, assuming a semi-confining unit thickness of 130 feet between the two production horizons in MF-40. Using K', the leakage coefficient (η) was calculated using Equation 11.

$$\eta = \frac{K'}{b'}$$ **Equation 11**

Using Equation 11 and the APT data, the leakage coefficient was 0.49 per day. Both the vertical hydraulic conductivity and the leakage coefficient confirm the highly fractured nature of the formation around MF-40, indicating a high degree of interconnection between the two monitor zones.

5.5.2 Aquifer Performance Test No. 2

The SFWMD conducted the second of two APTs on December 13, 2006 to determine the hydraulic performance of the production horizon between 1,100 and 1,305 feet bls (within the permeable zone of the Avon Park Formation). AWE, at the request of the SFWMD, drilled the production horizon to a greater depth than the corresponding monitor interval due to the different nature of the borehole. The production well borehole did not yield as much water under artesian flow as the observation well borehole. The principal factors of aquifer performance, such as transmissivity and storage coefficients, were calculated from the drawdown and recovery data obtained from the dual-zone monitor well, with the upper zone completed in the same interval (MF-40L) as the pumped horizon. Monitoring the zones above and below the tested interval can determine the hydraulic parameter of leakance of the semi-pervious layers.

AWE set a turbine pump 250 feet bls in MF-41 and the drawdown phase consisted of pumping the well at a constant rate of 1,300 gpm. This discharge rate was chosen after a brief step-drawdown test showed that the well would not be able to sustain a yield greater than this value. The discharge rate for this second test was lower than the first because this tested horizon did not yield as much water as the upper zone. Drawdown in the production well was 200 feet at 1,300 gpm. The drawdown phase of this test lasted for 24 hours as the water levels seen in the observation wells had stabilized. The drawdown phase was followed by a 24-hour recovery period. **Figure 20** shows the configuration of the dual-zone monitor and test-production wells used in the second APT.

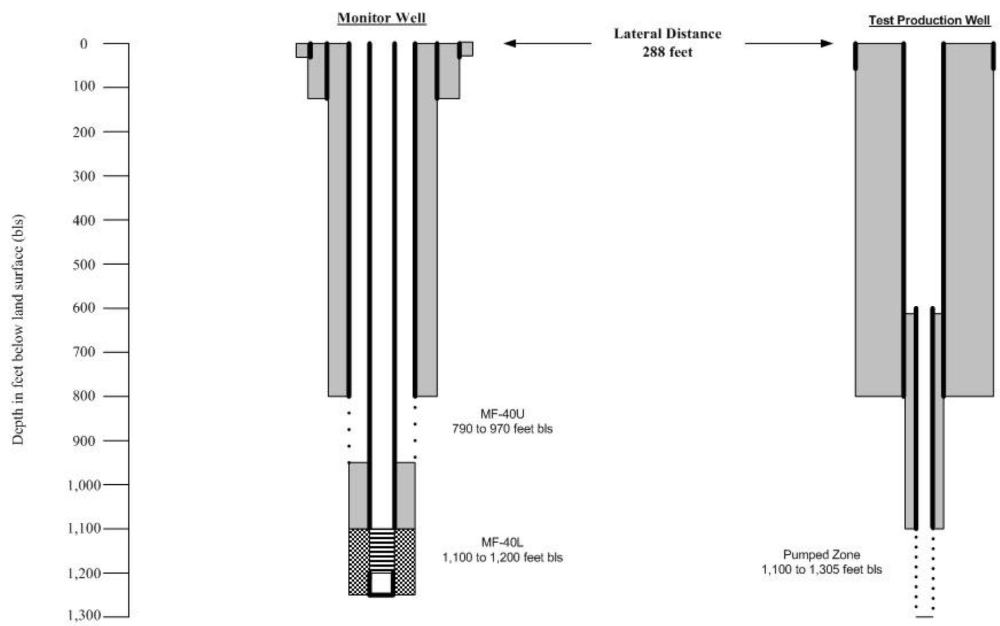

Figure 20. Cross-section of second aquifer performance test.

During the pumping phase of the APT, the maximum drawdown in MF-41 was approximately 200 feet with flow rates varying about 5 percent during the test. Water-level changes during the drawdown phase for both MF-40U (790–970 feet bls) and MF-40L (1,100–1,200 feet bls) showed an identical response to the pumping, indicating a high degree of interconnection between these two monitor zones. **Figure 21** is a log-log plot showing the drawdown in both zones of the monitor well.

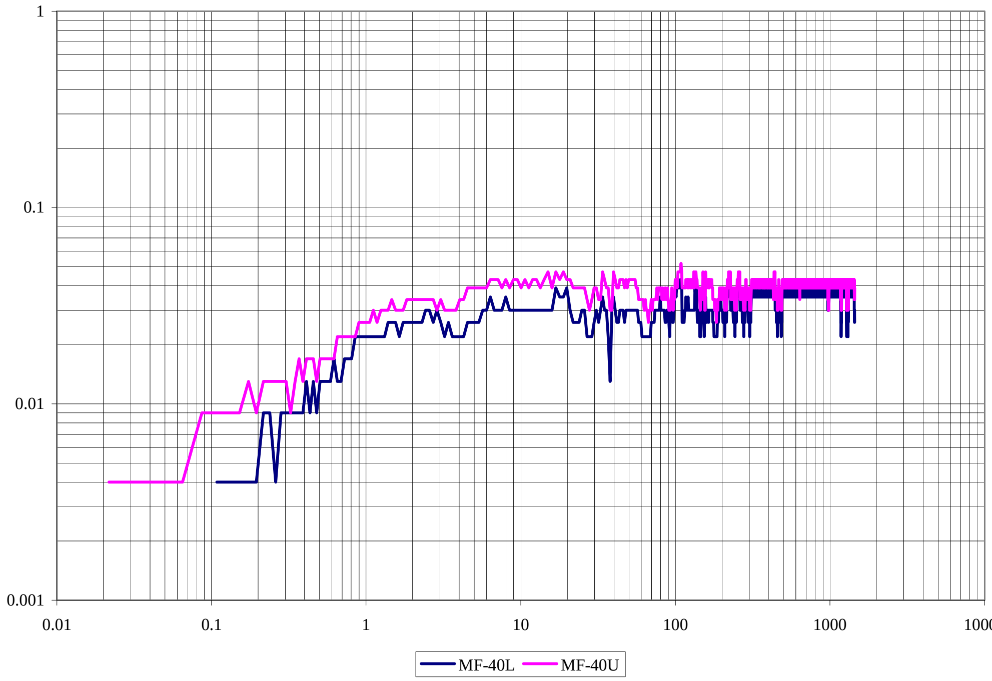

Figure 21. Observation well drawdown, MF-40.

Before pumping stopped, the SFWMD reconfigured the various data loggers to record the recovery data. AWE manually stopped the pump and water levels slowly recovered to static conditions. The recovery phase of the APT continued for 24 hours, ending on December 15, 2006. Electronic copies of the original drawdown, recovery, and orifice weir (pump rate) data for the APT are archived and available for review at the SFWMD headquarters in West Palm Beach, Florida.

Figure 22 is a log-log plot of drawdown versus time for MF-40L. The drawdown curve of MF-40L indicates that this zone is a leaky-type aquifer, as it falls below the Theis curve (orange line in **Figure 22**). A leaky (semi-confined) aquifer is one that loses or gains water (depending on the pressure gradients) through a semi-confining unit. If a semi-confining unit(s) is composed of a thick layer of unconsolidated or poorly indurated, high porosity sediments, it may provide water to the pumped interval. The lithologic and geophysical data for MF-40 (the monitor well) indicate that the overlying units are composed of highly fractured carbonate rocks, which have the potential to transmit water through them, and to supply additional water released from storage to the tested interval. In addition, the similar drawdown response seen in both MF-40U and MF-40L supports this assumption.

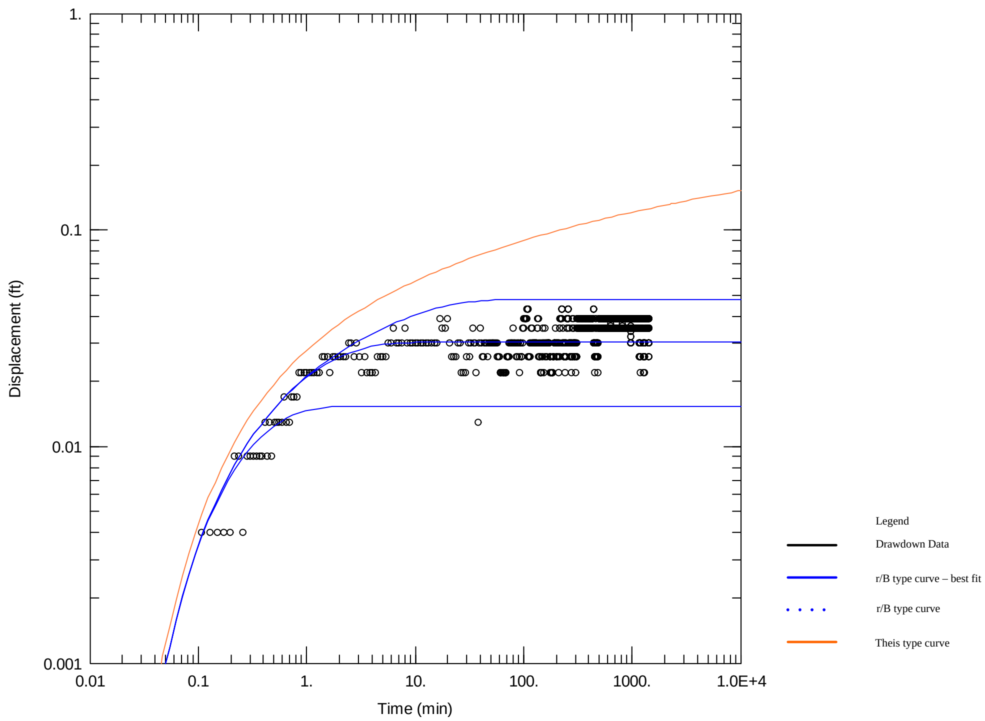

Figure 22. Log-log plot of drawdown data for MF-40L using the Hantush and Jacob (1955) solution.

Hantush and Jacob (1955) derived an analytical solution for predicting water level displacements in response to pumping a well that either fully or partially penetrates an aquifer. Moench (1985), Papadopulos and Cooper (1967), and Hantush (1960) used other solutions. Based on the site-specific hydrogeologic data collected during drilling and aquifer testing and the assumptions of Hantush and Jacob (1955), this analytical model appears to best represent the conditions present at this site. The solution yielded a transmissivity value of 1,107,000 ft^2/day, storage coefficient of 0.0037, and an r/B value of 0.4. The dimensionless parameter r/B characterizes the leakance across the semi-confining unit(s) to the pumped aquifer, from this value a leakance value of 2.13 per day was calculated using Equations 9, 10, and 11. Both the storage coefficient and leakance value are high possibly due to the highly fractured natured of the formation around the observation well and the lack of drawdown seen in it during this test.

5.5.3 MH-40 Slug Test

On April 7, 2008, District staff performed a slug test on MH-40 to determine the hydraulic conductivity of the monitored interval in the ICU. As the hydraulic conductivity of the ICU was expected to be low, staff conducted the test by adding a “slug” of water to the well and measuring the rate at which the water level in the well returned to its static level. An In-Situ, Inc. Hermit 3000 data logger and In-Situ, Inc. PXD-261 30-psi pressure transducer collected water level data during the slug test. District staff added 2.5 gallons of water (potable quality) in a very short time frame (approximately 10 seconds) to raise the water level in the well approximately 3.5 feet above its static level. As the water was added, the data logger started recording and was left running for 2.5 hours as the water level in the well decreased to static conditions. After 2.5 hours, the water level in the well had recovered 70 percent of its increase and there was sufficient data to analyze the slug test.

Bouwer and Rice (1976) developed a method to analyze slug test data and determine the aquifer hydraulic conductivity around boreholes (production, monitoring, or test wells). The wells can be partially penetrating and partially screened, perforated, or otherwise open. While originally developed for unconfined aquifers, the method can also be used for confined or stratified aquifers if the top of the screen or perforated section is some distance below the upper confining layer (Bouwer 1989). Using the Bouwer-Rice method, the hydraulic conductivity for the ICU around the screened interval of MH-40 (305–375 feet bls) is 0.014 ft/day. **Figure 23** is a semi-log plot of the MH-40 slug test data with the Bouwer-Rice (1976) best-fit line.

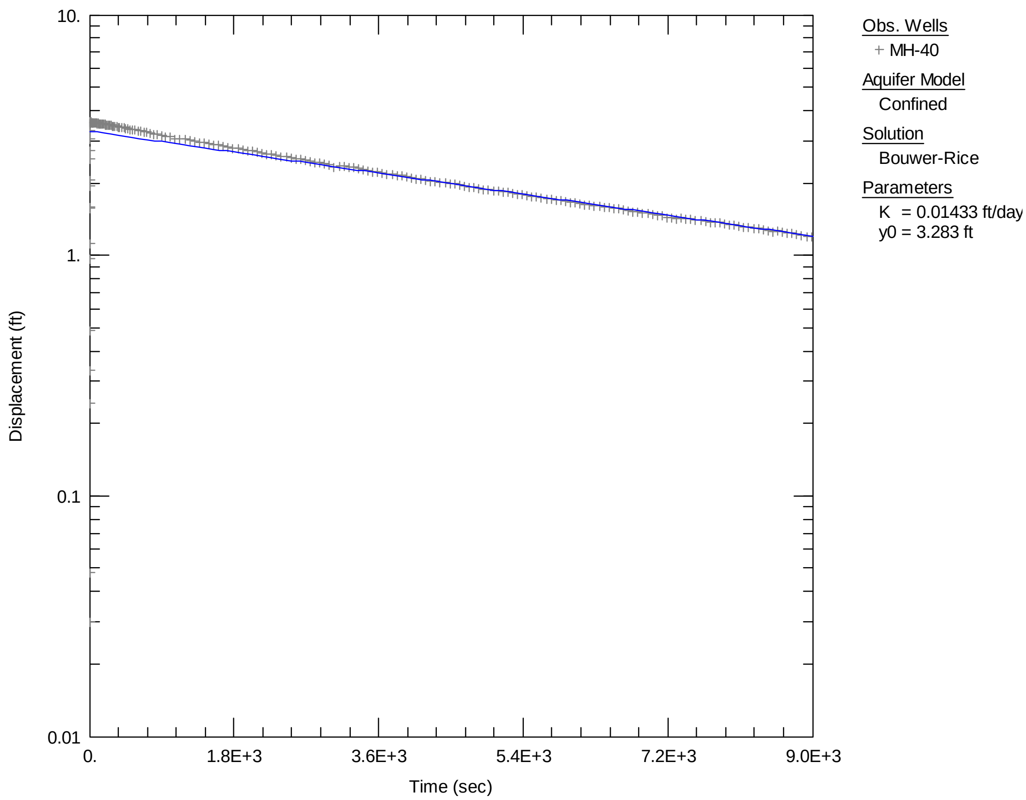

Figure 23. Semi-log plot of recovery data for MH-40 slug test data using the Bouwer-Rice (1976) model.

