Hydrogeologic Investigation of the Floridan Aquifer System Moore Haven Site Glades County, Florida

Technical Publication WS-39

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ACRONYMS AND ABBREVIATIONS

ASR	aquifer storage and recovery
bpl	below pad level
CERP	Comprehensive Everglades Restoration Plan
cm	centimeter
DDC	Diversified Drilling Corp
FAS	Floridan aquifer system
ft	foot
ft^3	cubic foot
gal	gallon
gpm	gallons per minute
HDPE	high-density polyethylene
in.	inch
lb	pound
m	meter
mg/L	milligrams per liter
mi	mile
µmhos	micro-mhos
psi	pounds per square inch
psig	pounds per square inch gauge
SAS	surficial aquifer system
SFWMD	South Florida Water Management District
TDS	total dissolved solids
UFA	upper Floridan aquifer
USACE	U.S. Army Corps of Engineers
USDW	Underground Source of Drinking Water
yd^3	cubic yard

EXECUTIVE SUMMARY

The Comprehensive Everglades Restoration Plan (CERP) – a joint effort by the U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD) – focuses on storing available water otherwise lost to tide. Aquifer storage and recovery (ASR) technology has been identified as a major storage option, particularly in the vicinity of Lake Okeechobee. The Lake Okeechobee ASR Pilot Project was designed to address some of the technical and regulatory uncertainties of storing treated surface water via ASR systems. Hydrogeologic testing of monitor wells at three distinct sites was one of the first tasks in evaluating ASR potential proximal to Lake Okeechobee.

The purpose of this project was to provide site-specific hydrogeologic characterization of the Floridan aquifer system (FAS) at three separate sites in support of the Lake Okeechobee ASR Pilot Project. Data collected from the testing and monitoring of the wells will be instrumental for site selection of future ASR systems, inclusion in the CERP ASR Regional Study, development of a hydrogeologic model, and other future regional hydrogeologic and hydrogeochemical assessments.

This report primarily describes the drilling, construction, and testing of the test/monitor well identified as GLF-6 (the designation used to obtain a SFWMD well construction permit [Permit Number SF041901A]) at Moore Haven, Florida. It summarizes and presents data obtained during drilling and testing operations as well as analyses conducted. GLF-6 was constructed on SFWMD-owned right-of-way proximal to the S-77 water control structure on the C-43 Canal (Caloosahatchee River) in the northwest quarter of Section 12 of Township 42 South, Range 32 East.

The scope of the investigation consisted of constructing and testing a test/monitor well drilled to a total depth of 2,030 feet (ft) below pad level (bpl). If Moore Haven is chosen as a site for an ASR system in the future, GLF-6 will have to be modified to accommodate monitor zone(s) consistent with any future ASR well.

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

- Lithologic information and geophysical logs obtained from GLF-6 indicate that soft non-indurated detrital clays, silts, sands, and poorly indurated mudstones of the Hawthorn Group are present from 160 to 850 ft bpl. These low-permeability sediments act as confining units separating the FAS from the overlying surficial aquifer system (SAS).
- 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 845 ft bpl.
- Lithologic and geophysical logs, packer test results, and specific capacity test results indicate a low-production capacity of the upper Floridan aquifer (UFA) from 855 to 1,110 ft bpl.
- The lower Ocala Limestone and upper Avon Park Formation from 1,110 to 1,600 ft bpl form an inter-aquifer confining unit within the FAS at the Moore Haven site.
- A productive horizon in the Avon Park Permeable Zone (APPZ) from 1,600 to 1,740 ft bpl yielded a specific capacity of 175 gallons per minute (gpm)/ft of drawdown.
- The drilling data as well as open hole and production-type logs (e.g., flow, temperature logs) indicated good production from 1,600 to 1,740 ft bpl. Below 1,740 ft bpl, the productive capacity is limited (as indicated by the fluid-type logs), suggesting low-permeability, semi-confining units are present near the base of the productive horizon.
- Composite water quality sampling during straddle-packer testing and geophysical log data were used to identify the base of the Underground Source of Drinking Water (USDW) at approximately 1,860 ft bpl. Total dissolved solids (TDS) concentrations below 1,950 ft bpl are similar to seawater concentrations.

INTRODUCTION

Background

The Comprehensive Everglades Restoration Plan (CERP) – a joint effort by the U.S. Army Corps of Engineers (USACE) and South Florida Water Management District (SFWMD) – focuses on storing available water otherwise lost to tide. Aquifer storage and recovery (ASR) technology has been identified as a major storage option, particularly in the vicinity of Lake Okeechobee. The Lake Okeechobee ASR Pilot Project was designed to address some of the technical and regulatory uncertainties of storing treated surface water via ASR systems. Hydrogeologic testing of monitor wells at three distinct sites was one of the first tasks in evaluating ASR potential proximal to Lake Okeechobee.

The purpose of this project was to provide site-specific hydrogeologic characterization of the Floridan aquifer system (FAS) at three separate sites in support of the Lake Okeechobee ASR Pilot Project. Data collected from the testing and monitoring of the wells will be instrumental for site selection of future ASR systems, inclusion in the CERP ASR Regional Study, development of a hydrogeologic model, and other future regional hydrogeologic and hydrogeochemical assessments.

Scope

This report primarily describes the drilling, construction, and testing of a 12-inch (in.) diameter test/monitor well identified as GLF-6 at a site in Moore Haven, Florida. It summarizes and presents data obtained during drilling and testing as well as the analyses conducted.

Project Description

The Moore Haven test site is located approximately 65 miles (mi) west of the Atlantic Ocean and approximately 500 feet (ft) west of the western boundary of Lake Okeechobee in unincorporated Glades County, Florida. The test/monitor well (GLF-6) was constructed on a SFWMD-owned right-of-way proximal to the S-77 water control structure on the C-43 Canal (Caloosahatchee River) in the northwest quarter of Section 12 of Township 42 South, Range 32 East (**Figure 1**).

The SFWMD issued a notice to proceed to Diversified Drilling Corp (DDC) on April 16, 2001 to drill and construct three test/monitor wells at separate locations proximal to Lake Okeechobee. On July 18, 2001, construction began on the test/monitor well identified as GLF-6. Drilling, testing, and construction of the well was completed on January 15, 2002, with some follow-up geophysical logging occurring on February 1, 2002.

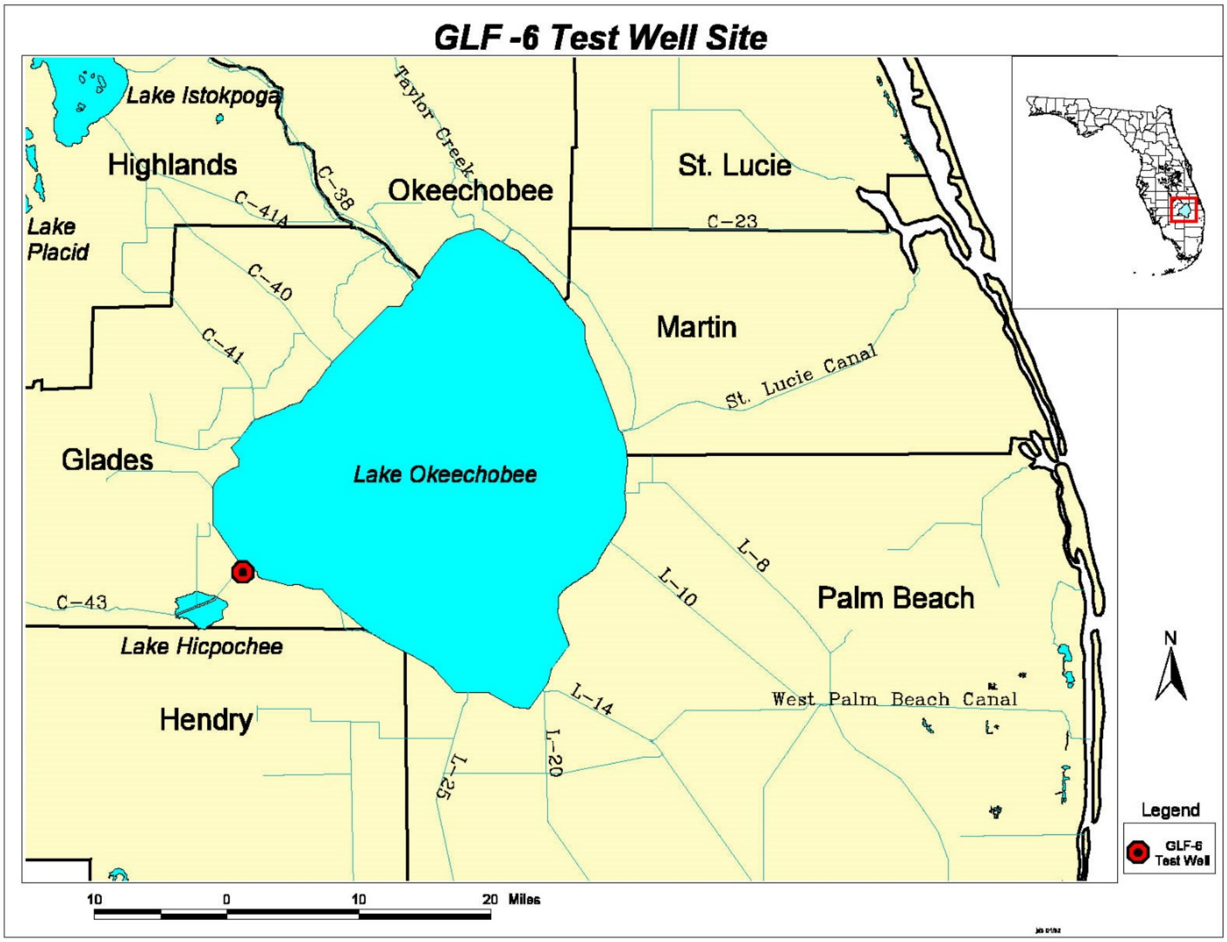

Figure 1. Project Location Map (GLF-6)

EXPLORATORY DRILLING AND WELL CONSTRUCTION

Test/Monitor Well (GLF-6)

DDC began site preparation in June 2001. After minor clearing and rough grading of the site, the ground surface beneath the drill rig and settling tanks was lined with an impermeable high-density polyethylene (HDPE) liner, which was covered with 10 in. of granular fill to protect the liner. A temporary drilling pad was constructed using crushed limestone 2 ft in height above pad level, surrounding the perimeter of the rig and settling tanks. The well pad was constructed to contain drilling fluids and formation waters produced during well drilling, testing, and construction activities (**Figure 2**).

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

Lithologic (well cuttings), packer test, and borehole geophysical log data were used to determine the actual casing setting depths. The pilot hole was reamed to specific diameters and casings were installed. Three concentric steel casings (24-, 18-, and 12-in. diameters) were used in the construction of GLF-6.

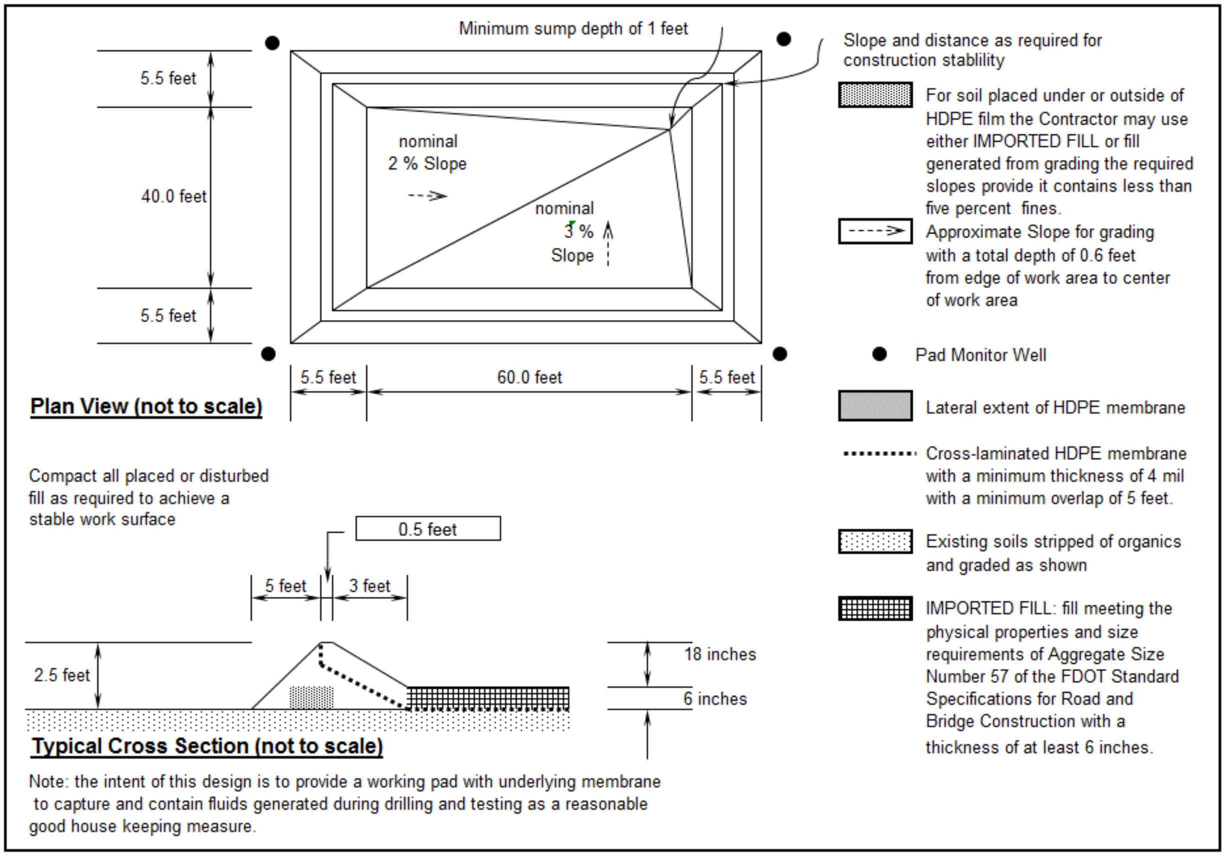

Figure 2. Well Pad Schematic

DDC initiated drilling activities for GLF-6 on July 18, 2001. Drilling operations began by advancing a 12.75-in. diameter pilot hole to a depth of 83 ft below pad level (bpl) via the mud-rotary method, using a nominal 29-in. diameter staged reaming bit. In accordance with well construction specifications, the reamed borehole was geophysically logged to verify depths and to calculate cement volumes for subsequent casing cement grouting operations (**Appendix A**, Figure A-1) (Note: figure number corresponds to the geophysical logging run number.) On July 19, 2001, DDC installed the nominal 24-in. diameter steel pit casing, (ASTM A53, Grade B, and 0.375-in. wall thickness) in the borehole to a depth of 81 ft bpl. The annulus was pressure grouted to land surface using 231 cubic feet (ft^3) of ASTM Type II Portland cement (15.6 pounds per gallon [lb/gal]). A factory mill certificate for the 24-in. diameter steel pit casing is provided in **Appendix B**.

After installing the 24-in. diameter pit casing, DDC continued drilling the pilot hole with a nominal 8-in. diameter bit using the mud-rotary method. On July 24, 2001, DDC advanced the pilot hole through the Pleistocene/Pliocene-aged sediments and into the Hawthorn Group to a depth of 216 ft bpl. That same day, MV Geophysical Surveys, Inc. (MV Geophysical) of Fort Myers, Florida, geophysically logged the pilot hole from 80 to 216 ft bpl. The logging suite consisted of the following: four-arm caliper, natural gamma ray, spontaneous potential, borehole compensated sonic, and dual induction/laterolog combination. The individual log traces from geophysical log are presented in **Appendix A**, Figure A-2.

Using well cuttings and geophysical log data, the base of the surficial aquifer system (SAS) was identified at approximately 160 ft bpl where a greenish-gray phosphatic sand-silt-clay unit was first encountered. In addition, the natural gamma log indicated an increase in natural gamma ray emissions, which corresponded to the less permeable silty phosphatic clays found at similar depths. On July 25, 2001, DCC reamed the nominal 8-in. diameter pilot hole to 207 ft bpl using a nominal 23-in. diameter staged bit reamer. The nominal 23-in. borehole was geophysically logged to verify depth and calculate cement volumes for subsequent grouting operations. The caliper log showed no unusual borehole conditions that would prohibit proper installation of the 18-in. diameter casing (**Appendix A**, Figure A-3). DDC then installed the 18-in. diameter steel casing (ASTM A53, Grade B, and 0.375-in. wall thickness) in the nominal 23-in. diameter borehole to a depth of 205 ft bpl. Once installed, the 18-in. diameter steel pipe was pressure grouted using 246 ft^3 of ASTM Type II neat cement. An additional 64 ft^3 of ASTM Type II neat cement was used to bring cement levels in the annulus to the surface, completing surface casing installation on July 26, 2001.

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

With the surface casing installed, DDC advanced the nominal 8-in. diameter pilot hole inside the surface casing via the closed circulation mud-rotary drilling method on August 3, 2001. Drilling operations continued through the Oligocene and upper Eocene-aged carbonates of the upper Floridan aquifer (UFA) to a depth of 1,299 ft bpl. Several 4-in. diameter conventional cores were collected from the following depth intervals: 784 to 798 ft bpl, 874 to 886 ft bpl, and 988 to 1,006 ft bpl. During coring operations, various lengths of core were retrieved. A total core recovery efficiency of 73% was achieved from 784 to 1,006 ft bpl.

While preparing the pilot hole for logging operations, water flow developed at a depth of approximately 1,140 ft bpl, which diluted the drilling fluids and reduced the hydrostatic pressure of the mud column. As a result of this pressure reduction, unconsolidated quartz sand intervals within the lower Arcadia Formation (i.e., the Hawthorn Group) became unstable and backfilled the borehole from 750 to 1,299 ft bpl. Consequently, DDC removed the quartz sand from within the borehole to a depth of 1,075 ft bpl, allowing the remaining volume of sand to stay in place to help seal off a potentially permeable zone at 1,120 ft bpl.

On August 15, 2001, Schlumberger Wireline Services began geophysical logging operations within the nominal 8-in. diameter pilot hole from 205 to 1,075 ft bpl. The geophysical logging suite included conventional and specialty logs as follows: caliper, spontaneous potential, natural gamma ray spectrometry, high resolution array induction, dipole sonic imager, compensated density with photoelectric factor, compensated neutron, ultrasonic borehole imager, and full bore formation micro-imager. A composite of the available geophysical logs are included in **Appendix A**, Figure A-4.

Lithologic data are included in **Appendix C**. A review of lithologic data and geophysical logs from the subject borehole indicates that the top of the FAS was at a depth of approximately 850 ft bpl. The final 12-in. steel production casing was set at a depth of 855 ft bpl in order to

- seal off overlying silty clays of the Hawthorn Group;
- facilitate reverse-air drilling operations to an anticipated depth of 2,000 ft bpl; and
- locate the casing in a competent, well-indurated rock unit.

Therefore, on August 16, 2001, the nominal 8-in. diameter pilot hole was temporarily backfilled with ⅜-in. diameter crushed limestone gravel to approximately 710 ft bpl. DDC reamed the nominal 8-in. diameter pilot hole using a nominal 17-in. diameter staged bit reamer to a depth of 859 ft bpl. On August 23, 2001, DDC circulated and geophysically logged (caliper and natural gamma) the nominal 17-in. diameter borehole to its total depth. The caliper log trace showed no unusual borehole conditions that would prohibit proper installation of the 12-in. diameter casing to 855 ft bpl (**Appendix A**, Figure A-5). The 12-in. diameter casing was installed (ASTM A53, Grade B, and 0.375-in. wall thickness) to a depth of 855 ft bpl. The factory mill certificate and the casing installation log for the 12-in. diameter casing are provided in

Appendix B. DDC circulated approximately 15,000 gal of fluid through the annular space to displace the heavy drilling mud that was previously required for borehole stabilization to reduce potential mixing of grout and drilling mud.

After the post-conditioning water flush, pressure-grouting operations began on August 23, 2001, by installing tremie pipe (2.375-in. diameter) to 752 ft bpl. A volume of 410 ft^3 (350 sacks at 94 lb/sack) of ASTM C-150 Type II neat cement was pumped during pressure-grouting operations. A temperature/gamma survey was conducted 12 hours after cementing operations ceased (**Appendix A**, Figure A-6) to confirm the top of the cement within the annulus as a result of pressure grouting. An additional 285 ft^3 of ASTM Type II neat cement was pumped on August 24, 2001, via the tremie method causing cement returns at the surface. Actual cement volumes pumped during casing installation were in close agreement to theoretical volumes.

Once grouting operations were completed, DDC installed a well header on the 12-in. diameter steel casing and a pressure test was conducted on August 29, 2001. During the course of the 60-minute pressure test (from 10:06 am to 11:06 am), the total pressure within the 12-in. diameter casing decreased by 0.75 pounds per square inch (psi), representing a 1.5% decline, which was well within the test tolerance limit of ±5% (**Table 1**).

Table 1. Summary of Pressure Test of 12-in. Diameter Casing (GLF-6)

Elapsed Time (minutes)	Pressure Reading (psi)	Change in Pressure (psi)
0	50.00	0.00
5	50.00	0.00
10	50.00	0.00
15	50.00	0.00
20	50.00	0.00
25	50.00	0.00
30	50.00	0.00
35	49.75	0.25
40	49.75	0.25
45	49.50	0.50
50	49.50	0.50
55	49.25	0.75
60	49.25	0.75

Total pressure change = 0.75 psi.

Following the pressure test, DDC drilled through the cement plug at the base of the final casing string and began to remove the temporary backfill material (⅜-in. diameter crushed limestone and quartz sand) from the original pilot hole via the mud-rotary technique. DDC re-drilled the pilot hole to its original total depth of 1,299 ft bpl on August 30, 2001.

On September 11, 2001, the fourth conventional core was collected from 1,299 to 1,317 ft bpl. The recovered length of core material was 18 ft (100% recovery efficiency). DDC then drilled a nominal 8-in. diameter pilot hole from 1,317 to 1,571 ft bpl via the mud-rotary method. On September 15, 2001, DDC completed the fifth conventional core from 1,571 to 1,591 ft bpl, with 100% of the core recovered at the surface. Mud-rotary drilling continued through the Eocene-aged carbonates to a depth of 1,602 ft bpl.

A cavernous dolomitic limestone-dolostone unit was encountered 1,602 ft bpl that caused a loss of mud circulation and a 2-ft drop of the drill rod. DDC re-mixed and circulated approximately 12,000 gal of drilling fluid in an effort to regain circulation; these efforts were unsuccessful. A decision was made to switch to the reverse-air drilling method to continue pilot-hole drilling to the anticipated depth of 2,000 ft bpl. Consequently, DDC reconfigured the drilling equipment to accommodate reverse-air drilling. In the C-43 Canal, SFWMD personnel installed water quality probes equipped with sondes to collect temperature, pH, specific conductance, dissolved oxygen, and turbidity data. The probes were deployed 100 meters (m) upstream, 100 m downstream, and 800 m downstream from the point of discharge. During reverse-air drilling, formation water was diverted through a series of 7,500-gal settling tanks then discharged into the C-43 Canal via a 12-in. diameter PVC pipe equipped with a silt screen to minimize particulate matter being discharged. SFWMD personnel collected water quality data (three times daily) from the C-43 Canal during discharges produced from GLF-6 to comply with Florida Department of Environmental Protection-issued National Pollutant Discharge Elimination System (NPDES) permit monitoring requirements (Permit No. FL0186279).

On September 18, 2001, DDC began to drill a nominal 8-in. diameter pilot hole from 1,602 to 1,788 ft bpl via the reverse-air drilling method. On September 21, 2001, the sixth conventional core was completed from 1,788 to 1,795 ft bpl. The recovered length of core material was only 2 ft (29% recovery efficiency) as the core barrel plugged at 1,795 ft bpl. On September 25, 2001, DDC completed drilling operation of the pilot hole to a total depth of 2,030 ft bpl. Once the pilot hole was completed, it was air developed and prepared for geophysical logging operations.

On September 26, 2001, Schlumberger Wireline Services began specialty geophysical logging operations within the nominal 8-in. diameter pilot hole from 855 to 2,030 ft bpl. The following geophysical logs were run: natural gamma-induction neutron-density combination; formation micro-resistivity imager; dipole sonic imager; density caliper; spontaneous potential; resolution array induction; compensated density with photoelectric factor; and compensated neutron. A composite of the available geophysical logs is included in **Appendix A**, Figure A-7.

On October 3, 2001, DDC placed a nominal 8-in. diameter bit and drill string into the pilot hole and removed the naturally occurring backfill material from 1,690 to 2,030 ft bpl via the reverse-air drilling method. A video survey was conducted to evaluate borehole stability within the open section (855 to 2,030 ft bpl) of the borehole. On October 8, 2001, MV Geophysical completed an unobstructed video log to the full depth of the nominal 8-in. diameter pilot hole. The video survey indicated that the borehole was relatively stable but highly fractured and cavernous below 1,600 ft bpl. On October 12, 2001, MV Geophysical successfully ran a suite of production logs, including a flowmeter run under dynamic and static conditions, a fluid resistivity/high-resolution temperature log, and a four-arm caliper natural gamma log to 1,970 ft bpl. A composite of the production log traces completed by MV Geophysical is included **Appendix A**, Figure A-8.

Straddle-packer test intervals were selected using the information provided by analysis of the geophysical logs and lithologic data, and the first of six tests began on October 22, 2001. The purpose of the tests was to characterize the water quality and production capacities of specific intervals within the larger open-hole interval (855 to 2,030 ft bpl). Hydraulic characterization of intervals having total dissolved solids (TDS) concentration >10,000 milligrams per liter (mg/L) was not considered due to their limited potential for ASR application. This TDS concentration also corresponds to the Underground Source of Drinking Water (USDW), defined as an aquifer containing water with a TDS concentration of <10,000 mg/L.

During the course of packer testing operations, MV Geophysical obtained water samples from the well bore every 100 ft from 1,500 to 1,970 ft bpl via a downhole wireline fluid sampler. Field parameters analyzed included temperature, pH, specific conductance, oxidation-reduction potential, and chloride. The water quality results from the individual fluid samples are summarized in the geophysical logging section of this report.

During hydraulic testing of the lower section of the nominal 8-in. pilot hole, DDC began incremental but permanent back-plug operations of the bottom 285 ft of the diameter pilot hole. The purpose of the back-plugging was to permanently isolate the lowermost permeable zone above the base of the USDW. Back-plugging operations began on October 25, 2001, and completed on November 8, 2001. During back-plugging operations, DDC pumped 21 cubic yards (yd^3) of pea-sized gravel and 40 sacks (52 ft^3) of Type II neat cement. This volume brought cement levels from the base of the pilot hole at 2,030 ft bpl to 1,745 ft bpl.

DDC completed packer-testing operations on November 21, 2001 (see the packer test section of this report for a description of the methods and a summary of the results). The water quality data obtained from the straddle-packer tests were used with the geophysical logs to identify the base of the USDW at approximately 1,860 ft bpl.

On January 11, 2002, the final stage of well construction began with DDC installing a semi-permanent inflatable packer at 1,560 ft bpl. The purpose of the packer was to isolate the brackish to saline waters below 1,560 ft bpl, prohibiting inter-aquifer transfer of water and allowing flexibility in the future, final design of GLF-6 (e.g., single or dual-zone monitor well). The well completion for GLF-6 is summarized here and illustrated in **Figure 3**:

- Permanent steel casing (12-in. diameter) set to 855 ft bpl;
- Open hole interval from 855 to 1,560 ft bpl;
- Long-term 7-in. diameter (Tam) inflatable packer set at 1,560 ft bpl;
- Open hole interval from 1,560 to 1,745 ft bpl; and
- Nominal 8-in. diameter pilot hole, back-plugged using pea-sized gravel and topped with neat cement from 1,745 to 2,030 ft bpl.

From January 7 to 11, 2002, DDC installed a 12-in. diameter wellhead and a 6-ft by 6-ft concrete pad with 4-ft high steel bollards, completing well construction activities at this site. DDC completed demobilization and site restoration on January 15, 2002. On February 1, 2002, a final suite of production logs were run to better assess the production capacity of the open hole section of the well from 855 to 1,565 ft bpl (**Appendix A**, Figure A-9). **Table 2** summarizes activities related to GLF-6 during the approximately 10 months of well construction and testing. After construction was completed, GLF-6 was surveyed relative to permanent reference points by a Florida-registered land surveyor, and located on a site plan map by latitude and longitude.

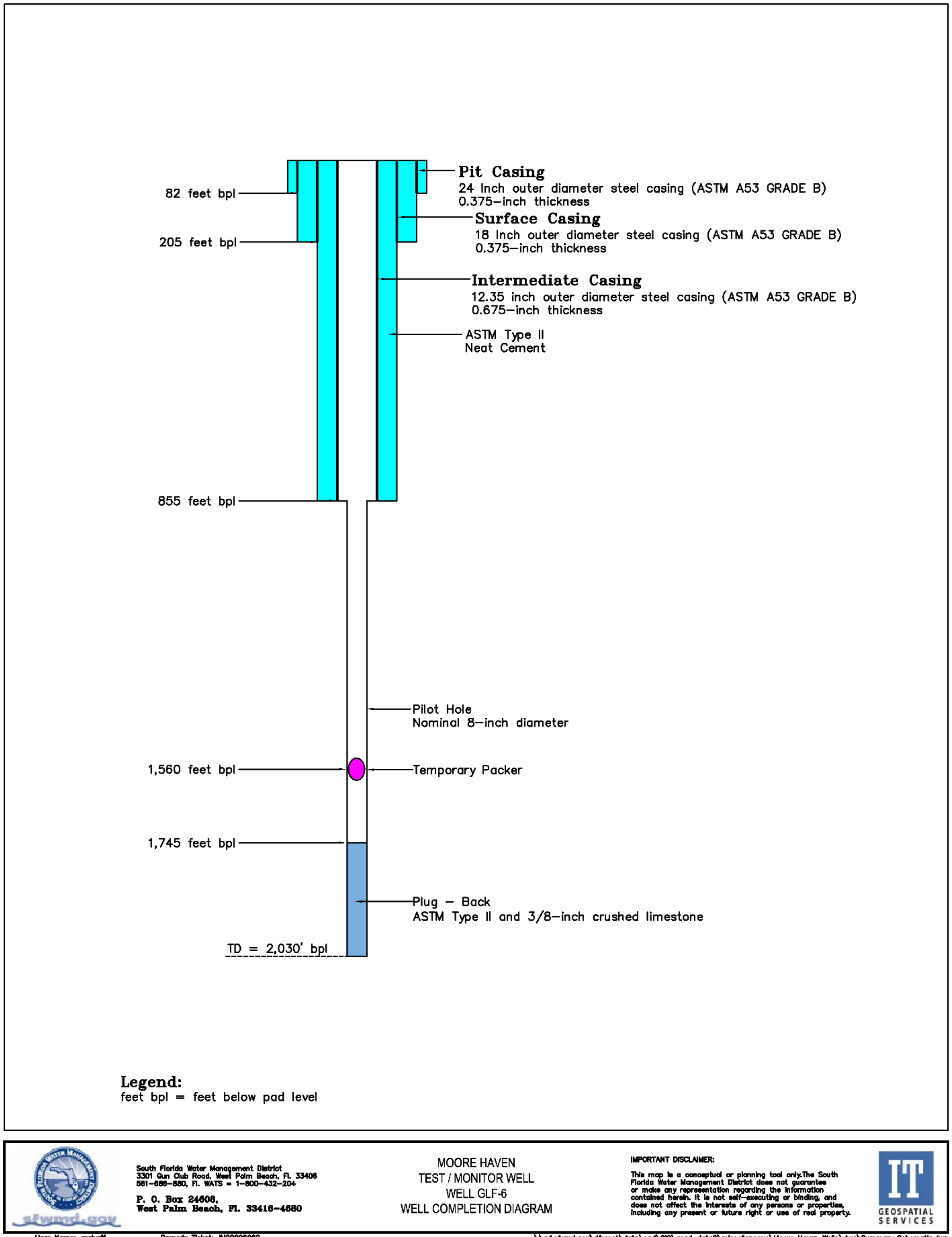

Figure 3. Well Completion Diagram; Test/Monitoring Well GLF-6

Table 2. Summary of Well Construction and Testing Activities (GLF-6)

Date	Description of Activities
04/16/01	Project Initiation (Notice to Proceed)
06/28/01	Site preparation and mobilization
07/18/01	Drilled a 12.750-in. pilot hole to 83 ft bpl
07/19/01	Reamed pilot hole using a nominal 30 in. diameter bit to 83 ft bpl
07/19/01	Conducted caliper/natural gamma survey on reamed borehole (Run 1)
07/19/01	Installed pit casing (80 ft; 24-in. diameter steel)
07/24/01	Drilled a 7.875-in. diameter pilot hole to 216 ft bpl
07/24/01	Conducted geophysical logging on pilot hole to 216 ft bpl (Run 2)
07/25/01	Reamed pilot hole with a nominal 23-in. diameter bit to 206 ft bpl
07/25/01	Conducted caliper/natural gamma survey on reamed borehole (Run 3)
07/25/01	Installed surface casing (205 ft; 18-in. diameter steel)
08/01/01	Drilled a 7.875-in. diameter pilot hole to 784 ft bpl
08/02/01	Cored from 784 to 798 ft bpl (2 ft of recovery)
08/03/01	Drilled a 7.875-in. diameter pilot hole to 875 ft bpl
08/06/01	Cored from 874 to 886 ft bpl (12 ft of recovery)
08/07/01	Drilled a 7.875-in. diameter pilot hole to 988 ft bpl
08/08/01	Cored from 988 to 1,006 ft bpl (18 ft of recovery)
08/09/01	Drilled a 7.875-in. diameter pilot hole to 1,299 ft bpl
08/15/01	Conducted geophysical logging on pilot hole to 1,075 ft bpl (Schlumberger Wireline Service - Run 4)
08/16/01	Back filled pilot hole to 710 ft bpl with crushed limestone
08/21/01	Reamed pilot hole with nominal 17-in. diameter bit to 859 ft bpl
08/23/01	Conducted caliper/natural gamma survey on reamed borehole to 859 ft bpl (Run 5)
08/23/01	Installed 12-in. diameter steel production casing to 855 ft bpl
08/23/01	Pressure grouted using 350 sacks of neat cement
08/24/01	Run temperature survey to verify top of cement at 336 ft bpl (Run 6)
08/24/01	Second stage of grouting (225 sacks of neat cement) completed to land surface
08/29/01	Conducted 50-psi pressure test of 12-in. diameter casing
08/30/01	Drilled a 7.875-in. diameter pilot hole to 1,299 ft bpl
09/11/01	Cored from 1,299 to 1,317 ft bpl (18 ft of recovery)
09/13/01	Drilled a 7.875-in. diameter pilot hole to 1,571 ft bpl
09/15/01	Cored from 1,571 to 1,591 ft bpl (20 ft of recovery)
09/17/01	Drilled a 7.875-in. diameter pilot hole to 1,603 ft bpl (lost circulation at approximately 1,603 ft bpl)
09/18/01	Drillers switched to reverse-air drilling method
09/20/01	Drilled a 7.875-in. diameter pilot hole to 1,788 ft bpl
09/21/01	Cored from 1,785 to 1,795 ft bpl (2 ft of recovery)
09/22/01	Drilled a 7.875-in. diameter pilot hole to 1,910 ft bpl
09/24/01	Drilled a 7.875-in. diameter pilot hole to 1,975 ft bpl
09/25/01	Drilled a 7.875-in. diameter pilot hole to 2,020 ft bpl
09/26/01	Conducted geophysical logging on pilot hole to 2,020 ft bpl (Schlumberger Wireline Services-Run No. 7). Note: Dipole seismic imager tool stuck in hole at 855 ft bpl
10/03/01	Cleaned pilot hole with 7.875-in. diameter bit from 1,650 to 1,970 ft bpl
10/04/01	Cleaned pilot hole with 7.875-in. diameter bit from 1,970 to 2,030 ft bpl
10/08/01	Ran video survey on pilot hole to 2,026 ft bpl (part of Run No.8)
10/10/01	Cleaned pilot hole with 7.875-in. diameter bit to 2,030 ft bpl
10/12/01	Conducted geophysical logging on pilot hole to 1,970 ft bpl (Production Type Logs - Run No. 8)
10/22/01	Packer test conducted on interval from 1,587 to 2,030 ft bpl

Date	Description of Activities
10/24/01	Collected water samples using thief sampler every 100 ft from 1,500 to 1,970 ft bpl
10/26/01	Pumped 7 yd^3 of pea gravel in wellbore
10/29/01	Pumped 6 yd^3 of pea gravel and 10 sacks of neat cement in wellbore
11/02/01	Packer test conducted on interval from 1,587 to 1,884 ft bpl
11/05/01	Pumped 3 yd^3 of pea gravel in wellbore
11/06/01	Pumped 3 yd^3 of pea gravel and 10 sacks of neat cement in wellbore
11/07/01	Pumped 2 yd^3 of pea gravel and 20 sacks of neat cement in wellbore
11/09/01	Packer test conducted on interval from 1,587 to 1,745 ft bpl
11/15/01	Packer test conducted on interval from 1,440 to 1,490 ft bpl
11/19/01	Packer test conducted on interval from 1,135 to 1,185 ft bpl
01/11/02	Set temporary Packer at 1,560 ft bpl
01/15/02	Completed site restoration and demobilization

HYDROGEOLOGIC TESTING

Specific information was collected during the drilling program to determine the lithologic, hydraulic, and water quality characteristics of the FAS at the Moore Haven site. The data were used in the preliminary design of test/monitor well GLF-6.

Formation Sampling

Geologic formation samples (i.e., well cuttings) were collected, washed, and described (using the Dunham [1962] classification scheme) on site while drilling the pilot hole. Formation samples were collected and separated based on their dominant lithologic or textural characteristics and, to a lesser extent, color. The representative formation samples were sent to the Florida Geological Survey for detailed analysis and long-term storage. The field lithologic descriptions and Florida Geological Survey lithologic well log for GLF-6 are provided in **Appendix C**. During drilling of GLF-6, DDC obtained conventional cores using a 4-in. diameter, 20-ft long diamond-tipped core barrel. Six rock cores of various lengths were recovered from the FAS between 784 and 1,795 ft bpl, with core recoveries ranging from 14% to 100%. The cores were sent to Core Laboratories in Midland, Texas to determine the following parameters: horizontal and vertical permeability; porosity; grain density; elastic, electrical, and acoustic properties; and lithologic character. **Appendix D** provides a photolog of the entire length of the core as well as thin-section data interpretation on select locations within the core.

Formation Fluid Sampling

During reverse-air drilling of the pilot hole, samples were taken from circulated return fluids (composite formation water) at 30-ft intervals (average length of drill rod) from 1,650 to 2,030 ft bpl. A Hydrolab® multi-parameter probe measured field water quality parameters (temperature, specific conductance, and pH) on each sample. A field titration method (Hach® Kit) determined chloride concentrations. **Figure 4** shows field-determined specific conductance values as well as chloride and calculated TDS concentrations (Hem, 1992) with respect to depth. Between 1,650 to 1,850 ft bpl, specific conductance values gradually increase from 6,000 to 13,400 micromhos per centimeter (µmhos/cm) with a corresponding increase in TDS concentrations from 3,500 to 8,000 mg/L. Specific conductance readings increase rapidly from 13,400 to 25,000 µmhos/cm between 1,850 and 1,880 ft bpl. Within this 30-ft interval, specific conductance almost doubled with calculated TDS concentrations of 14,900 mg/L, which transects the base of the USDW. Specific conductance values gradually increased from 24,888 µmhos/cm at 1,880 ft bpl to 52,620 µmhos/cm at 1,972 ft bpl. In the next 60-ft interval, specific conductance values remain constant, with an average value of 53,150 µmhos/cm.

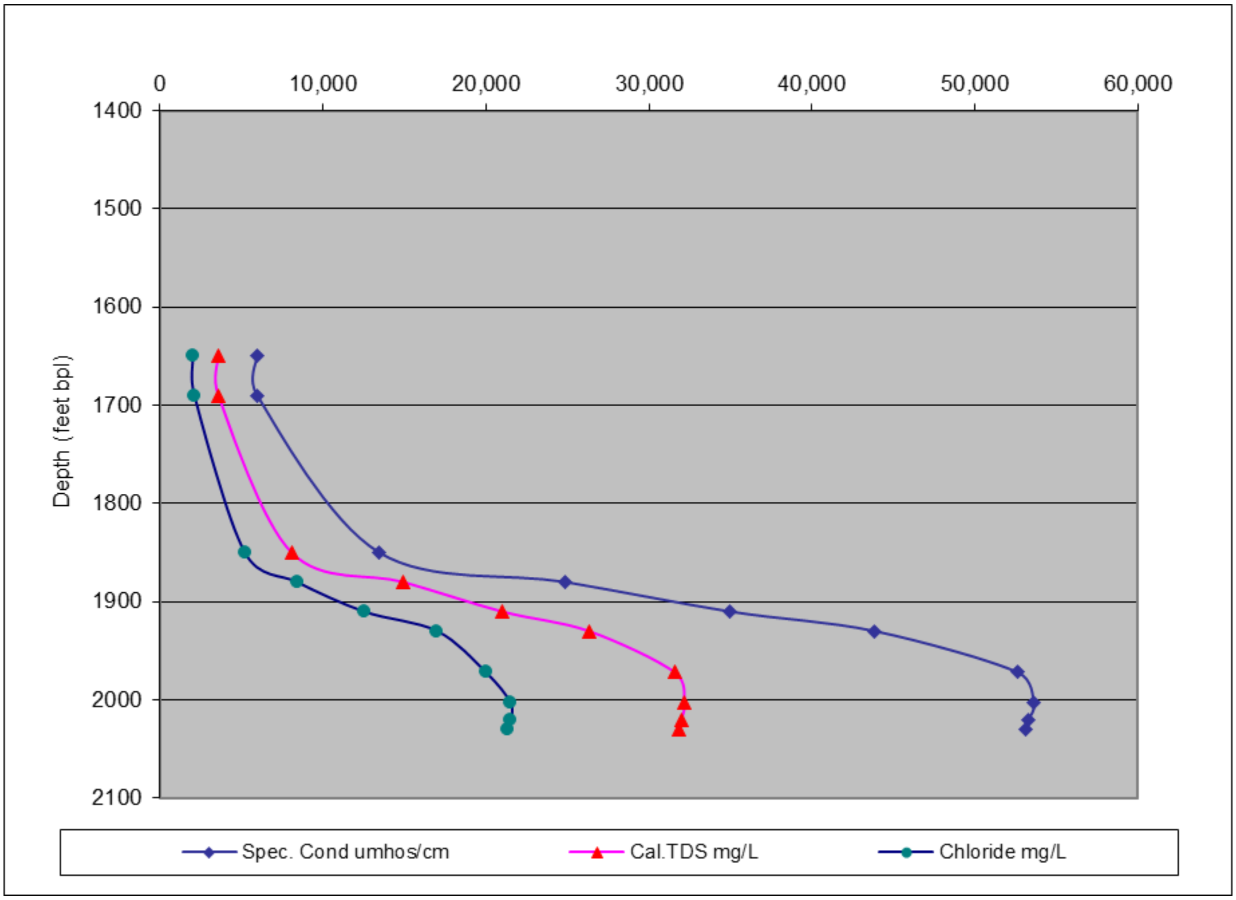

Figure 4. Water Quality with Depth – Reverse-Air Formation Fluid Returns

Geophysical Logging

Geophysical logging was conducted in the pilot hole after each stage of drilling and before casing installation. The logs were conducted to provide a continuous record of the physical properties of the subsurface formations and their contained fluids. Subsequently, the logs were used to assist in the interpretation of lithology; to provide estimates of permeability, porosity, bulk density, and resistivity of the aquifer (**Appendix E**); and to determine the salinity of the groundwater (using Archie's [1942] equation). In addition, the extent and degree of confinement of specific intervals could be determined from the individual logs. The geophysical logs also provided data to determine the desired casing setting depths on GLF-6. A cement bond log was conducted on the 12-in. diameter casing to assess the quality of grouting operations.

MV Geophysical obtained water samples from the wellbore every 100 ft from 1,500 to 1,968 ft bpl via a downhole wireline fluid sampler. Field water quality parameters included temperature, pH, specific conductance, oxidation-reduction potential, and chloride. **Table 3** summarizes the water quality results from the individual fluid samples.

The geophysical log traces from log runs 1 through 9 for GLF-6 are presented in **Appendix A**, Figures A-1 through A-9. **Table 4** provides a summary of the conventional geophysical logging operations conducted at the Moore Haven site.

Table 3. Water Quality Results of Downhole Samples

Depth (ft bpl)	Temperature (°C)	pH	Specific Conductance (µmhos/cm)	Field Chlorides (mg/L)	Lab Chlorides (mg/L)	Lab TDS (mg/L)
1,500	32.63	7.3	10,808	3,560	3,100	6,300
1,600	33.33	7.3	10,811	3,600	3,000	6,400
1,700	32.76	7.29	12,992	5,100	3,400	7,600
1,800	32.16	7.33	13,685	5,400	4,000	8,000
1,900	32.09	7.14	39,505	15,340	14,000	24,000
1,968	32.14	6.95	51,597	20,100	18,000	33,000

Table 4. Summary of Conventional Geophysical Logging Program

Run #	Date	Logging Company	Logged Interval (ft bpl)	Caliper	Natural Gamma	SP	DIL	Sonic	Flow Meter	Temp.	Fluid Res.	Cement Bond Log	Video
1	07/19/01	MV Geophysical	0-83	X	X								
2	07/24/01	MV Geophysical	0-216	X	X	X	X	X					
3	07/25/01	MV Geophysical	83-206	X	X								
5	08/23/01	MV Geophysical	205-859	X	X								
6	08/24/01	MV Geophysical	205-855		X					X			
8	10/12/01	MV Geophysical	855-2,020	X	X	X	X		X	X	X		X
9	02/01/02	MV Geophysical	855-1,560	X	X	X	X		X	X	X	X	X

DIL = dual induction log; SP = spontaneous potential.

Specialty logging operations conducted by Schlumberger Wireline Services are summarized in **Table 5**. **Appendix E** includes an integrated geophysical log well montage providing a synoptic illustration of the interpreted results of this logging.

Table 5. Summary of Specialty Geophysical Logging Program

Run #	Date	Logging Company	Logged Interval (ft bpl)	Natural Gamma Ray Spectrometry	Array Induction Imager	Compensated Density - Neutron	Dipole Sonic Imager	Formation Micro-Imager	Ultrasonic Borehole Imager
4	08/15/01	Schlumberger	205-1,075	X	X	X	X	X	X
7	09/26/01	Schlumberger	855-2,020	X	X	X	X	X	

Packer Tests

Six straddle-packer tests were conducted in the FAS from 855 to 2,030 ft bpl in GLF-6 at the Moore Haven site. The purpose of the tests was to gain water quality and production capacity data on discrete intervals (approximately 50 ft in length) and to establish the depth of the 10,000-mg/L TDS interface.

The following procedures were used to conduct individual packer tests in GLF-6 at the Moore Haven site:

1. Lower packer assembly to the interval selected for testing based on geophysical logs and lithologic data.
2. Set and inflate packers, and open the ports between the packers to the test interval.

3. Install a 15-horsepower submersible pump to a depth of 60 to 120 ft below the drill floor, with a pumping capacity of 30 to 300 gallons per minute (gpm).
4. Install two 100-pounds per square inch gauge (psig) pressure transducers inside the drill pipe and one 30-psig transducer in the annulus connected to a Hermit® 3000 Data Logger to measure and record water level changes during testing operations.
5. Purge a minimum of three drill-stem volumes.
6. Monitor pressure transducer readings and field water quality parameters (e.g., temperature, specific conductance, pH) from the purged formation water until stable. These parameters were used to determine the quality of isolation of the packed-off interval.
7. Perform constant-rate drawdown and recovery tests once the interval is effectively isolated.
8. Collect formation water samples for laboratory water quality analyses following the SFWMD's QA/QC sampling protocol.
9. Record recovery data until water levels return to static conditions.

Before groundwater sampling, the packer intervals were purged until three drill stem volumes were evacuated, or until field water quality parameters of samples collected from the discharge port stabilized. A limit of ±5% variation in consecutive field parameter readings was used to determine chemical stability. Field water quality parameters (temperature, specific conductance, pH) were measured on each sample using a Hydrolab® multi-parameter probe. Chloride concentrations were measured using a field titration method (Hach® Kit). The flow of water from the discharge point was then adjusted to minimize the aeration and disturbance of the samples. Unfiltered and filtered water quality samples were collected directly from the discharge point into a clean plastic bucket by SFWMD staff. Equipment blanks were obtained prior to sampling in accordance with SFWMD's QA/QC sampling procedures. Replicate samples were collected from consecutive bailers in accordance with the SFWMD (1999) Comprehensive Quality Assurance Plan. Samples were preserved and immediately placed on ice in a closed container. Composite samples were submitted to the SFWMD Water Quality Laboratory and analyzed for major cations and anions using U.S. Environmental Protection Agency and standard method procedures (SFWMD, 1999). The analytical results for the samples obtained during the packer tests are reported in **Table 6**.

Table 6. Packer Test Water Quality Data

Identifier	Depth Interval (ft bpl)	Sample Date	Cations				Anions			TDS	Field Parameters		
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	Alka as $CaCO_3$	SO_4^{2-}		Specific Conductance (μmhos/cm)	Temp. (°C)	pH
GLF6_PT6	930-980	11/20/01	1,040	34	176	144	1,938	77	554	4,141	7,139	27.99	7.49
GLF6_PT4	1,440-1,490	11/15/01	525	14	147	120	1,151	79	406	2,625	4,439	29.64	7.91
GLF6_PT3	1,587-1,745	11/09/01	2,428	67	359	313	4,711	81	824	9,505	15,160	30.85	7.33
GLF6_PT2	1,587-1,884	11/02/01	1,897	50	302	240	3,647	81	665	7,412	12,060	30.81	7.35
GLF6_PT1	1,587-2,030	10/22/01	1,405	39	253	199	2,908	82	595	5,850	9,533	30.77	7.51

Note: Cations, anions, and TDS are measured in mg/L.

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

SC = Q/s
Q = pumping rate in gpm as measured by an in-line flowmeter
s = aquifer head loss in feet; measured drawdown minus the pipe friction loss component

The drawdown and recovery semi-log plots from the individual packer tests are provided in **Appendix F**. The production and static water level data from the individual packer tests are summarized in **Table 7**.

Table 7. Packer Test Specific Capacity Data

Test Name	Interval Tested (ft)	Pump Rate (gpm)	Total Volume Pumped (gal)	Initial Head (ft/H_2O)	Final Head (ft/H_2O)	Total Drawdown (ft)	Total Friction Loss (ft)	Corrected Drawdown (ft)	Specific Capacity (gpm/ft)
GLF6_PT6	930-980	100	25,200	105.30	105.31	98.70	19.70	79.00	1.3
GLF6_PT5	1135-1185	1.0	720	107.56	NR	102.69	0.25	102.44	0.01
GLF6_PT4	1440-1490	25	11,500	106.34	106.71	77.40	2.60	74.80	0.33
GLF6_PT3	1587-1745	290	58,900	100.10	100.24	75.50	73.85	1.65	175.76
GLF6_PT2	1587-1884	288	71,200	119.53	119.66	71.92	--	--	NR
GLF6_PT1	1587-2030	320	37,200	37.31	36.92	25.43	--	--	NR

NR = not reported due to high friction loss calculation.

HYDROGEOLOGIC FRAMEWORK

Two major aquifer systems underlie the Moore Haven site: the SAS and the FAS, with the FAS being the focus of this test well program. The SAS and FAS are composed of multiple discrete aquifers separated by low permeable "confining" units (e.g., the Intermediate Confining Unit) that occur throughout this Tertiary/Quaternary-aged sequence. **Figure 5** shows a hydrogeologic section underlying the Moore Haven site.

Surficial Aquifer System

The SAS extends from land surface (top of the water table) to a depth of 160 ft bpl. It consists of Holocene- and Pliocene/Pleistocene-aged sediments. Undifferentiated Holocene sediments occur from land surface to 10 ft bpl, and consist of unconsolidated light gray, very fine to coarse-grained quartz sands and silt. The sediments from 10 to 82 ft depth are composed primarily of medium to dark gray, poorly to moderately indurated shell hash mixed with up to 50% fine-grained quartz sand. Unconsolidated, poorly sorted (fine to coarse-grained) quartz sands are present from 82 to 160 ft bpl. Low permeability, poorly sorted silty-sands at 160 ft bpl form the base of the SAS at the Moore Haven site. An increase in the natural gamma ray activity below 160 ft bpl suggests an increase in clay content and phosphate percentages.

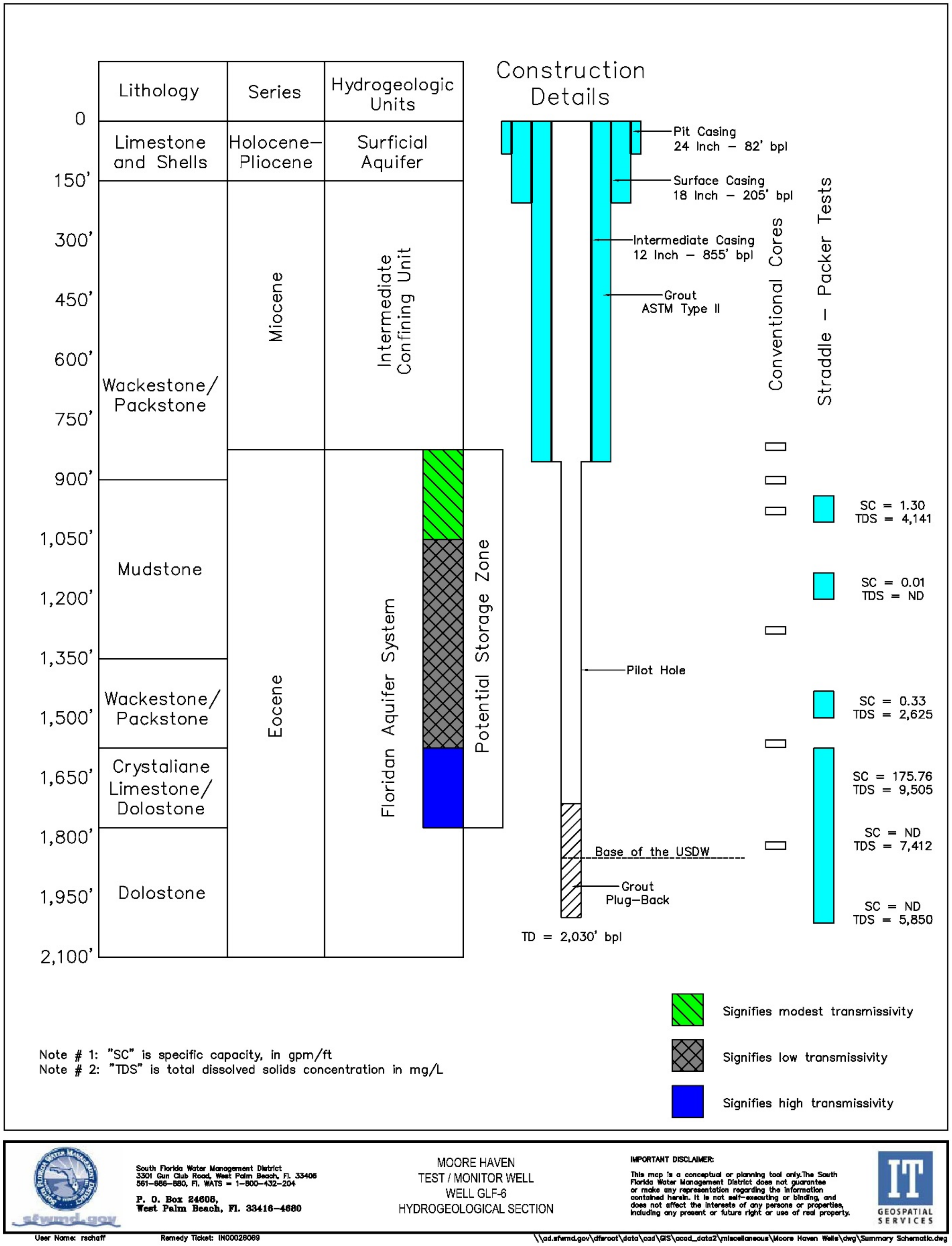

Figure 5. Hydrogeologic Section for the Moore Haven Site (GLF-6)

Intermediate Confining Unit

Below the SAS lies the Intermediate Confining Unit, which extends from 160 to 850 ft bpl at the Moore Haven site. The Peace River and Arcadia Formations of the Miocene/Pliocene-aged Hawthorn Group (Scott, 1988) act as confining units, separating the FAS from the overlying SAS. Lithologic information obtained from drill cuttings from GLF-6 indicates that the Hawthorn Group sediments consist predominately of soft non-indurated detritial clays, silts, and poorly to moderately indurated mudstones/wackestone with minor amounts of quartz sand and shell (see lithologic description in **Appendix C**).

The geophysical log data correspond well with the lithologic data. The signature of the photoelectric log (PFEZ) from 160 to 460 ft bpl indicated a clayey silt to fine-sand unit with a minor carbonate component. The bulk density (RHOZ) and the derived porosity (DPHZ and neutron porosity [NPHI]) logs suggest that this unit is composed of low-density, high-porosity siliciclastic sediments within a calcilutite matrix. Qualitatively, the induction log also suggests a porous horizon, whereby the resistivity profile shows separation between the resistivity curves as a result of drilling mud invading the porous sediments (**Appendix A**, Figure A-4). The base of this interval is marked by washouts at 430 and 445 ft bpl, as seen on the caliper log. The washouts correspond to friable quartz sand/silt lenses and were used to identify the base of this predominately siliciclastic unit (interpreted to be the Peace River Formation).

A transition in lithology occurs from 460 to 520 ft bpl, whereby the carbonate fraction increases with corresponding decreases in siliciclastics. This transition is evident on the geophysical logs by a slight increase in the photoelectric log values and by the signature of the derived porosity curves. The top of this interval is identified by an increase in natural gamma activity, positive shift in the spontaneous potential log trace and slight increase in borehole diameter.

A change in lithology occurred below 520 ft bpl, identified by an increase in bulk density readings and natural gamma radiation with a corresponding decrease in derived porosity and sonic transit times. Thin, intermittent, moderately indurated carbonate units are apparent on the sonic log from 520 to 730 ft bpl. The natural gamma log below 520 ft bpl indicates thin intervals of significant phosphate sand/silt content (**Appendix A**, Figure A-4).

The lithology from 730 to 850 ft bpl shifts to a mixed carbonate/siliciclastic unit composed of poorly to moderately indurated mudstones, with 30% to 40% greenish-gray clays and silts among intervals of unconsolidated quartz sand. These low-permeability units form the lower boundary of the Intermediate Confining Unit.

FLORIDAN AQUIFER SYSTEM

The FAS consists of a series of Tertiary-age limestones and dolostones. The system includes permeable sediments of the lower Arcadia Formation, Suwannee Limestone, Ocala Limestone, Avon Park Formation, and Oldsmar Formation. The Paleocene-age Cedar Keys Formation with evaporitic gypsum and anhydrite forms the lower boundary of the FAS (Miller, 1986).

