Hydrogeologic Investigation of the Floridan Aquifer System

LaBelle, Hendry County, Florida
Technical Publication WS-15

Title: LAB-TW Tri-Zone Monitor Well

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EXECUTIVE SUMMARY

The Lower West Coast Planning Area (LWCPA) includes Collier and Lee counties and portions of Hendry, Charlotte, and Glades counties. A combination of natural drainage basins and political boundaries define the extent of this planning area. Water supply plans developed for the LWCPA have identified the Floridan aquifer system (FAS) as a possible water supply alternative. Based on these plans, the South Florida Water Management District (SFWMD) initiated a program of exploratory well construction, aquifer testing, and long-term monitoring (water quality and potentiometric heads) to provide data needed to assess the FAS underlying this area. These wells will supply information needed to characterize the water supply potential of the FAS and for use in the development of ground water flow models, which will support future planning and regulatory decisions.

Three previous system test sites located in the LWCPA were completed under this program (Bennett, 2001a, 2001b, and 2002). **Figure 1** shows the location of the Floridan aquifer test site completed by SFWMD in the LWCPA. The fourth site, the focus of this report, is located in northwest Hendry County, proximal to the Caloosahatchee River and identified as "LAB-TW, Study Area". The SFWMD selected this site to augment existing data and to provide broad spatial coverage within the LWCPA.

SFWMD provided oversight during all well drilling, construction, and testing operations of the two FAS wells. Diversified Drilling Corporation (DDC), a Tampa based corporation was responsible for all drilling, construction, and testing services associated with the two Floridan aquifer system wells (LAB-TW and LAB-PW) under SFWMD Contract C-7663.

The first well identified as LAB-TW was drilled to a total depth of 2,500 feet below land surface (bls). The Contractor completed the well in three distinct hydrogeologic zones within the Floridan aquifer system. The second well (identified as LAB-PW) is located 270 feet south of well LAB-TW and constructed to facilitate aquifer testing of two horizons in the upper portion of the Floridan aquifer system.

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

- The top of the FAS as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 665 feet bls. The upper Floridan aquifer extends for 665 to 850 feet bls. The middle-confining unit extends from 850 to 2,325 feet bls and includes the middle Floridan aquifer from 1,645 to 1,780 feet bls. The lower Floridan aquifer extends from 2,325 to 2,500 feet bls, the total depth of the test-monitor well.
- Lithologic and geophysical logs, specific capacity and packer test results, and petrophysical data indicate moderate production capacity of the upper Floridan aquifer.
- Water quality data from packer tests and completed monitor zones indicate that chloride and total dissolved solid (TDS) concentrations in the Floridan aquifer between 670 and 920 feet bls exceed potable drinking water standards. Chloride and TDS concentrations within this interval average 640 to 1,680 milligrams per liter (mg/L), respectively.
- The base of the Underground Source of Drinking Water, those waters having TDS concentrations less than 10,000 mg/L, occurs at an approximate depth of 1,675 feet bls.

- Stable isotope results show that the upper Floridan aquifer and middle confining unit waters are depleted in both ^{18}O and deuterium as compared to the reference standard of Standard Mean Ocean Water (SMOW). In addition, these waters plot near the Global Meteoric Water Line indicating that they may be meteoric in origin.
- Stable isotope results indicate that the middle Floridan aquifer water is slightly enriched in both ^{18}O and deuterium as compared to SMOW. The inorganic chemistry indicates the interval between 1,645 to 1,759 feet bls is saline in composition. The inorganic chemistry combined with the stable isotope data suggests that the middle Floridan aquifer has in part been intruded by seawater.
- The petrophyscial data suggest moderately strong linear relationship between horizontal permeability and porosity with a correlation coefficient of 0.74.
- The highest horizontal permeabilities (2,901 and 2,224 milli-darcies) correspond to cored sections at approximately 726 and 821 feet bls, respectively. These two intervals consist of packstone-boundstone, likely deposited in an open-lagoonal shoal environment.
- The upper Floridan aquifer from 670 to 850 feet bls yielded a transmissivity of 68,630 gpd/ft, a storage coefficient of 6.7×10^{-5}, a (r/B) value of 0.06, and a leakance of 3.39×10^{-3} gpd/ft^3.
- An interval from 1,110 to 1,465 feet bls yielded a transmissivity of 26,460 gpd/ft, a storage coefficient of 1.2×10^{-4}, a (r/B) value of 0.09, and a leakance of 2.9×10^{-3} gpd/ft^3.
- The average measured hydraulic heads during the period from 12/1998 to 3/1999 for the three Floridan aquifer monitor intervals are as follows:
  51.9 feet above mean sea level for the 670 to 837 feet bls interval
  52.1 feet above mean sea level for the 1,142 to 1,458 feet bls interval
  51.1 feet above mean sea level for the 1,645 to 1,759 feet bls interval.
- Water levels in the Floridan aquifer system respond to external stresses such as tidal loading and barometric pressure variations.
- The inorganic water quality, stable isotopes, radiocarbon, and hydraulic head data summarized in this report suggests that two horizons (670 to 837 feet and 1,142 to 1,458 feet bls) in the Floridan aquifer system are hydraulically connected.
- Inorganic, stable isotope, and radiocarbon data suggests that middle Floridan aquifer waters (LAB MZ-3) are composed of Pleistocene-aged meteoric water, which were later intruded by seawater.

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INTRODUCTION

Background

The Lower West Coast Planning Area includes Collier and Lee counties and portions of Hendry, Charlotte, and Glades counties. A combination of natural drainage basins and political boundaries define the extent of this planning area. Water supply plans developed for the Lower West Coast Planning area (LWCPA) identified the Floridan aquifer system (FAS) as a possible water supply alternative. Based on these plans, the South Florida Water Management District (SFWMD) initiated a program of exploratory well construction, aquifer testing, and long-term monitoring (water quality and potentiometric heads) to provide data needed to assess the FAS underlying this area. These wells will supply information needed to characterize the water supply potential of the FAS and for use in the development of a ground water flow model, which will support future planning and regulatory decisions.

Three previous Floridan aquifer system test sites located in the LWCPA were completed under this program (Bennett, 2001a, 2001b, and 2002). The fourth site, the focus of this report is located near the town of LaBelle in northwest Hendry County. **Figure 1** shows the location of the Floridan aquifer test site completed by SFWMD in the LWCPA. These wells are located approximately 1,200 feet north of the Caloosahatchee River in the northeast quadrant of Section 12 of Township 43 South, Range 28 East **(Figure 2).** The geographic coordinates of the LaBelle test/monitor well are 26° 45’11.4” N latitude and 81° 28’ 17.7” W longitude (North American Datum of 1983 – NAD, 1983). Land surface was surveyed at 18.2 feet relative to the National Geodetic Vertical Datum of 1929 (NGVD, 1929).

Purpose

The purpose of this report is to document the hydrogeologic data collected during the SFWMD-initiated FAS well drilling, aquifer testing and monitoring program at the LaBelle site. The information includes a summary of: 1) well drilling and construction details; 2) lithostratigraphy and hydrogeology; 3) water quality and productive capacity; 4) stable isotope and ^{14}Carbon data; 5) petrophysical and petrologic data; 6) aquifer performance test data and analyses; and 7) long-term hydraulic-head data.

Project Description

Site preparation and equipment mobilization at the project site began on January 20, 1997. Two wells were constructed to facilitate aquifer testing and long-term monitoring of the FAS. The first well, a telescoping style, multi-zone monitor well (referred to as LAB-TW) was drilled to a total depth of 2,500 feet below land surface (bls) and completed in three distinct hydrogeologic units. The second well, a dual-zone, test-production well (referred to as LAB-PW) was completed to 1,460 feet with 12-inch diameter casing set at 1,110 feet in depth (**Figure 2).**

SFWMD provided oversight during all well drilling, construction, and testing operations. Diversified Drilling Corporation (DDC), a Tampa based corporation was responsible for all drilling, well construction, and testing services associated with the two FAS wells (LAB-TW and LAB-PW) under SFWMD Contract C-7663.

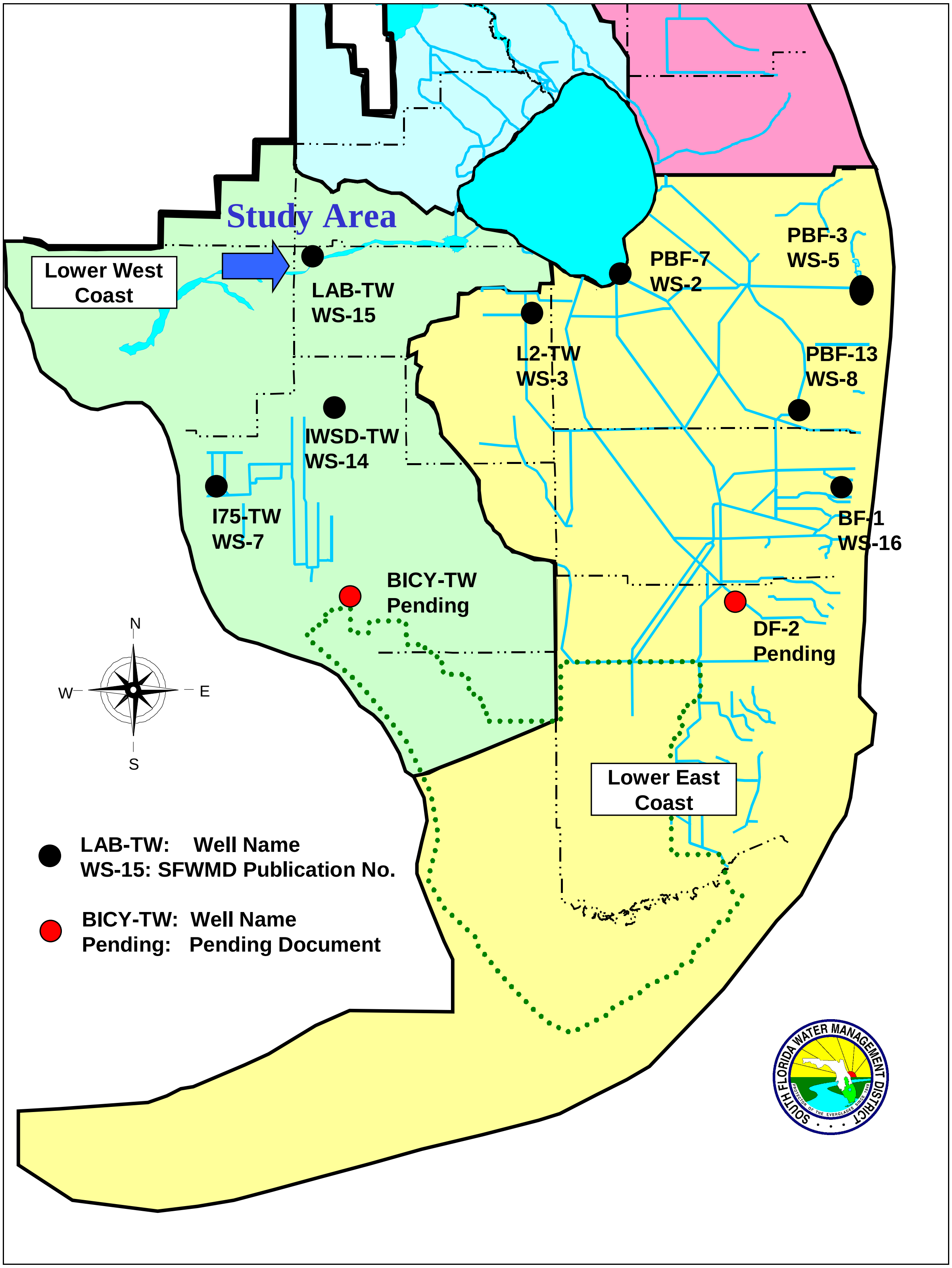

Figure 1. Study Area and Locations of SFWMD Floridan Aquifer Test Sites.

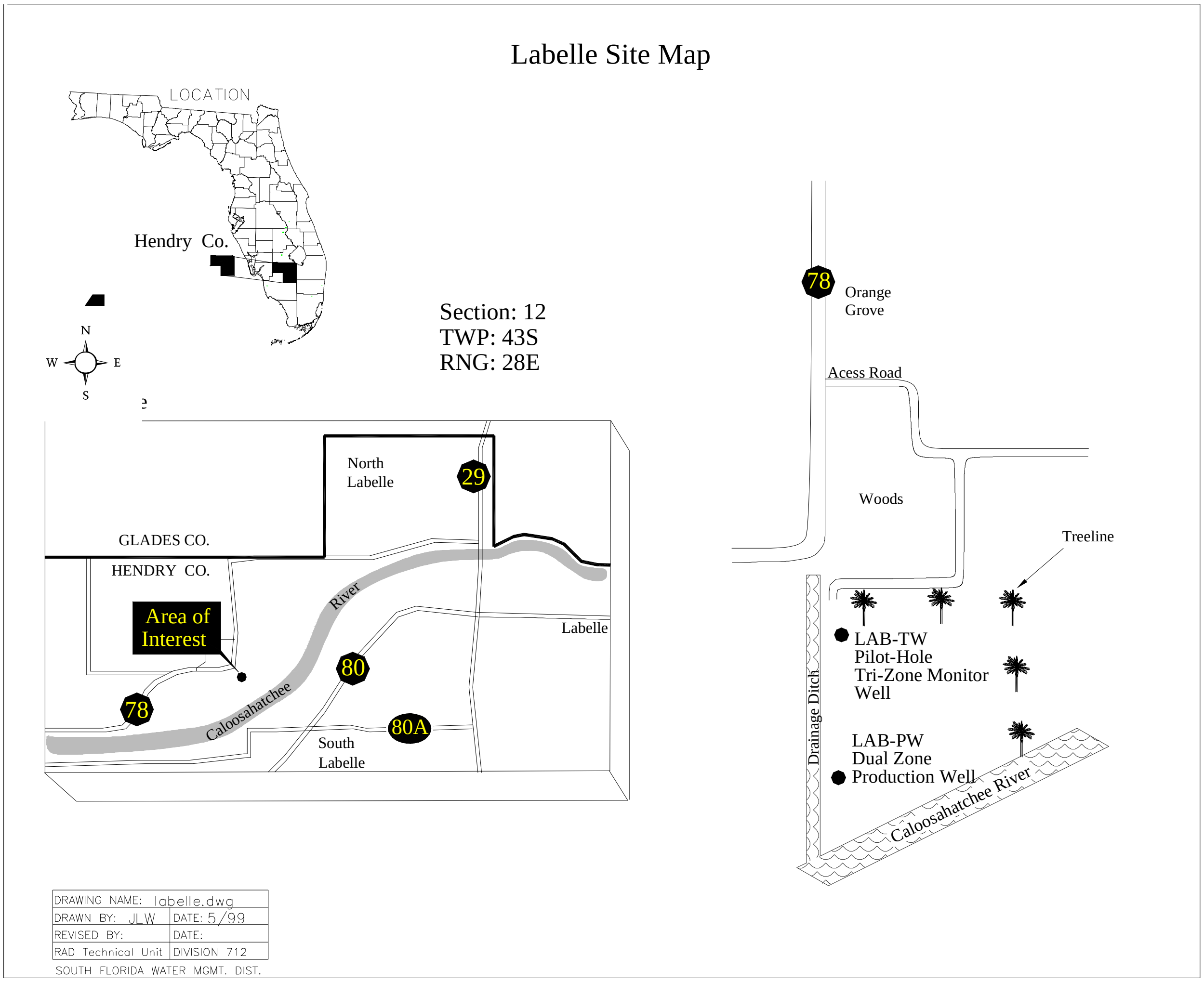

Figure 2. Project Location Map and Site Plan with Detailed Well Locations.

EXPLORATORY DRILLING AND WELL CONSTRUCTION

LaBelle Tri-Zone Monitor Well

On January 20, 1997, DDC delivered drilling and support equipment to begin site preparation for drilling and construction of the Floridan aquifer system monitor well (referred to as LAB-TW). DDC cleared and rough graded the site and lined the ground surface beneath the temporary drilling pad with a high-density polyethylene membrane. DDC then constructed a two-foot thick, drilling pad using crushed limestone with an earthen wall, two feet in height placed around the perimeter of the rig and settling tanks. The drilling pad served to contain drilling fluids and/or formation waters produced during drilling, testing, and construction activities.

Mud rotary and reverse-air techniques were used during drilling operations. Closed-circulation mud rotary drilling was used to advance a nominal 10 to 12-inch diameter pilot hole from land surface to 1,710 feet below land surface (bls). DDC employed the reverse-air, open circulation method to drill the pilot-hole from 1,710 to 2,500 feet bls due to a highly permeable, fractured/cavernous dolostone sequence present below 1,700 feet bls, which prohibited continued mud circulation.

SFWMD used formation samples (well cuttings), packer tests results, and geophysical logs to determine casing setting depths. Once identified, the Contractor reamed the pilot hole to specified diameter and depth for the selected casing setting. Five concentric casings (30-, 24-, 18-, 12-, and 7-inch diameter) were used in the construction of the telescoping style monitor well. **Figure 3** shows a completion diagram of the tri-zone Floridan aquifer system monitor well identified as LAB-TW.

On February 11, 1997, DDC began drilling operations by advancing a 36-inch diameter borehole to a depth of 40 feet bls. DDC then installed 30-inch diameter, steel casing, (ASTM A53, Grade B) to 40 feet bls and pressure grouted the annulus to surface using 71 cubic feet (ft^3) of ASTM Type II neat cement. **Appendix A** contains the factory mill certificates for the well casings.

After installing the 30-inch diameter pit casing, DDC advanced a nominal 12-inch diameter pilot hole using the mud-rotary method from 40 to 210 feet bls. Based on formation samples collected, SFWMD identified low permeability sediments at a depth of 160 feet bls, which marked the base of the surficial aquifer system. However, SFWMD selected the casing point for the 24-inch diameter surface casing at approximately 205 feet bls (45 feet into the confining unit) due to the poorly indurated nature of the sediments at 160 feet bls. DDC then reamed the pilot hole to 207 feet bls using a nominal 29-inch diameter staged bit reamer. Once completed, DDC circulated-out the borehole to remove any residual debris and to stabilize it for subsequent casing installation. On February 18, 1997, CH2M-Hill caliper logged (4-arm caliper) the nominal 29-inch borehole. The caliper log showed no unusual borehole conditions that would prohibit proper installation of the 24-inch diameter surface casing (ASTM A53, Grade B). As a result, DDC installed it to a depth of 205 feet bls and pressure grouted back to 30 feet bls using 355 ft^3 of ASTM Type II neat cement. On February 19, 1997, DDC pumped an additional stage (45 ft^3) of ASTM Type II neat cement causing cement returns at surface. The purpose of the surface casing is to prevent

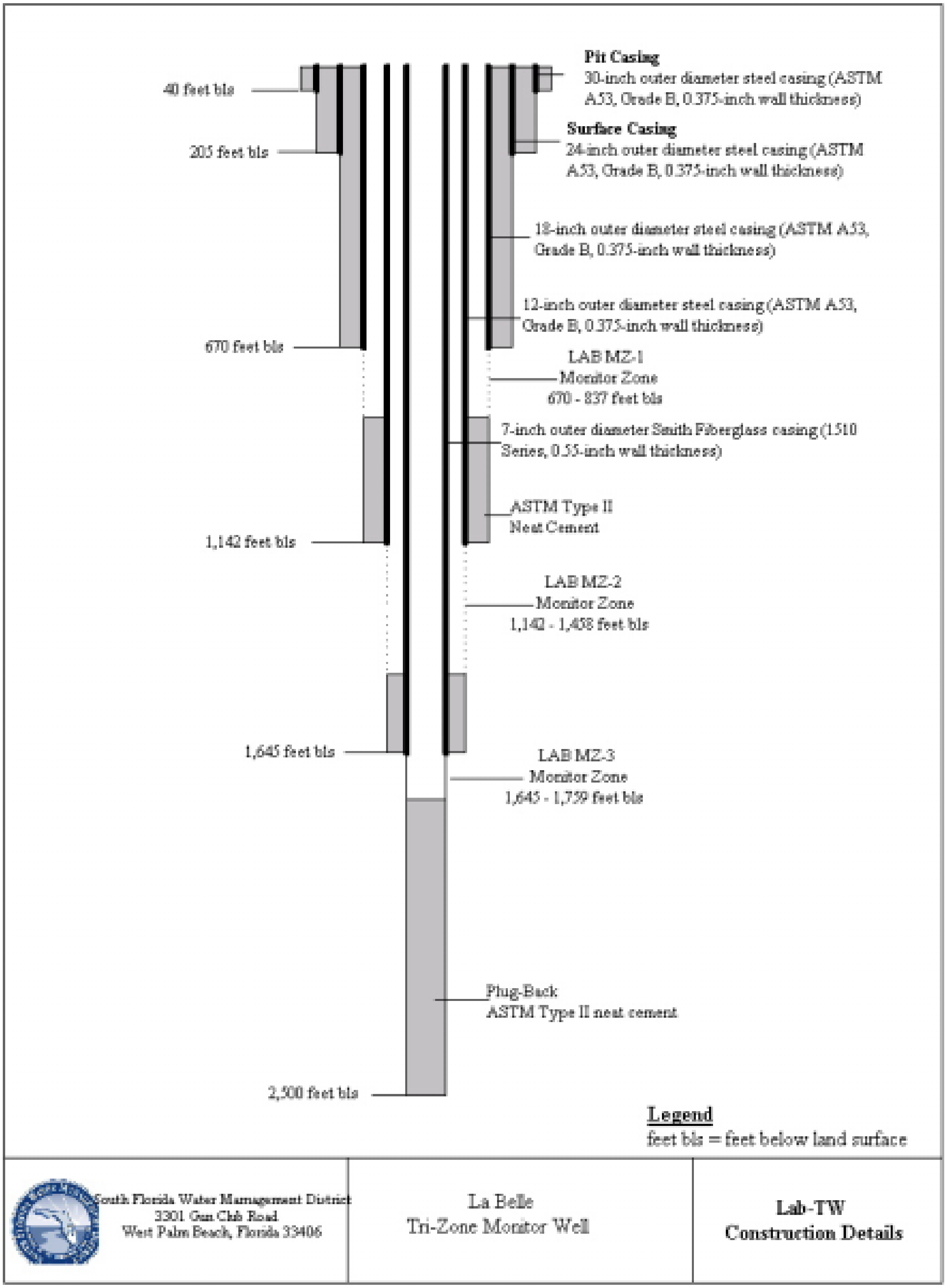

Figure 3. Well Completion Diagram, Tri-Zone Monitor Well LAB-TW.

unconsolidated surface sediments from collapsing into the drilled hole, to isolate potable water sources from brackish water contamination, and to provide drill rig stability during subsequent drilling operations.

With the surface casing in place, DDC installed a pressure control device to handle potential artesian conditions while drilling through the intermediate and Floridan aquifer systems. On February 20, 1997, DDC began to drill a nominal 10-inch diameter pilot-hole via mud rotary method through unconsolidated to semi-consolidated, Miocene-aged sediments and Oligocene/Eocene-aged carbonates. On March 2, 1997, DDC drilled to a depth of 1,100 feet bls, with minor fluid losses (50 gpm) observed from 805 to 850 feet bls. On March 6, 1997, Western Atlas Logging Services (WALS) geophysically logged the water-filled nominal 10-inch diameter pilot hole from 205 to 1,100 feet bls. The logging suite consisted of the following: a Caliper Log, Gamma Ray Log, Spectralog®, Dual Induction-Focused Log, Multipole Array Acoustilog℠, Compensated Z-Densilog℠, a Compensated Neutron Log, Temperature and a Flowmeter log. WALS encountered several problems during logging operations, which required DDC to trip the drill bit assembly in several times to clear the borehole of unstable clays and unconsolidated siliciclastic sediments present in the lower portion of the Arcadia Formation. **Appendix B** contains the individual log traces from Geophysical Run No. 1.

SFWMD reviewed the geophysical logs (**Appendix B**) and lithologic data (located in **Appendix C**) from the subject borehole and identified the top of the Floridan aquifer system at a depth of approximately 665 feet bls. However, the final 18-inch steel casing was set at a depth of 670 feet bls to:

1. Seal off overlying silty clays of the Hawthorn Group and carbonate mud stringers and fine quartz and phosphatic sands within the lower portion of the Arcadia Formation at 660 feet bls to avoid future drilling problems.
2. Facilitate reverse-air drilling operations through the underlying permeable horizons of the Floridan aquifer system to the anticipated depth of 2,500 feet bls.
3. Locate the casing in a competent, well-indurated rock unit to reduce undermining (erosion) at its base as a result of natural and induced high-velocity upward flow.
4. Evaluate flow characteristics of the Floridan aquifer system within the anticipated open-hole interval of 670 to 2,500 feet bls.

Before setting the casing into the top of the upper Floridan aquifer, SFWMD conducted a packer test in a dolostone section of the Arcadia Formation to gain water quality and hydraulic data (see Packer Test Section for results). These efforts provided valuable data on the intermediate aquifer system in an area where it is currently being used for agricultural purposes.

Once the testing operations were completed, DDC installed temporary back-fill material (clean 3/8-inch diameter crushed limestone) in the nominal 10-inch diameter pilot hole to 660 feet bls. This elevation was based on the proposed depth of 670 feet bls at which to set the casing. The temporary backfill material reduced the potential of formation damage to the permeable carbonate section from 670 to 1,100 feet bls by prohibiting Hawthorn Group sediments from entering the previously drilled borehole during mud rotary reaming operations. DDC then reamed a nominal 23-inch diameter borehole to 670 feet bls using the mud rotary method. On

March 19, 1997, CH2M-Hill caliper logged the nominal 23-inch diameter borehole to 670 feet bls without incident. The caliper log trace showed no unusual borehole conditions that would prohibit proper installation of the 18-inch diameter steel casing to 670 feet bls. DDC installed the 18-inch diameter steel casing (ASTM A53, Grade B) to a depth of 670 feet bls and pressure grouted the annular space using 826 ft^3 of ASTM Type II neat cement. Steel tubing was then used to physically locate (hard tag) cement levels within the annulus. The hard tag indicated cement levels at 210 feet bls, which was in close agreement to calculated theoretical volumes using the caliper log data. On March 20, 1997, DDC pumped an additional 150 ft^3 of ASTM Type II neat cement via the tremie method causing cement returns at surface. **Appendix A** contains a factory mill certificate for the 18-inch diameter steel casing.

Once the 18-inch diameter steel casing was installed, DDC drilled out the cement plug at the base of the 18-inch diameter casing (a result of pressure grouting) using a nominal 17-inch diameter bit. DDC reconfigured the drill bit assembly using a 10-inch diameter bit and removed the temporary backfill material (crushed limestone) from 670 feet to 1,100 feet bls. DDC began to develop the open-hole interval from 670 to 1,100 feet by the reverse-air method for subsequent packer testing activities. On March 31, 1997, SFWMD conducted a packer test from 670 to 920 feet bls to gain hydraulic and water quality data from the upper portion of the Floridan aquifer. See Packer Test Section of this report for further details and results.

Upon completion of the packer tests, DDC advanced the nominal 10-inch diameter pilot hole using the mud rotary method through moderately to well-indurated wackestones, packstones, and dolostones of the Ocala Limestone and Avon Park Formation. A cavernous dolostone unit was encountered at 1,700 feet bls, which caused a loss of mud circulation and a 4-foot drop of the drill rod. The DDC mixed and circulated approximately 15,000 gallons of drilling fluid in an effort to regain circulation; these efforts were unsuccessful. Based on cost and time considerations, SFWMD decided to switch to the reverse-air drilling method to continue pilot-hole drilling to an anticipated depth of 2,500 feet bls. Consequently, DDC reconfigured their drilling equipment and site to accommodate reverse-air-drilling operations.

On April 9, 1997, DDC resumed drilling operations via reverse-air method through this predominately dolostone sequence. Drilling rates slowed considerably between 1,710 to 1,876 feet bls, with corresponding increases in drill bit chatter and minor drops in the drill rod indicating potential fractured intervals. In addition, while drilling through this interval, reverse-air discharge rates increased and circulated return fluids began to foam. These two observations indicate the presence of a highly permeable horizon that contains formation water of poor quality (elevated sodium chloride and total dissolved solids concentrations) within this interval. Drilling continued through the dolostone sequence and into a predominately limestone sequence that extended from 1,876 to 2,500 feet bls. On April 21, 1997, DDC completed reverse-air drilling of the nominal 10-inch diameter pilot hole to a total depth 2,500 feet bls.