5.6 VERTICAL HYDRAULIC GRADIENT

After the construction of MF-40, a licensed surveyor established a benchmark with an elevation on the northwest corner of the cement pad. A copy of the survey report is provided in **Appendix G**. District staff surveyed the measuring point elevation for MF-40U and MF-40L on the FAS monitor well and MH-40 on the ICU monitor well with a Laserline Mfg., Inc. laser level. This is a temporary measuring point elevation survey so the SFWMD could determine the vertical gradient in the monitor wells. A licensed surveyor will provide the measuring point elevations before a contractor installs long-term monitoring equipment in each monitor well in 2008. For this exercise, the District used the background data collected before the first APT. A 30-psi transducer and an In-Situ, Inc. Hermit 3000 data logger recorded pressures from MF-40U, MF-40L, and MH-40. Over a period of 3 days, the unit collected readings every hour from each zone. The data logger converted the readings from each pressure transducer to freshwater heads in feet using a conversion factor of 2.31 feet of head per psi. The District then calculated the water level in each well from the surveyed measuring point elevation with all elevations referenced to NGVD 1929. As a SAS well was not available, surface water level data from the C-23 Canal represented the aquifer.

Figures 24 and **25** are hydrographs for a 3-day period before the first APT, showing the water levels in MF-40L, MF-40U, MH-40, and the C-23 Canal. The figures show that the water level is highest in MF-40L and lowest in the C-23 Canal. This implies that the vertical groundwater flow component is moving up through the FAS into the ICU and ultimately the SAS. **Table 12** lists the monitor intervals within the C-23 Canal, the ICU and the FAS, average recorded hydraulic head, and degree of variation over the 3-day period. The SFWMD generated the hydrographs for these monitor zones using hourly pressure readings. The density of the water in the two MF-40 zones was calculated based on total dissolved solids (TDS) and water temperature data collected during the September 6, 2007 groundwater sampling event. This water density was used to calculate the hydraulic head values for the FAS zones. These hydrographs show water level fluctuations that may be attributed to tidal loading, earth tides, and changes in atmospheric pressure (i.e., barometric effect).

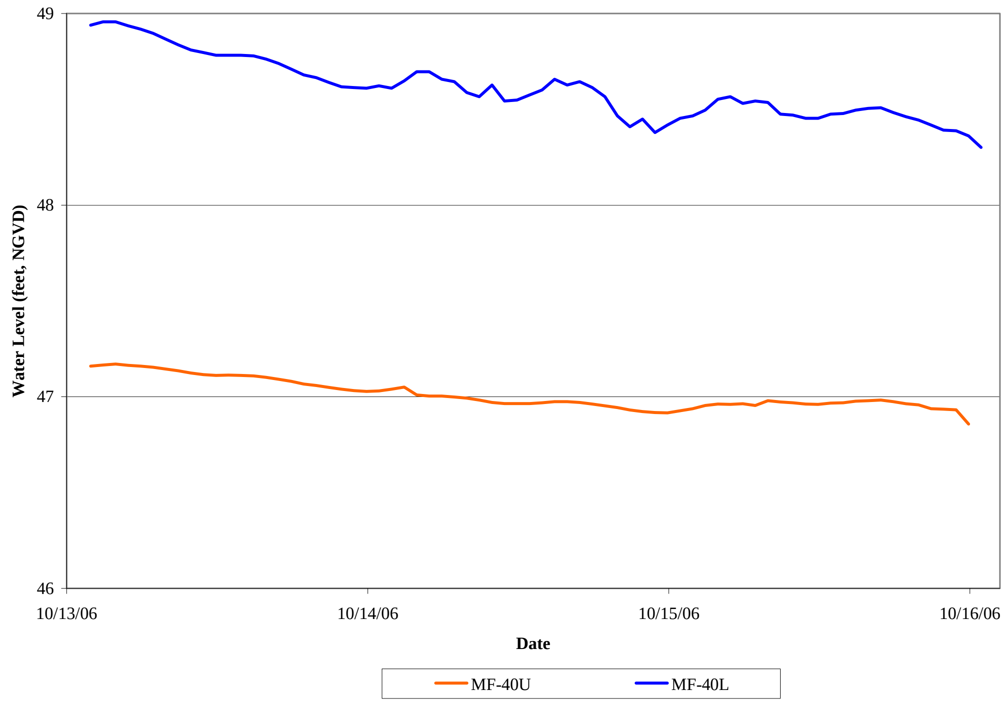

Figure 24. 3-day hydrograph for MF-40U and MF-40L.

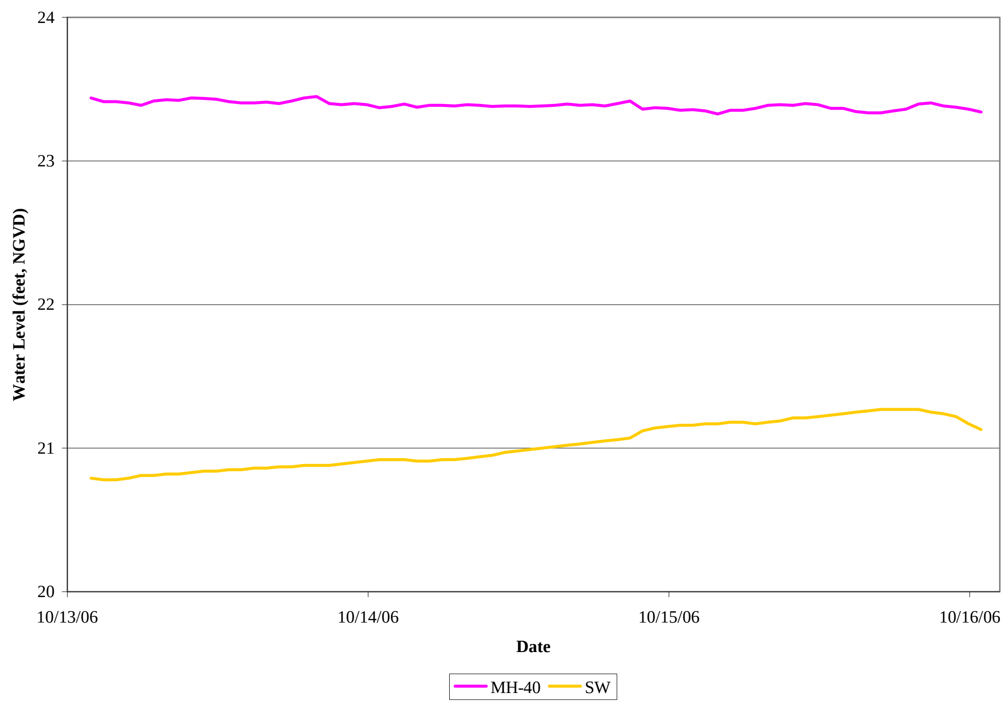

Figure 25. 3-day hydrograph for MH-40 and the C-23 Canal.

Table 12. Average hydraulic head measurements October 13—October 16, 2006.

Identifier	Monitor Interval (feet, bls)	Average Measured Hydraulic Head (feet, NGVD)	Standard Deviation (feet)
C-23 Canal	Surface Water	21.02	0.08
MH-40	305—375	23.39	0.03
MF-40U	790—970	47.01	0.08
MF-40L	1,100—1,200	48.61	0.16

Period of Record 10/13/06—10/16/06.

6

Summary

The results of this drilling program determined that the top of the FAS, as defined by the Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition (1986), was identified at a depth of approximately 730 feet bls. There was a noticeable difference in the structure of the boreholes for the FAS test production well and the monitor well. The borehole for the monitor well was highly fractured with some excellent water-bearing zones. The test production well borehole had very few fractures and yielded less water under natural artesian flow. Aquifer testing of both the upper and lower monitor zones yielded similar drawdown responses in both wells, indicating a high degree of hydraulic connection. It is hard to distinguish between the Upper Floridan aquifer and the Avon Park permeable zone (APPZ) in either well. The borehole for the FAS monitor well showed little confinement, while the test production well showed few production horizons. Further investigation is needed to discover if there is a major structural feature, such as a fault or erosional surface, running perpendicular to the layout of the two wells at this site, or if separating the FAS into distinct aquifers in this region is warranted.

The formation evaluation logs, rock geochemistry, and lithologic description of the well cuttings matched well. Inorganic water quality data and stable isotope data suggest that the groundwater in MF-40 has a meteoric origin when it entered the aquifer during the last interglacial period around 36,000 years ago. However, the major constituents in the water are sodium and chloride, indicating a chemical makeup similar to seawater. The two APTs yielded varying results, but the fractured rock solution by Moench (1984) yielded the best transmissivity values from a regional perspective. The leakance and storativity values are abnormally high and probably a result of the highly fractured nature of the FAS monitor well borehole and the difference in formation characteristics between the monitor and test production wells. The vertical hydraulic gradient at the site has groundwater flowing upward from MF-40L to the SAS. This matches the regional picture for the FAS, as this site is in a discharge area for the aquifer.

MF-40 will be beneficial to the SFWMD when it is included in the regional groundwater-monitoring network in 2008. This site is approximately 3 miles south of a wellfield the City of Port St. Lucie plans to install. It will be an excellent monitoring point when this wellfield comes on-line at some point in the future.

Well Logging

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A

Geotechnical Report for Well Pad Construction

All Webb's Enterprises, Inc.
309 Commerce Way
Jupiter, Florida 33458

July 6, 2005
Project No. 05-21-5508

Attention: Mr. David Webb, Jr.

Subject: ***Geotechnical Services***
Drilling Rig Pad
South of Intersection of CR 609 and C-23 Canal
Martin County, Florida

Dear Mr. Webb:

INTRODUCTION

Pursuant to your authorization, Dunkelberger Engineering & Testing, Inc. (DET) has completed geotechnical services for the above referenced project. The site is located approximately 400 yards east of County Road CR 609, on the southern bank of the C-23 canal in Martin County, Florida. Our scope of work included field exploratory work consisting of auger borings, and engineering evaluation (report preparation) and design recommendations for the proposed drilling rig pad. The results of the work are presented hereafter.

PROJECT CONSIDERATIONS

We understand that the project will involve the construction of a bearing pad for a deep well drilling rig. The rig will be used to drill a Tri Zone Monitoring Well that will penetrate into the Floridan Aquifer at a maximum depth of approximately 2300 feet below grade. Water will flow from this depth to the ground surface where it will be collected. We understand that the South Florida Water Management District (SFWMD) requires that the water flow be controlled in an effort to minimize impacts to the surficial aquifer. For this purpose, the drilling rig pad will include an impermeable liner under a layer of surficial fill that is graded to collect surficial water.

The rig will be supported through several steel platforms that will bear on the pad. The platforms will transmit the weight of the rig and any additional vertical loads (imposed on the rig during well drilling activities) to the ground surface. Of these platforms, we expect the principal load carrying members to be the four platforms located beneath the mast of the rig. On May 27, 2005 Mr. Jaime Velez, E.I. of DET and Mr. David Webb, Jr. measured the dimensions of these four platforms. The two steel platforms that lie beneath the mast of the rig were each measured to have a surface area of approximately 43.5 square feet while the two steel platforms that rest under the rear tires of the rig were each measured to have surface areas of approximately 35.5 square feet (i.e. total surface area of 158 square feet). Based on information provided by Mr. Webb, we understand that the rig trailer weighs approximately 65 kips while the rig mast weighs approximately 40 kips. The maximum weight of the drilling pipe (i.e. 2300 feet of drill pipe) will be approximately 65 kips. The heaviest static hook load supported by the rig will be approximately 97 kips and will occur during the setting of a 12 inch diameter steel casing to a depth of 1300 feet below grade within the borehole. The casing weight of 97 kips includes a safety factor of 1.5. For purposes of bearing capacity analysis we assumed the total possible load of 267 kips (i.e. 65 kips + 40 kips + 65 kips + 97 kips) will be supported solely on the four principal bearing platforms resulting in an average bearing pressure of approximately 1.7 kips per square foot (ksf) for the bearing pads.

The drill rig pad will be positioned approximately 25 feet from the edge of the C-23 canal. Based on information provided by Mr. Webb, Jr. we understand that the canal slope is steep and inclined at approximately 1 horizontal to 2 vertical.

SUBSURFACE CONDITIONS

Two exploratory borings were drilled within the area of the proposed drilling rig pad to gain information of the subsurface conditions. The auger borings were drilled to a depth of 8 feet below grade by hand turning a three-inch diameter bucket auger. Samples of the subsoils encountered in the borings were visually examined and classified in accordance with the Unified Soil Classification System (ASTM D 2487). The shear strength and compressibility of the soils were evaluated with a Brainard-Kilman Model S-214 hand held cone penetrometer. Logs of the auger boring results and cone penetrometer tests are presented on Sheets 1 and 2.

The borings disclosed the area of the proposed pad to be mantled by approximately 4 to 4.5 feet of fill consisting of clayey fine sand with gravel. The fill overlies relatively clean sands to approximately 6 feet below grade. Clayey sands and silty sands underlie the clean sands to 8 feet below grade. Cone penetration resistances generally indicated that the soils are in a loose to medium dense condition.

The groundwater table was not encountered in the borings.

DRILLING RIG PAD RECOMMENDATIONS

General

The area of the proposed drilling rig pad is generally suitable for support of the rig. The bearing pad may be constructed by placing the SFWMD specified impermeable geomembrane liner on the existing clayey sands following surface compaction of those sands with a heavy vibratory roller. The liner should then be covered with 8 inches (minimum) of compacted, clean fine sand. A surface bearing layer consisting of compacted crushed concrete (8 inch thick minimum) should be placed on the sand bed. The surface of the pad should be graded (see Figure No. 2) to promote runoff of surface water to the sump area.

Provided the bearing pad and subgrade soils are prepared as described in this report, the rig should be safe with respect to shearing failure of the soils to the south of the rig (i.e. conventional bearing capacity). We have estimated the factor of safety with respect to bearing capacity is in excess of 3.0 when the rig bearing pads are inducing the maximum expected bearing pressure (i.e. 1.7 ksf). However, the factor of safety with respect to a shearing failure of soils to the north of the rig is considerably lower (i.e. 1.4) due to the presence of the nearby canal. This safety factor is for a static load and is dependent on the rig not being closer than 25 feet from the edge of the canal bank. Vibrations induced through the drilling operations will result in a greater risk of slope instability. Canal bank stability can be improved by installing sheet piling into the canal bank slope or drilling the well further south from the canal.

If the drilling operation is initiated without installation of sheet piling, the canal bank will need to be closely monitored. If signs of canal bank instability are observed during the monitoring, sheet piling will need to be installed.

More detailed recommendations regarding site preparation, drilling rig pad construction and monitoring of the canal bank follows.

Clearing, Grubbing And Stripping

Clearing and grubbing should consist of the complete removal and disposal of brush, roots, rubbish and debris and all other obstructions resting on or protruding through the surface of the pad area. Stripping should include the complete removal of topsoil or mineral soils contaminated with organic debris from within the pad area.

In-Situ Densification

Following stripping and any additional excavations, the pad subgrade should be rigorously compacted in order to uniformly densify the shallow subsoils prior to foundation construction and/or placement of fill. The subgrade soils should be moisture conditioned to within 2 percent of the optimum for compaction and be compacted to at least 95 percent of the maximum dry density determined in accordance with the Modified Proctor Test (ASTM D 1557). This density requirement should be achieved and measured to a depth of at least 12 inches below the subgrade.