Upper Floridan Aquifer

The top of the FAS, as defined by the Southeastern Geological Society Ad Hoc Committee on Florida Hydrostratigraphic Unit Definition (1986), coincides with the top of a vertically continuous permeable carbonate sequence. The UFA consists of thin, highly permeable water-bearing horizons interspersed within thick, low-permeability units of early Miocene to middle Eocene-aged sediments, including the Arcadia

Formation, Suwannee Limestone, Ocala Limestone, and Avon Park Formation. At the Moore Haven site, the top of the FAS occurs at a depth of 850 ft bpl, which coincides with the top of the Ocala Limestone.

The sharp formation contact between the Miocene/Oligocene-aged Arcadia Formation (Hawthorn Group) and the underlying Eocene-aged Ocala Limestone at 850 ft bpl is identified by a change in lithology from a dark gray to green, moderately indurated, arenaceous limestone to a light gray to white, moderately indurated mudstone. This discontinuity coincides with a significant attenuation of the natural gamma activity, an increase in the formation resistivity and bulk density, and a corresponding decrease in porosity.

Generally, two predominant permeable zones exist within the UFA, with the uppermost typically occurring between 700 and 1,300 ft bpl. The most transmissive part usually occurs near the top, coincident with an unconformity at the top of the Oligocene- or Eocene-aged formations (Miller, 1986). Well cuttings and production-type geophysical logs suggest that neither of these productive horizons at formation contacts exist within the UFA at the Moore Haven site, resulting in limited productive capacities. A slight deflection in the temperature gradient/differential and dynamic flowmeter log traces at 950 ft bpl suggests the presence of a minor flow zone (**Appendix A**, Figure A-8). However, a specific capacity test on an interval from 930 to 980 ft bpl, which straddled the flow indicators present in the Ocala Formation, yielded only 1.3 gpm/ft of drawdown when pumped at a rate of 100 gpm. Bennett (2001) noted similar production in the UFA at a site in northeastern Hendry County with a reported specific capacity of 3 gpm/ft of drawdown.

The lower portion of the Ocala Limestone from 980 to 1,110 ft bpl consists of white to light gray friable mudstones and wackestones. There was little evidence of significant water production during drilling operations or from the lithologic and geophysical log data in this interval. However, a minor flow zone may be present based on a minor deflection in the temperature and fluid resistivity log traces at the base of this interval (**Appendix A**, Figure A-8).

Middle Floridan Confining Unit

The lithologic character of the upper portion of the Avon Park Formation is very similar to the lower Ocala Limestone. The top of the Avon Park Formation is identified at depth of 1,215 ft bpl at the Moore Haven site, based on a lithologic change from a white mudstone/wackestone to a tan moderately indurated packstone. In addition, this lithologic change is confirmed in the geophysical log data by a slight increase in natural gamma activity, and a general decrease in borehole diameter, bulk density, and derived porosity values (**Appendix A**, Figure A-7). The lower Ocala Limestone and the upper Avon Park Formation from 1,110 to 1,600 ft bpl form an inter-aquifer confining unit within the FAS at the Moore Haven site. The interval consists of low-permeability mudstones and wackestones. A packer test in the lower Ocala Limestone (1,135 to 1,185 ft) and the Avon Park Formation (1,440 to 1,490 ft bpl) yielded specific capacities of 0.01 gpm/ft and 0.3 gpm/ft, respectively. Formation samples from this interval did not show evidence of large-scale secondary porosity development. In addition, the production-type geophysical logs traces indicated no significant productive horizons.

Avon Park Permeable Zone

Permeable intervals have been documented within the Avon Park Formation, ranging from 1,400 to 1,600 ft bpl (Miller, 1986). These permeable zones typically consist of fractured dolostones and are referred to as the Avon Park Permeable Zone by Reese and Richardson (2007). At the Moore Haven site, moderate to well indurated mudstones to packstones interbedded with well-indurated crystalline limestones and dolostones occur from 1,600 to 1,740 ft bpl. The dolostone units are cryptocrystalline to sucrosic in nature, with the limestone units showing evidence of varying degrees of pinhole and moldic porosity development. A cavernous dolostone unit was encountered at 1,600 ft bpl, which caused a loss of mud circulation and a 2-ft drop of the drill rod. During reverse-air drilling, the majority of the natural artesian flow from the wellbore is produced below this depth, which is supported by the flowmeter data. A specific capacity test on an interval from 1,587 to 1,745 ft bpl, which straddled the cavernous dolostone unit, yielded a specific capacity value of approximately 175 gpm/ft of drawdown. Water quality analysis yielded chloride and TDS concentrations of 4,711 mg/L and 9,505 mg/L, respectively. Once the pilot hole was back-plugged to 1,745 ft bpl, the open-hole section (855 to 1,745 ft bpl) produced approximately 4,200 gpm under natural artesian flow. After the semi-permanent packer was installed at 1,560 ft bpl, the open-hole section (855 to 1,560 ft bpl) produced 300 to 400 gpm under natural artesian flow, representing a 90% reduction in artesian flow.

Miller (1986) observed that portions of the lower Avon Park Formation are fine-grained and have low permeability, thereby acting as inter-aquifer confining units within the FAS. At this site, an inter-aquifer confining unit composed of brown to black, well-indurated, crystalline dolostones with intermittent mudstone to packstone units occurs in the subsurface from 1,740 to 1,850 ft bpl.

Lower Floridan Aquifer

A textural change from well-indurated cryptocrystalline dolostones to predominantly well-indurated sucrosic to microcrystalline dolostones occurred below 1,850 ft bpl. These dolostones are moderately to highly permeable, fractured, and cavernous, and they are interspersed within less permeable dolostone and limestone units. This change is noted by a highly variable caliper log, a decrease in formation resistivity, and a positive deflection in the temperature gradient log (**Appendix A**, Figure A-8).

A well-defined flow zone from 1,850 to 1,880 ft bpl was noted during reverse-air drilling by a substantial increase in water production and a significant change in water quality of the reverse-air returns. Specific conductance readings increased rapidly from 13,400 to 25,000 µmhos/cm between 1,850 and 1,880 ft bpl, with calculated TDS concentrations of 14,900 mg/L, transecting the base of the USDW. Specific conductance values gradually increased from 24,888 µmhos/cm at 1,880 ft bpl to 52,620 µmhos/cm at 1,972 ft bpl. Over the next 60-ft interval, specific conductance values remained constant with an average value of 53,150 µmhos/cm.

Based on information provided by Meyer (1988) and Reese (2000), the interval from 1,850 to 2,030 ft bpl was identified as the upper dolostone unit of the lower Floridan aquifer, part of the lower Avon Park Formation.

The top of the Oldsmar Formation is often difficult to identify because of a lack of diagnostic microfossils, generally obliterated by diagenetic effects or a lithologic character similar to the overlying Avon Park Formation. The top of the Oldsmar Formation in South Florida is often identified based on the presence of a dolostone unit detected on geophysical logs by increased gamma ray counts and resistivity values. Based on lithologic criteria defined by Miller (1986), the lack of a glauconite marker bed used by Duncan et al. (1994), and the absence of Early Eocene index fossils such as *Helicostegina gyralis* (Chen, 1965), it was concluded that the Oldsmar Formation was below the depth of investigation at the Moore Haven site.

SUMMARY

A 12.75-in. diameter test/monitor well (GLF-6) was successfully constructed at the Moore Haven site and tested in accordance with SFWMD technical specifications and the Class V UIC Well Construction Permit (**Appendix G**). The location of GLF-6 was resurveyed in May 2016 to provide accurate coordinates and a land surface elevation (15.0 feet) in NAVD88 (**Appendix H**).

Lithologic information and geophysical logs obtained from GLF-6 indicated that soft, non-indurated detrital clays, silts, and poorly indurated mudstones of the Hawthorn Group were present from 160 to 850 ft bpl. These low-permeability sediments act as a confining unit, separating the FAS from the overlying SAS.

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 850 ft bpl. Lithologic and geophysical logs, packer test results, and specific capacity test results indicated a low-production capacity of the UFA from 855 to 1,110 ft bpl. The lower Ocala Limestone and upper Avon Park Formation from 1,110 to 1,600 ft bpl form an inter-aquifer confining unit within the FAS at the Moore Haven site. A productive horizon in the Avon Park Permeable Zone from 1,600 to 1,740 ft bpl yielded a specific capacity of 175 gpm/ft of drawdown.

The drilling data as well as open-hole and production-type logs (e.g., flow, temperature logs) indicated good production from 1,600 and 1,740 ft bpl. Below 1,740 ft bpl, the productive capacity was limited (as indicated by the fluid-type logs), suggesting low-permeability semi-confining units near the base of the productive horizon.

Composite water quality sample data collected during straddle packer tests and geophysical logging were used to identify the base of the USDW at approximately 1,860 ft bpl. TDS concentrations below 1,950 ft bpl were similar to sea water concentrations.

CONCLUSIONS

1. Potential ASR zones generally exist from the top of the FAS (855 ft bpl) to 1,740 ft bpl (Avon Park Permeable Zone). A productive interval beginning at a depth of 1,850 ft bpl (Lower Floridan Aquifer) is highly productive but of poor water quality – corresponding to the base of the USDW (1,860 ft bpl) – and is therefore not deemed to be a good candidate for an ASR horizon at the Moore Haven site.
2. Additional production-type geophysical logging (i.e., flowmeter, temperature, fluid resistivity) should be conducted from the base of casing (855 ft bpl) down to the temporary packer (1,560 ft bpl) to more fully evaluate the upper and middle portions of the FAS for ASR potential. This approach will ensure that the highly productive zones below 1,600 ft bpl will not overwhelm the less permeable overlying zones during testing so a better evaluation of the interval for ASR potential can be obtained.
3. Following the recommended flow logging, an evaluation should be conducted if acidization or additional specific capacity testing of GLF-6 is warranted to further evaluate ASR potential.
4. If the Moore Haven site is chosen as a site for an ASR system as part of the future Lake Okeechobee ASR Project, GLF-6 will need to be modified to accommodate monitor zone(s) consistent with any future ASR well.

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APPENDICES

Appendix A

Geophysical Logs (Runs 1-9)

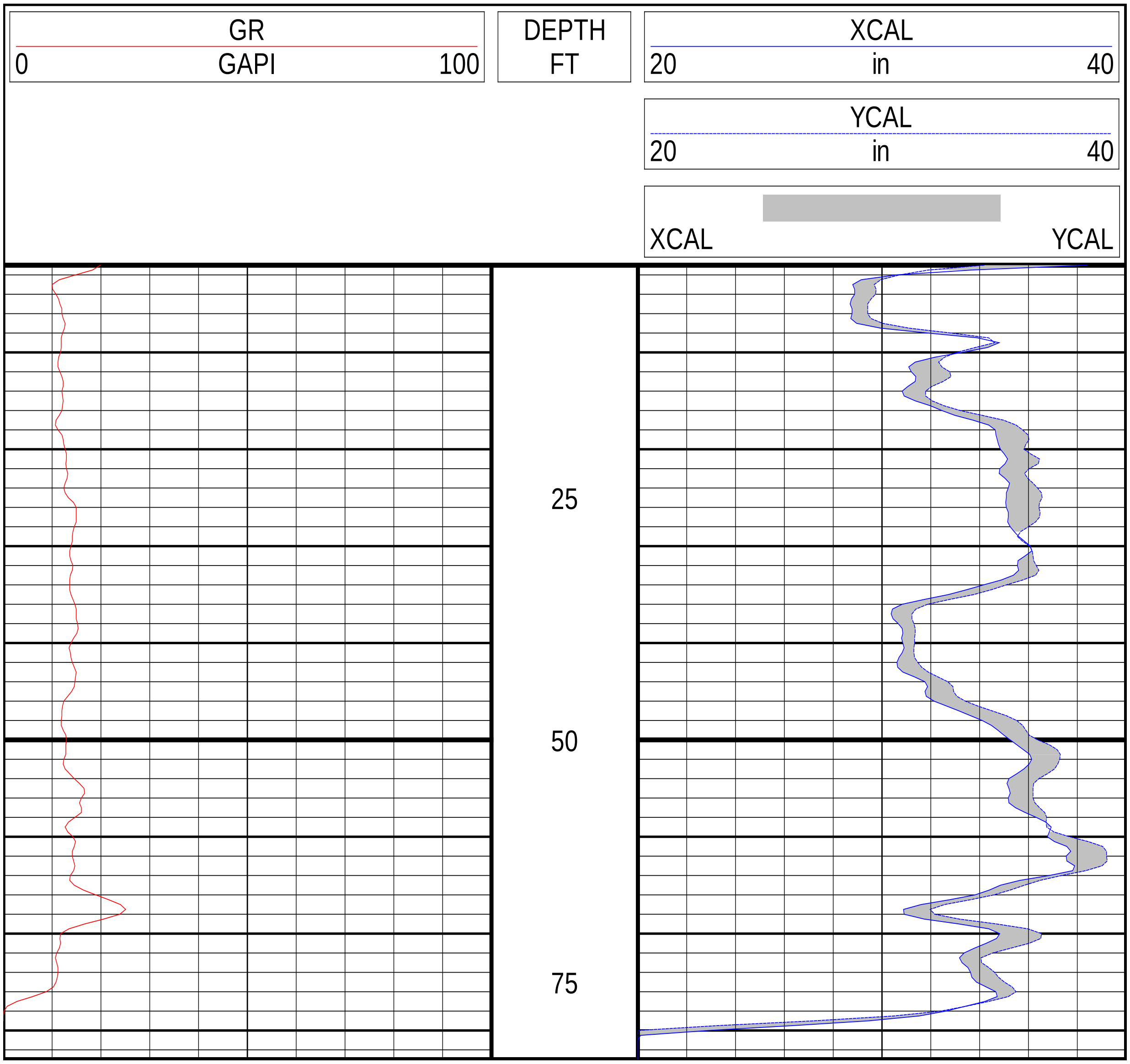


Figure A-1. Geophysical Log Run Number 1 (GLF-6)

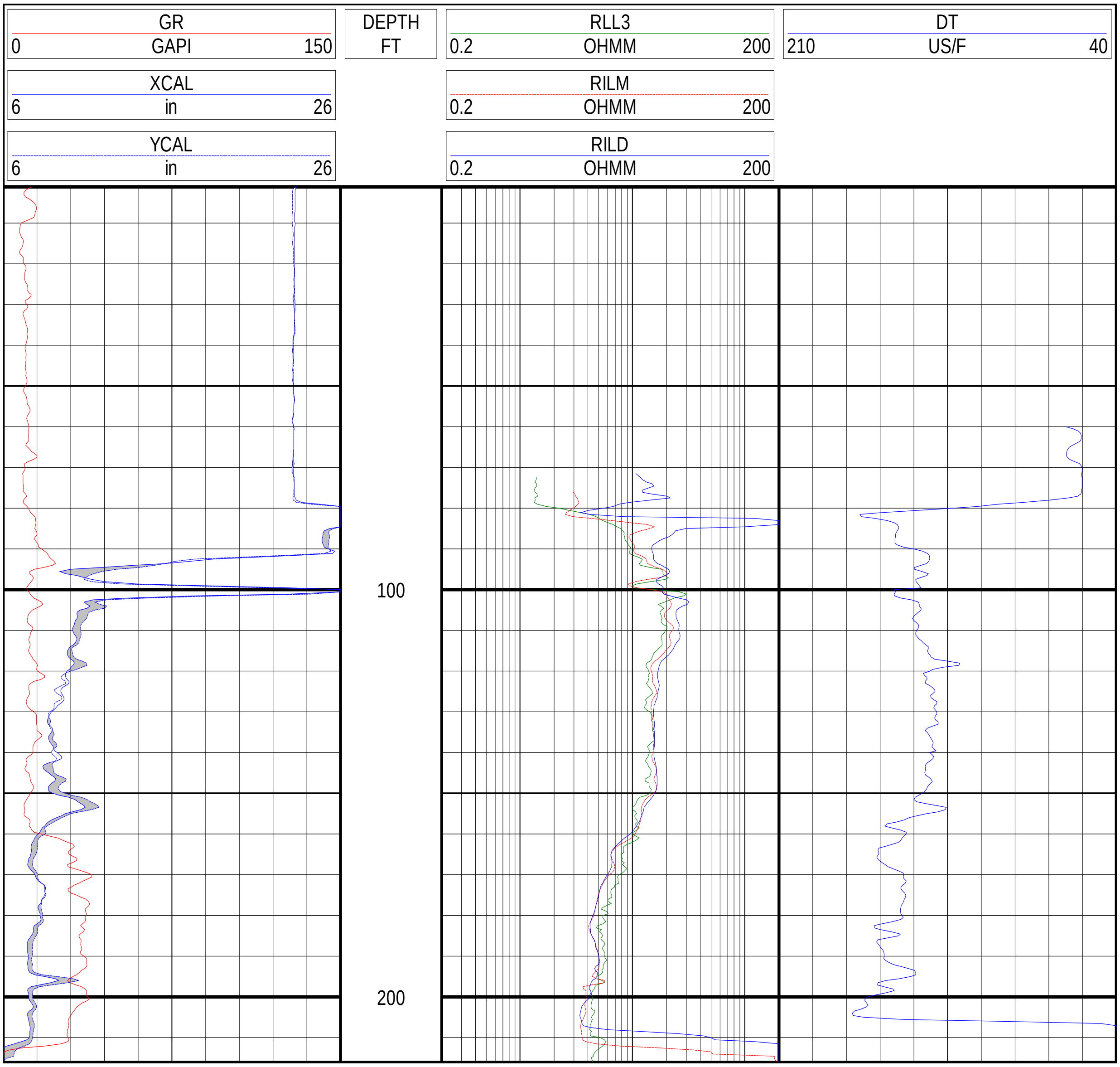


Figure A-2. Geophysical Log Run Number 2 (GLF-6)

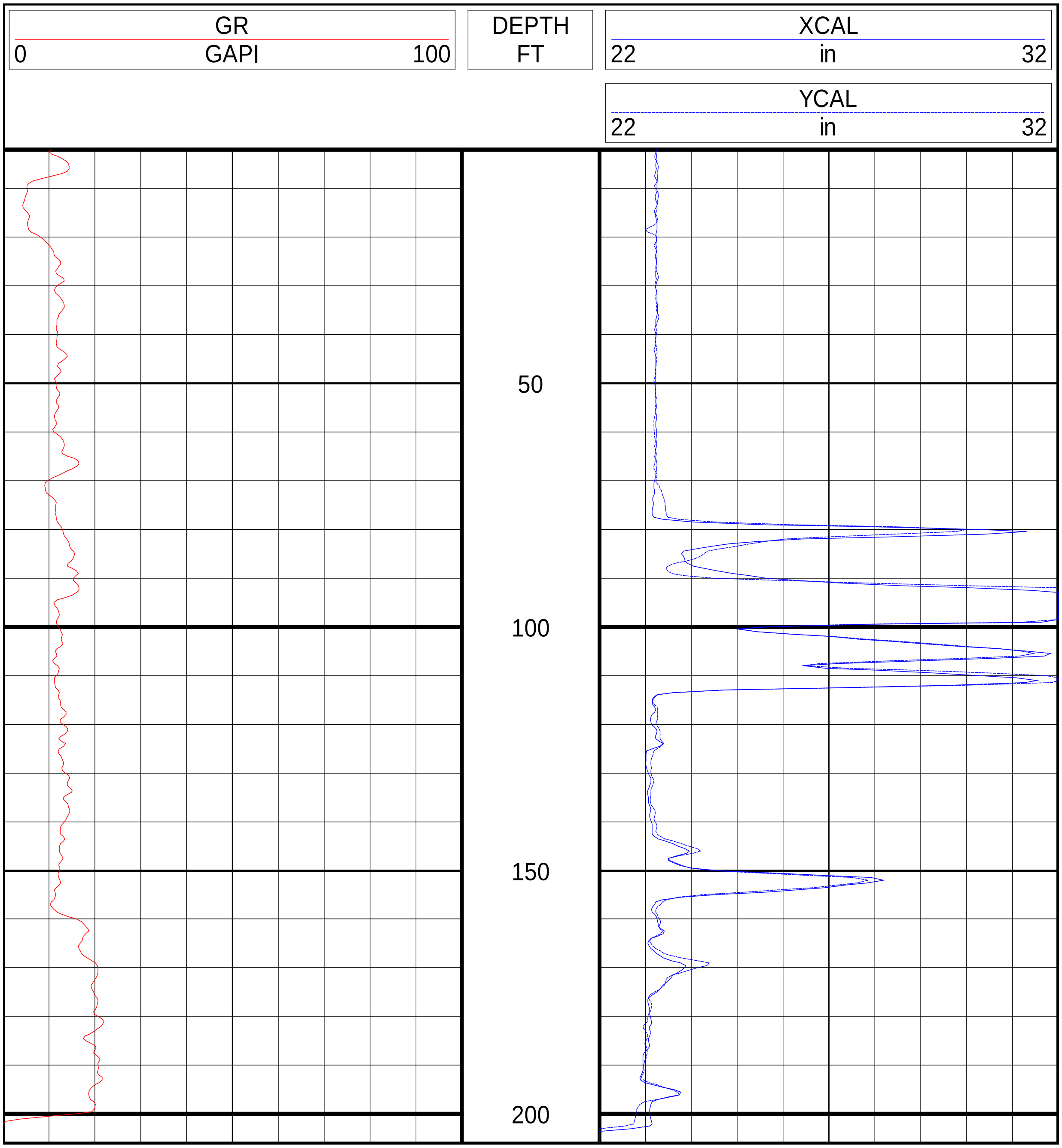


Figure A-3. Geophysical Log Run Number 3 (GLF-6)

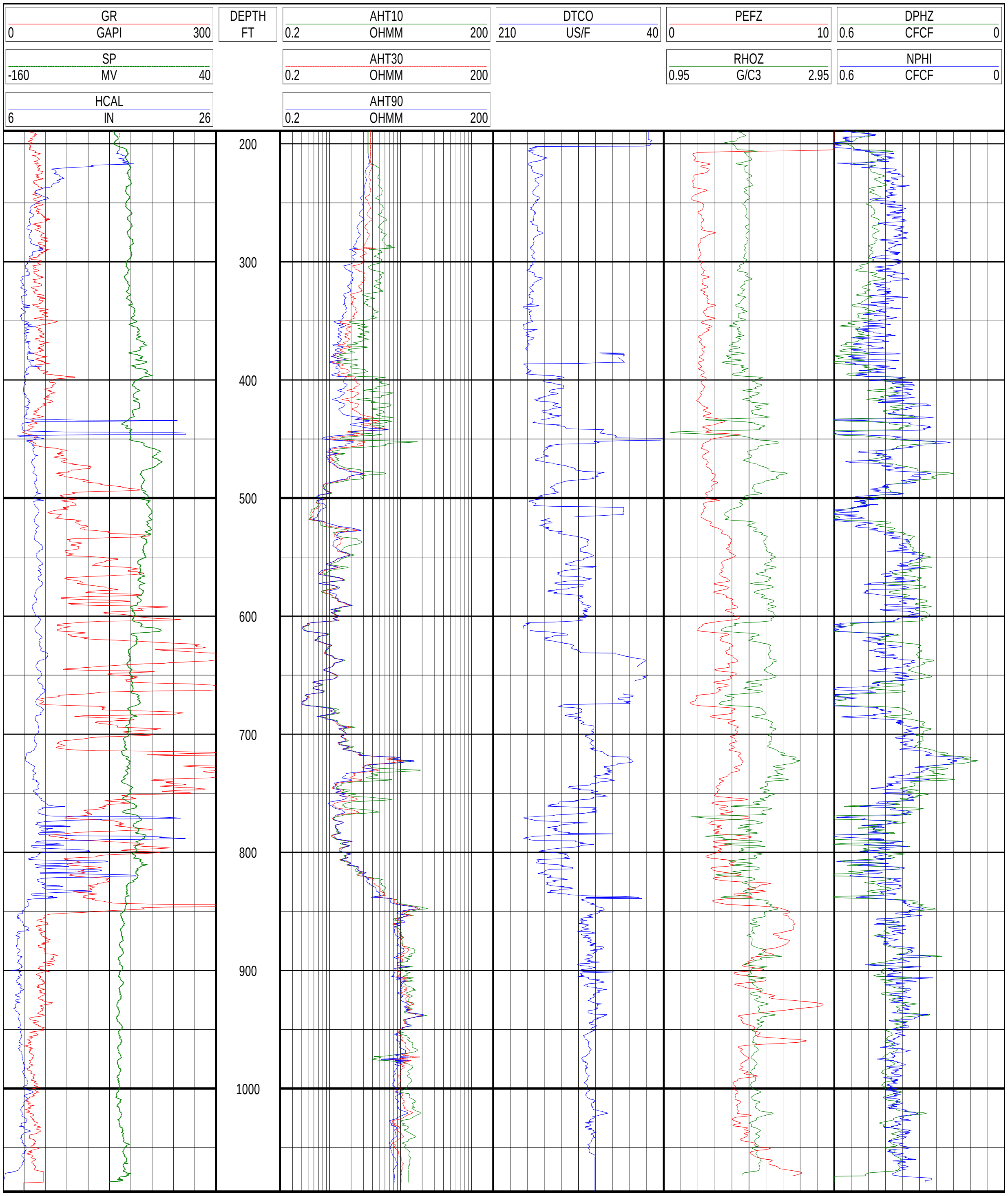


Figure A-4. Geophysical Log Run Number 4 (GLF-6)

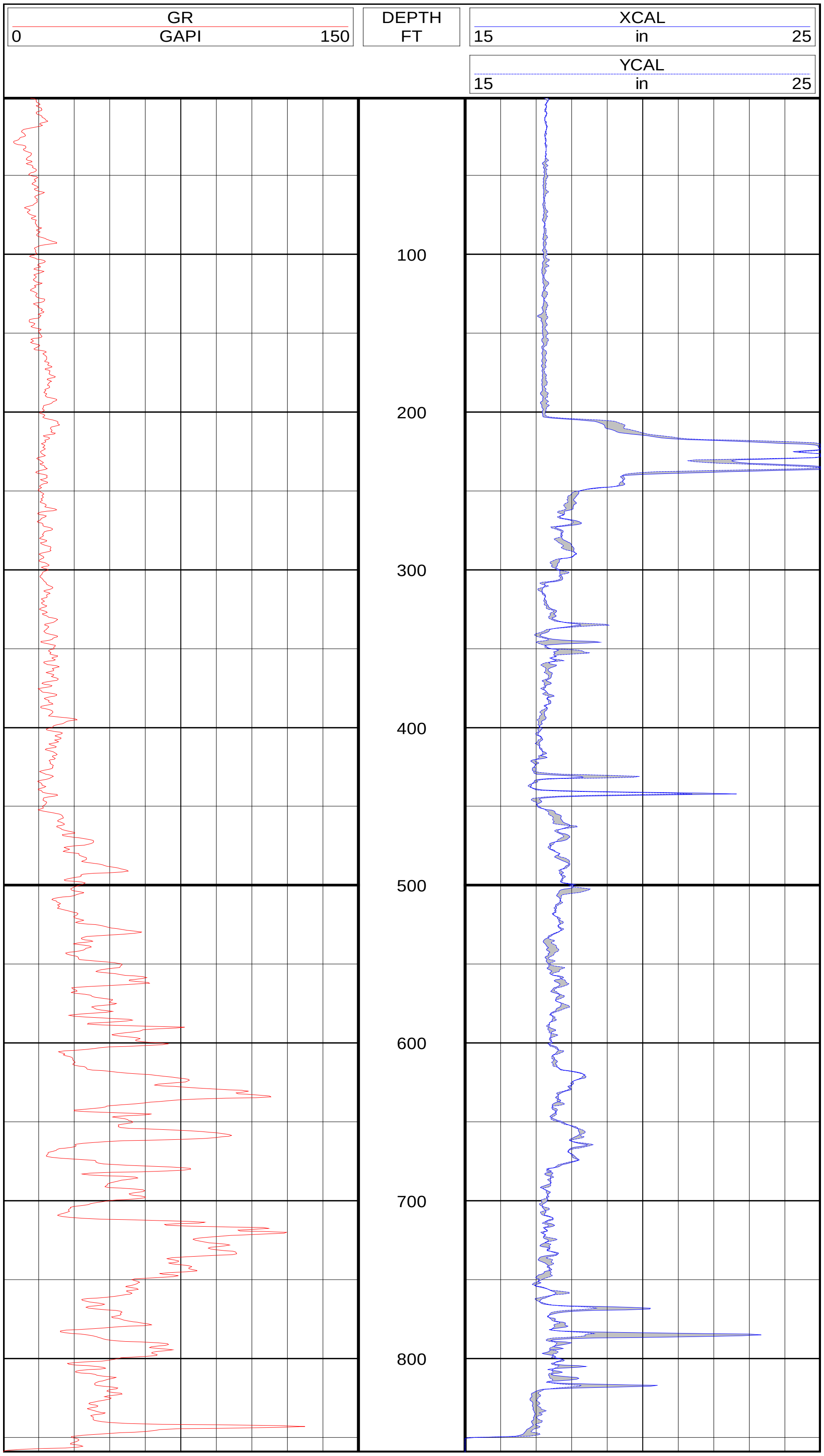


Figure A-5. Geophysical Log Run Number 5 (GLF-6)

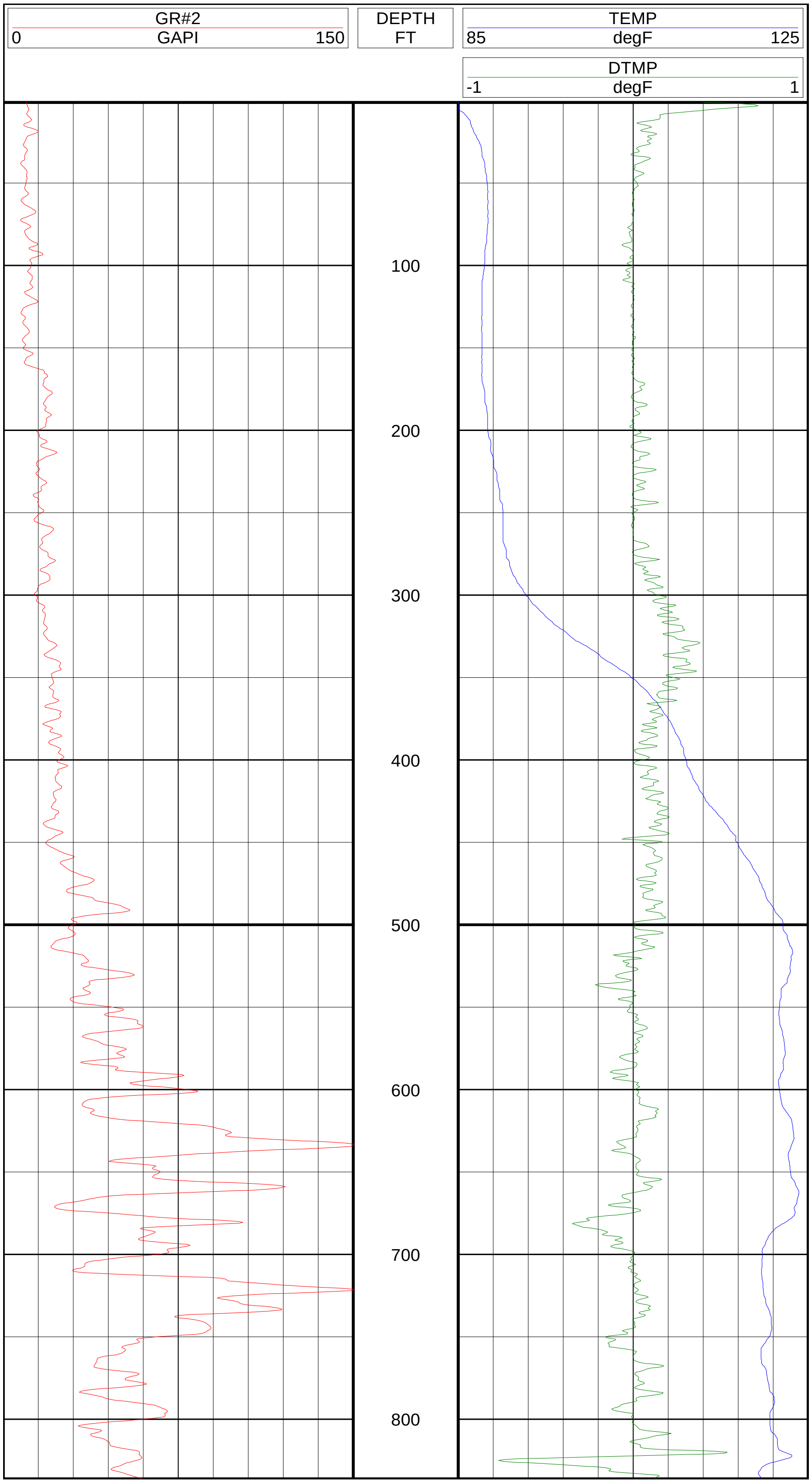


Figure A-6. Geophysical Log Run Number 6 (GLF-6)

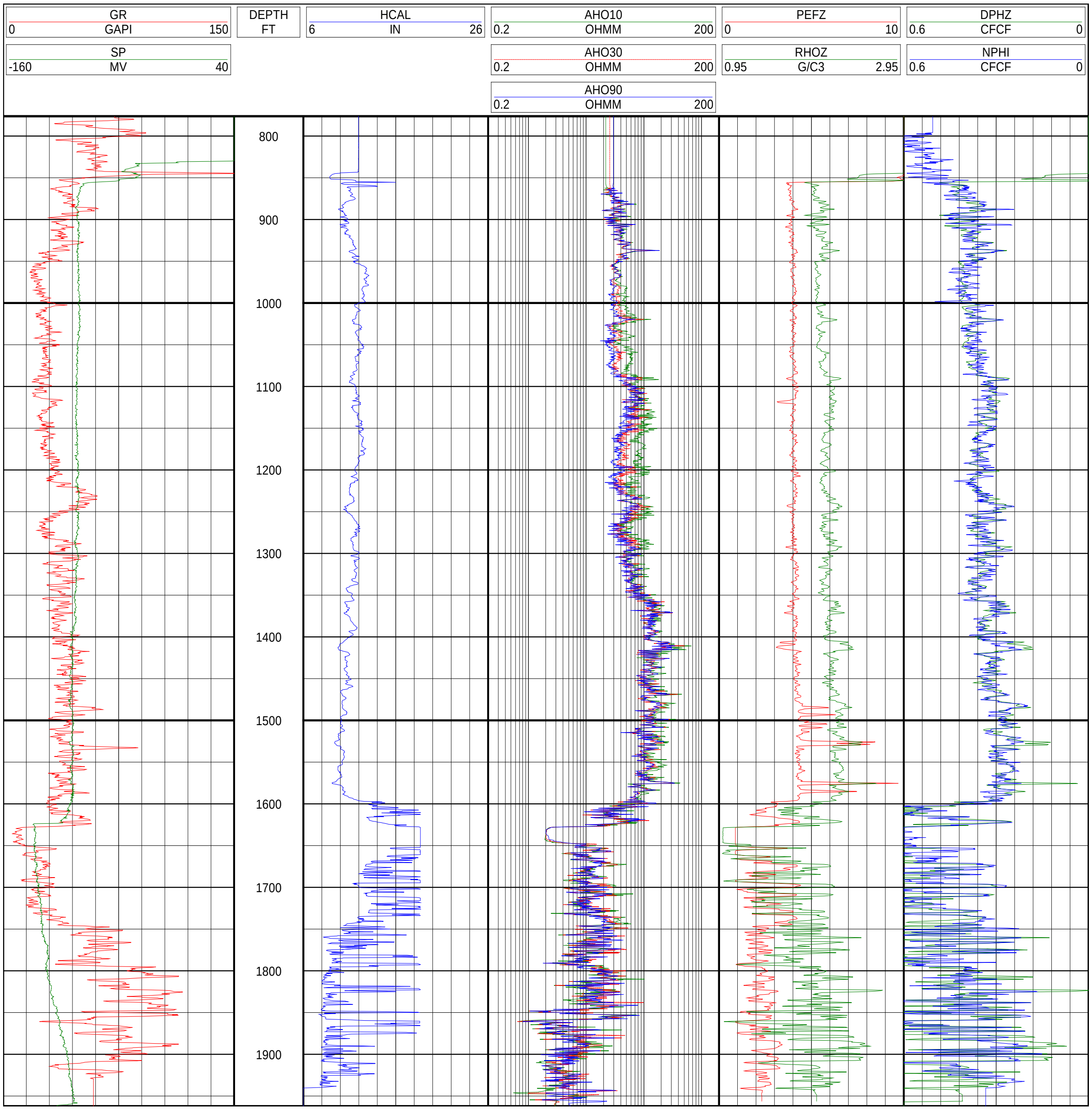


Figure A-7. Geophysical Log Run Number 7 (GLF-6)

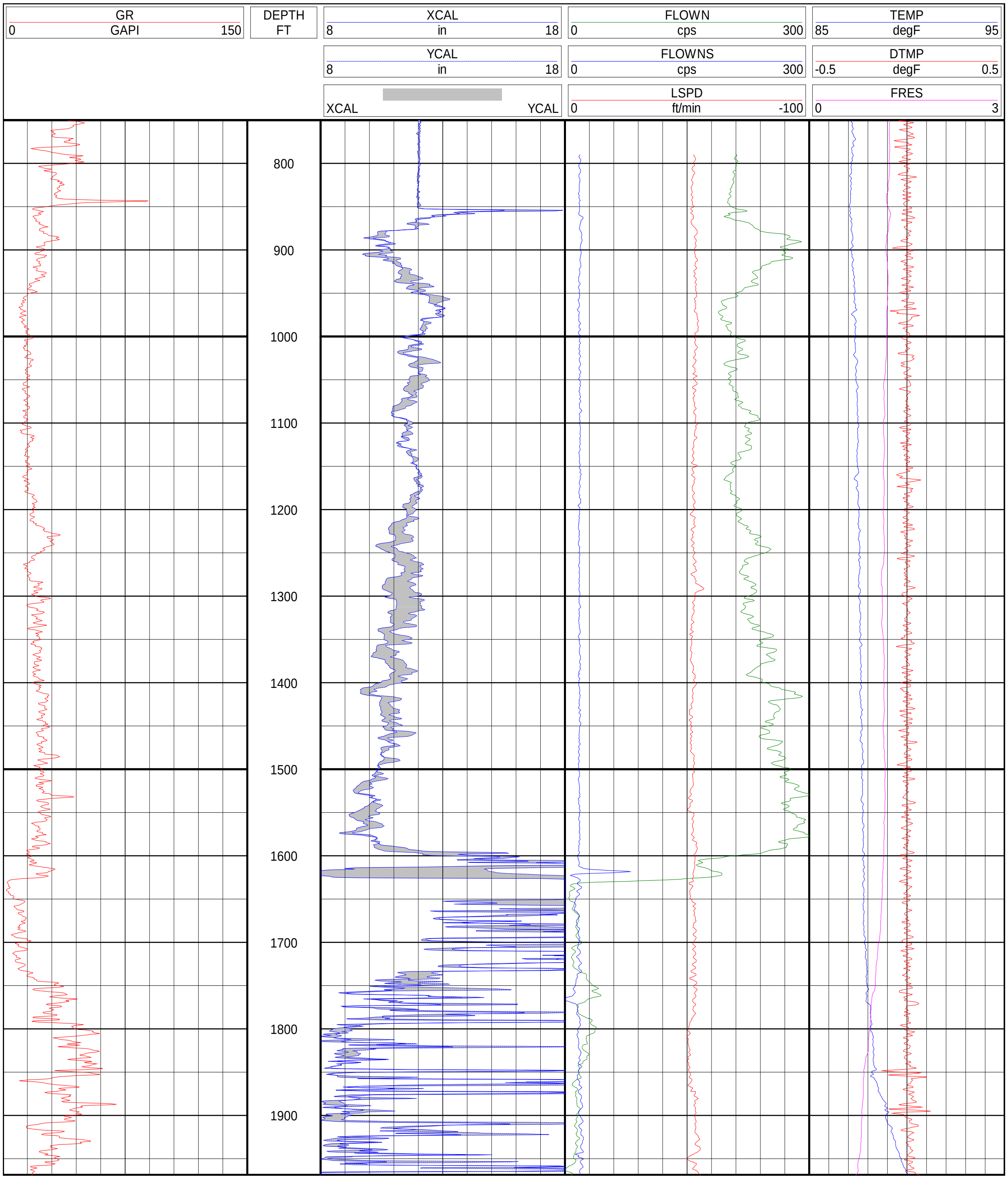


Figure A-8. Geophysical Log Run Number 8 (GLF-6)

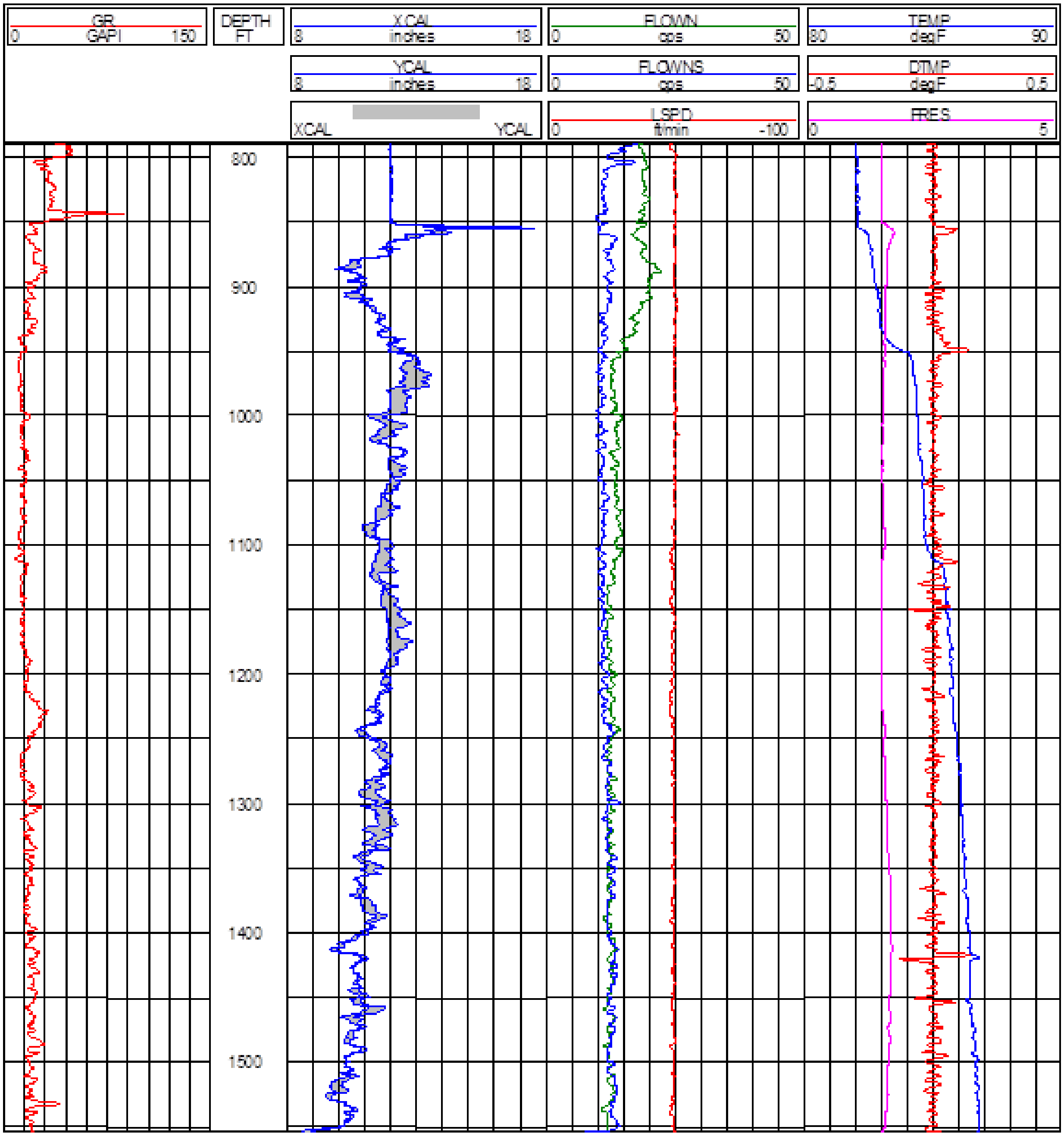


Figure A-9. Geophysical Log Run Number 9 (GLF-6)

Appendix B

Casing Factory Mill Certificates

검 사 증 명 서(A)
MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
• 본사 · 공장 : 울산광역시 북구 염포동 265번지
HEAD OFFICE : # 265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
(ULSAN PLANT) TEL.280-0114 FAX.(052)287-8916
TLX HDPIPE K 53776
• 서울사무소 : 서울특별시 중구 무교동 77번지 100-170
SEOUL OFFICE : # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL.3455-0500 FAX 775-7095

성적서번호 CERTIFICATE NO : E09070 페이지 PAGE 1
발행일자 DATE OF ISSUE : AUG. 28. 2000. 64035103
계약번호 CONTRACT (P/O) NO :
품명 COMMODITY : E.R.W. STEEL PIPE
적용규격 SPECIFICATION : API 5L X42/API 5LB/ASTM A53B/ASME SA53B
수요가 CUSTOMER :

G:GOOD

Type of pipe end ÷1	÷2	Dimension (Outdia. x Thick. x Length) ÷3 ÷4	Quantity (PCS)	Weight (KG)	Hydrostatic test (MPa / kg/cm² / PSI)	÷5	6 Visual & Dimension test	7 Flattening test	8 Weld ductility test	9	Heat treatment	Heat No.	Yield strength (PSI)	Tensile strength ÷15	Tensile strength W ÷16	Elongation %	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	Nb	Al	Ceq
BE	OD 24"	x .375" x21.000'	106	95.451	83	G	G	G	G	G	G	A00707	35.8	50.9	53.5	36	20	2	86	18	5	1	2	1	Tr	Tr			
		(610.0mm x 9.53mm x 6.401M)			1180								50900	72400	76100														
												A01636	34.5	49.2	52.0	34	18	1	80	15	7	1	2	1	Tr	Tr			
													49100	70000	74000														
												A01638	34.2	49.3	52.0	37	17	2	78	15	5	1	2	1	1	Tr			
													48600	70100	74000														
												A91700	32.5	47.4	50.0	39	18	1	74	13	8	1	2	1	Tr	Tr			
													46200	67400	71100														
BE	OD 24"	x .375" x42.000'	145	261.139	83	G	G	G	G	G	G	A88920	31.7	48.5	51.2	37	18	1	80	15	7	1	1	2	Tr	Tr			
		(610.0mm x 9.53mm x 12.802M)			1180								45100	69000	72800														
												A01636	34.5	49.2	52.0	34	18	1	80	15	7	1	2	1	Tr	Tr			
													49100	70000	74000														
												A01638	34.2	49.3	52.0	37	17	2	78	15	5	1	2	1	1	Tr			
													48600	70100	74000														
												A01641	37.0	51.5	53.9	30	20	2	76	15	7	1	2	1	Tr	Tr			

Units: C, Si, Mn ×100; P, S ×1000; Cu, Ni, Cr, Mo ×100; V, Nb, Al ×1000.

REMARK

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 10871
BARTOW STEEL REF. # 38148

Okeechobee Sito "C"
Attn: Paul

NOTES
÷1 Type of pipe End 관종
X: B : Black; G : Galvanized; E : Enameled
X: V : Varnish; R : Removed Varnish; O : Oiling Coating; F : PE Coating; C : Coaltar Coating; A : Asphalt Coating
XX: PE : Plain End; BE : Bevel End; TE : Thread End; TC : Thread Coupling; BL : Ball End; SE : Swaging End; VJ : Victaulic Joint
÷2 NB : Nominal Bore 호칭경, OD : Outside Diameter
÷3 Unit 단위 (M : mm, I : Inch)
÷4 Unit 단위 (M : Meter, F : Feet, I : Inch)
÷5 G : Good
÷6 Visual & Dimension Test 외관 및 치수검사
÷7 Flattening or Bending Test 편평 또는 굽힘시험
÷8 Weld Ductility Test 용접부 연성시험
÷9 Nondestructive Test 비파괴검사
÷10 Drift Test 관통시험
÷11 Flaring Test 확관시험
÷12 Crush Test 압궤시험
÷13 Reverse Flattening Test 역편평시험
÷14 Heat Treatment 열처리
÷15 B : Base Metal 모재부
÷16 W : Weld Part 용접부
÷17 H : Heat(Ladle) Analysis 용강분석, P : Product Analysis 제품분석

본 제품은 관련규격에 합격 ... 을 보증합니다.
WE CERTIFY THAT THE DESCRIBED ... RIAL HAS HEREIN BEEN

18" OKEECHOBEE SITE "C"

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
• 본사·공장: 울산광역시 북구 염포동 265번지
HEAD OFFICE: #265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
(ULSAN PLANT) TEL:280-0114 FAX:(052)287-8916
TLX:HDPIPE K 53776
• 서울사무소: 서울특별시 중구 무교동 77번지
SEOUL OFFICE: #77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0500 FAX:775-7095

성적서번호 CERTIFICATE NO: 614210 페이지 PAGE: 1
발행일자 DATE OF ISSUE: APR. 25. 2001. E4113102
계약번호 CONTRACT (P/O) NO:
품명 COMMODITY: E.R.W. STEEL PIPE
제품규격 SPECIFICATION: API 5L X42/API 5LB/ASTM A53B
수요가 CUSTOMER:

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 10871
BARTOW STEEL REF. # 38148

G:GOOD

관종 TYPE OF PIPE END ※1	※2	치수 DIMENSION 외경×두께×길이 (OUTDIA. × THICK. × LENGTH) ※3 ※4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST MPa / kg/cm² PSI	※5	※6 VISUAL & DIMENSION TEST	※7 FLATTENING (B) TEST	※8 WELD DUCTILITY TEST	※9 N.D.T	※10 DRIFT TEST	※11 FLARING TEST	※12 CRUSH TEST	※13 R-FLATTENING TEST	※14 HEAT TREATMENT	도막시험 COATING TEST 아연부착량 WEIGHT OF ZINC COAT oz/ft²	균일성 DIP TEST	경도 HARDNESS HRB HV	제강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ※15 kg f/mm²	W ※16 N/mm²	연신율 ELONGATION %	※17	C ×100	Si	Mn	P ×1000	S	Cu ×100	Ni	Cr	Mo	V	Nb ×1000	Al	Ceq	탄소당량
BVBE	OD	18" x .375" x21.000'	121	81.210	105	G	G	G	G	G					G				A08352	33.5	49.0	52.0	37		18	2	81	12	7	2	1	1	Tr	Tr				
		(457.0mm x 9.53mm x 6.401M)			1490															47600	69700	74000																
																			A08747	35.6	51.8	54.5	37		19	1	78	14	7	2	1	1	1	Tr				
																				50600	73700	77500																
																			137277	32.6	49.2	52.0	46		17	2	73	11	10	1	2	1	1	Tr				
																				46400	70000	74000																
BVBE	OD	18" x .375" x42.000'	73	97.989	105	G	G	G	G	G					G				A08352	33.5	49.0	52.0	37		18	2	81	12	7	2	1	1	Tr	Tr				
		(457.0mm x 9.53mm x 12.802M)			1490															47600	69700	74000																
BVBE	OD	20" x .375" x21.000'	101	75.486	100	G	G	G	G	G					G				A05999	35.3	51.9	54.5	35		18	2	80	17	8	1	2	1	Tr	Tr				
		(508.0mm x 9.53mm x 6.401M)			1420															50200	73800	77500																
																			Y07773	34.4	50.5	53.5	35		20	1	80	14	8	1	2	1	Tr	Tr				
																				49900	71800	76100																
BVBE	OD	20" x .375" x42.000'	58	86.697	100	G	G	G	G	G					G				Y07773	34.4	50.5	53.5	35		20	1	80	14	8	1	2	1	Tr	Tr				
		(508.0mm x 9.53mm x 12.802M)			1420															48900	71800	76100																
		TOTAL ->	353	341.382																																		

비고 REMARK

ORIGINAL

주 NOTES

※1 Type of pipe End 관종
X: B: Black, G: Galvanized, E: Enameled
X: V: Varnish, R: Removal Varnish, O: Oiling Coating, F: PE Coating, C: Coaltar Coating, A: Asphalt Coating
XX: PE: Plain End, BE: Bevel End, TE: Thread End, TC: Thread Coupling, BL: Bell End, SE: Swaging End, VJ: Victaulic Joint

※2 NB: Nominal Bore 호칭경, OD: Outside Diameter
※3 Unit 단위 (M: mm, I: Inch)
※4 Unit 단위 (M: Meter, F: Feet, I: Inch)
※5 G: Good
※6 Visual & Dimension Test 육안 및 치수검사
※7 Flattening or Bending Test 편평 또는 굽힘시험
※8 Weld Ductility Test 용접부 연성시험
※9 Nondestructive Test 비파괴검사
※10 Drift Test 관통시험
※11 Flaring Test 압확시험
※12 Crush Test 종압시험
※13 Reverse Flattening Test 역편평시험
※14 Heat Treatment 열처리
※15 B: Base Metal 모재부
※16 W: Weld Part 용접부
※17 H: Heat(Ladle)Analysis 용강분석, P: Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WIT HE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURAN[CE] [TEA]M GENERAL M[ANAGER]

12" PIPE

2001-08-21 09:42 #450 P.02/03

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
• 본사·공장: 울산광역시 북구 염포동 265번지 683-040
HEAD OFFICE: # 265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
(ULSAN PLANT) TEL:280-0114 FAX:(052)287-8916
TLX:HDPIPE K 53776
• 서울사무소: 서울특별시 중구 무교동 77번지 100-170
SEOUL OFFICE: # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0500 FAX:775-7095

성적서번호 CERTIFICATE NO: E14219 페이지 PAGE: 1
발행일자 DATE OF ISSUE: APR. 25. 2001. E4113101
계약번호 CONTRACT (P/O) NO:
품명 COMMODITY: E.R.W. STEEL PIPE
제품규격 SPECIFICATION: ASTM A53 GR.B

수요가 CUSTOMER:

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 11359
BARTOW STEEL REF. # 39347

G:GOOD

관종 TYPE OF PIPE END ※1	※2	치수 DIMENSION 외경×두께×길이 (OUTDIA. × THICK. × LENGTH) ※3 ※4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDRO-STATIC TEST MPa kgf/cm² PSI	※5	※6 VISUAL & DIMENSION TEST	※7 FLATTENING (B) TEST	※8 WELD DUCTILITY TEST	※9 N.D.T.	※10 DRIFT TEST	※11 FLARING TEST	※12 CRUSH TEST	※13 R-FLATTENING TEST	※14 HEAT TREATMENT	도막시험 COATING TEST 아연부착량 WEIGHT OF ZINC COAT g/m² OZ/Ft²	균일성 DIP TEST Ti-MES	※5	경도 HARDNESS HRB HV	제강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ※15 kgf/mm² N/mm²	W ※16	연신율 ELONGATION %	※17	C ×100	Si	Mn	P ×1000	S	Cu ×100	Ni	Cr	Mo	V	Nb ×1000	Al	Ceq	충격시험 IMPACT 흡수에너지 Absorbed EGY. JOULE	취성파면율 SHEAR AREA %
BVBE	NB	3" x .216" x21.000'	756	54.613	176	G	G	G		G					G					31341843	30.5	47.2		29		16	Tr	68	14	7	1	2	1	Tr	Tr					
		(88.9mm x 5.49mm x 6.401M)			2500																43400	67100																		
																				31341853	35.4	48.0		36		16	3	33	16	7	1	2	1	Tr	1					
																					50400	68300																		
																				31341873	34.2	46.5		30		15	1	68	12	9	1	2	1	Tr	Tr					
																					48600	66100																		
BVBE	NB	3" x .216" x42.000'	252	36.409	176	G	G	G		G					G					31341843	30.5	47.2		29		16	Tr	68	14	7	1	2	1	Tr	Tr					
		(88.9mm x 5.49mm x 12.802M)			2500																43400	67100																		
BVBE	NB	12" x .375" x21.000'	365	172.386	88	G	G	G		G					G					B33090	33.3	51.1	53.9	31		19	2	76	12	7	1	2	1	Tr	Tr					
		(323.8mm x 9.53mm x 6.401M)			1250																47400	72700	76700																	
																				B33092	32.5	50.0	52.8	34		19	1	78	12	6	1	2	1	Tr	Tr					
																					46200	71100	75100																	
BVBE	NB	12" x .375" x42.000'	201	189.861	88	G	G	G		G					G					B33090	33.3	51.1	53.9	31		19	2	76	12	7	1	2	1	Tr	Tr					
		(323.8mm x 9.53mm x 12.802M)			1250																47400	72700	76700																	
																				B33092	32.5	50.0	52.8	34		19	1	78	12	6	1	2	1	Tr	Tr					

비고 REMARK

ORIGINAL

주기 NOTES

※1 Type of pipe End 관종

X
- B : Black
- G : Galvanized
- E : Enameled

X
- V : Varnish
- R : Removal Varnish
- O : Oiling Coating
- F : PE Coating
- C : Coaltar Coating
- A : Asphalt Coating

XX
- PE : Plain End
- BE : Bevel End
- TE : Thread End
- TC : Thread Coupling
- BL : Bell End
- SE : Swaging End
- VJ : Victaulic Joint

※2 NB : Nominal Bore 호칭경, OD: Outside Diameter
※3 Unit 단위 (M : mm, I : Inch)
※4 Unit 단위 (M : Meter, F : Feet, I : Inch)
※5 G : Good
※6 Visual & Dimension Test 육안 및 치수검사
※7 Flattening or Bending Test 편평 또는 굽힘시험
※8 Weld Ductility Test 용접부 연성시험
※9 Nondestructive Test 비파괴검사 ( )
※10 Drift Test 관용시험
※11 Flaring Test 압확시험
※12 Crush Test 충압시험
※13 Reverse Flattening Test 전개시험
※14 Heat Treatment 열처리
※15 B : Base Metal 모재부
※16 W : Weld Part 용접부
※17 H : Heat(Ladle)Analysis 열연분석, P:Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR.