On April 25, 1997, WALS geophysically logged the water-filled nominal 10-inch diameter pilot hole from 670 to 2,500 feet bls. The logging suite included Caliper Log, Gamma Ray Log, Spectralog®, Dual Induction-Focused Log, Multipole Array Acoustilog^{SM}, Compensated Z-Densilog^{SM}, and a Compensated Neutron Log. As part of this logging suite, WALS would conduct a nuclear magnetic resonance log (MRIL- a permeability log), however, after a review of the caliper log, WALS's logging engineer identified that the borehole diameters exceeded the tool design limit of 13-inches (over 90% of the proposed log interval) and the subsequent data would be of little value. Therefore, WALS did not conduct the MRIL. On April 26, 1997, CH2M-Hill successfully ran production evaluation logs under artesian flow (dynamic) conditions. These production logs included a flowmeter, high-resolution temperature log, and fluid resistivity log. **Appendix B** contains the individual log traces from well LAB-TW including formation evaluation (Geophysical Run No. 2) and production logs (Geophysical Run No. 3).

SFWMD attempted to conduct a borehole video survey of the pilot hole on April 27, 1997. However, several large dolostone boulders at 1,780 feet bls obstructed the borehole. Consequently, DDC tripped the drill bit assembly into the borehole, cleared the obstruction at 1,780 feet bls, and redeveloped the interval from 1,780 to 2,500 feet bls. SFWMD successfully completed the borehole video log from 670 to 2,500 feet bls on April 29, 1997.

SFWMD selected packer test intervals based on information provided by analysis of the geophysical logs, video survey, and formation samples (well cuttings). The first of two tests began on May 1, 1997. The purpose of these tests was to characterize the water quality and production capacities of specific intervals within the middle portion of the Floridan aquifer system (1,145 to 1,495 feet bls). This was done to identify intervals having total dissolved solid (TDS) concentrations less than 10,000 mg/L for long term monitoring and aquifer testing purposes. From a water resource perspective, intervals having TDS concentration greater than 10,000 mg/L were not considered for further aquifer hydraulic characterization because they are not considered potential sources of drinking water as defined in Chapter 62-520 of the Florida Administrative Code. An "Underground Source of Drinking Water" (USDW) is defined as an aquifer containing water with a TDS concentration of less than 10,000 mg/L. SFWMD completed packer testing operations on May 5, 1997.

Following packer testing operations, all available information was compiled and used to select the open-hole sections for the two lower monitor zones. SFWMD selected 1,142 feet bls as the casing point for the nominal 12-inch diameter steel casing. DDC used a nominal 17-inch diameter bit to ream the pilot hole from 670 feet bls (base of the 18-inch diameter casing) to 1,142 feet bls. On May 8, 1997, the reamed borehole was caliper logged by CH2M-Hill to evaluate borehole stability and to calculate cement volumes for grouting operations. DDC attached three steel cement baskets to the nominal 12-inch diameter steel casing at 1,125, 1,130, and 1,135 feet bls and installed the casing at 1,142 feet bls. DDC then cement-grouted the annular space via the tremie method using multiple stages of ASTM Type II neat cement pumping 345 ft^3 of ASTM Type II neat cement. This volume brought cement level to 837 feet bls, which formed the base of the first Floridan aquifer system monitor interval (referred to as LAB MZ-1). **Appendix A** contains a factory mill certificate for the 12-inch diameter steel casing.

Next, DDC installed threaded-and-coupled nominal 7-inch diameter fiberglass reinforced pipe (FRP-Smith Fiberglass, SDT 1510 series) to a depth of 1,645 feet bls. DDC secured three cement baskets to the FRP at 1,630 1,635, 1,640 feet bls, then installed the FRP and cement-grouted it in place via the tremie method using 225 ft^3 of ASTM Type II neat cement pumped in multiple stages. Stage grouting operations caused cement levels to rise to 1,458 feet bls, which formed the base of the second Floridan aquifer system monitor interval (referred to as LAB MZ-2). On June 3, 1997, DDC completed cement grouting of the nominal 7-inch diameter FRP that secured it in place and completed the upper limit of the third Floridan aquifer system monitor zone. **Appendix A** contains a material specification sheet for the 7-inch diameter FRP.

SFWMD originally designed LAB-TW to monitor four distinct hydrogeologic units within the Floridan aquifer system including the lower Floridan aquifer. However, unstable borehole conditions below 1,700 feet bls (fractured and cavernous interval within this dolostone unit) prohibited installation of the proposed 2-inch diameter fiberglass tubing necessary to complete the lower Floridan aquifer monitor well. DDC attempted to install the 2-inch diameter FRP several times but were unsuccessful. Consequently, SFWMD decided to back plug the nominal 10-inch diameter borehole to 1,759 feet bls. During back-plugging operations, DDC installed 2,680 ft^3 of ASTM Type II cement and 15 cubic yards of clean limestone gravel. The cement level at 1,759 feet bls formed the lower limit of third Floridan aquifer system monitor interval (referred to as LAB MZ-3).

DDC installed three, 2-inch diameter, stainless steel extensions equipped with 2-inch inner diameter stainless steel ball valves to complete the wellhead for the tri-zone Floridan aquifer system monitor well. The completed telescoped-style well allows SFWMD to monitor water levels and water quality in three distinct intervals. The uppermost monitor zone (LAB MZ-1) is constructed using 18-inch diameter casing and completed with an annular zone between 670 and 837 feet bls. The intermediate zone (LAB MZ-2) is completed above the USDW from 1,142 to 1,458 feet bls. The lowermost well (LAB MZ-3) constructed of 7-inch diameter threaded FRP was completed below the USDW with an open hole of 1,645 to 1,759 feet bls. **Table 1** lists the monitor intervals and completion methods for the tri-zone Floridan aquifer system monitor well.

Identifier	Monitor Interval (feet bls)	Completion Method
LAB MZ-1	670 to 837	Annular Zone
LAB MZ-2	1,142 to 1,458	Annular Zone
LAB MZ-3	1,645 to 1,759	Open-Hole

Table 1. Summary of Monitor Interval and Completion Method for Tri-Zone Floridan Aquifer System Monitor Well.

DDC developed the three monitor intervals by over-pumping and artesian flow techniques until the sediment concentration of the formation waters was 5 milligrams per liter (mg/L) or less (using an Imhoff cone). DDC then constructed a 5-foot by 5-foot reinforced concrete pad at the surface of the monitor well head with a 6-foot high chain link fence erected around the perimeter of the well pad. DDC completed well construction operations related to LAB-TW on July 20, 1997. **Figure 4** is a photograph of the completed tri-zone monitor well head and fence enclosure.

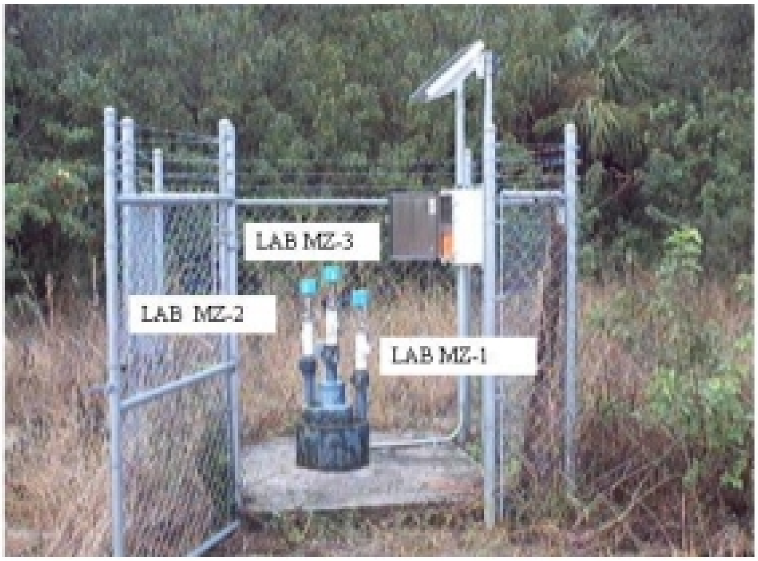

Figure 4. Photograph of Completed Tri-Zone Monitor Wellhead and Fence Enclosure (LAB-TW).

LaBelle Test-Production Well

DDC cleared and rough graded the proposed location of the test-production well and began construction of a 60-foot by 40-foot temporary drilling pad. The drilling pad consisted of two feet of crushed limestone, lined with a high-density polyethylene membrane. DDC then moved the drill rig and support equipment from the monitor well pad (LAB-TW) and configured the equipment on the newly constructed drilling pad to begin drilling operations for the test-production well. Once DDC moved their equipment, they constructed an earthen wall, two feet high around the perimeter of the drilling pad that surrounded the rig and settling tanks. The purpose of the temporary drilling pad was to contain drilling fluids and/or formation waters produced during well drilling, testing, and well construction activities.

SFWMD initiated the construction of this well to facilitate aquifer testing of two horizons identified between 670 and 1,460 feet bls. DDC began actual construction of the test-production well on June 26, 1997. **Figure 5** is a completion diagram of the dual-zone Floridan aquifer system test-production well identified as LAB-PW.

SFWMD designed the dual-zone, test-production well using three concentric steel casings (24-, 18-, and 12-inch diameter). DDC installed the 24-inch diameter pit casing (ASTM A53, Grade B) to 40 feet bls and pressure grouted it to surface using 75 ft^3 of ASTM Type II neat cement. Once completed, DDC advanced a nominal 23-inch diameter borehole by the mud rotary method to depth of 680 feet bls, 10 feet into the top of the upper Floridan aquifer. On July 7, 1997, CH2M-Hill ran a caliper log in the nominal 23-inch diameter borehole to evaluate stability and to calculate cement volumes for grouting operations. DDC then installed the first production casing, which consisted of 18-inch diameter steel pipe (ASTM A53, Grade B, and 0.375-inch wall thickness) to 670 feet bls. The casing was pressure grouted in place using 970 ft^3 of Type II neat cement, which caused cement returns at surface. On July 15, 1997, DDC drilled-out the cement plug at the base of the 18-inch diameter casing (a result of pressure grouting) using a

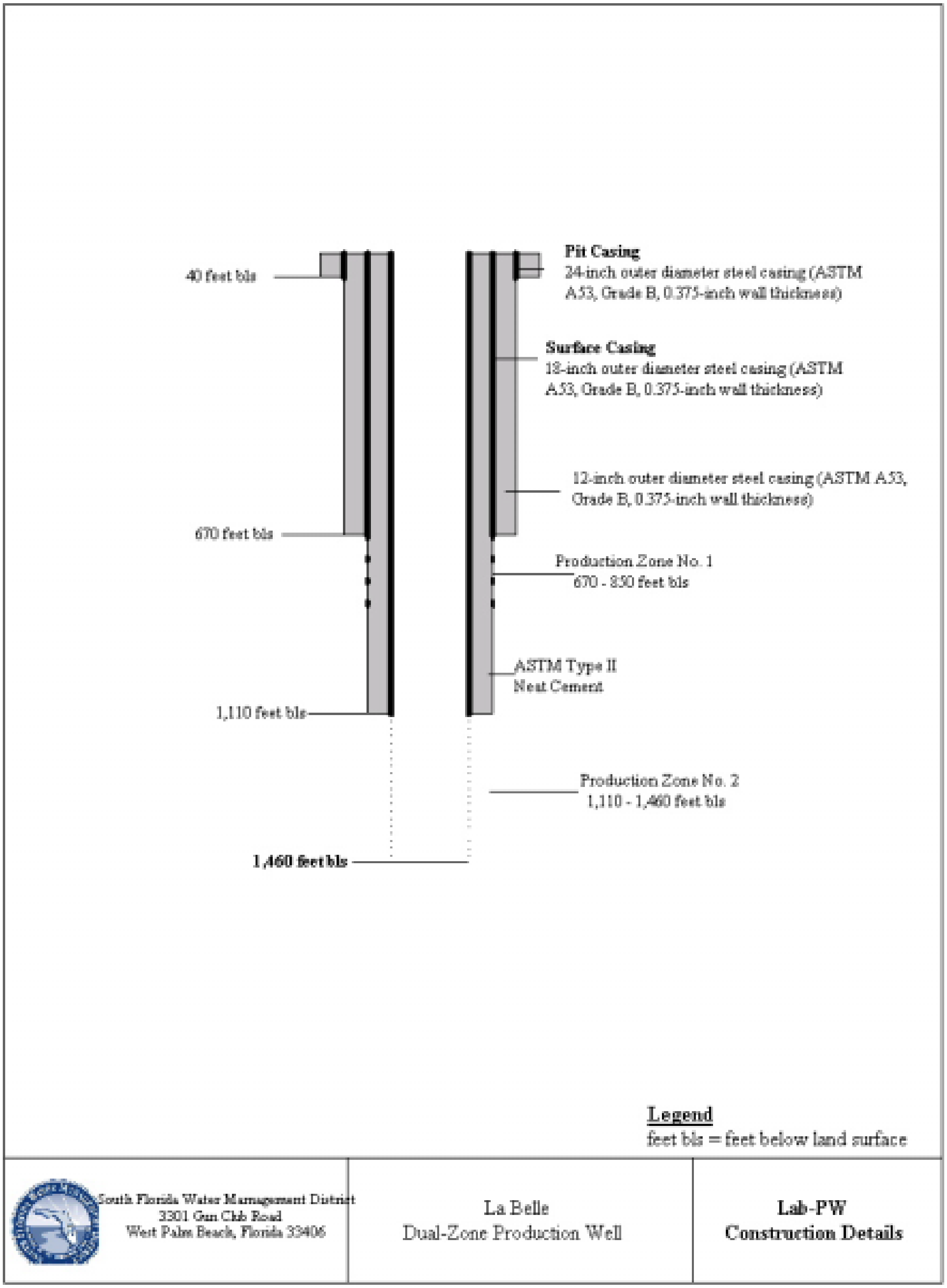

Figure 5. Well Completion Diagram, Test Production Well LAB-PW.

nominal 17-inch diameter bit. DDC re-configured the drill bit assembly and began to advance a nominal 10-inch diameter borehole through the upper Floridan aquifer to 850 feet bls via reverse-air method. While DDC drilled through the uppermost section of the Floridan aquifer system, they retrieved four, 10-foot long, full-diameter rock cores (4-inch diameter) with an overall recovery efficiency of 41 percent.

DDC developed the production interval from 670 to 850 feet bls using reverse-air and artesian flow techniques until the sediment concentration of the produced water was 5 mg/L or less (using an Imhoff tube). Once well development was completed, DDC geophysically logged the production horizon. SFWMD then conducted an aquifer performance test (APT) on the upper Floridan production interval during the middle part of August 1997 (see APT section for details and results).

After successfully completing the first APT, DDC advanced the borehole via reverse-air drilling method using a nominal 17-inch diameter bit to the top of the second test horizon at 1,110 feet bls. Southern Resource Exploration ran a caliper log to help SFWMD evaluate borehole stability and to calculate cement volumes for subsequent grouting operations. The second stage of well construction consisted of DDC installing 12-inch diameter steel casing (ASTM A53, Grade B, and 0.375-inch wall thickness) to 1,110 feet bls. The second production casing was grouted to land surface using 1,345 ft^3 of ASTM Type II neat cement using both pressure and tremie grouting methods. DDC completed installation of the 12-inch diameter, steel production casing on August 26, 1997.

DDC drilled the second test interval using a nominal 12-inch bit by the reverse-air method to a total depth of 1,460 feet bls. DDC retrieved a total of three, 10-foot long, full-diameter rock cores (4-inch diameter) from the second production interval (1,110 to 1,460 feet bls – lower Ocala Limestone - Avon Park Formation). SFWMD sent these cores, plus the four previously obtained cores from the first production interval to Core Laboratories in Midland, Texas for petrophysical and petrologic analyses (See Petrophysical/Petrologic Section for further information). On September 5, 1997, DDC completed drilling of the second test interval to a depth of 1,460 feet bls.

DDC developed the second production horizon using reverse-air and artesian flow techniques until the sediment concentration of the produced water was 5 mg/L or less (using an Imhoff cone). Once sufficiently developed, DDC geophysically logged the open-hole section (1,110 to 1,460 feet bls). SFWMD conducted and successfully completed the second APT on October 14, 1997 (see APT section for test details and results).

DDC installed a standard 12-inch diameter well head, which consisted of an iron body, bronze-mounted valves with flanged ends, solid wedge gate, and outside screw and yoke gate valves with an 8-inch diameter side discharge port. DDC then constructed a 5-foot by 5-foot reinforced concrete pad at the surface on November 12, 1997 to complete the construction of the test-production well. **Figure 6** is a photograph LAB-PW showing the completed well head and fence enclosure.

Figure 6. Photograph of Completed Test-Production Wellhead and Fence Enclosure (LAB-PW).

STRATIGRAPHIC FRAMEWORK

SFWMD collected geologic formation samples (well cuttings) from the pilot hole during drilling operations for the tri-zone monitor well (LAB-TW) and separated them based on their dominant lithologic or textural characteristics, and to a lesser extent color. The onsite geologist then washed and described the samples using the Dunham (1962)-classification scheme. SFWMD sent these samples to the Florida Geological Survey for further analysis and long-term storage. **Appendix C** contains a copy of the Florida Geological Survey's detailed lithologic description for the pilot hole/monitor well LAB-TW (reference no. W-17591). An electronic version of the lithologic description can be downloaded directly from Florida Geological Survey's Internet site. **Figure 7** shows a generalized lithostratigraphic and hydrogeologic section underlying the LaBelle site.

Pliocene-Pleistocene Series

Undifferentiated Sediments

The undifferentiated Pliocene-Pleistocene age sediments occur from land surface to a depth of 125 feet at this site. These sediments consist of unconsolidated, yellowish-gray clay, shell beds, and yellowish-gray, fine to very coarse-grained quartz sand units. The interval from 125 to 200 feet bls consists of white to yellowish-gray mudstones and packstones identified by the Florida Geological Survey as the Ochopee Limestone member of the Tamiami Formation (personal communication Rick Green, FGS).

Miocene-Pliocene Series

Hawthorn Group

The Hawthorn Group is composed of a heterogeneous mixture of silt, clay, calcareous clay, dolosilt, quartz sand, phosphate, limestone, and dolomite. The Group can be subdivided into two lithostratigraphic units. The upper unit is composed of predominantly siliciclastic material of the Peace River Formation. The lower unit is composed principally of carbonates of the Arcadia Formation (Scott, 1988). A major regional disconformity separates these two units and can often be identified by the occurrence of a rubble bed of coarse sand to pebble-sized quartz and phosphatic grains (Missimer, 1997, 2002). If present, this unit produces a distinctive response ("peak") on the natural gamma ray log.

Peace River Formation

The top of the Peace River Formation is recognized as yellowish-gray unconsolidated clayey shell beds with minor phosphate component. These unconsolidated to poorly indurated shell beds occur at a depth of 200 feet bls and continue to 255 feet bls where an unconsolidated, yellowish-gray to black colored phosphatic sand is found.

Arcadia Formation

Generally, the Arcadia Formation is identified from the Peace River Formation by a lithologic change from predominately siliciclastic to mixed siliciclastic-carbonate sediments. At this site, the natural gamma log below 255 feet bls indicates thin, intermittent gamma radiation peaks associated primarily with intervals of significant phosphatic sand/silt content. The presence of a phosphate lag deposit that produced a distinctive peak on the natural gamma ray log at depth of 255 feet bls marks the top of Arcadia Formation (Missimer, 2002). This yellowish-gray to black, unconsolidated phosphatic sand unit combined with shell material, quartz sand, and clay extends from 255 to 275 feet bls. Sediments of similar lithologic character with varying phosphate content continue from 275 to 315 feet bls. An orange to light gray, moderately indurated wackestone occurs at a depth of 315 feet bls and continues to 330 feet bls where a poorly indurated, medium olive-green to gray, clayey-silty mudstone and clay units are found. These low permeability sediments are approximately 165 feet thick and extend to a depth of 495 feet bls.

A distinctive lithologic break occurs at 495 feet bls where a yellowish-gray to light gray, moderately indurated, crystalline dolostone is encountered. The top of this dolostone unit is noted by a gauged borehole (as seen on the caliper log), an increase in bulk density and electrical resistivity readings and decrease in sonic transit times and density/neutron derived porosity values (see Geophysical Log Run No. 1 – **Appendix B**). This competent low porosity dolostone unit continues to a depth of 545 feet bls.

The lithology below 545 feet bls shifts to a predominately siliciclastic unit. This siliciclastic sequence is composed of poorly indurated, yellowish-gray to olive-gray clays and silts with intervals of unconsolidated quartz sand. The top of this interval is marked by a reduction in resistivity, photoelectric and bulk density values, and an increase in sonic transit times. The photoelectric log (used as a lithologic indicator based on electron density) readings of 2 barnes per electron (b/e) from 545 to 665 feet bls indicates a clayey silt to fine-sand unit with a minor carbonate component. The bulk density (ZDEN) and derived porosity logs (e.g., PORZ and CNCF curves) from 545 to 665 feet bls suggest low density, high porosity sediments with average derived porosity in excess of 50 porosity units. WALS calculated the sonic, neutron and density log derived porosity units using a limestone matrix with a bulk density of 2.71 gram per cubic centimeter (g/cc). Several sections of the borehole are enlarged ("washed out") between 610 and 665 feet bls (see caliper log traces from Geophysical Log Run No. 1 – **Appendix B**), which correspond to unconsolidated quartz sand and silt lenses.

The basal portion of the Arcadia Formation at this site is composed primarily of moderately indurated, sandy, phosphatic carbonate mudstones and wackestones that occur from 665 to 740 feet bls. The top of this interval is identified by a gauged borehole, an increase in electrical resistivity and bulk density and lower natural gamma ray activity and sonic transit times (see Geophysical Log Run No. 1 - **Appendix B**). Well-indurated, low porosity limestones (from 665 to 690 feet bls) provided a suitable point to set the base of the 18-inch diameter steel casing. This casing served as the uppermost monitor interval for the tri-zone well.

Oligocene

Suwannee Limestone

The Florida Geological Survey and SFWMD identified the contact between the Arcadia Formation and the Suwannee Limestone at a depth of 740 feet bls based on lithologic character and changes in physical characteristics recorded on the geophysical logs. Lithologically, the basal portion of the Arcadia Formation is composed of a light gray, sandy (35% quartz sand), phosphatic (10% phosphate grains) wackestone whereas the Suwannee Limestone is a yellowish-gray packstone containing considerably less quartz (10%) and phosphate (2%) sands than the Arcadia Formation. Geophysically, this contact is marked by an attenuation of the natural gamma activity primarily due to the decrease in phosphate content in the upper Suwannee Limestone. In addition, the Suwannee Limestone at this site is characterized by lower sonic transit times, higher bulk density values and lower density and neutron log derived porosity as compared to the basal facies of the Arcadia Formation.

The Suwannee Limestone occurs from 740 to 810 feet bls and consists predominantly of packstone and grainstone units. Through this interval, the photoelectric log values average 3.5 b/e indicating a carbonate lithology with a minor silt/sand component (Hallenburg, 1998) with high density and neutron log derived porosity values (average 40 porosity units). A well-indurated, dark gray, low porosity, clay/mudstone from 805 feet to 810 feet bls marks the base of this lithostratigraphic unit. The presence of a clay unit in a predominately carbonate sequence marks a change in depositional environment and is noted on the natural gamma log by an increase in gamma ray activity consistent with increased clay content.

Upper Eocene

Ocala Limestone

The Ocala Limestone is identified at a depth of 810 feet bls. The upper boundary is marked by a change in lithology from a dark gray clay/mudstone at the base of the Suwannee Limestone to a light orange to grayish orange, moderately indurated, phosphate free dolostone. In addition, this formation boundary coincides with attenuation in natural gamma ray activity, higher electrical resistivity, and lower density and neutron log derived porosity values. However, the first occurrence of Lepidocyclina sp., a diagnostic microfossil (used extensively as a biostratigraphic indicator for the Ocala Limestone) occurs at 855 feet bls, 45 feet below the identified top of the Ocala Limestone. The dolostone present at the top of the Ocala Limestone may have formed in a shallow water (supratidal?) near-shore depositional environment. The dolostone at the top of the Ocala Limestone overlain by a clayey carbonate unit of the basal Suwannee Limestone may reflect a sea level change and a transition from a supratidal to lagoonal depositional environment.

The Ocala Limestone occurs from 810 to 1,150 feet bls. It consists primarily of light orange to gray, poorly to moderately indurated mudstones and wackestones. The allochemical constituent are primarily larger foraminiferal tests such as Lepidocyclina sp., Nummulites sp., and mollusks. Through this lithostratigraphic unit, the natural gamma log records low emissions, the photoelectric log values average 4 b/e, and the neutron and density porosity curves record similar values (see Geophysical Log Run No 2 - **Appendix B**). These geophysical log responses indicate a relatively clean limestone unit.

Middle Eocene

Avon Park Formation

The Avon Park Formation ranges from beige to light brown, moderately to well-indurated packstone to brown to gray colored, well-indurated dolostones. The Florida Geological Survey and SFWMD identified the top of the Avon Park Formation at a depth of 1,150 feet. At this depth, a lithologic change occurs from a mudstone/wackestone to a dolomitic/crystalline wackestone/packstone sequence marked by a change in fossil assemblage and an increase in natural gamma activity. The Florida Geological Survey first observed the diagnostic microfossil Dictyoconus sp. in formation samples at a depth of 1,195 feet bls.

The Avon Park Formation from 1,150 to 1,645 feet bls consists predominantly of moderately indurated, tan to yellowish brown wackestone and packstone units with minor to moderate recrystallization. A significant change in lithology occurs at a depth of 1,645 feet and continues to 1,885 feet bls. Well-indurated crystalline (euhedral to subhedral) dolostones which are cavernous and highly fractured, dominate this interval. Thin stringers of moderately indurated mudstones and wackestones are interspersed throughout this dolostone sequence. The resistivity, photoelectric, density, neutron, sonic, and caliper logs record the change in lithology, porosity, and structure of this dolostone sequence as seen in their individual log traces obtained from Geophysical Log Run No. 2 - **Appendix B**.

The Avon Park Formation below 1,885 feet bls returns to a limestone sequence, which consists almost entirely of poorly to moderately indurated wackestones and packstones (partially recrystallized and dolomitic), interspersed with a few well-indurated dolostone units. The photoelectric log with values near 4 b/e records this lithologic change to a limestone sequence. At a depth of 2,365 feet bls, the Florida Geological Survey observed minor amounts (1 to 5%) of gypsum and anhydrite in the formation samples. Dictyoconus sp., a diagnostic microfossil of the Avon Park Formation, is present in formation samples to a depth of 2,500 feet bls.

Lower Eocene

Oldsmar Formation

The top of the Oldsmar Formation is often difficult to identify. Its diagnostic microfossils are often obliterated by diagenetic effects and its lithologic character is similar to the overlying Avon Park Formation. However, a review of the borehole data indicates that the Oldsmar Formation was not present to a depth of 2,500 feet bls, based on established lithologic and paleontologic criteria (Applin and Applin, 1944; Chen, 1965; Miller, 1986; Duncan et al., 1994).