Soil densification should be accomplished using a self-propelled vibratory compactor that imparts a dynamic drum force of not less than 44,000 pounds (Dynapac CA-25S or equivalent). Densification should be performed with the compactor operated at its maximum vibrational frequency and a travel speed of no more than 1.5 miles per hour (normal walking speed). The pad area should be subjected to multiple coverages of the compactor with no less than 10 roller coverages. A geotechnical engineer or his representative should carefully observe the compaction operations. Pumping, weaving or excessive deflection of the subgrade that occurs during the rolling operations may be evidence of weak or compressible subgrade soils, or perhaps randomly placed backfill for the pre-existing C-23 canal. Such soils should be removed over their full extent within the pad area. Replacement fill for these excavations should consist of clean granular fill (USCS Classification of SP).

Drilling Rig Pad Construction

Following compaction of the subgrade soils, the impermeable high-density polyethylene (HDPE) geomembrane liner should be placed. The liner should have a minimum thickness of 30 mils (per the SFWMD requirements) and be installed in accordance with the manufacturer specifications and be secured within an anchor trench around the perimeter of the pad using a berm composed of granular fill. We expect that the existing clayey sands with gravel can be used as berm fill.

An 8-inch thick (minimum) bedding layer of clean fine sand should be placed over the liner. To avoid puncturing the liner the sands should contain no gravel size particles (i.e. particles greater than 5 millimeters in diameter). The fill should be moisture conditioned and compacted to at least 95 percent of the maximum density (ASTM D 1557) using a light hand-led vibratory plate compactor. Fill placement and compaction should be done with care to avoid puncturing the liner.

An 8-inch thick (minimum) layer of crushed concrete should be placed above the sand bed. The crushed concrete or stone should have a maximum particle size of approximately 2 inches and should be compacted to at least 95 percent of maximum density (ASTM D 1557) using the plate compactor. The surface of the rig pad should be graded so that surface water will flow into a sump for pumping and discharge (see Figure No. 2).

Groundwater Monitoring Well

A surficial aquifer monitoring well should be installed within 10 feet of the outside of the pad to monitor the quality of the surficial groundwater, per the SFWMD specifications.

Canal Bank Considerations

Installing a sheet pile wall into the southern canal bank slope can reduce the risk of canal bank slope failure. If sheet piling is not installed in the bank of the C-23 canal, the bank slope will need to be monitored closely for any movement including soil raveling. The ground around the rig will need to be monitored for settlement and the presence of ground cracks. If cracks are observed, the drilling operations will need to cease until sheet piles can be installed into the canal bank slope. The ground and canal bank should be observed several times daily including during transport of the rig (or other heavy construction equipment) to/from the site. All such equipment should be positioned not less than 25 feet from the edge of the canal bank at any time.

____oOo____

We appreciate the opportunity to assist you on this project. Should the report contents require any clarification or amplification, please contact us.

Very truly yours,

DUNKELBERGER ENGINEERING & TESTING, INC.

Jaime Velez

Jaime Velez, E.I.
Staff Engineer

Craig E. Dunkelberger, P.E.
Vice President
FL Registration No. 49932
7/6/05

5508rpt:jv

Attachments: Sheets 1 and 2 - Logs of Hand Auger Borings
Figure No. 1 - Proposed Site Layout
Figure No. 2 - Drilling Pad Slope Details
Figure No. 3 - Cross Section of Berm

cc: Addressee (3) ... *via hand delivery*

DE&T **DUNKELBERGER ENGINEERING & TESTING, INC.**

LOG OF AUGER BORING	
Project Number: 05-21-5508	**Boring Number:** AB-1
Client: All Webb's Enterprises, Inc.	
Project: Drilling Rig Pad, Martin County, Florida	
Boring Location: 10 feet east and 10 feet south of northeast corner of proposed drilling rig pad	
Date Drilled: 06/02/05	**Drilled By:** A.P.
Ground Elevation: Not Determined	**Depth of Groundwater Table:** Not Encountered

Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 4.0	SP – SC, SC	Brown slightly clayey to clayey fine SAND with trace to some gravel (FILL)
4.0 – 6.5	SP	Light brown fine SAND
6.5 – 7.5	SP – SM	Dark brown slightly silty fine SAND
7.5 – 8.0	SP – SC, SC	Gray slightly clayey to clayey fine SAND

*CONE PENETROMETER TEST RESULTS**	
Depth (feet)	**Cone Penetrometer Resistance (tsf)**
0.0 - 1.0	38
1.0 - 2.0	42
2.0 - 3.0	45+
3.0 - 4.0	45+
4.0 – 5.0	45+
5.0 – 6.0	45+
6.0 – 7.0	45+
7.0 – 8.0	45+
Total Depth of Boring: 8.0 feet	

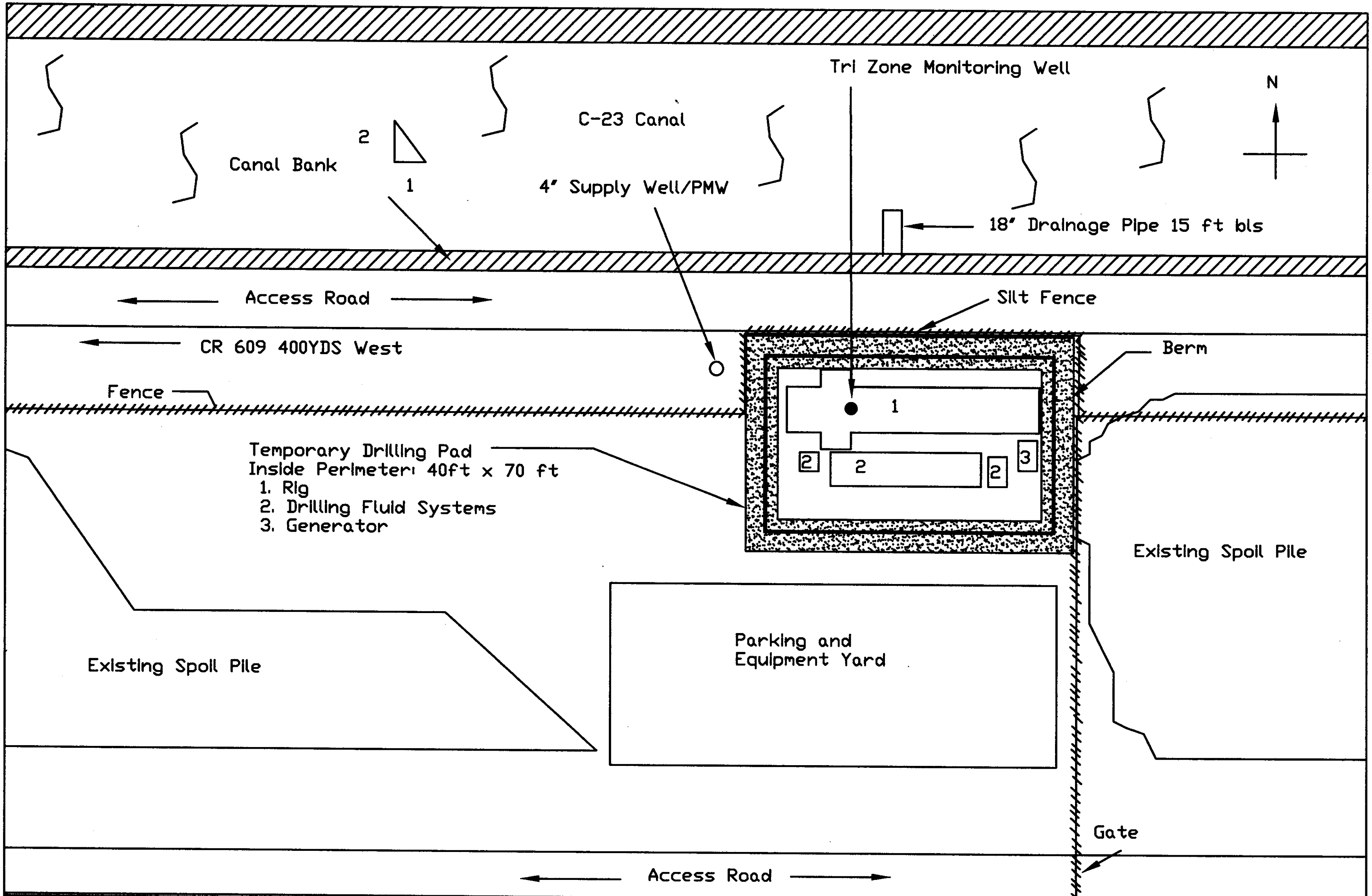
* Cone penetrometer resistance determined using a Brainard-Kilman Model S-214 hand-held static cone penetrometer.

LOG OF AUGER BORING	
Project Number: 05-21-5508	**Boring Number:** AB-2
Client: All Webb's Enterprises, Inc.	
Project: Drilling Rig Pad, Martin County, Florida	
Boring Location: 10 feet north and 10 feet west of southeast corner of proposed drilling rig pad	
Date Drilled: 06/02/05	**Drilled By:** A.P.
Ground Elevation: Not Determined	**Depth of Groundwater Table:** Not Encountered

Depth (feet)	*Soil Type*	*Soil Description*
0.0 – 1.5	SP	Brown to gray fine SAND, trace clay and silt (FILL)
1.5 - 4.5	SP – SC, SC	Brown slightly clayey to clayey fine SAND with trace to some gravel (FILL)
4.5 – 5.5	SP	Light brown fine SAND
5.5 – 7.5	SP – SM	Dark brown slightly silty fine SAND
7.5 – 8.0	SP – SC, SC	Gray slightly clayey to clayey fine SAND

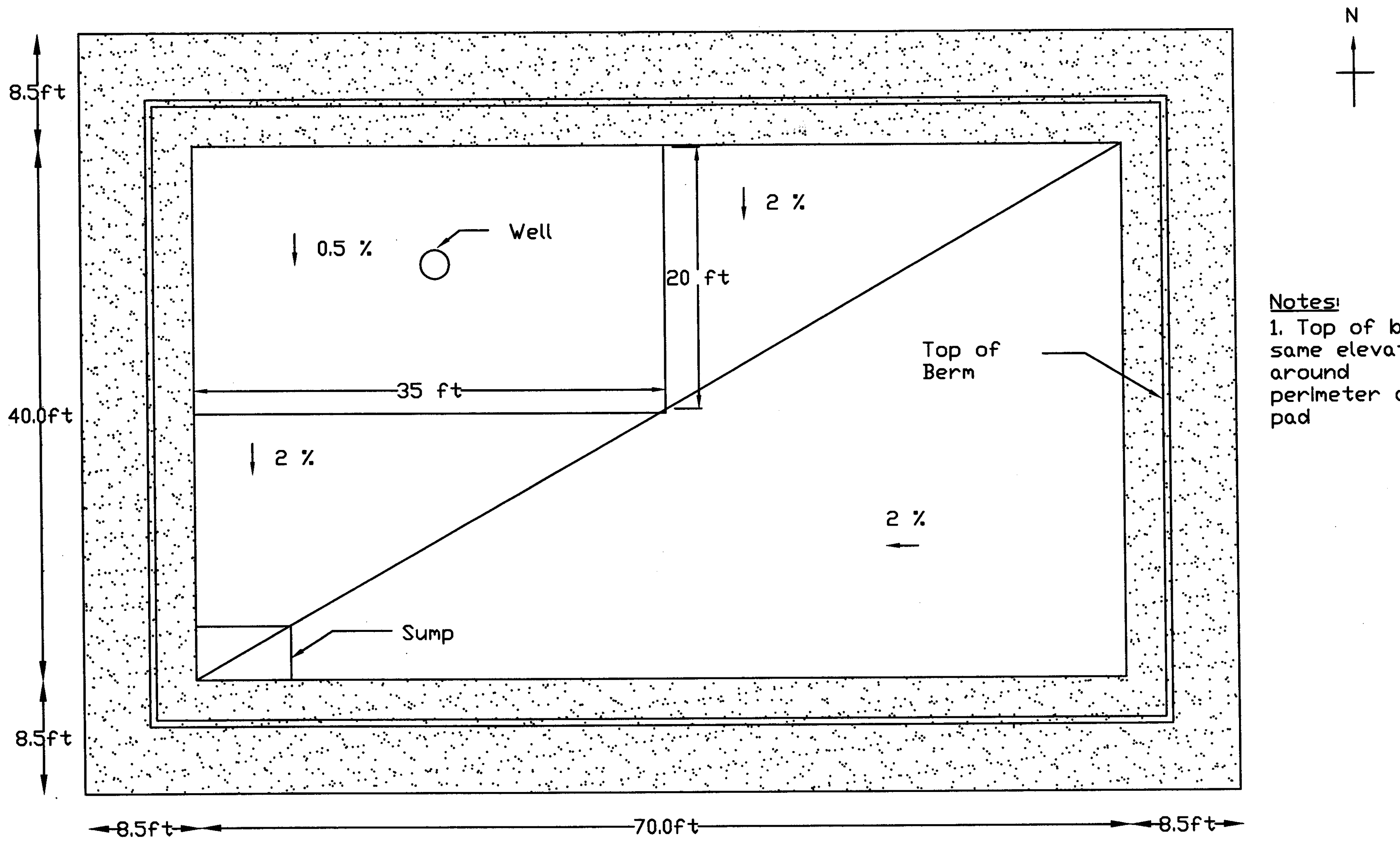
*CONE PENETROMETER TEST RESULTS**	
Depth (feet)	**Cone Penetrometer Resistance (tsf)**
0.0 - 1.0	41+
1.0 - 2.0	45+
2.0 - 3.0	45+
3.0 - 4.0	45+
4.0 – 5.0	45+
5.0 – 6.0	45+
Total Depth of Boring: 8.0 feet	

* Cone penetrometer resistance determined using a Brainard-Kilman Model S-214 hand-held static cone penetrometer.