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

성적서번호 CERTIFICATE NO: E14219 페이지 PAGE: 2
발행일자 DATE OF ISSUE: APR. 25. 2001. E4113101
계약번호 CONTRACT (P/O) NO:
품명 COMMODITY: E.R.W. STEEL PIPE
제품규격 SPECIFICATION: ASTM A53 GR.B
수요가 CUSTOMER:

THESE MILL TEST REPORTS APPLY TO
YOUR P.O. # 11359
BARTOW STEEL REF. # 39347

현대강관주식회사
HYUNDAI PIPE CO.,LTD.
* 본사·공장 : 울산광역시 북구 염포동 265번지 ☎283-0400
HEAD OFFICE : # 265, YUMPO-DONG, BUK-KU, ULSAN, KOREA
(ULSAN PLANT) TEL:280-0114 FAX:(052)287-8916
TLX:HDPIPE K 53776
* 서울사무소:서울특별시 중구 무교동 77번지 ☎100-170
SEOUL OFFICE : # 77, MUGYO-DONG, JOONG-KU, SEOUL, KOREA
TEL:3455-0500 FAX:775-7095

G:GOOD

관종 TYPE OF PIPE END ※1	※2	치수 DIMENSION 외경×두께×길이 (OUTDIA. × THICK. × LENGTH) ※3 ※4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST MPa kg f/cm² PSI	※5	※6 VISUAL & DIMENSION TEST	※7 FLATTENING (B) TEST	※8 WELD DUCTILITY TEST	※9 N.D.T	※10 DRIFT TEST	※11 FLARING TEST	※12 CRUSH TEST	※13 R-FLATTENING TEST	※14 HEAT TREATMENT	도막시험 COATING TEST 아연부착량 WEIGHT OF ZINC COAT g/m² OZ/Ft²	균일성 DIP TEST TIMES ※5	경도 HARDNESS HRB HV	제강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ※15 kg f/mm² N/mm²	W ※16	연신율 ELONGATION %	※17	C ×100	Si ×100	Mn ×100	P ×1000	S ×1000	Cu ×100	Ni ×100	Cr ×100	Mo ×100	V ×100	Nb ×1000	Al ×1000	Ceq ×1000	충격시험 IMPACT 흡수에너지 Absorbed EGY. JOULE	전단면적 SHEAR AREA %
		(323.8mm x 9.53mm x 12.802M)			1250															46200	71100	75100																	
																			B33098	31.6	49.4	52.1	36		18	1	77	13	6	1	2	1	Tr	Tr					
																				44900	70300	74100																	
BVBE	NB	12" x .500" x21.000'	33	20.582	116	G	G	G		G					G				A06394	32.6	50.0	52.8	33		18	1	80	16	8	1	2	1	Tr	Tr					
		(323.8mm x12.70mm x 6.401M)			1650															46400	71100	75100																	
																			B33089	31.1	49.1	52.0	34		17	3	74	11	6	1	2	1	Tr	Tr					
																				44200	69800	74000																	
																			B33098	31.6	49.4	52.1	36		18	1	77	13	6	1	2	1	Tr	Tr					
																				44900	70300	74100																	
																			B33100	31.4	49.1	52.0	38		17	1	77	14	5	2	1	1	Tr	Tr					
																				44700	69800	74000																	
BVBE	NB	12" x .500" x42.000'	16	19.958	116	G	G	G		G					G				B33098	31.6	49.4	52.1	36		18	1	77	13	6	1	2	1	Tr	Tr					
		(323.8mm x12.70mm x 12.802M)			1650															44900	70300	74100																	
		TOTAL ->	1623	493.809																																			

비고 REMARK

ORIGINAL

주기 NOTES

※1 Type of pipe End 관종

X
- B : Black
- G : Galvanized
- E : Enameled

X
- V : Varnish
- R : Removal Varnish
- O : Oiling Coating
- F : PE Coating
- C : Coaltar Coating
- A : Asphalt Coating

XX
- PE : Plain End
- BE : Bevel End
- TE : Thread End
- TC : Thread Coupling
- BL : Bell End
- SE : Swaging End
- VJ : Victaulic Joint

※2 NB : Nominal Bore 호칭경, OD: Outside Diameter
※3 Unit 단위 (M : mm, I : Inch)
※4 Unit 단위 (M : Meter, F : Feet, I : Inch)
※5 G : Good
※6 Visual & Dimension Test 육안 및 치수검사
※7 Flattening or Bending Test 편평 또는 굽힘시험
※8 Weld Ductility Test 용접부 연성시험
※9 Nondestructive Test 비파괴검사 ( )
※10 Drift Test 관확시험
※11 Flaring Test 압확시험
※12 Crush Test 종압시험
※13 Reverse Flattening Test 전개시험
※14 Heat Treatment 열처리
※15 B : Base Metal 모재부
※16 W : Weld Part 용접부
※17 H : Heat(Ladle)Analysis 열연분석, P:Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.
WE CERTIFY THAT THE DESCRIBED MATERIAL HAS HEREIN BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

H. G. Lee
QUALITY ASSURANCE TEAM GENERAL MGR.

HPS - B 301 - 631 - 0 - OLT

HYUNDAI PIPE CO.,LTD.

(350 × 280)

FORM RP-59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT Lake Okee. ASR Pilot Project WELL NO. GLF-6 DATE 8/23/01

12 inch dia. Casing Tally

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER					
Casing #	Set #	Heat #	Tag #	Length (ft)	Start Weld	End Weld
12	1	B33098	75583	42.10	11:07	11:17
11	2	B33092	72056	42.10	11:40	11:47
10	3	B33092	75583	42.10	12:07	12:10
9	4	B33092	75583	42.09	12:40	12:47
8	5	B33092	72058	42.13	13:13	13:20
7	6	B33092	72054	42.10	1330	13:40
6	7	B33098	75583	42.10	1350	13:57
5	8	B33092	72049	42.10	14:02	14:12
4	9	B33098	72055	42.12	14:19	14:30
3	10	B33092	72060	42.11	14:44	14:51
2	11	B33098	72057	42.10	15:00	15:10
1	12	B33098	75583	42.11	15:17	15:25
20	13	B33092	75583	42.10	15:36	15:45
19	14	B33092	75583	42.10	15.57	16:05
18	15	B33092	75583	42.10	16:17	16:25
16	16	B33092	75583	42.10	16:35	16:44
17	17	B33098	75583	42.10	16:54	17:05
15	18	B33090	75583	42.10	17:10	17:18
14	19	B33092	75583	42.09	17:47	18:00
13	20	B33098	72053	42.11	18:10	18:20
21	21	B33098	75583	24.65	18:28	18:35
			Total:	866.71		

Appendix C

Lithologic Descriptions

Lithologic Log
SFWMD Moore Haven Test Well GLF-6
Glades County, Florida

Depth in Feet Below Pad

From	To	Lithologic Description GLF-6
0	10	Light gray fine quartz sand/silt mix, 40% quartz (dirty sugar sand). Note: shallow sediments may have been reworked, site is near Hoover Dike, the Caloosahatchee and a road. Poor to moderate induration.
10	25	Medium to dark gray shell hash (pelcypods, gastropods, barnacles, bryozoams, and oyster fragments) This shell hash has a fine sand(quartz)/silt matrix . Poor induration.
25	35	Same as above with some large well rounded quartz sand grains (2mm by 4mm and roughly 5% of cuttings)
35	50	Medium to dark gray shell hash (pelcypods, gastropods, barnacles, bryozoams, and oyster fragments) This shell hash has a silt/clay matrix and is better indurated than above. Moderate induration.
50	70	Medium to dark gray shell hash (pelcypods, gastropods, barnacles, bryozoams, and oyster fragments) This shell hash has a fine quartz sand matrix, sand content estimated to approach 50 %. Poor induration
70	82	Medium to dark gray shell hash (pelcypods, gastropods, barnacles, bryozoams, and oyster fragments) This shell hash has a fine sand(quartz)/silt matrix . Poor to moderate induration.
82	160	Light Gray, Poorly sorted quartz sand, predominantly fine but with some larger grains 5mm by 7mm
160	180	Light Gray, Poorly sorted dirty quartz sand, increasing silt matrix compared to above
180	185	Light gray green clay with some sand and silt
185	190	Gray green silty clay
190	217	Green plastic clay with some silt
217	240	Light Green, poorly indurated, sandy silty clay
240	245	Light gray sandy, silty, clay
245	250	Green Gray, soupy, silt, fine sand, clay mix
250	290	Green Silty Clay, fine sand mix, friable
290	305	Gray green silty, sandy clay, slightly plastic
305	310	Light gray green friable silt, fine sand, clay mix, dry
310	355	Light gray green friable silt, fine sand, clay mix, hydrated
355	401	Light gray green plastic clay with significant silt and fine sand.
401	405	Dark grayish-green plastic clay with coarse quartz sandand phosphatic sand grains (2-4mm)
405	460	Gray green friable Clay with varying amounts of sand and silt.
460	475	Light gray green plastic clay
475	540	Mixed green and white phosphatic clay
540	545	Light gray plastic silty clay
545	560	Light gray to white micritic limestone/clay mix
560	605	Light gray clay marl with shell fragments and fine sand sized phosphorite grains
605	615	Green plastic clay with little to no sand and silt.
615	650	Mixture of green clay with white micritic marl
650	670	White micrite with some phosphorite

Lithologic Log
SFWMD Moore Haven Test Well GLF-6
Glades County, Florida

Depth in Feet Below Pad

675	680	Green Clay
680	710	White micrite with clay and phosphorite
710	743	White shelly micrite with clay
743	784	Gray green friable silt, fine sand mix with clay
784	804	Hard green clay, interval was cored, but poor capture.
804	845	Light gray green clay with phosphate and shell
845	874	White mudstone
874	886	(Core, 100% recovery) White Mudstone
886	988	White mudstone
988	1,006	(Core, 100% recovery) White Mudstone
1,006	1,125	White mudstone
1,125	1,173	White Wackestone/packstone Large quantities of leps
1,173	1,210	White Wackestone/packstone
1,210	1,215	White Wackestone/packstone, with phosphorite
1,215	1,245	Tan Packstone, interfingered with sandy clay
1,245	1,265	Tan Packstone , better indurated than above
1,265	1,299	White mudstone
1,299	1,317	(Core, 100% recovery) White to tan mudstone
1,317	1,418	White to tan mudstone, friable, micritic, <5% allochems, low intergranular porosity.
1,418	1,463	White to tan mudstone, friable, micritic, <5% allochems, 30% dolomite, low intergranular porosity.
1,463	1,478	White to tan mudstone, friable, micritic, <5% allochems, 10% dolomite, low intergranular porosity.
1,478	1,508	White to tan mudstone, friable, micritic, <5% allochems, 5% dolomite, low intergranular porosity.
1,508	1,528	White to tan mudstone, friable, micritic, <5% allochems, <1% dolomite, low intergranular porosity.
1,528	1,538	White to tan mudstone, friable, micritic, <5% allochems, <1% dolomite, 1-3 % white clay/lime mud low intergranular porosity.
1,538	1,543	White to tan mudstone, friable, micritic, <5% allochems, 10% dolomite, 1-3 % white and brown clay/ lime mud, low intergranular porosity.
1,543	1,571	White to tan mudstone, friable, micritic, <5% allochems, 10% dolomite, low intergranular porosity.
1,571	1,591	(Core, 100% recovery) Tan mudstone to wackestone
1,591	1,605	White to tan mudstone with small amounts of packstone (sand sized grains)
1,605	1,610	Dark brown to black sucrosic dolostone
1,610	1,615	Tan mudstone
1,615	1,620	Tan mudstone with 30% dolomite

Lithologic Log
SFWMD Moore Haven Test Well GLF-6
Glades County, Florida

Depth in Feet Below Pad

1,620	1,625	Tan mudstone with 30% dolomite, friable
1,625	1,633	Mudstone
1,633	1,664	Cavity
	1,650	**Reverse-air Water Quality Data taken on 9/18/01** **Temp = 30.62C; pH = 7.63 s.u.; SpCond = 5,931 umhos/cm; Cl**
1,664	1,669	Light tan mudstone
1,669	1,680	Light to dark tan mudstone
1,680	1,735	Moderately indurated, white to light tan mudstone, low intergranular porosity
	1,690	**Reverse-air Water Quality Data taken on 9/19/01** **Temp = 30.94C; pH = 7.05 s.u.; SpCond = 5,960 umhos/cm;**
1,740	1,750	Well indurated, dark brown, crystalline dolostone (sucrosic)
1,750	1,765	Moderately to well indurated, tan colored, crystalline dolostone. 5% white, poorly inudurated mudstone
1,765	1,780	Moderately to well indurated, tan to dark brown cystalline dolostone (sucrousic) moderate intercystalline porosity
1,780	1,788	Moderately to well indurated, tan to dark brown cystalline dolostone (sucrousic) moderate intercystalline porosity; 5 to 10% white moderately indurated mudstone
1,788	1,795	(Core, 28 % recovery) Well indurated tan to dark brown crystalline dolostone (sucrosic) minor vuggy porosity development
1,819	1,855	Well indurated, medium brown to black crystalline (sucrosic) to cyptocrystalline dolostone minor vuggy porosity development; 5 to 10% white to tan poorly to moderately indurated mudstone to wackestone - Dictyoconus present; signficant bit chatter; drilling rate 4 minutes/foot
	1,850	**Reverse-air Water Quality Data taken @ 10:13 hr on 9/22/01** **Temp = 30.75C; pH = 8.11 s.u.; SpCond = 13,444 umhos/cm; ORP = 205 CL = 5,200 mg/l**
1,855	1,860	Moderatley indurated, medium brown to golden brown, cryptocrystalline to crystalline (sucrosic) dolostone, good intercrystalline porosity; recystallized irregular echinoids; some bit plugging
1,860	1,870	Well indurated, medium to dark brown crytalline dolostone, few irregular echinoids present minor intercystalline porosity
1,870	1,880	Moderately indurated, medium to golden brown crystalline (sucrosic) dolostone , good intercrystalline porosity development - good permeability- increased water flow at land surface and reverse-air returns began to foam
	1,880	**Reverse-air Water Quality Data taken @ 1230 hr on 9/22/01** **Temp = 31.61 C; pH = 7.67; SpCond = 24,882 umhos/cm; ORP = 262; Cl = 8,400 mg/l**
1,880	1,890	Well indurated, medium brown to dark gray microcrystalline to crystalline dolostone minor pin-hole porosity, low intercrystalline porosity - low permeability
1,890	1,900	Moderately indurated, golden brown crystalline (sucrosic) dolostone, good intercrystalline porosity develop. good pin-hole porosity -good permeability
1,900	1,905	Very well indurated, brown to black microcystalline to crystalline dolostone; minor intercrystalline porosity and pin-hole porosity - low permeability - good confinement

Lithologic Log
SFWMD Moore Haven Test Well GLF-6
Glades County, Florida

Depth in Feet Below Pad

1,905	1,910	Moderately to well indurated, medium to golden brown to dark gray microcrystalline to crystalline (sucrosic) dolostone good intercystalline porosity, minor pin-hole porosity; moderately indurated light gray wackstone near base (1,908 to 1,910) with minor pin-hole porosity
	1,910	**Reverse-air Water Quality Data taken @ 1431 hr on 9/22/01** **Temp = 32.59 C; pH = 7.67; SpCond = 34,953 umhos/cm; ORP = 243; Cl = 12,500 mg/l**
1,910	1,920	Moderately to well indurated, medium to golden brown to dark gray microcrystalline to crystalline (sucrosic) dolostone good intercrystalline porosity, minor pin-hole porosity
1,920	1,925	Moderately to well indurated, dark tan to dark gray microcrystalline to crystalline (sucrosic) dolostone good intercrystalline porosity,
1,925	1,940	Moderately to well indurated, dark tan to dark gray striated microcrystalline to crystalline (sucrosic) dolostone good intercrystalline porosity,
1,940	1,945	Dark tan to dark gray dolostone, dark gray is cryptocrystalline and well indurated (70%), dark tan is crystalline sucrosic, and moderately indurated (30%), good intercrystalline porosity,
	1,940	**Reverse-air Water Quality Data taken @ 11:47 hr on 9/24/01** **Temp = 33.56 C; pH = 7.32; SpCond = 43,840 umhos/cm; ORP = 219; Cl = 17,000 mg/l**
	1,945	**Reverse-air Water Quality Data taken @ 12:30 hr on 9/24/01** **Temp = 31.51 C; pH = 7.50; SpCond = 43,818 umhos/cm**
	1,945	**Reverse-air Water Quality Data taken @ 12:45 hr on 9/24/01** **Temp = 31.28 C; pH = 7.43; SpCond = 45,150 umhos/cm; ORP = 172** (Note: the flow stopped shortly after taking the 12:45 water quality sample. The driller (Bruce Harman) speculated that the density of the water might be suppressing the flow. The site geologist (Jeff Herr) believes that we encountered a producing zone with a lower head, or less dense (better quality) water which would take water. The driller added 40 feet to the airline and the well did produce water, it took approximately 40 minutes to add more airline. The flow rate increased with time.
1,945	1,972	Dark gray cryptocrystalline well indurated dolostone with a tan crystalline (sucrosic) coating, high intercrystalline porosity.
	1,972	**Reverse-air Water Quality Data taken @ 13:50 hr on 9/24/01** **Temp = 31.51 C; pH = 7.16; SpCond = 52,620 umhos/cm; ORP 150; Cl = 20,000 mg/l**
		(Entire open hole discharge) Water Quality Taken @1348 Temp = 31.67 C; pH = 7.40; SpCond = 6,797 umhos/cm; ORP -65
1,972	1,980	Dark gray with Tan and white mottling, crystalline dolostone, well indurated platy fracture. some faces have well developed sucrosic fracture with some graine sizes to 0.5 mm
1,980	1,995	Dark gray with Tan and white mottling, crystalline dolostone, well indurated platy fracture.
1,995	2,000	Light gray with Tan and white mottling, crystalline dolostone, well indurated platy fracture.
2,000	2,005	Dark gray with some tan and brown colored crystalline dolostone, well indurated with some pin-ppoint porosity Sucrosic dolomite crystals coating the interior of vugs.
	2,003	**Reverse-air Water Quality Data taken @ 1500 on 9/25/01** **Temp = na C; pH = 7.36; SpCond = 53,600 umhos/cm; ORP 150; Cl = 22,500 mg/l**
2,005	2,010	Golden-brown to gray tan cryptocrystalline dolostone, some faces have a crystralline (sucrosic) coating moderate induration, platy fracture
	2,010	**Reverse-air Water Quality Data taken @ 15:45 on 9/25/01** **Temp = 31.89 C; pH = 7.43; SpCond = 52,462 umhos/cm; ORP 229**
	entire OH	(Entire Open Hole Discharge) sample taken @ 15:55 on 9/25/01

Lithologic Log
SFWMD Moore Haven Test Well GLF-6
Glades County, Florida

Depth in Feet Below Pad

		Temp = 31.67 C; pH = 7.76; SpCond = 7,009 umhos/cm; ORP -62
2,010	2,015	light tan and light gray crystalline dolostone, moderately indurated with platy fracture. Larger crystaline size on interior surface of vugs.
2,015	2,020	Light-tan gray cryptocrystalline moderately indurated dolostone, rare crystalline coating on some faces.
	2,020	**Reverse-air Water Quality Data taken @ 16:02 on 9/25/01** **Temp = 31.51 C; pH = 7.50; SpCond = 53,299 umhos/cm; ORP 240; Cl = 21,500 mg/l**
2,020	2,026	Mottled gray white and tan, moderately to well indurated dolostone.
2,026	2,027	Grayish tan moderately indurated crystalline dolomite with platy fractures.
2,027	2,030	Grayish tan moderately indurated crystalline dolomite with platy fractures, sucrosic coating on some surfaces.
	2,030	**Drill Stem Reverse-air Water Quality Data taken @ 14:45 on 10/04/01** **Temp = 31.54 C; pH = 7.21; SpCond = 53,100 umhos/cm;**

```
LITHOLOGIC WELL LOG PRINTOUT                  SOURCE - FGS

WELL NUMBER:   W-18253                        COUNTY -   GLADES
TOTAL DEPTH:    2030  FT.                     LOCATION:  T.42N R.32E S.12
SAMPLES - NONE                                           LAT = 26D 83M 85S
                                                         LON = 81D 85M 44S
COMPLETION DATE: //02                         ELEVATION: 15 FT
OTHER TYPES OF LOGS AVAILABLE - NONE

OWNER/DRILLER:SOUTH FLORIDA WATER MANAGEMENT DISTRICT

WORKED BY:FRANCIS FLORES AND ED MARKS
CUTTINGS BAGGED IN FIVE-FOOT INTERVALS
WELL FOR MONITOR AND TEST INJECTION
MISSING SAMPLE INTERVALS: 365-370, 905-910, 985-1005, 1190-1195,
1300-1320, 1395-1603, 1985-1990, 2010-2015.
CAVITY: 1631-1664,  UNWASHED: 0-1605, WASHED: 1605-2030.

    0.   -  155.   121PCPC   PLIOCENE-PLEISTOCENE
  155.   -  530.   122PCRV   PEACE RIVER FM.
  530.   -  840.   122ARCA   ARCADIA FM.
  840.   -  950.   123SWNN   SUWANNEE LIMESTONE
  950.   - 1230.   124OCAL   OCALA GROUP
 1230.   -     .   124AVPK   AVON PARK FM.

    0  -    5   SAND; VERY LIGHT ORANGE TO VERY LIGHT GRAY
                POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: SHELL-03%, PHOSPHATIC SAND-01%
                LIMESTONE-01%

    5  -   10   SAND; VERY LIGHT ORANGE TO VERY LIGHT GRAY
                POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: LIMESTONE-02%, SHELL-01%
                PHOSPHATIC SAND-01%

   10  -   15   SHELL BED; VERY LIGHT GRAY TO YELLOWISH GRAY
                POROSITY: INTERGRANULAR, INTRAGRANULAR
                POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
                ACCESSORY MINERALS: QUARTZ SAND-40%, PHOSPHATIC SAND-01%
                FOSSILS: BARNACLES, BRYOZOA
                SHELLS CONSIST OF 99% BARNACLES AND 1%BRYOZOANS

   15  -   20   SAND; VERY LIGHT ORANGE TO VERY LIGHT GRAY
                POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: MEDIUM; RANGE: FINE TO COARSE
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: SHELL-01%, PHOSPHATIC SAND-01%

   20  -   30   SHELL BED; MODERATE LIGHT GRAY TO YELLOWISH GRAY
                POROSITY: INTERGRANULAR, INTRAGRANULAR
```

POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, PHOSPHATIC SAND-01%
FOSSILS: BARNACLES, BRYOZOA
QUARTZ IS MTOC TEXT GRN SUPPORTED IN CALCILUTITE SHELL IS CHIEFLY BARNACLES

30 - 45 SHELL BED; MODERATE LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, PHOSPHATIC SAND-01%
FOSSILS: BARNACLES, BRYOZOA, CORAL, MOLLUSKS
SHELLS CONSIST OF MOSTLY BARNACLES AND BRYOZOA

45 - 60 SHELL BED; MODERATE LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-10%
FOSSILS: BARNACLES, BRYOZOA, CORAL, MOLLUSKS
SHELLS ARE 70% BARNACLE MOLLUSKS ARE GASTROPODS AND BIVALVES

60 - 80 SHELL BED; MODERATE LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%
FOSSILS: BARNACLES, BRYOZOA, MOLLUSKS

80 - 85 SHELL BED; MODERATE LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, PHOSPHATIC SAND-01%
FOSSILS: BARNACLES, BRYOZOA, MOLLUSKS

85 - 90 PACKSTONE; VERY LIGHT GRAY TO LIGHT GRAY
GRAIN TYPE: CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: COARSE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-01%, PHOSPHATIC SAND-01%

90 - 95 SAND; YELLOWISH GRAY TO LIGHT GRAY
POROSITY: POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO VERY COARSE
ROUNDNESS: SUB-ROUNDED TO ROUNDED; MEDIUM SPHERICITY
ACCESSORY MINERALS: LIMESTONE-30%, PHOSPHATIC SAND-01%
FOSSILS: BARNACLES, MOLLUSKS
LIMESTONE IS WACKESTONE AND PACKSTONE

95 - 100 SAND; VERY LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: GRAVEL; RANGE: GRANULE TO GRAVEL
ROUNDNESS: SUB-ROUNDED TO ROUNDED; MEDIUM SPHERICITY
ACCESSORY MINERALS: LIMESTONE-30%, QUARTZ SAND-05%
PHOSPHATIC SAND-01%
LIMESTONE IS WACKESTONE TO PACKSTONE SECONDARY MODE SAND IS VERY FINE TO FINE

100 - 105 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: GRAVEL; RANGE: GRANULE TO GRAVEL
ROUNDNESS: SUB-ROUNDED TO ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-05%, LIMESTONE-03%
CLAY-01%, PHOSPHATIC SAND-01%
SECONDARY MODE SAND IS VERY FINE TO FINE CLAY IS PLATY

105 - 110 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: COARSE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-03%, CLAY-01%
PHOSPHATIC SAND-01%
LIMESTONE IS WACKSTONE CLAY IS PLATY

110 - 115 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: COARSE; RANGE: VERY FINE TO GRAVEL
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-01%, PHOSPHATIC SAND-01%
OTHER FEATURES: FROSTED

115 - 120 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: COARSE; RANGE: VERY FINE TO GRAVEL
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-01%, PHOSPHATIC SAND-01%
CLAY-01%
OTHER FEATURES: FROSTED

120 - 125 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO ROUNDED; HIGH SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-01%, PHOSPHATIC SAND-01%

125 - 130 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO VERY COARSE
ROUNDNESS: SUB-ANGULAR TO ROUNDED; HIGH SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-01%, PHOSPHATIC SAND-01%

130 - 140 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO VERY COARSE
ROUNDNESS: SUB-ANGULAR TO ROUNDED; HIGH SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: PHOSPHATIC SAND-01%

140 - 155 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: COARSE; RANGE: VERY FINE TO VERY COARSE
ROUNDNESS: SUB-ROUNDED TO SUB-ROUNDED; HIGH SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: PHOSPHATIC SAND-01%

155 - 165 SAND; VERY LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: COARSE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-03%, PHOSPHATIC SAND-01%
CLAY-01%
OTHER FEATURES: FROSTED

165 - 170 SAND; VERY LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-03%, PHOSPHATIC SAND-01%
LIMESTONE IS WACKESTONE WITH FINE SAND GRAINS

170 - 175 SAND; VERY LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRAVEL
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-03%, PHOSPHATIC SAND-01%
LIMESTONE IS WACKESTONE WITH FINE SAND GRAINS

175 - 180 SAND; VERY LIGHT GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-05%, PHOSPHATIC SAND-01%
CLAY-01%
LIMESTONE IS WACKESTONE WITH FINE SAND GRAINS

180 - 190 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRAVEL
ROUNDNESS: SUB-ROUNDED TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: DOLOMITE-40%, LIMESTONE-03%
PHOSPHATIC SAND-01%
DOLOMITE IS DOLOSILT

190 - 195 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO SUB-ANGULAR; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: DOLOMITE-20%, LIMESTONE-20%
PHOSPHATIC SAND-01%

DOLOMITE IS DOLOSILT LIMESTONE IS MODERATELY INDURATED AND
CONTAINS FINE SAND

195 - 210 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: DOLOMITE-20%, LIMESTONE-20%
PHOSPHATIC SAND-01%, MICA-01%
DOLOMITE IS DOLOSILT LIMESTONE IS MODERATELY INDURATED AND
CONTAINS FINE SAND

210 - 220 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: DOLOMITE-10%, LIMESTONE-05%
PHOSPHATIC SAND-01%, MICA-01%
DOLOMITE IS DOLOSILT LIMESTONE IS MODERATELY INDURATED AND
CONTAINS FINE SAND

220 - 225 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
ACCESSORY MINERALS: QUARTZ SAND-30%, PHOSPHATIC SAND-01%
MICA-01%, DOLOMITE-20%
QUARTZ IS FINE SAND

225 - 235 SAND; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: CALCILUTITE-01%, PHOSPHATIC SAND-01%
MICA-01%
FOSSILS: MOLLUSKS

235 - 245 SAND; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: CALCILUTITE-01%, SHELL-01%
PHOSPHATIC SAND-01%
CALCILUTITE IS CEMENT IN POORLY INDURATED MEDDUM SAND

245 - 250 WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM
MODERATE INDURATION
ACCESSORY MINERALS: QUARTZ SAND-10%, PHOSPHATIC SAND-01%
SAND IS FINE. POORLY INDURATED IN CALCILUTITE

250 - 270 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, LIMESTONE-03%
MICA-01%, PHOSPHATIC SAND-01%

270 - 275 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-20%, LIMESTONE-03%
MICA-01%, PHOSPHATIC SAND-01%

275 - 285 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, LIMESTONE-03%
MICA-01%, PHOSPHATIC SAND-01%

285 - 295 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, LIMESTONE-03%
MICA-01%, PHOSPHATIC SAND-01%
CUTTINGS ARE LARGER THAN 285 INTERVAL

295 - 300 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-20%, LIMESTONE-20%
MICA-01%, PHOSPHATIC SAND-01%
FOSSILS: BARNACLES
CLAY IS PLATY OF POOR MODERATE INDURATION AND CONTAINS SAND

300 - 305 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-30%, LIMESTONE-10%
SHELL-01%, MICA-01%
CLAY IS PLATY OF POOR TO MODERATE INDURATION AND CONTAINS
SAND

305 - 320 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: QUARTZ SAND-20%, LIMESTONE-05%
MICA-01%, PHOSPHATIC SAND-01%
SAME TYPE OF CLAY LIMESTONE CUTTINGS ARE COARSER THAN
PREVIOUS INTERVAL DESCRIBED

320 - 340 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-30%, MICA-01%
PHOSPHATIC SAND-01%
INTERVAL 330-335 MISSING DOLOSILT IS MIXED WITH MEDIUM SAND

340 - 350 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY

POROSITY: INTERGRANULAR, LOW PERMEABILITY; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-10%, MICA-01%
PHOSPHATIC SAND-01%

350 - 355 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-01%, MICA-01%
PHOSPHATIC SAND-01%

355 - 365 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-03%, MICA-01%
PHOSPHATIC SAND-01%
QUARTZ IS COARSE-GRANULES SUBROUNDED

365 - 385 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
ACCESSORY MINERALS: QUARTZ SAND-03%, MICA-01%
PHOSPHATIC SAND-01%
INTERVAL 365-370 MISSING SAME TYPE OF QUARTZ AS PREVIOUS
INTERVAL

385 - 400 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-03%, MICA-01%
PHOSPHATIC SAND-01%
DOLOSTONE IS DOLOSILT SAME TYPE OF QUARTZ

400 - 420 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO LIGHT GRAY
POROSITY: INTERGRANULAR; POOR INDURATION
ACCESSORY MINERALS: QUARTZ SAND-40%, MICA-01%
PHOSPHATIC SAND-01%
QUARTZ IS OPAQUE WHITE-BLACK ROUNDED COARSE-PEBBLES

420 - 430 SILT-SIZE DOLOMITE; LIGHT OLIVE GRAY TO MODERATE LIGHT GRAY
POROSITY: INTERGRANULAR
ACCESSORY MINERALS: QUARTZ SAND-20%, MICA-01%
PHOSPHATIC SAND-01%
SAME TYPE OF QUARTZ AS PREVIOUS INTERVAL

430 - 450 PACKSTONE; YELLOWISH GRAY TO MODERATE LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: MICA-01%, PHOSPHATIC SAND-01%
GRANULES ARE OPAQUE TO DARK AND SUBROUNDED CEMENT IS
YELLOWISH GRAY

450 - 465 SAND; YELLOWISH GRAY TO MODERATE LIGHT GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

ACCESSORY MINERALS: MICA-01%, PHOSPHATIC SAND-01%
MORE COARSE CUTTINGS THAN PREVIOUS INTERVAL

465 - 475 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-20%, QUARTZ SAND-05%, MICA-01%
PHOSPHATIC SAND-01%
GRANULES APPEAR TO BE SECOND MODE ROUNDED OPAQUE-DARK
CLAY PREDOMINATES COLOR

475 - 480 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
UNCONSOLIDATED
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-05%, CLAY-01%
PHOSPHATIC SAND-01%, SHELL-01%

480 - 485 PACKSTONE; LIGHT OLIVE GRAY TO WHITE
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-05%, CLAY-01%
PHOSPHATIC SAND-01%

485 - 490 PACKSTONE; LIGHT OLIVE GRAY TO MODERATE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC GRAVEL-05%
CLAY-01%, SHELL-01%
FOSSILS: SHARKS TEETH

490 - 500 WACKESTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
UNCONSOLIDATED
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-10%, LIMESTONE-03%
CLAY-01%, SHELL-01%
FOSSILS: SHARKS TEETH
PHOSPATIC GRAVEL SAME

500 - 505 WACKESTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-20%, PHOSPHATIC GRAVEL-03%
PHOSPHATIC SAND-01%

505 - 510 WACKESTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-30%, PHOSPHATIC GRAVEL-05%
PHOSPHATIC SAND-01%
FOSSILS: SHARKS TEETH

510 - 515 WACKESTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-03%
PHOSPHATIC SAND-01%

515 - 530 WACKESTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: INTRACLASTS, CALCILUTITE
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-03%
PHOSPHATIC SAND-01%

530 - 535 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-10%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-01%, QUARTZ SAND-20%
FOSSILS: BRYOZOA, CORAL, SHARKS TEETH

535 - 540 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION

CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-05%, PHOSPHATIC SAND-03%
QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

540 - 545 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-05%, CLAY-01%
QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

545 - 555 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-03%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

555 - 570 PACKSTONE; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-03%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-10%, SHELL-30%
FOSSILS: CORAL, BRYOZOA, MOLLUSKS

570 - 575 PACKSTONE; YELLOWISH GRAY TO MODERATE LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-10%, CLAY-03%
PHOSPHATIC SAND-20%, SHELL-30%
FOSSILS: SHARKS TEETH, BRYOZOA, MOLLUSKS, CORAL
PHOSPHATIC GRANULES APPEAR TO BE FOSSILS

575 - 585 PACKSTONE; YELLOWISH GRAY TO VERY LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-40%, PHOSPHATIC SAND-15%

PHOSPHATIC GRAVEL-01%, CLAY-01%
FOSSILS: BRYOZOA, CORAL
PHOSPHATIC GRANULES ALLOCHEMS

585 - 590 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%, PHOSPHATIC SAND-03%
PHOSPHATIC GRAVEL-03%, CLAY-03%
FOSSILS: BRYOZOA, CORAL

590 - 600 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-30%, PHOSPHATIC SAND-03%
CLAY-01%
FOSSILS: BRYOZOA, CORAL

600 - 605 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%
PHOSPHATIC SAND-01%

605 - 610 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-15%
PHOSPHATIC SAND-01%, CHERT-01%
FOSSILS: BRYOZOA, CORAL

610 - 620 CLAY; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-01%, CHERT-01%
FOSSILS: BRYOZOA, CORAL
BRYOZOANS ABUNDANT

620 - 625 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY

POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-02%, SHELL-03%, QUARTZ SAND-05%
FOSSILS: BRYOZOA

625 - 635 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, PHOSPHATIC GRAVEL-20%
PHOSPHATIC SAND-01%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

635 - 640 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-20%, PHOSPHATIC GRAVEL-10%
PHOSPHATIC SAND-01%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

640 - 645 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-05%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-01%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

645 - 650 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-03%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-10%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

650 - 655 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE

70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-01%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-05%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

655 - 660 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-01%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-03%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

660 - 665 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-01%, PHOSPHATIC GRAVEL-03%
PHOSPHATIC SAND-01%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

665 - 675 PACKSTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-01%, PHOSPHATIC GRAVEL-20%
PHOSPHATIC SAND-01%, QUARTZ SAND-05%

675 - 680 WACKESTONE; OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SHELL-01%, QUARTZ SAND-05%
FOSSILS: BRYOZOA, CORAL

680 - 685 PACKSTONE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT

ACCESSORY MINERALS: PHOSPHATIC GRAVEL-30%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA, CORAL

685 - 700 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-20%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA

700 - 710 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-05%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA

710 - 725 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA

725 - 740 PACKSTONE; YELLOWISH GRAY TO MODERATE DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-02%
FOSSILS: BRYOZOA

740 - 755 PACKSTONE; YELLOWISH GRAY TO LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-05%

FOSSILS: BRYOZOA

755 - 770 PACKSTONE; YELLOWISH GRAY TO LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-20%
PHOSPHATIC SAND-03%
FOSSILS: BRYOZOA

770 - 780 PACKSTONE; YELLOWISH GRAY TO LIGHT GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO VERY FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PHOSPHATIC SAND-01%, QUARTZ SAND-10%
CLAY-01%
FOSSILS: BRYOZOA

780 - 785 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: QUARTZ SAND-20%, PHOSPHATIC GRAVEL-01%
PHOSPHATIC SAND-01%, CLAY-01%
FOSSILS: BRYOZOA

785 - 800 NO SAMPLES

800 - 805 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-30%, SHELL-05%, CLAY-05%
PHOSPHATIC GRAVEL-01%
FOSSILS: BRYOZOA, CORAL
GREATER ABUNDANCE LIMESTONE IS TAN MICRITE/SPAR WITH
PHOSPHATIC AND QUARTZ SAND LESSER LIMESTONE IS GRAY
MUDSTONE OF GOOD INDURATION

805 - 810 SAND; OLIVE GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-30%, CLAY-30%
FOSSILS: BRYOZOA

810 - 820 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-30%, CLAY-05%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA, MOLLUSKS, SHARKS TEETH
LIMESTONE CONSISTS OF VARIOUS TYPES CLAY IS WELL
WELL-INDURATED GRAY PIECES

820 - 835 SAND; OLIVE GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-30%, LIMESTONE-20%
PHOSPHATIC SAND-01%
FOSSILS: BRYOZOA
CLAY AND VARIED LIMESTONE SIMILAR TO PREVIOUS INTERVAL

835 - 840 SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-30%, PHOSPHATIC SAND-01%
CLAY-01%
LIMESTONE IS 'PEPPERED' WHITE WACKESTONE CLAY IS LIGHT
GRAY, CONTAINS FINE SAND, AND IS POORLY IND.

840 - 845 PACKSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: INTRACLASTS, CRYSTALS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-30%, CLAY-01%

845 - 865 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, CLAY-01%

865 - 880 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

880 - 885 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: FOSSIL MOLDS
SAMPLE IS VERY SMALL

885 - 900 PACKSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

900 - 905 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

905 - 910 NO SAMPLES

910 - 915 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

915 - 920 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, SKELETAL, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-06%
FOSSILS: FOSSIL MOLDS

920 - 925 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM

MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS, MOLLUSKS

925 - 935 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

935 - 940 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS, SHARKS TEETH

940 - 950 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS, MOLLUSKS

950 - 960 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, VUGULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

960 - 970 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

970 - 980 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY

GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

980 - 985 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

985 - 1005 NO SAMPLES

1005 - 1015 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1015 - 1020 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1020 - 1035 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1035 - 1055 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1055 - 1070 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1070 - 1080 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1080 - 1100 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1100 - 1110 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1110 - 1130 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1130 - 1140 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM

MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1140 - 1160 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1160 - 1180 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1180 - 1190 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1190 - 1195 NO SAMPLES

1195 - 1215 PACKSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS LEPIDOCYCLINA

1215 - 1230 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM

MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FOSSILS: FOSSIL MOLDS

1230 - 1245 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%

1245 - 1255 MUDSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-03%

1255 - 1265 MUDSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-03%

1265 - 1275 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-03%
FOSSILS: BENTHIC FORAMINIFERA
FORAM IS DICTYOCONUS

1275 - 1280 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%

1280 - 1300 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM

MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%

1300 - 1320 NO SAMPLES

1320 - 1335 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%
QUARTZ IS GRANULES

1335 - 1355 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%
QUARTZ IS GRANULES

1355 - 1375 MUDSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%
QUARTZ IS GRANULES

1375 - 1395 MUDSTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%

1395 - 1603 NO SAMPLES

1603 - 1605 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%, CHERT-01%
BEGINNING OF WASHED INTERVALS

1605 - 1610 DOLOSTONE; MODERATE YELLOWISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 50-90% ALTERED EUHEDRAL
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-10%, QUARTZ SAND-03%
LIMESTONE IS WACKESTONE WITH FINE GRAINS

1610 - 1615 WACKESTONE; YELLOWISH GRAY TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%, QUARTZ SAND-03%

1615 - 1620 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1620 - 1625 WACKESTONE; YELLOWISH GRAY TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-20%, QUARTZ SAND-03%

1625 - 1630 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1630 - 1664 NO SAMPLES
CAVITY

1664 - 1669 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%, QUARTZ SAND-03%

1669 - 1674 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY

POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-01%, QUARTZ SAND-03%

1674 - 1690 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1690 - 1700 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1700 - 1715 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1715 - 1725 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1725 - 1740 WACKESTONE; YELLOWISH GRAY TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
FORAM IS DICTYOCONUS

1740 - 1745 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL

GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1745 - 1750 DOLOSTONE; GRAYISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%, QUARTZ SAND-03%

1750 - 1755 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1755 - 1760 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-10%, QUARTZ SAND-03%

1760 - 1765 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-10%, QUARTZ SAND-03%

1765 - 1770 DOLOSTONE; GRAYISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-05%, QUARTZ SAND-03%
SECONDARY MODE DOLOSTONE (30%) COMPRISED OF EUHEDRAL MEDIUM GRAINS

1770 - 1775 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED EUHEDRAL
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%, QUARTZ SAND-03%

1775 - 1780 DOLOSTONE; GRAYISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED EUHEDRAL

GRAIN SIZE: FINE; RANGE: FINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1780 - 1785 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 50-90% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-40%, QUARTZ SAND-03%
LIMESTONE IS WACKESTONE WITH VERY FINE GRAINS

1785 - 1790 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 50-90% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%, QUARTZ SAND-03%
LIMESTONE IS WACKESTONE WITH VERY FINE GRAINS

1790 - 1805 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%, QUARTZ SAND-03%
EUHEDRAL MEDIUM DOLOSTONE PRESENT (~3%)

1805 - 1810 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%, QUARTZ SAND-03%

1810 - 1815 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-10%, QUARTZ SAND-03%

1815 - 1819 DOLOSTONE; GRAYISH BROWN TO YELLOWISH GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%, QUARTZ SAND-03%
LIMESTONE IS WACKESTONE WITH VERY FINE GRAINS; FORAM IS DICTYOCONUS

1819 - 1830 DOLOSTONE; DARK GRAY TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%, QUARTZ SAND-03%
BROWN DOLOSTONE COMPOSED OF EUHEDRAL MEDIUM GRAINS

1830 - 1840 DOLOSTONE; DARK YELLOWISH BROWN TO DARK GRAY
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%, QUARTZ SAND-03%
EUHEDRAL AND ANHEDRAL DOLOSTONE PRESENT

1840 - 1855 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
BROWN DOLOSTONE (~20%) COMPOSED OF EUHEDRAL MEDIUM GRAINS

1855 - 1865 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1865 - 1870 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1870 - 1880 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1880 - 1890 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

ACCESSORY MINERALS: QUARTZ SAND-03%
SUCROSIC DOLOSTONE ~20%

1890 - 1895 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
SUCROSIC DOLOSTONE ~30%

1895 - 1900 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
EUHEDRAL
GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
SECOND MODE DOLOSTONE (~30%)IS ANHEDRAL

1900 - 1905 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%
EUHEDRAL MEDIUM-TEXTURE GRAINS ~10%

1905 - 1910 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE YELLOWISH BRO
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-03%

1910 - 1920 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%
EUHEDRAL MEDIUM-TEXTURE GRAINS ~10%

1920 - 1925 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1925 - 1935 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM

GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1935 - 1945 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%

1945 - 1950 DOLOSTONE; MODERATE YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%

1950 - 1955 DOLOSTONE; MODERATE YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
ANHEDRAL
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SUBHEDRAL-EUHEDRAL GRAINS COMPRISE ~40%

1955 - 1965 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1965 - 1970 DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1970 - 1972 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1972 - 1975 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1975 - 1985 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL

GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%

1985 - 1990 NO SAMPLES

1990 - 1995 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%

1995 - 2000 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
ANHEDRAL
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%

2000 - 2010 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%

2010 - 2015 NO SAMPLES

2015 - 2020 DOLOSTONE; GRAYISH BROWN TO VERY LIGHT ORANGE
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
ANHEDRAL
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-03%
EUHEDRAL GRAINS ~5%

2020 - 2024 DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

2024 - 2030 DOLOSTONE; GRAYISH BROWN TO GRAYISH BROWN
POROSITY: INTERGRANULAR, LOW PERMEABILITY; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-01%
EUHEDRAL GRAINS ~3%

2030 TOTAL DEPTH

Appendix D

Core Sample Descriptions

GLF-6: Core Thin-section Data Interpretation

For The Comprehensive Everglades Restoration Plan Aquifer Storage and Recovery Pilot Study

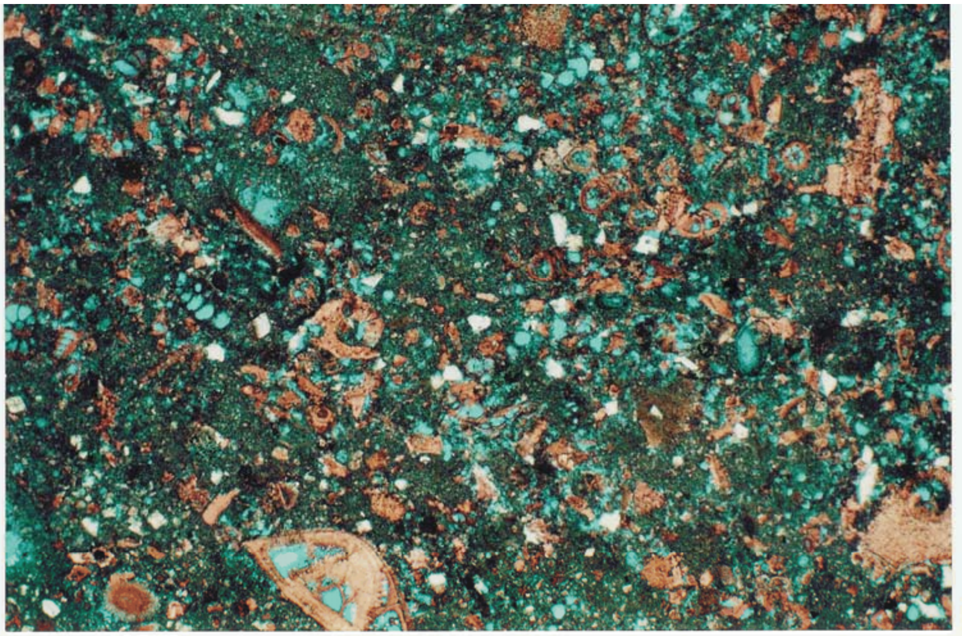
Prepared for

South Florida Water Management District

2001

COLLIER CONSULTING

Collier Consulting, Inc. 702
East South Loop
Stephenville, TX 76401
Office: (254) 968-8721 Fax:
(254) 968-8725
www.collierconsulting.com

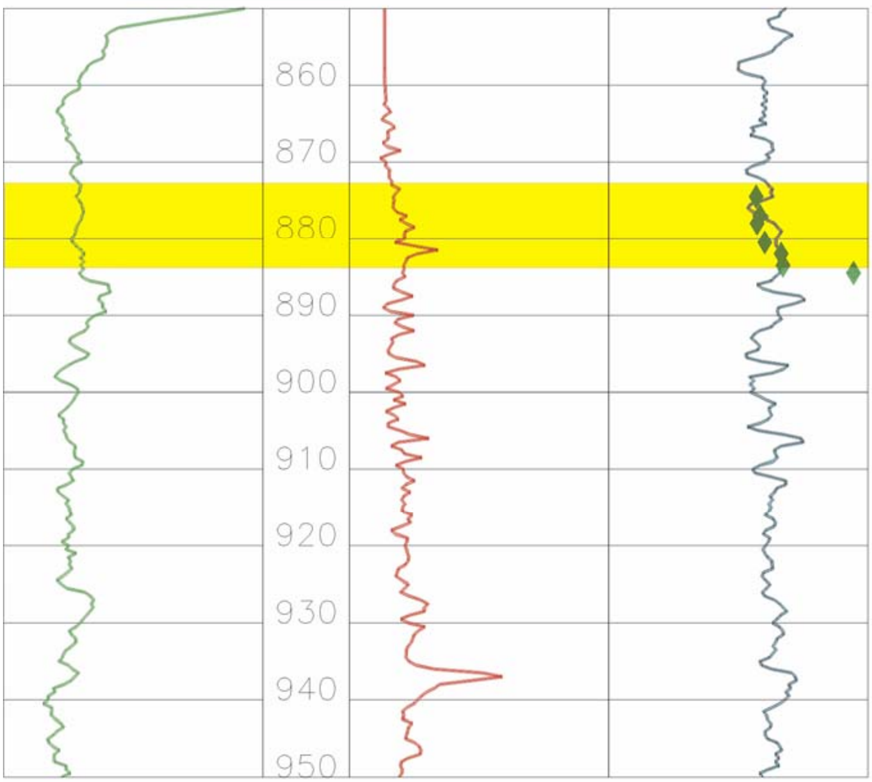


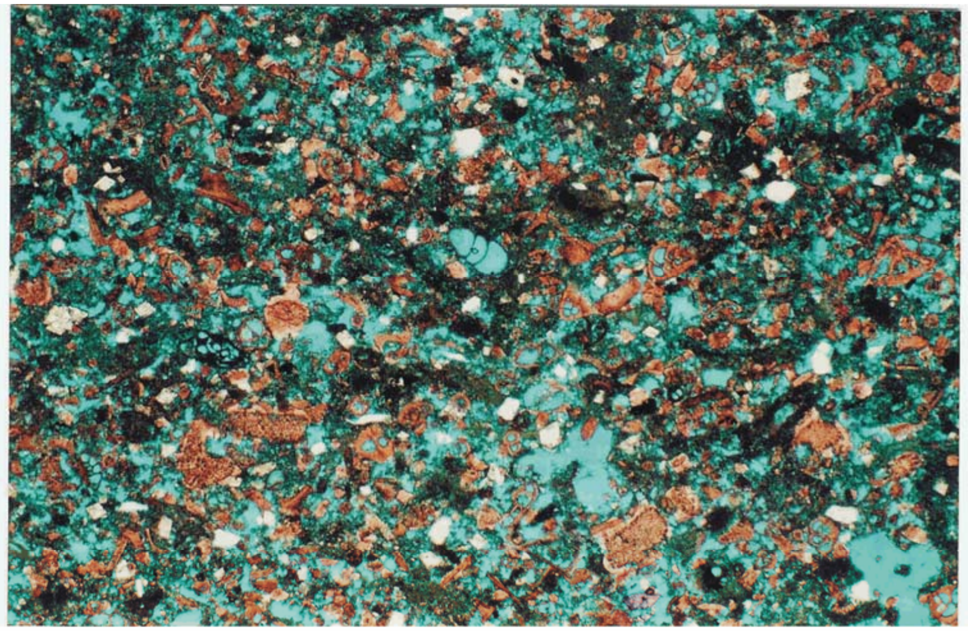
WELL: GLF-6
DEPTH: 874.3
MAGNIFICATION: 40X

Lithofacies:	Foram Pellet Packstone
Depositional Environment:	Shoal Flank
Porosity:	Fair; interparticle, intraparticle, moldic
Other Constituents:	5% quartz silt, <5% dolomite

Core Interval

Thin Section Location



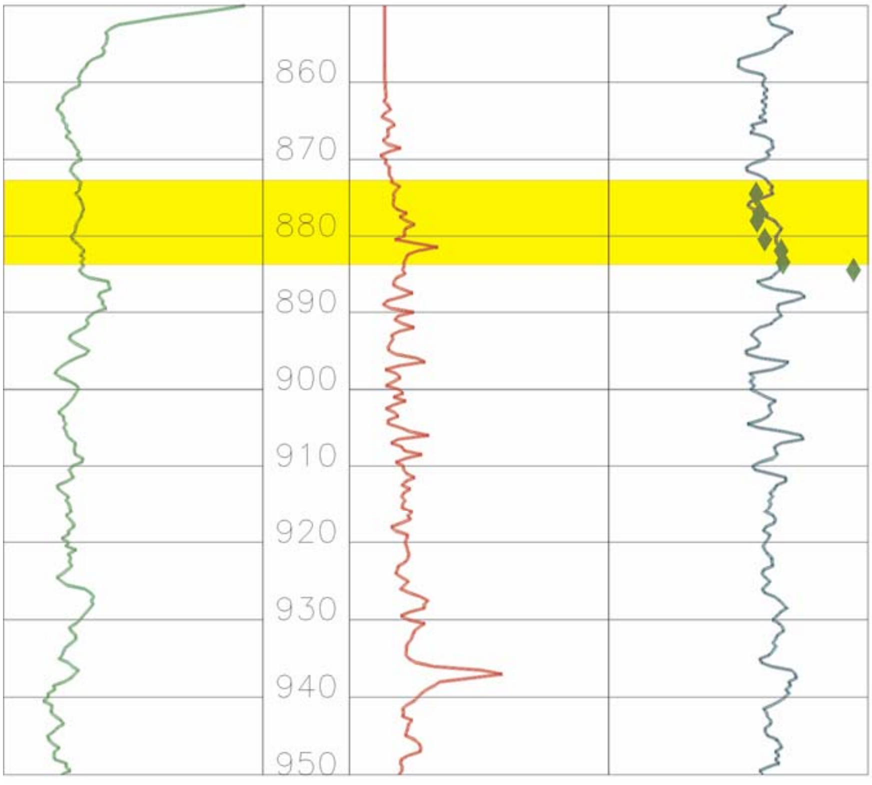


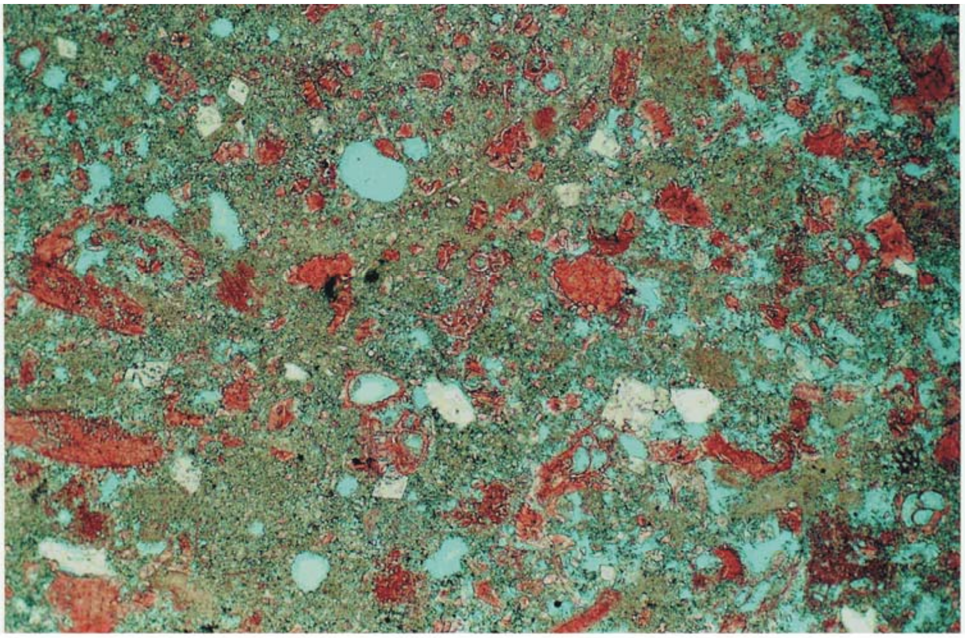
WELL: GLF-6
DEPTH: 875.9
MAGNIFICATION: 40X

Lithofacies:	Foram Pellet Grainstone
Depositional Environment:	Shoal Flank
Porosity:	Very Good; interparticle, intraparticle, moldic
Other Constituents:	5% quartz silt

Core Interval

Thin Section Location



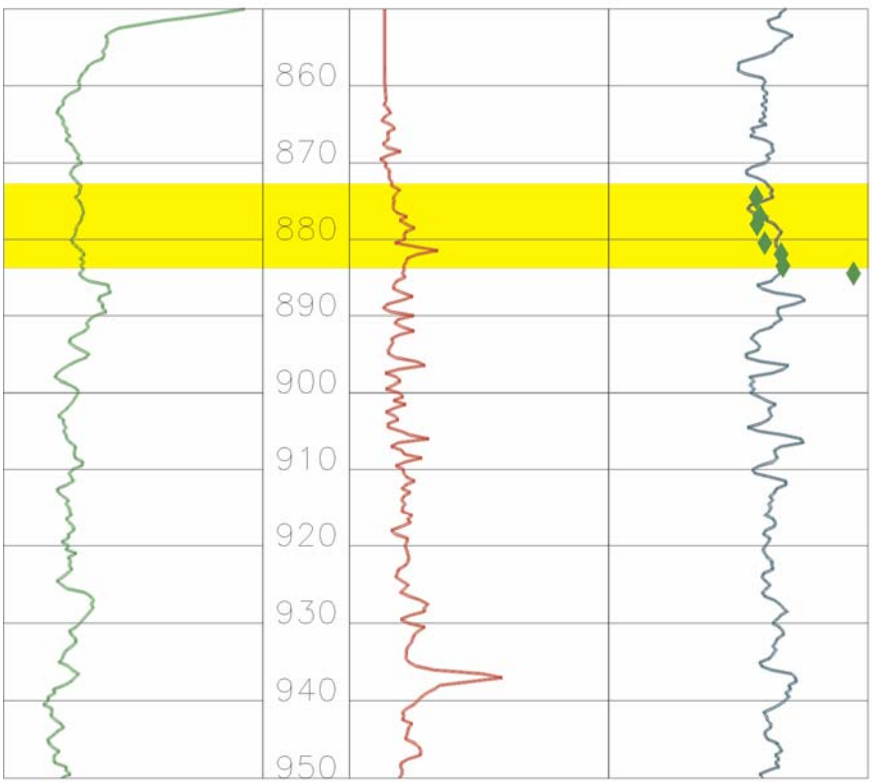


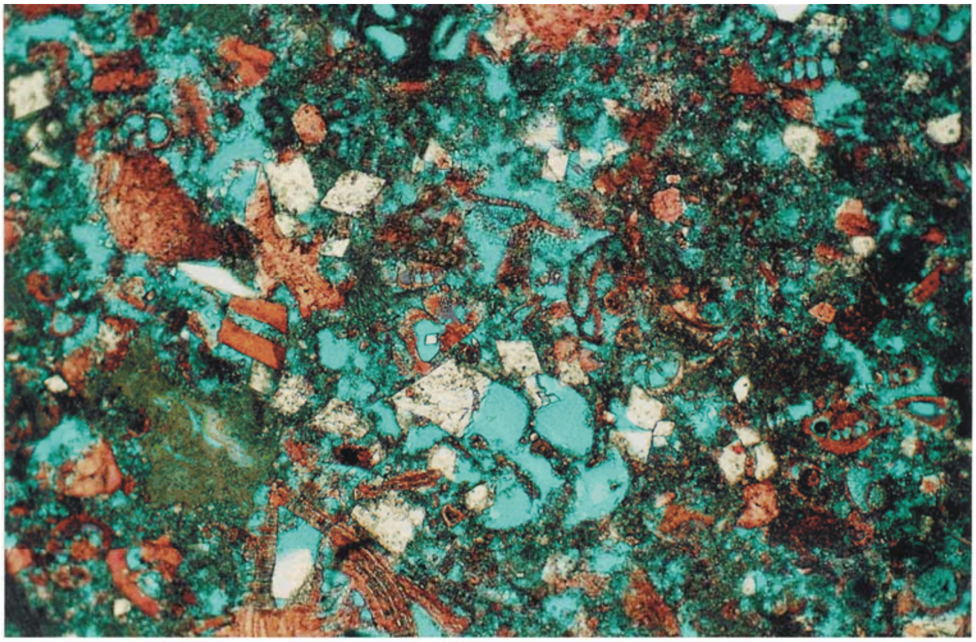
WELL: GLF-6
DEPTH: 876.5
MAGNIFICATION: 100X

Lithofacies:	Foram Wackestone
Depositional Environment:	Shoal Flank
Porosity:	Fair; moldic, intraparticle, interparticle
Other Constituents:	