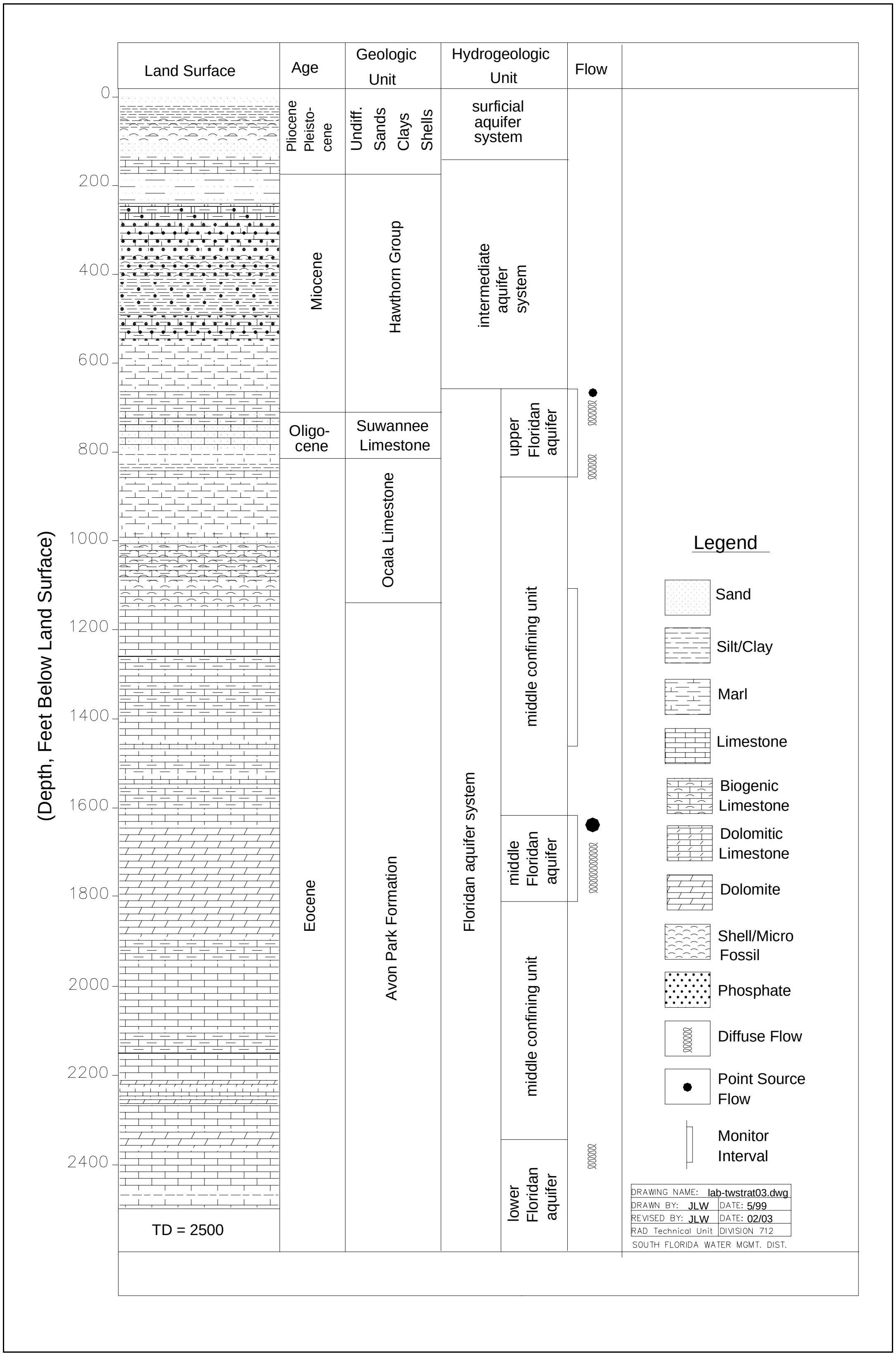

Figure 7. Generalized Hydrogeologic Section.

HYDROGEOLOGIC FRAMEWORK

Three major aquifer systems underlie this site, the surficial aquifer system, the intermediate aquifer system, and the Floridan aquifer system with the Floridan aquifer system being the focus of this test well program. These aquifer systems are composed of multiple, discrete aquifers separated by low permeability "confining" units that occur throughout this Tertiary/Quaternary-aged sequence.

Surficial Aquifer System

The surficial aquifer system consists of several productive units separated by low permeability sediments that extend from land surface to a depth of 160 feet bls. An unconfined aquifer is present from land surface to 25 feet bls with a zone of lost circulation present near its base. An intervening confining unit from 25 feet to 70 feet bls consists of poorly indurated, bluish-gray clay. A second productive interval is present from 75 feet to 125 feet bls and consists of unconsolidated medium to very coarse-grained quartz sand (referred to by the drilling superintendent as "ball bearing sands"). The Contractor also noted significant losses of drilling fluids through this interval suggesting a moderately productive horizon.

A change in lithology to a yellowish-gray, moderately indurated packstone sequence occurs below 125 feet bls and continues to a depth of 160 feet bls (part of Ochopee Limestone Member of the Tamiami Formation per Florida Geological Survey). A white to light orange, poorly-indurated low permeability arenaceous calcilutite (mudstone) unit at 160 feet bls forms the base of the surficial aquifer system at this site.

Intermediate Aquifer System

Below the surficial aquifer system lies the intermediate aquifer system, which extends from 160 to 665 feet bls. The lower portion of the Pliocene-aged Tamiami Formation and the Miocene/Pliocene-aged Hawthorn Group (Scott, 1988) act as confining units, separating the Floridan aquifer system from the surficial aquifer system. Lithologic information obtained from drill cuttings from LAB-TW indicates that the Hawthorn Group sediments consist of unconsolidated shell beds, soft non-indurated clay, silt and quartz-phosphate sand units, and poorly to moderately indurated mudstones and wackestones (see Florida Geological Survey lithologic description in **Appendix C**).

The intermediate aquifer system underlying the lower west coast region contains multiple productive zones separated by low permeability inter-aquifer confining units. However, at this site, regionally extensive hydrogeologic units are absent or of low productivity. The top of the intermediate aquifer system is marked by low permeability arenaceous mudstones and silty clays from 160 to 190 feet bls. A low to moderately productive unit occurs from 190 to 315 feet bls and consists of unconsolidated shell beds with varying percentage of detrital clay, silt and quartz sand and phosphate grains. Below this minor productive interval is a relatively thick inter-aquifer confining unit that extends from 315 to 495 feet bls. This confining unit consists of low permeability, light gray to medium gray, lime mud (micrite) with minor biogenic limestone stringers and poorly indurated olive gray to dark greenish-gray clay.

A distinctive lithologic break occurs at 495 feet bls where a yellowish-gray to light gray, moderately indurated, crystalline dolostone is encountered and continues to 545 feet bls. Based on well cuttings, this interval indicated moderate production capacity, but a specific capacity test conducted on this interval only yielded 0.6 gallon per minute per foot (gpm/ft) of drawdown.

The lithology from 545 to 665 feet bls shifts in lithologic character to a predominately siliciclastic unit composed of poorly indurated clay, sandstone, unconsolidated sand units, and 5 to 20% calcilutite. This interval is noted by an irregular sonic log trace, increase in sonic transit times and computed porosity values, lower bulk density and resistivity values, and a photoelectric average value of 2 b/e. These geophysical log responses are typically associated with the above mentioned lithologic units. Two washouts at 610 and 640 feet bls are seen on the caliper log trace (XCAL), corresponds to unconsolidated quartz sand/silt lenses that mark the base of this interval. These low permeability siliciclastics form the lower boundary of the intermediate aquifer system at 665 feet bls.

Floridan Aquifer System

The Floridan aquifer system consists of a series Tertiary limestone and dolostone units. The system includes sediments of the lower Arcadia Formation, Suwannee and Ocala Limestones, Avon Park Formation, and the Oldsmar Formation.

Upper Floridan Aquifer

The top of the Floridan aquifer system, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) coincides with the top of a vertically continuous permeable early Miocene to Oligocene-aged carbonate sequence. The upper Floridan aquifer consists of thin, high permeability water-bearing horizons interspersed with thick, low permeability units of early Miocene to middle-Eocene age sediments, including the basal Arcadia Formation, Suwannee and Ocala Limestones, and the Avon Park Formation. At this site, the top of the Floridan aquifer system occurs at a depth of 665 feet bls, which coincides with the top of the lower portion of the Arcadia Formation (Basal Hawthorn Unit, Reese, 2000).

On a regional scale, two zones of high permeability exist within the upper Floridan aquifer and typically lies between 700 and 1,300 feet bls. 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). The first transmissive unit at the LaBelle site occurs from 670 to 850 feet bls and includes the basal Arcadia Formation, the Suwannee Limestone and upper Ocala Limestone. This productive unit is composed of light orange to medium gray, poorly to moderately indurated wackestone to packstone units. While drilling, the Contractor lost mud circulation at 795 feet and 810 feet bls and noted moderate drilling fluid losses on the daily drilling reports within an interval from 810 to 850 feet bls. Fluid losses are indicative of porous or permeable horizons. These lost circulation horizons coincide with a transition between the Oligocene-aged Suwannee Limestone and Eocene-aged Ocala Limestone. Deflections in the temperature log trace at this contact and within this interval suggest minor flow zones. In addition, the positive deflection in the flowmeter log trace indicates increased water production at specific depths, which closely correspond to the temperature log and drilling data through this interval. SFWMD selected the interval between 670 and 850 feet bls for long-term monitoring and hydraulic testing based on analysis of the drilling, geophysical and lithologic data that indicate moderate to good water production. A transmissivity value of 68,630 gpd/ft was calculated from data obtained during an aquifer performance test.

Middle Floridan Confining Unit

Below the upper productive unit is a relatively thick, low permeability, semi-confining carbonate unit that extends from 850 to 1,675 feet bls. The Ocala Limestone forms the upper portion of this inter-aquifer confining unit from 850 to 1,120 feet bls, which consists of poorly indurated, chalky mudstone and wackestone units. Formation samples from this interval do not show evidence of large-scale secondary porosity development (e.g., good pinhole or moldic porosity). In addition, the production-type geophysical logs indicate no significant productive horizons, as seen by smooth temperature and flowmeter log traces (after correcting for borehole diameter), which supports the confining nature of this interval.

At this site, SFWMD identified minor productive intervals with similar water quality characteristic (e.g., TDS concentration) from 1,120 to 1,460 feet bls (lower Ocala Limestone – Avon Park Formation) based on resistivity log data. This interval consists of moderately indurated dolomitic wackestones to packstones with minor mudstones and dolostone units. Within this interval, limited secondary porosity development (primarily pinhole porosity) was observed in the formation samples. In addition, the geophysical log data shows a general increase in bulk density, a decrease in sonic transit times, and decreased log derived porosity values **(Appendix B)**. The flowmeter log was of limited use due to the enlarged borehole muting evidence of water production, but the borehole video survey was invaluable in identifying small productive intervals (evidence of minor fractures and vuggy porosity) within this 350-foot section. The 72-hour pump test results however, indicate low production capacity for this interval with a transmissivity of 26,460 gpd/ft. These minor productive intervals terminate in low permeability, poorly indurated packstones of the Avon Park Formation at a depth of 1,460 feet bls.

The Avon Park Formation from 1,460 to 1,675 feet bls consists of low permeability poorly indurated wackestone and packstone units and mirocrystalline dolostone forming an inter-aquifer confining unit. Again, formation samples from this interval did not show evidence of large-scale secondary porosity development. Also, temperature and flowmeter log traces indicate limited production horizons, which supports the overall confining nature of this interval.

Middle Floridan Aquifer

As previously mentioned, permeable intervals have been documented within the Avon Park Formation (Miller, 1986). At this site, well-indurated crystalline (euhedral to subhedral) dolostones with only minor stringers of wackestone and packstone occur from 1,675 feet to 1,780 feet bls. The dolostone units are cryptocrystalline to surcosic in nature with the limestone units showing evidence of varying degrees of pinhole and moldic porosity development. A cavernous dolostone unit at 1,700 feet bls caused a loss of mud circulation and a four-foot drop of the drill rod. The Contractor mixed and circulated an additional 15,000 gallons of drilling fluid to regain circulation but was unsuccessful. Through this highly fractured and cavernous dolostone unit, the caliper log records an enlarged borehole with diameters that exceed 20 inches (twice the drilling bit diameter). In addition, the resistivity and sonic log traces show sharp deflections within this interval (see **Appendix B**). The dynamic flowmeter log indicates that the great majority of the upward flow occurs near the top of this cavernous zone. The flowmeter log trace below 1,700 bls indicates upward flow is substantially less. The temperature (gradient) log shows an influx of warmer waters within this cavernous dolostone sequence between 1,680 and 1,780 feet bls. A temperature of 91° Fahrenheit (F) was recorded at the top and a 98° F reading at the base of this dolostone sequence, which equates to a geothermal gradient of 0.07^{o} F/ft. This is a seven-fold increase, as compared to the normal geothermal gradient of 0.01^{o}F/ft (or 1°F of change per 100 foot of depth). SFWMD could not conduct a packer test in this interval to quantify the productive capacity due to the rugosity and enlargement of the borehole (see caliper log from LAB-TW Geophysical Log Run No 3 – **Appendix B**). The completed monitor zone from 1,645 to 1,759 feet bls identified as LAB MZ-3 produced waters with chloride and TDS concentrations of 9,900 and 18,000 mg/L, respectively.

This productive unit is underlain by low permeability, well-indurated, microcrystalline dolostone, which acts as an inter-aquifer confining unit within the Floridan aquifer system. The top of this confining unit was identified at 1,780 feet bls by a gauged borehole (see caliper log trace in **Appendix B**) and pronounced shifts in the resistivity, bulk density, and sonic log traces. Resistivity values through this interval (1,780 to 1,890 feet bls) increase to 90 ohm-meters (ohm-m); bulk density values average 2.80 gram per centimeter (non-porous dolostone average 2.87 gm/cc); sonic transit times average 50 microseconds; and log derived porosity values average 3 porosity units. Similar lithologic and geophysical log characteristics continue from 1,780 to 1,890 feet bls. This inter-aquifer confining unit continues below 1,890 feet bls but changes from a dolostone to well-indurated, low permeability mudstones and wackestones interspersed with thin dolostone units. The limestone units have varying degree of pinhole porosity development and the crystalline limestone and dolostone stringers are slightly vuggy in nature. Minor flow zones appear as small deflections on the temperature-differential log trace (see LAB-TW Geophysical Log Run No 3 – **Appendix B**). Based on well cuttings and geophysical log data, well-indurated, low permeability mudstone to packstone units with intermittent brown to gray dolostones occur in the subsurface from 1,890 to 2,325 feet bls.

The signature of the deep induction log indicates a water quality transition occurs below 1,900 feet bls. Between 1,900 and 2,050 feet bls, resistivity values decrease from 10 ohm-m to 1.5 ohm-m with minor changes in lithology or porosity (as noted in the well cuttings and computed porosity curves) indicating a change in formation water quality. Reese (1994) suggests that deep induction resistivity values of 2 ohm-m or less are indicative of saline water, defined as having TDS concentrations of 35,000 mg/L or greater. In an effort to determine the water quality at the base of the transition (depth of 2,050 feet bls), Archie's equation (Archie, 1942) coupled with linear regression analyses results from Reese (1994) were employed as discussed in the Hydrogeologic Testing Section. The results of this analysis yielded chloride and TDS concentrations of 20,370 mg/L and 37,600 mg/L, respectively. Based on additional calculations using the same approach, saline waters continue to the base of the borehole at 2,500 feet bls.

Lower Floridan Aquifer

Below the confining unit identified between 1,780 and 2,325 feet bls, a moderate to high permeability, fractured, and cavernous dolostone occurs from 2,325 to 2,370 feet bls. This change in lithology and structure is exhibited by individual geophysical log traces. The caliper log indicates a relatively gauged borehole with cavernous intervals seen as spikes on the log trace. The induction log shows an increase in resistivity and the photoelectric log produces values of 3 barnes per electron, which are indicative of well-indurated dolostones. The signature of sonic and bulk density logs and corresponding porosity values indicate fractured or cavernous zones of high porosity and permeability (see LAB-TW Geophysical Log Run No. 2 – **Appendix B**). A minor flow zone, present near the top of this dolostone sequence, was initially identified during reverse-air drilling when flow rates from the wellbore increased. A deflection in the temperature log and images from the borehole video log confirmed its productive nature. The interval from 2,325 to 2,370 feet bls forms the upper dolostone units of the lower Floridan aquifer based on Meyer (1989) and Reese (2000). Poorly indurated, low permeability carbonates interspersed with thin, moderately indurated dolostones are present from 2,370 feet bls to the total depth of the pilot-hole at 2,500 feet bls.

HYDROGEOLOGIC TESTING

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

Geophysical Logging

Geophysical logging was conducted in the pilot holes after each stage of drilling and before reaming of the boreholes for casing installations. The resulting logs provide a continuous record of the physical properties of the subsurface formations and their respective fluids. These logs were later used to assist in the interpretation of lithology, provide estimates of permeability, porosity, and bulk density of the aquifer. In addition, they were used to determine the resistivity profile of the formation water (using Archie's equation, Archie, 1942). The extent of confinement of discrete intervals can also be discerned from the individual logs. **Table 2** lists the formation evaluation logs, their physical characteristics, and properties measured:

Log Name	Log Type	Principal Application	Maximum Hole Size	Benefit to Ground Water Studies
4-arm Caliper	Mechanical (inches)	Determines borehole diameter and rugosity in two horizontal planes and used to correct other logs	22 inches	Used to correct flowmeter logs and aids in identifying suitable inflatable packer and casing placement depths
Gamma Ray	Passive Nuclear reported in American Petroleum Institute Units (API)	Correlation, stratigraphic boundaries	24 inches	Correlation, used to estimate clay content
Spectralog®	Nuclear –Natural Gamma Emissions of the 256 Mineral spectrum reported in API units.	Correlation, mineral identification – U, Th, and K and clay content	22 inches	Correlation, defines clay content, aids in mineral identification and fracture detection
Dual Induction-Focused Log	Conductivity converted to Resistivity. Bedding thickness resolution to 3 feet in smooth borehole values reported in ohm-meter (ohm-m)	Provides invasion profile and an accurate estimate of formation water resistivity (R_w)	20 inches	Water Quality - through R_w used in Archie Equation and provides estimates of permeability from invasion profile
Compensated Z-Density with Photoelectric Absorption Factor	Nuclear – Induced Radioactive – Pad mounted reports bulk density in grams per cubic centimeters (gm/cc) and porosity in porosity units (p.u)	Porosity analysis, bulk density and lithologic and fluid determination	14 inches; effected by rugged borehole	Porosity estimates and lithologic indicator – porosity may be used in Archie Equation.
Compensated Neutron	Nuclear – Induced Radioactive reports porosity in p.u.	Porosity analysis, and lithologic determination	14 inches; good in rough or washed out borehole	Porosity estimates and porosity may be used in Archie Equation.
Multipole Array Acoustilog^{SM}	Acoustic Sonic - Full wave form records the primary, secondary and tube wave velocities and reports these data in microseconds per foot (usec/ft)	Porosity and permeability analysis, dynamic and mechanical properties	15-inches; sensitive to washouts	Evaluates porosity and permeability plus rock mechanical properties aids in fracture and lithology estimates

Table 2. Formation Evaluation Logs.

The geophysical logging contractor(s) downloaded the data directly from the onsite logging processor into diskettes using log ASCII standard (LAS) version 1.2 or 2.0 format. SFWMD and CH2M-Hill provided supplemental geophysical logging services. **Appendix B** contains the geophysical log traces from the various log runs for LAB-TW. The original geophysical logs and video surveys from the LaBelle site are archived (SFWMD reference no. 051-000031) and available for review at SFWMD's headquarters in West Palm Beach, Florida. **Table 3** is a summary of the geophysical logging program conducted at this site.

Date	Logging Company	Logged Interval feet bls	Caliper	Natural Gamma Ray	SP	Dual Induction	Sonic	Density-Neutron	Flow-Meter	Temp	Fluid Resist	Video
02/18/97	CH2M Hill	0-205	x	x								
03/06/97	Western-Atlas	205-1100	x	x	x	x	x	x	x	x		
03/19/97	CH2M Hill	200-670	x	x								
04/25/97	Western-Atlas	670-2500	x	x	x	x	x	x				
04/26/97	CH2M Hill	670-2500							x	x	x	
04/29/97	SFWMD	670-2500										x
05/08/97	CH2M Hill	670-1142	x	x								
Mesuring Point Elevation is Land Surface at 18.17 feet NGVD, 1929												

Table 3. Summary of Geophysical Logging Operations.

Since formation water samples could not be obtained below 1,759 feet bls using inflatable packer or from a completed monitor zone due to borehole conditions, a secondary approach was used to determine in situ water quality. SFWMD used the geophysical log data to identify water quality changes (as related to TDS concentration) to assist in determining the depth of the base of the USDW (TDS concentrations greater than 10,000 mg/L).

Archie (1942) discovered that the resistivity of a water-saturated rock (R_o) varies by a constant value as the resistivity of the formation water (R_w) changes. He qualified the relationship as:

$$R_o = F * R_w \qquad \textit{(Equation 1)}$$

Where:

R_o = the resistivity in ohm-meters of the formation 100% water saturated
F = the formation factor, a proportionality constant.
R_w = the resistivity in ohm-meters of the water saturating the formation.

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

$$F = 1/\phi^m \qquad \textit{(Equation 2)}$$

Where:

F = formation factor
ϕ = porosity in decimal form
m = cementation factor

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

$$F = a/\phi^{m} \qquad \textit{(Equation 3)}$$

Where:

a = tortuosity factor

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

Therefore, to determine the resistivity of the formation water, the Archie's equation can be rearranged as $R_w = R_o/F$. The temperature corrected (to 77°F) deep induction (RILD) resistivity log values were substituted for R_o and the formation factor (F) determined using the empirical relationship of $F = a/\phi^m$ (with a = 1, m = 2 and ϕ = sonic derived porosity values). The resulting resistivity values (R_w in ohm-m) were converted to specific conductance by taking the inverse of R_o ($1/R_o$) then multiplying by 10,000 to produce values in micromhos per centimeters. SFWMD translated the calculated specific conductance values to TDS using a two-step approach described in Reese (1994). **Figure 8** shows the calculated formation water TDS log compared to measured TDS concentrations of water samples taken during packer tests and from completed monitor zones. The base of the USDW is identified at approximately 1,675 feet bls, which is in close agreement with laboratory determined TDS concentrations of water samples taken from similar depths.

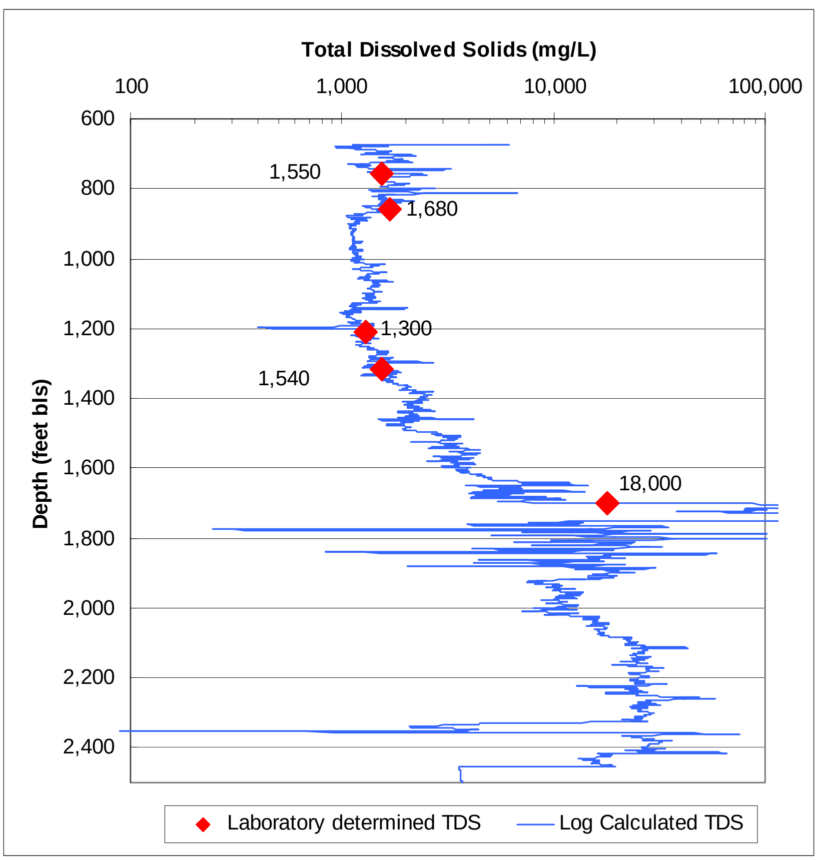

Figure 8. Calculated Formation Water Resistivity Log – LAB-TW (670 – 2,500 feet bls).

Petrophysical and Petrologic Data

During drilling of the test-production well identified as LAB-PW, the Contractor obtained conventional cores using a 4-inch diameter, 10-foot long, diamond-tipped core barrel. DDC retrieved six rock cores from the upper portion of the Floridan aquifer system between 725 and 1,460 feet bls with core recoveries between 25 and 60 percent. **Table 4** is a summary of the full-diameter coring program conducted at this site.

Core No.	Core Interval (feet bls)	Core Footage (feet)	Core Recovered (feet)	Percent Recovery
1	725-735	10	2.5	25.0
2	755-765	10	4.0	40.0
3	820-830	10	6.0	60.0
4	1194-1204	10	4.0	40.0
5	1295-1305	10	3.0	30.0
6	1450-1460	10	5.0	50.0
Totals:		**60**	**24.5**	**40.8**

Table 4. Summary of Full Diameter Coring Operations.

Petrophysical Analyses

SFWMD sent six rock cores to Core Laboratories (CoreLabs) located in Midland, Texas to determine the following parameters: horizontal permeability, porosity, grain density, and lithologic characteristics. Upon arrival, CoreLabs recorded a spectral gamma log on each core for downhole correlation. Full diameter and plug samples (when core conditions necessitated) were selected for core analyses and fluid removal was achieved by convection oven drying.

CoreLabs determined full diameter porosity by direct pore volume measurement using the Boyle's Law Helium Expansion Method. Once the samples were cleaned and dried, CoreLabs determined bulk volume by Archimedes Principle with grain density calculated from the dry weight, bulk volume and pore volume measurements using Equation No. 4 (American Petroleum Institute, 1998).

$$\text{Grain Density} = \text{Dry Weight} / (\text{Bulk Volume} - \text{Pore Volume}) \qquad \textit{(Equation 4)}$$

Porosity as a percent was calculated using bulk volume and grain volume measurements using Equation No. 5.

$$\text{Porosity} = ((\text{Bulk Volume} - \text{Grain Volume}) / \text{Bulk Volume}) \times 100 \qquad \textit{(Equation 5)}$$

CoreLabs measured direct grain volume on the 1-inch diameter plugs also using Boyle's Law Helium Expansion Method. After cleaning, they measured bulk volume on the individual plug samples by Archimedes Principle with porosity calculated using Equation No. 5. Steady-state air permeability was measured on the full diameter core samples in two horizontal directions and vertically while confined in a Hassler rubber sleeve at a net confining stress of 400 psi. **Appendix D, Table 2** lists the results of the petrophysical analyses. **Figure 9** shows a semi-log cross-plot of laboratory derived horizontal permeability versus (helium) porosity. The R-square statistic indicates that the linear regression model explains 57.8% of the variability of the $\log_{10}$ transformed horizontal permeability data. The equation of the fitted linear regression model, which describes the relationship between the $\log_{10}$ transformed horizontal permeability (y) and porosity (x) is $\log_{10}(y) = 0.0743(x) - 0.6042$. The correlation coefficient equals 0.76 (a value of 1.0 suggests a strong positive relationship), indicating a moderately strong relationship between the two variables.

After CoreLabs completed the petrophysical analyses, they slabbed and boxed the rock cores then photographed them under natural and ultraviolet light. CoreLabs then scanned the negatives of the core photographs and stored them on a compact disc. These photographs are reproduced in Figures 1 to 3 listed in **Appendix D**.