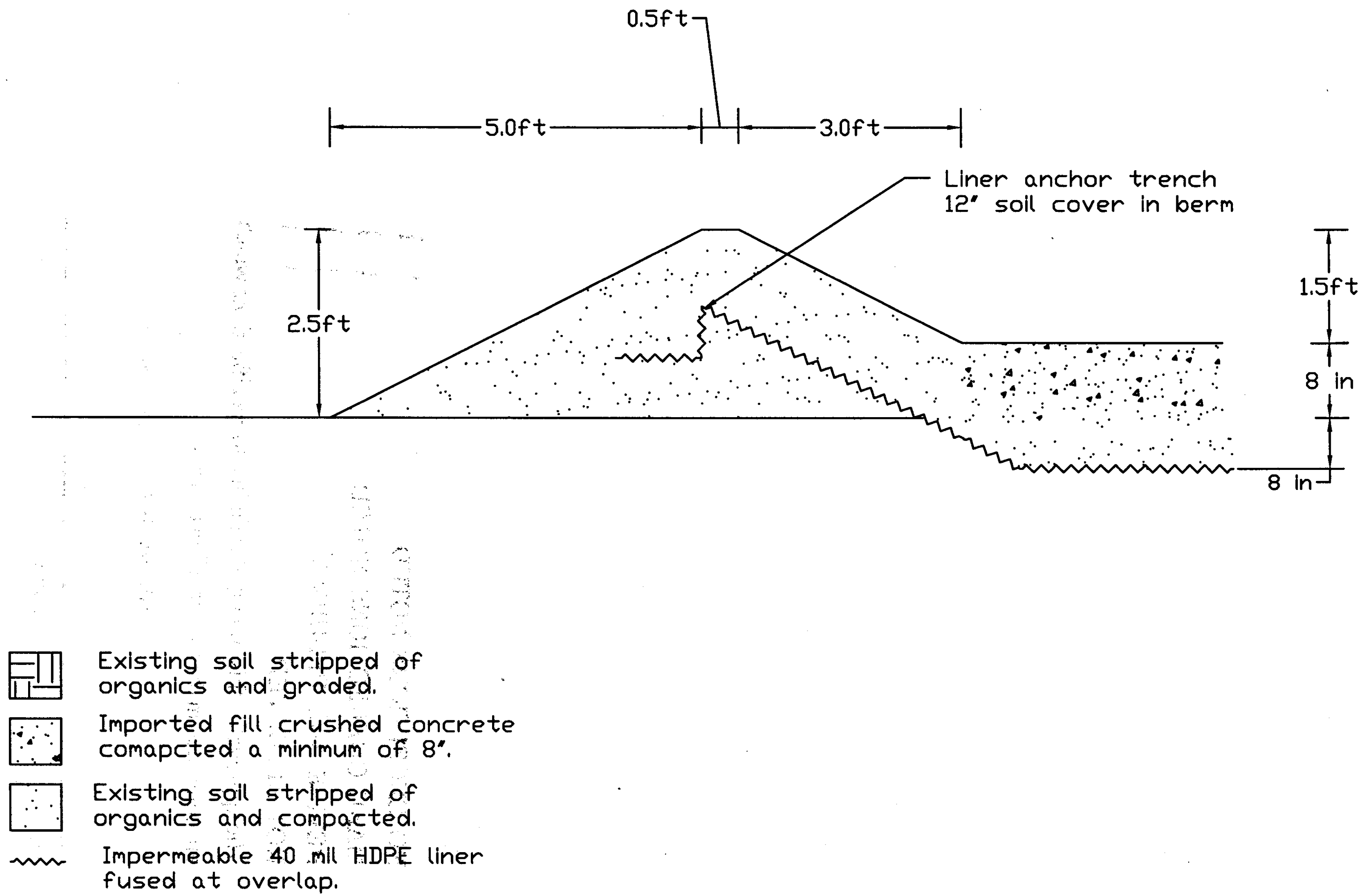
All Webb's Enterprises, Inc
Proposed Site Layout
South Florida Water Management District
CN050199 Tri-Zone Monitoring Well

Figure No. 1	
Date: 7-5-2005	
Drawn: D.W.	
Checked: J.V./C.D.	



Notes:
1. Top of berm same elevation around perimeter of pad

All Webb's Enterprises, Inc Temporary Drilling Pad Slope Details South Florida Water Management District CN050199 Tri-Zone Monitoring Well	Figure No. 2 Date: 7-5-2005 Drawn: D.W. Checked: J.V./C.D.



All Webb's Enterprises, Inc Cross Section of Berm South Florida Water Management District CN050199 Tri-Zone Monitoring Well	Figure No. 3 Date: 7-5-2005 Drawn: D.W. Checked: J.V./C.D.

B

Drilling Rig Hook and Load Capacity Report

June 29, 2005

All Webb's Enterprises, Inc.
309 Commerce Way
Jupiter, FL - 33458

Attention: Mr. David Webb, Jr.

Subject: Visual Observations
Load Test on Derrick & Draw Works
Lake Worth Water Tower Facility
Lake Worth, FL

QuEST Report No.: J-5099.001

Dear Mr. Webb:

As requested, a representative of Quest Engineering Services & Testing, Inc. (QuEST) visited the subject site on June 17, 2005 and observed the load test done on the Derrick and Draw Works. This report transmits a summary of our observations and the results of the test.

BACKGROUND

We understand that the subject derrick and draw works equipment is to be used in a South Florida Water Management District (SFWMD) project. The peak hook load/weight capacity that the derrick and draw works will be subjected to, during field operation, is anticipated to be 65 kips. The project specification (Section 02500) calls for the derrick and draw works assembly to be load tested to 1.5 times the anticipated peak field load. The tests are to be conducted in accordance with American Petroleum Institute (API) Spec 7K. Hence we were requested to witness the load test and issue a report.

FIELD OBSERVATIONS

On June 17, 2005, a representative of QuEST visited the subject site for observing the load test. When we arrived on site, the load test set-up had already been configured. We then proceeded to note the equipment details and verify the calibration certificate for the load cell. Pertinent equipment information obtained from our observations is listed below:

	Equipment	Manufacturer	Model No.	Serial No.
1.	Derrick Rig	Challenger Rig & Mfg. Co.	3T3 201 200 77SD	TR81867881D
2.	Derrick Engine	Caterpillar	3408	67U07172
3.	Transmission	Allison	CLT 754	2510055566
4.	Draw Works	Challenger Rig & Mfg. Co.	320	193
5.	Load Cell	Totco		0506075

The derrick (Serial No. 192) height was 77 feet. It was rated for a capacity of 200 kips with four 7/8" lines. The derrick and draw works were manufactured in Odessa, Texas in August 1981. The certificate of calibration provided for the load cell indicates that the load cell was calibrated to 100 kips by Martin-Decker Totco on April 4, 2005. The dial gage indicator connected to the load cell was capable of measuring loads of up to 320 kips in 2 kip increments. The dial gage had a zero error of 6 kips. This zero error was factored out of the readings indicated in subsequent sections of this report (i.e.) they are corrected readings.

TEST SET-UP

The test set-up was as follows. A Ø30" well casing was reportedly installed to a depth of 200 feet. The casing was cemented on the inside and out. A steel flange was welded to the casing. The I-beam that was being pulled was secured to the casing flange using four Ø1 ¼" bolts. The reaction was transferred via four legs to a steel I-beam lattice set on the ground over a 6" thick bed of crushed concrete. The I-beam lattice had a footprint area of 45 square feet (sf). For the test configuration, six lines were used. The load cell was hooked to one of the lines and connected to a dial indicator.

LOAD TEST

The test commenced at 11:05 AM. The loads were increased incrementally and a peak load of 106 kips was reached at 11:09 AM. The peak load was held till 11:17 AM. The unloading started at 11:17 AM and ended at 11:19 AM when all the load was released. After a 2-minute break, the assembly was reloaded, starting at 11:21 AM. The peak load of 100 kips was reached at 11:23 AM. The peak load was held till 11:26 AM. The unloading started at 11:26 AM and ended at 11:27 AM when all the load was released.

EVALUATION

The assembly was tested to 106 kips and the load was held in 8 minutes. The load was then completely released. The assembly was then reloaded to 100 kips and the load was held for three minutes. The tests were done in accordance with the project specifications. Based on our field observations, in our professional opinion, the subject derrick and draw works assembly is suitable for handling loads of up to 65 kips.

LIMITATIONS

The engineer warrants that the findings, professional opinions or advice contained herein, have been promulgated after witnessing the test. This report has been being prepared in accordance with generally accepted professional engineering practice in the field of testing of construction equipment. No other warranties are implied or expressed.

-oOo-

We appreciate the opportunity to be of service. If you have any questions, please call.

Sincerely,
Quest Engineering Services & Testing, Inc.

R. N. Sailappan 6/29/05
R. N. Sailappan, P.E.
Principal
Florida Registration No. 46696

C
Geophysical Logs

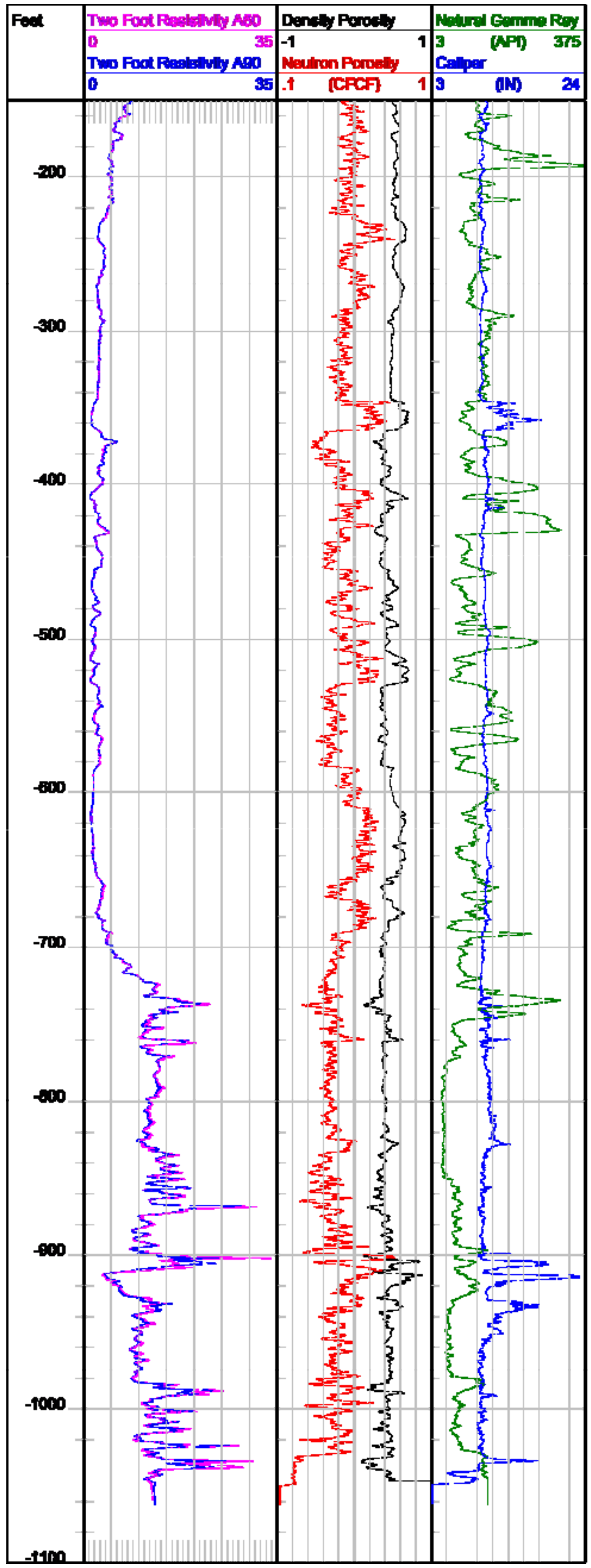


Figure C-1. MF-40 formation evaluations logs.

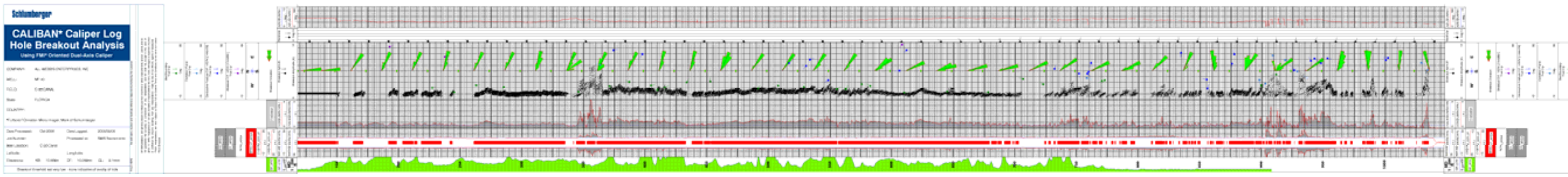


Figure C-2. MF-40 formation microimager logs.

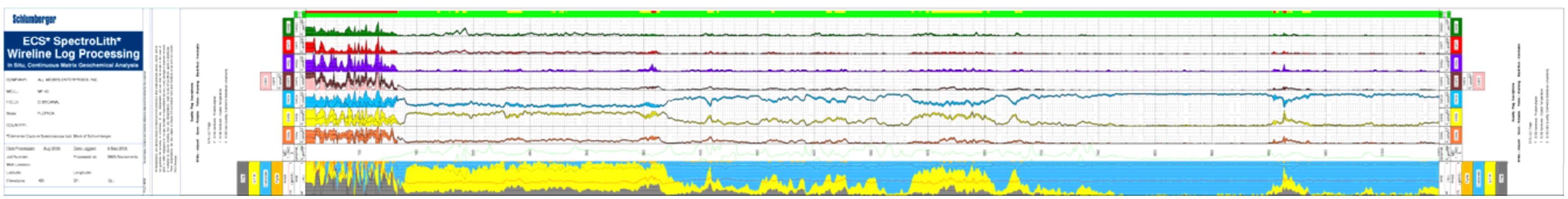


Figure C-3. ECS spectroscopy lithologic logs.

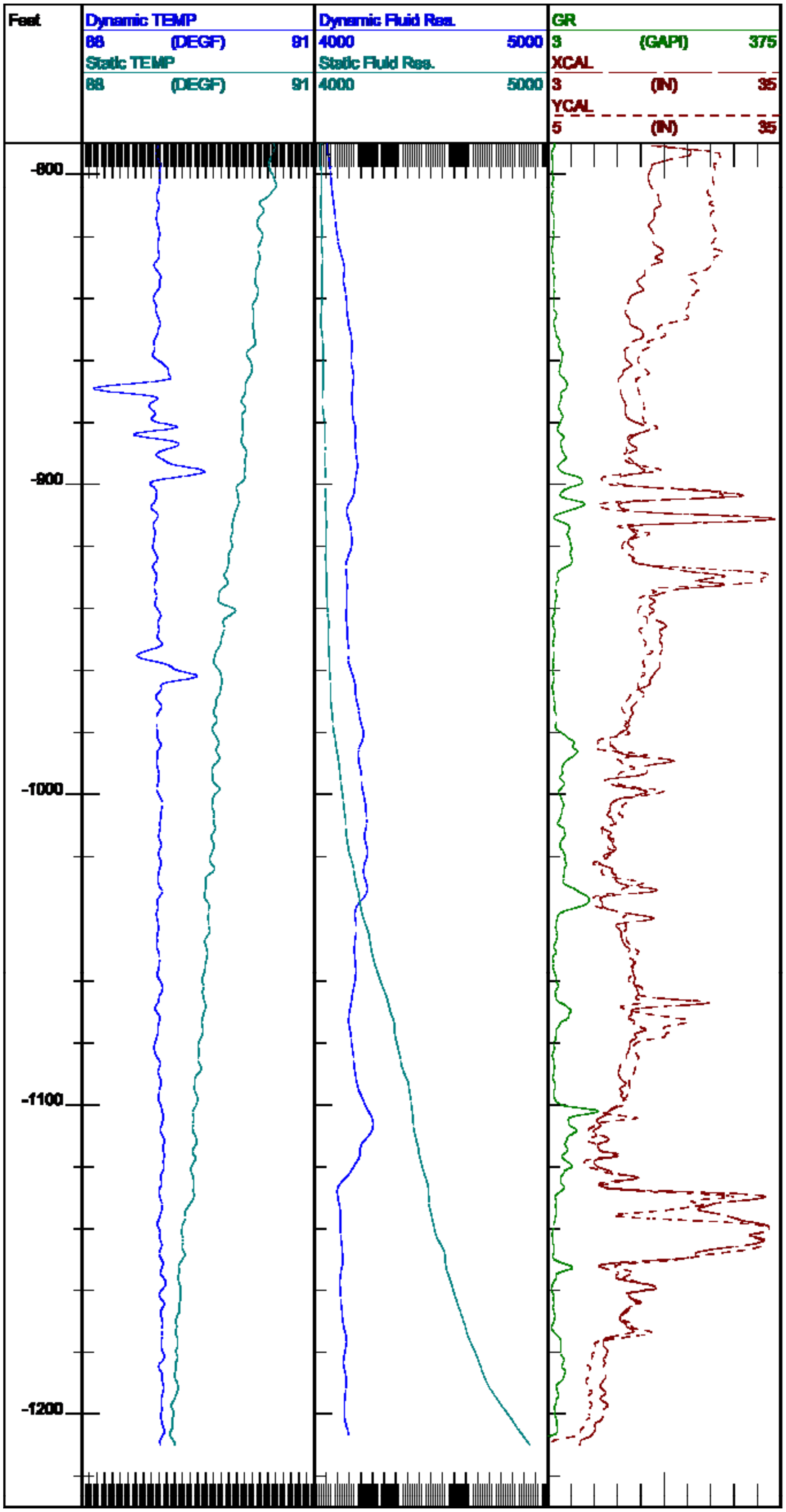


Figure C-4. MF-40 production logs.