Core Interval

Thin Section Location



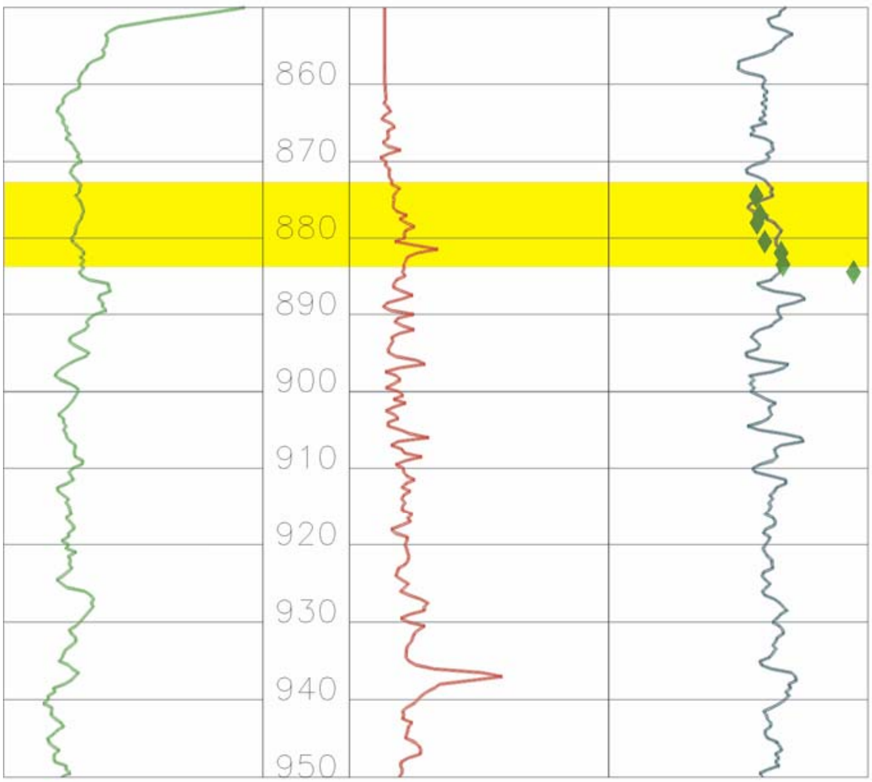


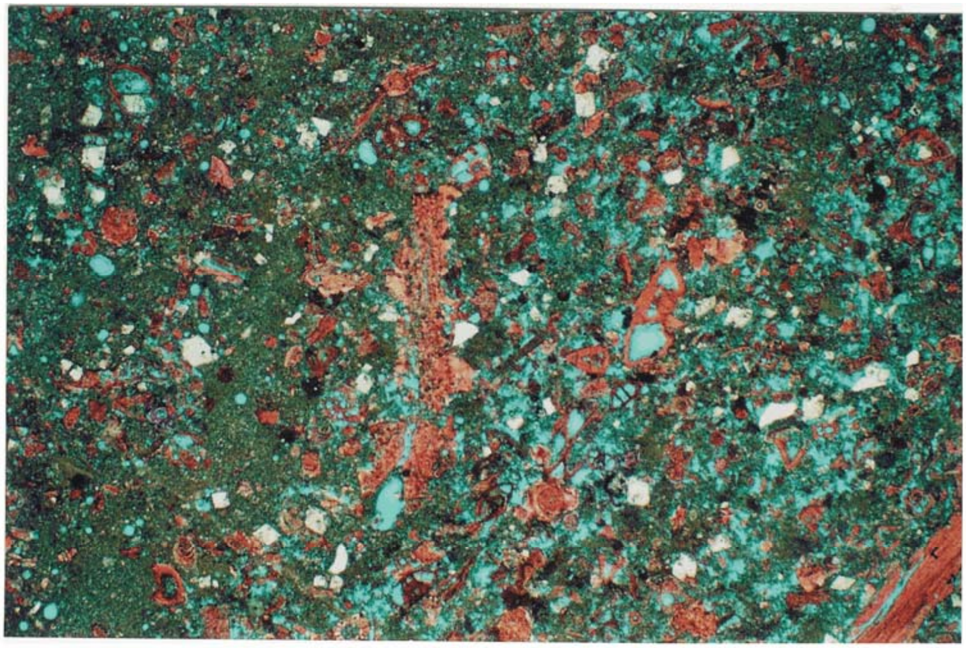
WELL: GLF-6
DEPTH: 879.1
MAGNIFICATION: 100X

Lithofacies:	Slightly Dolomitic Foram Pellet Packstone
Depositional Environment:	Shoal Flank
Porosity:	Good; interparticle, moldic, intraparticle, vuggy
Other Constituents:	trace quartz silt, 10% dolomite

Core Interval

Thin Section Location



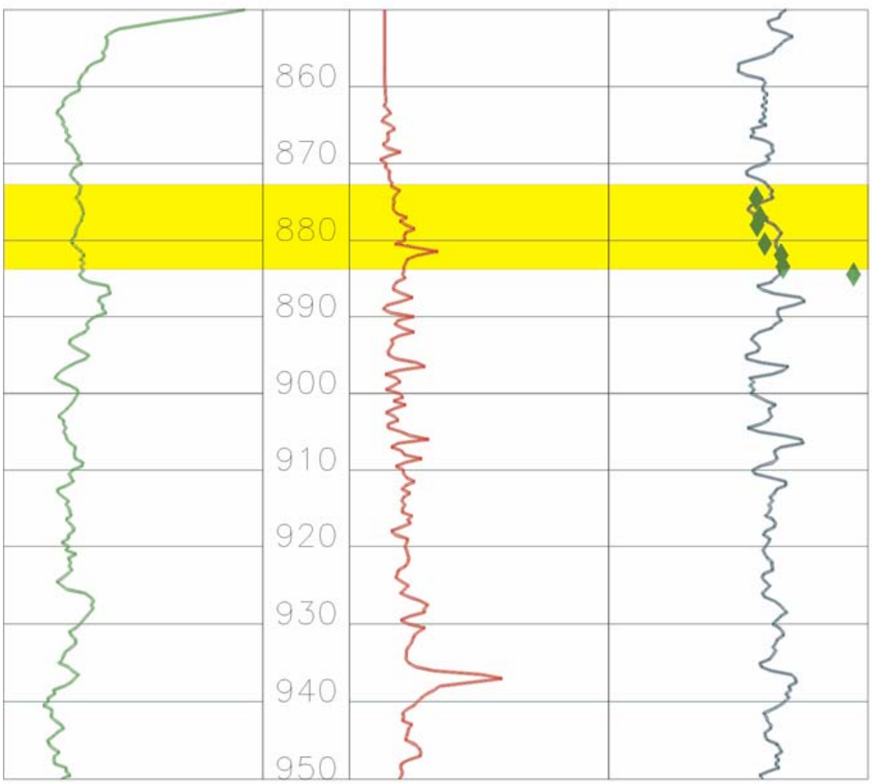


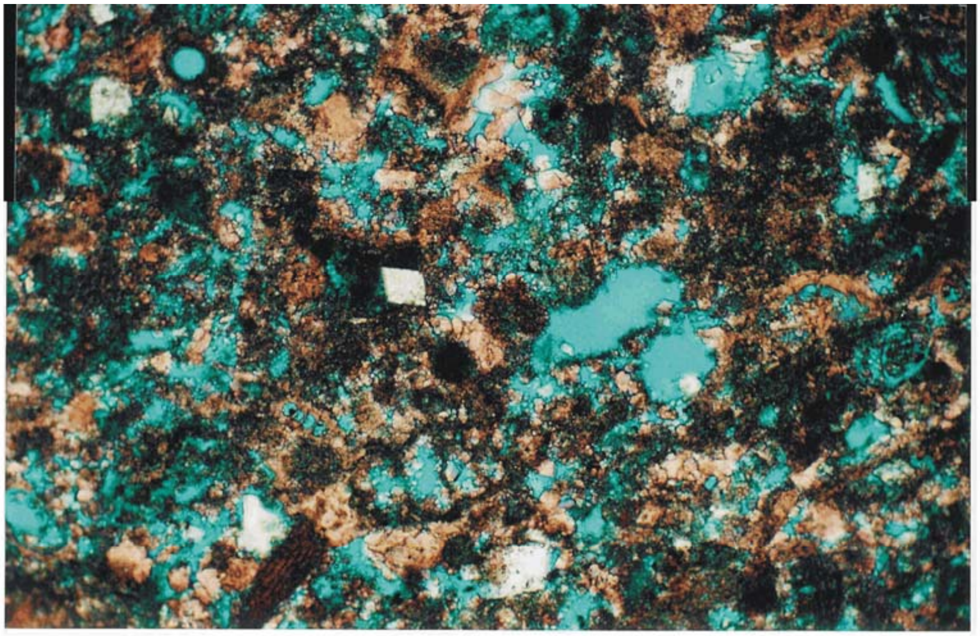
WELL: GLF-6
DEPTH: 880.2
MAGNIFICATION: 40X

Lithofacies:	Foram Pellet Wackestone
Depositional Environment:	Shallow Lagoon
Porosity:	Good; interparticle, moldic
Other Constituents:	trace quartz silt, 5% dolomite

Core Interval

Thin Section Location

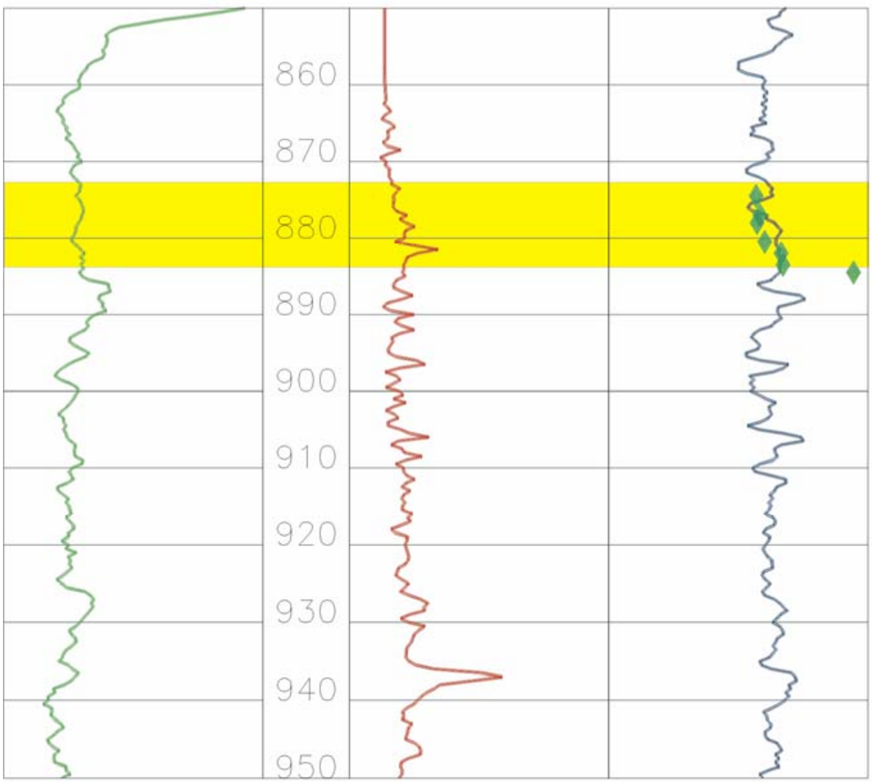




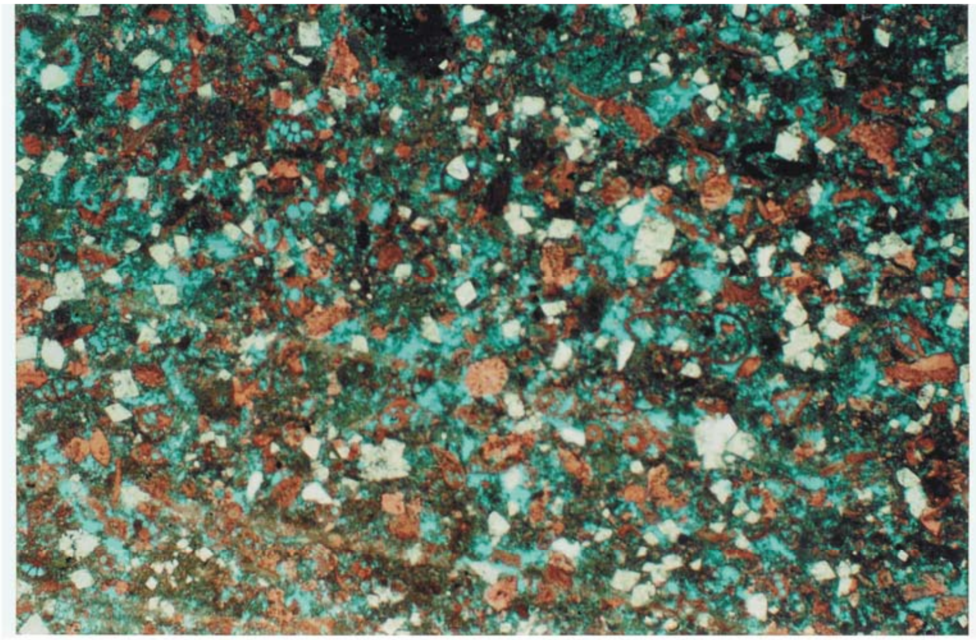
WELL: GLF-6
DEPTH: 880.9
MAGNIFICATION: 100X

Lithofacies:	Slightly Dolomitic Foram-Pellet Packstone
Depositional Environment:	Deep Lagoon Open
Porosity:	Good; interparticle, moldic, intraparticle
Other Constituents:	5% - 10% dolomite

Core Interval



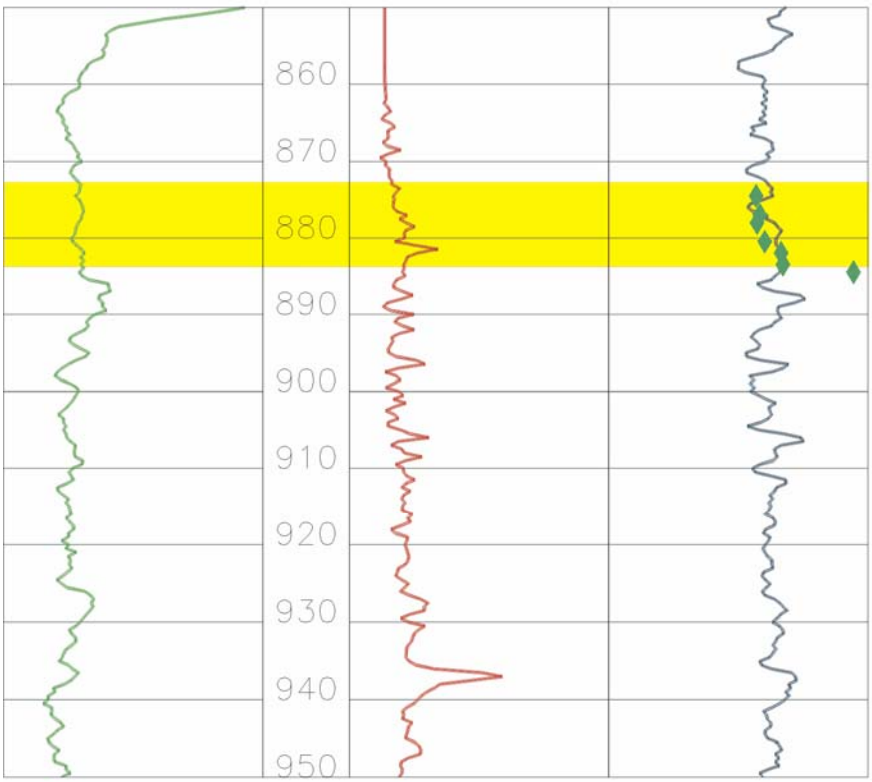
Thin Section Location



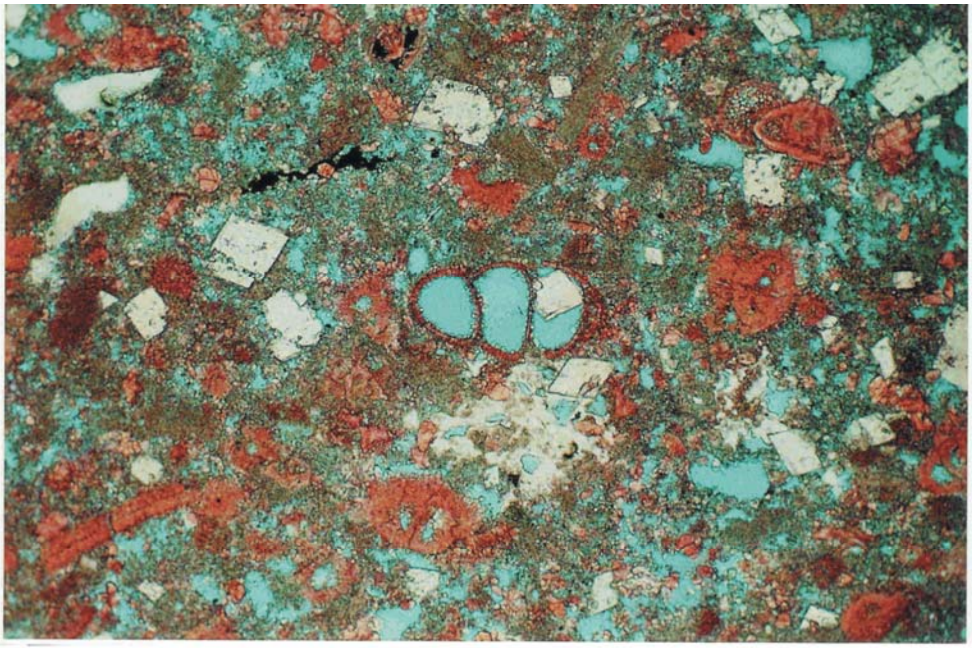
WELL: GLF-6
DEPTH: 881.6
MAGNIFICATION: 40X

Lithofacies:	Slightly Dolomitic Foram-Pellet Packstone
Depositional Environment:	Shoal Flank
Porosity:	Fair to Good; interparticle, moldic; intraparticle
Other Constituents:	trace quartz silt, 5% - 10% dolomite

Core Interval



Thin Section Location

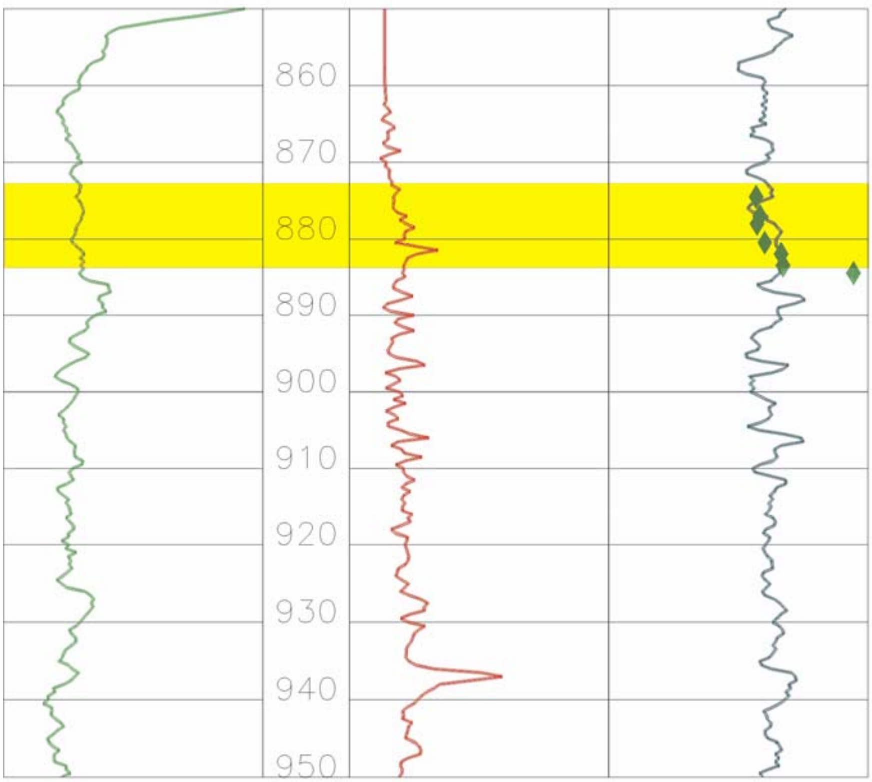


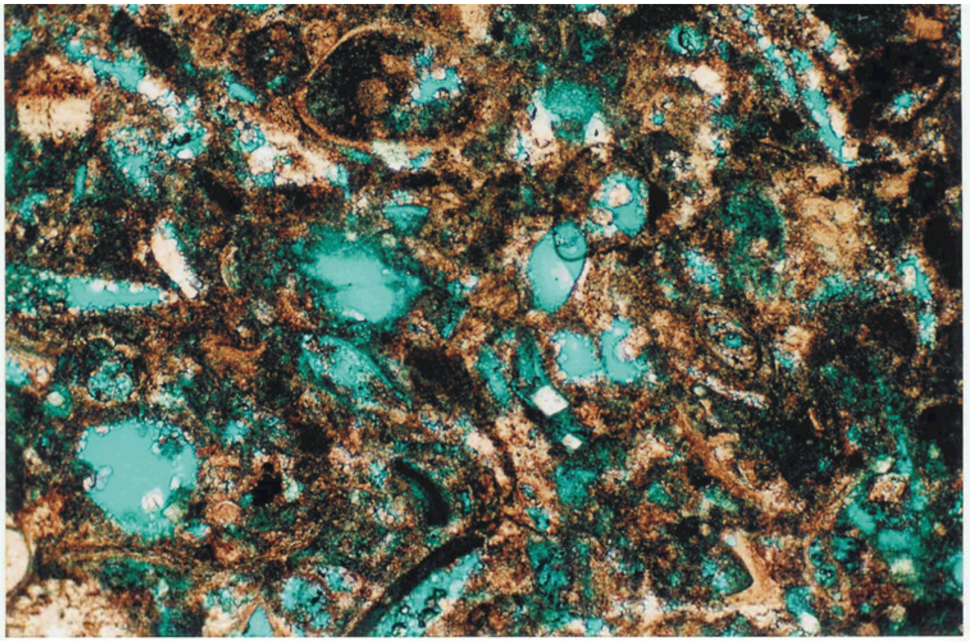
WELL: GLF-6
DEPTH: 883.1
MAGNIFICATION: 100X

Lithofacies:	Slightly Dolomitic Echinoderm-Form Packstone
Depositional Environment:	Subtidal Open
Porosity:	Good; interparticle; vuggy, moldic, intraparticle
Other Constituents:	trace quartz silt, 10% dolomite

Core Interval

Thin Section Location



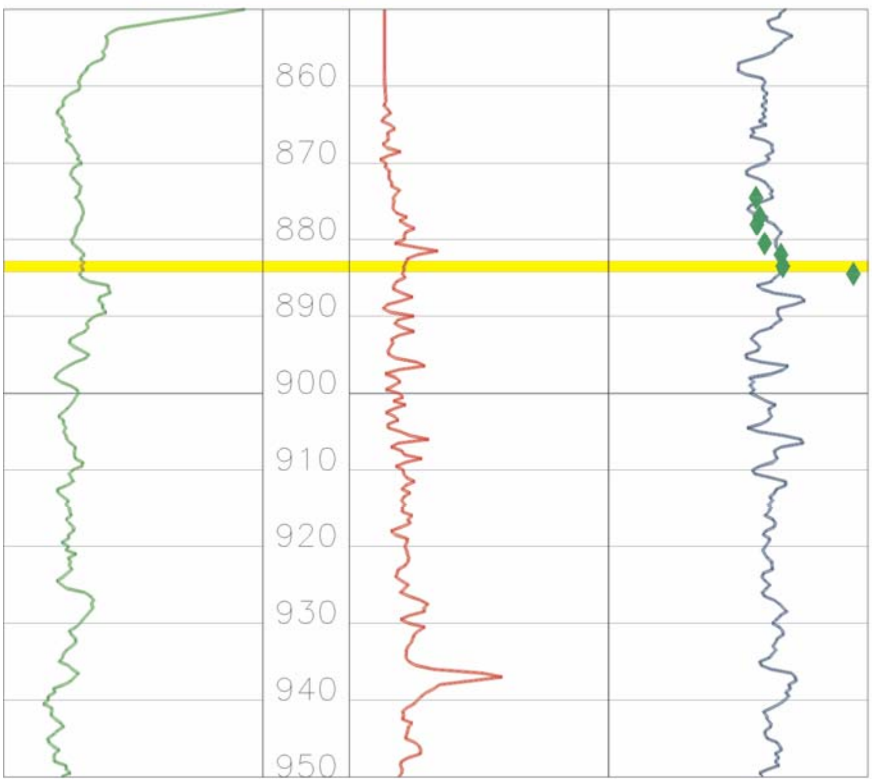


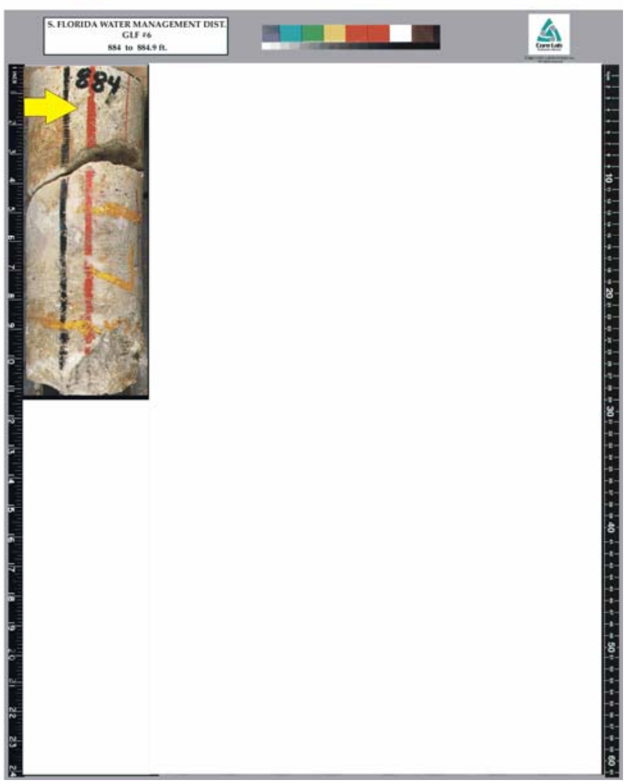
WELL: GLF-6
DEPTH: 884.1
MAGNIFICATION: 100X

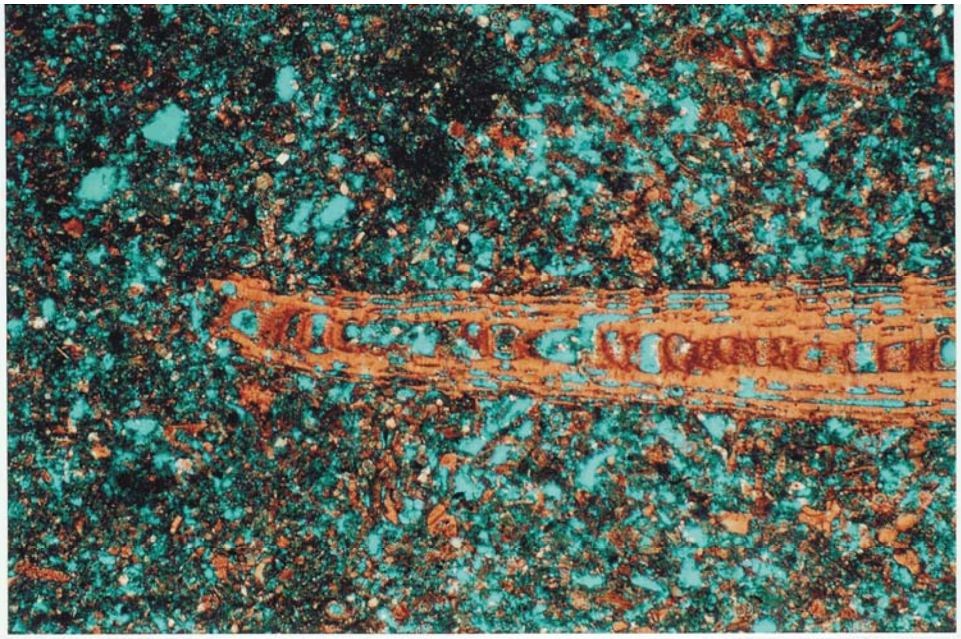
Lithofacies:	Algal Echinoderm-Foram-Pellet Packstone
Depositional Environment:	Red Algal Mound
Porosity:	Fair ; moldic, vuggy; interparticle, intraparticle
Other Constituents:	trace quartz, trace dolomite

Core Interval

Thin Section Location





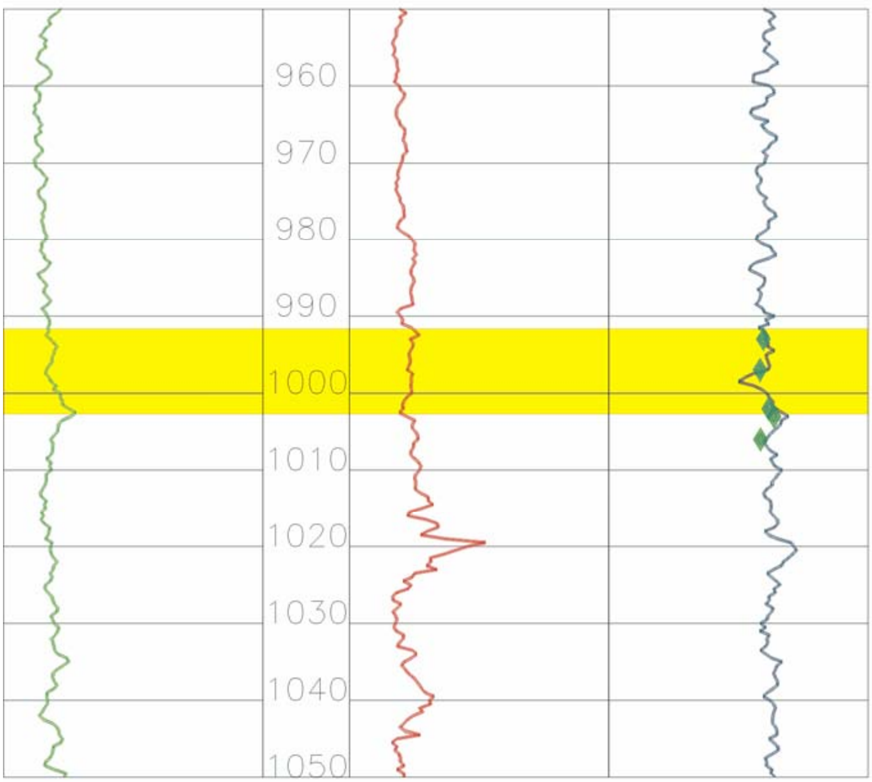


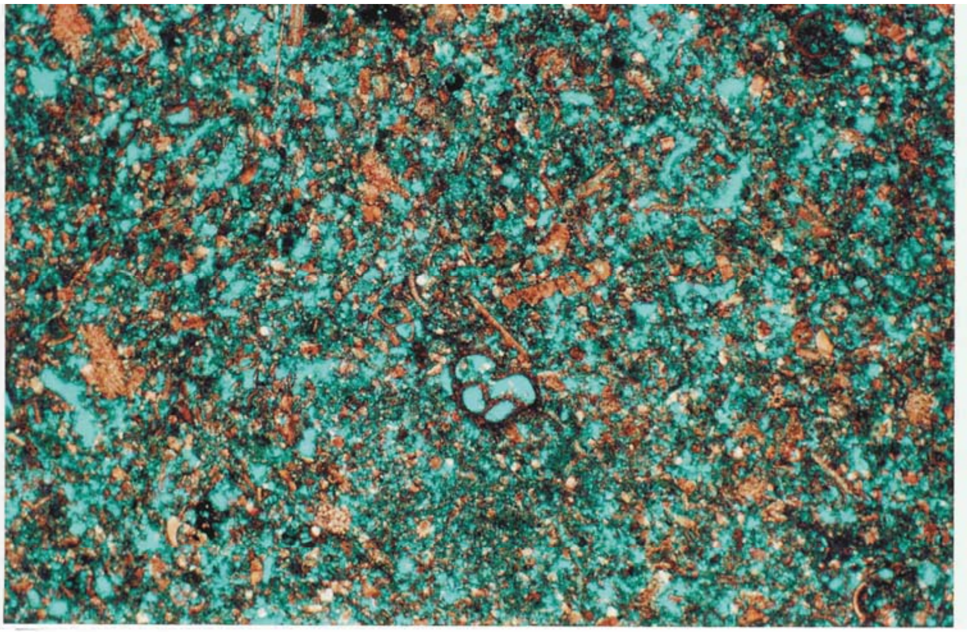
WELL: GLF-6
DEPTH: 994.4
MAGNIFICATION: 40X

Lithofacies:	Lepidocyclina-Foram-Pellet Packstone (Nummulites)
Depositional Environment:	Open Lagoon-Foram Bank
Porosity:	Good; interparticle, vuggy, moldic; intraparticle
Other Constituents:	trace quartz silt, trace dolomite

Core Interval

Thin Section Location





WELL: GLF-6
DEPTH: 995.8
MAGNIFICATION: 40X

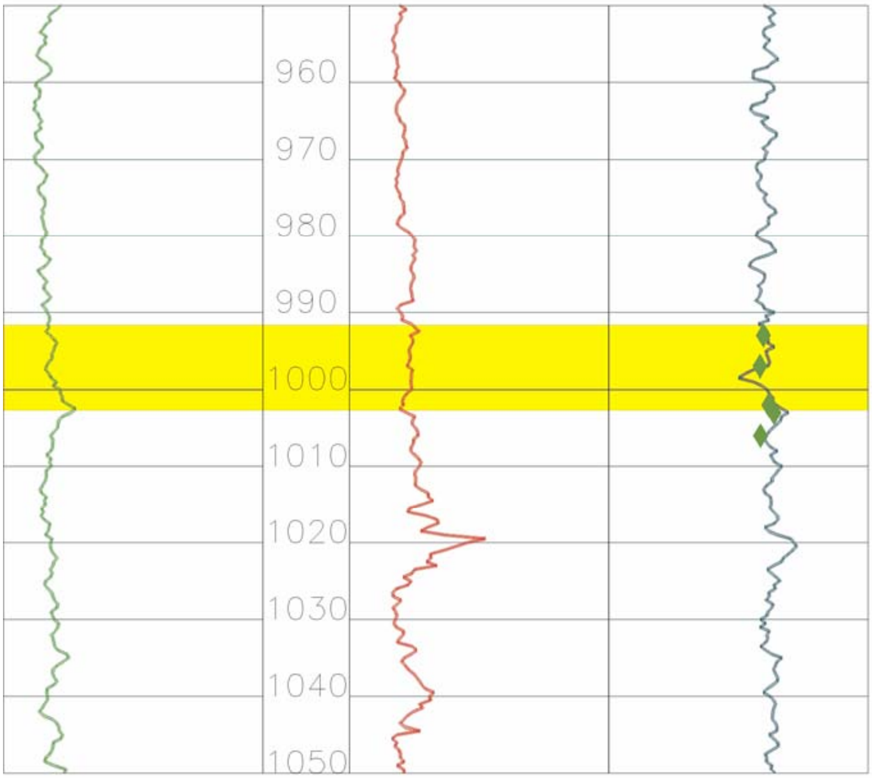
Lithofacies: Foram Pellet Pasckstone With Scattered Lepidocyclina

Depositional Environment: Open Lagoon - Foram Bank

Porosity: Very Good; interparticle, moldic, intraparticle

Other Constituents: trace quartz silt, trace dolomite

Core Interval



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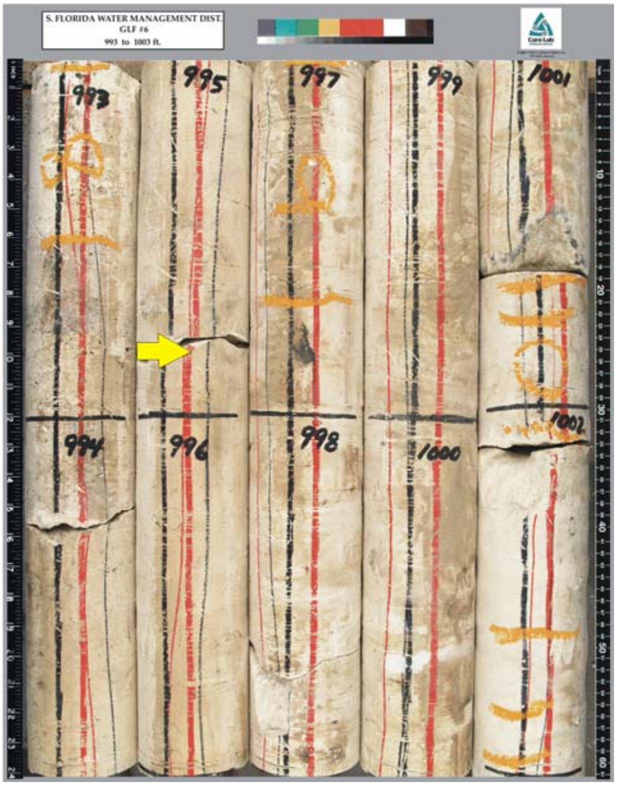
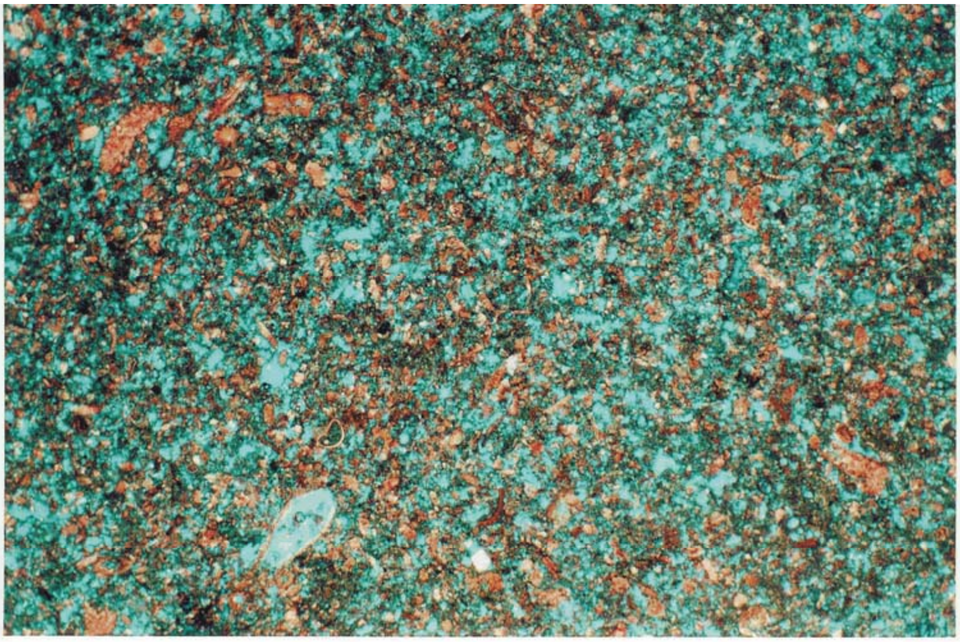




WELL: GLF-6
DEPTH: 997.8
MAGNIFICATION: 40X

Lithofacies: Lepidocyclina-Foram-Pellet Packstone

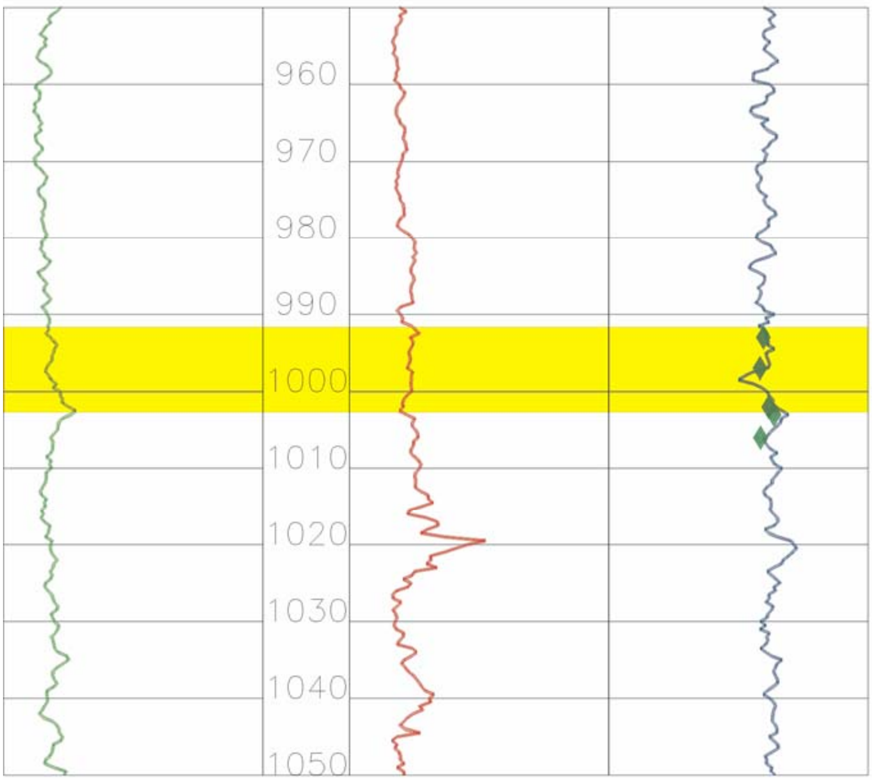
Depositional Environment: Open Lagoon - Foram Bank

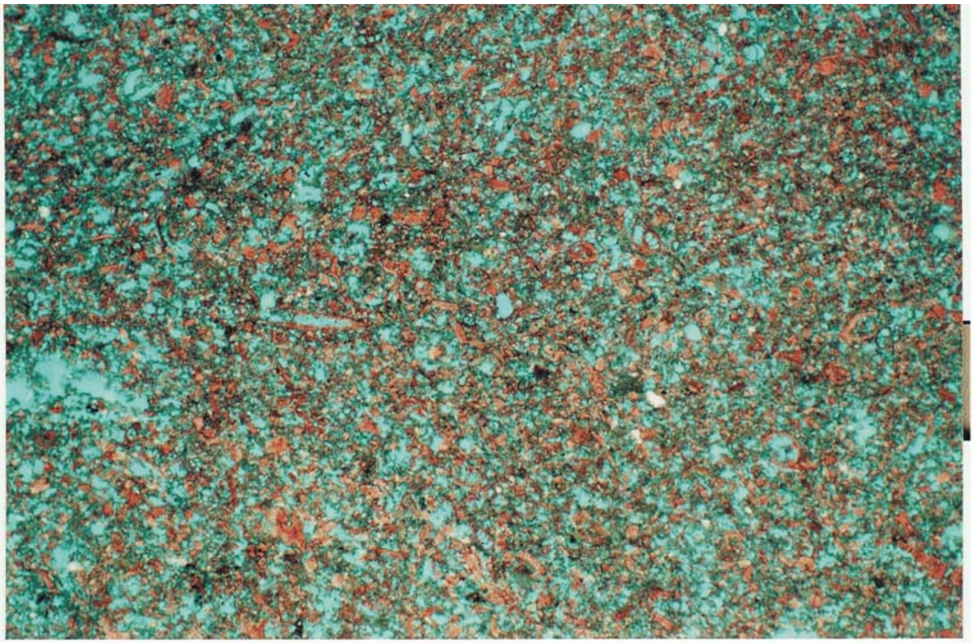
Porosity: Good; interparticle; moldic, intraparticle

Other Constituents:

Core Interval

Thin Section Location



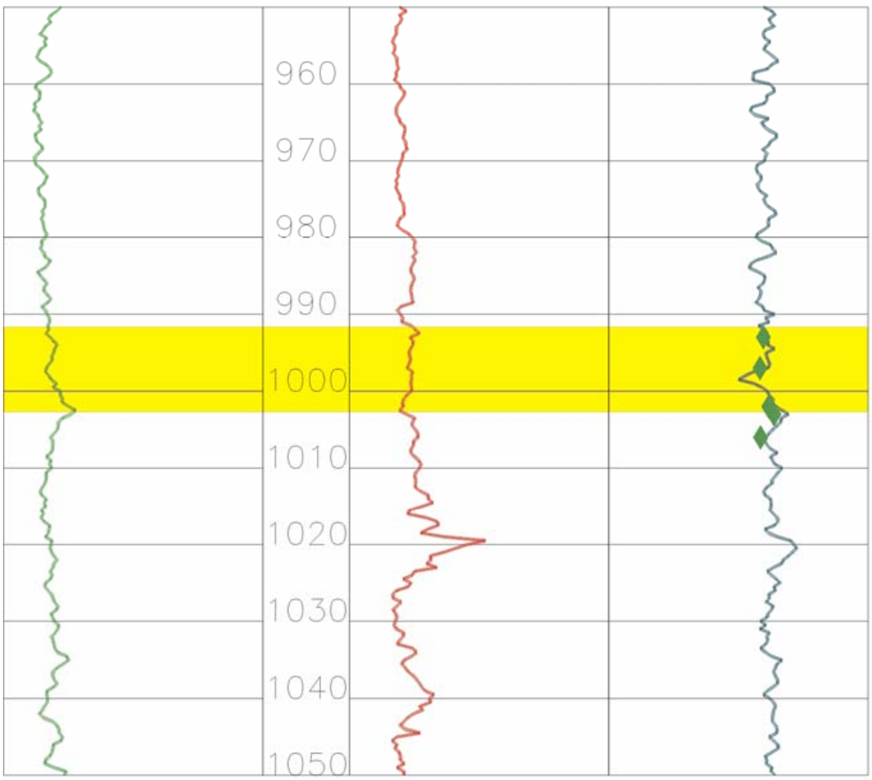


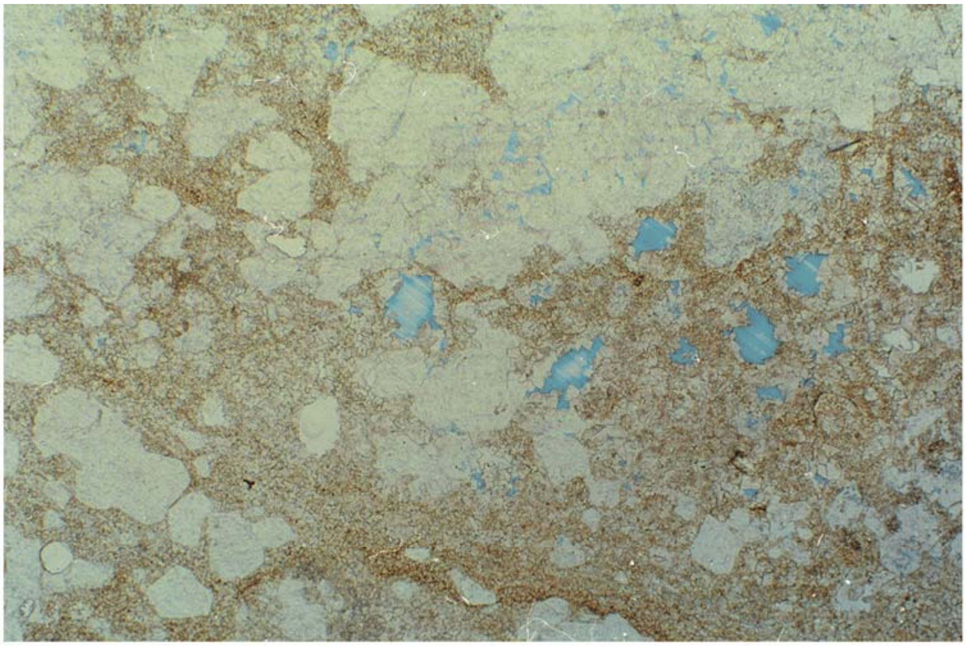
WELL: GLF-6
DEPTH: 998.9
MAGNIFICATION: 40X

Lithofacies:	Lepidocyclina-Foram-Pellet Packstone
Depositional Environment:	Open Lagoon - Foram Bank
Porosity:	Good; interparticle, moldic, intraparticle
Other Constituents:	trace quartz silt

Core Interval

Thin Section Location



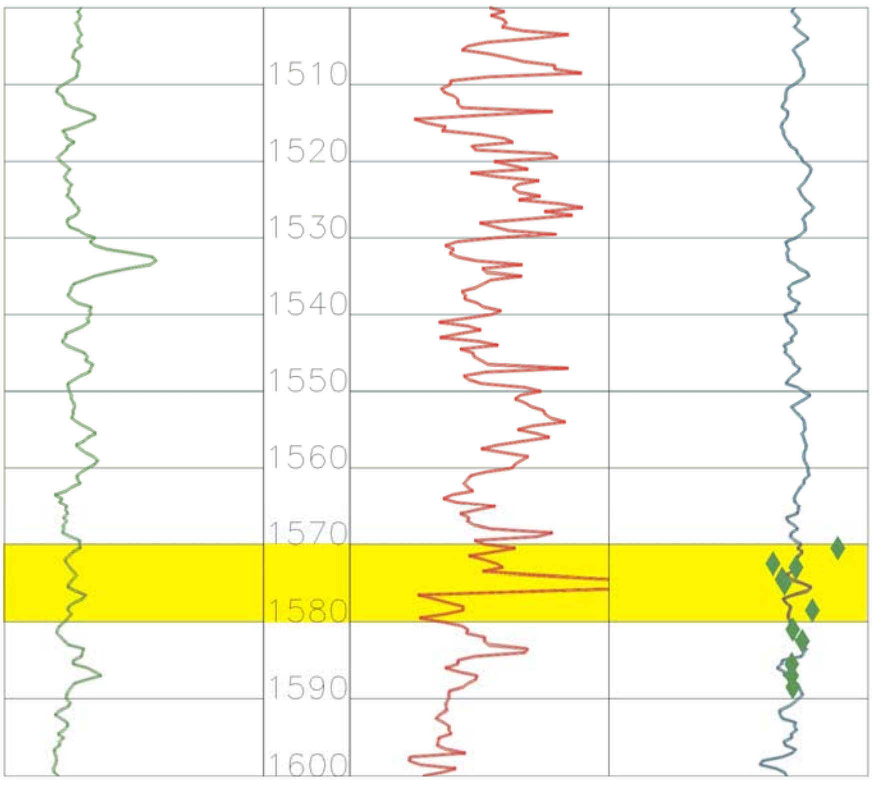


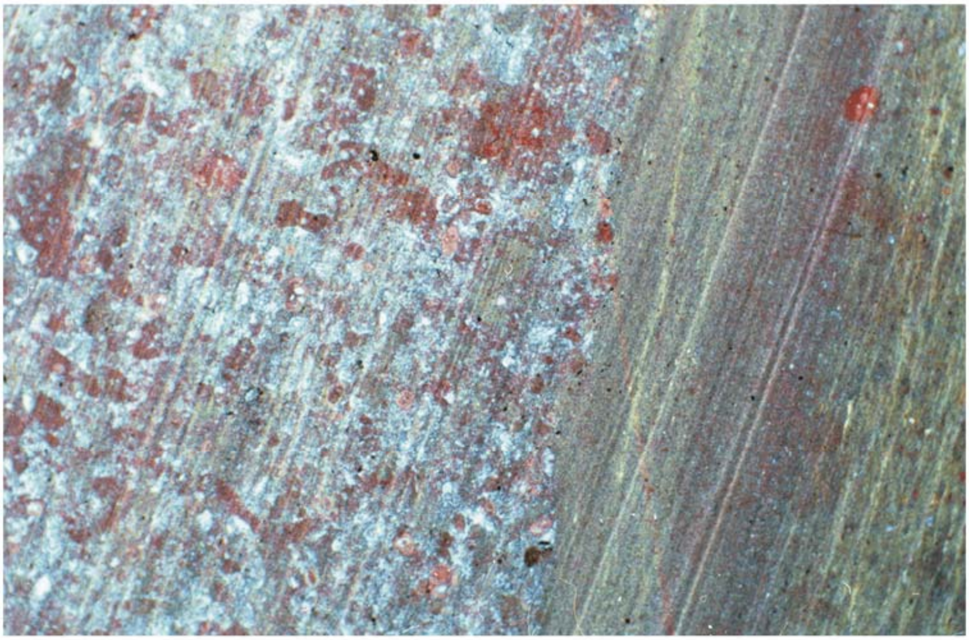
WELL: GLF-6
DEPTH: 1570.1
MAGNIFICATION: 20X

Lithofacies:	Dolomite
Depositional Environment:	Supratidal
Porosity:	Poor; vuggy, intercrystalline
Other Constituents:	Siderite

Core Interval

Thin Section Location



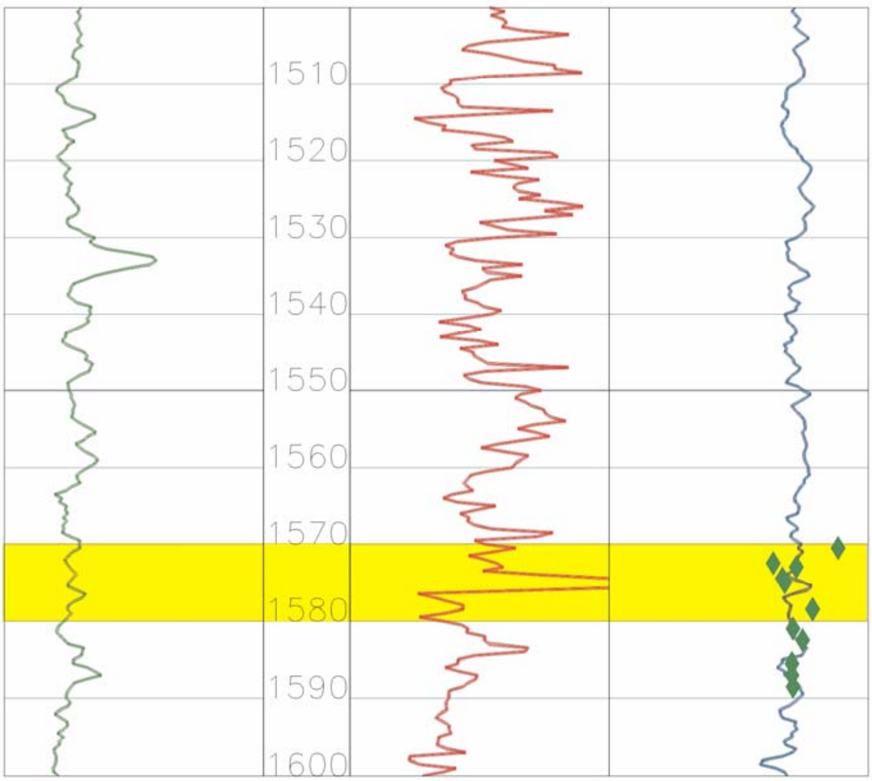


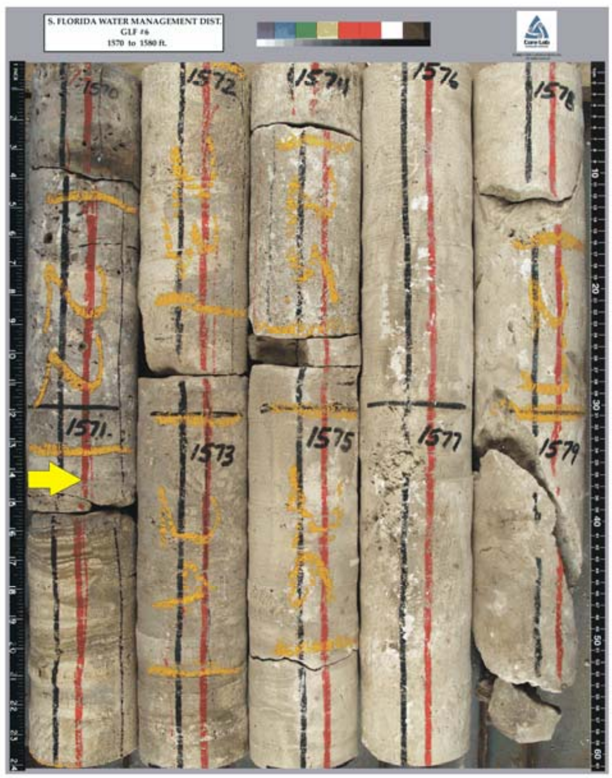
WELL: GLF-6
DEPTH: 1571.4
MAGNIFICATION: 40X

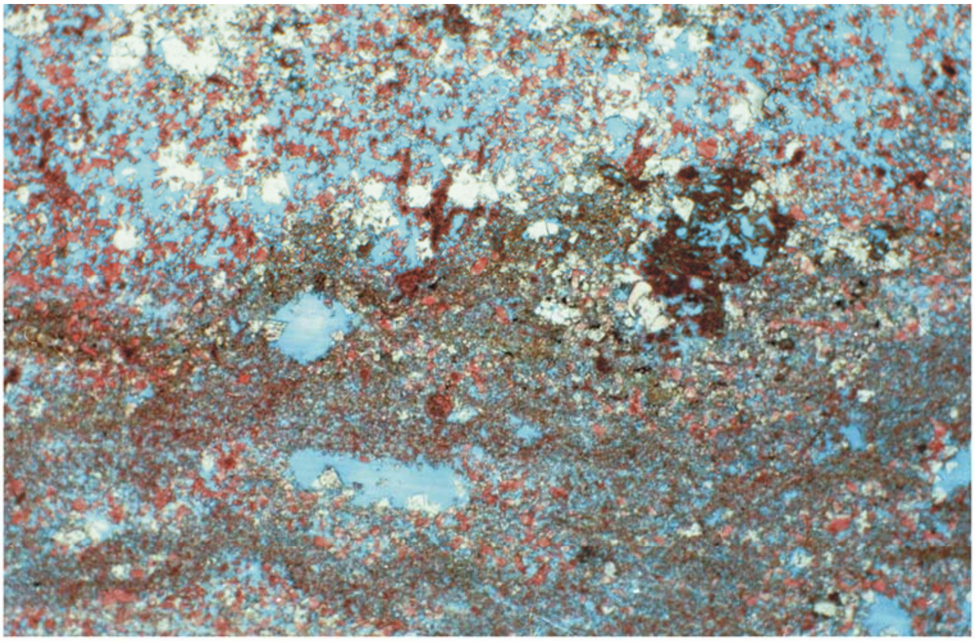
Lithofacies:	Interlaminated Intraclast Foram Pellet Packstone
Depositional Environment:	Intertidal
Porosity:	Poor; moldic, micro
Other Constituents:	laminated dolomite