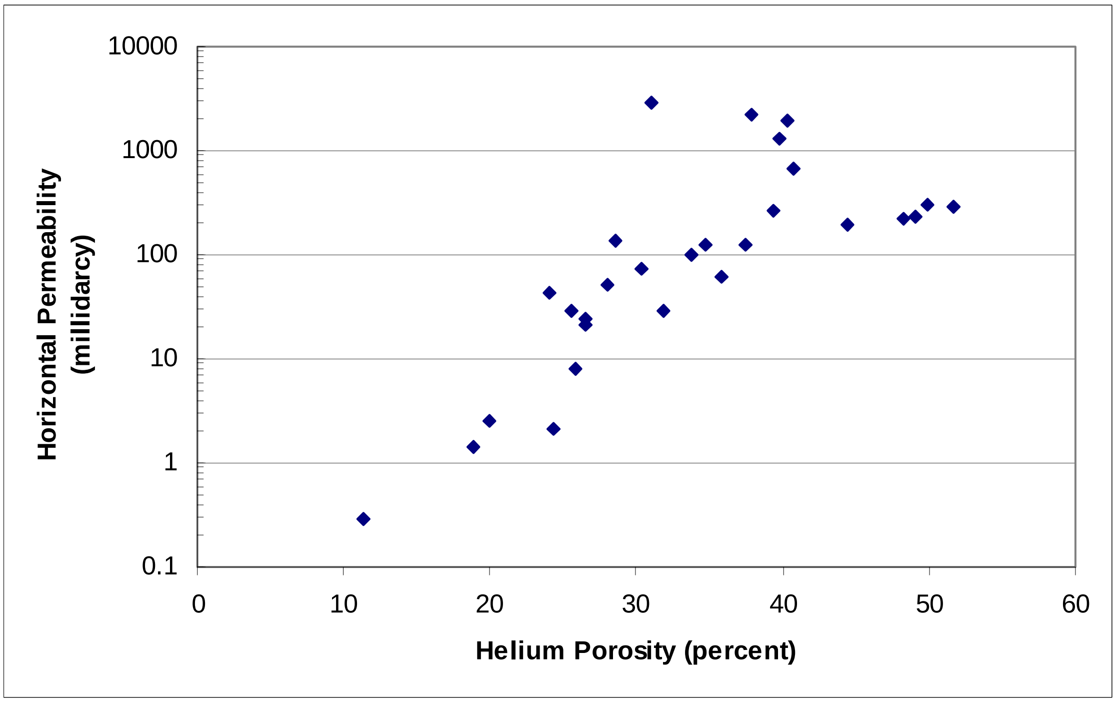

Figure 9. Cross-Plot of Laboratory Derived Horizontal Permeability and Porosity.

Petrologic Analyses

Once CoreLabs completed their measurements, Dr. Hughbert Collier of Collier Consulting Inc. conducted a petrologic study to provide preliminary data on the gross aquifer heterogeneity and depositional environment (facies) controls on porosity and permeability development within the Floridan aquifer system. As part of this study, Dr. Collier examined and described the slabbed cores in detail. He selected intervals from which to prepare thin sections and stained the thin-sections with Alizarin Red S to determine dolomite content. Dr. Collier then examined the thin sections using both a Nikon SMZ-2T binocular microscope and Nikon petrographic microscope. Thin section analyses included the identification of porosity types, visual estimation of porosity, rock type, cement type, mineralogy, dominant allochems, fossil types, grain size, sorting, and sand content. Once compiled, this information was used to determine the lithofacies and depositional environment of the various core intervals. **Appendix D**, **Table 3** is summary of the petrologic analysis generated by Collier Consulting Inc. **Appendix E** contains individual photomicrographs of selected cores. The petrologic analyses combined with the petrophysical data indicate variations in horizontal permeability and porosity based on lithofacies and corresponding depositional environments. The highest horizontal permeabilities (2,901 and 2,224 millidarcies) correspond to cored sections at approximately 726 and 821 feet bls, respectively. These two intervals consist of packstone and boundstone, likely deposited in an open-lagoonal shoal environment. Petrologic analyses of three other SFWMD-owned Floridan aquifer system wells, one located in eastern Hendry County (L2-TW) and two others in Collier County (I75-TW and ISWD-TW) had similar results with the highest mean horizontal permeability occurring in a packstone unit. These units were all thought to be deposited in an open-lagoonal shoal environment (Bennett, 2001a, 2001b, and 2002).

Stable Isotope and ^{14}Carbon Data

Stable isotope data complements inorganic geochemistry and physical hydrogeology investigations. SFWMD plans to use the isotopic data collected at this site in a regional investigation to better understand ground water circulation patterns of the Floridan aquifer system (Kohout, 1965, 1967) and to identify recharge and discharge areas. If an interval has a particular isotopic signature, it may be used to identify and map the lateral extent of an aquifer storage and recovery (ASR) and reverse osmosis (RO) zones within the upper Floridan aquifer. Radiocarbon data often complements stable isotope and inorganic data. These data have been used to estimate regional flow velocities within the Floridan aquifer (Hanshaw et al., 1964).

Water samples collected during packer tests and from completed monitor intervals from well LAB-TW were sent to the University of Waterloo Environmental Isotope Laboratory (EIL) for stable isotope determinations. The analytical services included the determination of the stable isotope compositions for the following parameters: $\delta^{18}O$, $\delta^{2}H$ or δD (deuterium), $\delta^{13}C$, and $\delta^{34}S$.

$\delta^{18}O$ values were determined by CO_2 equilibration using standard procedures outlined by Epstein and Mayeda (1953), and Drimmie and Heemskerk (1993). Hydrogen isotope compositions were determined using the methods of Coleman et al. (1982) and Drimmie et al. (1991). The results are presented as per mil (‰) deviations from a water standard using the δ-notation (delta):

$$\delta_{x} = \delta_{x-std} = \left(\frac{Rx}{R_{Standard}} - 1\right) x\ 1000 \qquad \textit{(Equation 6)}$$

Where:

Rx = the isotope ratio of the sample (e.g., $^{2}H/^{1}H$)

$R_{Standard}$ = the isotopic standard.

The standard related to deuterium and ^{18}O is Standard Mean Ocean Water (SMOW). The precision for $\delta^{18}O$ and δD were ± 0.05‰ and ±0.5‰, respectively.

Water samples received by EIL for $\delta^{13}C$ determinations were acidified under vacuum with phosphoric acid. The released CO_2, which is produced from dissolved inorganic carbon (DIC) in the sample, is then purified using cold distillation and analyzed by a mass spectrometry (Drimmie et al., 1990). These results are then compared to a carbon standard. The standard is the carbon isotope ratio derived from the CO_2 liberated from beleminites of the Cretaceous-aged

Pee Dee Formation of South Carolina. The results are presented as per mil (‰) deviations with respect to the standard using the δ-notation:

$$\delta^{13}C(‰, PDB) = \left(\frac{^{13}C/^{12}C_{sample}}{^{13}C/^{12}C_{standard}} - 1 \right) \text{x } 1000 \qquad \textit{(Equation 7)}$$

An accelerator mass spectrometer (AMS) at the Rafter Radiocarbon Laboratory (Institute of Geological and Nuclear Sciences, New Zealand) was used to determine radiocarbon age, delta ^{14}C, and percent modern carbon (pmC). The ^{14}C activities or pmC values are absolute percent of modern carbon, relative to the National Bureau of Standards (NBS) oxalic acid standard (HOxI) corrected for decay since 1950. The activity of "modern carbon" is 95 % of the ^{14}C in the 1950 NBS oxalic acid standard and Del ^{14}C is the relative difference between the absolute standard activity and the sample activity corrected for age.

$$\text{Del } ^{14}C = (A_s/A_{abs} - 1) \text{ x } 1000 \qquad \textit{(Equation 8)}$$

Where:

A_s = the activity of the sample
A_{abs} = the activity of the standard.

The modern activity of ^{14}C is set as 13.56 decays-per-minute per gram of carbon. The "zero year" for this activity is 1950 AD (pre-thermonuclear testing) with an activity of 100 pmC. The conventional radiocarbon age (^{14}C Age) is determine in the following manner:

$$t = -8033 \ln (A_{sn}/A_{on}) \qquad \textit{(Equation 9)}$$

Where:

A_{sn} = the normalized sample activity
A_{on} = the normalized oxalic acid activity (count rate).

Radiocarbon ages are reported in years before present (1950) and ^{14}C activities are reported as percent modern carbon (pmC). System error for $\delta^{13}C$ and ^{14}C are ± 0.3‰ and 0.4‰ (equals ± 32 radiocarbon years), respectively. However, (t) is not the actual date of recharge because ^{14}C may be preferentially added or removed as the water moves through the hydrologic system. Soil activities can concentrate ^{14}C, but dissolution of carbonate aquifer material with "dead carbon" can dilute the ^{14}C activity. In order to calculate the date of recharge, Equation 9 must be modified as follows:

$$t = -8267 \ln (A_t/ A_o) \qquad \textit{(Equation 10)}$$

Where:

t = the time since recharge
A_t = the current ^{14}C activity
A_o= the initial ^{14}C activity

Determining time since recharge requires information on the current ^{14}C activity (A_t), which is measured, and the initial activity (A_o), which is estimated.

Pearson and Hanshaw (1970) developed a method to correct the initial age estimate (as obtained from Equation 10) that considers both soil processes and carbonate dissolution. Their correction method uses approximations of the δ^{13}C values of the soil and aquifer material, along with information on soil activities. This information is used to evaluate the initial activity of the groundwater at time of recharge. The Pearson and Hanshaw correction method for ^{14}C is presented below.

$$A_o = [(A_g - A_c)(\delta_T - \delta_c)/ (\delta_g - \delta_c)] + A_c \qquad (\textit{Equation 11})$$

Where:

A = ^{14}C activity
δ = δ^{13}C stable isotope ratio
g = soil gas component
c = solid carbonate component
T= total dissolved inorganic carbon

Table 5 summarizes the stable isotope and radiocarbon results for the LaBelle site.

Identifier	Aquifer	Sample Interval ft. bls	Sample Date	d ^{18}O $^0/_{00}$ SMOW	d ^{2}H $^0/_{00}$ SMOW	d ^{37}Cl $^0/_{00}$ SMOC	d ^{13}C $^0/_{00}$ PDB	d ^{34}S $^0/_{00}$ CDT	d ^{14}C $^0/_{00}$	^{14}C pmC	Uncorrected ^{14}C Yr. B.P	*Corrected ^{14} C Yr. B.P
LAB PT-1	IAS	490-540	03/11/97	-1.47	-7.91	0.01	-3.98	21.64	-985.8	1.42	34,140	22,995
LAB MZ-1	UFA	670-837	12/10/97	-1.70	-8.07	-0.07	-3.60	21.75	-933.6	0.61	40,910	29,171
LAB PT-3	MCU	1145-1270	05/02/97	-1.49	-7.34	-0.23	-1.55	22.25	ND	ND	ND	ND
LAB MZ-2	MCU	1142-1458	12/10/97	-1.68	-7.67	-0.12	-1.39	22.06	-993.4	0.63	40,680	28,986
LAB MZ-3	MFA	1645-1759	12/10/97	-0.54	-7.37	0.09	-1.58	20.33	-991.5	0.80	38,690	20,403

ft. bls - feet below land surface	PDB - Pee Dee Belemnitella Standard	MZ = Monitor Zone
$^0/_{00}$ - per mil	CDT- Canon Diablo Meteorite Standard	PT = Packer Test
SMOW - Standard Mean Ocean Water	pmC - percent modern carbon	IAS = intermediate aquifer system
SMOC - Standard Mean Ocean Chloride	Yr. B.P. - Years Before Present -1950	UFA = upper Floridan aquifer
	ND - No Data	MCU = middle confining unit
* ^{14}C dates were corrected using Pearson & Hanshaw Method, ^{13}C Correction for Closed System		MFA = middle Floridan aquifer

Table 5. Summary of Stable Isotope and ^{14}Carbon Results.

The plot of δ^{18}O versus δD in **Figure 10** indicates depletion of the heavy isotopes among the LaBelle samples with respect to ocean water standard (SMOW), suggesting the role of meteoric precipitation in aquifer recharge. Samples are offset from the Global Meteoric Water Line (GMWL as defined by Craig, 1961) and mean isotopic composition of recent Everglades rainfall (Meyers et. al., 1993) possibly due to precipation during the last glacial period (Plummer, 1993). Stable isotope data from other locations in south Florida (Meyer, 1989, Bennett, 2001a, and 2001b, 2002) produce similar results where upper Floridan aquifer waters are depleted and plot near the GMWL. The occurrence of δ^{18}O and δD values near the GWML indicate that these waters are likely meteoric in origin.

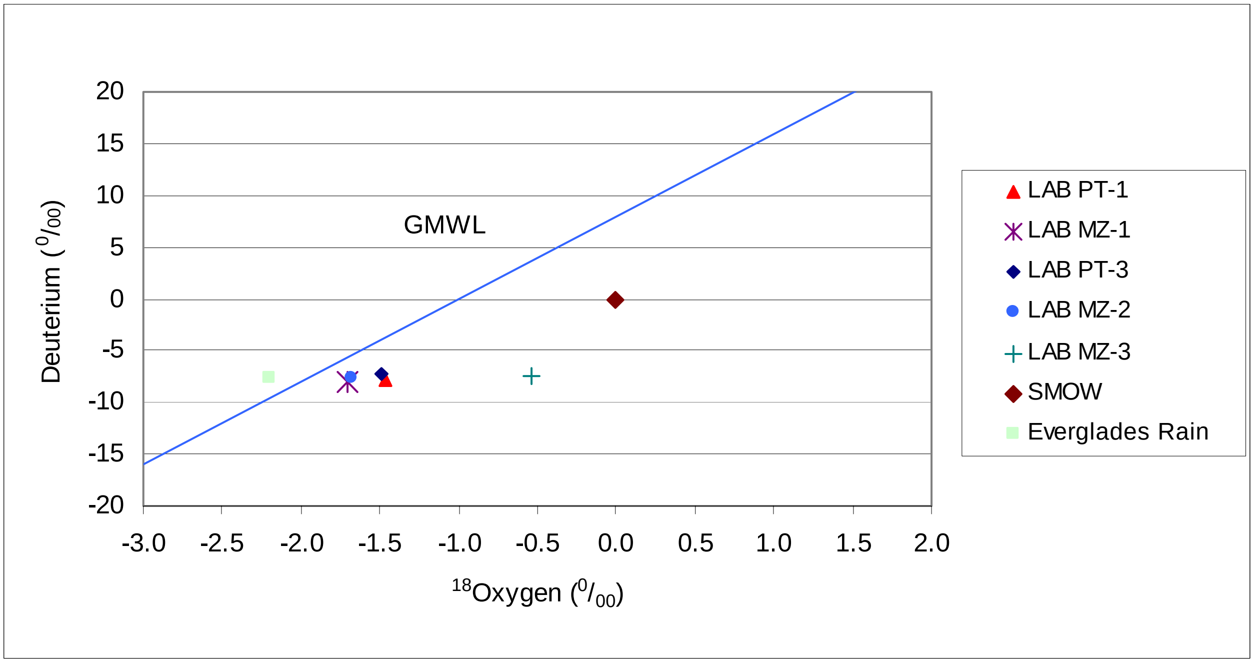

Figure 10 . Cross-Plot of Stable Isotopes Deuterium and ^{18}Oxygen.

Stable isotope result of the middle Floridan aquifer water is also depleted in both ^{18}O and deuterium as compared to SMOW but plot closer to SMOW than the upper Floridan aquifer samples. The inorganic water quality results from the cavernous dolostone from 1,645 to 1,759 feet bls (LAB MZ-3) indicate the water is brackish in composition. The stable isotope and inorganic data from this horizon suggests a mixing of ground water and seawater. The cavernous dolostone (zone of high permeability) unit may provide the mechanism (conduit) for the seawater inflow.

The ^{14}C activity of ground water samples from the upper Floridan aquifer (670 to 840 feet bls), and middle Floridan aquifer (1,645 to 1,759 feet bls) produced values of 0.62 and 0.83 pmC, respectively. The uncorrected radiocarbon ages of water from the upper Floridan aquifer and middle Floridan aquifer are approximately the same with radiocarbon ages of 40,795 and 38,690 years before present (bp), respectively. In order to be meaningful however, the reported radiocarbon ages where corrected using the Pearson and Hanshaw method (Pearson and Hanshaw, 1970), which uses a ^{13}C correction for a closed system. The corrected radiocarbon ages from the upper and middle Floridan aquifers are 29,171 and 20,403 years bp, respectively. If the corrected radiocarbon ages are considered absolute ages (assuming a closed-system and little or no chemical or isotopic dilution) meteoric recharge to the upper Floridan aquifer occurred during the late Pleistocene epoch. The stable isotope and corrected radiocarbon age for the middle Floridan aquifer suggests meteoric recharge during the late Pleistocene but with later intrusion by younger seawater as a result of sea level rise during the Holocene. The influx of younger seawater mixed with meteoric recharge may account for the lower corrected radiocarbon age and shift in the δ^{18}O and δD values towards SMOW.

^{18}O and δD data, ^{14}C activities, and reported radiocarbon ages of lower Floridan aquifer waters from other locations in south Florida suggests that two different water masses may be present in the

Floridan aquifer system (Meyers, 1989; Kaufmann and Bennett, 1997; Bennett, 2001b and Bennett 2002). The upper Floridan aquifer waters appear to be meteoric but the lower Floridan aquifer seems to have been intruded by younger seawater that entered somewhere along the Florida Straits and moved inland through the "Boulder Zone" or other highly permeable rock units during Holocene sea level rise. Unfortunately, SFWMD was unable to collect water samples from the lower Floridan aquifer at this location because of unstable borehole conditions below 1,760 feet bls prohibited sampling activities.

Packer Tests

The first packer test was limited to the lower portion of the intermediate aquifer system between 490 and 540 feet bls with the second set conducted in the Floridan aquifer system between 670 and 1,270 feet bls. The objectives of these tests were to gain water quality and production capacity data on discrete intervals. SFWMD selected intervals based on lithologic, hydraulic and water quality considerations using all available data.

The procedures listed below were used to conduct individual packer tests in well LAB-TW at the LaBelle site:

1) Lower packer assembly to the test interval based on geophysical and lithologic logs.
2) Set and inflate packers and open the ports between the packers.
3) Install a 4-inch diameter submersible pump to a depth of 60 to 120 feet below the drill floor.
4) Install two 50-psig-pressure transducers inside the drill pipe and one 10-psig transducer in the annulus.
5) Purge a minimum of three drill-stem volumes.
6) Monitor pressure transducer readings and field parameters (e.g., temperature, specific conductance, and pH) from the purged formation water until stable. These parameters were used to determine the quality of isolation of the “packed-off” interval.
7) Perform constant pumping rate drawdown and recovery tests, once the interval was effectively isolated.
8) Collect formation water samples per SFWMD sampling protocol for laboratory analyses.
9) Record recovery data until water level return to static (pre-pumping) conditions.

The Contractor purged the packer intervals a minimum of three borehole volumes or until field parameters of samples collected from the discharge pipe had stabilized, then SFWMD obtained individual ground water samples. A limit of +/-5% variation in consecutive field parameter readings was used to determine chemical stability. SFWMD staff used a Hydrolab® multi-parameter probe to measure field parameters including temperature, specific conductance, and pH on each sample. Chloride concentrations were determined using a field titration method (Hach® Kit). SFWMD personnel collected unfiltered and filtered water in accordance with sampling protocol. The water samples were transported to the SFWMD water quality laboratory where they were analyzed for major cations and anions using EPA and/or Standard Method procedures (SFWMD, Comprehensive Quality Assurance Plan, 1995). **Table 6** lists the field parameters and laboratory results for the individual packer tests.

			Cations				Anions					Field Parameters		
Identifer	Sample Interval (ft. bls)	Sample Date	Na^+ mg/L	K^+ mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	Cl^- mg/L	Alka as $CaCO_3$ mg/L	SO_4^{2-} mg/L	F^- mg/L	TDS mg/L	Specific Conduct. umhos/cm	Temp ^oC	pH s.u.
LAB PT-1	490-540	03/11/97	691.0	40.8	66.7	63.8	881.0	112.9	426.7	2.200	2,270	3,880	27.09	7.70
LAB PT-2	670-920	03/31/97	383.0	21.4	91.9	74.2	640.0	91.1	376.3	1.060	1,680	2,810	29.23	7.67
LAB PT-3	1145-1270	05/02/97	242.0	18.8	73.7	70.3	429.0	94.6	349.2	1.160	1,300	2,240	30.12	7.65

PT = Packer Test
ft. bls = feet below land surface
mg/L = milligrams per Liter
Alka as $CaCO_3$ = Alkalinity as Calcium Carbonate
umhos/cm = micromhos per centimeter at 25^{o}C
^{o}C = degree Celisus
s.u = standard unit
TDS = total dissolved solids

Table 6. Summary of Water Quality from Packer Tests.

The Hazen-Williams equation was used to calculate the friction (head) losses for all drawdown data because of induced flow up the drill pipe. These head losses were then used to correct the drawdown data for specific capacity determinations. Curve-matching techniques were not used to determine transmissivity values from the drawdown or recovery data. These type of tests generally involve partial penetration, have significant friction loss due to small pipe diameter, and have short pumping periods, which violate the various analytical method's basic assumptions.

<u>Packer Test No. 1 (490 to 540 feet bls)</u>: The purpose of this packer test was to obtain water samples for analyses and to determine the interval's productive capacity. The main intent of this packer test was to gather pertinent information to complement future ground water resource studies focusing on the intermediate aquifer system. DDC conducted this test on March 11, 1997, which consisted of pumping an interval between 490 and 540 feet bls (part of the Arcadia Formation).

During this test, DDC pumped this interval for 95 minutes at 55 gallons per minute (gpm), which produced a sustained drawdown of 91.5 feet. The results of the drawdown test indicate poor production, with a specific capacity of 0.6 gpm/ft of drawdown. The specific capacity (SC) was calculated using the following method:

SC = Q / Drawdown *(Equation 12)*

55 gpm/ (91.5 ft – 2.5 ft) = 0.6 gpm/ft-drawdown

Q = pumping rate in gpm as measured by an in-line flowmeter,

Drawdown = aquifer head loss in feet: measured drawdown minus the pipe friction losses (0.47 feet per 100 feet of pipe for a 3.5-inch inside diameter pipe with a flow rate of 55 gpm. The pipe extended to 540 feet bls which resulted in a pipe frictional loss of 2.5 feet. Friction loss coefficient determined from Driscoll - Appendix 17.A. Ground Water and Wells, 1989).

SFWMD determined the static water level at the end of the recovery phase at 47.93 feet above sea level based on a surveyed land surface elevation of 18.17 feet NGVD, 1929.

Packer Test No. 2 (670 to 920 feet bls): The purpose of this packer test was to determine the hydraulic properties and water quality characteristics of a productive interval within the upper Floridan aquifer. DDC set a single packer assembly to isolate an interval between 670 and 920 feet bls. SFWMD conducted and successfully completed a drawdown/recovery test on March 31, 1997.

During the drawdown phase, DDC pumped this interval for approximately 120 minutes at an average rate of 100 gpm, which produced a maximum drawdown of 12.1 feet. The results of the drawdown test indicate moderate productivity, with a specific capacity of 77.0 gpm/ft-drawdown calculated using the following method:

SC	=	Q / Drawdown
		100 gpm/ (12.1 ft – 10.8 ft) = 77.0 gpm/ft-drawdown
Q	=	pumping rate in gpm as measured by an in-line flowmeter,
Drawdown	=	aquifer head loss in feet: measured drawdown minus the pipe friction losses (1.18 feet per 100 feet of pipe for a 3.5-inch inside diameter pipe with a flow rate of 100 gpm. The pipe extended to 920 feet bls which resulted in a pipe frictional loss of 10.8 feet. Friction loss coefficient determined from Driscoll, Appendix 17.A. Ground Water and Wells, 1989)

SFWMD calculated the static water level at the end of the recovery phase at 50.93 feet above sea level using a surveyed land surface elevation of 18.17 feet NGVD, 1929.

Packer Test No. 3 (1,145 to 1,270 feet bls): The purpose of this packer test was to evaluate the hydraulic and water quality characteristics of a proposed long-term monitor interval within the middle confining unit at this site. DDC set a dual packer assembly, which isolated an interval between 1,145 and 1,270 feet bls. SFWMD conducted and successfully completed a drawdown/recovery test at this depth on May 2, 1997.

During the drawdown phase, DDC pumped the interval for 120 minutes at 85 gpm that produced a recorded drawdown of 99.2 feet. The results of the drawdown test indicate low productivity, with a specific capacity of 1.0 gpm/ft-drawdown calculated using the following method:

SC	=	Q / Drawdown
		85 gpm/ (99.2 ft – 12.2 ft) = 1.0 gpm/ft-drawdown
Q	=	pumping rate in gpm as measured by an in-line flowmeter,
Drawdown	=	aquifer head loss in feet: measured drawdown minus the pipe friction losses (0.96 feet per 100 feet of pipe for a 3.5-inch inside diameter pipe with a flow rate of 85 gpm. The pipe extended to 1,270 feet bls which resulted in a pipe frictional loss of 12.2 feet. (Friction loss coefficient determined from Driscoll, Appendix 17.A. Ground Water and Wells, 1989).

Static water level at the end of the recovery phase were measured at 51.58 feet above sea level using a surveyed land surface elevation of 18.17 feet NGVD, 1929.

Aquifer Performance Testing

Aquifer Performance Test No. 1

SFWMD conducted the first of two aquifer performance tests (APTs) to determine the hydraulic performance of the upper Floridan aquifer from 670 to 850 feet bls encompassing the lower Arcadia Formation, Suwannee Limestone, and upper Ocala Limestone. The principle factors of aquifer performance, such as transmissivity and storage coefficients, can be calculated from the drawdown and/or recovery data obtained from the proximal monitor well completed in the same interval (LAB MZ-1). If the aquifer tested is semi-confined, the hydraulic parameter of leakance of the semi-pervious layer(s) can also be determined.

The drawdown phase consisted of pumping water from the aquifer via the test-production well (LAB-PW) at a constant rate of 1,700 gpm for 72 hours while recording water level changes in the proximal tri-zone monitor well. The 72-hour drawdown phase was followed by a 24-hour recovery period, where pumping stopped and water levels were allowed to return to background condition. **Figure 11** shows configuration of the tri-zone monitor and test-production wells used in the first aquifer-performance test.

DDC installed a 12-inch diameter submersible pump in the test-production well with the pumping bowl set at 120 feet bls. SFWMD chose this depth based on preliminary data that indicated moderate drawdown would occur. The wellhead was re-installed with appurtenances consisting of a shut-off valve, discharge pressure gauge, and wellhead pressure transducer. A 12-inch diameter circular orifice weir with a 8-inch diameter orifice plate was used to measure discharge rates during pumping, verified by an in-line flowmeter. SFWMD personnel installed a pressure transducer on the orifice weir to record discharge rates during the pump test at 5-minute intervals. Additional pressure transducers were installed on/in both LAB-PW and monitor zones (LAB MZ-1 and LAB MZ-2) connected to a Hermit® 2000 (Insitu, Inc.) data logger using electronic cables. The transducers and data logger were used to measure and record water-level changes at pre-determined intervals during testing operations.

Following equipment setup, SFWMD conducted a step-drawdown test to determine an appropriate pumping rate for the planned 72-hour drawdown test. The step-drawdown test was successfully completed with a pump rate of 1,700 gpm selected for the drawdown test. At this pump rate, the calculated specific capacity was 17.3 gpm/ft of drawdown, sufficient enough to cause water level declines in the proximal Floridan aquifer system monitor well without creating turbulent flow in the pump interval. Once completed, SFWMD allowed water levels to recovery to static condition before starting the 72-hour drawdown test. On August 12, 1997, the drawdown phase of the APT started by initiating pumping of the test-production well at 1,700 gpm. SFWMD maintained the installed electronic devices, which continuously measured and recorded water levels, and pump rates during the drawdown phase. DDC operated the pump uninterrupted for the next 72 hours, completing the drawdown phase on August 15, 1997.