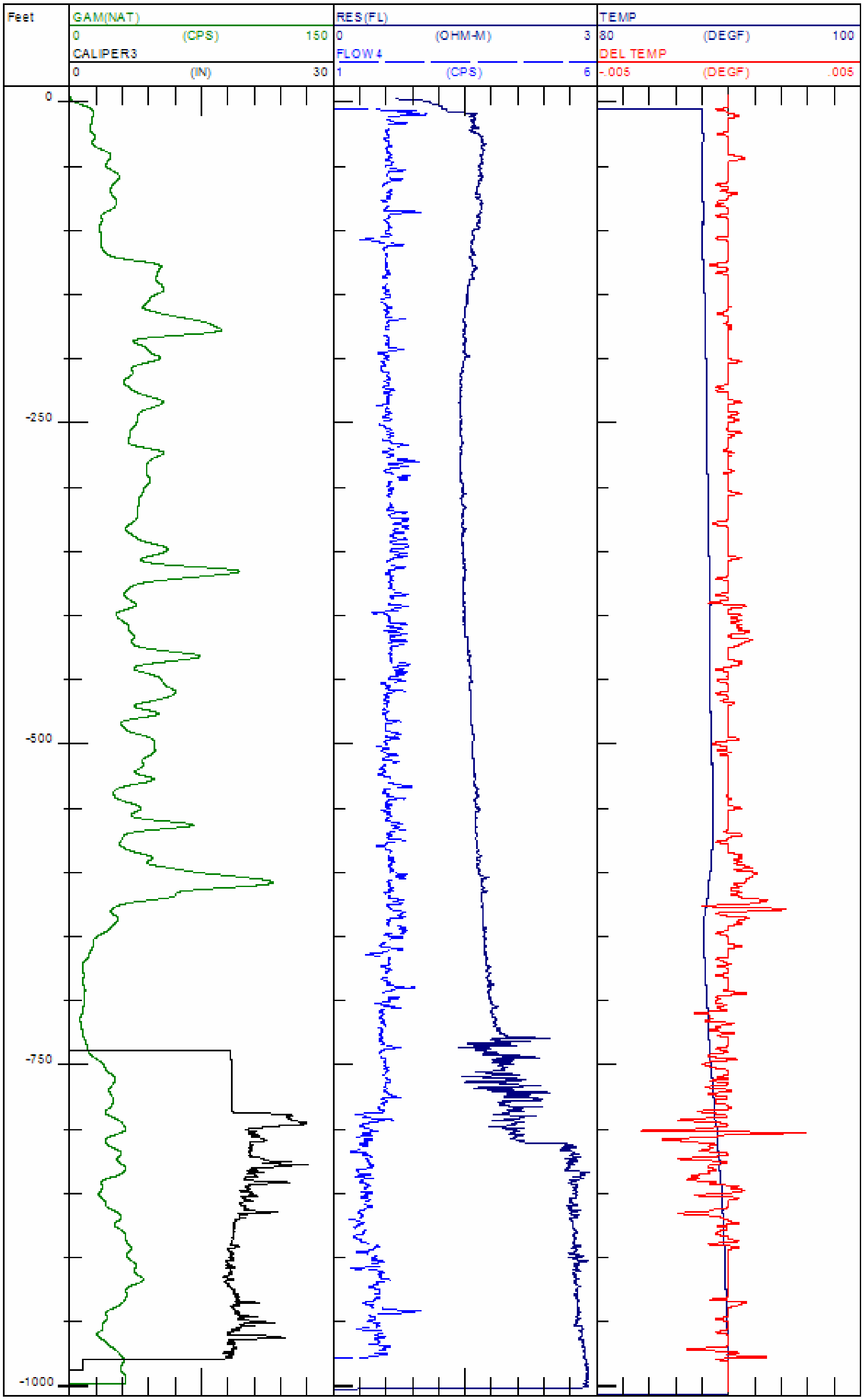


Figure C-5. MF-41 production logs, run 1.

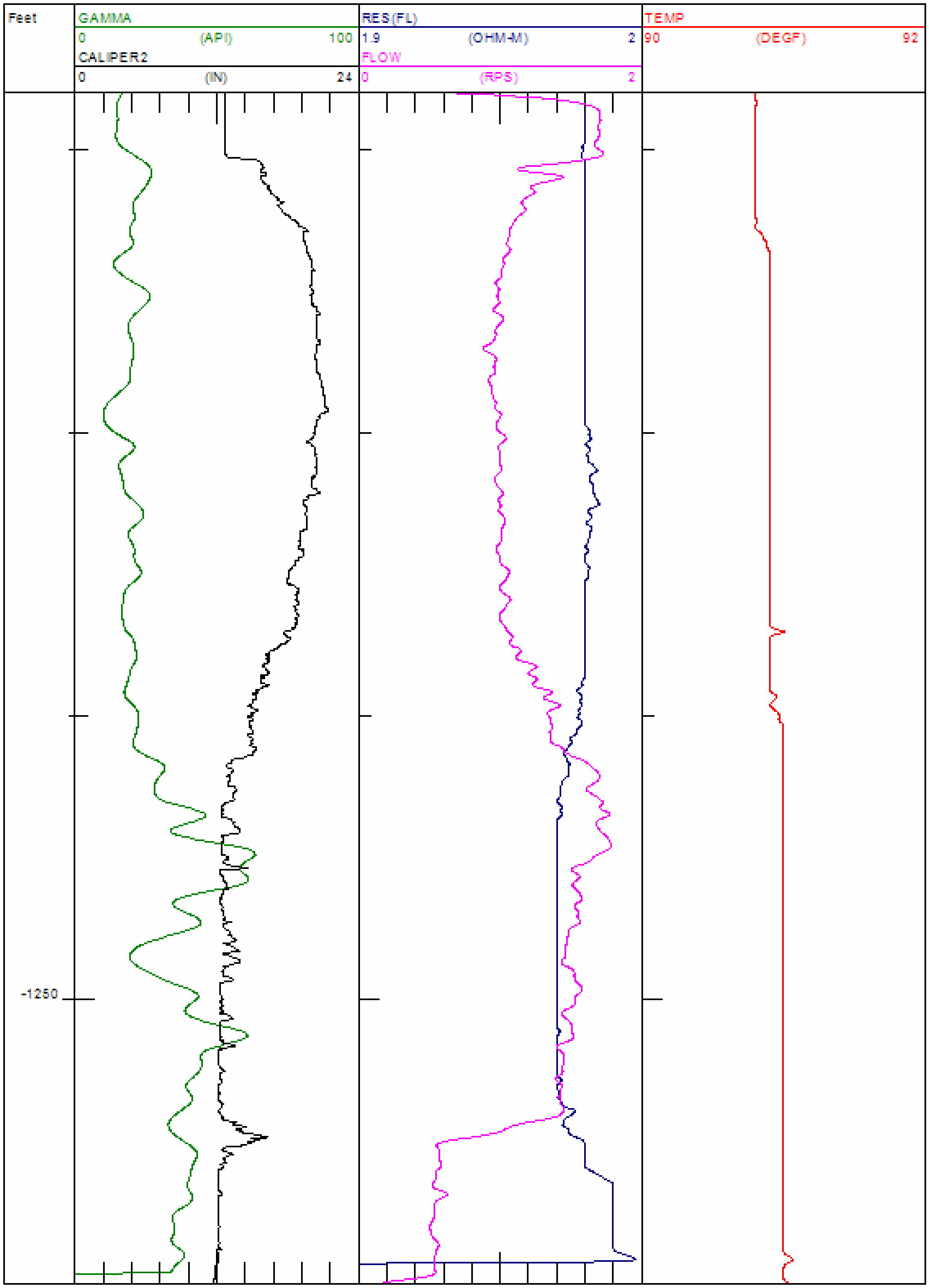


Figure C-6. MF-41 production logs, run 2.

D
Lithologic Logs

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LITHOLOGIC WELL LOG PRINTOUT                      SOURCE - FGS

WELL NUMBER:   W-18726                            COUNTY -   MARTIN
TOTAL DEPTH:    1250  FT.                         LOCATION:  T.38S R.39E S.06 BA
224 SAMPLES FROM 0 TO 1250 FT.                               LAT = 27D 12M 22S
                                                             LON = 80D 28M 34S
COMPLETION DATE: N/A                              ELEVATION: 36 FT
OTHER TYPES OF LOGS AVAILABLE - NONE

OWNER/DRILLER:SFWMD MF-40

WORKED BY:STEVEN PETRUSHAK 12FEB07
MIXTURE OF CORE AND CUTTINGS(CORE NOTED IN Z COMMENTS)
CUTTINGS (770-TD) MAY HAVE CONTAMINATION FROM OVERLYING UNITS
OF QUARTZ, PHOSPHATE AND LIMESTONE.
CORE SAMPLES DID NOT REFLECT CONTAMINATION.

    0.   -  115.   090UDSS   UNDIFFERENTIATED SAND, CLAY, AND SHELLS
  115.   -  410.   122PCRV   PEACE RIVER FM.
  410.   -  770.   122ARCA   ARCADIA FM.
  770.   -  890.   124OCAL   OCALA GROUP
  890.   - 1250.   124AVPK   AVON PARK FM.

    0  -    5   SAND; VERY LIGHT ORANGE
                POROSITY: INTERGRANULAR
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                POOR INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX
                ACCESSORY MINERALS: CALCILUTITE-05%, HEAVY MINERALS-01%

    5  -   10   SAND; MODERATE YELLOWISH BROWN
                POROSITY: INTERGRANULAR
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                POOR INDURATION
                CEMENT TYPE(S): IRON CEMENT, CALCILUTITE MATRIX
                CLAY MATRIX
                ACCESSORY MINERALS: CALCILUTITE-02%

   10  -   15   SAND; GRAYISH BROWN
                POROSITY: INTERGRANULAR
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                POOR INDURATION
                CEMENT TYPE(S): CLAY MATRIX, IRON CEMENT

   15  -   20   SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
                POROSITY: INTERGRANULAR
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                MODERATE INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX
                ACCESSORY MINERALS: CALCILUTITE-10%, HEAVY MINERALS-01%