Core Interval

Thin Section Location







WELL: GLF-6
DEPTH: 1573.2
MAGNIFICATION: 40X

Lithofacies: Intraclast Wackestone

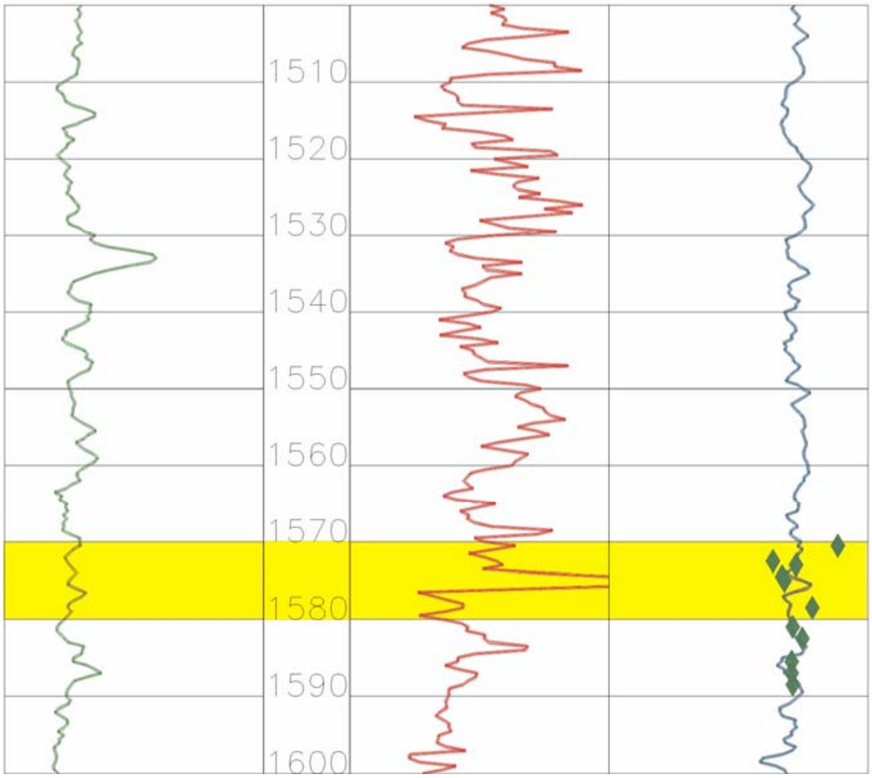
Depositional Environment: Intertidal

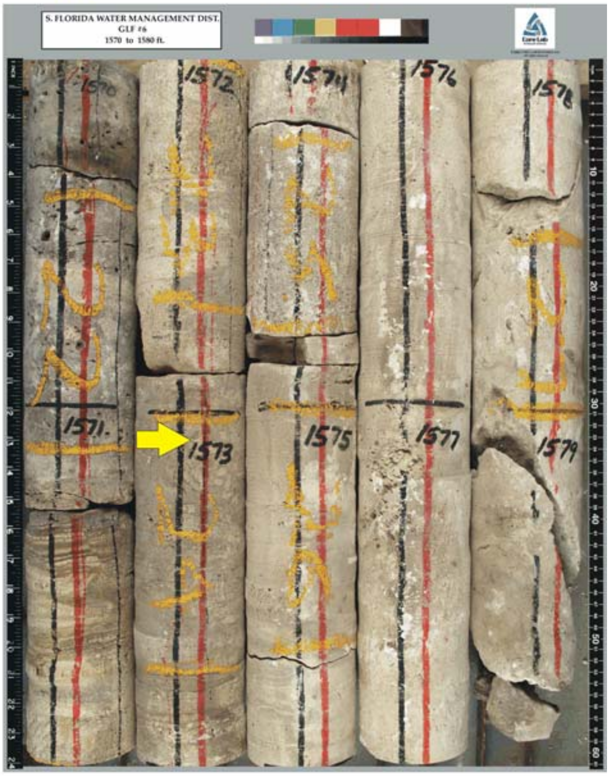
Porosity: Fair; moldic, intercrystalline; shelter

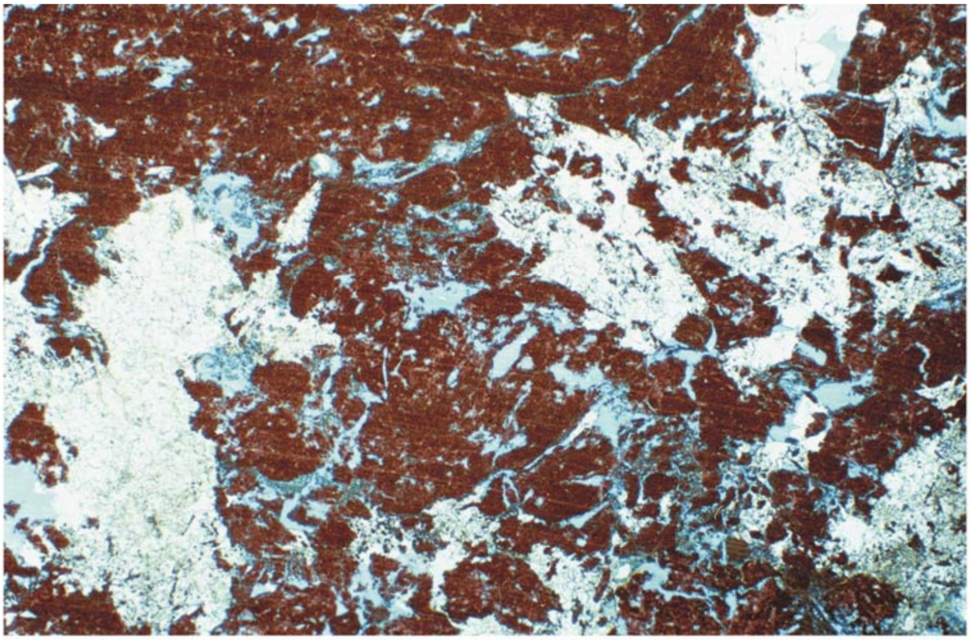
Other Constituents: dolomite

Core Interval

Thin Section Location







WELL: GLF-6
DEPTH: 1574
MAGNIFICATION: 20X

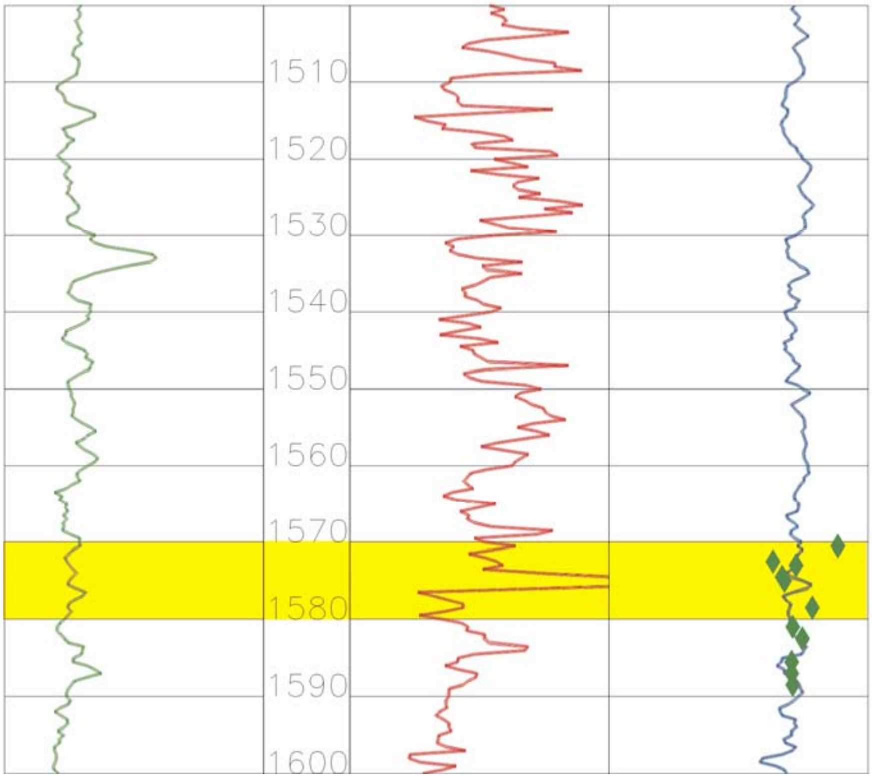
Lithofacies: Pellet Intraclast Packstone

Depositional Environment: Exposed Supratidal

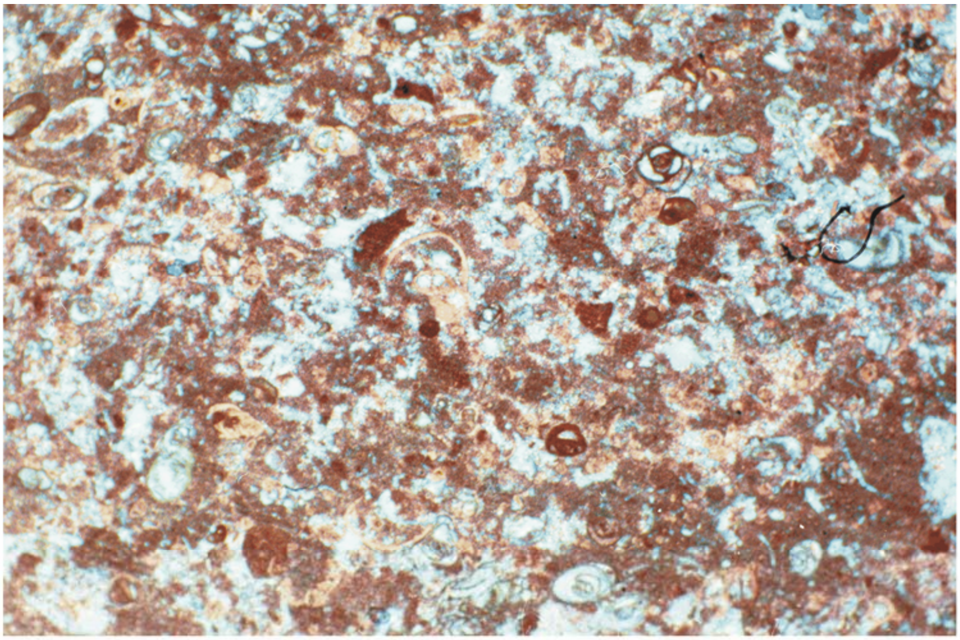
Porosity: Fair; moldic, shelte, intercrystalline

Other Constituents: dolomite

Core Interval



Thin Section Location



WELL: GLF-6
DEPTH: 1575.8
MAGNIFICATION: 40X

Lithofacies: Foram Pellet Packstone

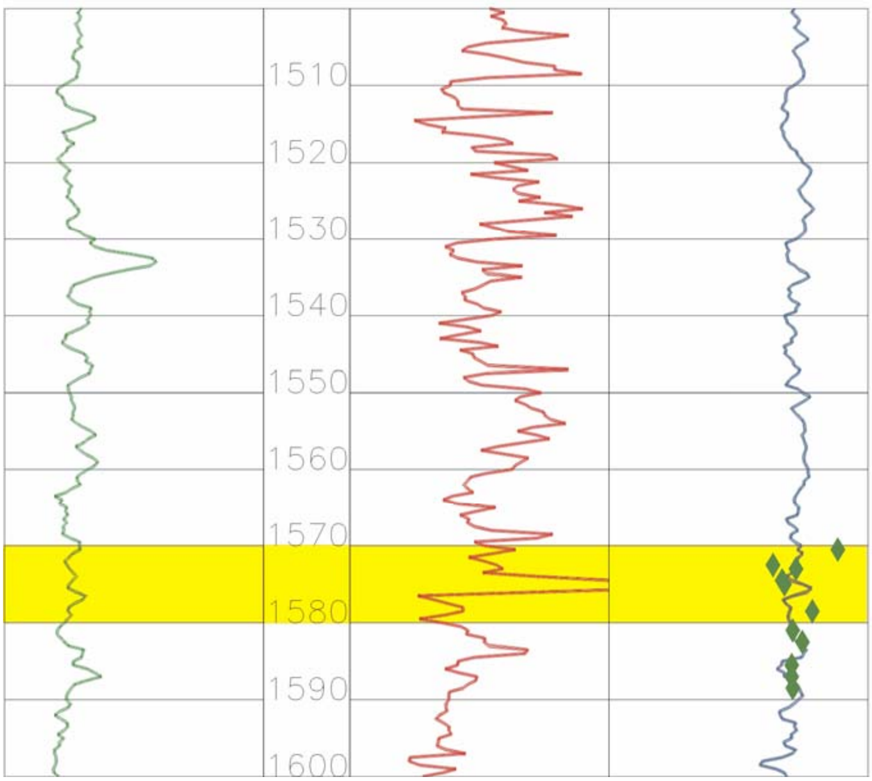
Depositional Environment: Shallow Lagoon

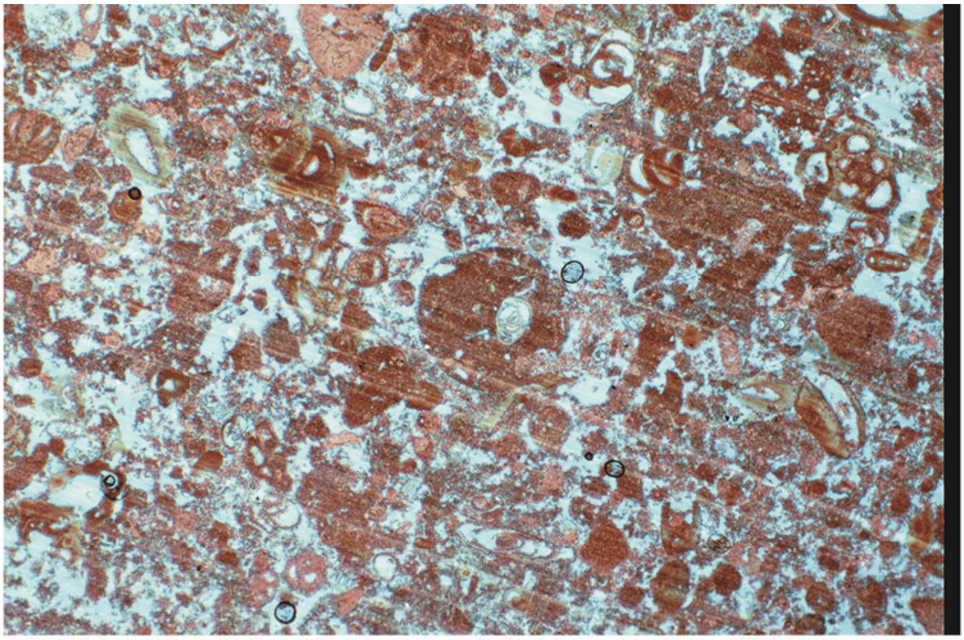
Porosity: Fair-Good; moldic, interparticle, intraparticle

Other Constituents:

Core Interval

Thin Section Location





WELL: GLF-6
DEPTH: 1576.1
MAGNIFICATION: 40X

Lithofacies: Foram Pellet Packstone

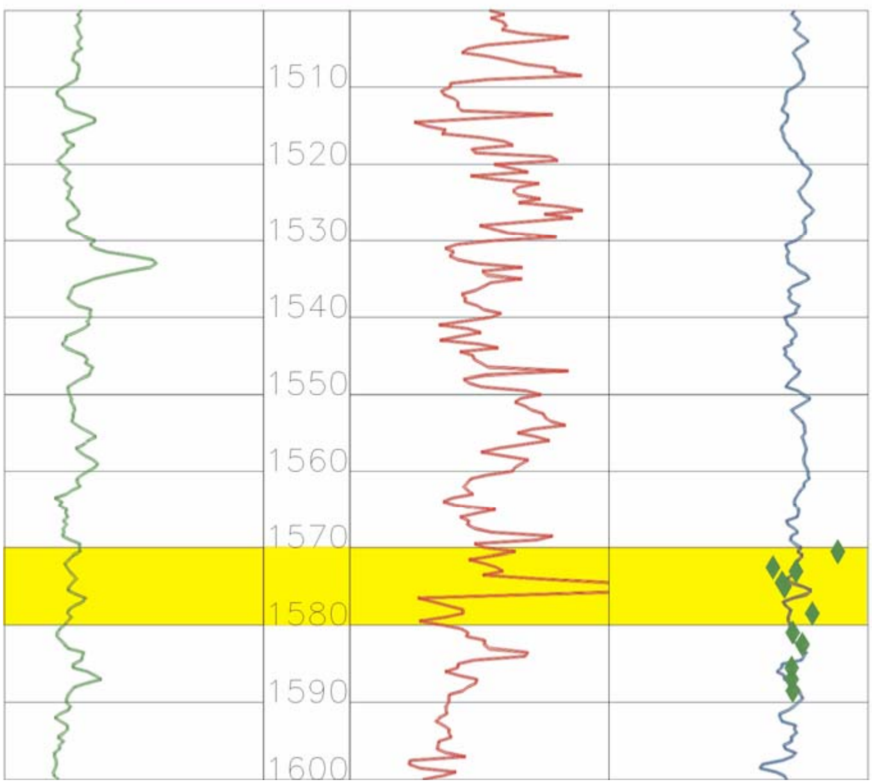
Depositional Environment: Deep Lagoon

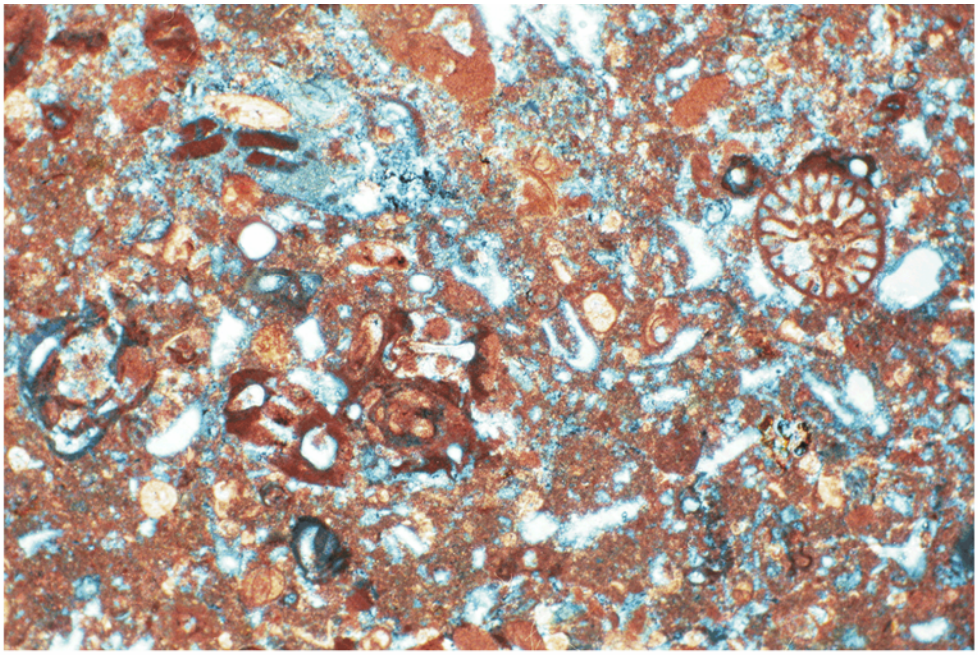
Porosity: Fair-Good; intraparticle, moldic, interparticle

Other Constituents:

Core Interval

Thin Section Location





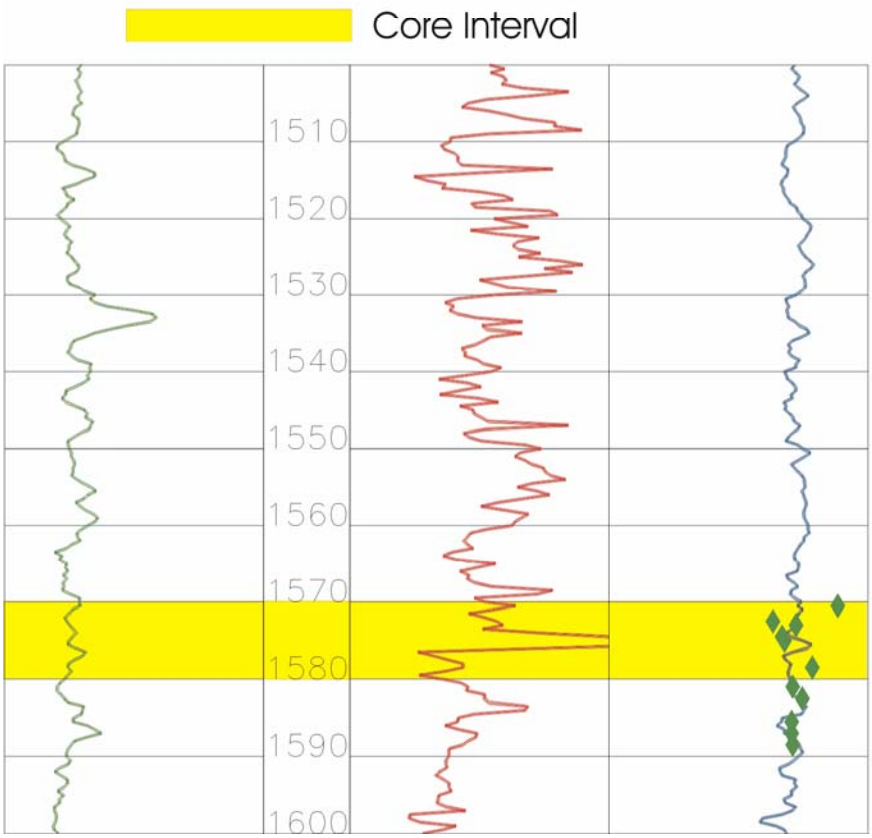
WELL: GLF-6
DEPTH: 1577
MAGNIFICATION: 40X

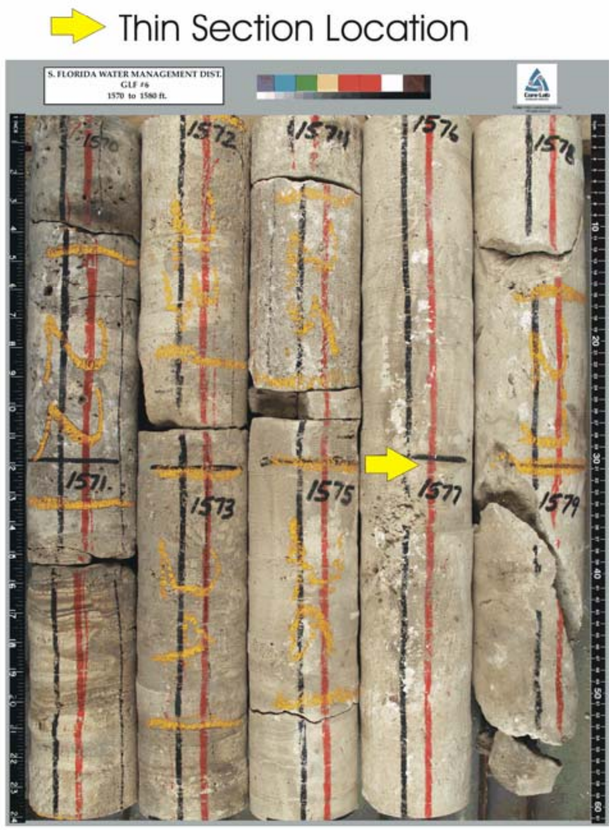
Lithofacies: Peloid Foram Pellet Packstone

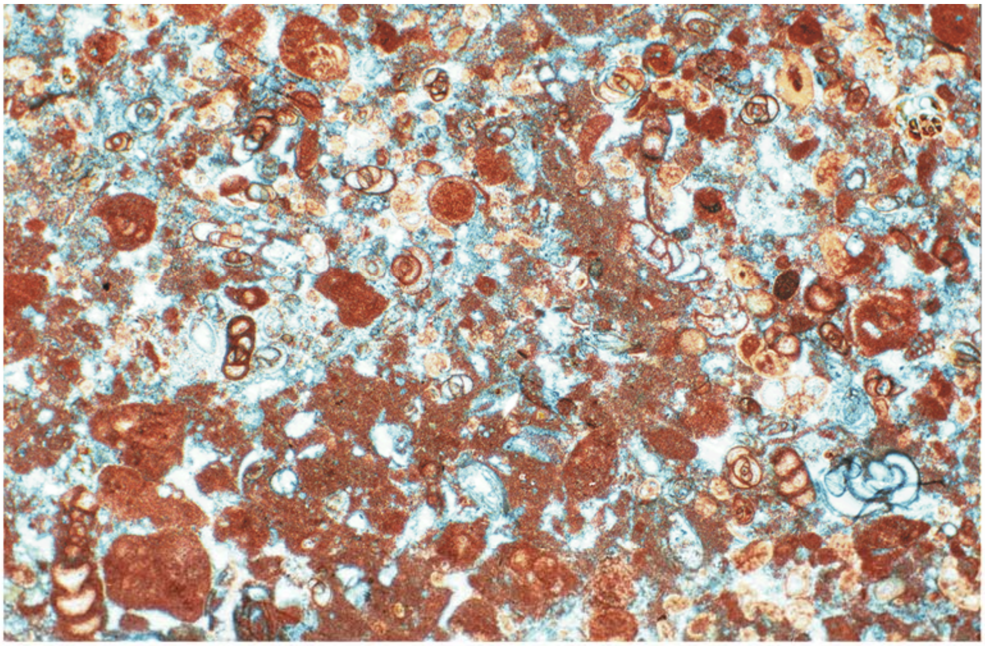
Depositional Environment: Shallow Lagoon

Porosity: Good; moldic, vuggy; intraparticle, interparticle

Other Constituents:



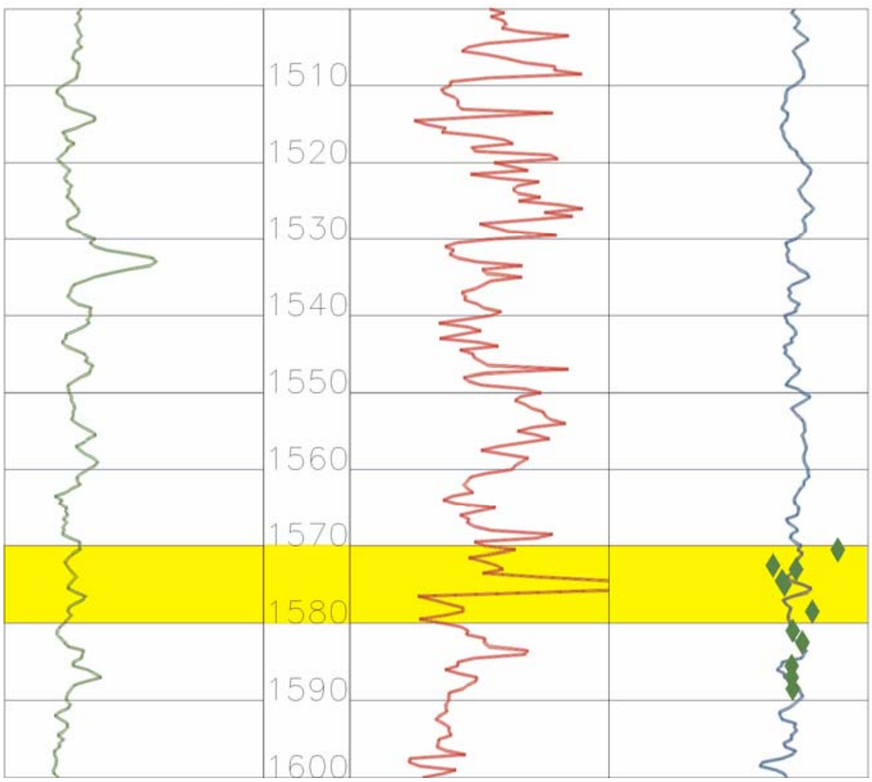




WELL: GLF-6
DEPTH: 1578
MAGNIFICATION: 40X

Lithofacies:	Intraclast Packstone
Depositional Environment:	Mound Flank
Porosity:	Good; interparticle, moldic, intraparticle
Other Constituents:	trace dolomite

Core Interval



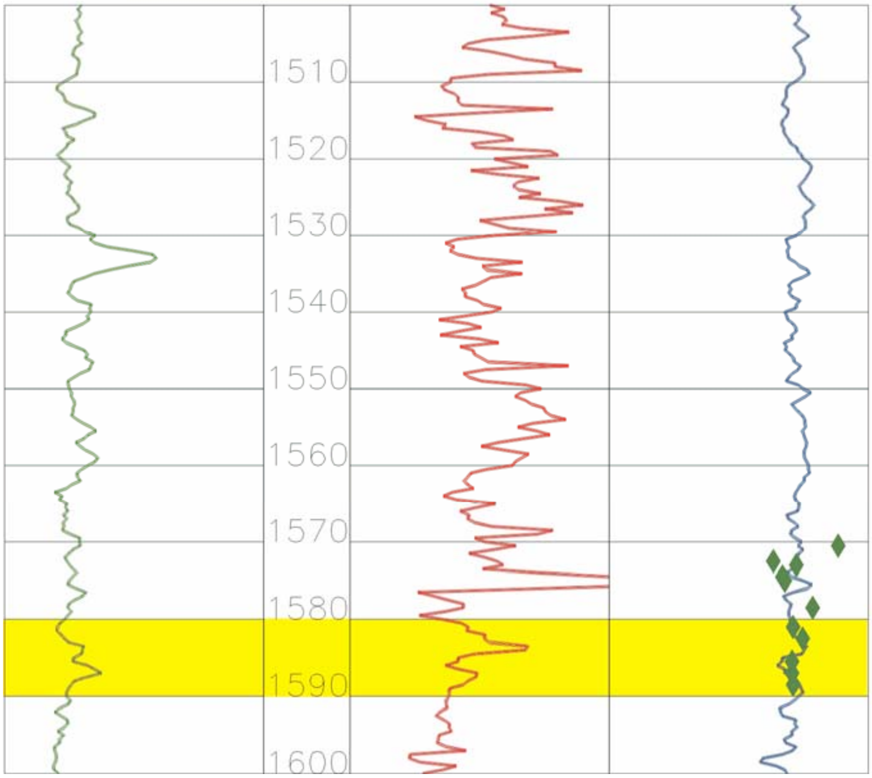
Thin Section Location

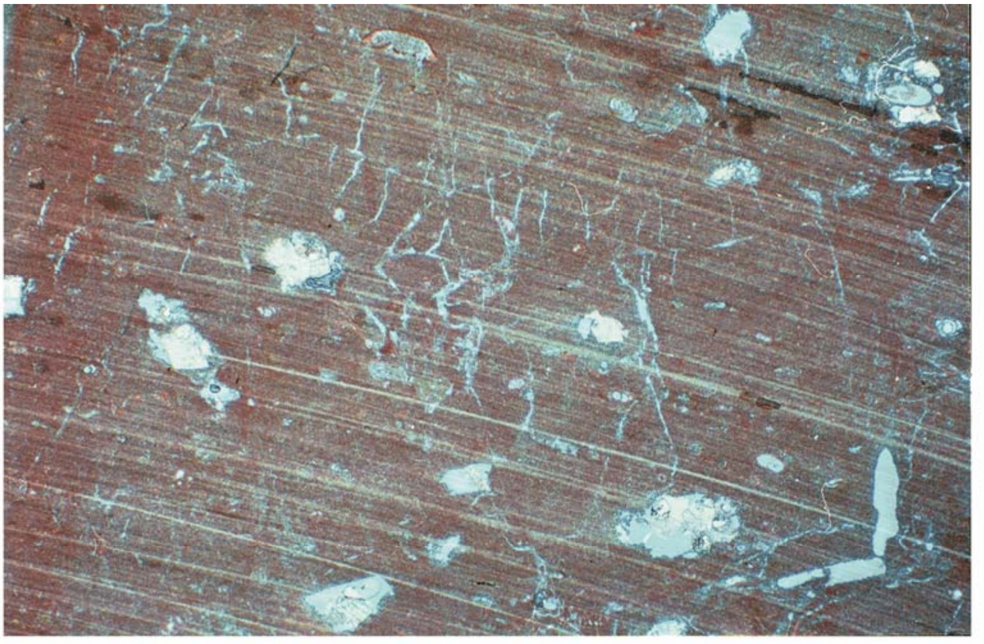
WELL: GLF-6
DEPTH: 1582.1
MAGNIFICATION: 40X

Lithofacies:	Algal Boundstone Packstone
Depositional Environment:	Algal Mound
Porosity:	Fair-Poor; intraparticle, interparticle, shelter; moldic
Other Constituents:	trace dolomite

Core Interval

Thin Section Location



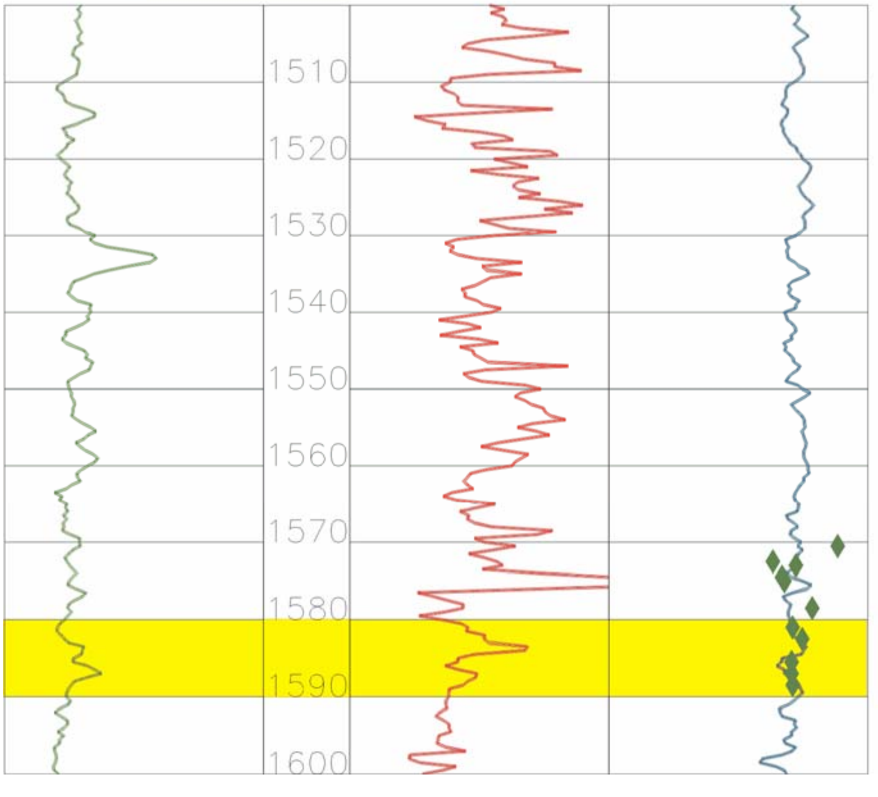


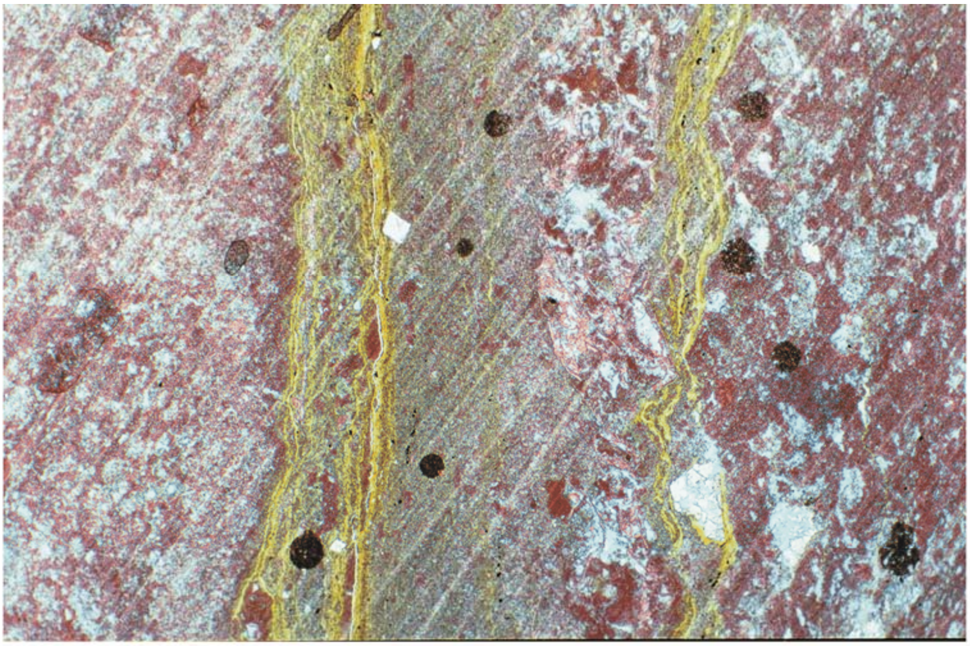
WELL: GLF-6
DEPTH: 1583.9
MAGNIFICATION: 20X

Lithofacies:	Dessicated Wackestone Mudstone
Depositional Environment:	Intertidal
Porosity:	Poor; fracture, interparticle, moldic
Other Constituents:	

Core Interval

Thin Section Location

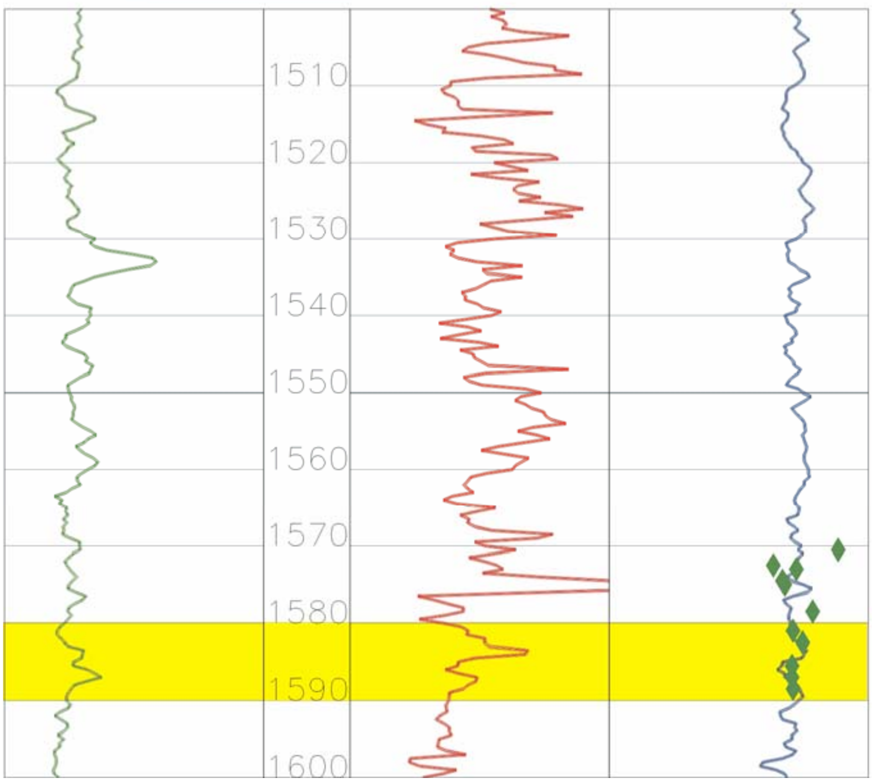




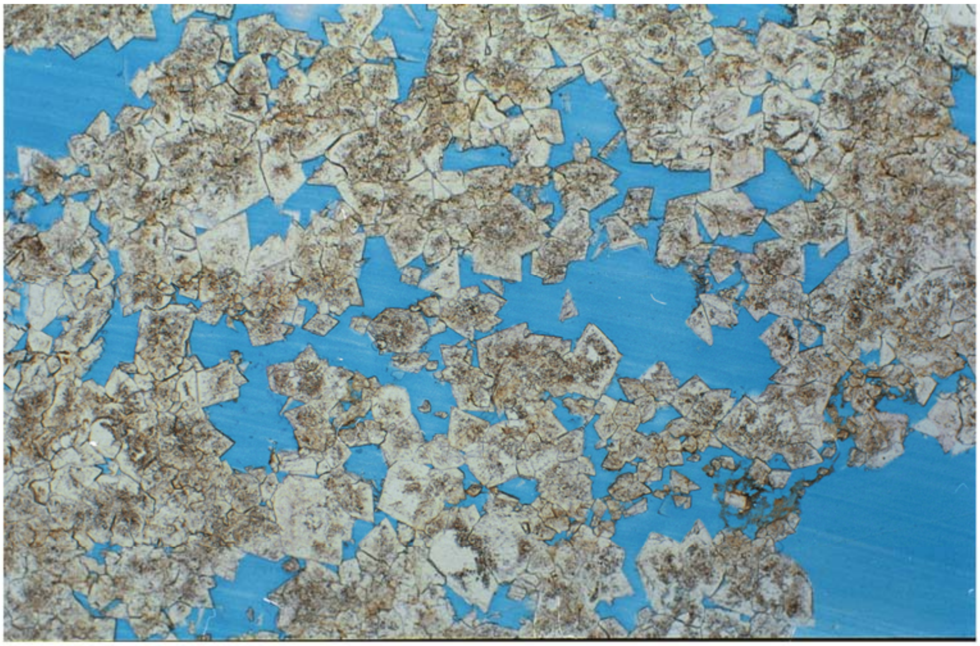
WELL: GLF-6
DEPTH: 1587.8
MAGNIFICATION: 40X

Lithofacies:	Laminated Dolomite Boundstone
Depositional Environment:	Algal Mound
Porosity:	Poor; vuggy, moldic
Other Constituents:	50% dolomite

Core Interval

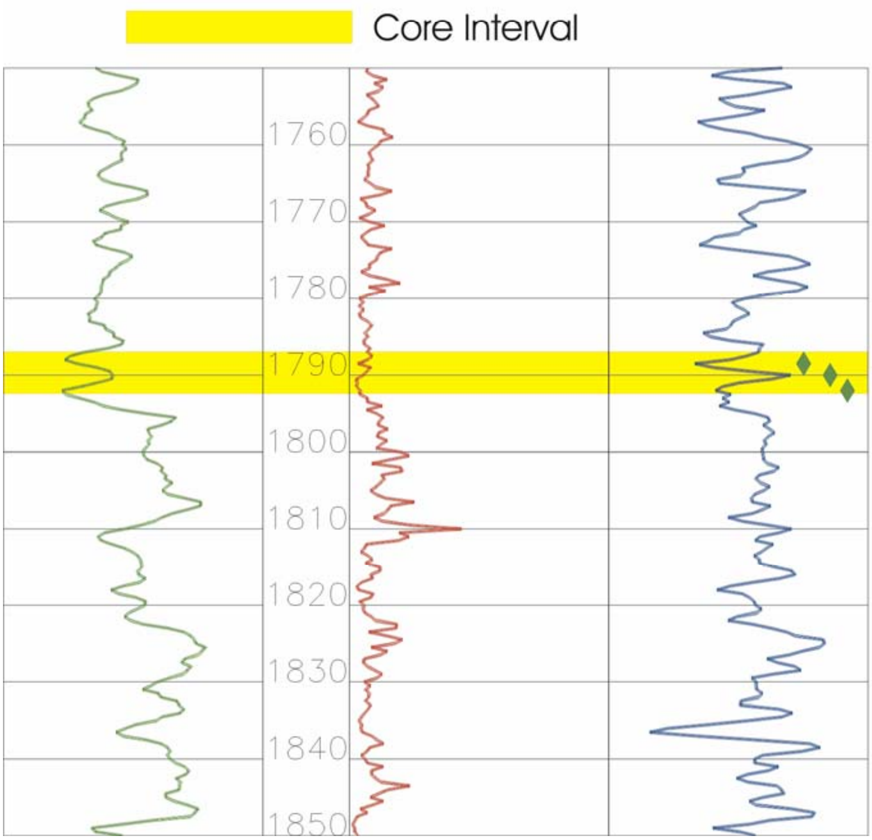


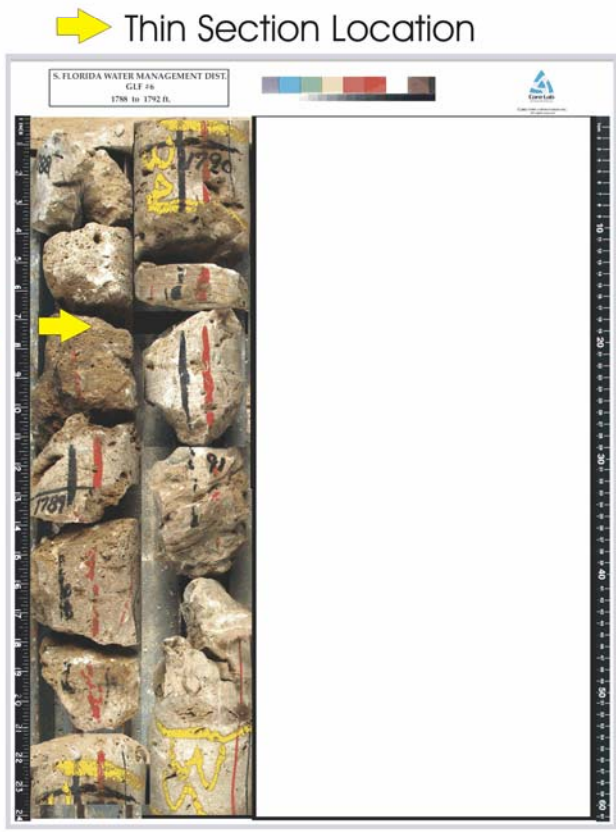
Thin Section Location

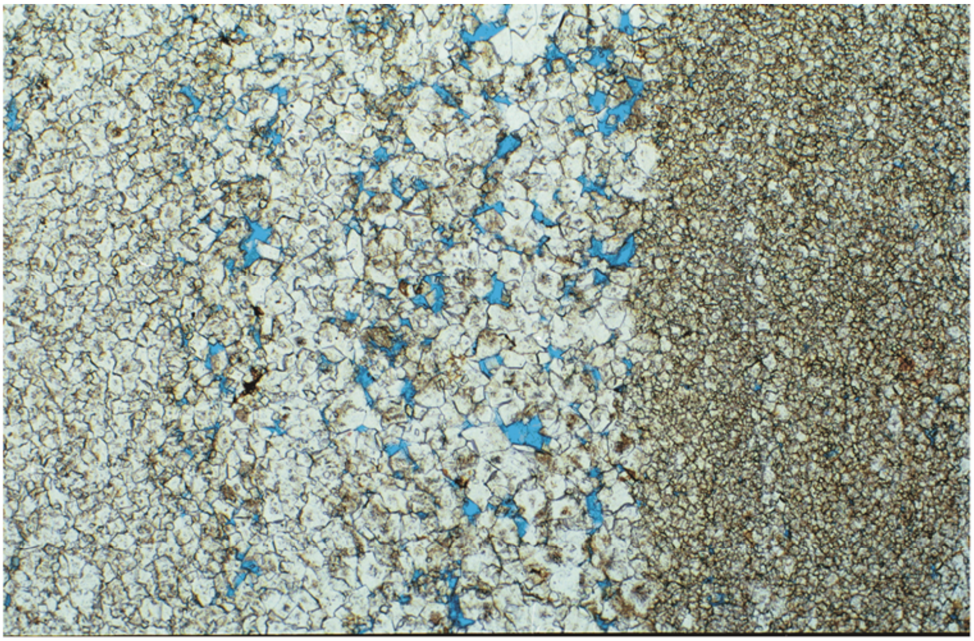


WELL: GLF-6
DEPTH: 1788.6
MAGNIFICATION: 40X

Lithofacies:	Laminated (Possibly) Algal Dolomite
Depositional Environment:	Supratidal
Porosity:	Good; intercrystalline, moldic, vuggy
Other Constituents:	





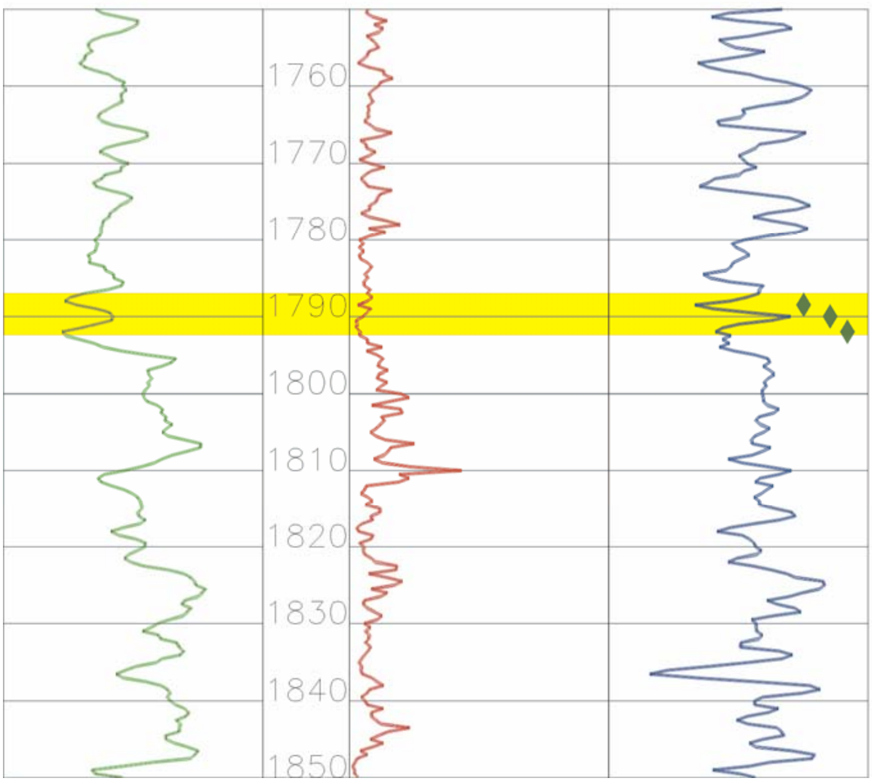


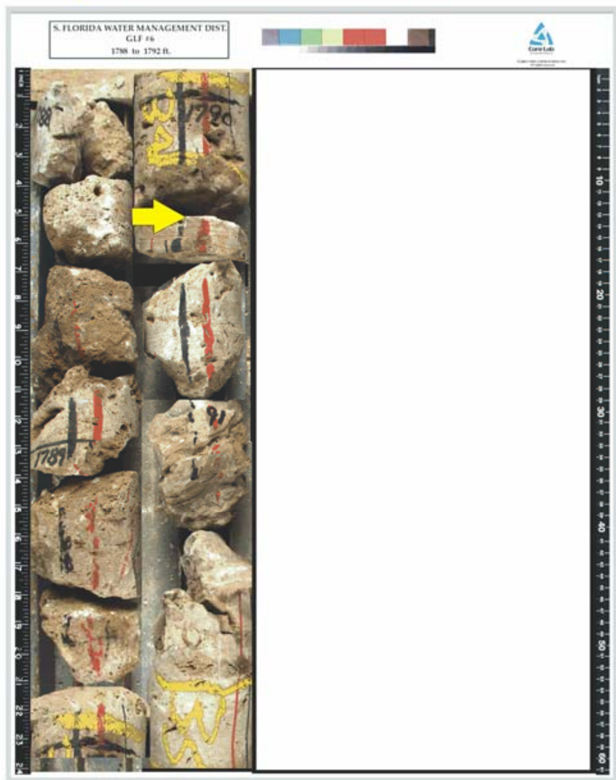
WELL: GLF-6
DEPTH: 1790.4
MAGNIFICATION: 40X

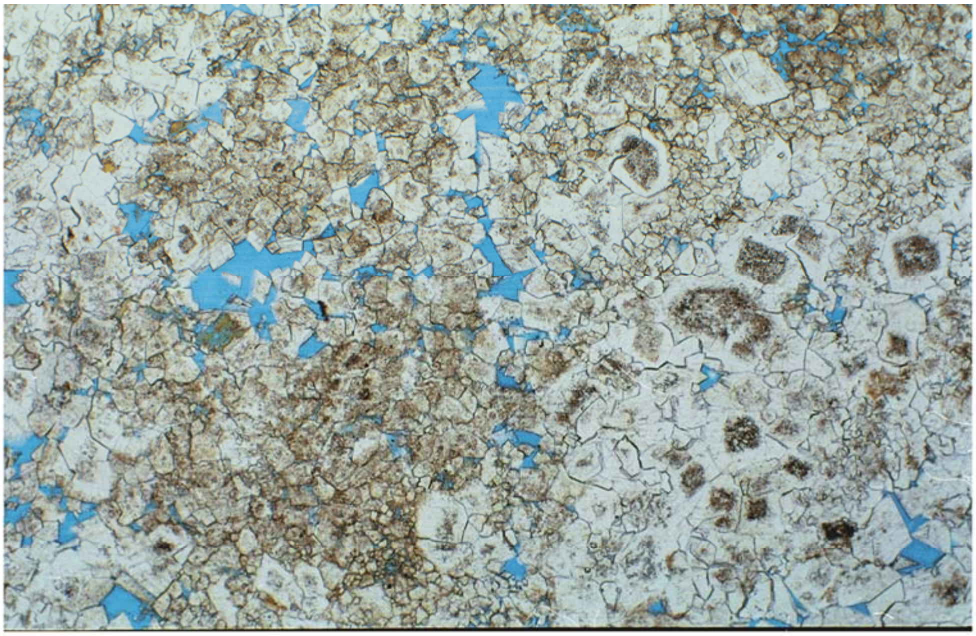
Lithofacies:	Dolomite
Depositional Environment:	Tidal Flat
Porosity:	Fair-Poor; intercrystalline
Other Constituents:	

Core Interval

Thin Section Location

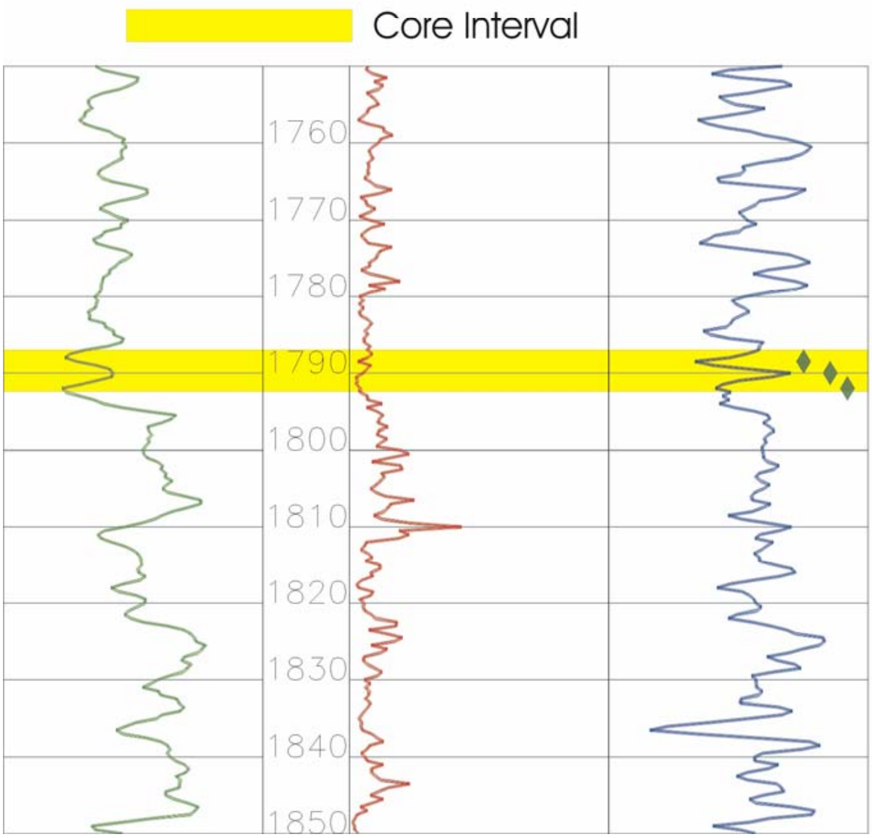


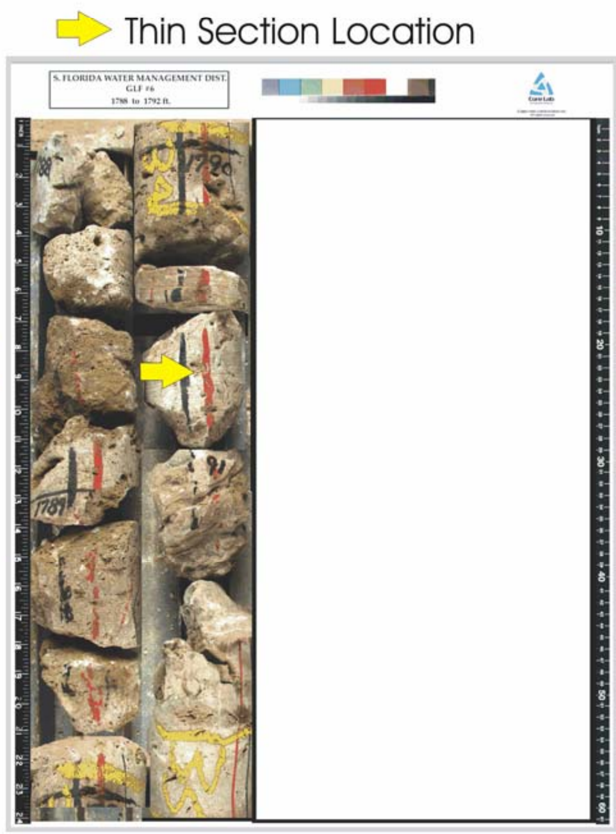




WELL: GLF-6
DEPTH: 1790.7
MAGNIFICATION: 40X

Lithofacies:	Dolomite
Depositional Environment:	Tidal Flat
Porosity:	Fair; intercrystalline, birds eye, fracture
Other Constituents:	





S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
874 to 884 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
884 to 884.9 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
993 to 1003 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1003 to 1007.1 ft.

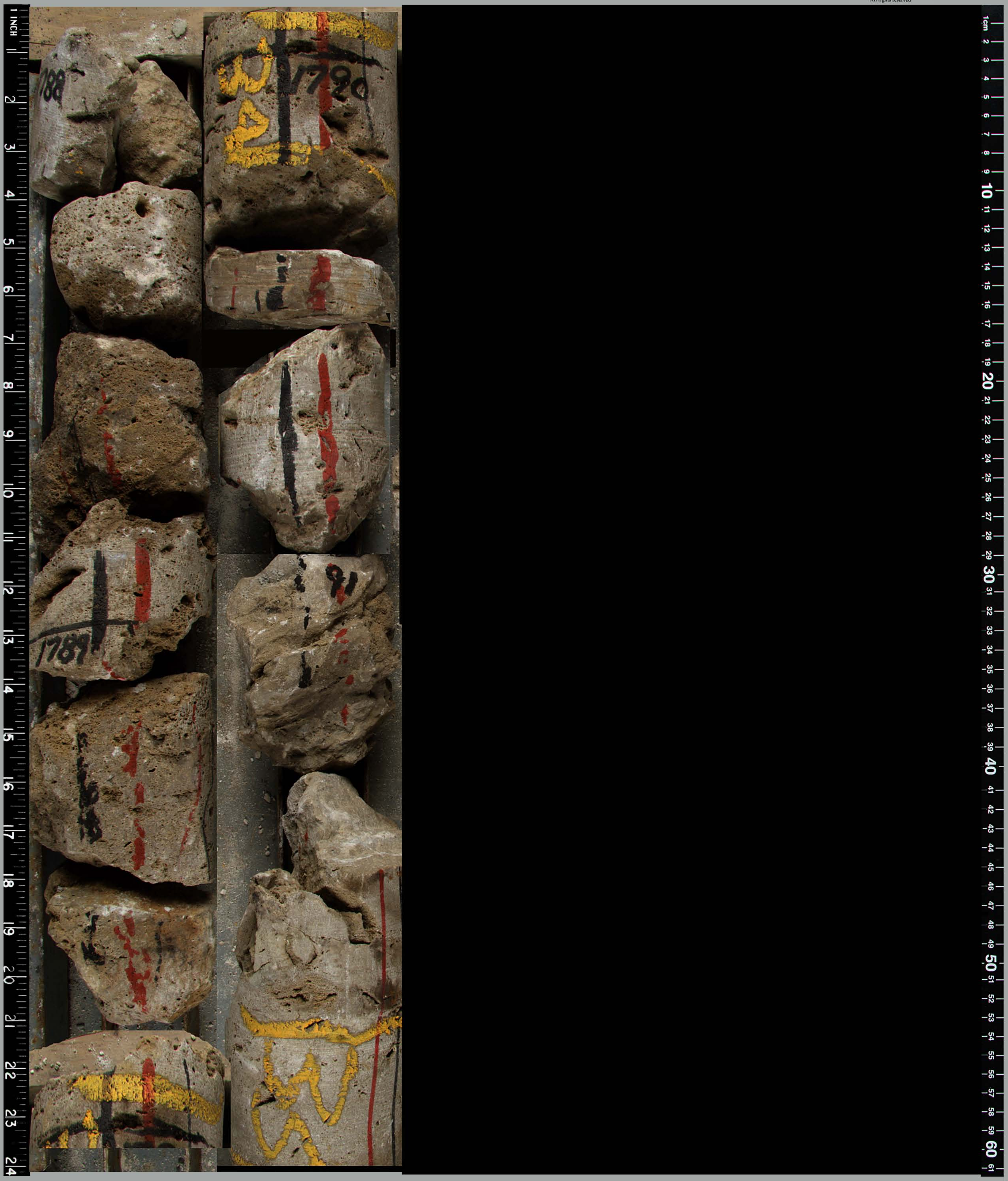
S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1300 to 1310 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1310 to 1318 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1570 to 1580 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1580 to 1590 ft.