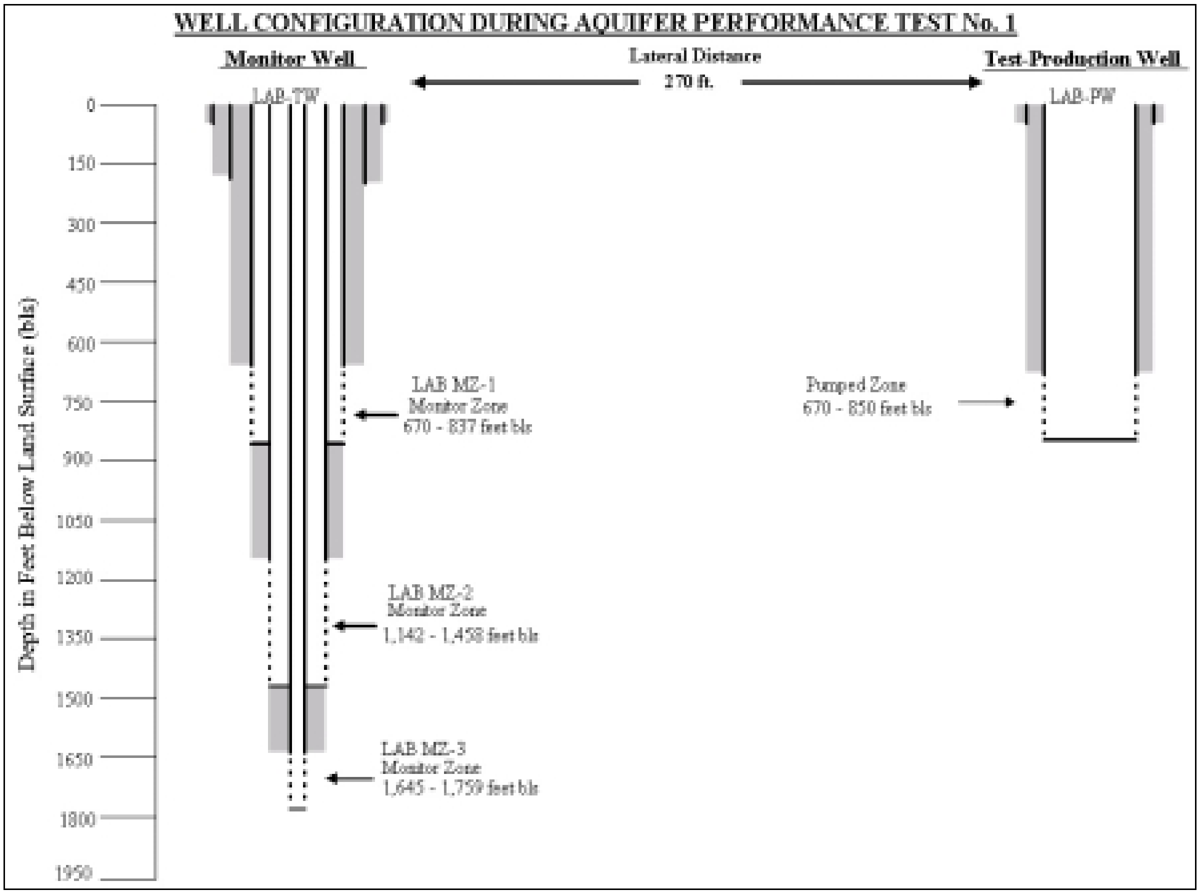

Figure 11. Aquifer Performance Test – Well Configuration APT No. 1.

Figure 12 is a time-series plot of the drawdown data for both the pumped well (LAB-PW) and corresponding monitor well (LAB MZ-1). Maximum drawdown in LAB-PW and LAB MZ-1 were 98.2 feet (42.5 psi) and 25.9 feet (11.2 psi), respectively.

Figure 13 is a time-series plot of water-level changes during the drawdown phase for the monitor zone LAB MZ-2 (1,142 to 1,460 feet bls). Maximum water-level change in this interval during pumping was 2.4 feet (1.03 psi), which indicates upward leakage. The lowermost monitor zone (LAB MZ-3 completed from 1,645 to 1,759 feet bls) was not available for monitoring during this test.

Figure 14 show a time-series plot of the discharge data collected from the 12-inch diameter, circular orifice weir during the pumping phase of the APT No.1. This figure shows minor fluctuations in pump rates during the course of the APT. These fluctuations were small enough (less than 3%) to be inconsequential to the overall test results. In addition, SFWMD collected water samples every 12 hours from LAB-PW. On each sample, SFWMD measured temperature, pH, specific conductance using a HydroLab® water quality probe, and chloride concentrations determined using a Hach® Kit. Both specific conductance values and chloride concentrations increased slightly during the drawdown phase of the APT. Specific conductance values and chloride concentrations ranged from 2,707 to 2,725 umhos/cm and 565 to 606 mg/L, respectively.

The change in water quality during pumping may indicate upward and/or downward leakage effects supported in part by declining water levels in LAB MZ-2 (-2.4 feet).

Approximately four hours after pumping started, SFWMD personnel collected water samples from LAB-PW for major cation/anion analyses in accordance with SFMWD QA/QC sampling protocol. Once collected, all water samples were preserved and immediately placed on ice and transported to the SFWMD water quality laboratory. The laboratory analyzed the samples using EPA and/or Standard Method procedures (SFWMD, Comprehensive Quality Assurance Plan, 1995). **Table 7** lists the results of the laboratory analyses.

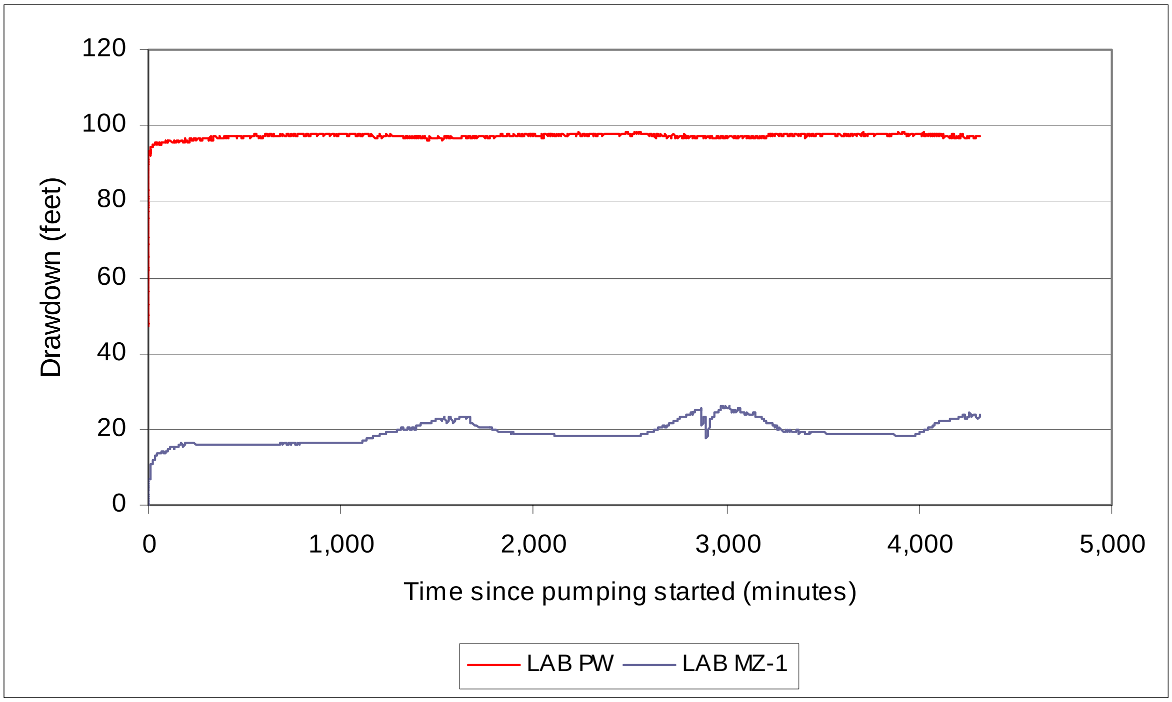

Figure 12. Time Series Plot of Drawdown Data from LAB MZ-1 and LAB-PW, APT-1.

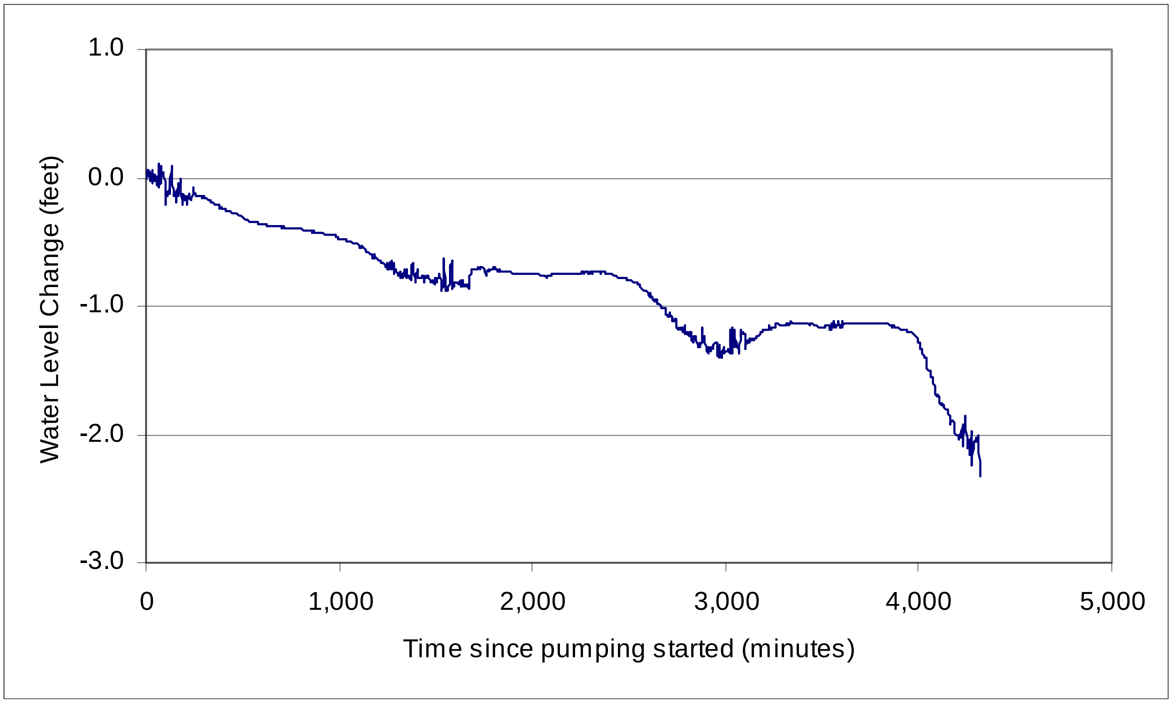

Figure 13. Time Series Plot of Water Levels from LAB MZ-2 During Pumping Phase of APT No. 1.

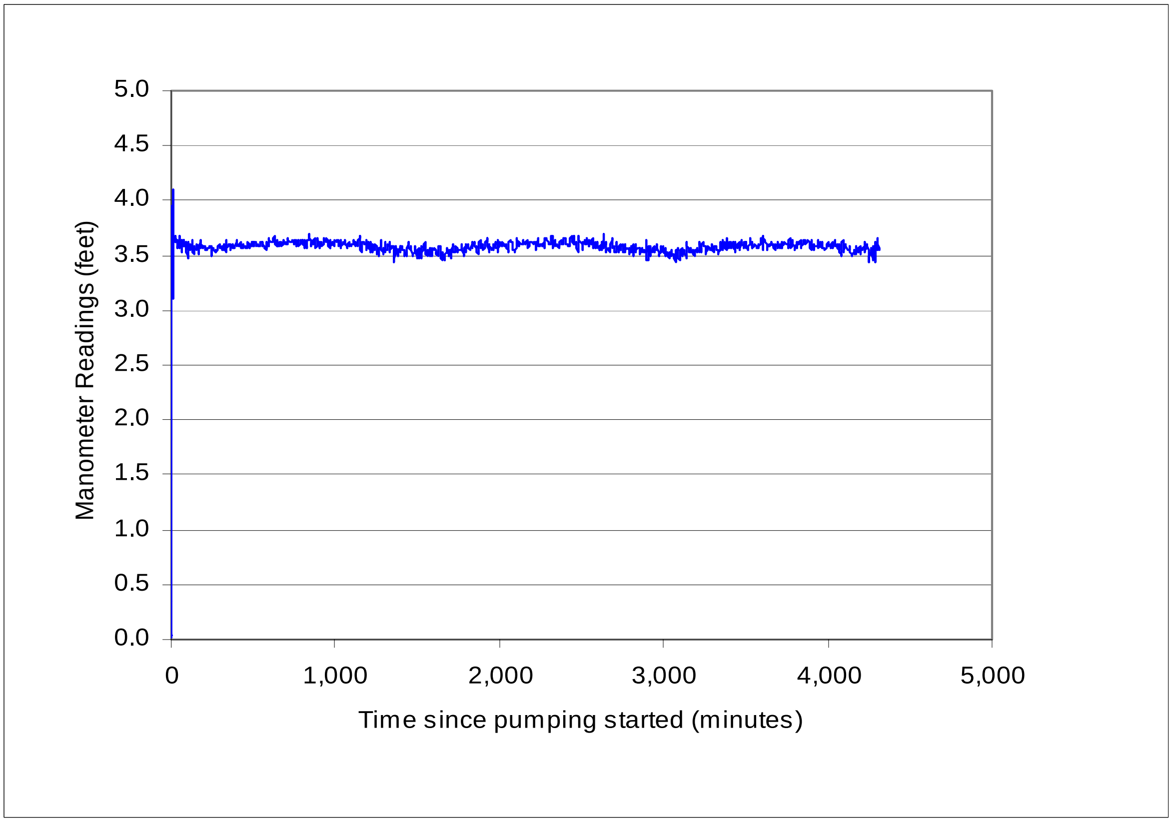

Figure 14. Time Series Plot of Manometer Readings from Discharge Orifice Weir and LAB-PW - APT No. 1.

			Cations				Anions					Field Parameters		
Identifer	Depth Interval (ft. bls)	Sample Date	Na^+ mg/L	K^+ mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	Cl^- mg/L	Alka as $CaCO_3$ mg/L	SO_4^{2-} mg/L	F^- mg/L	TDS mg/L	Specific Conduct. umhos/cm	Temp ^oC	pH s.u.
APT No. 1	670-850	08/14/97	390.0	17.0	78.0	62.0	591.0	86.6	351.6	0.590	1,590	2,716	29.50	7.77
APT No. 2	1110-1460	10/09/97	310.0	18.0	75.0	72.0	566.4	83.8	358.3	1.100	1,440	2,466	31.17	7.64

APT = Aquifer Performance Test
ft. bls = feet below land surface
mg/L = milligrams per Liter
Alka as $CaCO_3$ = Alkalinity as Calcium Carbonate
umhos/cm = micromhos per centimeter at 25°C
^oC = degree Celisus
s.u = standard unit
TDS = total dissolved solids

Table 7. Summary of Water Quality Data from APT No. 1 and APT No. 2.

Before pumping stopped, the various data loggers were re-configured to record the recovery data. DDC manually stopped the pump and water levels slowly recovered to static conditions. **Figure 15** is a semi-log plot of the recovery data for the pumped monitor zone (LAB MZ-1). Electronic copies of the original drawdown, recovery and orifice weir (pump rate) data for the APT are archived and available for review at the SFWMD's headquarters in West Palm Beach, Florida.

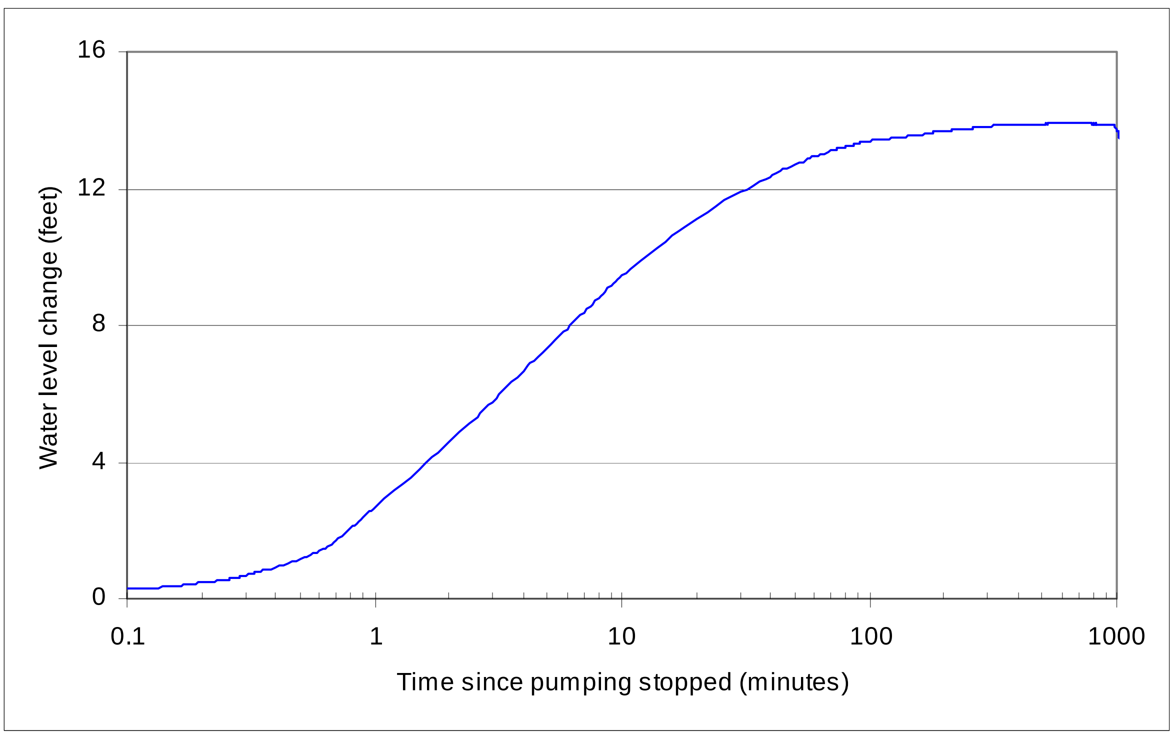

Figure 15. Time Series Plot of Recovery Data from LAB MZ-1, APT No. 1.

SFWMD applied various analytical models to the drawdown data collected during the APT to determine the hydraulic properties of the aquifer and aquitard(s) at this site. The analytical methods included both confined and semi-confined "leaky" solutions as part of the preliminary analysis of the drawdown data. The confined transient analytical solutions include the Theis (1935) non-equilibrium method and the Cooper-Jacob (1946) approximation. The semi-confined "leaky" analytical models include the Hantush-Jacob (1955), Hantush (1960), and Moench (1985). The methods referenced are based on various assumptions and interested readers should refer to the original articles for further details. Analyses of the recovery data from LAB MZ-1 produced similar hydraulic results. In general, drawdown data from a single observation well only provides an estimate of aquifer and aquitard properties because many of the type curves are similar in shape to one another and do not necessarily provide a unique match to a given data set.

Figure 16 is a log/log plot of drawdown versus time for the pumped monitor well LAB MZ-1 during APT-1. The shape of the drawdown curve (black squares) of LAB MZ-1 indicates a leaky-type aquifer. The red dotted line represents the Theis curve for a confined aquifer. A leaky (semi-confined) aquifer is one that loses or gains water (depending on the pressure gradients) through a semi-confining unit (aquitard). If a semi-confining unit(s) is composed of a thick layer of poorly indurated, high porosity sediments, it may provide water to the pumping well. The lithologic and geophysical data indicates that the overlying and underlying units are composed of porous (25% to 45% porosity) sediments, which have the potential to transmit water through them, and to supply additional water released from storage to the pumping well. A proximal monitor well completed above the test interval of 670 to 850 feet bls was not available for monitoring during the APT to quantify the relative contribution of the overlying semi-confining unit. During pumping, however, water levels in LAB MZ-2 (completed from 1,142 to 1,460 feet bls) declined 2.4 feet **(Figure 13),** which indicates upward leakance.

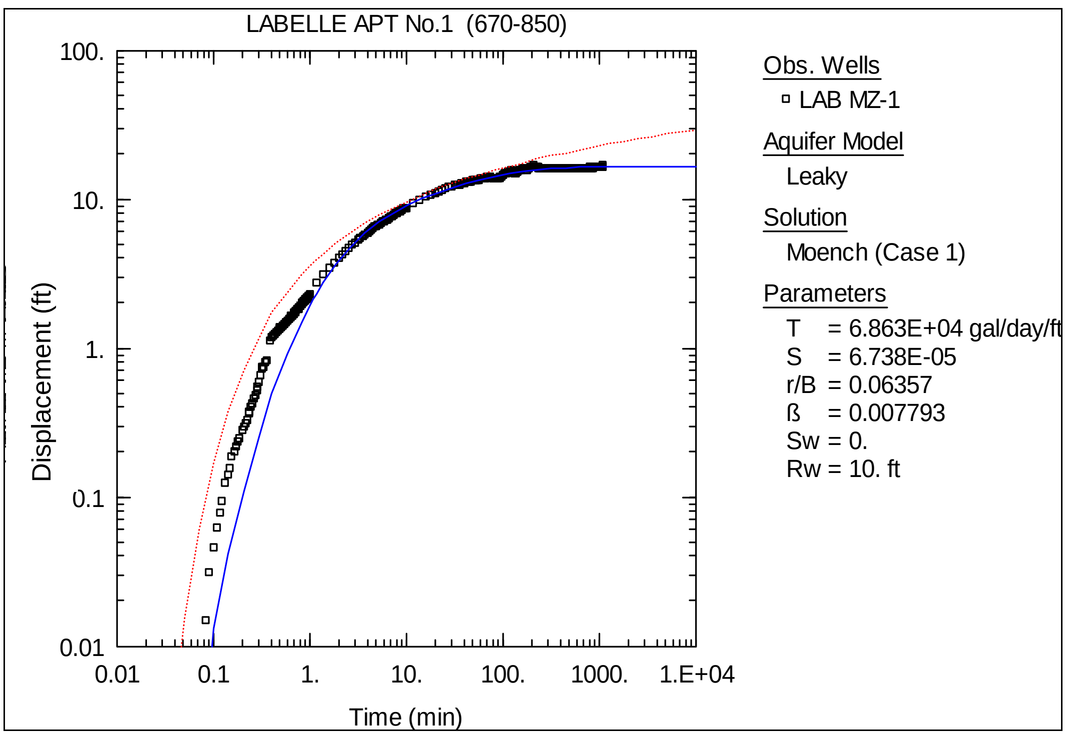

Figure 16. Log-Log Plot of Drawdown versus Time for Monitor Well LAB MZ-1, APT No. 1.

Moench (1985) derived an analytical solution for predicting water-level displacements in response to pumping a large diameter well that takes into account well bore storage in a leaky confined aquifer and assumes storage in the aquitard(s) and wellbore skin effects. Moench (1985) also builds upon several previously established analytical solutions such as Hantush (1960), Papadopulos and Copper (1967), and Agarwal et al., (1970). Based on these considerations and the site-specific hydrogeologic data collected during drilling and aquifer testing, the Moench analytical model appears to best represent the conditions present at this site. The results of this solution yielded a transmissivity value of 68,630 gpd/ft, a storage coefficient of 6.7×10^{-5}, and a (r/B) value of 0.06. The dimensionless parameter r/B characterizes the leakage across the aquitard(s) to the pumped aquifer; from this value a leakance value of 3.39×10^{-3} gpd/ft^3 was calculated (Walton, 1960).

Aquifer Performance Test No. 2

The SFWMD conducted a second APT to determine in-situ hydraulic characteristics of the Floridan aquifer system from 1,110 to 1,465 feet bls within the Ocala Limestone (lower 40 feet) and Avon Park Formation. The drawdown phase consisted of pumping this interval at a constant-rate of 310 gpm for 72 hours. **Figure 17** shows the well configuration of the tri-zone monitor well (LAB-TW) and test-production well (LAB-PW) used in the APT. The 72-hour drawdown phase was followed by a 24-hour recovery period, where water levels were allowed to return to background conditions.

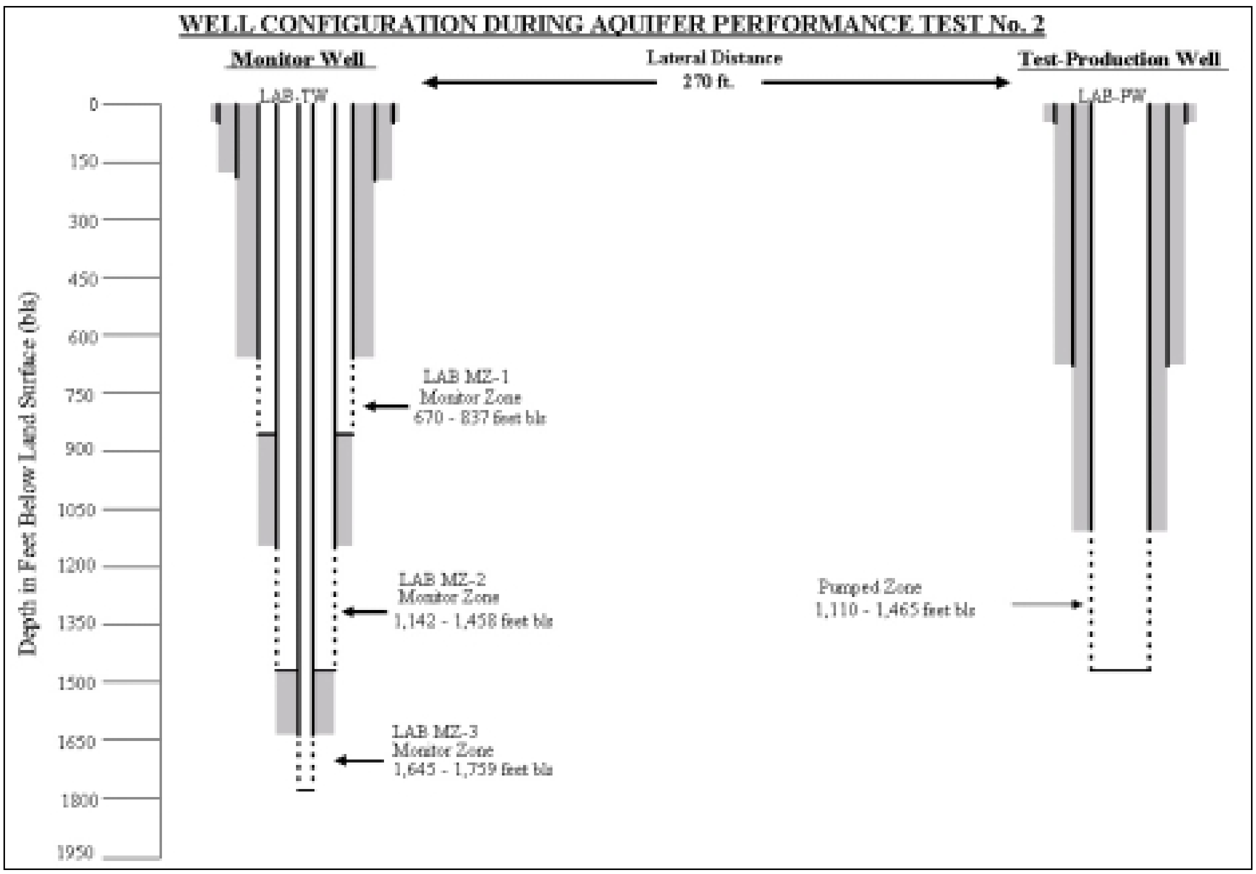

Figure 17. Aquifer Performance Test – Well Configuration APT No. 2.

DDC installed an 8-inch diameter submersible pump in the test-production well with the pumping bowl set at 200 feet bls. SFWMD chose this depth based on preliminary data indicating moderate to large drawdown would occur. The wellhead was re-installed with appurtenances consisting of a shut-off valve, discharge pressure gauge, and wellhead pressure transducer. A 6-inch diameter circular orifice weir with a 4-inch diameter orifice plate was used to measure discharge rates during pumping, verified by an in-line flowmeter. SFWMD personnel installed a pressure transducer on the orifice weir to record discharge rates during the pump test at 5-minute intervals. Additional pressure transducers were installed on/in both the test-production (LAB-PW) and monitor zones (LAB MZ-1, LAB MZ-2, and LAB MZ-3) connected to a newly acquired Hermit® 3000 (Insitu, Inc) data logger using electronic cables. The transducers and data logger were used to measure and record water level and barometric pressure changes at pre-determined intervals during testing operations.