   20  -   25   SAND; LIGHT OLIVE GRAY TO GRAYISH BROWN
                POROSITY: INTERGRANULAR
```

GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-15%, SPAR-03%
HEAVY MINERALS-02%

25 - 30 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-15%, SPAR-10%

30 - 35 WACKESTONE; MODERATE LIGHT GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: FINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: SPAR-40%, QUARTZ SAND-15%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION

35 - 40 AS ABOVE

40 - 45 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-15%, SPAR-10%

45 - 50 AS ABOVE

50 - 55 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-05%, SPAR-03%
FOSSILS: MOLLUSKS

55 - 60 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-25%, SHELL-07%, SPAR-01%
FOSSILS: MOLLUSKS

60 - 65 SHELL BED; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

ACCESSORY MINERALS: CALCILUTITE-15%, QUARTZ SAND-05%
PHOSPHATIC GRAVEL-03%, HEAVY MINERALS-01%
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA
PRESENCE OF PHOSPHATE MAY INDICATE REWORKING OF HAWTHORN

65 - 70 AS ABOVE

70 - 75 SHELL BED; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-15%, LIMESTONE-10%
HEAVY MINERALS-01%
FOSSILS: MOLLUSKS, BRYOZOA

75 - 80 AS ABOVE

80 - 85 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-10%, QUARTZ SAND-10%
OTHER FEATURES: MUDDY
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS
FORAMINIFERA SORITIES SP. AND AMPHISTEGINA LESSONI PRESENT

85 - 90 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, QUARTZ SAND-10%
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, BARNACLES
BRYOZOA, FOSSIL FRAGMENTS

90 - 95 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, QUARTZ SAND-15%
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, BARNACLES
BRYOZOA, FOSSIL FRAGMENTS

95 - 100 AS ABOVE

100 - 105 AS ABOVE

105 - 110 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-15%, QUARTZ SAND-15%

FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, BARNACLES
BRYOZOA, FOSSIL FRAGMENTS

110 - 115 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, QUARTZ SAND-15%
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, BARNACLES
BRYOZOA, FOSSIL FRAGMENTS

115 - 120 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-35%, QUARTZ SAND-20%
PHOSPHATIC SAND-01%
FOSSILS: MOLLUSKS, BARNACLES, BRYOZOA, FOSSIL FRAGMENTS

120 - 125 AS ABOVE

125 - 130 AS ABOVE

130 - 135 AS ABOVE

135 - 140 PACKSTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-20%, SHELL-15%
PHOSPHATIC SAND-05%
FOSSILS: MOLLUSKS, BRYOZOA, FOSSIL FRAGMENTS

140 - 145 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-35%, SHELL-10%
PHOSPHATIC SAND-07%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

145 - 150 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, CALCILUTITE-10%
PHOSPHATIC SAND-07%

FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

150 - 155 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, PHOSPHATIC SAND-10%
CALCILUTITE-10%
FOSSILS: MOLLUSKS, BARNACLES, FOSSIL FRAGMENTS

155 - 160 AS ABOVE

160 - 165 AS ABOVE

165 - 170 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, PHOSPHATIC SAND-15%
CALCILUTITE-10%
FOSSILS: MOLLUSKS, BRYOZOA, BARNACLES, FOSSIL FRAGMENTS

170 - 175 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, PHOSPHATIC SAND-15%
CALCILUTITE-10%
FOSSILS: MOLLUSKS, BARNACLES, FOSSIL FRAGMENTS

175 - 180 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, PHOSPHATIC SAND-15%
CALCILUTITE-10%
FOSSILS: MOLLUSKS, BRYOZOA, FOSSIL FRAGMENTS

180 - 185 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, CALCILUTITE-10%
PHOSPHATIC SAND-10%
FOSSILS: MOLLUSKS, BRYOZOA, BARNACLES, FOSSIL FRAGMENTS

185 - 190 AS ABOVE

190 - 195 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, PHOSPHATIC SAND-15%
CALCILUTITE-07%
FOSSILS: MOLLUSKS, BRYOZOA, BARNACLES, FOSSIL FRAGMENTS

195 - 200 AS ABOVE

200 - 205 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, PHOSPHATIC SAND-15%
CALCILUTITE-07%
FOSSILS: MOLLUSKS, BRYOZOA, BARNACLES, SHARKS TEETH
FOSSIL FRAGMENTS

205 - 210 SAND; LIGHT OLIVE GRAY TO GREENISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, PHOSPHATIC SAND-15%
CALCILUTITE-10%
FOSSILS: MOLLUSKS, BARNACLES, FOSSIL FRAGMENTS

210 - 215 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, PHOSPHATIC SAND-15%
SHELL-10%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS

215 - 220 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, CALCILUTITE-20%
PHOSPHATIC SAND-15%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, SHARKS TEETH

220 - 225 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM

ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, PHOSPHATIC SAND-10%
SHELL-07%
FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS, BARNACLES

225 - 230 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, PHOSPHATIC SAND-07%
FOSSILS: FOSSIL FRAGMENTS

230 - 235 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, PHOSPHATIC SAND-05%
FOSSILS: FOSSIL FRAGMENTS

235 - 240 AS ABOVE

240 - 245 AS ABOVE

245 - 250 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, PHOSPHATIC SAND-05%
SHELL-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

250 - 255 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-07%
PHOSPHATIC SAND-07%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

255 - 260 AS ABOVE

260 - 265 AS ABOVE

265 - 270 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY

POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-10%
PHOSPHATIC SAND-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

270 - 275 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-10%
PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

275 - 280 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-15%
PHOSPHATIC SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

280 - 285 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-15%
PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

285 - 290 AS ABOVE

290 - 295 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-05%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS

295 - 300 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-10%, CLAY-02%
PHOSPHATIC SAND-01%
FOSSILS: FOSSIL FRAGMENTS

300 - 305 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-15%, CLAY-02%
PHOSPHATIC SAND-01%
FOSSILS: FOSSIL FRAGMENTS

305 - 310 SHELL BED; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-35%, CALCILUTITE-20%
CLAY-02%, PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

310 - 315 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-35%, QUARTZ SAND-20%
PHOSPHATIC SAND-02%, CLAY-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

315 - 320 WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-40%, QUARTZ SAND-15%, CLAY-02%
PHOSPHATIC SAND-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

320 - 325 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-30%, CALCILUTITE-20%, CLAY-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

325 - 330 AS ABOVE

330 - 335 AS ABOVE

335 - 345 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-25%, SHELL-15%, CLAY-03%

FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

345 - 350 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-25%, SHELL-20%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

350 - 355 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-15%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

355 - 360 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, CALCILUTITE-20%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

360 - 365 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-25%, CALCILUTITE-20%
SHELL-15%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

365 - 370 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-25%, CALCILUTITE-15%
QUARTZ SAND-15%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

370 - 375 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-15%, CLAY-05%

FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

375 - 380 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, CLAY-05%, QUARTZ SAND-05%
FOSSILS: FOSSIL FRAGMENTS, BARNACLES, MOLLUSKS

380 - 385 AS ABOVE

385 - 390 SAND; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
ACCESSORY MINERALS: CALCILUTITE-20%, SHELL-20%
PHOSPHATIC SAND-05%, CLAY-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

390 - 395 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-30%, QUARTZ SAND-10%
PHOSPHATIC SAND-05%, CLAY-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

395 - 400 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-30%, PHOSPHATIC SAND-15%
QUARTZ SAND-10%, CLAY-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH

400 - 405 WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-10%, SHELL-10%
QUARTZ SAND-10%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH
BARNACLES

405 - 410 WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR

GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-10%
PHOSPHATIC GRAVEL-10%, SHELL-10%, QUARTZ SAND-10%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH
BARNACLES

410 - 415 PHOSPHATE; DARK GRAY
POROSITY: INTERGRANULAR; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-60%
PHOSPHATIC GRAVEL-15%, QUARTZ SAND-15%, CALCILUTITE-10%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH
BARNACLES
CLASSIFIED AS PHOSPHATIC SAND (>75% TOTAL PHOSPHATE)

415 - 420 PACKSTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-10%, SHELL-10%
QUARTZ SAND-07%, PHOSPHATIC GRAVEL-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

420 - 425 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%, SHELL-10%
PHOSPHATIC SAND-05%, QUARTZ SAND-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

425 - 430 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%, SHELL-10%
PHOSPHATIC SAND-05%, QUARTZ SAND-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH

430 - 435 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, SKELETAL, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-20%, SHELL-15%
PHOSPHATIC SAND-05%, QUARTZ SAND-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BRYOZOA

435 - 440 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%, SHELL-10%
QUARTZ SAND-07%, PHOSPHATIC SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

440 - 445 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE, SKELETAL
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%, SHELL-10%
QUARTZ SAND-05%, PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

445 - 450 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-10%, SHELL-10%
QUARTZ SAND-03%, PHOSPHATIC SAND-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, SHARKS TEETH

450 - 455 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-15%, PHOSPHATIC GRAVEL-10%
QUARTZ SAND-03%, PHOSPHATIC SAND-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES
SHARKS TEETH

455 - 460 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-10%, PHOSPHATIC GRAVEL-07%
QUARTZ SAND-05%, PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

460 - 465 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION

CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-15%, SHELL-10%
PHOSPHATIC GRAVEL-05%, PHOSPHATIC SAND-03%
OTHER FEATURES: DOLOMITIC
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

465 - 470 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-05%, SHELL-05%
QUARTZ SAND-03%, PHOSPHATIC SAND-01%
OTHER FEATURES: DOLOMITIC
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BARNACLES

470 - 475 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-05%
PHOSPHATIC GRAVEL-05%, SHELL-03%, QUARTZ SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

475 - 480 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-15%
PHOSPHATIC GRAVEL-05%, SHELL-03%, QUARTZ SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

480 - 485 WACKESTONE; LIGHT OLIVE GRAY TO OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-20%, QUARTZ SAND-07%
SHELL-05%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

485 - 490 WACKESTONE; OLIVE GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

ACCESSORY MINERALS: PHOSPHATIC SAND-15%
PHOSPHATIC GRAVEL-07%, SHELL-03%, QUARTZ SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

490 - 495 WACKESTONE; LIGHT OLIVE GRAY TO OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-10%
PHOSPHATIC GRAVEL-03%, QUARTZ SAND-03%, SHELL-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

495 - 500 AS ABOVE

500 - 505 AS ABOVE

505 - 510 WACKESTONE; LIGHT OLIVE GRAY TO OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-15%, QUARTZ SAND-05%
PHOSPHATIC GRAVEL-02%, SHELL-02%
FOSSILS: FOSSIL FRAGMENTS

510 - 515 AS ABOVE

515 - 520 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-10%, SHELL-07%
QUARTZ SAND-05%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS

520 - 525 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, PHOSPHATIC SAND-07%
SHELL-03%
FOSSILS: FOSSIL FRAGMENTS

525 - 530 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE

70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-07%, PHOSPHATIC GRAVEL-05%
QUARTZ SAND-05%, PHOSPHATIC SAND-03%
FOSSILS: FOSSIL FRAGMENTS

530 - 535 AS ABOVE

535 - 540 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-10%, PHOSPHATIC SAND-07%
QUARTZ SAND-05%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS

540 - 545 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-05%, QUARTZ SAND-05%
PHOSPHATIC GRAVEL-03%, SHELL-03%
FOSSILS: FOSSIL FRAGMENTS

545 - 550 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-25%, QUARTZ SAND-05%
PHOSPHATIC GRAVEL-03%, SHELL-01%

550 - 555 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-05%, PHOSPHATIC SAND-03%
PHOSPHATIC GRAVEL-03%, QUARTZ SAND-02%
FOSSILS: FOSSIL FRAGMENTS

555 - 560 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-30%, PHOSPHATIC SAND-10%
PHOSPHATIC GRAVEL-02%, SHELL-02%
FOSSILS: FOSSIL FRAGMENTS

560 - 565 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-20%, PHOSPHATIC SAND-07%
PHOSPHATIC GRAVEL-03%, SHELL-02%
FOSSILS: FOSSIL FRAGMENTS

565 - 570 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, PHOSPHATIC SAND-07%
SHELL-07%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS

570 - 575 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-25%, SHELL-07%
PHOSPHATIC SAND-05%, PHOSPHATIC GRAVEL-02%

575 - 580 AS ABOVE

580 - 585 AS ABOVE

585 - 631 NO SAMPLES

631 - 634.5 CLAY; GRAYISH OLIVE GREEN
POROSITY: LOW PERMEABILITY; POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
CORE

634.5- 636 CLAY; GRAYISH OLIVE GREEN TO LIGHT OLIVE
POROSITY: LOW PERMEABILITY; POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, SHELL-02%
FOSSILS: MOLLUSKS
CORE

636 - 641 CLAY; GRAYISH OLIVE GREEN TO LIGHT OLIVE GRAY
POROSITY: LOW PERMEABILITY; POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: QUARTZ SAND-07%, PHOSPHATIC SAND-07%
SHELL-02%
FOSSILS: MOLLUSKS
CORE INTERLAYERED WITH LENSES OF FINE GRAIN
PHOSPHATIC/QUARTZ SAND.

641 - 645 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SILT-30%, QUARTZ SAND-20%, SHELL-03%
PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS

645 - 650 WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, CLAY-05%
PHOSPHATIC SAND-03%, PHOSPHATIC GRAVEL-01%

650 - 655 AS ABOVE

655 - 660 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-07%, PHOSPHATIC SAND-05%
PHOSPHATIC GRAVEL-03%, SHELL-03%
FOSSILS: FOSSIL FRAGMENTS

660 - 665 AS ABOVE

665 - 670 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-07%, PHOSPHATIC SAND-05%
PHOSPHATIC GRAVEL-02%, SHELL-02%
FOSSILS: FOSSIL FRAGMENTS

670 - 675 AS ABOVE

675 - 680 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-07%, SHELL-07%
CLAY-07%, PHOSPHATIC SAND-03%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

680 - 685 WACKESTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-15%, CLAY-07%
PHOSPHATIC GRAVEL-07%, PHOSPHATIC SAND-05%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

685 - 690 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
ACCESSORY MINERALS: CLAY-10%, SHELL-03%
PHOSPHATIC GRAVEL-03%, PHOSPHATIC SAND-02%

690 - 695 AS ABOVE

695 - 700 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
ACCESSORY MINERALS: CLAY-07%, PHOSPHATIC SAND-01%
PHOSPHATIC GRAVEL-01%
OTHER FEATURES: MUDDY

700 - 705 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-10%
PHOSPHATIC SAND-07%, QUARTZ SAND-03%, SHELL-02%
OTHER FEATURES: DOLOMITIC

705 - 710 WACKESTONE; LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE

75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC SAND-05%, CLAY-03%
DOLOMITE-02%, PHOSPHATIC GRAVEL-01%

710 - 715 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC SAND-03%
PHOSPHATIC GRAVEL-03%, DOLOMITE-02%, SHELL-01%

715 - 720 AS ABOVE

720 - 725 WACKESTONE; YELLOWISH GRAY TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: SHELL-20%, DOLOMITE-07%
PHOSPHATIC GRAVEL-03%, PHOSPHATIC SAND-02%
FOSSILS: FOSSIL FRAGMENTS

725 - 730 WACKESTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-20%, SHELL-07%
PHOSPHATIC SAND-03%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS

730 - 735 WACKESTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-20%, IRON STAIN-15%
PHOSPHATIC SAND-03%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH

735 - 740 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
EUHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION

CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, LIMESTONE-10%
PHOSPHATIC SAND-03%, PHOSPHATIC GRAVEL-03%
FOSSILS: FOSSIL FRAGMENTS

740 - 745 DOLOSTONE; GRAYISH BROWN TO LIGHT OLIVE GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED EUHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-15%, PHOSPHATIC SAND-03%
PHOSPHATIC GRAVEL-03%, QUARTZ SAND-03%
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH

745 - 750 DOLOSTONE; GRAYISH BROWN TO LIGHT OLIVE GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-10%, PHOSPHATIC SAND-05%
PHOSPHATIC GRAVEL-03%, QUARTZ SAND-03%
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH

750 - 755 DOLOSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-07%, PHOSPHATIC SAND-02%
PHOSPHATIC GRAVEL-01%, QUARTZ SAND-01%
FOSSILS: FOSSIL FRAGMENTS

755 - 760 DOLOSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%, SHELL-02%
PHOSPHATIC SAND-01%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS

760 - 765 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%, PHOSPHATIC GRAVEL-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS

765 - 770 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE

75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%

770 - 775 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA
FORAMINIFERA LEPIDOCYCLINA OCALANDA PRESENT

775 - 780 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA
ABUNDANT LEPIDOCYCLINA SP. PRESENT.

780 - 785 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%
FOSSILS: FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA
FORAMINIFERA NUMMULITIES SP. PRESENT.

785 - 790 AS ABOVE

790 - 795 WACKESTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%, PHOSPHATIC GRAVEL-02%
FOSSILS: FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA

795 - 800 AS ABOVE

800 - 805 AS ABOVE

805 - 810 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR

GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

810 - 815 AS ABOVE

815 - 820 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-02%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

820 - 825 AS ABOVE

825 - 830 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
TEXTURE VARIES FROM A WACKSTONE TO A MUDDY PACKSTONE.

830 - 835 AS ABOVE

835 - 840 PACKSTONE; VERY LIGHT ORANGE TO NO COLOR GIVEN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-01%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

840 - 845 PACKSTONE; VERY LIGHT ORANGE
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

845 - 850 NO SAMPLES

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850  -  855   PACKSTONE; VERY LIGHT ORANGE TO NO COLOR GIVEN
              POROSITY: INTERGRANULAR
              GRAIN TYPE: INTRACLASTS, CALCILUTITE
              80% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
              GOOD INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: DOLOMITE-03%, PHOSPHATIC GRAVEL-02%
              FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
              SHARKS TEETH

855  -  855.6 PACKSTONE; VERY LIGHT ORANGE
              POROSITY: INTERGRANULAR
              GRAIN TYPE: INTRACLASTS, PELLET, SKELETAL
              80% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE
              GOOD INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              OTHER FEATURES: CHALKY
              FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS
              CORE

855.6-  857   AS ABOVE

857  -  862   DOLOSTONE; VERY LIGHT ORANGE
              POROSITY: INTERCRYSTALLINE, VUGULAR, INTERGRANULAR
              10-50% ALTERED; SUBHEDRAL
              GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
              GOOD INDURATION
              CEMENT TYPE(S): DOLOMITE CEMENT
              CORE

862  -  865   DOLOSTONE; VERY LIGHT ORANGE
              POROSITY: INTERCRYSTALLINE, VUGULAR, INTERGRANULAR
              10-50% ALTERED; SUBHEDRAL
              GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
              GOOD INDURATION
              CEMENT TYPE(S): DOLOMITE CEMENT
              CORE

865  -  870   PACKSTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
              POROSITY: INTERGRANULAR
              GRAIN TYPE: INTRACLASTS, CALCILUTITE
              80% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
              GOOD INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
              ACCESSORY MINERALS: DOLOMITE-05%, PHOSPHATIC GRAVEL-01%
              FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

870  -  875   PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
              POROSITY: INTERGRANULAR
              GRAIN TYPE: INTRACLASTS, CALCILUTITE
              80% ALLOCHEMICAL CONSTITUENTS
              GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
              GOOD INDURATION
              CEMENT TYPE(S): CALCILUTITE MATRIX
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ACCESSORY MINERALS: DOLOMITE-20%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA

875 - 880 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
OTHER FEATURES: VARVED, MEDIUM RECRYSTALLIZATION, FROSTED

880 - 885 AS ABOVE

885 - 890 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%, PHOSPHATIC GRAVEL-01%
ORGANICS-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
ECHINOID
ECHINOID NEOLAGANUM DALLI PRESENT. ORGANIC LAMINAE PRESENT.

890 - 895 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%, PHOSPHATIC GRAVEL-01%
ORGANICS-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
3-5% OF SAMPLE IS COARSE GRAINED, MODERATLY-LIGHTLY ALTERED
DOLOSTONE

895 - 900 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-20%, PHOSPHATIC GRAVEL-02%
ORGANICS-01%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
FORAMINIFERA CRIBOBULIMINA (VALVULINA) CUSHMANI PRESENT.

900 - 905 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%, PHOSPHATIC GRAVEL-02%
ORGANICS-02%
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
ECHINOID

905 - 910 DOLOSTONE; LIGHT OLIVE GRAY TO GRAYISH BROWN
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: MEDIUM TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-20%, ORGANICS-02%
PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, BENTHIC FORAMINIFERA, CONES
ECHINOID
LIMESTONE COLOR IS YELLOWISH GRAY. FORAMINIFERA DICTYOCONUS
AMERICANUS PRESENT.

910 - 915 AS ABOVE

915 - 920 AS ABOVE

920 - 925 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%, ORGANICS-02%
PHOSPHATIC GRAVEL-01%
FOSSILS: BENTHIC FORAMINIFERA, CONES
FORAMINIFERA LITUONELLA FLORIDANA AND CRIBROBULIMINA
(VALVULINA) CUSHMANI PRESENT.

925 - 930 WACKESTONE; WHITE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-20%, PHOSPHATIC GRAVEL-01%
ORGANICS-01%
FOSSILS: BENTHIC FORAMINIFERA, CONES

930 - 935 AS ABOVE

935 - 1005 NO SAMPLES

1005 - 1010 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%, PHOSPHATIC GRAVEL-01%
ORGANICS-01%
FOSSILS: CONES, FOSSIL FRAGMENTS

1010 - 1015 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%, QUARTZ SAND-05%
PHOSPHATIC GRAVEL-01%, ORGANICS-01%
FOSSILS: FOSSIL FRAGMENTS, CONES, BENTHIC FORAMINIFERA
COARSE GRAINED, WELL ROUNDED AND FROSTED QUARTZ SAND
PRESENT MAY BE CAVINGS.

1015 - 1020 AS ABOVE

1020 - 1025 WACKESTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%, ORGANICS-02%
QUARTZ SAND-02%, PHOSPHATIC GRAVEL-01%
FOSSILS: FOSSIL FRAGMENTS, CONES, BENTHIC FORAMINIFERA

1025 - 1030 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%, ORGANICS-02%
QUARTZ SAND-02%, HEAVY MINERALS-02%
FOSSILS: FOSSIL FRAGMENTS, CONES

1030 - 1035 DOLOSTONE; GRAYISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR; 10-50% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-25%, QUARTZ SAND-25%
HEAVY MINERALS-02%
FOSSILS: FOSSIL FRAGMENTS, CONES, BENTHIC FORAMINIFERA

1035 - 1040 AS ABOVE

1040 - 1045 AS ABOVE

1045 - 1050 DOLOSTONE; GRAYISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR; 10-50% ALTERED; SUBHEDRAL

GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-30%, QUARTZ SAND-20%
HEAVY MINERALS-02%
FOSSILS: CONES, BENTHIC FORAMINIFERA

1050 - 1055 GRAINSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, HEAVY MINERALS-03%
PHOSPHATIC GRAVEL-01%
FOSSILS: BENTHIC FORAMINIFERA

1055 - 1060 GRAINSTONE; GRAYISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO COARSE; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, HEAVY MINERALS-03%
PHOSPHATIC GRAVEL-01%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1060 - 1065 DOLOSTONE; OLIVE GRAY TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE; 10-50% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-07%

1065 - 1070 DOLOSTONE; LIGHT OLIVE GRAY TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-20%, QUARTZ SAND-02%
PHOSPHATIC GRAVEL-01%
FOSSILS: BENTHIC FORAMINIFERA

1070 - 1075 DOLOSTONE; LIGHT OLIVE GRAY TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE; 10-50% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-05%

1075 - 1080 DOLOSTONE; LIGHT OLIVE GRAY TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-10%, PHOSPHATIC GRAVEL-01%

FOSSILS: BENTHIC FORAMINIFERA

1080 - 1085 DOLOSTONE; LIGHT OLIVE GRAY TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-25%

1085 - 1090 PACKSTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%
FOSSILS: BENTHIC FORAMINIFERA

1090 - 1095 AS ABOVE

1095 - 1100 PACKSTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%
FOSSILS: BENTHIC FORAMINIFERA

1100 - 1105 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE; 10-50% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
40% OF DOLOMITE HAS LIGHT AND DARK COLOR BANDING.

1105 - 1110 DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 10-50% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1110 - 1115 DOLOSTONE; GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 10-50% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1115 - 1120 DOLOSTONE; DARK YELLOWISH BROWN
POROSITY: INTERCRYSTALLINE

1120 - 1125 DOLOSTONE; DARK YELLOWISH ORANGE
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; EUHEDRAL

GRAIN SIZE: FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1125 - 1130 DOLOSTONE; GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1130 - 1135 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1135 - 1140 DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1140 - 1145 WACKESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-07%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1145 - 1150 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 50-90% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-20%

1150 - 1155 AS ABOVE

1155 - 1160 AS ABOVE

1160 - 1165 DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1165 - 1170 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-25%

1170 - 1175 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN

	POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-02%
1175 - 1180	DOLOSTONE; DARK YELLOWISH BROWN POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-02%
1180 - 1185	AS ABOVE
1185 - 1190	DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-07% FOSSILS: BENTHIC FORAMINIFERA
1190 - 1195	DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE POROSITY: INTERCRYSTALLINE, INTERGRANULAR; 50-90% ALTERED SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-10% FOSSILS: BENTHIC FORAMINIFERA, CONES
1195 - 1200	DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-07%
1200 - 1201.4	DOLOSTONE; GRAYISH BROWN POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT CORE
1201.4- 1209	DOLOSTONE; GRAYISH BROWN TO VERY LIGHT ORANGE POROSITY: INTERCRYSTALLINE; 10-50% ALTERED; ANHEDRAL GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT CORE THIN ORGANIC LAMINAE PRESENT.
1209 - 1210	WACKESTONE; WHITE POROSITY: INTERGRANULAR GRAIN TYPE: INTRACLASTS, CALCILUTITE 40% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY
CORE

1210 - 1215 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
CORE

1215 - 1220 DOLOSTONE; GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1220 - 1225 NO SAMPLES

1225 - 1230 DOLOSTONE; GRAYISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-02%

1230 - 1235 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

1235 - 1240 AS ABOVE

1240 - 1245 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-03%

1245 - 1250 PACKSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: INTRACLASTS, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: FINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
FOSSILS: CONES

TOTAL DEPTH

E

Pressure Gauge Calibration Report

Certificate of Calibration

WIKA

Certificate No.: 32073
Page 1 of 2
Date of Calibration: 8/23/2005

Customer : FLOW TECHNOLOGY

P.O. BOX 8889
JACKSONVILLE, FL 32239-8889

Pressure and Temperature Measurement
WIKA Instrument Corporation
Wiegand Boulevard
Lawrenceville, Georgia 30043

Tel 770-513-8200
Fax 770-338-5118
www.wika.com
info@wika.com

Order No. : 3285916

Specification of the device under test

Object	: Dial Gauge
Manufacturer	: WIKA
Model	: 342.11 10"
Serial No.	: Z70075P
Tag	: -
Pressure range	: 0 ... 200 psi
Accuracy	: 0.1 % (of span)
Scale division / Resolution	: 0.5 psi
Method of measurement	: Gauge pressure
Output signal	: -

Working Standard (WS)

Name	: Electr. Gauge
Pressure range	: 0 ... 16 bar
Calibration-number	: 22253 12-02-2004
Accuracy	: 0.02 % (of span)
Identity	: SS 107
Recal Interval	: 1 year

Calibration parameters

Place of calibration	: Cal-Lab (Lawrenceville)
Test temperature (in °F)	: 72.0
Humidity (in %)	: 37.0
Amb. pressure (in inHg)	: 29.0
Pressure medium	: dry air
Angle position	: vertical
local gravity (in m/s^2)	: 9.79541

Used auxiliary instruments

Multimeter	: -
Resistor	: -

Comments :

Kuldeep Patel

Quality Assurance : K. Patel

Calibration technician : C. Mathew

ISO 9001 Certified

WIKA

Certificate No.: 32073

Pressure and Temperature Measurement
WIKA Instrument Corporation
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www.wika.com
info@wika.com

Calibration results

Reading DUT psi	Reading WS psi M 1	Reading WS psi M 2	Hysteresis psi	Deviation % M 1	Deviation % M 2	Pass/Fail
0.00	0.000	-0.005	0.005	0.000	0.002	PASS
20.00	20.070	20.034	0.036	-0.035	-0.017	PASS
40.00	39.946	39.904	0.042	0.027	0.048	PASS
60.00	59.895	59.868	0.027	0.052	0.066	PASS
80.00	79.892	79.881	0.011	0.054	0.060	PASS
100.00	99.886	99.875	0.011	0.057	0.063	PASS
120.00	119.993	119.915	0.078	0.004	0.042	PASS
140.00	139.932	139.902	0.030	0.034	0.049	PASS
160.00	159.948	159.904	0.044	0.026	0.048	PASS
180.00	179.962	180.058	0.096	0.019	-0.029	PASS
200.00	200.002	199.997	0.005	-0.001	0.002	PASS

The DUT is labeled with a calibration sticker, which shows the date of calibration and the date for recalibration. The recommended cycle is one year from current calibration.

Declaration of conformity:

The device under test meets the specifications as required by the manufacturer.

WIKA Instrument Corporation certifies that the above named instrument has been calibrated by comparison to laboratory standards traceable to the National Institute of Standards and Technology (NIST)

Calibration is carried out according to the following procedures:

-

ISO 10012-1 Edition 15-0101992
ANSI / NCSL Z 540-1-1994
WIKA Procedure SOP 0.2

ISO 9001 Certified

F

Generic Discharge Permit and Analytical Data

Department of Environmental Protection

Southeast District
400 N. Congress Avenue, Suite 200
West Palm Beach, Florida 33401

Jeb Bush
Governor

Colleen M. Castille
Secretary

April 15, 2005 ELECTRONIC CORRESPONDENCE

Mr. Simon A. Sunderland, P.G.
Senior Hydrologist
Water Supply Department
South Florida Water Management District
P.O. Box 24680
West Palm Beach, Florida 33416-4680
Email: ssunder@sfwmd.gov

RE: Generic Permit for Discharge of Produce Ground Water
C-23 Canal Floridan Aquifer Well Construction and Testing
DEP File No. FLG070219-001-IWF/GN

Dear Mr. Sunderland:

In response to your request for coverage under the Generic Permit for Discharges of Produced Ground Water, dated November 24, 2004, the Department of Environmental Protection hereby grants your request effective on the date of this letter. Your permit number is FLG070294. Please refer to this number in all correspondence or permit inquiries. Under F.A.C. Rule 62-621.250(19), coverage granted under this permit shall expire after five years from the issuance date of this letter.

Enclosed is a copy of the final permit. You should review the permit to become familiar with the terms and conditions. In addition to the rule requirements, the discharge for this project shall be subject to the following specific conditions:

- The discharge (end-of-pipe) shall be monitored for Turbidity and Specific Conductance every four hours during discharge, at the point of discharge. The canal water shall also be sampled and monitored for Turbidity and Specific Conductance every four hours during discharge, 150 meters upstream (background) and downstream of the discharge (within the discharge plume on the downstream side).
- The limit for Turbidity is 29 NTU above background at the downstream monitoring point; the limit for Specific Conductance is no more than 50% above background or up to 1275 micromhos/cm , whichever is greater.
- The discharge shall be shut down immediately if either limit is exceeded at the downstream sampling point, until corrective actions can be taken.

Within 30 days of the end of the project, all water quality data shall be submitted to the Department's West Palm Beach office at the letterhead mailing address, attention: Industrial Waste Section.

If you have any questions, please contact Tim Powell at telephone number (561) 681-6684 or by email to Tim.Powell@dep.state.fl.us

Executed in West Palm Beach, Florida.

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

________________________________4/15/05______
Linda A. Horne, P.G. Date
Water Facilities Administrator
Southeast District

LAH/tp

Attachment: Generic Permit for Discharge of Produce Ground Water

ec: Terry Davis, DEP/PSL terry.davis@dep.state.fl.us
Paul Sze, DEP/WPB paul.sze@dep.state.fl.us

STATE OF FLORIDA

DEPARTMENT OF ENVIRONMENTAL PROTECTION

GENERIC PERMIT

FOR THE

DISCHARGE OF PRODUCED GROUND WATER

FROM ANY NON-CONTAMINATED SITE ACTIVITY

Generic Permit for the Discharge of Produced Ground Water from any Non-Contaminated Site Activity

(1) The facility is authorized to discharge produced ground water from any non-contaminated site activity which discharges by a point source to surface waters of the State, as defined in Chapter 62-620, F.A.C., only if the reported values for the parameters listed in Table 1 do not exceed any of the listed screening values. Before discharge of produced ground water can occur from such sites, analytical tests on samples of the proposed untreated discharge water shall be performed to determine if contamination exists.