S. FLORIDA WATER MANAGEMENT DIST.
GLF #6
1788 to 1792 ft.



Appendix E

Geologic Characteristics and Synoptic Interpretation of Specialty Geophysical Logs

ULTRASONIC VELOCITY

File No: 030601
Date: 7/15/03
Company South Florida Water Management
Wells GLF 6
Contact: Hugh Collier - Collier Consulting

Well Name	Sample Number	Depth ft	Net Stress, psi	Bulk Density, gm/cc	Acoustic Velocity: Compressional ft/sec	Acoustic Velocity: Compressional µs/ft	Acoustic Velocity: Shear ft/sec	Acoustic Velocity: Shear µs/ft	Bulk Modulus, 1.00E+06	Young's Modulus, 1.00E+06	Shear Modulus, 1.00E+06	Poisson's Ratio
GLF 6	10	997.0	500	1.96	9082	110.11	4841	206.56	1.36	1.61	0.62	0.30
GLF 6	11	1302.5	700	2.08	9645	103.68	5185	192.86	1.60	1.95	0.75	0.30
GLF 6	12	1585.7	900	2.18	11671	85.68	6736	148.45	2.22	3.33	1.33	0.25
GLF 6	13	1790.0	1000	2.49	19995	50.01	12419	80.52	6.52	12.28	5.18	0.19

COMPANY: SFWMD
WELL: GLF 6

NO	DEPTH TOP feet	DEPTH BOTTOM feet	K(max) md	K(90) md	K(vert) md	POR %	GD gm/cc	Description
1	874.3	874.6	93.38173	86.33	62.63	43.07	2.71	Lim, wht, foss, chalk, pp moldic
2	876.9	877.2	74.70588	73.77	56.08	41.73	2.72	Lim, wht, foss, chalk, pp moldic
3	877.8	878.2	60.06757	57.21	50.08	42.81	2.71	Lim, wht, foss, chalk, pp moldic
4	880.3	880.8	52.19915	51.66	50.37	39.77	2.73	Lim, wht, foss, chalk, pp moldic
5	881.8	882.5	29.99497	28.72	26.58	33.46	2.74	Lim, wht, foss, chalk, pp moldic
6	883.5	884	63.5	49.46	38.48	32.80	2.71	Lim, wht, foss, chalk, pp moldic moldic
7	884.4	884.7	62.85859	51.31313	49.62605	35.60198	2.712203	Lim, wht, foss, chalk, pp moldic moldic
8	993	993.5	61.28853	58.90196	49.59937	40.42718	2.715334	Lim, wht, foss, chalk, pp moldic
9	997	997.7	63.14269	63.14269	57.11119	41.74955	2.720396	Lim, wht, foss, chalk, pp moldic
10	1001.6	1002.1	30.2281	29.12603	43.59818	38.29689	2.711779	Lim, wht, foss, chalk, pp moldic
11	1002.6	1003.3	15.84158	14.93921	11.39129	36.3499	2.714996	Lim, wht, foss, chalk, pp moldic
12	1005.8	1006.5	64.8802	61.15756	45.64186	41.54284	2.717645	Lim, wht, foss, chalk, pp moldic
13	1300.3	1300.5	456.8516	405.0581	304.2605	35.52324	2.721632	Lim, wht, foss, chalk, pp moldic ipp
14	1302.8	1303.5	124.9297	119.9351	75.92349	31.75746	2.71171	Lim, wht, foss, chalk, pp moldic ipp
15	1305.3	1306	18.5	7.9375	13.0249	32.86913	2.736165	Lim, tn wht, foss, chalk, lam, pp moldic
16	1307	1307.7	82.29502	77.01719	48.5891	37.04223	2.713811	Lim, wht, foss, chalk, pp moldic
17	1309	1309.5	54.49319	52.61064	15.89255	35.08009	2.715995	Lim, tn wht, foss, chalk, pp moldic
18	1310	1310.6	643.6895	605.5895	49.17633	33.24479	2.71178	Lim, wht, foss, rk frag, lam, pp
19	1311.9	1312.6	257.4766	239.6411	113.3201	33.55549	2.72216	Lim, wht, foss, rk frag, pp moldic
20	1314.4	1315.1	58.3088	52.45751	39.8434	32.68708	2.710532	Lim, wht, foss, rk frag, pp moldic
21	1316.6	1317.2	553.72	29.845	14.63102	34.89366	2.706315	Lim, wht, foss, chalk, lam, pp moldic
22	1570.4	1571.1	2.513928	2.295325	0.201176	11.61078	3.357803	Dol, gry brn, siderite, sl vug
23	1572	1572.7	374.9386	369.7432	351.1849	36.67236	2.703038	Lim, wht, foss, chalk, pp moldic
24	1573	1573.7	94.81644	89.2274	53.33001	27.83721	2.717625	Lim, brn tn, foss, chalk, lam, pp moldic
25	1574.2	1574.8	1119.684	1092.895	1516.109	33.18353	2.729144	Lim, gry, foss, rk frag, pp
26	1575	1575.7	118.487	116.5304	81.22567	32.28423	2.714255	Lim, wht, foss, chalk, pp moldic
27	1578.5	1579	10.15935	7.696479	6.888898	21.47397	2.702755	Lim, wht gry, foss, chalk, rk frag, rootlet, pp moldic
28	1581	-999	-999	30.352	-999	29.04866	2.686604	Lim, wht tn, foss, lam, pp moldic
29	1582.5	1583.1	13.60714	13.49375	3.376299	25.29008	2.714014	Lim, wht tn, foss, lam, sl rootlet, sl pp moldic
30	1585.4	1586	49.79855	22.95181	29.79801	29.47207	2.719118	Lim, wht, chalk, sl pp
31	1587	1587.3	31.19438	21.43125	16.92089	29.52325	2.69005	Lim, wht, chalk, lam, sl pp
32	1588.2	1588.8	145.7349	103.8361	43.88855	29.03801	2.69534	Lim, tn wht, foss, chalk, lam, pp moldic
33	1788.5	-999	-999	5701.807	-999	24.88668	2.808564	Dol, brn, vf xln, vug ixp
34	1790	1790.3	52.24318	21.52682	17.5415	14.58956	2.807569	Dol, brn, vf xln, sl vug ixp
35	1791.7	1792	10.65232	3.33	0.035487	7.930611	2.820279	Dol, brn, vf xln, sl vug ixp
1A-36	784	800	-999	10.8	-999	31.74167	2.684288	Sltstn, gry, brn, slt-vf gr, calc, lam
2A-37	784	800	-999	74	-999	40.32487	2.453782	Sd, gry, vf gr, abund cly
3A-38	784	800	-999	26.7	-999	33.27694	2.640836	Sltstn, gry, brn, slt-vf gr, calc, lam
4A-39	784	800	-999	41.324	-999	39.48703	2.763016	Sd, gry, slt-vf gr, cly, lam

GEOFRAME PROCESSED INTERPRETATION

Integrated Log Well Montage

From Borehole Geophysical Measurements

Using the following logs: FMI*, UBI*, Platform Express*, HNGS*, AITH*

*A Mark of Schlumberger

COMPANY: South Florida Water Management District
WELL: Okeechobee Well Site C (GLF-6)
FIELD: Caloosahatchee River
COUNTY:
STATE: Florida
COUNTRY:
Date Logged: 15-Aug-2001 Date Processed: Oct-2001
Well Location:
Elevations: KB: 23.00 ft DF: 22.00 ft GL: 15.00 ft
API Number: Job Number:

FOLD HERE The well name, location, borehole reference data were furnished by the customer.

Field Recording:	Location: Laurel, MS	Software Version: 9C2-303	Engineer: G. Dillewyn, E. Rice, V
Office Recording:	ICS Center: IWS Denver	Baseline:	Log Analyst: N. Clayton

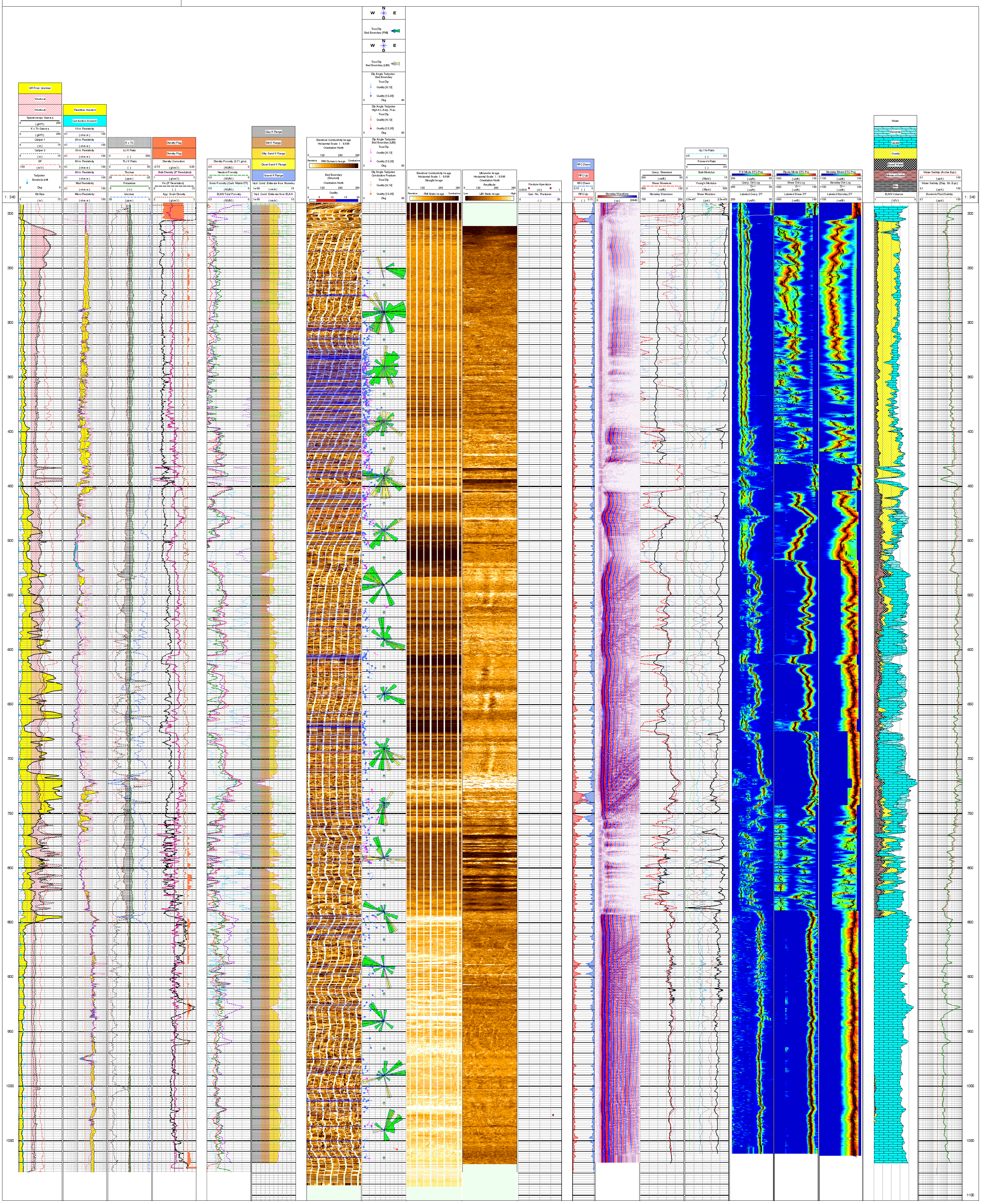
Mud and Borehole Measurements:

Rm @ Measured temperature: 1.625 ohm.m @ 81.0 degF	BHT: 65.0 degF	Bitsize: 7.9 in
Rmf @ Measured temperature: 1.320 ohm.m @ 81.0 degF	Type Fluid in Hole	Fresh Mud
Rmc @ Measured temperature: 2.290 ohm.m @ 81.0 degF	Mud Density: 9.20 lbm/gal	

Remarks:

Tool ran as depict in tool sketch

Log ran on Limestone Matrix=2.71 g/cc



GEOFRAME PROCESSED INTERPRETATION

Integrated Log Well Montage

Processed Data

Using the following logs:

Platform Express*
DSI* Dipole Shear Imager
UBI* Ultrasonic Borehole Imager

*A Mark of Schlumberger

COMPANY: South Florida Water Management District
WELL: Okeechobee Well Site C (GLF-6)
FIELD: Caloosahatchee River
COUNTY: Glades
STATE: Florida
COUNTRY: U.S.
Date Logged: 26-Sep-2001   Date Processed: 4-June-2002
Well Location: Lat: 26-50-18.6N
Long: 81-05-7.6W
Elevations: KB: 25.50 ft   DF: 24.50 ft   GL: 15.00 ft
API Number: Job Number:

FOLD HERE   The well name, location, borehole reference data were furnished by the customer.

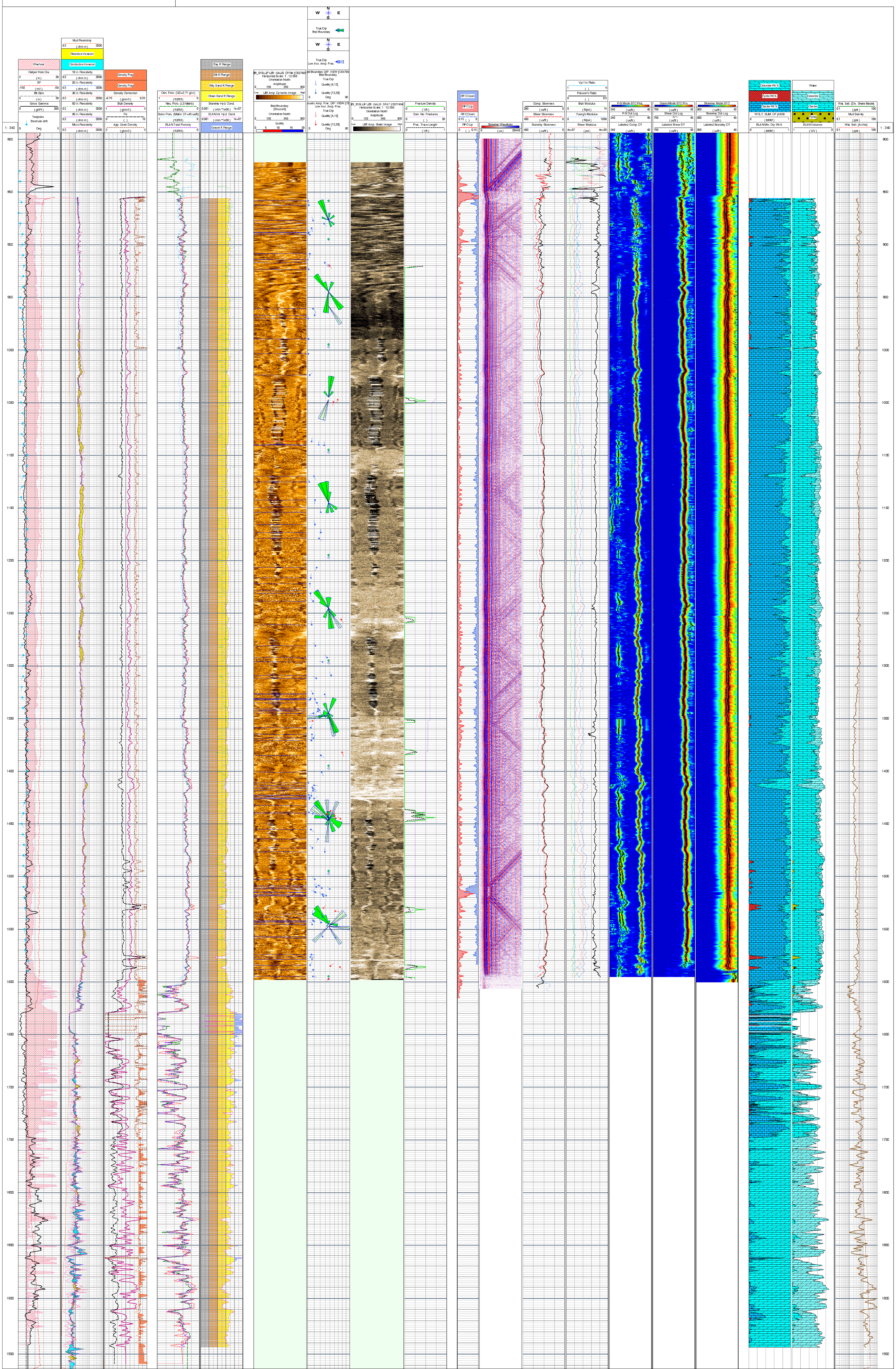
Field Recording:	Location: Laurel, MS	Software Version:	Engineer: S. Henley, C. Ertle
Office Recording:	ICS Center: SKS Sacramento	Baseline: GF3.8.1	Log Analyst: N. Clayton

Mud and Borehole Measurements:

Rm @ Measured temperature: 1.180 ohm.m @ 87.0 degF	BHT: 100.0 degF	Bitsize: 7.9 in
Rmf @ Measured temperature: 0.890 ohm.m @ 87.0 degF	Type Fluid in Hole	Fresh Mud
Rmc @ Measured temperature: 1.780 ohm.m @ 87.0 degF	Mud Density: 8.50 lbm/gal	

Remarks:

Run 2 (bottom of hole) of 2 runs
Depth matched to Run 1 processed logs
Poor hole conditions from 1598 - 1942 ft. (bottom of hole)
Log measurements severely impacted by poor hole conditions in above-mentioned interval
ELAN model reflects washout response on measurements



Appendix F

Packer Test Drawdown and Recovery Data

(Full text provided electronically only)

Table F-1. Packer Test Drawdown and Recovery Data for GLF-6 (October-November 2001)

Excel File Tab Name	Pump Test Designation	Date	Start Time	End Time
PT1_Rec_1	Pump Test 1 Recovery-1	10/22/01	12:08	12:38
PT1_Rec_2	Pump Test 1 Recovery-2	10/22/01	12:45	13:00
PT2_PreRec	Pump Test 2 Pre-Recovery	11/2/01	8:37	9:40
PT2_DD	Pump Test 2 Drawdown	11/2/01	10:14	12:14
PT3_PreRec	Pump Test 3 Pre-Recovery	11/9/01	8:11	9:14
PT3_DD	Pump Test 3 Drawdown	11/9/01	9:31	11:30
PT3_Rec	Pump Test 3 Recovery	11/9/01	11:35	13:15
PT4_PreRec	Pump Test 4 Pre-Recovery	11/15/01	10:06	12:40
PT4_DD	Pump Test 4 Drawdown	11/15/01	12:45	15:09
PT4_Rec	Pump Test 4 Recovery	11/15/01	15:14	18:08
PT5_Rec	Pump Test 5 Recovery	11/19/01	17:18	19:22
PT6_PreRec	Pump Test 6 Pre-Recovery	11/20/01	12:50	14:29
PT6_DD	Pump Test 6 Drawdown	11/20/01	14:33	16:32
PT6_Rec	Pump Test 6 Recovery	11/20/01	16:42	18:46
PT4_GenInfo_WQ	Pump Test 4 General Information & Water Quality	11/15/01		
PT5_GenInfo_WQ	Pump Test 5 General Information & Water Quality	11/19/01		
PT6_GenInfo_WQ	Pump Test 6 General Information & Water Quality	11/20/01		

Appendix G

Class V UIC Well Permit Application and Supporting Information

Exploratory Well near the S-77 Water Control Structure, Moore Haven, Florida

Lake Okeechobee Aquifer Storage and Recovery Pilot Project

CENTRAL & SOUTHERN FLORIDA PROJECT

Comprehensive Everglades Restoration Plan

Prepared By:

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

5/18/01
PAUL F. LINTON
42637

In Association With:

U.S. Army Corps of Engineers
Jacksonville District
Jacksonville, Florida

Peter J. Kwiatkowski
May 18, 2001

May 2001

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

3301 Gun Club Road, West Palm Beach, Florida 33406 • (561) 686-8800 • FL WATS 1-800-432-2045 • TDD (561) 697-2574
Mailing Address: P.O. Box 24680, West Palm Beach, FL 33416-4680 • www.sfwmd.gov

ADM 02 06

May 18, 2001

Mr. Jose L. Calas, P.E.
Program Administrator, Environmental Affairs
Florida Department of Environmental Protection
400 N. Congress Avenue
P.O. Box 15425
West Palm Beach, FL 33416

Dear Mr. Calas:

Subject: Class V Exploratory Well Permit Application, Moore Haven, Florida, Lake Okeechobee ASR Pilot Project.

Thank you for meeting with the South Florida Water Management District (SFWMD) and U.S. Army Corps of Engineers (USACE) at your office on May 2, 2001 to discuss pre-application issues for the Lake Okeechobee ASR Pilot Project. Enclosed are two (2) copies of the subject application, with additional copies provided to the Technical Advisory Committee (TAC).

As you know, the test well contract has begun, and we anticipate that minor changes in the design of the subject exploratory well will occur based on results of test well construction and testing. As we discussed at our meeting and during the Project Delivery Team meetings, we believe the TAC's early review of the subject application will accelerate the schedule for this most important project.

Please contact me if you or the TAC has any questions or comments regarding the subject permit application. We look forward to working closely with your office – and other Project Delivery Team members – throughout this project.

Sincerely,

Peter J. Kwiatkowski, P.G.
SFWMD Project Manager
Lake Okeechobee ASR Pilot Project

PJK/kh
Enclosures

c: Glenn Landers, USACE-Jacksonville
Michael Fies, USACE-Jacksonville

Florida Department of Environmental Protection
Twin Towers Office Bldg., 2600 Blair Stone Road,
Tallahassee, Florida 32399-2400

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No.:	(Filled in by DEP)

APPLICATION TO CONSTRUCT/OPERATE/ABANDON CLASS I, III, OR V INJECTION WELL SYSTEMS

Part I. Directions

A. All applicable items must be completed in full in order to avoid delay in processing this application. Where attached sheets or other technical documentation are utilized in lieu of the blank space provided, indicate appropriate cross-reference in the space and provide copies to the Department in accordance with C. below. Where certain items do not appear applicable to the project, indicate N/A in the appropriate spaces.

B. All information is to be typed or printed in ink.

C. Four (4) copies of this application and four (4) copies of supporting information such as plans, reports, drawings and other documents shall be submitted to the appropriate District/Subdistrict office. An engineering report is also required to be submitted to support this application pursuant to the applicable sections of Rule 62-528, F.A.C. The attached list* shall be used to determine completeness of supporting data submitted or previously received. A check for the application fee in accordance with Rule 62-4.050, F.A.C., made payable to the Department shall accompany the application.

D. For projects involving construction, this application is to be accompanied by four (4) sets of engineering drawings, specifications and design data as prepared by a Professional Engineer registered in Florida, where required by Chapter 471, Florida Statutes.

E. Attach 8 1/2" x 11" USGS site location map indicating township, range and section and latitude/longitude for the project.

PART II. General Information

A. Applicant Name Joseph A. Schweigart, P.E. Title Director, Programs Mgmt.

Address 3301 Gun Club Road

City West Palm Beach State Florida Zip 33406-4680

Telephone Number 561-682-6102

B. Project Status: ☒ New ☐ Existing

☐ Modification (specify) ________

*"Engineering and Hydrogeologic Data Required for Support of Application to Construct, Operate and Abandon Class I, III, or V Injection Wells"

C. Well Type: ☒ Exploratory Well ☐ Test/Injection Well

D. Type of Permit Application

- ☐ Class I Test/Injection Well Construction and Testing Permit
- ☐ Class I Well Operation Permit
- ☐ Class I Well Operation Repermitting
- ☐ Class I Well Plugging and Abandonment Permit
- ☐ Class III Well Construction/Operation/Plugging and Abandonment Permit
- ☐ Class I Exploratory Well Construction and testing Permit
- ☒ Class V Well Construction Permit
- ☐ Class V Well Operation Permit
- ☐ Class V Well Plugging and Abandonment Permit
- ☐ Monitor Well Only

E. Facility Identification:

Name Moore Haven Exploratory Well

Facility Location: Street S-77 Control Structure Access Road

City Moore Haven County Glades

SIC Code(s) ________

F. Proposed facility located on Indian Lands: Yes ☐ No ☒

G. Well Identification:

Well No. 1 of 1 Wells
(total #)

Purpose (Proposed Use) Exploratory Aquifer Storage and Recovery

Well Location: Latitude: N 26° 50′ 10″ Longitude: W 81° 05′ 14″
(attach separate sheet(s), if necessary, for multiple wells)

Subpart B. General Project Description:

H. General Project Description: Describe the nature, extent and schedule of the injection well project. Refer to existing and/or future pollution control facilities, expected improvement in performance of the facilities and state whether the project will result in full compliance with the requirements of Chapter 403, F.S., and all rules of the Department. Attach additional sheet(s) if necessary or cross-reference the engineering report.

Project consists of construction and testing of an exploratory ASR well as part of the Lake Okeechobee ASR Pilot Project component of the Comp. Everglades Restoration Plan.

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No.:	(Filled in by DEP)

PART III. Statement by Applicant and Engineer

A. Applicant

I, the owner/authorized representative* of South Fla. Water Mgmt. District, certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment. I understand that this certification also applies to all subsequent reports submitted pursuant to this permit. Where construction is involved, I agree to retain the design engineer, or other professional engineer registered in Florida, to provide inspection of construction in accordance with Rule 62-528.455(1)(c), F.A.C.

Joseph A. Schweigart
Signed

05/18/01
Date

Joseph A. Schweigart, P.E.
Name and Title (Please Type)

561-682-6102
Telephone Number

*Attach a Letter of Authorization.

B. Professional Engineer Registered in Florida

This is to certify that the engineering features of this injection well have been designed/examined by me and found to be in conformity with modern engineering principles applicable to the disposal of pollutants characterized in the permit application. There is reasonable assurance, in my professional judgement, that the well, when properly maintained and operated, will discharge the effluent in compliance with all applicable statutes of the State of Florida and the rules of the Department. It is also agreed that the undersigned will furnish the applicant a set of instructions for proper maintenance and operation of the well.

Paul F. Linton 5/18/2001 42637
Signed

Paul Ferguson Linton
Name (Please Type)

South Florida Water Management District
Company Name (Please Type)

(Please Affix Seal)

3301 Gun Club Road West Palm Beach, FL 33406
Mailing Address(Please Type)

Florida Registration No. 42637 Date 05/18/01 Phone No. 561-682-2871

**ENGINEERING AND HYDROLOGIC DATA
REQUIRED FOR SUPPORT OF APPLICATION
TO CONSTRUCT, OPERATE, AND ABANDON
CLASS I, III, OR V INJECTION WELL SYSTEMS**

The following information shall be provided for each type of permit application.

A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT

1. A map showing the location of the proposed injection wells of well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data.

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program.

15. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

B. CLASS I INJECTION WELL OPERATION PERMIT

1. A report shall be submitted with each application for a Class I Well operating permit, which shall include, but not be limited to, the following information:

   (a) Results of the information obtained under the construction permit described in A. CLASS I TEST/INJECTION WELL CONSTRUCTION AND TESTING PERMIT, including:

      (1) All available logging and testing program data and construction data on the well or well field;

      (2) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C;

      (3) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

      (4) The actual injection procedure;

      (5) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone; and,

      (6) The status of corrective action on defective wells in the area of review.

   (b) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

   (c) Certification of completion submitted by the engineer of record;

   (d) If requested by the Department, operation manual including emergency procedures;

(e) Proposed monitoring program and data to be submitted;

(f) Proof that the existence of the well has been recorded on the surveyor's plan at the county courthouse; and,

(g) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

C. CLASS I WELL OPERATION REPERMITTING

1. An updated map showing the location of the injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of pubic record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the injection zone, confining zone, or monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Contingency plans to cope with all shut-ins or well failures, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

7. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

8. A certification that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

9. A report shall be submitted with each application for repermitting of Class I Well operation which shall include the following information:

   (a) All available logging and testing program data and construction data on the well or well field;

(b) A satisfactory demonstration of mechanical integrity for all wells pursuant to Rule 62-528.300(6), F.A.C.;

(c) The actual operating data, including injection pressures versus pumping rates where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

(d) The actual injection procedure;

(e) The compatibility of injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone;

(f) The status of corrective actin on defective wells in the area of review;

(g) Record drawings, based upon inspections by the engineer or persons under his direct supervision, with all deviations noted;

(h) Certification of completion submitted by the engineer of record;

(i) An updated operation manual including emergency procedures;

(j) Proposed revisions to the monitoring program or data to be submitted; and,

(k) Proposed plugging and abandonment plan pursuant to Rule 62-528.435(2), F.A.C.

D. CLASS I WELL PLUGGING AND ABANDONMENT PERMIT

1. The reasons for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods, and justification for use.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

E. CLASS III WELLS CONSTRUCTION/OPERATION/PLUGGING AND ABANDONMENT PERMIT

Construction Phase

1. A map showing the location of the proposed injection wells or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water system, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

2. A tabulation of data on all wells within the area of review which penetrate into the proposed injection zone, confining zone, or proposed monitoring zone. Such data shall include a description of each well's type, construction, date drilled, location, depth, record of plugging and/or completion, and any additional information the Department may require.

3. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

4. Maps and cross sections detailing the hydrology and geologic structures of the local area.

5. Generalized maps and cross sections illustrating the regional geologic setting.

6. Proposed operating data:

   (a) Average and maximum daily rate and volume of the fluid to be injected;

   (b) Average and maximum injection pressure; and,

   (c) Source and an analysis of the chemical, physical, radiological and biological characteristics of injection fluids, including any additives.

7. Proposed formation testing program to obtain an analysis of the chemical, physical and radiological characteristics of and other information on the injection zone.

8. Proposed stimulation program.

9. Proposed injection procedure.

10. Engineering drawings of the surface and subsurface construction details of the system.

11. Contingency plans to cope with all shut-ins or well failures or catastrophic collapse, so as to protect the quality of the waters of the State as defined in Rule 62-3 and 62-520, F.A.C., including alternate or emergency discharge provisions.

12. Plans (including maps) and proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

13. For wells within the area of review which penetrate the injection zone but are not properly completed or plugged, the corrective action proposed to be taken under Rule 62-528.300(5), F.A.C.

14. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, and a drilling, testing and coring program.

15. A certificate that the applicant has ensured, through a performance bond or other appropriate means, the resources necessary to close, plug or abandon the well as required by Rule 62-528.435(9), F.A.C.

16. Expected changes in pressure, native fluid displacement, direction of movement of injection fluid.

17. A proposed monitoring plan, which includes a plan for detecting migration of fluids into underground sources of drinking water, a plan to detect water quality violation in the monitoring wells, and the proposed monitoring data to be submitted.

Operation Phase

1. The following information shall be provided to the Department prior to granting approval for the operation of the well or well field:

   (a) All available logging and testing program data and construction data on the well or well field;

   (b) A satisfactory demonstration of mechanical integrity for all new wells pursuant to Rule 62-528.300(6), F.A.C.;

   (c) The actual operating data, including injection pressure versus pumping rate where feasible, or the anticipated maximum pressure and flow rate at which the permittee will operate, if approved by the Department;

   (d) The results of the formation testing program;

   (e) The actual injection procedure; and,

   (f) The status of corrective action on defective wells in the area of review.

Plugging and abandonment Phase

1. The justification for abandonment.

2. A proposed plan for plugging and abandonment describing the preferred and alternate methods.

   (a) The type and number of plugs to be used;

   (b) The placement of each plug including the elevation of the top and bottom;

   (c) The type and grade and quantity of cement or any other approved plugging material to be used; and,

   (d) The method for placement of the plugs.

3. The procedure to be used to meet the requirements of Rule 62-528.435, F.A.C.

F. EXPLORATORY WELL CONSTRUCTION AND TESTING PERMIT

1. Conceptual plan of the injection project. Include number of injection wells, proposed injection zone, nature and volume of injection fluid, and proposed monitoring program.

2. Preliminary Area of Review Study. Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

3. Proposed other uses of the exploratory well.

4. Drilling and testing plan for the exploratory well. The drilling plan must specify the proposed drilling program, sampling, coring, and testing procedures.

5. Abandonment Plan.

DEP Form No:	62-528.900(1)
Form Title:	Application to Construct/ Operate/Abandon Class I, III, or V Injection Well Systems
Effective Date:	
DEP Application No.:	(Filled in by DEP)

G. CLASS V WELL CONSTRUCTION PERMIT

(This form should be used for Class V Wells instead of Form 62-528.900(3), F.A.C., when there is a need for a Technical Advisory Committee and an engineering report.)

1. Type and number of proposed Class V Wells:

   ________ Wells Receiving Domestic Waste

   ________ Desalination Process Concentrate Wells (Reverse Osmosis, etc.)

   1 Aquifer Storage and Recovery Wells

   ________ Aquifer Remediation Wells

   ________ Salt-water Intrusion Barrier Wells

   ________ Cooling Water Return Flow Wells Open-looped System

   ________ Subsidence Control Wells

   ________ Sand Backfill Wells

   ________ Experimental Technology Wells

   ________ Wells used to inject spent brine after halogen recovery

   ________ Radioactive Waste Disposal Wells*

   ________ Borehole Slurry Mining Wells

   ________ Other non-hazardous Industrial or Commercial Disposal Wells

   (explain) ________________________________

   ________ Other (explain) ________________________________

   *Provided the concentrations of the waste do not exceed drinking water standards contained in Chapter 62-550, F.A.C.

2. Project Description:

   (a) Description and use of proposed injection system;

   (b) Nature and volume of injected fluid (the Department may require an analysis including bacteriological analysis) in accordance with Rule 62-528.635(2)(b), F.A.C.; and,

   (c) Proposed pretreatment.

3. Water well contractor's name, title, state license number, address, phone number and signature.

4. Well Design and Construction Details. (For multi-casing configurations or unusual construction provisions, an elevation drawing of the proposed well should be attached.)

   (a) Proposed total depth;

   (b) Proposed depth and type of casing(s);

   (c) Diameter of well;

   (d) Cement type, depth, thickness; and,

   (e) Injection pumps (if applicable): ______ gpm @ ______ psi

   Controls: ______

   ______

   ______

5. Water Supply Wells - When required by Rule 62-528.635(1), F.A.C., attach a map section showing the locations of all water supply wells within a one-half (1/2) mile radius of the proposed well. The well depths and casing depths should be included. When required by Rule 62-528.635(2), F.A.C., results of bacteriological examinations of water from all water supply wells within one-half (1/2) mile and drilled to approximate depth of proposed well should be attached.

6. Area of review (When required by Rule 62-528.300(4), F.A.C.)

   Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or well field area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

H. CLASS V WELL OPERATION PERMIT

(Final report of the construction that includes the following information may be submitted with the application to operate.)

1. Permit Number of Class V Construction Permit: ______

2. Owner's Name: ______

3. Type of Wells: ______

4. Construction and Testing Summary:

(a) Actual Dimensions:

Diameter (inches)	Well Depth (feet)	Casing Depth (feet)
______	______	______
______	______	______
______	______	______
______	______	______
______	______	______

(b) Result of Initial Testing

5. Proposed Operating Data:

(a) Injection Rate (GPM);

(b) Description of injected waste; and,

(c) Injection pressure and pump controls.

6. Proposed Monitoring Plan (if any):

(a) Number of monitoring wells;

(b) Depth(s);

(c) Parameters;

(d) Frequency of sampling; and,

(e) Instrumentation (if applicable) Flow ______________________

Pressure ______________________

I. CLASS V WELLS PLUGGING AND ABANDONMENT PERMIT

1. Permit number of Class V construction or operating permit.
2. Type of well.
3. Proposed plugging procedures, plans and specifications.
4. Reasons for abandonment.

J. MONITOR WELL PERMIT

This section should be used only when application is made for a monitor well only. If a monitor well is to be constructed under a Class I, III, or V injection well construction permit, it is necessary to fill in this section.

1. A site map showing the location of the proposed monitor wells for which a permit is sought. The map must be to scale and show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, water wells and other pertinent surface features including structures and roads.

2. Maps and cross sections indicating the general vertical and lateral limits within the area of review of all underground sources of drinking water, their position relative to the injection formation and the direction of water movement, where known, in each underground source of drinking water which may be affected by the proposed injection.

3. Maps and cross sections detailing the hydrology and geologic structures of the local area.

4. Generalized maps and cross sections illustrating the regional geologic setting.

5. Proposed formation testing program to obtain an anlysis of the chemical, physical and radiological characteristics of and other information on the monitor zone(s).

6. Proposed monitoring procedure.

7. Engineering drawings of the surface and subsurface construction details of the monitoring system.

8. Proposed monitoring data to be reported for meeting the monitoring requirements in Rule 62-528.425, F.A.C.

9. Construction procedures including a cementing and casing program, logging procedures, deviation checks, proposed methods for isolating drilling fluids from surficial aquifers, proposed blowout protection (if necessary), and a drilling, testing and coring program

10. Monitor Well Information:

☐ On-site ☐ Multizone ☐ Single-zone

☐ Regional ☐ Other (specify) ____________________________

Proposed Monitoring Interval(s) ____________________________

Distance and Direction From Associated Injection Well ____________________

____

South Florida Water Management District
P.O. Box 24682 * West Palm Beach, Fl. 33416-4682

CHECK NO. 0243371

PAYMENT VOUCHER	VENDOR INVOICE NO.	VOUCHER DATE	DESCRIPTION	AMOUNT
V5=01000681	23514	05-09-01	PERMIT APP OKEE PILOT	750.00
			TOTAL	750.00

SRC 011 (REV 12/98)

PLEASE DETACH AND RETAIN THIS STATEMENT BEFORE DEPOSITING THE CHECK

VERIFY THE AUTHENTICITY OF THIS MULTI-TONE SECURITY DOCUMENT. CHECK BACKGROUND AREA CHANGES COLOR GRADUALLY FROM TOP TO BOTTOM.

South Florida Water Management District

P.O.Box 24682 * West Palm Beach, FL. 33416-4682
(561) 686-8800 * WATTS 1-800-432-2045

63-202 / 670

CHECK NO. 0243371

SouthTrust Bank
Cape Coral, FL

PAY ONLY SEVEN 7 FIVE 5 ZERO 0 00 CTS CTS

DATE: 05-11-01

VOID AFTER 180 DAYS

PAY SEVEN HUNDRED FIFTY DOLLARS AND 00 CENTS **********

CHECK AMOUNT
********$750.00

TO THE ORDER OF
FL DEPT OF ENVIRON PROTECTION
400 N CONGRESS AVENUE
SE DISTRICT OFFICE
WEST PALM BEACH FL 33406

VOID OVER $750.00

⑈0243371⑈ ⑆067012028⑆ 64 052 631⑈

Supporting Information - Class V UIC Well Construction Permit Application

Exploratory Well near the S-77 Water Control Structure, Moore Haven, Florida

Lake Okeechobee Aquifer Storage and Recovery Pilot Project

Comprehensive Everglades Restoration Plan

Prepared By:

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33416

In Association With:

U.S. Army Corps of Engineers
Jacksonville District
Jacksonville, Florida

May 2001

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Executive Summary

The South Florida Water Management District (SFWMD) -- in association with the U.S. Army Corps of Engineers (USACE) -- is pleased to present this application for a Class V Underground Injection Control (UIC) exploratory well construction permit. The purpose of this application is to construct and test an exploratory well at the site of a proposed aquifer storage and recovery (ASR) facility associated with the Lake Okeechobee ASR Pilot Project – a component of the Comprehensive Everglades Restoration Plan (CERP). Pending the results of a source- and native-water quality characterization program, it is our intention to re-permit this exploratory well, in the future, as part of a functional ASR facility.

The site is located near the Town of Moore Haven, at the confluence of Lake Okeechobee and the Caloosahatchee River in eastern Glades County, Florida. In addition to the required permit application form (FDEP Form No. 62-528.900[1]), supporting information follows the format of *Item (G), Class V Well Construction Permit* as presented on the form. Supplementary information on regional and local hydrogeology, a construction and testing plan, and a plugging and abandonment plan is also provided herein.

Regional hydrogeologic data indicate that favorable conditions exist at the site for construction of ASR well(s) within the Floridan Aquifer System (FAS). Regional data indicates that upper portions of the FAS are brackish, with water quality containing a total dissolved solids (TDS) concentration ranging from 800 to 7,000 milligrams per liter (mg/L). The principal confining unit overlying the FAS is the Hawthorn Group, consisting of relatively impermeable clays that extend from approximately 120 to 800 feet below land surface (bls). These sediments impede upward migration of FAS water into the overlying Surficial Aquifer System (SAS), which extends from land surface to approximately 120 feet bls.

The exploratory well will be completed into permeable zones within the upper FAS. The proposed production zone extends from the base of the Hawthorn Group confining unit at approximately 800 feet bls to 1,600 feet bls. This zone has been correlated with formations of the upper FAS; namely, the Suwannee Limestone, Ocala Limestone, and Avon Park Formation. The actual production zone will be determined during the construction and testing of the exploratory well. The production zone – intended to serve as the future ASR interval -- will be based on several objectives and constraints including:

- Maximize the recharge and recovery pumping rates
- Maximize recovery efficiency
- Maximize upper confinement
- Maximize native water quality (e.g., interval with lower TDS)

- Minimize the depth of the well (i.e., higher costs with greater depth)

Some of these objectives are inter-related. For example, maximizing the recharge/recovery rate and maximizing the recovery efficiency are related. Upper confinement is preferred because it will tend to increase the recovery efficiency by preventing upward movement of stored water. The recovery efficiency is also related with the native water quality of the ASR interval. If the interval has a lower TDS concentration, then more water can be recovered before the water quality limit is achieved (resulting in higher recovery efficiency). The goal during the construction and testing of the exploratory/ASR well will be to evaluate each of these objectives, and install a cost-effective well that meets these objectives. Results from this and other exploratory/ASR wells will be used to refine the evaluation of future CERP ASR wells.

Introduction

The *Central and Southern Florida Project Comprehensive Review Study (Restudy, April 1999)* -- developed jointly by the South Florida Water Management District (SFWMD) and the U.S. Army Corps of Engineers (USACE) – presents a framework for Everglades restoration. Now known as the Comprehensive Everglades Restoration Plan (CERP), this plan contains 68 components, including structural and operational changes to the Central and Southern Florida Project (C&SF). One of these components is the Lake Okeechobee Aquifer Storage and Recovery (ASR) Project. At a planned buildout ASR capacity of 1 billion gallons per day (e.g., 200, 5-mgd wells), this component is designed to better manage Lake Okeechobee water levels, store water in ASR wells during wet periods and recover during dry periods, and minimize high-volume water releases to the St. Lucie and Caloosahatchee River estuaries.

Before initiating this large-scale ASR project, the CERP includes a Lake Okeechobee ASR Pilot Project. The purpose of the Lake Okeechobee ASR Pilot Project is to evaluate the technical and regulatory uncertainties of applying the ASR technology at the scale proposed in the CERP. The project concept is to store partially treated surface water from Lake Okeechobee and/or its tributaries into ASR wells completed into the underlying, confined, brackish Floridan Aquifer System (FAS) for subsequent recovery. Installation and testing of the exploratory/ASR well at Moore Haven – the subject of this permit application – is one of the first tasks to be completed for this project. Further details regarding the Lake Okeechobee ASR Pilot Project are contained in the Project Management Plan, available at the www.evergladesplan.org website.

The Lake Okeechobee ASR Pilot Project will be used to evaluate the effectiveness and limitations of ASR technology at the site. This information will be used to refine the long-term operational goals of these and other ASR wells around Lake Okeechobee, and provide insight for other ASR projects that may be constructed for similar purposes. Information to be collected and evaluated during construction and testing of the exploratory/ASR well includes:

- Lithologic and geophysical properties of potential storage intervals and confining layers
- Identification and evaluation of suitable ASR storage interval(s)
- Aquifer characteristics
- Limitations of recharge and recovery pumping rates
- Water quality of the upper FAS

Site Description

The site is located in the northwestern corner of Section 12, Township 42 South, Range 32 East, near the confluence of the Caloosahatchee River and Lake Okeechobee in the Town of Moore Haven, Florida. The site is located on a SFWMD-owned parcel of land adjacent to the S-77 spillway and lock, which conveys water to and from Lake Okeechobee's interior rim canal and the Caloosahatchee River. A location map for the site is presented in **Figure 1**. The proposed location of the exploratory well is shown in **Figure 2**.

The site was chosen based on several criteria considered important in the planning of an ASR system including:

- Land is publicly owned (i.e., no time consuming or costly land acquisition procedures required)
- Site will ultimately provide operational flexibility to recharge or recover water from the Caloosahatchee River and/or Lake Okeechobee
- Site location –coupled with the other exploratory/ASR wells – will provide a broader geographic understanding of subsurface hydrogeology (**Figure 1**)
- Regional hydrogeologic data confirms the confined nature of the FAS, and the strong potential of the existence of permeable zones conducive to ASR implementation
- Proximity of the site to Lake Okeechobee's littoral zone, known to have relatively good water quality (i.e., low suspended solids)
- Site is adjacent to a body of water (Caloosahatchee River) that has flow, considered critical to comply with mixing-zone requirements during well discharge as required by an NPDES permit

Pilot Facility Description

The completed Lake Okeechobee ASR Pilot Project is anticipated to consist of the following components:

- Up to five (5) ASR wells completed into the upper FAS, each with an anticipated capacity of 5 mgd.
- Surficial Aquifer System (SAS) and FAS monitor wells at each site
- Pre-discharge water treatment facility (for water recovered from the ASR wells before discharge to surface-water bodies).
- Piping between ASR wells and discharge points
- Surface facilities (e.g., pumps, valves, electrical, instrumentation, etc.) to operate and monitor the system.

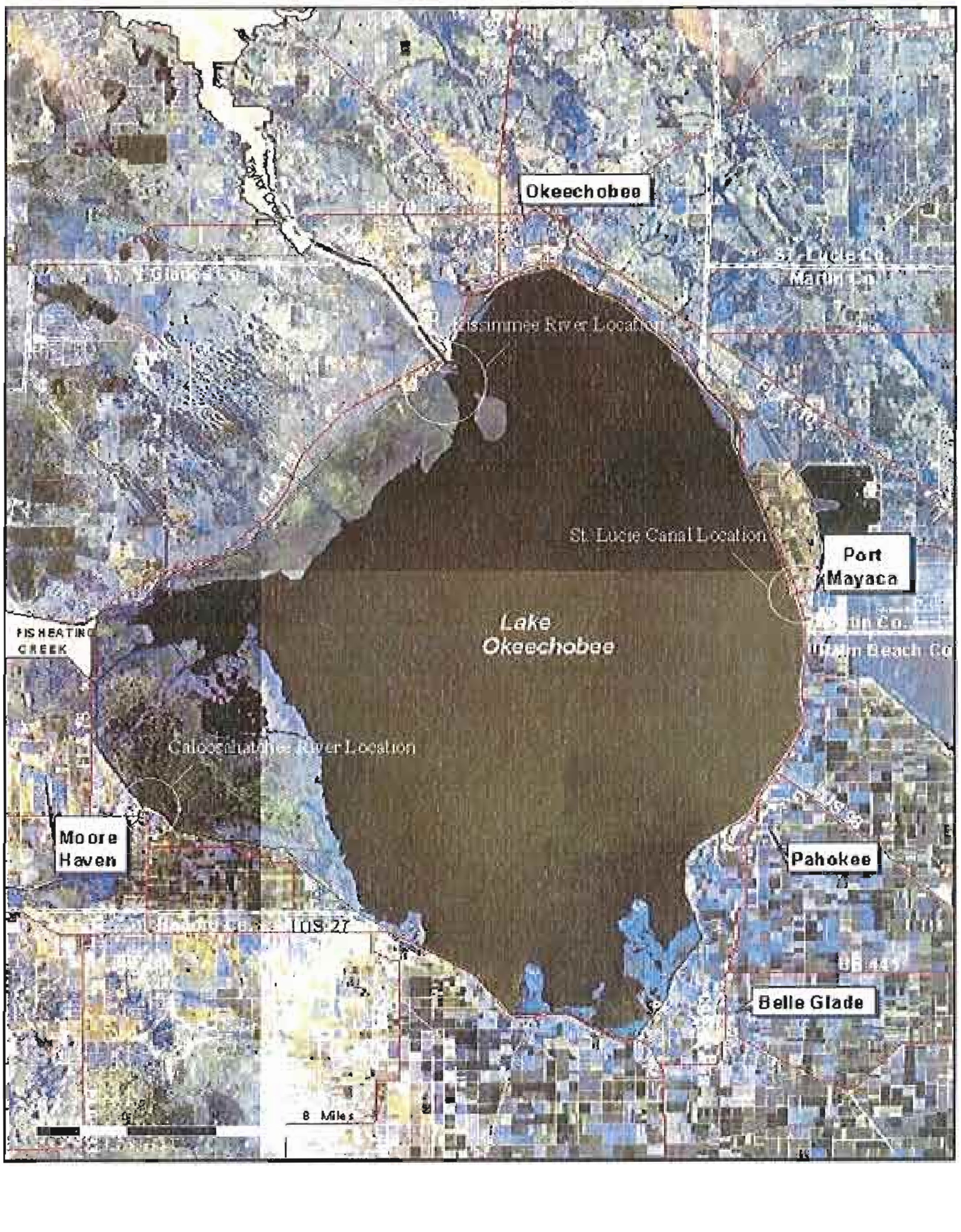
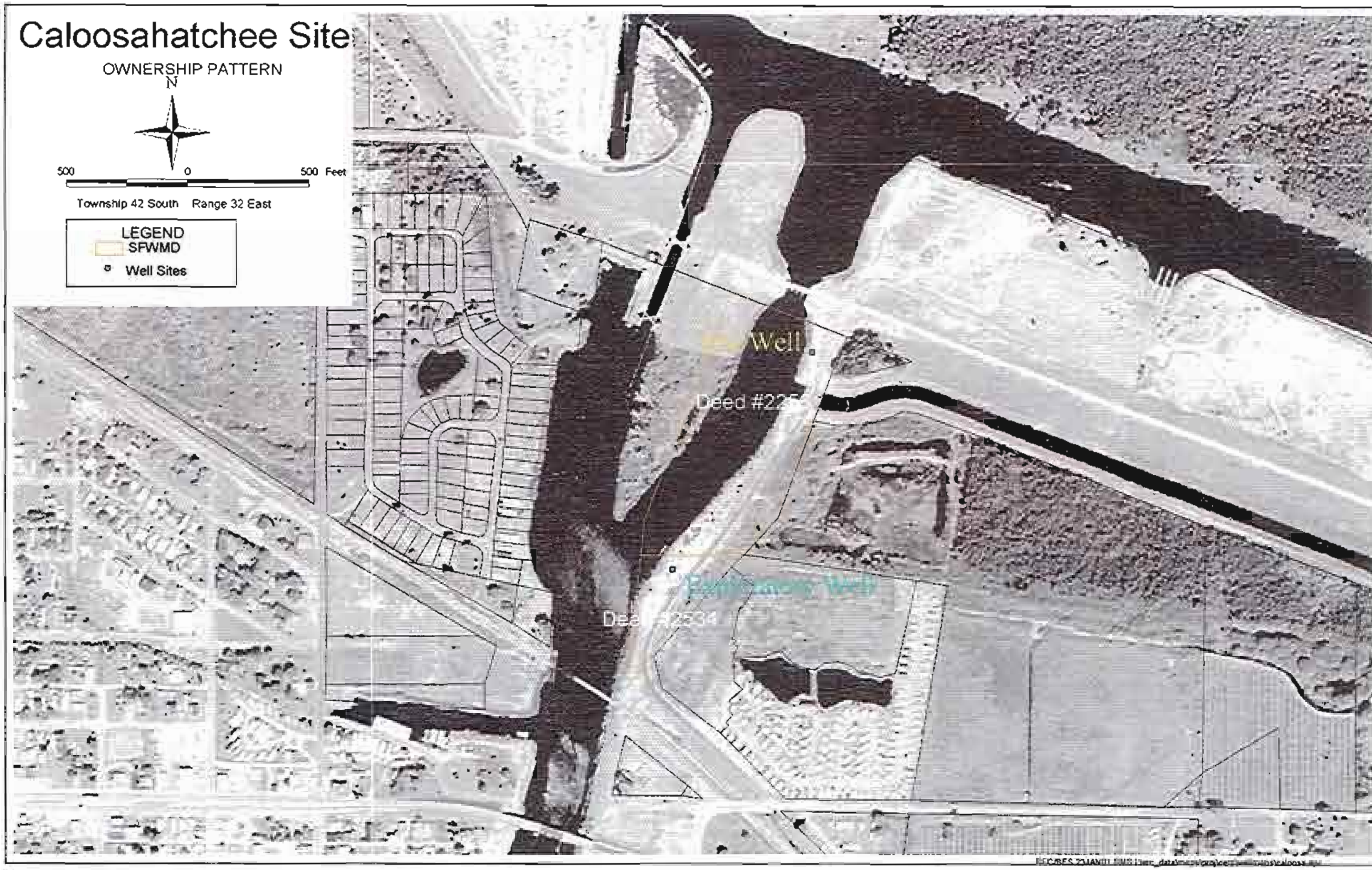


Figure 1. Location Map



Caloosahatchee Site
OWNERSHIP PATTERN
N
500
0
500 Feet
Township 42 South Range 32 East
LEGEND
SFWMD
Well Sites
Well

Engineering and Hydrologic Data Required for Support of Application to Construct, Operate, and Abandon Class I, III, or V Injection Well Systems

Item (G) Class V Well Construction Permit

(1) Type and number of proposed Class V Wells:

The proposed exploratory well is classified as a Class V, Group 8 well under Chapter 62-528 Florida Administrative Code (FAC). This application is for one exploratory well completed into the Floridan Aquifer System (FAS). No injection is planned for the exploratory well; however, in accordance with 62-528.603(5)(a) FAC, we request the right to conduct limited injection testing with partially treated surface water should temporary treatment systems be available. Please note that responses to *(2) Project Description* questions below describe the proposed Lake Okeechobee ASR Pilot Project and are provided for information purposes only.

(2) Project Description:

a. Description and use of proposed injection system:

The proposed Lake Okeechobee ASR Pilot Project as currently envisioned consists of up to five (5) ASR wells. This application is for the construction of one exploratory/ASR well near the Town of Moore Haven, Florida. The project concept is to store partially treated surface water from the Caloosahatchee River and/or Lake Okeechobee via ASR wells. The exploratory/ASR well will be completed into the brackish, FAS. A location map for the site is presented in **Figure 1**. The proposed location of the exploratory/ASR well is shown in **Figure 2**.

b. Nature and volume of injected fluid:

The injected fluid will be partially treated surface water from the Caloosahatchee River and/or Lake Okeechobee. The surface water is of generally high quality, with all primary drinking water standards (DWS) parameters expected to be met except coliform bacteria. A sampling and analysis plan will be implemented in the next few months to better characterize surface-water quality at the site. The current project conceptualization is that the proposed exploratory/ASR well will be designed to pump 5 million gallons per day (mgd; 3,500 gallon per minute [gpm]).

c. Proposed pretreatment.

Water quality data from the surface water bodies -- proposed as the source water for the ASR systems -- will be reviewed to evaluate the type of pretreatment facilities that may be required. It is envisioned that at least some filtration will be required to minimize the potential for plugging of the aquifer during recharge (injection) due to algae, floating or suspended solids. Pilot testing will be conducted to identify a cost-effective treatment technology that meets project objectives. Again, no long-term injection is planned for the exploratory well; however, in accordance with 62-

528.603(5)(a) FAC, we request the right to conduct limited injection testing for surface facility design purposes, with partially treated water should temporary treatment systems be available.

(3) Water well contractor's name, title, state license number, address, phone number and signature.

A water well contractor has not been selected at this time. During the permit review process, procurement procedures will be initiated to select a qualified, Florida-licensed water-well contractor experienced in the construction of large-diameter wells completed into the FAS. The contractor's name and requested information will be submitted to FDEP upon selection and contract execution. The contract notice-to-proceed will not be issued until the Class V exploratory well permit has been received.

(4) Well Design and Construction Details.

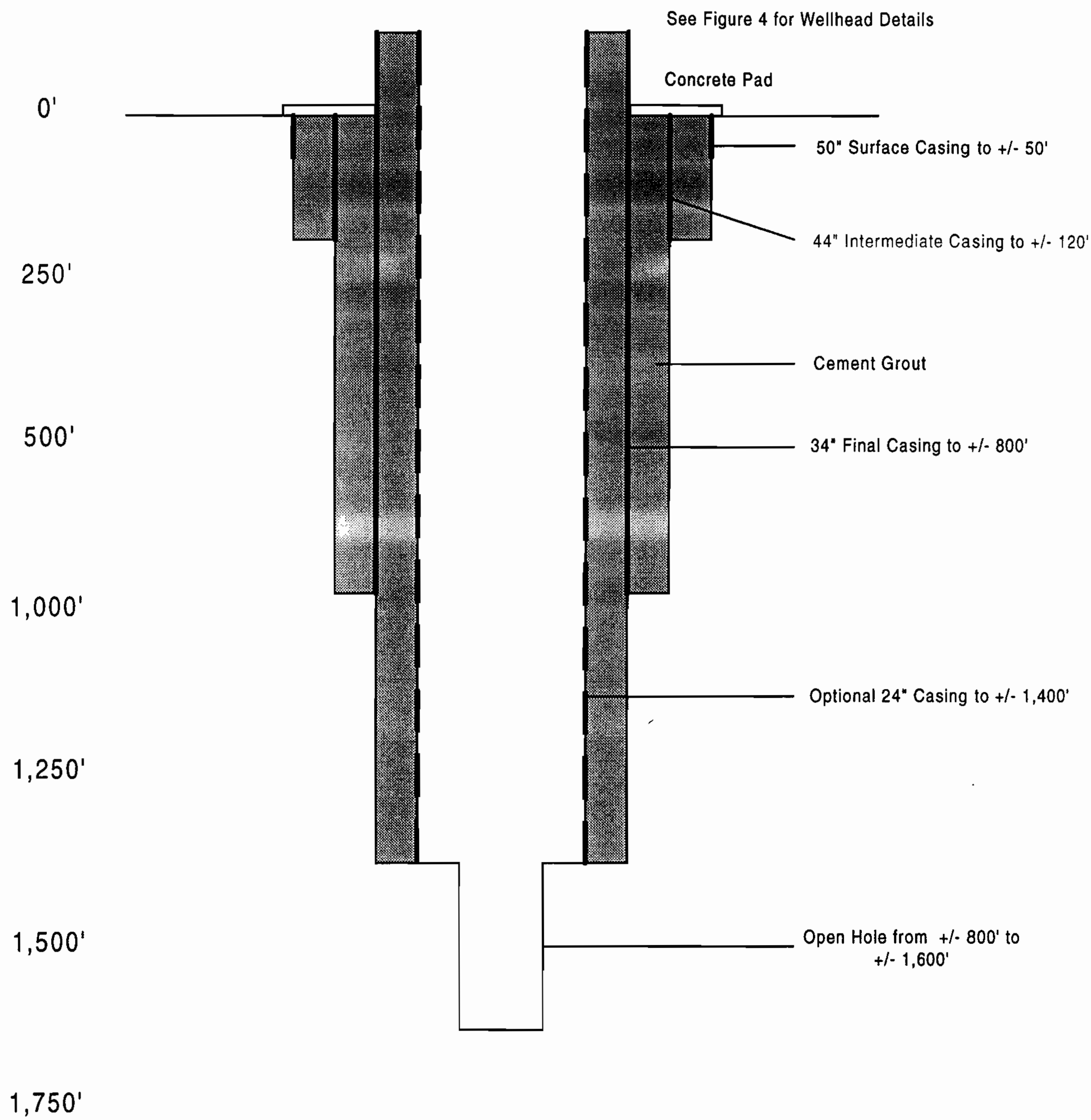
a. Proposed total depth:

The proposed total depth of the exploratory/ASR well is approximately 1,600 feet below land surface (bls). This depth may change based on field conditions, as well as on results of a test well program currently being implemented.

b. Proposed depth and type of casing(s):

The exploratory/ASR well will be constructed according to design and construction standards set forth in Chapter 62-528, FAC. The exploratory/ASR well will consist of concentric, steel casings (50-, 44-, 34-inch and 24-inch [optional] outside diameter) designed to isolate overlying aquifers and maintain confining unit integrity. Construction details of the exploratory/ASR well are provided in **Figure 3**, and a wellhead detail is provided in **Figure 4.** Except for the 50-inch surface casing, all casings will be fully cemented from bottom to land surface. The 44- and 34-inch casings will isolate the well from the SAS and from the overlying Hawthorn Group confining units. The 34-inch casing set to approximately 800 feet bls will isolate the upper FAS from the overlying Hawthorn Group confining units.