Following equipment setup, SFWMD conducted an initial a step-drawdown test on October 7, 1997. The step-drawdown test results helped to determine an appropriate pumping rate of 310 gpm for the planned 72-hour drawdown test. Once completed, SFWMD allowed water levels to recovery to static conditions before starting the 72-hour APT. On October 8, 1997, SFWMD started the drawdown phase of the second APT by initating pumping of LAB-PW at 310 gpm. SFWMD maintained the installed electronic devices, which continuously measured and recorded water levels and pump rates during the drawdown phase. Pumping continued for approximately 24 hours before an electrical problem in the generator caused pumping to cease. The Contractor repaired the generator and restarted the drawdown phase of the APT on October 10, 1997. DDC then operated the pump uninterrupted for the next 72 hours at an average pumping rate of 310 gpm, completing the drawdown phase on October 13, 1997. **Figure 18** is a time series plot of the drawdown data from both the pump well (LAB-PW) and corresponding monitor zone (LAB MZ-2). Maximum drawdown in LAB-PW and LAB MZ-2 were 189.5 feet (82 psi) and 7.1 feet (3 psi), respectively.

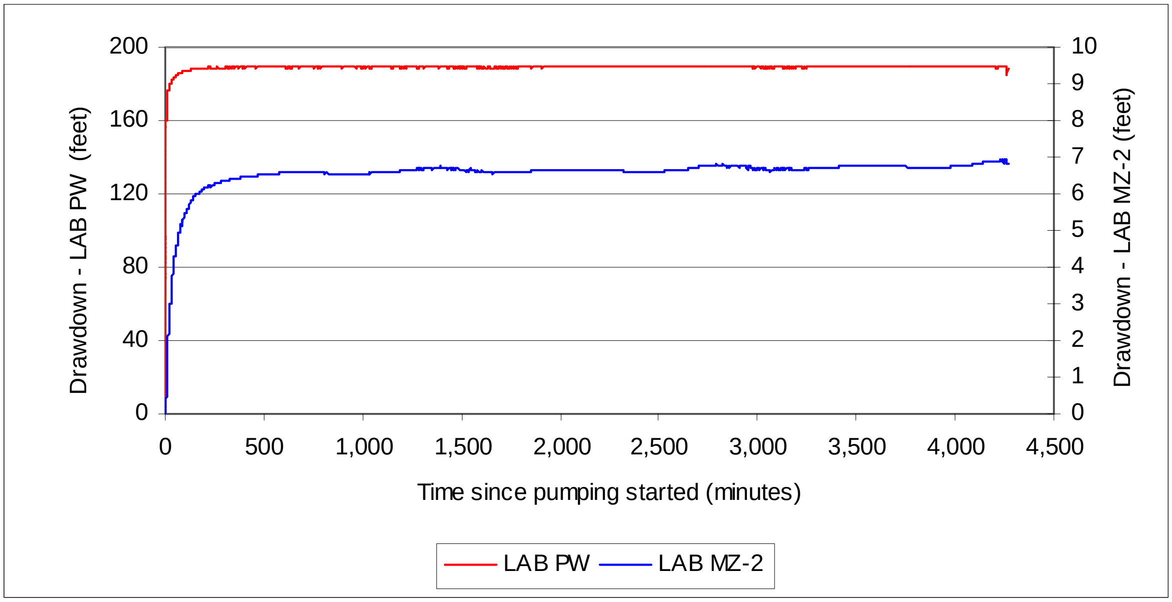

Figure 18. Time Series Plot of Drawdown versus Time for Monitor Well LAB MZ-2 and LAB-PW, APT No. 2.

Figure 19 is a time-series plot of water level changes during the drawdown phase for the upper monitor zone LAB MZ-1 (670 to 837 feet bls), lower monitor zone LAB MZ-3 (1,645 to 1,759 feet bls) and barometric pressure. Maximum water-level change in LAB MZ-1 during pumping was -0.80 feet, which indicates the effects of downward leakage. However, water levels in the middle Floridan aquifer monitor zone (LAB MZ-3) increased 0.2 feet and appears to be in part a function of declining barometric pressure during this test.

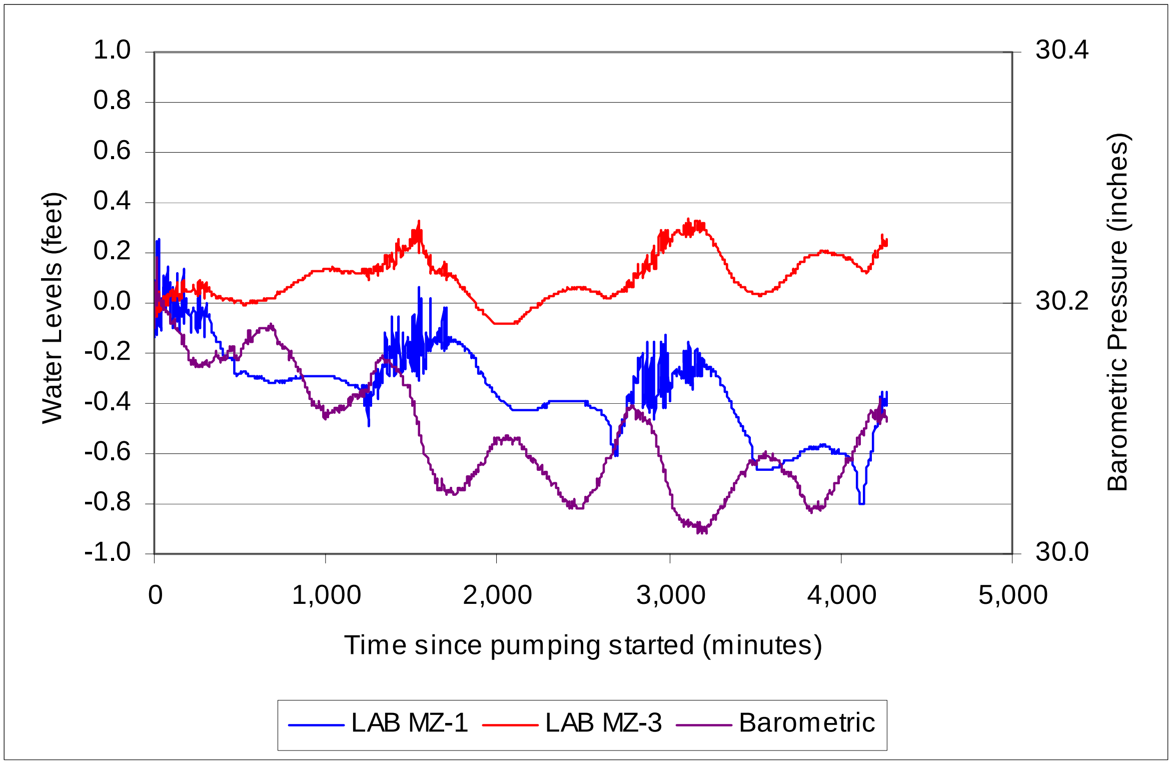

Figure 19. Time Series Plot of Water Levels from LAB MZ-1, LAB MZ-3, and Barometric Pressure During Pumping Phase of APT No. 2.

Figure 20 show a time series plot of the discharge data collected from the 6-inch diameter, circular orifice weir during the pumping phase of the APT No. 2. This figure shows minor fluctuations in pump rates during the course of the APT. These fluctuations were small enough (less than +/- 3%) to be inconsequential to the overall test results.

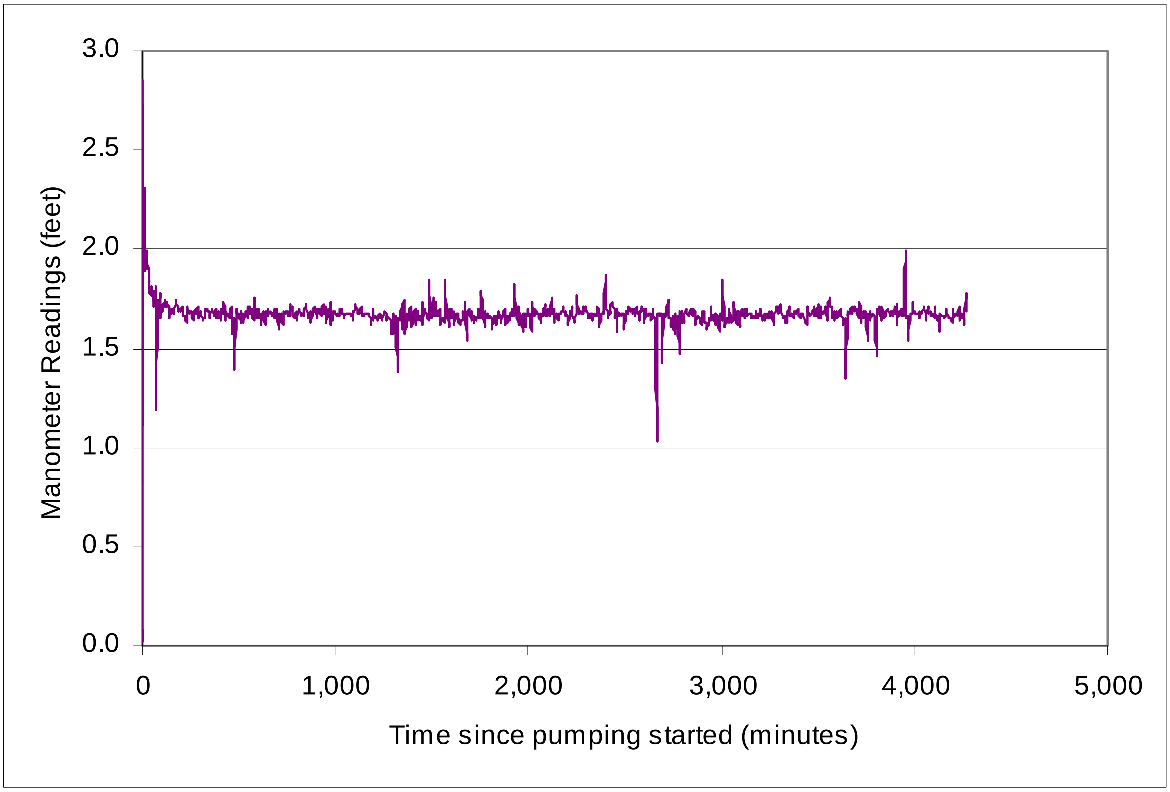

Figure 20. Time Series Plot of Manometer Readings from Discharge Orifice Weir – APT No. 2.

Approximately six hours after pumping started, SFWMD personnel collected water samples from LAB-PW for major cation/anion analyses in accordance with SFWMD sampling protocol. These samples were then analyzed using EPA and/or Standard Method procedures (SFWMD, Comprehensive Quality Assurance Plan, 1995). **Table 7** lists the results of the laboratory analyses.

Before pumping stopped, SFWMD reconfigured the various dataloggers to record the recovery data. DDC manually stopped the pump and water levels slowly recovered to static conditions. The recovery phase of the APT continued for 24 hours, ending on October 14, 1997. **Figure 21** is a semi-log plot of the recovery data for the pumped monitor zone (LAB MZ-2). Electronic copies of the original drawdown, recovery and orifice weir (pump rate) data for the APT are archived and available for review at the SFWMD headquarters in West Palm Beach, Florida.

Again, SFWMD applied various analytical models to the drawdown data collected during the second APT to determine the hydraulic properties of the aquifer and aquitard(s) consistent with those used to analyze data from APT No. 1. Analyses of the recovery data from LAB MZ-2 produced similar transmissivity values.

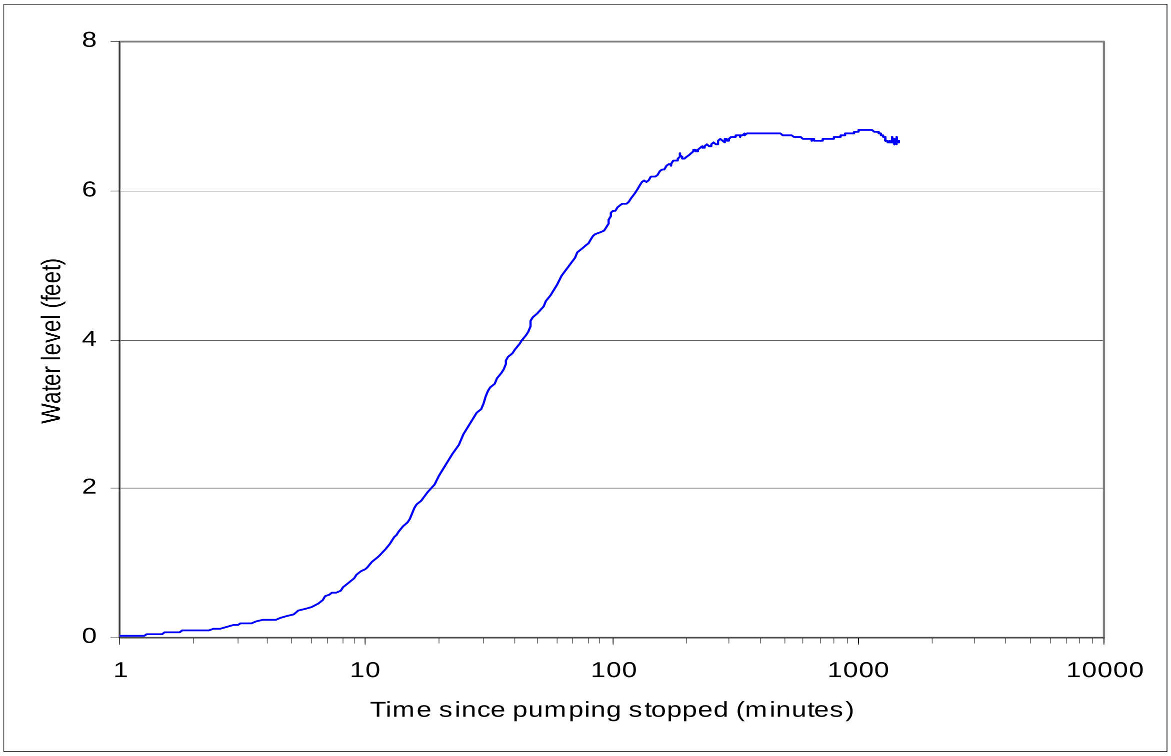

Figure 21. Semi-Log Plot of Recovery Data from LAB MZ-2, APT No. 2.

Figure 22 is a log/log plot of drawdown versus time for the pumped monitor well (LAB MZ-2) during APT No. 2. The shape of the drawdown curve from LAB MZ-2 is indicative of a leaky-type aquifer. The lithologic data shows that the overlying confining beds are composed of porous (25% to 45% porosity) carbonate sediments, which have the potential to transmit water through them, and to supply additional water released from storage to the pumping well. The proximal monitor well (LAB MZ-1) completed above the test interval of 1,110 to 1,465 feet bls showed a discernable negative trend with a water level decline of 0.65 feet. However, water levels in the lower monitor zone (LAB MZ-3) increased 0.2 feet during pumping and this response may be a function of barometric pressure variations. These data suggest the low permeability carbonates and crystalline dolostones between 1,465 and 1,700 feet bls effectively isolated the lower monitor zone from the pumped interval.

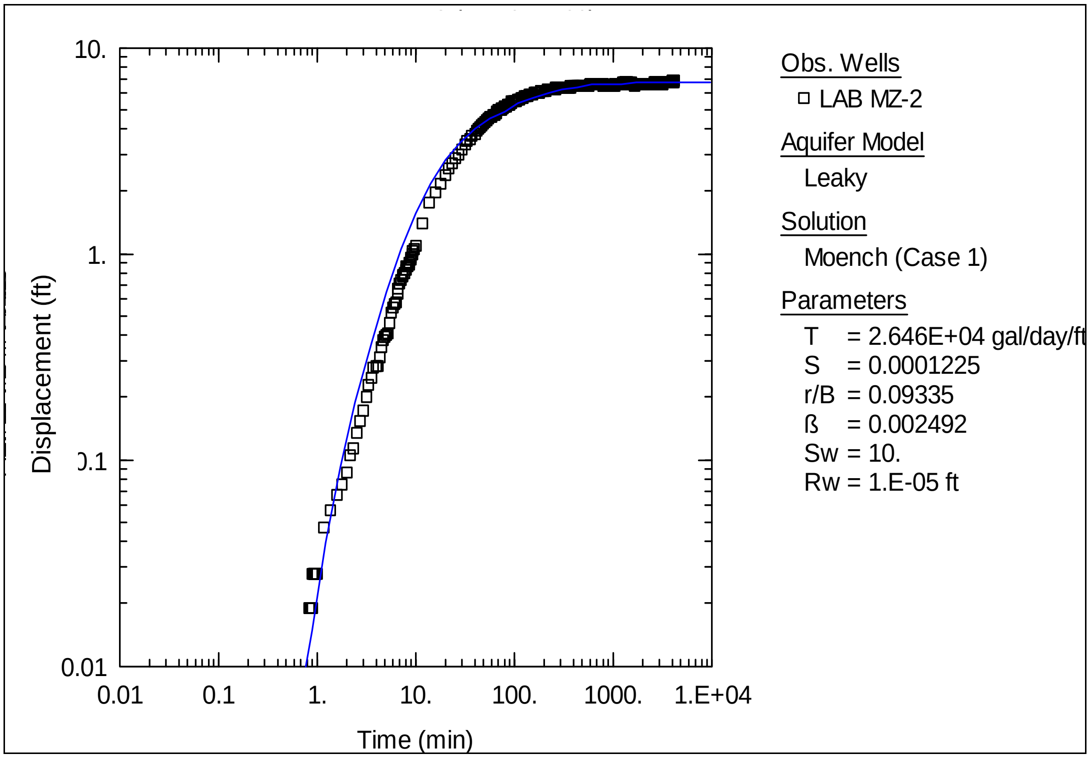

Figure 22. Log-Log Plot of Drawdown versus Time for Monitor Well LAB MZ-2, APT No. 2.

Based on these analytical considerations and the site-specific hydrogeologic data collected during drilling and aquifer testing, the Moench analytical model appears to best represent the conditions present at this site. The results of this solution yielded a transmissivity value of 26,460 gpd/ft, a storage coefficient of 1.2×10^{-4}, and a (r/B) value of 0.09. The dimensionless parameter r/B characterizes the leakage across the aquitard(s) to the pumped aquifer; from this value a leakance value of 2.9×10^{-3} gpd/ft^3 was calculated (Walton, 1960).

Long-Term Ground Water Level/Quality Monitoring Program

Shortly after completion of the tri-zone Floridan aquifer system monitor well (LAB-TW), SFWMD staff collected water quality samples from each monitor interval and submitted them to the SFWMD laboratory for cation/anion analyses to establish baseline conditions. **Table 8** summarizes the analytical results for each interval.

			Cations				Anions					Field Parameters		
Identifer	Depth Interval (ft. bls)	Sample Date	Na^+ mg/L	K^+ mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	Cl^- mg/L	Alka as $CaCO_3$ mg/L	SO_4^{2-} mg/L	F^- mg/L	TDS mg/L	Specific Conduct. umhos/cm	Temp °C	pH s.u.
LAB MZ-1	670-837	12/10/97	460.0	17.0	92.0	74.0	700.0	90.0	350.0	0.810	1,800	2,777	29.94	7.78
LAB MZ-2	1142-1458	12/10/97	330.0	16.0	81.0	70.0	500.0	88.0	350.0	1.200	1,500	2,177	30.54	7.69
LAB MZ-3	1645-1759	12/10/97	5100.0	160.0	450.0	570.0	9900.0	93.0	1200.0	0.550	18,000	26,582	32.83	7.17

MZ = Monitor Zone
ft. bls = feet below land surface
mg/L = milligrams per Liter
Alka as $CaCO_3$ = Alkalinity as Calcium Carbonate
TDS = total dissolved solids
umhos/cm = micromhos per centimeter at 25°C
°C = degree Celisus
s.u = standard unit

Table 8. Summary of Water Quality from Tri-Zone Monitor Well.

In addition, SFWMD established a monthly potentiometric-head monitoring program. As part of this program, a 30-psig transducer and Hermit 3000® (Insitu, Inc.) data logger were used to measure the pressure from the various monitor zones once a month. On November 24, 1997, automated pressure recorders (Insitu® Troll 4000) were installed on the individual monitor zones with sample frequencies set to hourly readings to identify short- and long-term stresses to the Floridan aquifer system.

The pressure transducer converts all pressure readings internally to equivalent fresh-water heads in feet using a conversion factor of 2.31 feet of head per psig. The converted pressure readings are then added to the surveyed measuring point elevation to obtain a hydraulic head referenced to NGVD, 1929.

Figure 23 illustrates the long-term hourly water level data for three of the Floridan aquifer system monitor intervals from December 9, 1998 to March 3, 1999. **Table 9** lists the monitor intervals; average recorded hydraulic head, and degree of variation. SFWMD generated the hydrographs for the upper Floridan aquifer and middle-confining unit using hourly pressure readings. These hydrographs show water level fluctuations that may be attributed to tidal loading and changes in atmospheric pressure (i.e., barometric effect).

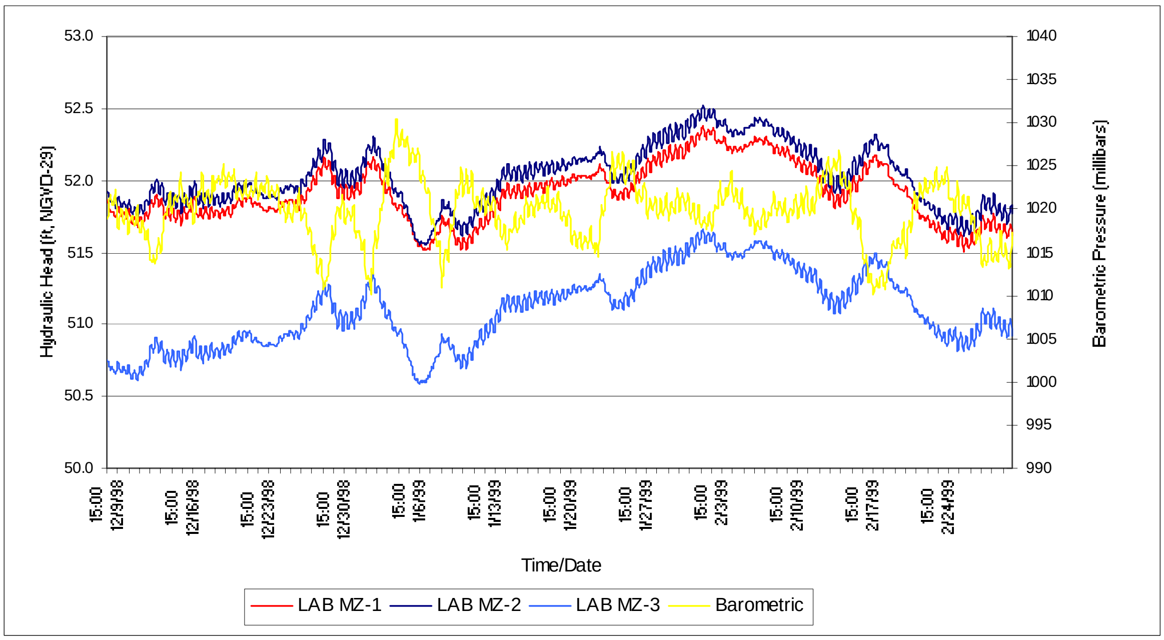

Figure 23. Long Term Hydrograph – Tri-Zone Floridan Aquifer System Monitor Well.

Identifier	Monitor Interval (feet bls)	Average Measured Hydraulic Head (feet NGVD, 1929)	Standard Deviation (feet)
LAB MZ-1	670 to 837	51.9	0.203
LAB MZ-2	1,142 to 1,458	52.1	0.216
LAB MZ-3	1,645 to 1,759	51.1	0.265
Period of Record from 12/09/98 to 03/03/99			

Table 9. Tri-Zone Monitor Well – Hydraulic Head Summary.

SUMMARY & CONCLUSIONS

1. The top of the Floridan aquifer system as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 665 feet bls. The upper Floridan aquifer extends for 665 to 850 feet bls. The middle-confining unit extends from 850 to 2,325 feet bls and includes the middle Floridan aquifer from 1,645 to 1,780 feet bls. The lower Floridan aquifer extends from 2,325 to 2,500 feet bls, the total depth of the test-monitor well.
2. Lithologic and geophysical logs, specific capacity and packer test results, and petrophysical data indicate moderate production capacity of the upper Floridan aquifer.
3. Water quality data from packer tests and completed monitor zones indicate that chloride and TDS concentrations in the upper portion of the Floridan aquifer system exceed potable drinking water standards. Chloride and TDS concentrations between 670 and 920 feet bls average 640 to 1,680 mg/L, respectively.
4. The base of the Underground Source of Drinking Water, those waters having TDS concentrations less than 10,000 mg/L, occurs at an approximate depth of 1,675 feet bls.
5. The stable isotope data from the LaBelle site indicate that the upper Floridan waters are depleted in both ^{18}O and deuterium as compared to the reference standard SMOW, which indicate they are meteoric in origin.
6. Stable isotope results indicate that the middle Floridan aquifer water is depleted in both ^{18}O and deuterium as compared to SMOW. The inorganic chemistry indicates the interval between 1,645 to 1,759 feet bls is saline in composition. The inorganic chemistry combined with the stable isotope data suggests that the middle Floridan aquifer has in part been intruded by seawater.
7. The petrophysical data suggest a moderately strong linear relationship between horizontal permeability and porosity with a correlation coefficient of 0.76.
8. The highest horizontal permeabilities (2,901 and 2,224 millidarcies) correspond to cored sections at approximately 726 and 821 feet bls, respectively. These two intervals consist of packstones and boundstones, likely deposited in an open-lagoonal shoal environment.
9. The upper Floridan aquifer from 670 to 850 feet bls yielded a transmissivity of 68,630 gpd/ft, a storage coefficient of 6.7×10^{-5}, a (r/B) value of 0.06, and a leakance of 3.39×10^{-3} gpd/ft^3.
10. An interval from 1,110 to 1,465 feet bls yielded a transmissivity value of 26,460 gpd/ft, a storage coefficient of 1.2×10^{-4}, a (r/B) value of 0.09, and a leakance value of 2.9×10^{-3} gpd/ft^3.
11. The average measured hydraulic heads for the system monitor intervals are as follows:
    - 51.9 feet above mean sea level for the 670 to 837 feet bls monitor interval (LAB MZ-1)
    - 52.1 feet above mean sea level for the 1,142 to 1,458 feet bls monitor interval (LAB MZ-2)
    - 51.1 feet above mean sea level for the 1,645 to 1,759 feet bls monitor interval (LAB MZ-3).
12. Water levels in the Floridan aquifer system respond to external stresses such as tidal loading and barometric pressure variations.
13. The inorganic chemistry, stable isotopes, radiocarbon, and potentiometric head data summarized in this report suggests that two horizons (670 to 837 and 1,142 to 1,458 feet bls) in the Floridan aquifer system are hydraulically connected.
14. Inorganic, stable isotope, and radiocarbon data suggests that middle Floridan aquifer waters (LAB MZ-3) are composed of Pleistocene-aged meteoric water, which were later intruded by seawater.