(2) Minimum reporting requirements for all produced ground water dischargers. The effluent shall be sampled before the commencement of discharge, again within thirty (30) days after commencement of discharge, and then once every six (6) months for the life of the project to maintain continued coverage under this generic permit. Samples taken in compliance with the provisions of this permit shall be taken prior to actual discharge or mixing with the receiving waters. The effluent shall be sampled for the parameters listed in Table 1.

Table 1

	Screening Values for Discharges into:	
Parameter	Fresh Waters	Coastal Waters
Total Organic Carbon (TOC)	10.0 mg/l	10.0 mg/l
pH, standard units	6.0-8.5	6.5-8.5
Total Recoverable Mercury	0.012 μg/l	0.025 μg/l
Total Recoverable Cadmium	9.3 μg/l	9.3 μg/l
Total Recoverable Copper	2.9 μg/l	2.9 μg/l
Total Recoverable Lead	0.03 mg/l	5.6 μg/l
Total Recoverable Zinc	86.0 μg/l	86.0 μg/l
Total Recoverable Chromium (Hex.)	11.0 μg/l	50.0 μg/l
Benzene	1.0 μg/l	1.0 μg/l
Naphthalene	100.0 μg/l	100.0 μg/l

(3) If any of the analytical test results exceed the screening values listed in Table 1, except TOC, the discharge is not authorized by this permit.

(a) For initial TOC values that exceed the screening values listed in Table 1, which may be caused by naturally-occurring, high molecular weight organic compounds, the permittee may request to be exempted from the TOC requirement. To request this exemption, the permittee shall submit additional information with a Notice of Intent (NOI), described below, which describes the method used to determine that these compounds are naturally occurring. The Department shall grant the exemption if the permittee affirmatively demonstrates that the TOC values are caused by naturally-occurring, high molecular weight organic compounds.

(b) The NOI shall be submitted to the appropriate Department district office thirty (30) days prior to discharge, and contain the following information:

1. the name and address of the person that the permit coverage will be issued to;
2. the name and address of the facility, including county location;
3. any applicable individual wastewater permit number(s);
4. a map showing the facility and discharge location (including latitude and longitude);
5. the name of the receiving water; and
6. the additional information required by paragraph (3)(a) of this permit.

(c) Discharge shall not commence until notification of coverage is received from the Department.

(4) For fresh waters and coastal waters, the pH of the effluent shall not be lowered to less than 6.0 units for fresh waters, or less than 6.5 units for coastal waters, or raised above 8.5 units, unless the permittee submits natural background data confirming a natural background pH outside of this range. If natural background of the receiving water is determined to be less than 6.0 units for fresh waters, or less than 6.5 units in coastal waters, the pH shall not vary below natural background or vary more than one (1) unit above natural background for fresh and coastal waters. If natural background of the receiving water is determined to be higher than 8.5 units, the pH shall not vary above natural background or vary more than one (1) unit below natural background of fresh and coastal waters. The permittee shall include the natural background pH of the receiving waters with the results of the analyses required under paragraph (2) of this permit. For purposes of this section only, fresh waters are those having a chloride concentration of less than 1500 mg/l, and coastal waters are those having a chloride concentration equal to or greater than 1500 mg/l.

(5) In accordance with Rule 62-302.500(1)(a-c), F.A.C., the discharge shall at all times be free from floating solids, visible foam, turbidity, or visible oil in such amounts as to form nuisances on surface waters.

(6) If contamination exists, as indicated by the results of the analytical tests required by paragraph (2), the discharge cannot be covered by this generic permit. The facility shall apply for an individual wastewater permit at least ninety (90) days prior to the date discharge to surface waters of the State is expected, or, if applicable, the facility may seek coverage

under any other applicable Department generic permit. No discharge is permissible without an effective permit.

(7) If the analytical tests required by paragraph (2) reveal that no contamination exists from any source, the facility can begin discharge immediately and is covered by this permit without having to submit an NOI request for coverage to the Department. A short summary of the proposed activity and copy of the analytical tests shall be sent to the applicable Department district office within one (1) week after discharge begins. These analytical tests shall be kept on site during discharge and made available to the Department if requested. Additionally, no Discharge Monitoring Report forms are required to be submitted to the Department.

(8) All of the general conditions listed in Rule 62-621.250, F.A.C., are applicable to this generic permit.

(9) There are no annual fees associated with the use of this generic permit.

Chain of Custody Record

BAR CODE

LAB USE ONLY

J.E.L. Log # 514195
P.O. #
Quote#

Jupiter Environmental Laboratories

561-718-5092 David

Company Name: ALL WEBB'S ENTERPRISES, INC
Address: 309 COMMERCE WAY
City: JUPITER State: FL Zip: 33458
Sampling Site Address: C-23 CANAL
Attn: D WEBB JR Fax/Email: davidwebbjr@allwebbs.com
Project Name: SFWMD Project #: CW050199
Sampler Name/Signature: [signature]

LAB ANALYSIS

#	Sample Label (Client ID)	Collected Date	Collected Time	Matrix Code*	# of Cont	Hex Cr	ToC	Total Hg, Cd, Cu, Pd, Zn	~~Diss~~ BM PH	8260							Field Filtered (Y/N)	Integrity OK (Y/N)	Comments
1	MC-1	10/3/05	12:00	GW	5	X	X	X	X	X									
2				~~GW~~															
3				~~GW~~															
4				~~GW~~															
5				~~GW~~															
6				~~GW~~															
7																			
8																			
9																			
0																			

Press Codes

Matrix Codes*

S Soil/Solid Sediment; GW Ground Water; WW Waste Water; DW Drinking Water; SW Surface Water; SL Sludge; O Other (Please Specify)

Pres Codes **

A- none; B- HNO_3; C- H_2SO_4; D- NaOH; E- HCl; I- Ice; O- Other; M- MeOH

Relinquished by	Date	Time	Received by	Date	Time
[signature]	10/3/05	12:50	[signature]	10/3/05	12:50

QA/QC level with report
None ___ 1 ___ 2 ___ 3 ___ See price guide for applicable fees

T.A.T. Request: ___ Standard; X Rush 24hr
FDEP ___ SFWMD ___ Date Required ___

Temp Control: Ice °C

Page 1 of ___

Jupiter Environmental Laboratories, Inc.
150 Old Dixie Highway, Jupiter, FL 33458
(561) 575-0030 • Fax (561) 575-4118 • jupiterlabs@bellsouth.net

C.O.C.# 22832A

ORIGINAL

Jupiter
Environmental Laboratories, Inc.

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

Tuesday, October 04, 2005

David Webb, Jr.
All Webb's Enterprises, Inc.
309 Commerce Way
Jupiter, FL 33458

RE: Project: 514195
Project ID: CN050199 SFWMD

Dear David Webb, Jr.:

Enclosed are the analytical results for sample(s) received by the laboratory on Monday, October 03, 2005. Results reported herein conform to the most current NELAC standards, where applicable, unless otherwise narrated in the body of the report.

The enclosed Chain of custody is a component of this package and should be retained with the package and incorporated therein.

Results for all solid matrices are reported in dry weight unless otherwise noted. Results for all liquid matrices are analyzed as received in the laboratory unless otherwise noted.

Samples are disposed of after 30 days of their receipt by the laboratory unless archiving is requested in writing. The laboratory maintains the right to charge storage fees for archived samples.

Certain analyses are subcontracted to outside NELAC certified laboratories and are designated on the report as follows: BM/E86048, ESC/E87487, KNL/E84025, PB/E82001.

A Statement of Qualifiers are available upon request.

If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Kacia Baldwin

Kacia Baldwin
kbaldwin@jupiterlabs.com

Enclosures

REPORT OF LABORATORY ANALYSIS

Jupiter
Environmental Laboratories, Inc.

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

SAMPLE SUMMARY

Project: 514195
Project ID: CN050199 SFWMD

Lab ID	**Sample ID**	Matrix	Date Collected	Date Received
514195001	MC-1	Aqueous Liquid	10/3/2005 12:00	10/3/2005 12:50

REPORT OF LABORATORY ANALYSIS

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

SAMPLE ANALYTE COUNT

Project: 514195
Project ID: CN050199 SFWMD

Lab ID	Sample ID	Method	Analytes Reported
514195001	**MC-1**	EPA 150.1	1
		EPA 200.8 (Total)	5
		EPA 7196	1
		EPA 8260B	76
		EPA 415.1	1

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

ANALYTICAL RESULTS

Project: 514195
Project ID: CN050199 SFWMD
Solid results are reported on a dry weight basis.

Lab ID: **514195001** Date Collected: 10/3/2005 12:00 Matrix: Aqueous Liquid
Sample ID: **MC-1** Date Received: 10/3/2005 12:50

GC/MS Volatiles

Preparation Method: NONE
EPA 8260B Full Scan (W) List

Parameters	Results	Units	Report Limit	DF	Prepared	By	Analyzed	By	CAS No.	Qual	RegLmt
1,1,1,2-Tetrachloroethane	U	ug/L	0.200	1	10/4/2005	KC	10/4/2005	KC	630-20-6		
1,1,1-Trichloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	71-55-6		
1,1,2,2-Tetrachloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	79-34-5		
1,1,2-Trichloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	79-00-5		
1,1-Dichloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-34-3		
1,1-Dichloroethene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-35-4		
1,1-Dichloropropene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	563-58-6		
1,2,3-Trichlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	87-61-6		
1,2,3-Trichloropropane	U	ug/L	0.200	1	10/4/2005	KC	10/4/2005	KC	96-18-4		
1,2,4-Trichlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	120-82-1		
1,2,4-Trimethylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	95-63-6		
1,2-Dibromo-3-Chloropropane	U	ug/L	0.020	1	10/4/2005	KC	10/4/2005	KC	96-12-8		
1,2-Dibromoethane (EDB)	U	ug/L	0.020	1	10/4/2005	KC	10/4/2005	KC	106-93-4		
1,2-Dichlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	95-50-1		
1,2-Dichloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	107-06-2		
1,2-Dichloropropane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	78-87-5		
1,3,5-Trimethylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-67-8		
1,3-Dichlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	541-73-1		
1,3-Dichloropropane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	142-28-9		
1,4-Dichlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	106-46-7		
2,2-Dichloropropane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	594-20-7		
2-Chloroethyl vinyl ether	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	110-75-8		
2-Chlorotoluene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	95-49-8		
2-Hexanone	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	591-78-6		
4-Chlorotoluene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	106-43-4		
4-Isopropyltoluene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	99-87-6		
4-methyl-2-pentanone	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-10-1		
Acetone	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	67-64-1		
Acrolein	U	ug/L	5.00	1	10/4/2005	KC	10/4/2005	KC	107-02-8		
Acrylonitrile	U	ug/L	5.00	1	10/4/2005	KC	10/4/2005	KC	107-13-1		
Benzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	71-43-2		
Bromobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-86-1		
Bromochloromethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	74-97-5		
Bromodichloromethane	U	ug/L	0.500	1	10/4/2005	KC	10/4/2005	KC	75-27-4		
Bromoform	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-25-2		
Bromomethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	74-83-9		

REPORT OF LABORATORY ANALYSIS

Jupiter Environmental Laboratories, Inc.

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

ANALYTICAL RESULTS

Project: 514195

Project ID: CN050199 SFWMD

Solid results are reported on a dry weight basis.

Lab ID:	**514195001**	Date Collected:	10/3/2005 12:00	Matrix:	Aqueous Liquid
Sample ID:	**MC-1**	Date Received:	10/3/2005 12:50		

Parameters	Results	Units	Report Limit	DF	Prepared	By	Analyzed	By	CAS No.	Qual	RegLmt
Carbon disulfide	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-15-0		
Carbon tetrachloride	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	56-23-5		
Chlorobenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-90-7		
Chloroethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-00-3		
Chloroform	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	67-66-3		
Chloromethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	74-87-3		
Dibromochloromethane	U	ug/L	0.400	1	10/4/2005	KC	10/4/2005	KC	124-48-1		
Dibromomethane	U	ug/L	0.500	1	10/4/2005	KC	10/4/2005	KC	74-95-3		
Dichlorodifluoromethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-71-8		
cis-1,3-Dichloropropene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	10061-01-5		
Ethyl methacrylate	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	97-63-2		
Ethylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	100-41-4		
Hexachlorobutadiene	U	ug/L	0.500	1	10/4/2005	KC	10/4/2005	KC	87-68-3		
Iodomethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	74-88-4		
Isopropylbenzene (Cumene)	U	ug/L	0.800	1	10/4/2005	KC	10/4/2005	KC	98-82-8		
Methyl ethyl ketone (MEK)	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	78-93-3		
Methylene chloride	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-09-2		
Naphthalene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	91-20-3		
Styrene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	100-42-5		
Tetrachloroethene	1.87	ug/L	0.200	1	10/4/2005	KC	10/4/2005	KC	127-18-4		
Toluene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-88-3		
Trichloroethene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	79-01-6		
Trichlorofluoromethane	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-69-4		
Vinyl acetate	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	108-05-4		
Vinyl chloride	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	75-01-4		
cis-1,2-Dichloroethene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	156-59-2		
cis-1,4-Dichloro-2-butene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	1476-11-5		
m & p-xylene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	1330-20-7[m		
n-Butylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	104-51-8		
n-propylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	103-65-1		
o-Xylene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	95-47-6		
sec-Butylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	135-98-8		
tert-Butyl methyl ether (MTBE)	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	1634-04-4		
tert-Butylbenzene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	98-06-6		
trans-1,2-Dichloroethene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	156-60-5		
trans-1,3-Dichloropropene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	10061-02-6		
trans-1,4-Dichloro-2-butene	U	ug/L	1.00	1	10/4/2005	KC	10/4/2005	KC	110-57-6		
Dibromofluoromethane (S)	110	%	64-144	1	10/4/2005	KC	10/4/2005	KC	1868-53-7		
Toluene d8 (S)	77	%	75-130	1	10/4/2005	KC	10/4/2005	KC	2037-26-5		
4-Bromofluorobenzene (S)	87	%	75-135	1	10/4/2005	KC	10/4/2005	KC	460-00-4		

REPORT OF LABORATORY ANALYSIS

Jupiter Environmental Laboratories, Inc.
150 S. Old Dixie Highway
Jupiter, FL 33458
Phone: (561)575-0030
Fax: (561)575-4118

ANALYTICAL RESULTS

Project: 514195
Project ID: CN050199 SFWMD
Solid results are reported on a dry weight basis.

Lab ID: **514195001** Date Collected: 10/3/2005 12:00 Matrix: Aqueous Liquid
Sample ID: **MC-1** Date Received: 10/3/2005 12:50

Parameters	Results	Units	Report Limit	DF	Prepared	By	Analyzed	By	CAS No.	Qual	RegLmt
General Chemistry											
pH by EPA 150.1 (ALL MATRIX) List											
pH	7.9	-log[H+]		1			10/3/2005	KC			
Hexavalent Chromium by EPA 7196 [REF] (W List											
Hexavalent Chromium	U	ug/L	10	1			10/4/2005	PB	18540-29-9		
TOC by EPA 415.1 [REF] (W) List											
TOC	6.4	mg/L	2.0	1			10/4/2005	PB			
Metals											
EPA 200.8 Metals (W) List											
Copper	U	mg/L	0.0012	1	10/4/2005	ZS	10/4/2005	ZS	7440-50-8		
Zinc	0.0036	mg/L	0.0020	1	10/4/2005	ZS	10/4/2005	ZS	7440-66-6		
Cadmium	U	mg/L	0.00020	1	10/4/2005	ZS	10/4/2005	ZS	7440-43-9		
Mercury	U	mg/L	0.0010	1	10/4/2005	ZS	10/4/2005	ZS	7439-97-6		
Lead	U	mg/L	0.0010	1	10/4/2005	ZS	10/4/2005	ZS	7439-92-1		

REPORT OF LABORATORY ANALYSIS

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Well Benchmark Survey Report

GCY
INCORPORATED
PROFESSIONAL SURVEYORS & MAPPERS

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LB 4108

SURVEYOR'S REPORT

1. This report is prepared for the benefit of All Webbs Enterprises, Inc.

2. A benchmark was placed at the new well-site which is located on the South side of the C-23 canal, ¼ miles east of County Road 609 at the approximate Latitude of N 27°12'21.3" and Longitude of W 080°28'32.5" as located by a Garmin handheld GPS unit. Said benchmark is described as a Mag-nail and aluminum washer on the Northwest corner of a 6'x 6' concrete pad constructed around the new well and is stamped "GCY, Inc BM 105-15A".

3. The elevation of the above described benchmark is 33.39 feet NGVD 1929. The origin of the elevation is benchmark "F009" (NGS PID AF7687). The NGVD 1929 elevation used for this benchmark came from the computer file "NGVD29.txt" file received from the South Florida Water Management District.

Date of Survey: March 6, 2006

Peter Andersen
Professional Surveyor and Mapper
Florida Certification No. 5199

Job Number: 05-1069-01-01

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