The casing diameters for the exploratory/ASR well are based on the flow characteristics of the proposed storage zone, and on the potential to drill, conduct geophysical logging, or perform other work inside the well. Based on the above specifications, a 34-inch-diameter, ½-inch wall thickness, seamless, carbon-steel casing was selected as the final casing for the ASR well. Note that if an additional casing within the FAS is required, provision has been made for a 24-inch-diameter casing as summarized in **Table 1** below.



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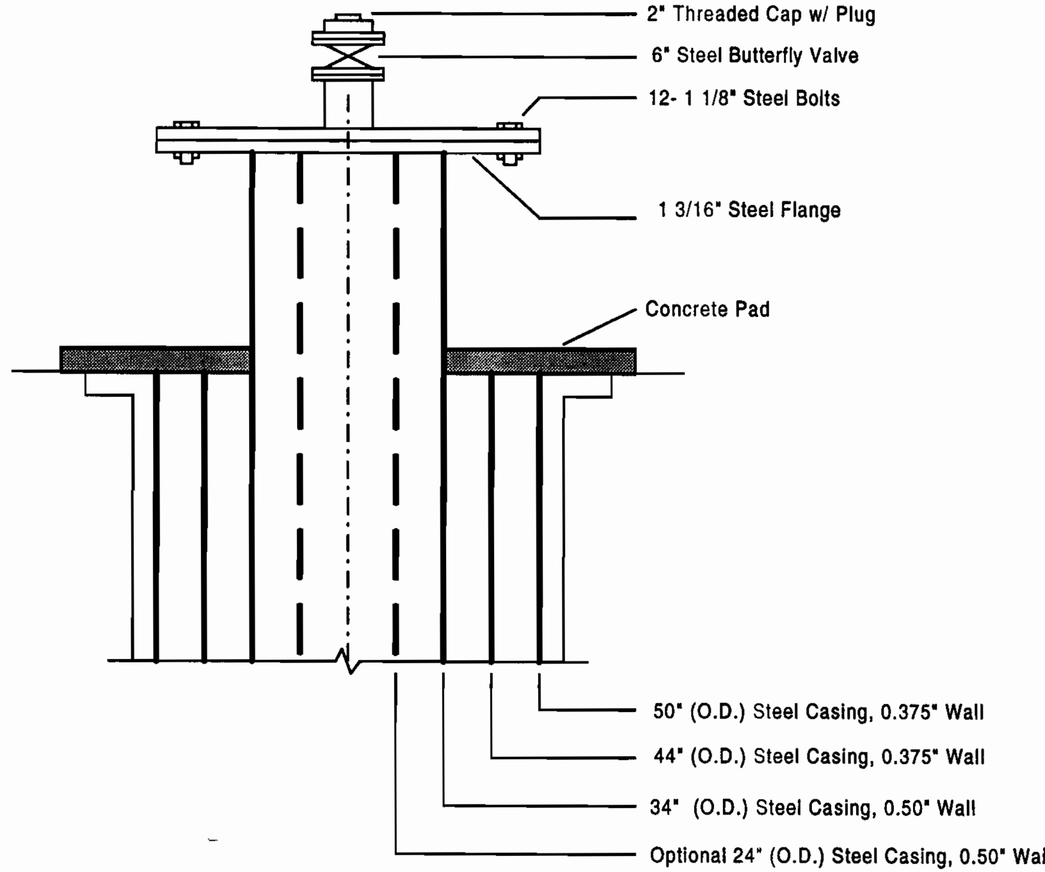
South Florida Water Managment District 3301 Gun Club Road West Palm Beach, Florida 33406	Town of Moore Haven Exploratory ASR Well	**Figure 3.** **ASR Well Diagram**



PAUL F LINTON

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South Florida Water Mamagement District 3301 Gun Club Road West Palm Beach, Florida 33406	Town of Moore Haven Exploratory ASR Well	**Figure 4.** **Wellhead Completion Drawing**

Table 1
Summary of Proposed Casing Specifications for the Exploratory/ASR Well

Nominal Diam. (inches)	I.D. (inches)	O.D. (inches)	Wall Thickness (inches)	Material	Depth (feet)	Comments
50	49.50	50	0.250	Carbon Steel	40	Surface Casing
44	43.25	44	0.375	Carbon Steel	120	Isolate Surficial Aquifer System
34	33.00	34	0.500	Carbon Steel	800	Isolate Hawthorn Group Confinement
24	23.00	24	0.500	Carbon Steel	1,400	Optional Final Casing

Notes:
I.D. = Inside Diameter
O.D. = Outside Diameter
Depths are approximate.

Several alternatives regarding casing material have been evaluated. First, for the anticipated depth (800 to 1,400 feet) and required diameter (34 to 24 inches) of the final casing, PVC's properties make it susceptible to rupturing due to the heat of hydration generated by cement curing. Second, budgetary constraints preclude use of the more expensive FRP or stainless steel casing options, especially in light of the non-corrosive nature of surface water at the site. Carbon-steel casing (with a 1/2-inch wall thickness) and a neat-cement sheath in the annulus around this casing are believed to provide adequate corrosion protection for this well. This design has been used successfully at many ASR and deep injection well sites in South Florida.

c. *Diameter of well:*

The proposed diameter of the final cemented casing is 33 inches (inside diameter [I.D.]/34 inches outside diameter [O.D.]). Should an additional casing be needed – based on results of an ongoing test well program -- provision is made in the design to install a 23-inch I.D./24-inch O.D. casing inside the 34-inch casing.

d. *Cement type, depth, and thickness:*

The casings will be cemented from bottom to top with Portland Type II neat cement with varying quantities of bentonite as an additive. The lower 200 feet of each casing, at a minimum, will be cemented with neat cement. Above this depth, a bentonite-cement slurry will be pumped from bottom to land surface. The percentage of bentonite additives will be determined in the field based on the properties of the formations encountered; however, the concentration of bentonite will not exceed 8-percent. The nominal cement thickness (annular space between the outside of the casing and the borehole wall) for the final casing string will be 5 inches. For further details, please see the attached well construction drawing (**Figure 3**).

e. Injection pumps (if applicable):______gpm @_______psi

Injection (recharge) and recovery pumps, piping, valves, flowmeters, pressure transducers, and other instrumentation will be a part of the permanent surface facilities of the proposed ASR system, though not part of the subject application for an exploratory/ASR well. In fact, installation and testing the exploratory/ASR well ahead of time will allow for more efficient surface-facility design given that the hydraulic characteristics of the storage zone will be known ahead of time. Upon completion of the construction and testing program, the wellhead will be sealed with a flanged coupling that will allow for later suppression of the artesian head and installation of the future ASR recovery pump and surface piping **(Figure 4).**

(5) Water Supply Wells

When required by Florida Administrative Code Rule 62-4.27, attach a map section showing the locations of all water supply wells within a one (1) mile radius of the proposed well. The well depths and casing diameters should be included. When required by Rule 62-4.27(2)(g), results of bacteriological examinations of water from all water supply wells within one (1) mile and drilled to approximate depth of proposed well should be attached.

Review of Water Use Permit files at the SFWMD, and the USGS and FGS well databases indicates that no public water supply wells exist within a one (1)-mile radius of the site.

(6) Area of Review (may be required at Department's discretion).

Include the proposed radius of the area of review with justification for that radius. Provide a map showing the location of the proposed injection well or wellfield area for which a permit is sought and the applicable area of review. Within the area of review, the map must show the number or name, and location of all producing wells, injection wells, abandoned wells, dry holes, surface bodies of water, springs, public water systems, mines (surface and subsurface), quarries, water wells, and other pertinent surface features including residences and roads. The map should also show faults, if known or suspected. Only information of public record and pertinent information known to the applicant is required to be included on this map.

A one-mile radius is considered appropriate for the area of review. This is justified by estimating the size of a hypothetical cylinder ("bubble") of fresh water that will be created within the upper FAS beneath the future ASR facility over time. This estimate uses a "plug flow" equation described in Warner and Lehr (1981). The equation variables are listed below:

- volume of injected water,
- aquifer porosity,
- storage-zone thickness, and

- aquifer dispersivity.

A scenario was conducted assuming a six-month period of injection at a rate of 5 mgd into a 100-foot-thick aquifer with an effective porosity of 25%. The equation yielded a radial distance (including the influence of dispersion) of 1,900 feet. A second scenario was conducted assuming continuous injection over a two-year period, and yielded a radial distance of 3,400 feet. The requested one-mile radius will conservatively encompass the computed cylinder sizes. As described in response to Item 5 above, no public water supply wells exist within a 1-mile radius of the site.

Figure 5 is a map showing cultural features and a more conservative two (2)-mile radius around the proposed exploratory well. A summary of wells located within the 2-mile radius is provided in **Table 2**. Two water use permit holders were identified within the subject area of review, but both use the surficial aquifer system for irrigation purposes only. The remaining wells are monitor wells, with four exceptions. One is the FAS test well currently under construction. Second and third are Wells W-5406 and W-5436, two test wells drilled by Coastal Petroleum. Fourth, an existing FAS test well was installed by SFWMD in themid-1990s to the upper FAS.

Supplementary Information

In addition to the information requested in *Item G., Class V Well Construction Permit* of the Permit Application Form, SFWMD has assembled additional information to assist the reviewer in evaluating the proposed exploratory/ASR well. This information includes a description of regional and local hydrogeology (Appendix A), a construction and testing plan (Appendix B), and a plugging and abandonment plan (Appendix C).

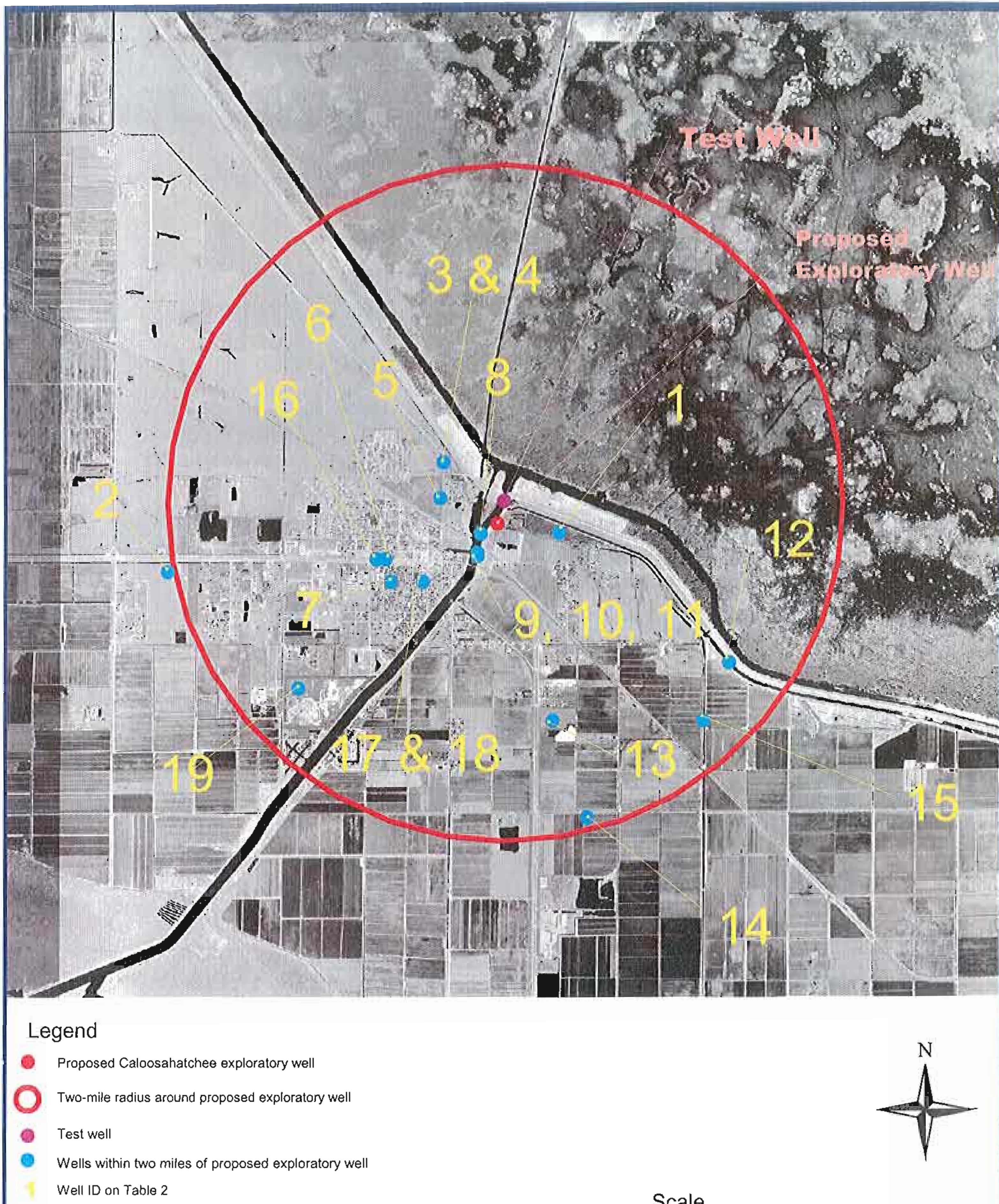


Figure 5. Wells within a two-mile radius of the proposed exploratory well.

Table 2. Wells within two miles of the proposed Caloosahatchee ASR exploratory well.

Well #	Well Name	Owner	Well Use	Permit Number	Latitude	Longitude	X	Y
1	ALVIN WARD BOAT RAMP FACILITY	ALVIN WARD BOAT RAMP FACILITY	Potable water use*	22-00220-W	265008	810450	629982	909556
2	J.J. WIGGINS YOUTH CENTER	J.J. WIGGINS YOUTH CENTER	Irrigation	22-00229-W	264956	810705	617741	908330
3	GL - 212	City of Moore Haven	Monitoring	NA	265030	810530	626345.0654	911750.9661
4	GL - 212A	City of Moore Haven	Monitoring	NA	265030	810530	626345.0654	911750.9661
5	GL - 213	USGS Monitoring Well	Monitoring	NA	265019	810531	626253.6818	910640.3869
6	GL - 2	USGS Monitoring Well	Monitoring	NA	265000	810550	624531.1793	908723.2863
7	GS - 28	USGS Monitoring Well	Monitoring	NA	264953	810548	624711.8102	908016.3744
8	GL - 209	USGS Monitoring Well	Monitoring	NA	265008	810517	627521.039	909528.8415
9	WATER PLANT HOOVE HAVEN	USGS Monitoring Well	Monitoring	NA	265001	810518	627429.9636	908822.1312
10	PUBLIC SUPPLY MOORE HAVEN	USGS Monitoring Well	Monitoring	NA	265002	810518	627430.034	908923.0988
11	WELL AT MOORE HAVEN FL	USGS Monitoring Well	Monitoring	NA	265002	810518	627430.034	908923.0988
12	GL - 221	USGS Monitoring Well	Monitoring	NA	264928	810351	635309.1348	905485.4588
13	S -1224	USGS Monitoring Well	Monitoring	NA	264910	810452	629781.8695	903671.2137
14	S -1225	USGS Monitoring Well	Monitoring	NA	264840	810440	630867.1628	900641.5125
15	W-5406	Coastal Petroleum (MH#3)	NA	NA	264910	810400	634492.853	903668.467
16	W-5436	Coastal Petroleum (MH#13)	NA	NA	265000	810553	624259.425	908723.496
17	W-12355	City of Moore Haven	Monitoring	NA	264953	810537	625708.26	908015.626
18	W-12373	City of Moore Haven	Monitoring	NA	264953	810537	625708.26	908015.626
19	W-17091/MH-1	South Florida Water Management District	Monitoring	NA	264920	810620	621810.274	904686.758

*Potable water use for restroom facility at boat ramp.
NA - Not available

Well #	Well Name	Total Depth (ft)	Cased Depth (ft)	Diameter (in)	Aquifer	Pump Type	Intake Depth (ft)	Database
1	ALVIN WARD BOAT RAMP FACILITY	40.00	25.00	NA	Surficial Aquifer System	NA	Pump	SFWMD
2	J.J. WIGGINS YOUTH CENTER	100.00	70.00	NA	Surficial Aquifer System	NA	Pump	SFWMD
3	GL - 212	85	NA	6	Surficial Aquifer System	NA	NA	USGS
4	GL - 212A	85	NA	6	Surficial Aquifer System	NA	NA	USGS
5	GL - 213	NA	NA	NA	NA	NA	NA	USGS
6	GL - 2	NA	NA	NA	NA	NA	NA	USGS
7	GS - 28	NA	NA	NA	NA	NA	NA	USGS
8	GL - 209	NA	NA	NA	NA	NA	NA	USGS
9	WATER PLANT HOOVE HAVEN	NA	NA	NA	NA	NA	NA	USGS
10	PUBLIC SUPPLY MOORE HAVEN	NA	NA	NA	NA	NA	NA	USGS
11	WELL AT MOORE HAVEN FL	NA	NA	NA	NA	NA	NA	USGS
12	GL - 221	NA	NA	NA	NA	NA	NA	USGS
13	S -1224	NA	NA	NA	NA	NA	NA	USGS
14	S -1225	NA	NA	NA	NA	NA	NA	USGS
15	W-5406	1000	NA	NA	Floridan Aquifer	NA	NA	FGS
16	W-5436	1010	NA	NA	Floridan Aquifer	NA	NA	FGS
17	W-12355	106	NA	NA	Surficial Aquifer System	NA	NA	FGS
18	W-12373	106	NA	NA	Surficial Aquifer System	NA	NA	FGS
19	W-17091/MH-1	710	660.00	4	Floridan Aquifer	NA	NA	FGS

*Potable water use for restroom facility at boat ramp.
NA - Not available.

Appendix A

GEOLOGY and HYDROGEOLOGY

Regional Geology

South Florida is underlain by Cenozoic-age rocks to a depth of approximately 5,000 feet below land surface (bls) -- comprised primarily of sand, limestone, clay and dolomite (Meyer, 1989). Within this province, Lake Okeechobee lies in a relatively stable structural area, represented by generally flat-lying sediments that accumulated in a quiet marginal-marine setting, similar to the modern-day Bahamas. Numerous wells have been constructed and tested to depths of up to approximately 3,500 feet bls in the general vicinity of the Lake, providing an accurate representation of the geology and hydrogeology of the area.

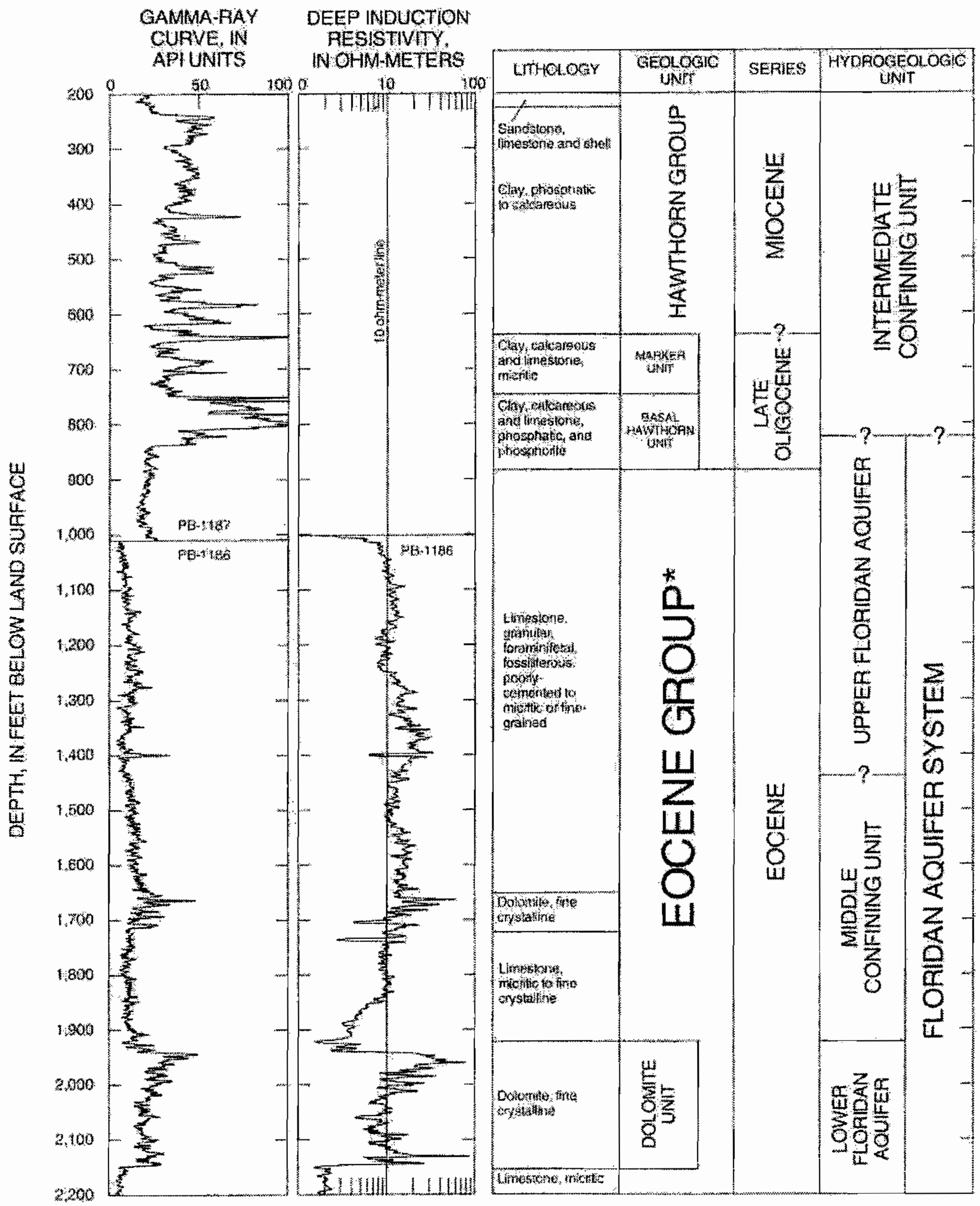
Soils and Plio-Pleistocene Series

From land surface to a depth of up to 10 feet bls, soils in the northern vicinity of the Lake are characterized as poorly drained, sandy "spodosols", currently used for pastures, citrus, and urban development. To the south of the Lake are organic-rich mucky soils underlain by marl, referred to as "histosols". These soils are currently used for sugar cane, sod and pasture.

Below the surficial soils, Plio-Pleistocene-aged sand, sandstone, clay and shells are present to a depth of approximately 200 feet bls. These sediments are representative of the Caloosahatchee, Tamiami, and the Fort Thompson Formations. These formations were deposited from between one to five million years ago.

Miocene Series

The Plio-Pleistocene sediments unconformably overly the dense, phosphatic clays and limey silts of the Miocene-aged Hawthorn Group. The Hawthorn Group sediments are encountered between 200 and 900 feet bls. **Figure A-1** presents a summary of the lithology penetrated from an injection well at the nearby City of Belle Glade wastewater treatment plant as presented in Reese and Memberg, (2000). Near the base of the Hawthorn Group, the limestone and phosphate content of these sediments increase, causing the gamma ray log to record high counts through this interval. This has resulted in the creation of distinctive "marker beds" that are geophysically correlatable throughout the vicinity of the Lake.



EXPLANATION

API — AMERICAN PETROLEUM INSTITUTE STANDARD UNITS

? — BOUNDARY BETWEEN HYDROGEOLOGIC UNITS UNCERTAIN

* The Eocene group as informally defined in this report includes the Suwannee Limestone, Ocala Limestone, Avon Park Formation, and Oklsmar Formation. The Suwannee Limestone is interpreted to be present only in the far western portion of the study area.

Source: Reese, R.S. and Memberg, S.J. 2000. Hydrogeology and the Distribution of Salinity in the Floridan Aquifer System, Palm Beach County, Florida. United States Geological Survey Water Resources Investigations Report 99-4061.

Figure A-1. Hydrogeologic Data from the City of Belle Glade Injection Well.

Oligocene Series

Lying below the Hawthorn Group sediments is the Suwannee Limestone of Oligocene age. It is described by Johnson (1984) as a "white to tan, pure to slightly argillaceous and arenaceous, coquinoid to chalky limestone, with some dolostone and dolomitic limestone present." It is regionally extensive and can attain a thickness ranging from 120 to 300 feet in south Florida (Miller, 1986). A phosphatic zone in the lower portion of this formation shows high natural radioactivity on a gamma log.

Eocene Series

Lying below the Suwannee Limestone at a depth of approximately 800 feet bls are the Eocene-aged Ocala Limestone and Avon Park Limestone. For purposes of this discussion, these formations are undifferentiated, although the Ocala Limestone is typically recognized as present within the uppermost 200 feet of the combined section. These formations are characterized by pale orange to brown-colored, poorly cemented granular limestone. The formations are also occasionally micritic and contain dolomite zones. The fossil content is not significant, although foraminifera and red algae debris is commonly observed. These formations are present to a depth of approximately 1,900 feet bls.

Lying below the Ocala and Avon Park Formations is the Oldsmar Formation. This formation contains significant quantities of hard, yellowish-brown finely crystalline dolomite. This formation is present to depths of nearly 3,500 feet bls.

Regional Hydrogeology

The hydrogeology in most of South Florida consists of a non-artesian shallow aquifer separated from a deeper artesian aquifer by several hundred feet of confining strata. The non-artesian shallow aquifer, generally known as the Surficial Aquifer System (SAS), is approximately 120 feet thick at the site. According to Klein and others (1964), "the shallow sediments in Glades County generally have low to moderate permeability. Thus, most large capacity wells penetrate the Floridan aquifer even though the quality of the water is usually poorer." The Pliocene Tamiami Formation generally forms the base of the SAS.

An Intermediate Confining System underlies the SAS, and is comprised of Hawthorn Group sediments. Confinement is provided by clays and marls that exhibit very low permeabilities, and isolate the SAS from the underlying Floridan Aquifer System (FAS). These Miocene-age confining beds are expected to occur at the site between approximately 120 and 800 feet below land surface (bls).
The FAS can generally be subdivided into several permeable zones, separated by low-permeability limestones. It is composed of limestone and dolostone beds generally dipping to the east and south, and contains brackish to saline water. The

permeable zones within the FAS are regionally grouped into upper and lower units, separated by a middle confining unit. These units are informally designated "upper Floridan Aquifer", "middle Confining Unit", and "lower Floridan Aquifer". The ASR storage interval will be in the upper Floridan Aquifer, based on existing information.

Upper Floridan Aquifer

The upper Floridan Aquifer consists of Oligocene to middle-Eocene formations, including the Suwannee (where present) and Ocala Limestones and the Avon Park Formation. Two predominant permeable zones exist within the upper Floridan Aquifer. The uppermost permeable zone typically lies between 700 and 1,200 feet bls. The most transmissive part of this upper permeable zone usually occurs near the top, coincident with an unconformity at the top of Eocene formations. A second permeable interval has been documented within the Avon Park Formation, ranging in approximate depth from 1,400 to 1,800 feet bls. The base of the upper Floridan Aquifer is located within the Avon Park Formation.

The transmissivity of the upper portions of the FAS in South Florida ranges from about 75,000 to 450,000 gallons per day per foot (gpd/ft; Bush and Johnston, 1988). Some of this variability may be due to variation in the thickness of the interval tested, as well as varying hydraulic properties. Bush and Johnston (1988) provide a range for the storage coefficient for the upper Floridan Aquifer from 1.0×10^{-5} to 2.0×10^{-2}, with the most common values in the range of 10^{-3} to 10^{-4}.

Middle Floridan Aquifer Confining Unit

Upper portions of the Oldsmar Formation and lower portions of the Avon Park Formation (Lake City Limestone) may be considered part of the confining interval between the upper and lower portions of the FAS. This confining sequence -- referred to as the middle Confining Unit -- is expected to occur between 1,800 and 2,100 feet bls. Miller (1986) reports that few differences exist in the lithologies between the middle Confining Unit and the permeable units above and below.

Lower Floridan Aquifer

The lower Floridan Aquifer may also contain several permeable and less permeable zones. Three dolostone layers have been identified by Meyer (1989) within the Oldsmar Formation separated by less permeable limestone layers. Meyer (1989) reported hydraulic connection between the lower and intermediate dolostone layers, but a weak connection between the upper and intermediate layers. The lowest permeable zone is a solution-worked fracture and cavernous interval that occurs in the Oldsmar Formation, and is also known as the "Boulder Zone". The Boulder Zone typically occurs at an estimated depth of 2,500 feet bls, extending to an approximate depth of 3,500 feet bls.

Local Geology and Hydrogeology

A location map of FAS wells used to construct hydrogeologic cross sections is provided as **Figures A-2**. These hydrogeologic cross sections are presented in **Figure A-3** (south to north) and **Figure A-4** (west-to-east), respectively.

Figures A-3 and **A-4** indicate that the regional hydrogeologic formations described above are present beneath the site, and are relatively flat and undisturbed. In general, the top of the FAS follows regional dip of the formations from north to south– a common observation in South Florida. A large gamma peak (interpreted to be the base of the Hawthorn Group) appears to become deeper in the Moore Haven area, but is progressively shallower away from the site.

Location Map of Wells For Hydrogeologic Cross-Section

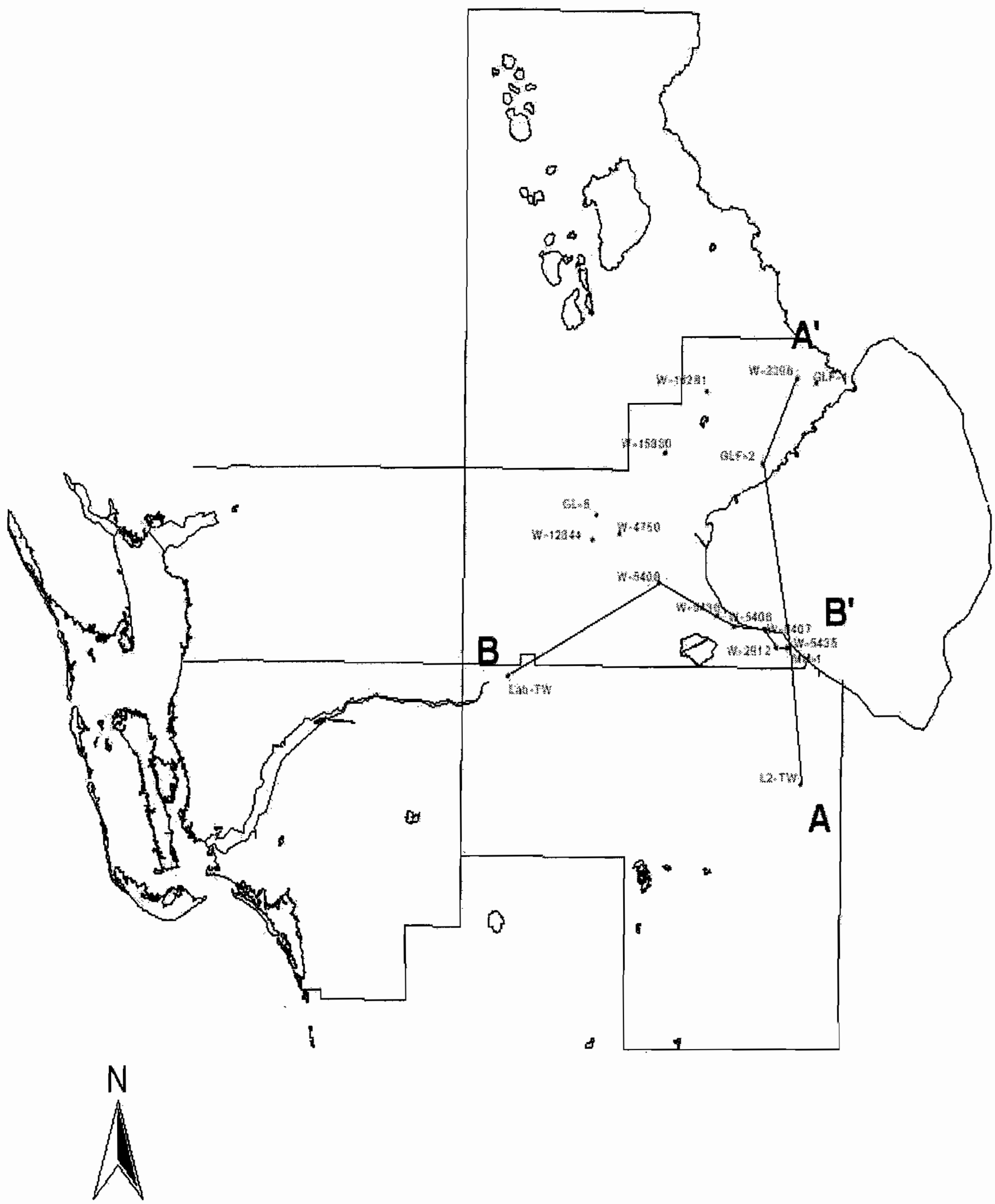
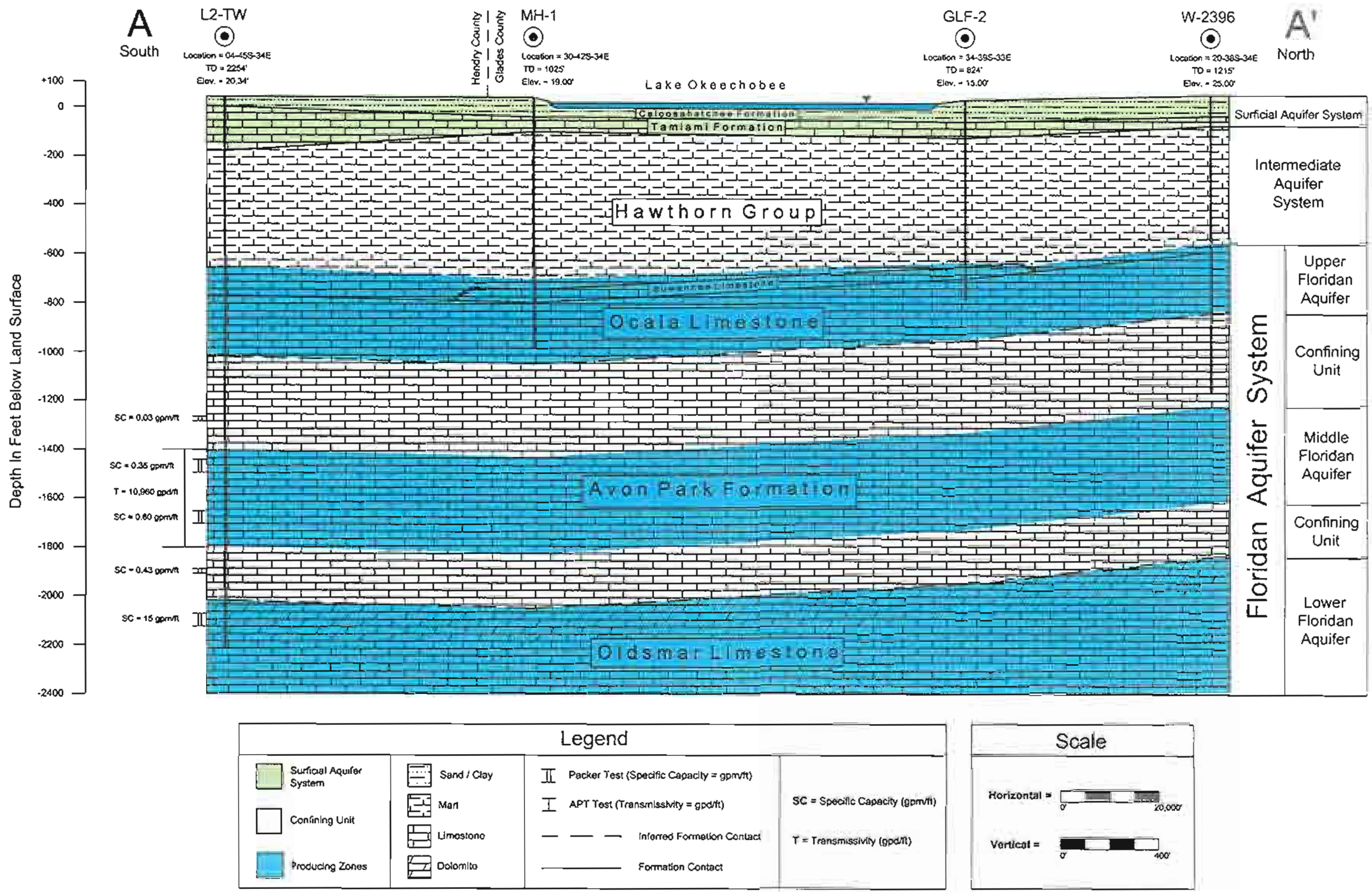
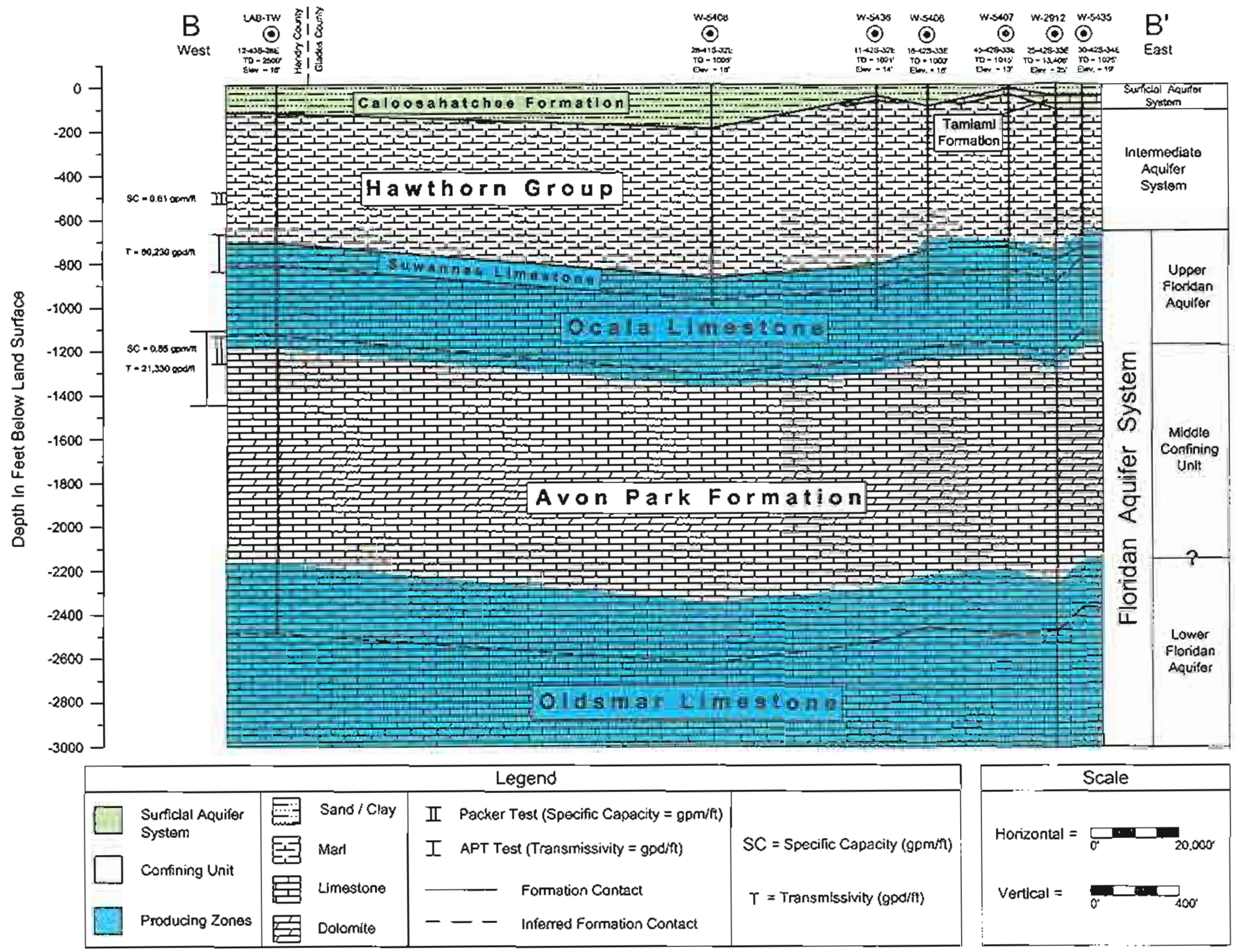


Figure A-2. Location Map showing Wells Used to Develop Hydrogeologic Cross Sections

Hydrogeologic Cross-section from A-A' for Construction of ASR Wells



Hydrogeologic Cross-section from B-B' for Construction of ASR Wells



The SAS extends from land surface to an approximate depth of 120 feet bls. The Hawthorn Group confining unit extends from 120 to 800 feet bls at the site. The upper Floridan aquifer appears to extend from 800 to 1,800 feet bls. The Middle Confining Unit is estimated to extend from 1,800 to 2,100 feet bls. The Lower Floridan aquifer was not penetrated by any of the wells used to develop the cross sections.

Water Quality in the Upper Floridan Aquifer System

Wells penetrating the upper Floridan aquifer (near a depth of 800 feet bls) in the vicinity of the Lake have yielded information regarding the quality of water contained within the strata. Most wells produce water containing a chloride concentration of between 500 milligrams per liter (mg/L) and 2,000 mg/L. The total dissolved solids (TDS) concentration ranges between 500 and 7,000 mg/L. **Figure A-5** is map indicating TDS concentrations of select FAS wells near the Lake. Hardness and sulfate concentrations, respectively are approximately 180 mg/L and 250 mg/L (SFWMD, 1984).

Wells completed near the base of the upper Floridan aquifer produce water with a chloride concentration of approximately 2,000 to 5,000 mg/L and a TDS concentration of approximately 4,000 to 8,000 mg/L. The base of the Underground Source of Drinking Water (USDW) -- as defined by FDEP as an aquifer with a TDS concentration of less than 10,000 mg/L -- is estimated to range from 1,900 to 2,100 feet bls, based on data from the L-2 Canal FAS monitor well (L2-TW; *SFWMD Lower West Coast Water Supply Plan, April 2000*). Below this depth, the water quality (within the lower Floridan aquifer at a depth of 2,070 feet bls) is very similar in composition to seawater.

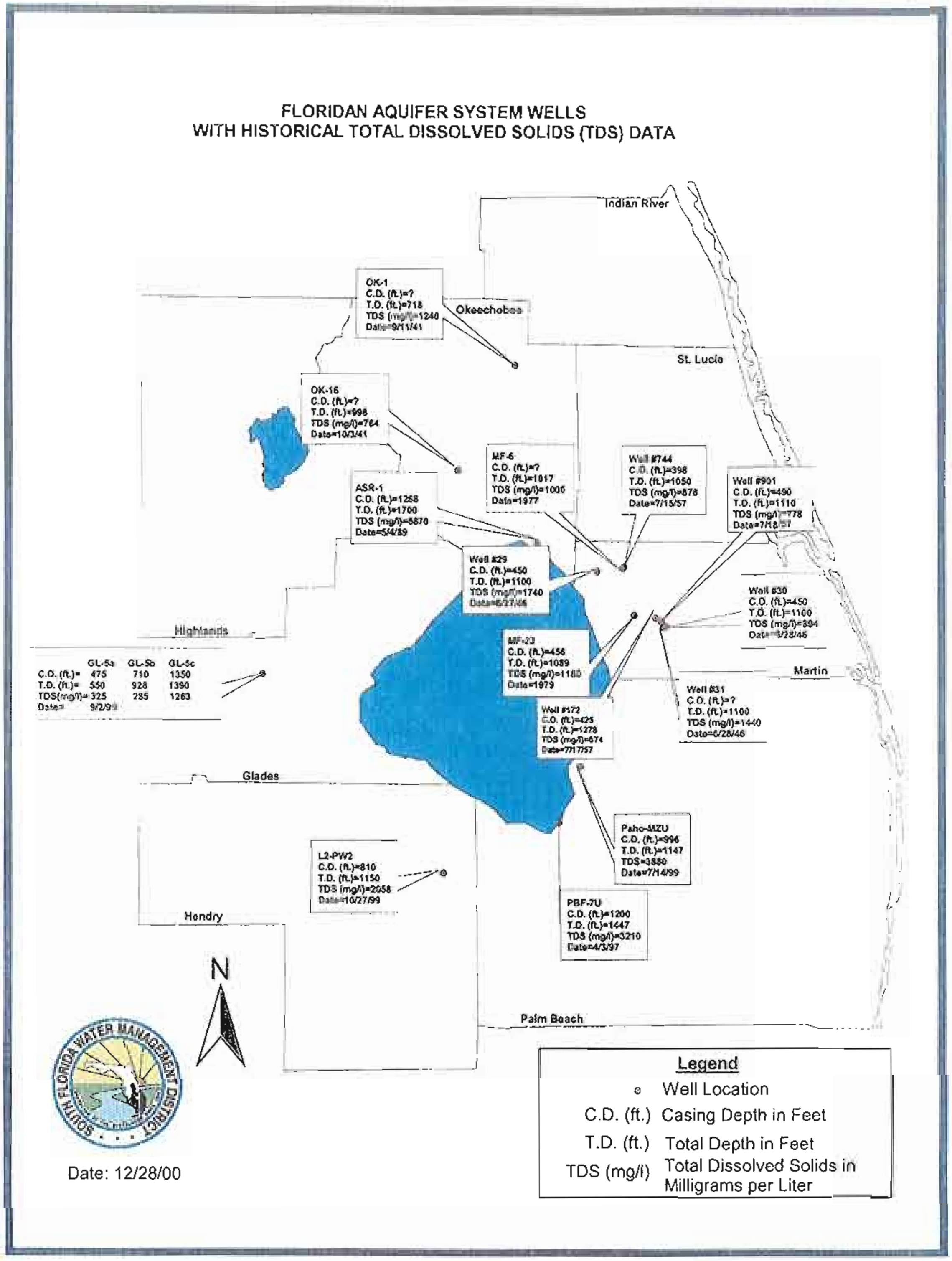


Figure A-5 Historical Water Quality Data From Select Floridan Aquifer System Wells Near Lake Okeechobee

Construction and Testing Plan

General

The exploratory/ASR well will be constructed by advancing the borehole with a pilot hole, conducting geophysical logging, reaming the pilot hole, installing casing, and progressing until total depth of the well is reached. Testing will occur throughout the drilling process, as summarized in **Table B-1**.

Table B-1 – Summary of Testing During Exploratory/ASR Well Construction

Test/Log/Sample	Description
Formation Samples:	
Cuttings	Pilot hole, every 5 feet
Conventional Cores	Collected from the Floridan Aquifer (and Hawthorn Group or Surficial Aquifer, if warranted)
Geophysical Logs:	
Caliper	Pilot and reamed boreholes, cementing, APT
Natural gamma	Pilot and reamed holes, cementing, APT
Spectral gamma	Pilot hole
Spontaneous potential	Pilot hole
Fluid resistivity	Pilot hole, APT
Temperature	Pilot holes, cementing, APT
Borehole-Compensated Sonic	Pilot holes
Dual induction	Pilot holes
Compensated-Density Neutron	Pilot holes
Cement bond	Final casing
Digital Borehole Televiewer	Pilot hole
Video	Pilot hole and Final well
Flowmeter	Pilot hole and/or during specific capacity test or APT
Pumping Tests:	
Packer tests	Zones within the Floridan Aquifer (and Hawthorn Group, if warranted)
Specific capacity tests	Yield of the ASR storage zone
APT	Characteristics of the ASR storage/monitor zone
Water Quality Sampling:	
During drilling	Sample during reverse-air drilling (if conducted)
Packer tests	Major ions and TDS for each interval
Storage zone	Background analysis of ASR zone (see **Table B-3**)
Mechanical Integrity Test:	
Casing pressure test	Test mechanical integrity of the well's final casing
Note: APT = Aquifer Performance Test	

Sequence

The proposed sequence for the drilling and testing program for the exploratory/ASR well is described below.

1. Install temporary, lined pad around well site prior to drill rig set up in accordance with Section *Temporary Drilling Pad.* Install pad monitor wells (PMWs) at four corners of pad. SFWMD staff to sample PMWs weekly during construction and analyze for specific conductivity, chlorides, and temperature. Set up drill rig, shale shaker, aboveground tanks, and appurtenances in accordance with Section *Drilling Procedures.*

2. Install by driving, drilling, or vibrating a minimum 50-inch-diameter surface casing to an approximate depth of 40 feet below land surface (bls); cement the annulus back to land surface if drilled.

3. Drill a 9-7/8-inch-diameter pilot hole with mud circulation to a depth of approximately 120 feet bls (the base of the Surficial Aquifer System). Conduct geophysical logging in accordance with Section *Geophysical Logging Program* and Table B-1, Schedule of Geophysical Logs).

4. Ream pilot hole to a nominal 50 inches, conduct caliper/gamma log, and install 44-inch-diameter steel casing to a depth of approximately 120 feet bls. Cement casing annulus to land surface in stages (primary stage with pressure-grout techniques) in accordance with Section *Casing Grout Program.*

5. Install and maintain blowout preventer (BOP). Resume drilling the 9-7/8-inch-diameter pilot hole with mud circulation from 120 to 800 feet bls. Conduct deviation surveys at 90-foot intervals during pilot- and reamed-hole drilling. Conduct pilot-hole logging in accordance with Section *Geophysical Logging Program.*

6. Ream pilot hole to a nominal 44 inches, conduct caliper/gamma log, and install 34-inch-diameter carbon steel casing to a depth of approximately 800 feet bls. Cement the casing annulus to land surface in stages (primary stage with pressure-grout techniques). Conduct temperature and gamma logs within casing to track height achieved by each stage of cement.

7. Install temporary, inflatable packer if necessary (or use cement plug at base of casing) to conduct 1-hour casing pressure test at approximately 100 psi for mechanical integrity testing of 34-inch casing in accordance with Section *Mechanical Integrity Testing.* Remove packer when complete.

8. Install and maintain blowout preventer (BOP). Resume drilling the 9-7/8-inch-diameter pilot hole with reverse-air circulation from 800 to 1,600 feet bls. Conduct deviation surveys at 90-foot intervals during pilot- and reamed-hole drilling. Conduct geophysical logging on borehole in accordance with Section *Geophysical Logging Program.*

9. Ream pilot hole to a nominal 34 inches in stages and conduct interval tests in accordance with Section *Interval Tests*.

10. If necessary, install 24-inch-diameter carbon steel casing to a depth of approximately 1,400 feet bls. Temporarily back-fill borehole with 3/8-inch diameter crushed limestone. Cement the casing annulus to land surface in stages (primary stage with pressure-grout techniques). Conduct temperature and gamma logs within casing to track height achieved by each stage of cement.

11. If Item 10 (24-inch casing) is installed, install temporary, inflatable packer if necessary (or use cement plug at base of casing) to conduct 1-hour casing pressure test at approximately 100 psi for mechanical integrity testing of final (24-inch) casing in accordance with Section *Mechanical Integrity Testing*. Remove packer when complete.

12. Conduct preliminary specific capacity tests at approximately three (3) pumping rates (2,000, 3,500 and 4,000 gpm) in accordance with Section *Specific Capacity Test*. Measure water levels in well for each pumping rate.

13. Conduct acidization of the open borehole (if necessary) with up to 5,000 gallons of hydrochloric acid in accordance with Section *Acidization*.

14. Conduct long-term (72-hour) aquifer performance test (APT) of the exploratory/ASR well, measuring background, drawdown, and water level recovery data in accordance with Section *Aquifer Performance Test*. Obtain background water quality samples in accordance with Section *Water Quality Testing*.

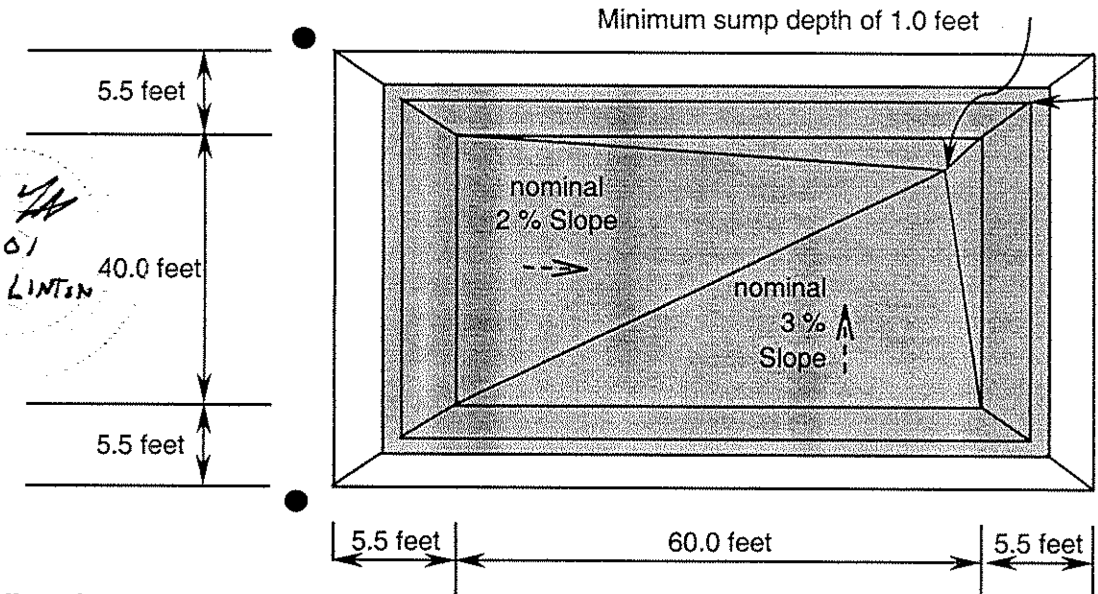
15. Conduct cement-bond log and video survey of completed well.

16. Complete wellhead, remove temporary pad, clean site, and demobilize.

Temporary Drilling Pad

A high-density polyethylene (HDPE)-lined membrane with bermed sides will be set up at the exploratory/ASR well site to contain drilling fluids that might leave the temporary mud tank. **Figure B-1** presents the design of the temporary drilling pad. This containment design has been successfully used in the construction of other FAS wells by SFWMD.

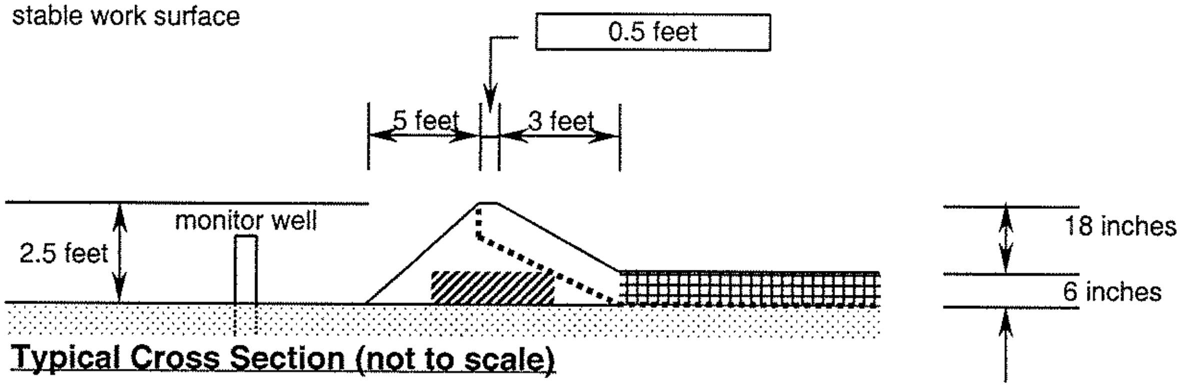
We propose to install four (4) pad monitor wells (PMWs) and that they be placed at the corners of the temporary drilling pads prior to construction of the exploratory/ASR well. **Figure B-2** is a proposed construction detail for a typical PMW. We propose to sample the PMWs weekly during exploratory/ASR well construction and analyze for chlorides, conductivity, and temperature. After well construction is complete, we propose to abandon these PMWs by placing neat cement grout from the well's total depth to land surface.



P.F.L.
5/18/01
PAUL F. LINTON

Plan View (not to scale)

Compact all placed or disturbed fill as required to achieve a stable work surface



Typical Cross Section (not to scale)

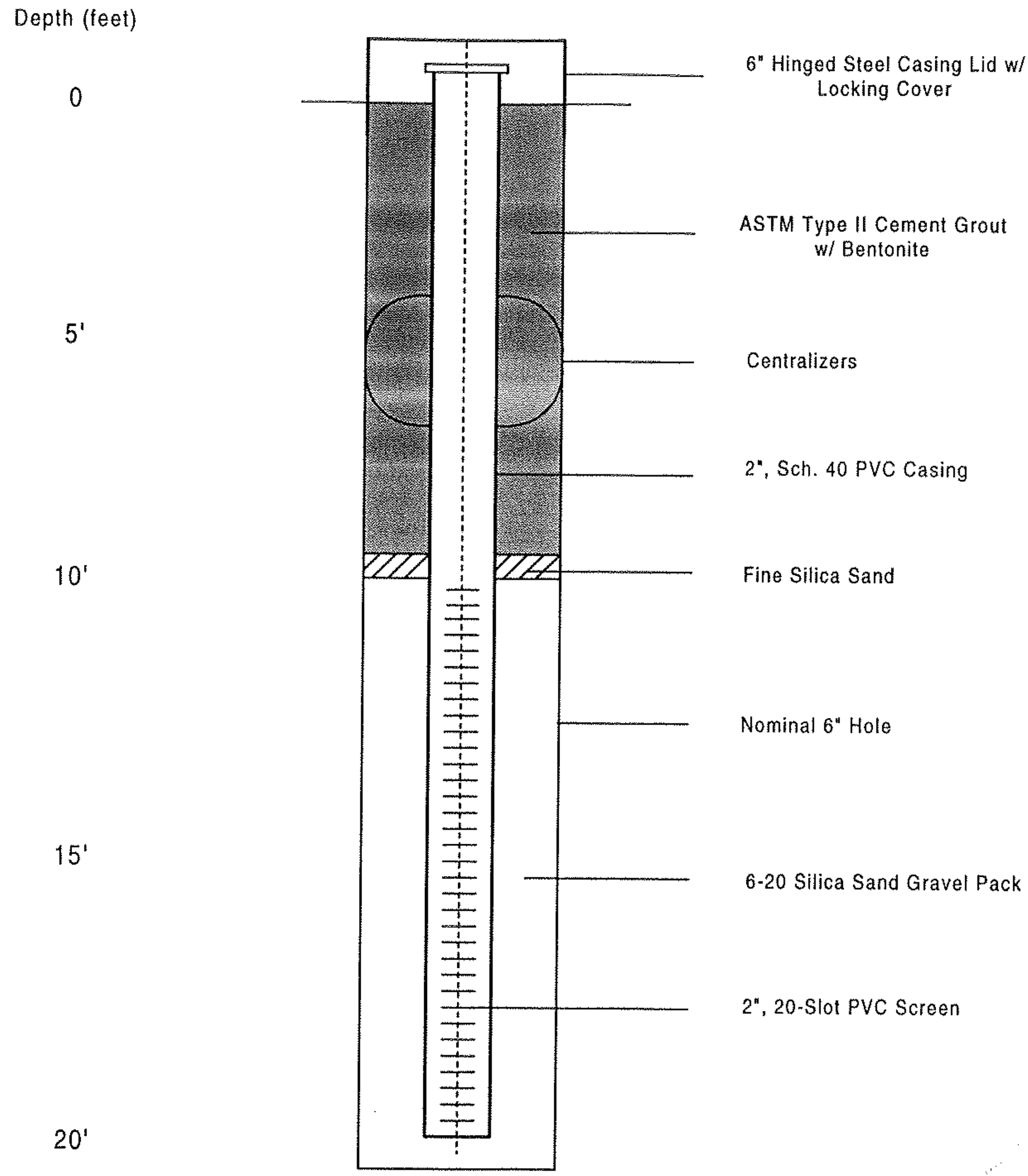
Note: the intent of this design is to provide a working pad with underlying membrane to capture and contain fluids generated during drilling and testing as a reasonable good house keeping measure.