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APPENDIX A
CASING MILL CERTIFICATES

검 사 증 명 서 (A)

MILL INSPECTION CERTIFICATE

LABelle PW 12'' CASING

LABELLE JOB

현 대 강 관 주 식 회 사
HYUNDAI PIPE CO., LTD.
※본 사 · 공 장 경남 울산시 중구 염포동 265번지
ULSAN PLANT : # 265, YUMPO-DONG, JUNG-KU, ULSAN, KOREA
TEL : 87-2101~9 FAX : (0522) 87-6916
TLX : HDPIPE K 53776
※서울사무소 서울특별시 중구 무교동 77번지
SEOUL OFFICE : # 77, MUKYO-DONG, JUNG-KU, SEOUL, KOREA
TEL : 773-0522 FAX : 775-7095
TLX : HDPIPE K 24656, K 22956

증 명 서 번 호 CERTIFICATE NO : E-7-05-213 페이지 PAGE : 1

발 행 일 자 DATE OF ISSUE : MAY. 29. 1997. E4702800

계 약 번 호 CONTRACT/P/O NO :

품 명 COMMODITY : E.R.W. STEEL PIPE

품 규 격 SPECIFICATION : API 5LB/ASTM A53B

수 요 가 CUSTOMER : 12" OD / 0.375

G : GOOD

※2	치 수 DIMENSION 외경 × 두께 × 길이 OUTDIA. × THICK. × LENGTH (※3, ※4)	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST (PSI)	※6–※13 Visual & Dimension / Flattening / Weld Ductility / Drift / Flaring / Crush / R-Flattening Tests	도금시험 COATING TEST (Weight of Zinc Coat / Dip Test)	제강번호 HEAT NO.	항복강도 YIELD STRENGTH (PSI)	인장강도 TENSILE STRENGTH (kg/mm²)	인장강도 TENSILE STRENGTH (PSI)	연신율 ELONGATION (%)	C (×100)	Si	Mn	P (×1000)	S	Cu (×100)	Ni	Cr	Mo	V	충격시험 IMPACT	비고 REMARK
OD	12-3/4" x .250" x42.000'	82	52,177	58	G G G G G		A09902	34.1	48.1	51.5	43	14	1	86	16	8	6	1	2	1	Tr		
	(323.9mm x 6.35mm x 12.802M)			820				48500	68400	73300													
OD	12-3/4" x .375" x21.000'	82	38,745	87	G G G G G	✓	8836779	33.4	48.7	51.3	38	14	Tr	75	18	10	6	1	2	1	Tr		
	(323.9mm x 9.53mm x 6.401M)			1240				47500	69300	73000													
OD	12-3/4" x .375" x42.000'	159	150,255	87	G G G G G	✓	A09913	32.0	51.8	54.4	30	18	Tr	85	16	8	6	1	2	1	Tr		
	(323.9mm x 9.53mm x 12.802M)			1240				45500	73700	77400													
	TOTAL ->	323	241,177																				

NOTES ※1 Type of pipe End 관종

Black Plain End Square-cut	GPE : Galvanized Plain End Square-cut
Black Plain End Beveled	GPEB : Galvanized Plain End Beveled
Black Threaded & Coupled	GTC : Galvanized Threaded & Coupled
Black Victaulic Joint	GVJ : Galvanized Victaulic Joint
Enameled Threaded & Coupled	

※2 NB : Nominal Bore호칭경, 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 Test육안 및 치수검사
※7 Flattening or Bending Test 편평 또는 굽힘시험
※8 Weld Ductility Test 용접부 연성시험
※9 Nondestructive Test 비파괴검사
※10 Drift Test관통시험
※11 Flaring Test 압확시험
※12 Crush Test 중압시험
※13 Reverse Flattening Test전개시험
※14 B : Base Metal 모재부
※15 W : Weld Part 용접부
※16 H : Heat (Ladle) Analysis 일괄분석, P : Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

INSPECTION MANAGER [signature]

1301-019-Q-T (350×260)

HYUNDAI PIPE CO., LTD.

검 사 증 명 서 (A)
MILL INSPECTION CERTIFICATE

LA BELLE JOB

성적서번 CERTIFICATE NO	E-7-03-372	페이지 PAGE : 2
발행일자 DATE OF ISSUE	APR. 3. 1997. E4702800
계약번호 CONTRACT P/O NO	
품명 COMMODITY	E.R.W. STEEL PIPE
제품규격 SPECIFICATION	API 5LB/ASTM A53B

수요가 CUSTOMER: 18" OD / 0.375" W.T CASING

현대강관주식회사
HYUNDAI PIPE CO., LTD.
*본사·공장 경남 울산시 중구 염포동 265번지 ☎ (0522) 87-2101
ULSAN PLANT : # 265, YUMPO-DONG, JUNG-KU, ULSAN, KOREA
TEL : 87-2101~9 FAX : (0522) 87-8916
TLX : HDPIPE K 53776
*서울사무소 서울특별시 중구 무교동 77번지
SEOUL OFFICE : #77, MUKYO-DONG, JUNG-KU, SEOUL, KOREA
TEL : 773-0522 FAX : 775-7095
TLX : HDPIPE K 24656, K 22956

G : GOOD

관종 TYPE OF PIPE END ※1	치수 DIMENSION 외경×두께×길이 OUTDIA. × THICK. × LENGTH ※2 ※3 ※4	수량 QUANTITY (PCS)	중량 WEIGHT (KG)	수압시험 HYDROSTATIC TEST PSI	※6–※13 (VISUAL & DIMENSION / FLATTENING / WELD DUCTILITY / DRIFT / FLARING / CRUSH / R-FLATTENING TEST)	제강번호 HEAT NO.	항복강도 YIELD STRENGTH PSI	인장강도 TENSILE STRENGTH B ※14	인장강도 TENSILE STRENGTH W ※15	연신율 ELONGATION %	C	Si	Mn	P	S	Cu	Ni	Cr	Mo	V	충격시험 IMPACT	비고 REMARK
						A07731	30.9	48.4	51.8	40	17	Tr	73	19	10	6	1	2	1	Tr		
							44000	68800	73700													
						A07781	31.8	50.5	53.1	38	16	1	78	14	7	6	1	2	1	Tr		
							45200	71800	75500													
BPEB	OD 16" x .500" x42.000'	20	31,567	92	G G G G G	A01670	34.8	49.1	52.5	34	18	1	78	15	8	6	1	2	1	Tr		
	(406.4mm x12.70mm x 12.802M)			1310			49500	69800	74700													
						A04753	32.9	51.9	54.0	40	17	Tr	74	17	6	6	1	2	1	Tr		
							46800	73800	76800													
BPEB	OD 18" x .375" x42.000'	115	154,802	62	G G G G G	A04636	30.6	49.1	52.5	38	18	1	81	19	8	6	1	2	1	Tr		
	(457.0mm x 9.53mm x 12.802M)			880			43500	69600	74700													
						A04640	33.4	48.7	51.7	38	17	Tr	72	16	5	6	1	2	1	Tr		
							47500	69300	73500													
						A05012	33.5	50.5	53.1	38	17	1	79	17	9	6	1	2	1	Tr		
							47600	71800	75500													
						A07232	31.1	49.6	52.2	41	16	3	78	16	8	6	1	2	1	Tr		
							44200	70500	74200													
BPEB	OD 18" x .500" x42.000'	39	69,500	82	G G G G G	A04640	33.4	48.7	51.7	38	17	Tr	72	16	5	6	1	2	1	Tr		
	(457.0mm x12.70mm x 12.802M)			1170			47500	69300	73500													
BPEB	OD 24" x .375" x40.000'	80	137,344	48	G G G G G	A06792	31.7	49.3	52.7	38	16	1	77	13	8	6	1	2	1	Tr		
	(610.0mm x 9.53mm x 12.192M)			650			45100	70100	75000													

Units: Tensile test B ※14 in kg/mm², W ※15 in N/mm²; C, Si, Mn × 100; P, S × 1000; Cu, Ni, Cr, Mo, V × 100.

참고—NOTES ※1 Type of pipe End 관종

BPE	:Black Plain End Square-cut	GPE	:Galvanized Plain End Square-cut
BPEB	:Black Plain End Beveled	GPEB	:Galvanized Plain End Beveled
BTC	:Black Threaded & Coupled	GTC	:Galvanized Threaded & Coupled
BVJ	:Black Victaulic Joint	GVJ	:Galvanized Victaulic Joint
ETC	:Enameled Threaded & Coupled		

※2 NB : Normal Bore호칭경, OD : Outside Diameter
※3 Unit단위(M) : mm, I : Inch
※4 Unit단위(L) : Meter, F : Feet, I : Inch
※5 G : Good
※6 Visual & Dimension Test육안 및 치수검사
※7 Flattening or Bending Test 편평 또는 굽힘시험
※8 Weld Ductility Test 용접부 인성시험
※9 Nondestructive Test 비파괴검사
※10 Drift Test 관통시험
※11 Flaring Test 압확시험
※12 Crush Test 종압시험
※13 Reverse Flattening Test 전개시험
※14 B : Base Metal 모재부
※15 W : Weld Part 용접부
※16 H : Heat (Ladle) Analysis 일인분석, P : Product Analysis 제품분석

본 제품은 관련규격에 합격되었음을 보증합니다.

WE HEREBY CERTIFY THAT THE MATERIAL DESCRIBED HEREIN HAS BEEN ACCEPTED IN ACCORDANCE WITH THE PRESCRIBED SPECIFICATION AND ORDER.

SURVEYOR

INSPECTION MANAGER

HPS-R301-019-QLT

△ HYUNDAI PIPE CO., LTD.

350 × 280

SOUTH FLORIDA WATER MANAGEMENT LABELLE 24" OD/0.375 W.T (Casing)

INSPECTION CERTIFICATE

Supplier : HYUNDAI CORPORATION
Contract No (L/C No) NY6035539K
Specification : ASTM A53B/API 5LB
Kind of Article : E. R. W. Steel pipe

주 식 회 사 신 호 스 틸
Shin Ho Steel Co., Ltd
C.P.O.Box904Seoul, Korea.
DAEBUL PLANT

Customer : HYUNDAI CORPORATION, U.S.A
Issued Date : JUN. 08. 1996
Certificate No : D960608 - 070
Manufactured No : 96 - 5 - 203

Lot No. (Heat)	Q.TY (pcs)	Type	Nominal Size (in)	Dimension O.D (mm)	Dimension W.T (in)	Dimension Length (ft)	Weight (kg/m)	Chemical Comp. (%) C	Si	Mn	Cu	Ni	Cr	Mo	P	S	V	Tension Test Tensile Strength (kgf/mm²)	Yield Strength (kgf/mm²)	Elongation (%)	WTS (kgf/mm²)
								x 100							x 1000						
A87246	60	BPEB	18	457.0	0.250	42	70.6	15	TR	75	2	2	2	TR	17	6	2	50	36	34	51
A87069	135	BPEB	18	457.0	0.375	42	105.1	16	TR	74	3	3	2	TR	16	6	2	50	36	34	51
A88857	285	BPEB	24	610.0	0.375	40	140.9	17	TR	76	3	2	2	TR	15	5	3	51	37	33	52
A83647	64	BPEB	24	610.0	0.500	40	187.1	16	TR	76	2	2	2	TR	16	6	3	52	37	32	53
A88861	44	BPEB	24	610.0	0.500	40	187.1	15	TR	75	3	2	2	TR	15	6	3	51	36	33	52
A88859	108	BPEB	24	610.0	0.500	40	187.1	16	TR	76	2	3	3	TR	16	6	2	52	37	32	53

Nominal Size (in)	NDT (UST)	F(B) Test	WDT	Hydrostatic Test (------, psi)	Ring Gage Test	Straightness (%)	V.I	REMARK
18	pass	G	G	580	pass	0.1	G	
18	pass	G	G	880	pass	0.1	G	
24	pass	G	G	660	pass	0.1	G	
24	pass	G	G	880	pass	0.1	G	
24	pass	G	G	880	pass	0.1	G	
24	pass	G	G	880	pass	0.1	G	
		-----	LAST ITEM	-----				

We hereby certify that the above products have been made in accordance with the requirements called for the order.

(1) O.D : Outside Diameter.
(2) W.T : Wall Thickness.
(3) WTS : Weld Tensile Test.
(4) F(B) : Flattening (Bend).
(5) V.I : Visual Inspection.
(6) WDT : Weld Ductility Test.
(7) NDT : Non Destructive Test.
UST : Ultrasonic Test.

Y. R. KIM
Inspector in charge

TUBULAR FIBERGLASS COMPANY
11611 Proctor Road, Houston, Texas 77038
TEL (713) 847-2987 FAX (713) 847-1931

April 1, 1995

RED BOX 2500

FIBERGLASS TUBING, CASING, AND LINERS
AROMATIC AMINE CURED EPOXY RESIN

DIMENSIONAL SPECIFICATIONS

Nominal Size (inches)	Nominal O.D.* (inches)	Nominal I.D. (inches)	Minimum Drift Dia. (inches)	Pin Upset Dia. (inches)	Max.Box O.D. (inches)	Nominal Wall* (inches)	Nominal Weight (lbs/ft)	Nominal Weight (lbs/jt)	Connection Type API 5B 2.6a*, 2.3**, 2.2***
2–3/8	2.44	2.00	1.91	2.70	3.35	0.22	1.4	42	2–3/8" 8Rd EUE Long*
2–7/8	3.03	2.48	2.39	3.19	3.88	0.27	2.2	65	2–7/8" 8Rd EUE Long*
3–1/2	3.63	3.00	2.91	3.85	4.86	0.32	3.0	91	3–1/2" 8Rd EUE Long*
4–1/2	4.85	3.99	3.90	4.85	5.67	0.43	5.3	160	4–1/2" 8Rd EUE Long*
5–1/2	5.42	4.42	4.33	5.60	6.78	0.50	7.1	212	5–1/2" 8Rd Csg Long**
6–5/8	6.63	5.43	5.34	6.73	8.00	0.60	10.3	309	6–5/8" 8Rd Csg Long**
7–5/8	7.60	6.21	6.12	7.73	9.23	0.70	13.6	409	7–5/8" 8Rd Csg Long**
9–5/8	9.58	7.84	7.75	9.73	11.60	0.87	21.6	649	9–5/8" 8Rd Csg Long**
10–3/4	10.63	8.85	8.76	10.85	13.00	0.99	27.5	826	10–3/4" 8Rd Csg Short***

* for products with resin–rich internal liner, add liner thickness.

Standard Joint Length: 30 ft

PERFORMANCE AND RATINGS (–60 deg F to +210 deg F)

Nominal Size	Pressure Rating (psi)	Mill Test Pressure (psi)	Collapse Rating (psi)	Axial Tension Rating (lbs)	Stretch vs. Tension Over Pipe Wt. (ft)
2–3/8	2,500	2,500	3,300	20,200	0.214 x P x L
2–7/8	2,500	2,500	3,300	27,100	0.134 x P x L
3–1/2	2,500	2,500	3,200	35,600	0.102 x P x L
4–1/2	2,500	2,500	3,300	51,000	0.055 x P x L
5–1/2	2,500	2,500	3,400	59,300	0.043 x P x L
6–5/8	2,500	2,500	3,300	79,200	0.030 x P x L
7–5/8	2,500	2,500	3,400	97,100	0.022 x P x L
9–5/8	2,500	2,500	3,300	123,100	0.014 x P x L
10–3/4	2,500	2,500	3,400	137,600	0.011 x P x L

P = Tensile Load (1,000 lbs)
L = String Length (1,000 ft)

MECHANICAL AND PHYSICAL PROPERTIES

PROPERTY	VALUE	UNIT	TEST METHOD
Tensile Strength, Hoop	31,300	psi	ASTM D1599
Tensile Strength, Axial	30,000	psi	ASTM D2105
Modulus of Elasticity, Axial	3.0	10E+06 psi	ASTM D2105
Long Term Hydrostatic Strength at 20 Years	15,000	psi	ASTM D2992(B)
Specific Gravity	1.9	---	ASTM D792
Density	0.07	lbs/cu.inch	ASTM D792
Thermal Conductivity	1.4	Btu/hr/ft2/in/degF	---
Thermal Expansion Coefficient (Linear)	1.1	10E–05 in/in/degF	ASTM D696
Flow Factor	150	---	Hazen Williams

RED BOX® CASING AND TUBING SYSTEM **YELLOW BOX® LINE PIPE SYSTEM**

LAW ENGINEERING
4919 WEST LAUREL STREET
TAMPA, FLORIDA 33607
(813) 289-0750

CLIENT: Southern Well Services
P.O. Box 17305
Clearwater, FL 33620

FILE NO: 467-00600.00
CERTIFICATION DATE: 4/12/94
PROCEDURE NO: AWS Pre-Qualified
WITNESSED BY: Others

TEST DATA

WELDER'S NAME: Norman R. Moon Jr.
IDENTIFICATION NO: 266-51-6997
BACKING USED: Yes
FILLER SPECIFICATION: AWS A5.1
PROCESS: SMAW
WELDING CODE: AWS D1.1-52

BASE MATERIAL: Carbon Steel
METAL THICKNESS: 1/4
THICKNESS QUALIFIED FOR: 1/8 - .0674
ELECTRODE: 7018 Dia. 3/32
POSITION: 2G Dia.: 5"
GROOVE DESIGN: B-U2a

TEST RESULTS

GUIDED BEND TEST

TYPE	RESULTS	TYPE	RESULTS

RADIOGRAPHIC TEST

ID	RESULTS	ID	RESULTS
R	Pass		

PASSED

QUALIFICATION TEST RESULTS

This welder qualifies for flat and horizontal position groove and flat and horizontal position fillet welding of pipe, tubing and plate within the limitations of AWS D1.1.

Contractor's representative

Respectfully submitted,
LAW ENGINEERING, INC.

AWS CWI

SDT 1510

Nominal Tubing Size (in.)	Nominal I.D. (in.)	Nominal I.D. (mm)	Nominal O.D. (in.)	Nominal O.D. (mm)	Nominal Wall Thickness (in.)	Nominal Wall Thickness (mm)	Nominal Coupling O.D. (in.)	Nominal Coupling O.D. (mm)	Nom. Weight (Tubing Only) (Lbs./Ft.)	Nom. Weight (Tubing Only) (kg/m)	Make-up Length (in.)	Make-up Length (mm)
1½	1.50	38	1.77	45	0.14	3.6	2.7	69	0.71	1.06	2.1	53
2⅜	2.00	51	2.38	60	0.19	4.8	3.3	84	1.22	1.82	2.6	66
2⅞	2.43	62	2.89	73	0.23	5.8	3.9	99	1.77	2.63	2.9	74
3½	3.00	76	3.51	89	0.26	6.6	4.6	117	2.45	3.65	3.1	79
4½	4.00	102	4.64	118	0.32	8.1	5.8	147	3.92	5.83	3.4	86
7	5.84	148	6.90	175	0.53	13.5	8.2	208	9.39	13.97	3.1	79

Nominal Tubing Size (in.)	Pressure Rating (psig)	Pressure Rating (MPa)	Tensile Rating (lbs.)	Tensile Rating (kg)	Collapse Rating (psig)	Collapse Rating (MPa)	Ultimate Burst(1) (psig)	Ultimate Burst(1) (MPa)	Ultimate Collapse(1) (psig)	Ultimate Collapse(1) (MPa)	Ultimate Tensile(1) (lbs.)	Ultimate Tensile(1) (kg)
1½	1,500	10.3	6,850	3,107	1,100	7.6	4,800	33.1	3,300	22.8	24,000	10,886
2⅜	1,500	10.3	11,700	5,307	1,200	8.3	5,800	40.0	3,600	24.8	41,400	18,779
2⅞	1,500	10.3	15,900	7,212	1,200	8.3	5,500	37.9	3,600	24.8	49,700	22,544
3½	1,500	10.3	23,200	10,524	1,100	7.6	5,500	37.9	3,250	22.4	78,400	35,562
4½	1,500	10.3	33,000	14,969	900	6.2	5,000	34.5	2,700	18.6	103,000	46,721
7	1,500	10.3	55,500	25,175	1,100	7.6	4,600	31.7	3,300	22.8	167,000	75,751

*All values are nominal. Tolerances or maximum/minimum limits can be obtained from Smith Fiberglass Products Inc.

(1)Calculated from random lab tests. All measured across the joint. Note: The elastic limit of SDT Downhole Tubing will be exceeded, and the tubing will be permanently damaged at 75 percent of ultimate values.

POST OFFICE BOX 140126 • ORLANDO, FLORIDA 32814 • PHONE (407) 894-1751
ROUTE 6 BOX 210 • DOTHAN, ALABAMA 36303 • PHONE (205) 983-4531
4949 SUNBEAM ROAD, SUITE 3 • JACKSONVILLE, FLORIDA 32257 • PHONE (904) 730-3213.

WELDING PROCEDURE
AND
WELDER'S QUALIFICATION TESTS

Company Meridith Associates
Date 4/26/96
Specification No. ASME IX
Manual Yes
Welding Process SMAW
Material Specification ASTM A53 Grade B
Thickness (if pipe, diameter and wall thickness) 6"
Filler Metal E-6011
Weld Metal Analysis
Describe Filler Metal
Covered Electrode
For oxyacetylene welding - State of Filler Metal is silicon or aluminum killed.

WELDING PROCEDURE
Single or Multiple Pass Multiple
Single or Multiple Arc Single
Position of Groove 6G

FOR INFORMATION

Filler Wire - Diameter 5/32
Trade Name Ideal Arc
Type of Backing NONE
Forehand or Backhand Backhand

WELDING TECHNIQUES
Joint Dimensions Accord with ASME IX
amps 140 volts 20 inches per min.
Current Direct Polarity Reverse

Welder's Name Clifford Carter
Stamp No. 215-64-4294

I certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements ASME IX.

Date 4/26/96
Signed [signature]

REDUCED SECTION TENSILE TEST

Specimen No.	Dimensions Width Thickness	Area	Ultimate Total Load, lb.	Ultimate Unit Stress, psi	Character or Failure and location

GUIDED BEND TESTS

Type and Figure No.	Result	Type and Figure No.	Result
ROOT	QW 462.3(a) accept	Face	QW 462.3(a) accept
ROOT	QW 462.3(a) accept	Face	QW 462.3(a) accept

QUALIFICATION BY RADIOGRAPHY N/A

Welder's Name Clifford Carter who by virtue of these tests does XXXX does not ( ) meet welder performance requirements.
Prepared By Space Science Services Inc. Laboratory Test No. 80-10032
Approved By [signature]

W-1

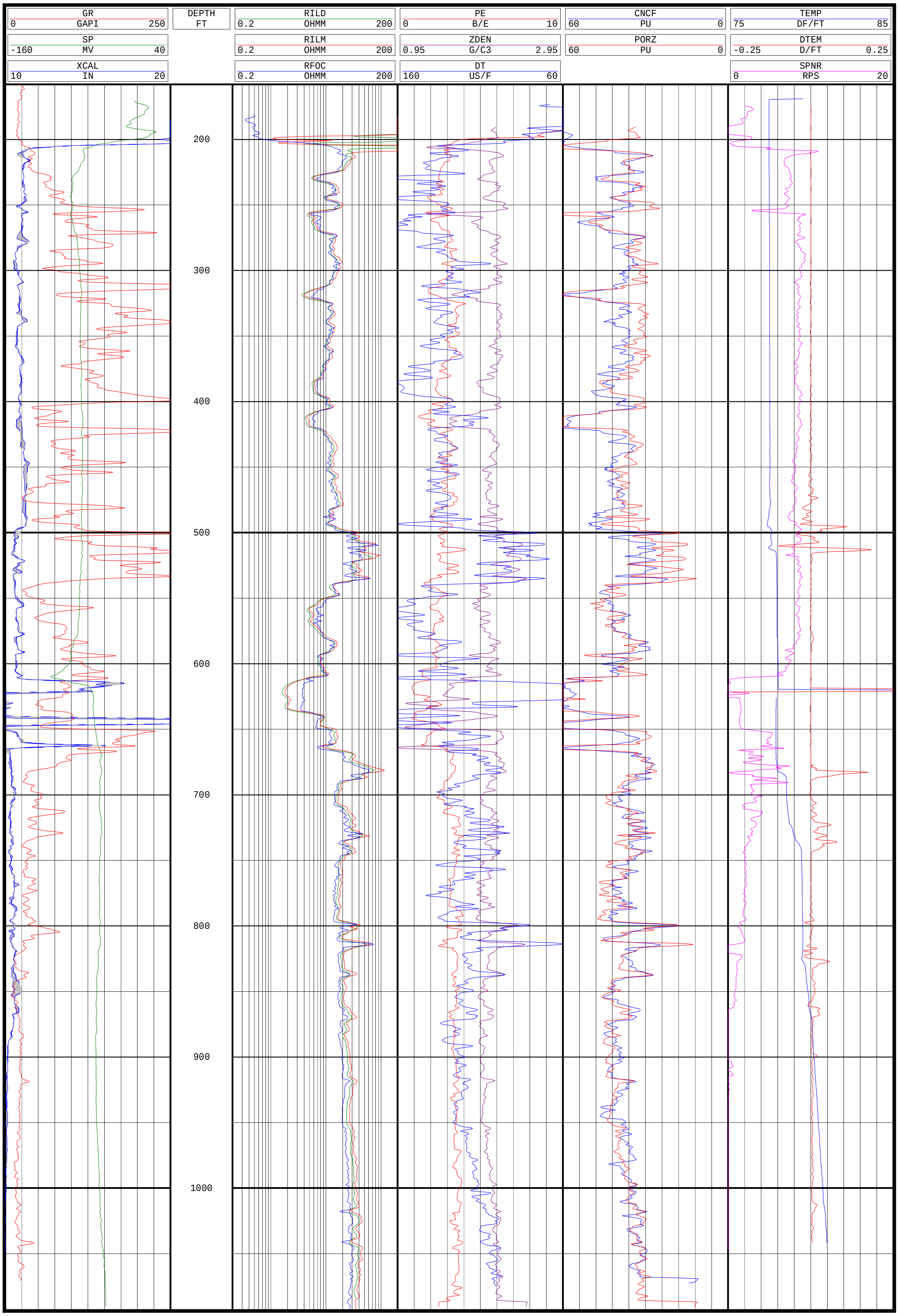
NON-DESTRUCTIVE, METALLURGICAL, PHYSICAL AND CHEMICAL TESTING AND INSPECTION PROGRAMS

SPACE SCIENCE SERVICES

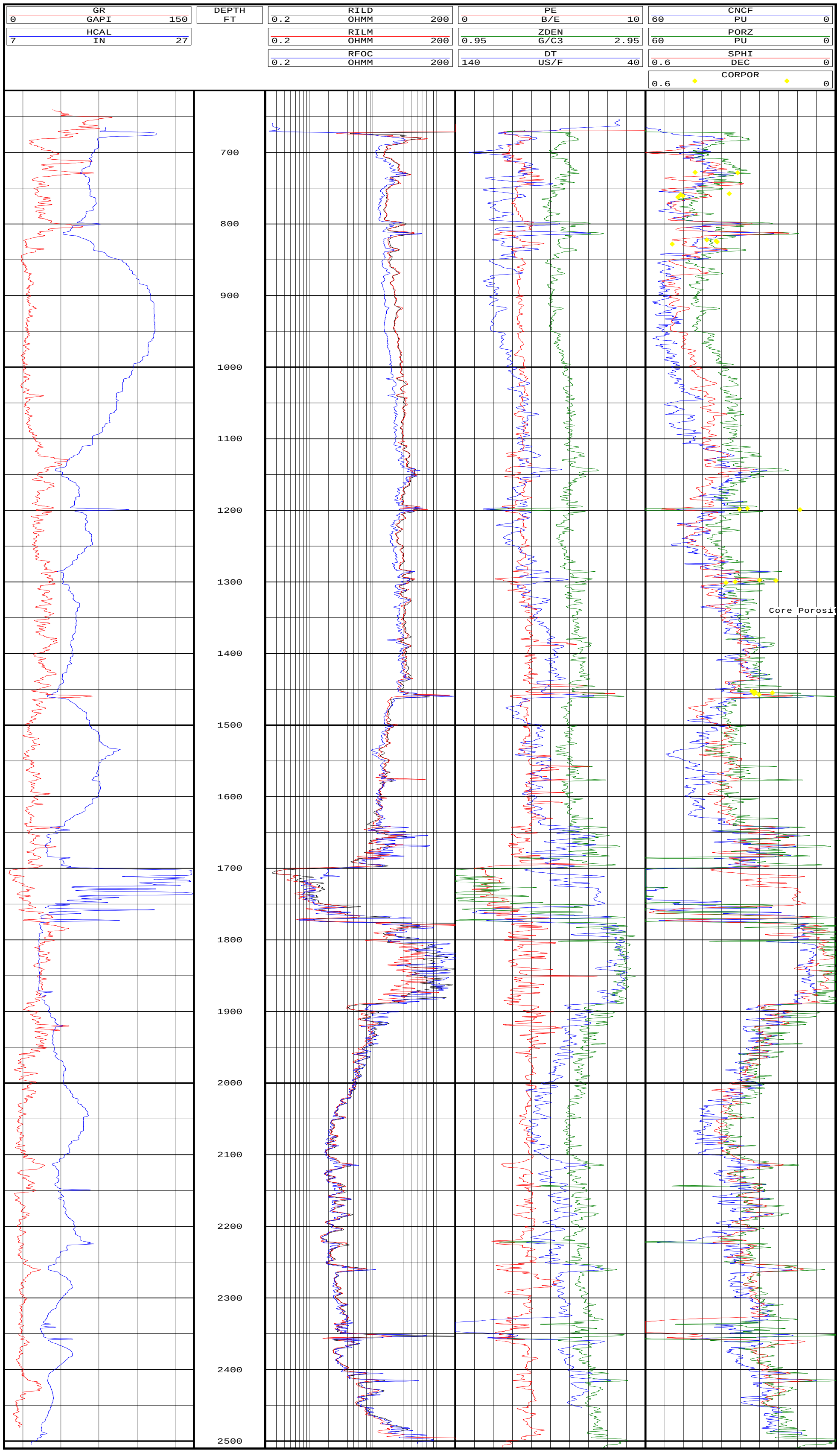
APPENDIX B
GEOPHYSICAL LOGS

LEGEND FOR GEOPHYSICAL LOG TRACES

2DEN	**bulk density**
B/E	**Barnes per Electron**
CNCF	**neutron porosity**
CORPOR	**laboratory determined porosity**
DegF	**degrees Fahrenheit**
D/ft	**degree per foot**
DT	**delta transient time**
DTEMP	**delta temperature**
FT	**feet**
GAPI	**gamma American Petroleum Institute units**
GR	**gamma ray**
g/cm^3	**grams per cubic centimeter**
Hcal	**density caliper**
in	**inches**
OHMM	**ohm-meters**
PE	**photoelectric effect**
POR2	**density porosity**
PU	**porosity units**
RFOC	**shallow focused resistivity**
RILD	**deep induction log**
RILM	**medium induction log**
RLL3	**shallow focused resistivity**
rps	**revolutions per second**
SP	**spontaneous potential**
SPHI	**sonic porosity**
SPNR	**flowmeter**
TEMP	**temperature gradient**
USEC	**microseconds per foot**
XCAL	**x-caliper**
YCAL	**y-caliper**