- For soil placed under or outside of HDPE film the Contractor may use either IMPORTED FILL or fill generated from grading the required slopes provide it contains less than five percent fines (passing #200 Sieve).
- Approximate Slope for grading with a total depth of 1.0 feet from edge of work area to center of the sump
- Pad Monitor Well
- Lateral extent of HDPE membrane
- Cross-laminated HDPE membrane with a minimum thickness of 4 mil with a minimum overlap of 5 feet.
- Existing soils stripped of organics and graded as shown.
- IMPORTED FILL: fill meeting the physical properties and size requirements of Aggregate Size Number 57 of the FDOT Standard Specifications for Road and Bridge Construction with a thickness of at least 6 inches. or a well graded fill with less than 5 percent passing the No 10 sieve.

Figure No. B-1

Lake Okeechobee Exploratory Well Containment Pad and Membrane
SFWMD

File: Containment_Pad.xls : Figure 1 Date: 5/18/01 Time: 4:03 PM



PAUL T. LINTON
42637 5/18/01

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, 33406

Town of Moore Haven
Exploratory ASR Well

Figure B-2.
Pad Monitor Well Schematic

Drilling Procedures

An aboveground circulation system will be used during drilling operations to clean the borehole of mud/cuttings as the drill bit is advanced. Mud/cuttings will be disposed of by the contractor at a FDEP-approved disposal site, with approval occurring prior to beginning drilling.

When drilling in the FAS, reverse-air water, development water, and water derived from interval and aquifer tests is expected to be generated. These brackish waters will be conveyed to an onsite storage tank equipped with baffles and silt screen. This setup allows for suspended sediments to settle out prior to conveyance to the discharge point. A discharge port at the top of the storage tank is the egress point for the water, further enhancing settling to occur. This port provides a good place to conduct preliminary water quality sampling/analysis as necessary. Temporary piping will then be set up to convey water from the storage tank to the proposed point of discharge (POD).

Lithologic Description

Drill cuttings will be obtained every five feet and at every formation change observed during drilling operations. A hydrogeologist will describe cuttings and prepare a lithologic description log. This information will be used in conjunction with other subsurface data described below to determine formation characteristics, contacts between formations, and evaluation of hydrogeologic properties of the aquifers, confining beds, and potential storage zone(s). One set of drill cuttings will be sent to the Florida Geological Survey at 903 West Tennessee Street, Tallahassee FL 32304-7700, phone number (850) 488-9380.

Interval/Packer Tests

Interval/Packer tests will be used to evaluate hydraulic characteristics and water quality within the upper portions of the FAS. The number and depth intervals of the interval/packer tests – and the likelihood that the packers will seat properly to provide a reliable test -- will be determined based on lithologic and geophysical logs. Anticipated intervals include:

- 800 to 1,000 feet bls
- 800 to 1,200 feet bls
- 800 to 1,400 feet bls
- 800 to 1,600 feet bls

Interval tests will be conducted by reaming the pilot hole to the designated depth, followed by removal of the drill string. Next, gravel will be added to fill the portion of the pilot hole not filled with cuttings from reaming. A 10-foot cement cap will placed via tremie method at the base of the reamed hole to prevent any potential upward fluid movement from the gravel-filled pilot hole. Once the cement is cured, a temporary pump will be installed into the well. The interval will be pumped at a rate commensurate with the flow characteristics of the formation (e.g., 500 to 2,000 gpm) for up to 8 hours, and water levels and flow rates measured prior to, during, and after each interval test. Flow rates and drawdown for each subsequent interval test can be compared to previous tests for analysis.

The interval test provides advantages to traditional packer testing when evaluating large-diameter wells because greater pumping rates can be achieved without the limits of pumping between packers inside drill pipe. In addition, the uncertainty of packer inflation is also addressed because no packer is used. Unforeseen borehole conditions may dictate the need for packers, which will then be utilized accordingly.

Geophysical Logging Program

Geophysical logs will be run for a variety of reasons including:

- Evaluate hydrogeologic/petrologic characteristics of the formations encountered
- Estimate confining and permeable zones (flow profile) of pilot holes
- Estimate water quality characteristics of the formations encountered
- Evaluate borehole diameters of reamed holes prior to cementing casings
- Evaluate height of cement during staged, cementing operations
- Evaluate cement integrity of cemented casings
- Perform visual inspection of casing and borehole

Specific logs to be conducted are tailored to meet the above-mentioned objectives. The proposed geophysical logging program for the exploratory/ASR well is presented in **Table B-2.**

Table B-2
Schedule of Geophysical Logs

Exploratory/ASR Well Logs	Type	Depth (ft-bls)
Caliper, Gamma, Dual Induction, SP	Mud-Filled Pilot Hole	120
Caliper, Gamma	Reamed Hole	120
Caliper, Gamma, Dual Induction, SP, Sonic	Mud-Filled Pilot Hole	800
Caliper, Gamma	Reamed Hole	800
Gamma, Temperature	Each Cement Stage	800
Caliper, Gamma, Dual Induction, SP, Sonic, Density-Neutron, Fluid Resistivity, Video Temperature, Flowmeter	Pilot Hole	1,600
Caliper, Gamma	Reamed Hole	1,400
Gamma, Temperature	Each Cement Stage	1,400
Caliper, Gamma, Fluid Resistivity, Flowmeter Temperature, Cement Bond Log, Video	Final Well	1,600

Notes:
1. Ft-bls = feet below land surface
2. SP = Spontaneous Potential

Casing Grout Program

Prior to cementing, the boreholes will be conditioned through circulation of drilling fluids to optimize the casing/cement bond and prevent channeling. After each casing is set, it will be cemented in place by a multi-staged process using ASTM Type II neat cement with 0- to 8-percent bentonite. The cement formulations are typically based on the fluid-loss properties of the formations being cemented. Lighter formulations (i.e., higher percentage of bentonite) are used when highly permeable formations are encountered, or when cementing a casing inside another casing.

Cement placement shall be in accordance with American Water Works Association (AWWA) Standard for Water Wells, Section A100-90. After each casing is positioned at the setting depth, a grout pipe is lowered inside the casing to within 25 feet above the casing bottom, and a header is installed on the casing to seal the grout pipe and casing. The first stage of cement is pumped through the grout pipe, out the bottom of the casing, and upward into the annulus. This first stage typically uses neat cement for the greater structural integrity required to support the casing.

After the first stage of cement has set, the top of the cement will be confirmed by geophysical logging (i.e., temperature and gamma logs), and tagging the top of the cement in the annulus with a grout pipe. Subsequent cement stages containing blends of from 0- to 8-percent bentonite will be pumped simultaneously through two grout pipes in the annular space. Staged cementing will continue until cement is observed in the annulus at land surface.

Mechanical Integrity Test

Mechanical Integrity Tests (MIT) for Class V wells are typically limited to a casing pressure test, cement bond log (CBL), and video survey. This is because the injection (storage) zone coincides with an underground source of drinking water (USDW), thereby prohibiting a radioactive tracer survey. A location map and site map for the facility are provided in **Figures 1** and **2** of the application

Sequence

1. Ensure well's artesian pressure is neutralized by mixing and injecting a brine solution into the ASR well, if necessary.
2. Notify FDEP at least 72 hours prior to start of official pressure test.
3. Install a temporary, retrievable, inflatable packer into the well. Lower the packer to the desired depth on drill pipe or tubing. Install ½-inch nominal diameter steel, flexible tubing and connect to packer to facilitate packer inflation. *NOTE: The cement plug at the base of the casing that results from cementing operations may be used as an alternative to the inflatable packer.*
4. Set packer within 20 feet of base of casing (approximately 800 feet bls for 34-inch casing; approximately 1,400 feet bls for 24-inch casing [if necessary]).
5. Inflate packer with compressed air via ½-inch steel tubing. Repeat as necessary to ensure an effective seal is obtained.
6. Install temporary, steel header with port for drill pipe, pressure gauge, etc.
7. Provide and install calibrated pressure gauge with minimum 0.5-psi increments, 0 to 200 psi scale. Provide calibration certificate to SFWMD/USACE one week prior to preliminary test.
8. Pressurize casing using water and high-pressure pump.
9. Seal leaks at wellhead, re-install and re-inflate packer, as necessary, to conduct successful test.
10. Set test pressure to 100 psi and conduct preliminary test. Notify SFWMD/USACE representative and FDEP of successful preliminary test. Schedule official test with SFWMD/USACE and FDEP representatives.
11. Conduct official casing pressure test for 1 hour, allowing maximum 5 percent deviation. SFWMD/USACE to provide certified pressure test signed and sealed by qualified, State of Florida professional engineer (PE) to FDEP.
12. Bleed off pressure (water) into 5-gallon bucket, or equal, to measure water volume equal to 100-psi test pressure.
13. Remove header, deflate and remove packer, and reinstall blowout preventer (BOP) as necessary.
14. Conduct cement bond log to evaluate cement bond around casing.
15. Conduct video survey to visually inspect casing and open hole.

Specific Capacity Test

A specific capacity test will be performed on the well to evaluate well yield, and assist in design of the recharge and recovery pumps.

Sequence

1. Install temporary, vertical turbine pump (powered by diesel-driven motor or temporary electric) into exploratory/ASR well with appurtenances (shut-off valve, discharge pressure gauge, wellhead pressure gauge).
2. Set up onsite, baffled tank and temporary piping system with silt screen to convey pumped waters to Caloosahatchee River. Comply with requirements of FDEP-issued NPDES Permit.
3. Install temporary, 1-inch PVC standpipe to facilitate water level measurement. Set up HERMIT 3000 data logger to facilitate test. Install 100-psi submersible pressure transducer inside standpipe in exploratory/ASR well to approximately 100 feet. Connect pressure transducer to data logger via electronic cable.
4. Measure water levels/pressures continuously before, during, and after the pumping phase of the specific capacity test. Back-up measurements will be collected by hand (electronic water-level indicator or wetted-tape methods). All measurements will be referenced to National Geodetic Vertical Datum (NGVD) of 1929.
5. Begin pumping exploratory/ASR well at three rates (2,000, 3,500, and 4,000 gpm), approximately 2 hours each step.
6. Measure water levels/pressures at logarithmic frequency during each pumping step.
7. Stop pumping; begin measuring recovery data for approximately 6 hours or until water levels recover to 90 percent of pre-pumping conditions.
8. Download data from data logger via laptop PC. Graph and analyze data.

Acidization

Should the specific capacity test indicate unfavorable well yields, acidization of the open borehole may be conducted. The process of acidization involves the reaction of hydrochloric acid with the calcium carbonate ($CaCO_3$) formations (e.g., limestone) of the target zone. This process results in dissolution of the formation, and increased openings (pores, fractures, and cavities) that can accept/release fluids. By accomplishing this task, flow rates should increase under a given pressure. The proposed acidization procedure is outline below.

Sequence

1. Neutralize well's artesian pressure by mixing/injecting brine solution to develop a salt wafer in the well.

2. Install temporary header at wellhead with injection ports, pressure gauges, and pressure-relief valves. Install temporary piping, flowmeters, etc.
3. Install 2-inch-diameter freshwater injection tubing to approximately 500 feet bls (or below salt wafer in well).
4. Install 2-inch-diameter acid injection tubing to target depth
5. Inject freshwater into freshwater tubing for ½ hour at an approximate rate of 200 gpm and evaluate flow versus wellhead pressure.
6. Continue freshwater injection.
7. Begin acid injection of up to 5,000 gallons of 32-percent hydrochloric acid at an approximate rate of 100 gpm, and monitor wellhead pressure and acid flowrate.
8. Upon completing acid injection, continue freshwater injection in both tubings for 1 hour.
9. Shut in well overnight to allow acid to react with the formation, and release wellhead pressure as necessary.
10. Pump/flow the well to evaluate effectiveness of procedure. Repeat if necessary.
11. Remove tubings and temporary header, and install wellhead cap.

Freshwater flow maintains a positive pressure in the well (thereby reducing the chances of acid migrating upward towards the casing) and forcing acid into the formation. Header pressures typically increase following acidization, due to the aggressive chemical reaction between the acid and the carbonate formation, yielding carbon dioxide gas buildup.

Aquifer Performance Test (APT)

An aquifer performance test (APT) will be conducted to evaluate aquifer characteristics. A submersible pressure transducer will be installed in the 1-inch PVC pipe installed in the well. The apparatus used to conduct the test will be the same as that outlined in *Specific Capacity Test* above. The pumping rate will be the design rate of 3,500 gpm, depending on results of the specific capacity test. Background water levels and barometric pressure will be measured at least 48 hours prior to the test. Test duration will be 72 hours pumping (if possible due to NPDES permit constraints) followed by approximately 48 hours to allow water levels to recover to background conditions. Water levels, flowrate, and pump-discharge pressure will be measured during the test. Drawdown versus time graphs will be developed using standard analytical solutions to estimate aquifer transmissivity, storativity, and leakance (depending on existence of monitor wells in the storage zone).

Sequence

1. Install temporary, vertical turbine pump (powered by diesel-driven motor or temporary electric) into exploratory/ASR well with appurtenances (shut-off valve, discharge pressure gauge, wellhead pressure gauge).

2. Set up temporary piping system with silt screen to convey pumped waters to Caloosahatchee River. Comply with requirements of FDEP-issued NPDES Permit.
3. SFWMD/USACE to set up HERMIT 3000 data logger to facilitate test. Install 50-psi submersible pressure transducer in the exploratory/ASR well to approximately 100 feet. Connect 30-psi pressure transducers to monitor well. SFWMD/USACE to connect pressure transducers to data logger via electronic cable.
4. SFWMD/USACE to measure water levels/pressures continuously before, during, and after the pumping phase of the aquifer performance test (APT). Back-up measurements will be collected by a second set of pressure transducers.
5. SFWMD/USACE to conduct background measurements (water levels/pressures, barometric pressure) for 48 hours prior to pumping phase of test.
6. SFWMD/USACE to measure static water level prior to pumping phase in all wells/zones.
7. Begin pumping exploratory/ASR well (constant rate) at approximately 3,500 gpm (5 mgd) for 72 hours. Measure instantaneous pumping rates by circular orifice weir and totalized flow using calibrated, in-line, propeller-type flowmeter or approved equal.
8. SFWMD/USACE to measure water levels/pressures at logarithmic frequency during the first 10-minutes of the test and at 5-minute intervals thereafter.
9. Stop pumping. SFWMD/USACE to begin measuring recovery data for approximately 48 hours or until water levels recover to 90 percent of pre-pumping conditions.
10. SFWMD/USACE to download data from data loggers via laptop PC. SFWMD/USACE to graph and analyze data with analytical techniques appropriate to the aquifer type to estimate aquifer parameters.

Water Quality Testing

The primary purpose of water quality testing is to obtain background water quality data on the proposed storage zone(s). This information will be used to evaluate compatibility of proposed recharge water from the SAS and the native fluid. This data will also be used to evaluate the location of the 10,000 mg/L interface, above which is classified as an USDW by FDEP.

Water quality samples will be obtained after the final casing is set and the well developed to determine background water quality. The subject zone(s) will be allowed to flow to flush out any non-native water. To establish background water quality in the storage zone, sample(s) will be obtained for a suite of parameters, as shown in **Table B-3**. In addition, a 5-gallon unacidized representative sample of native water from the ASR storage zone will be obtained and sent to FDEP-Tallahassee.

Table B-3 – Water Quality Parameter List

Primary Drinking Water Standards			
Inorganics	**MCL (mg/L)**	**Organics**	**MCL (ug/L)**
Antimony	0.006	**Pesticides/PCBs**	
Arsenic (Total and Inorganic)	0.05	Alachlor	2
Asbestos	7 MFL	Atrazine	3
Barium	2	Simazine	4
Beryllium	0.004	Endrin	2
Cadmium	0.005	Lindane	0.2
Chromium	0.10	Methyoxychlor	40
Cyanide	0.20	Toxaphene	3
Fluoride	4.0	Chlordane	2
Lead	0.015	Heptachlor	0.4
Mercury	0.0002	Heptachlor Epoxide	0.2
Nickel	0.1	PCBs	0.5
Nitrate (as N)	10.0	**Herbicides**	
Nitrite (as N)	1.0	2,4-D	70
Selenium	0.05	2,4,5-TP (Silvex)	50
Sodium	160	Pentachlorophenol	1
Thallium	0.002	Picloram	500
Turbidity	1 NTU	Dalapon	200
Coliform, Total (col/100 ml)	4	Dinoseb	7
Volatile Organics	**MCL (ug/L)**	**Base Neutrals**	
		Hexachlorobenzene	1
THMs (Total)	100	Hexachlorocyclopentadiene	50
Trichloroethene	3	Benzo(a)pyrene	0.2
Tetrachloroethene	3	Di(2-ethylhexyl)phthalate	6
Carbon Tetrachloride	3	Di(2-ethylhexyl)adipate	400
Vinyl Chloride	1	**Other Organics**	
1,1,1-Trichloroethane	200	Carbofuran	40
1,1,2-Trichloroethane	5	Oxamyl (Vydate)	200
1,2-Dichloroethane	3	Endothall	100
Benzene	1	Glyphosate (Roundup)	700
Cis-1,2-Dichloroethene	70	Diquat	20
1,1-Dichloroethene	7	**Radionuclides**	
1,2-Dichloropropane	5	Radium 226 and 228	5pCi/l
Ethylbenzene	700	Gross Alpha	15pCi/l
Monochlorobenzene	100		
1,2-Dichlorobenzene	600		
1,4-Dichlorobenzene	75		
Styrene	100		
Toluene	1,000		
Trans-1,2-Dichloroethene	100		
Xylenes (Total)	10,000		
Dichloromethane (Methylene Chloride)	5		
1,2,4-Trichlorobenzene	70		
Ethylene Dibromide	0.02		
Dibromochloropropane	0.2		

Note: mg/l = milligrams per liter
ug/L = micrograms per liter

Table B-3 – Water Quality Parameter List (cont.)

Secondary Drinking Water Standards			
	MCL (mg/L)		MCL (mg/L)
Aluminum	0.2	Odor	3 TON
Chloride	250	pH (at Collection Point)	6.5 - 8.5
Copper	1.0	Corrosivity	NA
Color	15 PCU	Silver	0.1
Fluoride	2.0	Sulfate	250
Foaming Agents (MBAS)	0.5	Total Dissolved Solids (TDS)	500
Iron	0.3	Zinc	5
Manganese	0.05		
Other Parameters			
Ammonia (ionized and unionized)	NA	Aldrin	NA
Total Kjeldahl Nitrogen (TKN)	NA	Dieldrin	NA
Total Phosphorous (TP)	NA	Ethion	NA
Orthophosphate (soluble)	NA	Bromacil	NA
Conductivity	NA	Ametryn	NA
Temperature	NA	Hexazinone	NA
Total Suspended Solids (TSS)	NA	Alkalinity	NA
Total Nitrogen (TN)	NA	Calcium	NA
BOD (5-day)	NA	Magnesium	NA
Dissolved Organic Carbon (DOC)	NA	Potassium	NA
Dissolved Oxygen (DO)	NA	Bicarbonate	NA
Total Mercury	NA	Carbonate	NA
Methyl Mercury	NA	Fecal Coliform	NA
Sulfide	NA	Giardia Lamblia	NA
Bromide	NA	Cryptosporidium	NA
Uranium (234 and 238)	NA	Enterococci	NA
Strontium	NA	Coliphage	NA
Tritium	NA	Clostridium Perfringens	NA

1. Maximum Contaminant Level (MCL) per Rules 62-550.310 and 62-550.320, FAC.
2. Mg/L = milligrams per liter

Appendix C

Plugging and Abandonment Plan

Exploratory/ASR Well

1. Mobilize rig and crew and stop artesian flow from the well with brine solution to lower the well's hydrostatic head below land surface.
2. Place limestone gravel with an average diameter not larger than 1 inch down the well to fill the open hole from 1,600 feet below land surface (bls) up to approximately 20 feet below the base of the 34-inch casing at 800 feet bls.
3. Place Class H neat cement through grout pipe, from approximately 20 feet below the base of the 34-inch casing to land surface.

Cost Estimate in 2001 Dollars

1.	Mobilize drill rig and neutralize well's artesian head	$15,000
2.	Fill the open hole of the exploratory well with gravel (approximately 200 cubic yards at $60/yd)	$12,000
3.	Place neat cement through grout pipe from 20 feet below base of the 34-inch casing of the exploratory well to land surface (4,200 sacks at $25/94-lb. sack)	$105,000

Subtotal	$132,000
10 Percent Contingency	$13,200
Total Estimated Cost	**$145,200**

Certification of Financial Responsibility

The South Florida Water Management District, a special taxing district established by the Florida legislature, hereby certifies that it has unconditionally obligated itself to have the financial resources necessary to close, plug, and abandon its Class V underground injection well as required by Chapter 62-528, Florida Administrative Code. It is further understood that the cost estimate to conduct plugging and abandonment, established on March 13, 2001, shall be reviewed on an annual basis, and this obligation shall incorporate accumulated inflation costs. An annual adjustment exceeding ten (10) percent in any one year shall require submission of an updated certification form.

List of Injection Wells Covered by this Agreement:
(For each injection well list the following information)

Facility Name: Lake Okeechobee ASR Pilot Project

Facility Address: ____________________

Facility Contact: Mr. Peter Kwiatkowski, P.G.

Phone Number: (561) 682-2547

Latitude/Longitude of Injection Well: N 26° 50' 10", W 81° 05' 14"

DEP/EPA Identification Number: NA

Current Plugging and Abandonment Cost Estimate (March 13, 2001) $145,200.00

It is hereby understood that the cancellation of this certification may not take place without the prior written consent of the Secretary of the Florida Department of Environmental Protection.

(Signature)

Mr. Joseph A. Schweigart
(Print Name)

Director, Program and Project Management
(Title)

5/21/01.
(Date)

 05/21/01

Appendix H

2016 Well Survey Report and Notes

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Rev. 1/16

Site Name: **GLF6** | Last Date of Field Work: **03-may-16**

Party Chief: **Strickland** | Field Book: **Misc 6Y** | Page(s) **36,37 & 41**

Site Benchmark:	Benchmark Elevation (NAVD88)	Corpscon 6.0.1 Conversion Factor (NAVD88 to NGVD29)
GLF6 2016	**15.137**	**+1.316**

Reference Elevation(s) (NAVD88):	Existing Tag Elevation (Datum):	Calibration Port Elevation(s) (NAVD88):
18.13 – “X” at top of ¼” 90^o elbow	**None**	**18.13 – “X” at top of ¼” 90^o elbow**

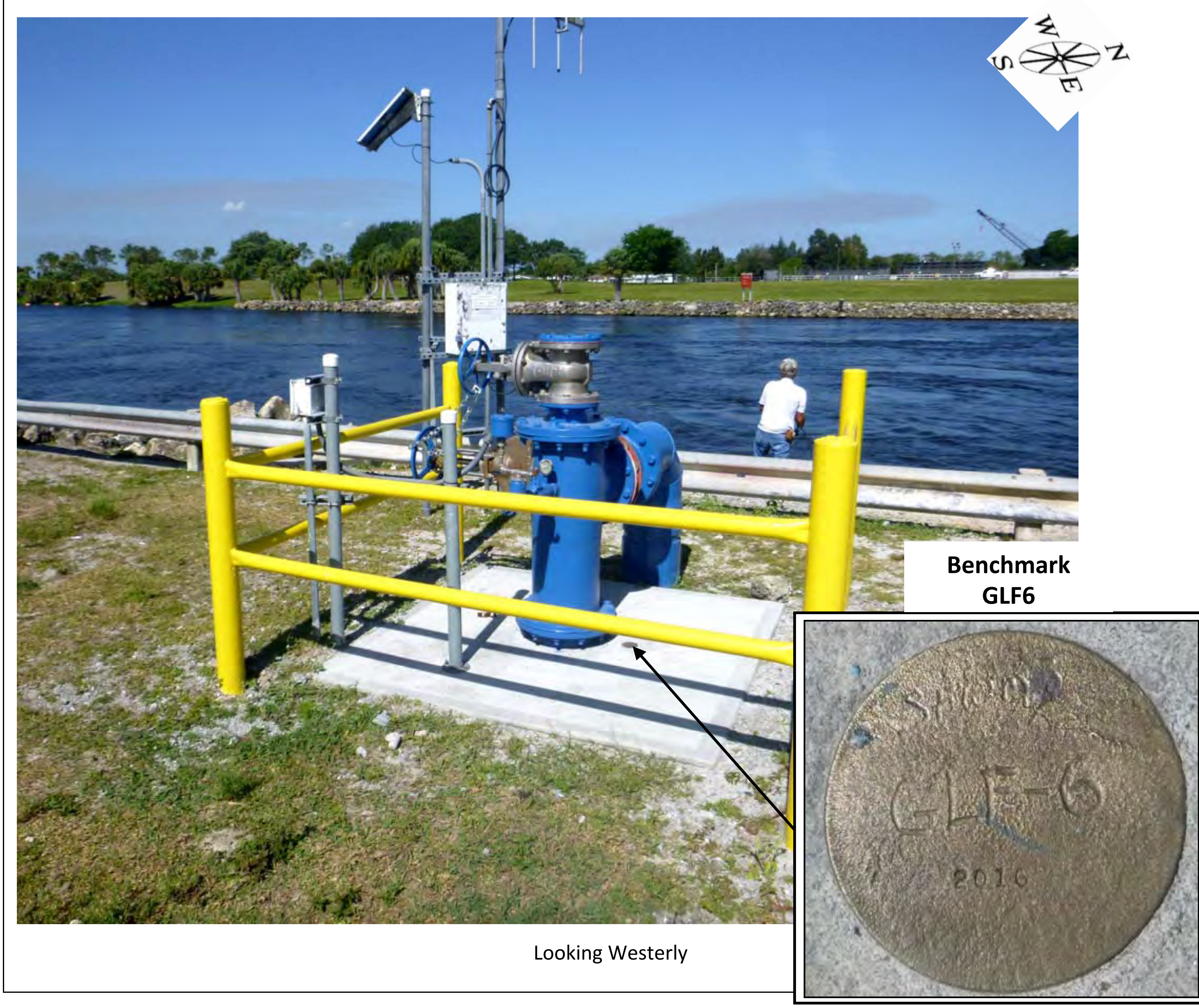
Ground Elevation (NAVD88):		Pad Elevation (NAVD88):	
15.0 – NW Corner	**15.0 – NE Corner**	**15.09 – NW Corner**	**15.13 – NE Corner**
14.9 – SW Corner	**15.1 – SE Corner**	**15.05 – SW Corner**	**15.09 – SE Corner**

Latitude: **26^o 50‘ 18.76“** | Longitude: **80^o 05‘ 07.33“**

Notes:
NAVD88 – North American Vertical Datum of 1988
NGVD29- National Geodetic Vertical Datum of 1929
Corpscon 6.0.1 – A MS-Windows-based program to convert coordinates and elevations between datum’s

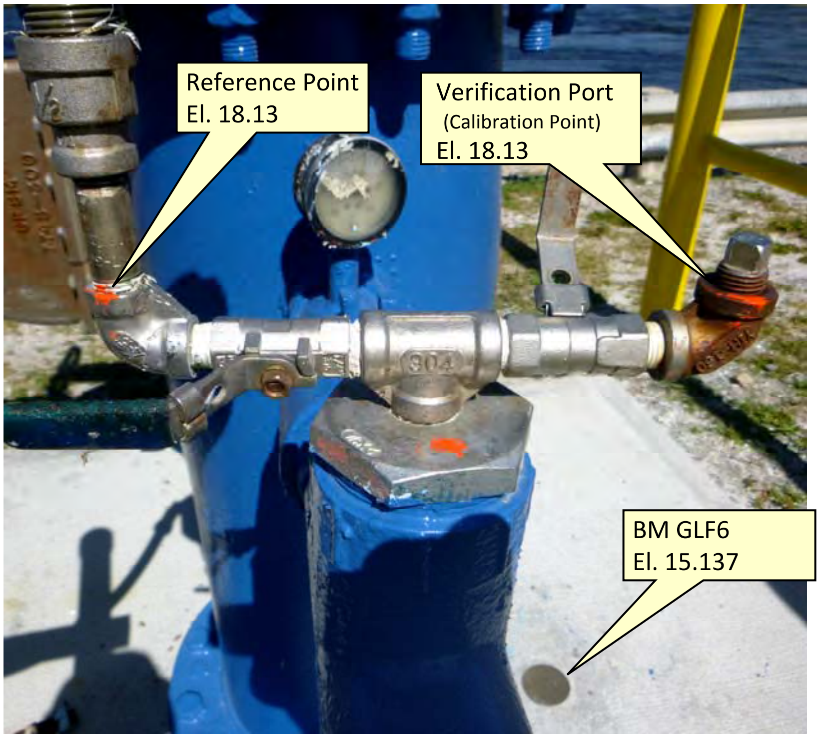
PICTURES

Overall Well Site



Benchmark GLF6

Looking Westerly

Brass Tag Close Up	Reference Marks
 Brass Tag to be added	

SEC 12 TWP 42 RGE 32

ESTABLISH NAVD 88 EL @ GLF6

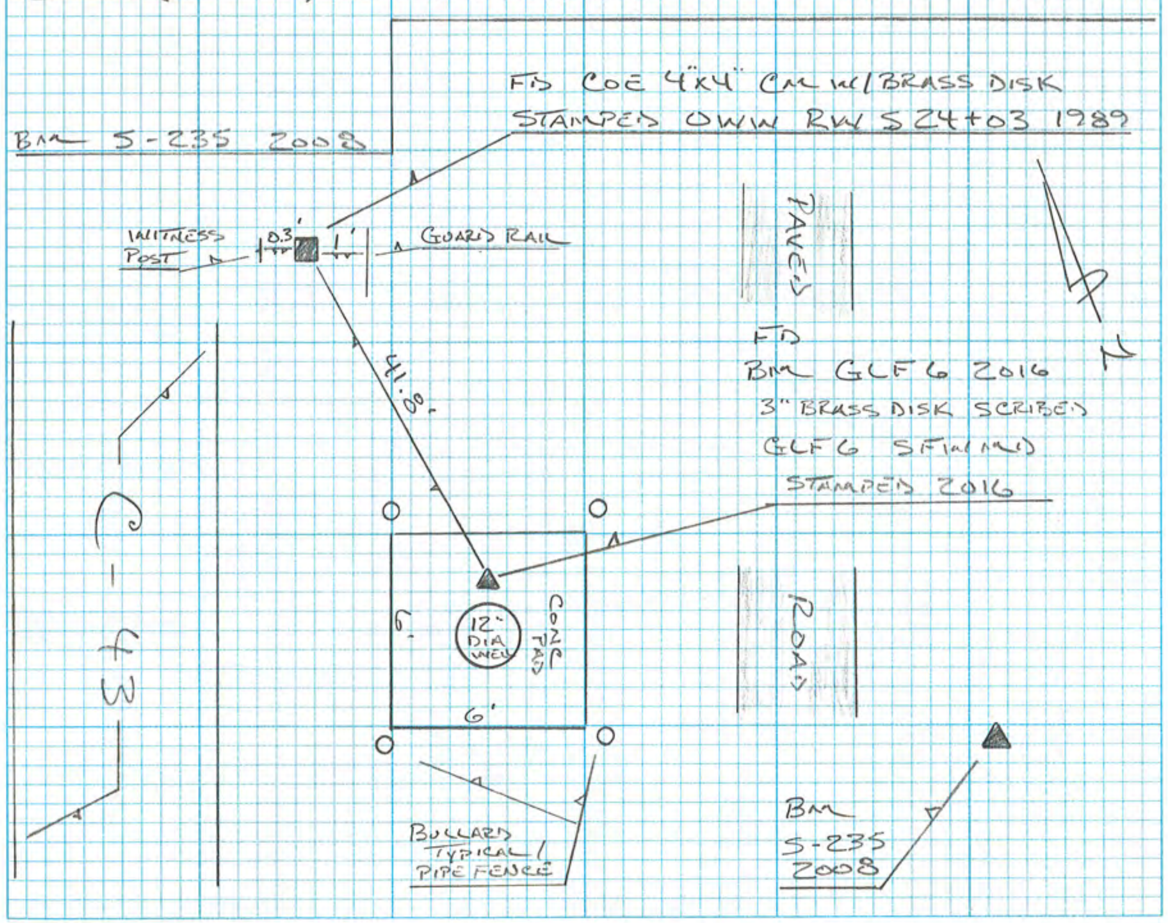
⊼ STRICKLAND
ø CLANTON

STA	+	HI	−	ELEV	BM EL	COMMENTS
BM				~~14.08~~ ~~14.47~~	~~14.079~~ ~~14.467~~ NAVD 88	BM S-235 2008 FD SFWMD BRASS DISK GOOD COND
	7.19	~~21.27~~ ~~21.66~~ 21.247				
BM			6.48	~~14.79~~ ~~15.18~~ 14.767	~~14.79~~ ~~15.18~~	BM OWW RW S24+03 1989 FD COE BRASS DISK IN 4"x4" CM GOOD COND
	6.38	~~21.17~~ ~~21.56~~ 21.147				
BM			6.01	~~15.16~~ ~~15.55~~ 15.137	~~15.16~~ ~~15.55~~	BM GLF6 2016 FD 3" BRASS DISK IN CONC PAD FOR WELL GLF6 (N. SIDE) STAMPED/SCRIBED SFWMD GLF6 2016
	6.60	~~21.76~~ ~~22.15~~ 21.737				
BM			7.68	~~14.08~~ ~~14.47~~	~~14.08~~ ~~14.47~~ 14.057	

14.057 (Adjusted Elevation - FCE117 Level line page 41)

WELL / PAD LOCATION

26 50 18.76 N
81 05 07.33 W



SEC 12 TWP 42 RGE 32

GLF 6 CONT'D

π ⊢⊣ STRICKLAND
Ø CLANTON

STA	+	HI	−	ELEV	BM EL	COMMENTS
BM	5.14	~~20.20~~ ~~20.69~~ 20.277			~~15.16~~ ~~15.55~~ 15.137 NAVD88	BM GLF 6 2016 SFWMD 3" BRASS DISK SEE PG 36 THIS BOOK
"X" 2"x 1/4" REDUCER			2.28	~~18.41~~	~~18.02~~ 17.997	"X" ATOP of 2" x 1/4" REDUCER
"X" 1/4" 90° N VERIFICATION PORT			2.15	~~18.54~~	~~18.15~~ 18.127	"X" ATOP of 1/4" 90° ELBOW (N. MOST) X ON E. SIDE
"X" 1/4" 90° S REF PT			2.15	~~18.54~~	~~18.15~~ 18.127	"X" A TOP of 1/4" 90° ELBOW (S. MOST) " " " "
CONC PAD NW			5.19	~~15.50~~	~~15.11~~ 15.087	CONC PAD NW CORNER
GRND NW			5.3	~~15.39~~	~~15.00~~ 14.977	GRND @ " "
CONC PAD NE			5.15	~~15.54~~	~~15.15~~ 15.127	CONC PAD NE CORNER
GRND NE			5.3	~~15.39~~	~~15.00~~ 14.977	GRND @ " "
CONC PAD SE			5.19	~~15.50~~	~~15.11~~ 15.087	CONC PAD SE CORNER
GRND SE			5.2	~~15.49~~	~~15.10~~ 15.077	GRND @ " "
CONC PAD SW			5.23	~~15.46~~	15.07 15.047	CONC PAD SW CORNER
GRND SW			5.4	~~15.29~~	14.90 14.877	GRND @ " "
BM			5.14	15.55	~~15.55~~ ~~15.16~~ 15.137	BM GLF 6 2016 SFWMD 3" BRASS DISK

SEC 12 TWP 42 RGE 32

VERIFY EL @ BM S235 2008 AS PER HOWARD EHMKE

STA / PT#	EL	BM EL
BM / 1		35.28 NAVD 88
BM / 6	14.061	
BM / 11	35.283	35.28

DB 1158.04
DF 1155.77
TOTAL = 2313.81

EQ USED DINI LEVEL SN: 771295 & BAR CODE ROD

[instrument symbol] STRICKLAND
[rod symbol] CLANTON

FILE NAME = GLF 6

NOTE: MADE SEARCH FOR E524 2001 DID NOT FIND WE DID FIND MAGNET.

BM FCE 117 US ENGINEER DEPT AD 193 FD BRASS DISK GOOD COND

BM S235 2008 FD SFWMD BRASS DISK GOOD COND SEE PG-36 THIS BOOK

BM FCE 117 AS ABOVE

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Rev. 1/16

DESIGNATION: **GFL6**	PROJECT: **GFL6 Well**
ESTABLISHED BY: **SOUTH FLORIDA WATER MANAGEMENT DISTRICT** RECOVERED BY:	SURVEYOR: **Strickland** DATE: **03-may-16**

GEOGRAPHIC POSITION

SECTION **12**	TOWNSHIP **42** SOUTH	RANGE **32** EAST

COUNTY **Glades**	NAME OF QUADRANGLE **Moore Haven** GEOGRAPHIC INDEX OF QUAD **2309**

HORIZONTAL DATUM: 1927 (1983) Other (circle one) ZONE (E) or W

VERTICAL DATUM: MSL 1929 (1988) Other (circle one)

VERTICAL ACCURACY: 1 2 (3)

STATE PLANE COORDINATE	X **628329**	Y **910491**	NAVD 88 EL. **15.137** NGVD 29 EL. **16.483**

CORPSCON 6.0.1 CONVERSION FACTOR (NAVD88 TO NGVD29):

LATITUDE: **26º50’18.76”N**	LONGITUDE: **81º05’07.33”W**

RECOVERY DATA

Stamping: **SFWM GFL6 2016**

To Reach: From the Glades County Court House in Moore Haven, go South on United States Highway 27 (U.S. 27) , 0.9 of a mile to the South foot of U.S. 27 bridge spanning the Caloosahatchee River (C-43) and an access road on the right; Follow the access road back toward river for 0.2 of a mile to the junction of Daniels Road; Turn right on Daniels road, passing underneath the bridge, and across a set of railroad tracks, for 0.1 of a mile to Alvin Ward Sr. Drive on left; Turn left and continue on Alvin Ward Sr. Drive, 0.3 of a mile to the intersection of the South Florida Water Management District Canal 20 (C-20) and Structure 235 (S-235); continue Northerly 130 feet more or less to station location on left at GFL-6 Well Site.
The station is a brass disk set on the concrete pad surrounding GFL-6 well and stamped “GFL 6 2016.”

NOTABLE LAND MARKS: **S-235**

NGS SOURCE BENCHMARK: **FCE 117 (AJ6194)**

FIELD BOOK **Misc 6Y** PAGES **36,37 &41**

PICTURES

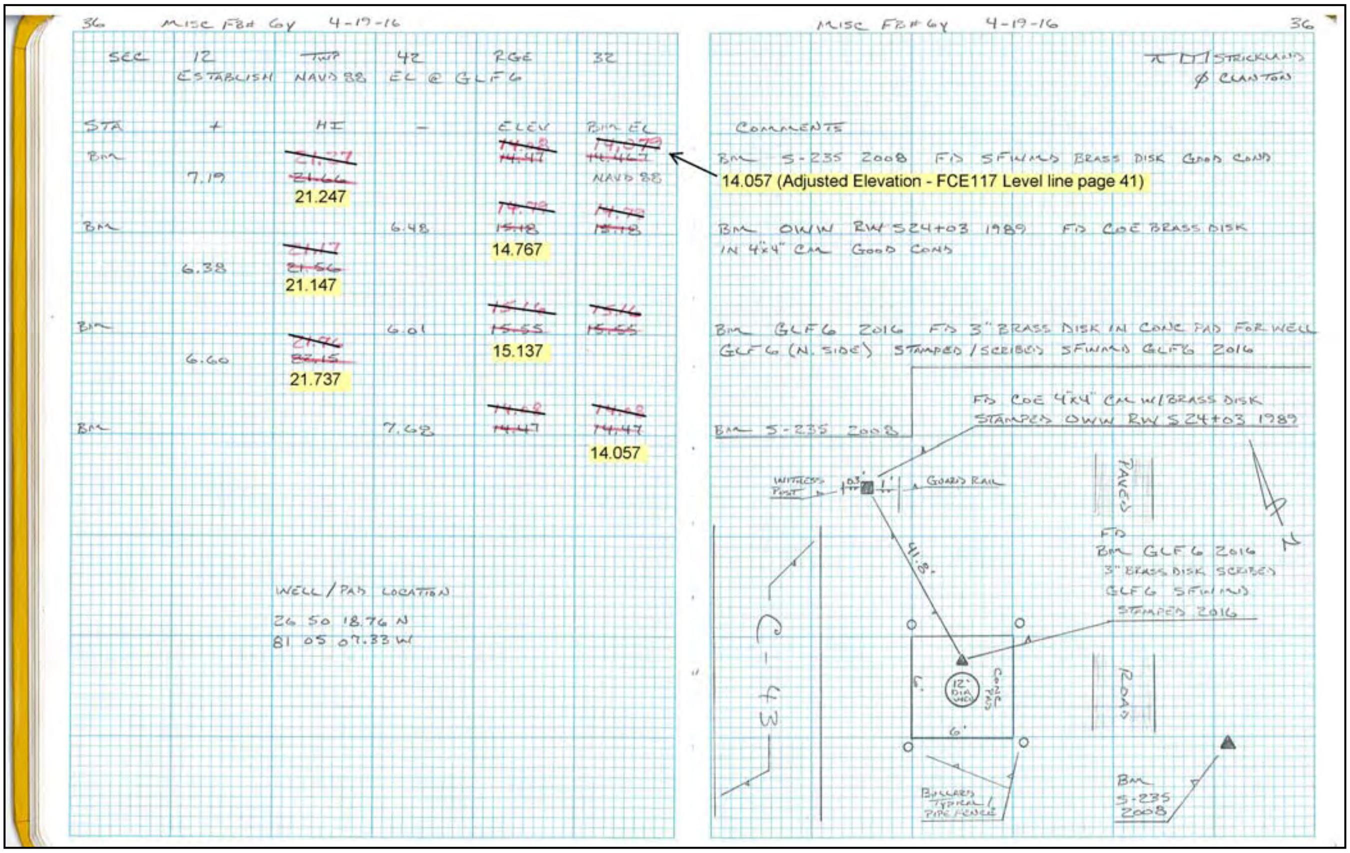
Overall Site

Looking Westerly

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Rev. 1/16

SKETCH



Source Benchmark
NGS FCE 117 (AJ6194)

From the "ngvd29.txt" file provided by NGS for the CERP Geodetic Vertical Control Project.
Line/Part: L26217/1 SSN+: mark floated, SSN*: mark constrained, SSN#: mark floated & constrained

Mark ID	SSN	PID	Designation	Geopotential	Elevation	Codes
1218	0047	AJ6194	FCE 117	10.9401	11.1633	

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.8
1        National Geodetic Survey,   Retrieval Date = MAY 10, 2016
 AJ6194 ***********************************************************************
 AJ6194  DESIGNATION -  FCE 117
 AJ6194  PID         -  AJ6194
 AJ6194  STATE/COUNTY-  FL/GLADES
 AJ6194  COUNTRY     -  US
 AJ6194  USGS QUAD   -  MOORE HAVEN (1970)
 AJ6194
 AJ6194                        *CURRENT SURVEY CONTROL
 AJ6194  ______________________________________________________________________
 AJ6194* NAD 83(2011) POSITION- 26 50 23.77019(N) 081 05 13.79801(W)   ADJUSTED
 AJ6194* NAD 83(2011) ELLIP HT-   -13.950 (meters)        (06/27/12)   ADJUSTED
 AJ6194* NAD 83(2011) EPOCH   -  2010.00
 AJ6194* NAVD 88 ORTHO HEIGHT -    10.753 (meters)       35.28   (feet) ADJUSTED
 AJ6194  ______________________________________________________________________
 AJ6194  NAD 83(2011) X  -    882,320.960 (meters)                     COMP
 AJ6194  NAD 83(2011) Y  - -5,626,138.598 (meters)                     COMP
 AJ6194  NAD 83(2011) Z  -  2,862,395.663 (meters)                     COMP
 AJ6194  LAPLACE CORR    -          -1.63  (seconds)                   DEFLEC12B
 AJ6194  GEOID HEIGHT    -         -24.702 (meters)                    GEOID12B
 AJ6194  DYNAMIC HEIGHT  -          10.736 (meters)       35.22   (feet) COMP
 AJ6194  MODELED GRAVITY -    979,120.3    (mgal)                      NAVD 88
 AJ6194
 AJ6194  VERT ORDER      -  FIRST     CLASS II
 AJ6194
 AJ6194  Network accuracy estimates per FGDC Geospatial Positioning Accuracy
 AJ6194  Standards:
 AJ6194         FGDC (95% conf, cm)     Standard deviation (cm)     CorrNE
 AJ6194            Horiz  Ellip            SD_N   SD_E   SD_h      (unitless)
 AJ6194  -------------------------------------------------------------------
 AJ6194  NETWORK    2.04   2.90            0.82   0.84   1.48     -0.21372955
 AJ6194  -------------------------------------------------------------------
 AJ6194  Click here for local accuracies and other accuracy information.
 AJ6194
 AJ6194
 AJ6194.The horizontal coordinates were established by GPS observations
 AJ6194.and adjusted by the National Geodetic Survey in June 2012.
 AJ6194
 AJ6194.NAD 83(2011) refers to NAD 83 coordinates where the reference
 AJ6194.frame has been affixed to the stable North American tectonic plate. See
 AJ6194.NA2011 for more information.
 AJ6194
 AJ6194.The horizontal coordinates are valid at the epoch date displayed above
 AJ6194.which is a decimal equivalence of Year/Month/Day.
 AJ6194
 AJ6194.The orthometric height was determined by differential leveling and
 AJ6194.adjusted by the NATIONAL GEODETIC SURVEY
 AJ6194.in January 2002.
 AJ6194
 AJ6194.Significant digits in the geoid height do not necessarily reflect accuracy.
```

```
AJ6194.GEOID12B height accuracy estimate available here.
AJ6194
AJ6194.Photographs are available for this station.
AJ6194
AJ6194.The X, Y, and Z were computed from the position and the ellipsoidal ht.
AJ6194
AJ6194.The Laplace correction was computed from DEFLEC12B derived deflections.
AJ6194
AJ6194.The ellipsoidal height was determined by GPS observations
AJ6194.and is referenced to NAD 83.
AJ6194
AJ6194.The dynamic height is computed by dividing the NAVD 88
AJ6194.geopotential number by the normal gravity value computed on the
AJ6194.Geodetic Reference System of 1980 (GRS 80) ellipsoid at 45
AJ6194.degrees latitude (g = 980.6199 gals.).
AJ6194
AJ6194.The modeled gravity was interpolated from observed gravity values.
AJ6194
AJ6194. The following values were computed from the NAD 83(2011) position.
AJ6194
AJ6194;                    North         East     Units Scale Factor Converg.
AJ6194;SPC FL E     -   277,672.635   191,336.629   MT  0.99994210   -0 02 21.7
AJ6194;SPC FL E     -   910,997.64    627,743.59   sFT  0.99994210   -0 02 21.7
AJ6194;UTM  17      - 2,968,709.876   491,339.585   MT  0.99960093   -0 02 21.7
AJ6194
AJ6194!             -  Elev Factor  x  Scale Factor =   Combined Factor
AJ6194!SPC FL E     -   1.00000219  x   0.99994210  =   0.99994429
AJ6194!UTM  17      -   1.00000219  x   0.99960093  =   0.99960312
AJ6194
AJ6194                          SUPERSEDED SURVEY CONTROL
AJ6194
AJ6194  NAD 83(2007)-  26 50 23.77035(N)    081 05 13.79875(W) AD(2002.00) 0
AJ6194  ELLIP H (02/10/07)  -13.929  (m)                       GP(2002.00)
AJ6194  NAD 83(1999)-  26 50 23.77035(N)    081 05 13.79908(W) AD(       ) 1
AJ6194  ELLIP H (12/12/02)  -13.904  (m)                       GP(       ) 4 1
AJ6194  NAVD 88 (12/12/02)   10.75   (m)           35.3    (f) LEVELING    3
AJ6194
AJ6194.Superseded values are not recommended for survey control.
AJ6194
AJ6194.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.
AJ6194.See file dsdata.txt to determine how the superseded data were derived.
AJ6194
AJ6194_U.S. NATIONAL GRID SPATIAL ADDRESS: 17RMK9133968709(NAD 83)
AJ6194
AJ6194_MARKER: DD = SURVEY DISK
AJ6194_SETTING: 36 = SET IN A MASSIVE STRUCTURE
AJ6194_SP_SET: FLOOD LOCK WALL
AJ6194_STAMPING: FCE 117
AJ6194_MARK LOGO: USE
AJ6194_MAGNETIC: O = OTHER; SEE DESCRIPTION
AJ6194_STABILITY: B = PROBABLY HOLD POSITION/ELEVATION WELL
AJ6194_SATELLITE: THE SITE LOCATION WAS REPORTED AS SUITABLE FOR
AJ6194+SATELLITE: SATELLITE OBSERVATIONS - January 06, 2015
AJ6194
AJ6194  HISTORY     - Date     Condition        Report By
AJ6194  HISTORY     - 1962     MONUMENTED       USE
AJ6194  HISTORY     - 20010616 GOOD             EMCINC
AJ6194  HISTORY     - 2002     GOOD             MAPTEC
AJ6194  HISTORY     - 20040929 GOOD             MCKIM
AJ6194  HISTORY     - 20110330 GOOD             MCKIM
```

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AJ6194  HISTORY     - 20130605 GOOD            BAKER
AJ6194  HISTORY     - 20150106 GOOD            USGS
AJ6194
AJ6194                          STATION DESCRIPTION
AJ6194
AJ6194'DESCRIBED BY EMC INCORPORATED 2001 (WJB)
AJ6194'THE STATION IS LOCATED IN MOORE HAVEN, FLORIDA ON THE MOORE
AJ6194'HAVEN LOCK AT LAKE OKEECHOBEE.  LOCATED ON THE MOORE HAVEN QUAD
AJ6194'SECTION 12, TOWNSHIP 42 SOUTH, RANGE 32 EAST.
AJ6194'
AJ6194'OWNERSHIP   U.S. ARMY CORPS OF ENGINEERS
AJ6194'
AJ6194'TO REACH THE STATION FROM THE INTERSECTION OF FIFTH STREET AND
AJ6194'U.S. HIGHWAY 27 AT THE GLADES COUNTY COURTHOUSE IN MOORE HAVEN,
AJ6194'FLORIDA GO EAST 0.16 KILOMETERS (0.1 MILES) TO AN EXIT TO THIRD
AJ6194'STREET, THENCE SOUTH 0.16 KILOMETERS (0.1 MILES) TO INTERSECTION
AJ6194'WITH AVENUE J, THENCE LEFT (EAST) ON AVENUE J 0.24 KILOMETERS (0.15
AJ6194'MILES) TO INTERSECTION WITH FIRST STREET, THENCE LEFT (NORTH) 0.96
AJ6194'KILOMETERS (0.6 MILES) ON FIRST STREET TO THE INTERSECTION WITH
AJ6194'COUNTY ROAD 720 NORTHWEST, THENCE RIGHT (EAST) ON COUNTY ROAD
AJ6194'720 NORTHWEST 0.16 KILOMETERS (0.1 MILES) TO PAVED ROAD TO MOORE
AJ6194'HAVEN LOCK, THENCE RIGHT (SOUTHEAST) ON PAVED ROAD 0.32
AJ6194'KILOMETERS (0.2 MILES) THROUGH THE COMPOUND TO THE TOP OF
AJ6194'HERBERT HOOVER LEVEE AT THE WEST SIDE OF MOORE HAVEN LOCK AND
AJ6194'THE MARK AHEAD APPROXIMATELY 10 METERS ON THE LOCK.
AJ6194'
AJ6194'THE STATION IS 7.5 METERS (24.6 FEET) WEST OF THE NORTHWEST CORNER
AJ6194'OF LOCK CONTROL HOUSE, 1.45 METERS (4.8 FEET) NORTHEAST OF A METAL
AJ6194'LIGHT POLE, 0.15 METERS (0.5 FEET) SOUTH OF THE TOP OF CONCRETE
AJ6194'STEPS AND APPROXIMATELY 0.6 METERS (2.0 FEET) ABOVE THE TOP OF HERBERT
AJ6194'HOOVER LEVEE.  THE MARK IS A UNITED STATES ENGINEER DEPARTMENT BRONZE
AJ6194'DISK WITH A RAISED TRIANGULAR CENTER POINT, SET FLUSH WITH THE TOP OF
AJ6194'CONCRETE ON THE WEST LOCK WALL.
AJ6194'
AJ6194
AJ6194                          STATION RECOVERY (2002)
AJ6194
AJ6194'RECOVERY NOTE BY MAPTECH INCORPORATED 2002 (WJB)
AJ6194'RECOVERED AS DESCRIBED.
AJ6194
AJ6194                          STATION RECOVERY (2004)
AJ6194
AJ6194'RECOVERY NOTE BY MCKIM AND CREED 2004 (BRH)
AJ6194'RECOVERED IN GOOD CONDITION.
AJ6194
AJ6194                          STATION RECOVERY (2011)
AJ6194
AJ6194'RECOVERY NOTE BY MCKIM AND CREED 2011 (CJB)
AJ6194'RECOVERED IN GOOD CONDITION.
AJ6194
AJ6194                          STATION RECOVERY (2013)
AJ6194
AJ6194'RECOVERY NOTE BY M BAKER JR INCORPORATED 2013 (SJC)
AJ6194'RECOVERED IN GOOD CONDITION.
AJ6194
AJ6194                          STATION RECOVERY (2015)
AJ6194
AJ6194'RECOVERY NOTE BY US GEOLOGICAL SURVEY 2015 (RDH)
AJ6194'RECOVERED IN GOOD CONDITION.
```

```
*** retrieval complete.
Elapsed Time = 00:00:03
```

Project Information		Coordinate System	
Name:		Name:	Default
Size:		Datum:	WGS 1984
Modified:	2/15/2012 8:48:57 AM (UTC:-7)	Zone:	Default
Time zone:	Mountain Standard Time	Geoid:	
Reference number:		Vertical datum:	
Description:			

Level Report

Imported file:	GLF6.DAT
Instrument:	DiNi
Standard error per kilometer of double leveling:	0.00230 ft
Standard error per turn/station setup:	0.00000 ft
Creation option:	Delta elevations
Description usage:	Feature codes

Run - 1 Raw Observations

Raw Misclosure:	0.00400 ft
Σ BS Distances:	1158.030 ft
Σ FS Distances:	1155.770 ft
Run Length:	2313.800 ft
Reduction:	Adjusted Values

Create	Point ID	BS	IS	FS	Δ Elevation	Raw Elevation	Correction	Adj. Elevation	Type	Distance	Description
☑	1	☑ 5.56300 ft			0.00000 ft	35.279 ft	0.00000 ft	35.279 ft	Benchmark	94.910 ft	FC117 3
☐	2			☑ 7.03600 ft	-1.47300 ft	33.806 ft	-0.00021 ft	33.806 ft	Computed	100.200 ft	3
	2	☑ 5.92100 ft								247.440 ft	3
☐	3			☑ 5.40800 ft	0.51300 ft	34.319 ft	-0.00156 ft	34.317 ft	Computed	248.980 ft	3
	3	☑ 5.02900 ft								100.030 ft	3
☐	4			☑ 9.58700 ft	-4.55800 ft	29.761 ft	-0.00179 ft	29.759 ft	Computed	101.510 ft	3
	4	☑ 0.31700 ft								37.040 ft	3
☐	5			☑ 8.31300 ft	-7.99600 ft	21.765 ft	-0.00182 ft	21.763 ft	Computed	38.580 ft	3
	5	☑ 0.30000 ft								92.750 ft	3
☐	6					14.059 ft	-0.00200 ft	14.057 ft	Computed	91.270 ft	S235 3

				☑ 8.00600 ft	-7.70600 ft						
	6	☑ 8.03100 ft								91.110 ft	S235 3
☐	7			☑ 0.32500 ft	7.70600 ft	21.765 ft	-0.00219 ft	21.763 ft	Computed	93.040 ft	3
	7	☑ 8.98600 ft								47.110 ft	3
☐	8			☑ 1.14400 ft	7.84200 ft	29.607 ft	-0.00224 ft	29.605 ft	Computed	47.150 ft	3
	8	☑ 9.55900 ft								96.690 ft	3
☐	9			☑ 4.84900 ft	4.71000 ft	34.317 ft	-0.00244 ft	34.315 ft	Computed	95.180 ft	3
	9	☑ 5.62400 ft								250.620 ft	3
☐	10			☑ 6.19400 ft	-0.57000 ft	33.747 ft	-0.00379 ft	33.743 ft	Computed	244.980 ft	3
	10	☑ 7.13200 ft								100.330 ft	3
☑	11			☑ 5.59600 ft	1.53600 ft	35.283 ft	-0.00400 ft	35.279 ft	Benchmark	94.880 ft	FC117 3

Run - 1 (N1) Reduced Observations

Observation	Status	Raw Δ Elevation	Correction	Final Δ Elevation	Setups	Length	Σ BS Readings	Σ FS Readings	Std. Error
1-11 (E1)	Enabled	0.00400 ft	-0.00400 ft	0.00000 ft	10	2313.800 ft	56.46200 ft	56.45800 ft	0.02226 ft

Run - 1 (N1) Reduced Coordinates

Point ID	Status	Elevation
1	Enabled	35.27900 ft
11	Enabled	35.27900 ft

Date: 5/9/2016 7:16:46 AM	Project:	Trimble Business Center