Geophysical Log Run No. 1



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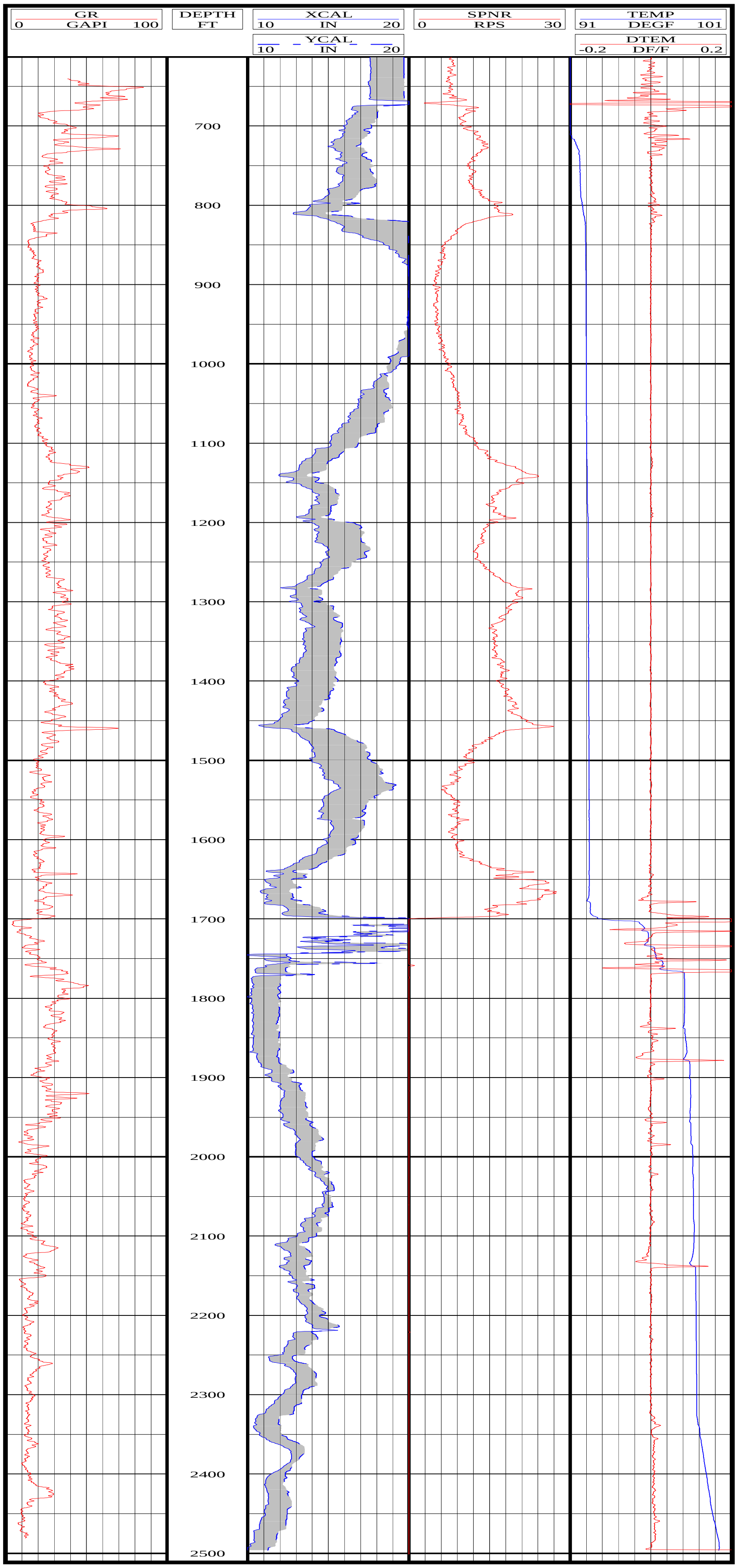

Geophysical Log Run No. 3

APPENDIX C
FLORIDA GEOLOGICAL SURVEY
LITHOLOGIC DESCRIPTIONS

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SOURCE - FGS

WELL NUMBER:   W-17591                          COUNTY -   HENDRY
TOTAL DEPTH:    2500  FT.                       LOCATION:  T.43S R.28E S.12 NE
491 SAMPLES FROM 40 TO 2500 FT.                            LAT = 26D 45M 11.4N
                                                           LON = 81D 28M 17.7W
COMPLETION DATE: 11/12/97                       ELEVATION: 17 FT
OTHER TYPES OF LOGS AVAILABLE - Natural Gamma, Caliper, Induction, Sonic,
Density, Neutron, Flowmeter, Temperature

OWNER/DRILLER: SFWMD part of the LWC FAS GROUNDWATER RESOURCE ASSESSMENT.
SFWMD Well ID = LAB-TW; SFWMD Geophysical Log ID No. 051-40; Driller:
Diversified Drilling Corporation

Rick Green/Tom Scott 7/2002
    0.    -  125.   122PCPC   122PCPC
  125.    -  200.   122TAM    TAMIAMI FM.
  200.    -  255.   122PCRV   PEACE RIVER FM.
  255.    -  750.   122ARCA   ARCADIA FM.
  750.    -  850.   123SWNN   SUWANNEE LIMESTONE
  850.    - 1150.   124OCAL   OCALA GROUP
 1150.    - 2500.   124AVPK   AVON PARK FM.

WORKED BY:Described by Joy Griffin
Formations in the Lower Eocene/Oldsmar are not discernible due to the
presence of cones which reflect Middle Eocene biostratigraphy.  In well
data to the east,the Lower Eocene formation is found ~2500-3000ft as
determined by a glauconite marker bed which is not apparent in the
cuttings associated with this well.

0     125  090UDSS UNDIFF. SAND AND SHELLS
125    740  122HTRN HAWTHRON GROUP
740    810  123SWNN SUWANNEE LIMESTONE
810   1150  124OCAL OCALA LIMESTONE
1150         124AVPK AVON PARK FORMATION

NOTE: PICKS ABOVE ARE ORIGINAL PICKS BY JOY GRIFFIN FOR THIS WELL. PICKS
BELOW
BY RICK GREEN/TOM SCOTT AND JON ARTHUR MADE 6/01.

    0.    -  060.   122PCPC   122PCPC
  060.    -  125.   122PCRV   PEACE RIVER FM.
  125.    -  750.   122ARCA   ARCADIA FM.
  750.    -  850.   123SWNN   SUWANNEE LIMESTONE
  850.    - 1150.   124OCAL   OCALA GROUP
 1150.    -     .   124AVPK   AVON PARK FM.

    0  -   45   CLAY; YELLOWISH GRAY
                10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
                POOR INDURATION
                CEMENT TYPE(S): CLAY MATRIX
                ACCESSORY MINERALS: CALCILUTITE-05%, IRON STAIN-01%

   45  -   50   SHELL BED; WHITE TO YELLOWISH GRAY
                20% POROSITY: INTERGRANULAR, INTRAGRANULAR
                POSSIBLY HIGH PERMEABILITY; POOR INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX
                ACCESSORY MINERALS: QUARTZ SAND-20%
                FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS
```

	FINE QUARTZ SAND SETTLED IN CALCILUTITE MATRIX OF POORLY CONSOLIDATED SHELLS
50 - 65	SHELL BED; VERY LIGHT ORANGE TO YELLOWISH GRAY 30% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY; UNCONSOLIDATED ACCESSORY MINERALS: QUARTZ SAND-10%, CLAY-05% FOSSILS: MOLLUSKS LAST 5 FT CONTAINS ~5% VERY COARSE TO GRANULE SIZED QUARTZ SAND
65 - 100	SAND; YELLOWISH GRAY TO MODERATE LIGHT GRAY 30% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN SIZE: GRANULE; RANGE: COARSE TO GRANULE ROUNDNESS: SUB-ROUNDED TO ROUNDED; LOW SPHERICITY UNCONSOLIDATED ACCESSORY MINERALS: SHELL-24%, PHOSPHATIC GRAVEL-07% OTHER FEATURES: CALCAREOUS FOSSILS: MOLLUSKS, FOSSIL FRAGMENTS SAMPLE INTERVAL RANGES FROM 25% SHELLY SAND TO 15% SANDY SHELL BED, SAMPLE FROM 80-85FT IS POORLY INDURATED QUARTZ SAND CEMENTED WITH CALCILUTITE
100 - 105	SAND; YELLOWISH GRAY TO DARK GRAY 35% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN SIZE: GRANULE; RANGE: VERY COARSE TO GRAVEL ROUNDNESS: SUB-ROUNDED TO ROUNDED; LOW SPHERICITY UNCONSOLIDATED ACCESSORY MINERALS: SHELL-10%, PHOSPHATIC GRAVEL-05% FOSSILS: MOLLUSKS QUARTZ GRAVEL IS WELL-ROUNDED AND OBLATE SHAPED
105 - 125	SAND; YELLOWISH GRAY TO LIGHT GRAY 35% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN SIZE: VERY COARSE; RANGE: VERY COARSE TO GRAVEL ROUNDNESS: SUB-ROUNDED TO ROUNDED; LOW SPHERICITY UNCONSOLIDATED ACCESSORY MINERALS: SHELL-05%, PHOSPHATIC GRAVEL-05% QUARTZ GRAVEL IS UP TO 15MM IN SIZE, PHOSPHATIC GRAVEL UP TO 10MM
125 - 140	WACKESTONE; WHITE 15% POROSITY: MOLDIC, INTRAGRANULAR, LOW PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 25% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY FINE; RANGE: MEDIUM TO FINE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT OTHER FEATURES: HIGH RECRYSTALLIZATION FOSSILS: FOSSIL MOLDS

140 - 145 DOLOSTONE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: MOLDIC, INTRAGRANULAR, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-30%
FOSSILS: MOLLUSKS
SAMPLE CONTAINS 30% HIGHLY RECRYSTALLIZED WACKESTONE

145 - 150 CALCILUTITE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: MOLDIC, INTRAGRANULAR, LOW PERMEABILITY
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS

150 - 160 DOLOSTONE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: MOLDIC, INTRAGRANULAR, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: GRANULE; RANGE: VERY COARSE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-30%

160 - 180 CLAY; WHITE TO YELLOWISH GRAY
05% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY; MODERATE INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: LIMESTONE-20%, DOLOMITE-15%
OTHER FEATURES: CALCAREOUS, UNWASHED SAMPLE
SAMPLE CONTAINS 30% LIMESTONE GRANULES IN A CLAY MATRIX
(POORLY INDURATED) AND MODERATELY INDURATED DOLOMITE AND
CLAY FRAGMENTS

180 - 190 CLAY; WHITE TO YELLOWISH GRAY
05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: LIMESTONE-10%, QUARTZ SAND-05%
DOLOMITE-05%
OTHER FEATURES: CALCAREOUS, UNWASHED SAMPLE, POOR SAMPLE

190 - 200 CALCARENITE; WHITE TO VERY LIGHT GRAY
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: GRAVEL TO VERY COARSE
UNCONSOLIDATED
ACCESSORY MINERALS: PHOSPHATIC SAND-02%, DOLOMITE-02%
QUARTZ SAND-10%, SPAR-02%
FOSSILS: MOLLUSKS, CORAL, BRYOZOA
SAMPLE CONTAINS 10% WELL INDURATED LIMESTONE THAT CONTAINS
40% QUARTZ SAND

200 - 215 SHELL BED; YELLOWISH GRAY TO VERY LIGHT GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: LIMESTONE-05%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS

215 - 230 SHELL BED; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
FOSSILS: FOSSIL FRAGMENTS

230 - 235 SHELL BED; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-10%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS

235 - 245 SHELL BED; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-10%, QUARTZ SAND-10%
PHOSPHATIC SAND-10%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH, MOLLUSKS
CLUMPS OF CLAY PRESENT

245 - 255 SHELL BED; YELLOWISH GRAY
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-10%, PHOSPHATIC SAND-30%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS

255 - 275 PHOSPHATE; YELLOWISH GRAY TO BLACK
25% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: SHELL-30%, CLAY-10%, QUARTZ SAND-05%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH
PHOSPHATIC SAND CONTENT RANGES FRON 60-40%

275 - 310 SHELL BED; YELLOWISH GRAY TO BLACK
30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-05%, PHOSPHATIC GRAVEL-10%
PHOSPHATIC SAND-25%, QUARTZ SAND-05%
OTHER FEATURES: UNWASHED SAMPLE, HIGH RECRYSTALLIZATION
FOSSILS: FOSSIL FRAGMENTS, SHARKS TEETH

310 - 315 SHELL BED; YELLOWISH GRAY
15% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: CLAY-25%, PHOSPHATIC SAND-15%
PHOSPHATIC GRAVEL-05%
OTHER FEATURES: UNWASHED SAMPLE, MEDIUM RECRYSTALLIZATION
FOSSILS: CORAL, FOSSIL FRAGMENTS
SAMPLE VARIES TO UNCONSOLIDATED

315 - 320 LIMESTONE; VERY LIGHT ORANGE TO LIGHT GRAY
10% POROSITY: INTRAGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO GRANULE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-07%, CLAY-07%
CHERT-02%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: FOSSIL FRAGMENTS

320 - 330 LIMESTONE; VERY LIGHT ORANGE TO LIGHT GRAY
10% POROSITY: INTRAGRANULAR, INTERGRANULAR
LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
25% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-40%, PHOSPHATIC SAND-07%
OTHER FEATURES: UNWASHED SAMPLE
SAMPLE CONTAINS MODERATELY INDURATED MICRITIC LIMESTONE AND
POORLY INDURATED CLAY CLUMPS, INCREASING PHOSPHATIC SAND
CONTENT

330 - 335 CALCILUTITE; WHITE TO BLACK
05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-15%, CLAY-05%
LIMESTONE-02%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: ECHINOID, MOLLUSKS
SAMPLE VARIES FROM CALCILUTITE MUD WITH 35% CALCARENITE TO
CALCARENITE WITH 35% CALCILUTITE

335 - 410 CALCILUTITE; WHITE TO YELLOWISH GRAY
05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO VERY COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-35%
OTHER FEATURES: UNWASHED SAMPLE, POOR SAMPLE
CALCARENITE CONTENT OF SAMPLE DECREASES FROM 30-07%
PHOSPHATIC SAND CONTENT DECREASES FROM ~35-10%

410 - 415 CLAY; LIGHT OLIVE GRAY TO GREENISH GRAY
05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: QUARTZ SAND-05%, PHOSPHATIC SAND-02%
LIMESTONE-05%
OTHER FEATURES: UNWASHED SAMPLE

415 - 420 PHOSPHATE; LIGHT OLIVE GRAY TO MODERATE DARK GRAY
10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-20%, LIMESTONE-20%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: BRYOZOA
SAMPLE VARIES TO POORLY INDURATED CEMENTED WITH CLAY

420 - 480 CALCILUTITE; WHITE TO YELLOWISH GRAY
05% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC GRAVEL-05%, CLAY-05%
PHOSPHATIC SAND-07%, LIMESTONE-10%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: BRYOZOA
PHOSPHATIC GRAVEL PRESENT IN TOP 15FT OF INTERVAL ~10-20%
SAMPLE DEPTH 425-430FT CONTAINS ~25% PHOSPHATIC GRAVEL AND
20% LIMESTONE

480 - 495 CLAY; LIGHT OLIVE GRAY TO DARK GREENISH GRAY
05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX
ACCESSORY MINERALS: LIMESTONE-20%, PHOSPHATIC GRAVEL-05%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: MOLLUSKS, BRYOZOA, ECHINOID
STRONG ORGANIC ODOR, LIMESTONE CONSISTS OF BRYOZOANS, 5%
SPARRY CALCITE, AND 15% CALCARENITE

```
495  -  525   DOLOSTONE; YELLOWISH GRAY TO WHITE
              15% POROSITY: INTERGRANULAR, INTRAGRANULAR
              LOW PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
              GRAIN SIZE: GRANULE; RANGE: VERY COARSE TO GRAVEL
              MODERATE INDURATION
              CEMENT TYPE(S): DOLOMITE CEMENT
              ACCESSORY MINERALS: PHOSPHATIC GRAVEL-02%, LIMESTONE-15%
              PHOSPHATIC SAND-05%
              OTHER FEATURES: HIGH RECRYSTALLIZATION
              FOSSILS: BRYOZOA, MOLLUSKS
              LIMESTONE IS CALCLUTITE CONTAINING ~20% PHOSPHATIC SAND.
              THE LIMESTONE CONTENT INCREASES FROM ~15-40%

525  -  545   DOLOSTONE; YELLOWISH GRAY TO OLIVE GRAY
              10% POROSITY: INTERGRANULAR, INTRAGRANULAR
              LOW PERMEABILITY
              MODERATE INDURATION
              CEMENT TYPE(S): DOLOMITE CEMENT
              ACCESSORY MINERALS: CLAY-15%, PHOSPHATIC SAND-03%
              LIMESTONE-20%
              OTHER FEATURES: UNWASHED SAMPLE
              POORLY INDURATED CLAY TO MODERATELY INDURATED LIMESTONE AND
              DOLOMITE, CLAY CONTENT DECREASES FROM 15-5% AT 540FT THEN
              INCREASES AGAIN, BUT THE CLAY HAS CHANGED FROM LIGHT OLIVE
              GRAY TO OLIVE GRAY

545  -  575   CLAY; YELLOWISH GRAY TO LIGHT OLIVE GRAY
              05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: DOLOMITE-10%, LIMESTONE-05%
              PHOSPHATIC SAND-01%, CALCILUTITE-05%
              OTHER FEATURES: UNWASHED SAMPLE
              STRONG ORGANIC ODOR, LAST 5FT OF INTERVAL (570-575FT) HAS
              AN INCREASED NUMBER OF DOLOMITE AND SHELL FRAGMENTS AND 5%
              SAND APPEARS

575  -  600   SANDSTONE; GRAYISH ORANGE TO LIGHT BROWN
              10% POROSITY: INTERGRANULAR, INTRAGRANULAR
              LOW PERMEABILITY
              GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
              ROUNDNESS: ANGULAR TO SUB-ROUNDED; LOW SPHERICITY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: CLAY-20%, LIMESTONE-10%
              PHOSPHATIC SAND-05%, DOLOMITE-05%
              OTHER FEATURES: UNWASHED SAMPLE
              CLAY CONTENT INCREASES IN SAMPLES 590-600FT TO ~35%

600  -  605   SILT; LIGHT OLIVE GRAY TO OLIVE GRAY
              05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
              POOR INDURATION
              CEMENT TYPE(S): CLAY MATRIX
              ACCESSORY MINERALS: CALCILUTITE-05%, DOLOMITE-05%
              CLAY-10%, LIMESTONE-10%
              OTHER FEATURES: UNWASHED SAMPLE
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605 - 610   SAND; MODERATE GRAY TO OLIVE GRAY
            10% POROSITY: INTERGRANULAR, LOW PERMEABILITY
            GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
            ROUNDNESS: ANGULAR TO SUB-ROUNDED; LOW SPHERICITY
            POOR INDURATION
            CEMENT TYPE(S): CLAY MATRIX
            ACCESSORY MINERALS: CALCILUTITE-10%, LIMESTONE-10%
            DOLOMITE-10%, CLAY-30%
            OTHER FEATURES: UNWASHED SAMPLE

610 - 650   CLAY; OLIVE GRAY TO GREENISH BLACK
            05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
            POOR INDURATION
            CEMENT TYPE(S): CLAY MATRIX
            ACCESSORY MINERALS: QUARTZ SAND-15%, LIMESTONE-10%
            CALCILUTITE-05%
            OTHER FEATURES: UNWASHED SAMPLE, MUDDY
            QUARTZ SAND CONTENT VARIES FROM ~10-35%, SANDSTONE PRESENT
            (POSSIBLY CAVINGS)

650 - 665   CLAY; OLIVE GRAY TO MODERATE GRAYISH GREEN
            05% POROSITY: INTERGRANULAR, LOW PERMEABILITY
            MODERATE INDURATION
            CEMENT TYPE(S): CLAY MATRIX
            ACCESSORY MINERALS: LIMESTONE-03%
            OTHER FEATURES: MUDDY

665 - 740   WACKESTONE; VERY LIGHT GRAY TO LIGHT OLIVE GRAY
            15% POROSITY: INTERGRANULAR, LOW PERMEABILITY
            GRAIN TYPE: CALCILUTITE, CRYSTALS, BIOGENIC
            10% ALLOCHEMICAL CONSTITUENTS
            MODERATE INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
            ACCESSORY MINERALS: PHOSPHATIC SAND-10%, QUARTZ SAND-35%
            OTHER FEATURES: UNWASHED SAMPLE
            FOSSILS: FOSSIL MOLDS, SHARKS TEETH, CRUSTACEA, MOLLUSKS
            LOW RECRYSTALLIZATION BECOMES HIGHLY RECRYSTALLIZED ~700FT
            ~25% CLAY CEMENTED SANDSTONE, CONTAINS ~5% CLAY POSSIBLY
            CAVINGS

740 - 765   PACKSTONE; VERY LIGHT ORANGE TO LIGHT GRAY
            20% POROSITY: INTERGRANULAR, INTRAGRANULAR
            POSSIBLY HIGH PERMEABILITY
            GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
            60% ALLOCHEMICAL CONSTITUENTS
            GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
            MODERATE INDURATION
            CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
            ACCESSORY MINERALS: PHOSPHATIC SAND-02%, QUARTZ SAND-10%
            FOSSILS: MOLLUSKS, CRUSTACEA
            SAMPLE CONTAINS ~5% SANDSTONE AND ~5% CLAY
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765 - 775	GRAINSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 85% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: MEDIUM TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-01% FOSSILS: CRUSTACEA, MOLLUSKS SAMPLE CONTAINS ~5% CLAY CLUMPS POSSIBLY CAVINGS
775 - 795	PACKSTONE; VERY LIGHT ORANGE TO DARK GRAY 15% POROSITY: INTERGRANULAR, INTRAGRANULAR LOW PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: MEDIUM TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-01% SAMPLE CONTAINS ~35% CLAY CLUMPS POSSIBLY CAVINGS
795 - 805	GRAINSTONE; VERY LIGHT ORANGE TO DARK GRAY 15% POROSITY: INTERGRANULAR, INTRAGRANULAR LOW PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL 90% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: MEDIUM TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-01%, QUARTZ SAND-05% OTHER FEATURES: MEDIUM RECRYSTALLIZATION SAMPLE CONTAINS 20% CLAY CLUMPS POSSIBLY CAVINGS
805 - 810	CLAY; MODERATE DARK GRAY 05% POROSITY: INTERGRANULAR, LOW PERMEABILITY POOR INDURATION CEMENT TYPE(S): CLAY MATRIX ACCESSORY MINERALS: DOLOMITE-25%, LIMESTONE-25% SAMPLE CONTAINS PEBBLE SIZED FRGMENTS OF CLAY, DOLOMITE AND LIMESTONE
810 - 815	DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE 10% POROSITY: INTERGRANULAR, INTRAGRANULAR LOW PERMEABILITY; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE MODERATE INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-10% OTHER FEATURES: HIGH RECRYSTALLIZATION SAMPLE CONTAINS ~15% CLAY CLUMPS

815 - 830 MUDSTONE; WHITE TO MODERATE DARK GRAY
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY COARSE TO GRAVEL
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-07%, DOLOMITE-10%
OTHER FEATURES: HIGH RECRYSTALLIZATION
FOSSILS: ECHINOID, FOSSIL MOLDS
SAMPLE CONTAINS ~10% GRAINSTONE,CONTAINS 7% CLAY CAVINGS

830 - 855 WACKESTONE; WHITE TO VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
GRAIN SIZE: VERY COARSE; RANGE: COARSE TO GRANULE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: DOLOMITE-05%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: MOLLUSKS
DOLOMITE CONTENT IN SAMPLE VARIES FROM 5-15%

855 - 920 MUDSTONE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%
FOSSILS: BENTHIC FORAMINIFERA, SPICULES, FOSSIL FRAGMENTS
LEPIDOCYCLINA FOUND, SAMPLE INTERVAL CONTAINS LARGE
FRAGMENTS OF CLAY(POSSIBLE CAVINGS), INTERVAL FROM
865-870FT CONTAINS ~40% OLIVE-GRAY CLAY FRAGMENTS

920 - 980 MUDSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS
LEPIDOCYCLINA sp. AND NUMMULITES sp.

980 - 1070 MUDSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY, MEDIUM RECRYSTALLIZATION
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, ECHINOID
LEPIDOCYCLINA AND NUMMULITES, SAMPLE VARIES FROM MUDSTONE
TO WACKESTONE AND CONTAINS UNCONSOLIDATED MATERIALCOMPRISED
OF ~60% FORAMS AND FOSSIL FRAGMENTS, ~5% CLAY CAVINGS
DOLOMITE APPEARS AT 995FT AND CONTINUES THROUGH INTERVAL AT
~5%

1070 - 1100 WACKESTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
OTHER FEATURES: CHALKY
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS, ECHINOID
NUMMULITES sp., SAMPLE CONTAINS ~5% CLAY CAVINGS AND ~2%
GRAINSTONE

1100 - 1140 CALCARENITE; VERY LIGHT ORANGE TO LIGHT BLUISH GRAY
10% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
55% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRANULE
UNCONSOLIDATED
ACCESSORY MINERALS: CLAY-35%
FOSSILS: BENTHIC FORAMINIFERA, FOSSIL FRAGMENTS
SAMPLE CONSISTS OF ~20-40% FORAMS (LEPIDOCYCLINA &
NUMMULITES) AND SHELL FRAGMENTS. IT ALSO CONTAINS 20-35%
PALE BLUE CLAY WHICH IS DIFFERENT THAN ANY OF THE OVERLYING
CLAY BEDS AND 20-40% MUDSTONE FRAGMENTS

1140 - 1150 MUDSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-05%, DOLOMITE-05%
OTHER FEATURES: CHALKY
FOSSILS: BENTHIC FORAMINIFERA
NUMMULITES sp.

1150 - 1155 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%, CLAY-02%
OTHER FEATURES: CHALKY
FOSSILS: BENTHIC FORAMINIFERA, BRYOZOA

1155 - 1195 DOLOSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-25%
OTHER FEATURES: CALCAREOUS
FOSSILS: BENTHIC FORAMINIFERA, BRYOZOA, FOSSIL MOLDS
MOLLUSKS

1195 - 1265 PACKSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
45% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%, SPAR-10%
FOSSILS: BENTHIC FORAMINIFERA, BRYOZOA, MOLLUSKS, ECHINOID
CONES
DICTYOCONUS sp. SAMPLE INTERVAL VARIES FROM A PACKSTONE
WITH 25% DOLOMITE TO DOLOMITE WITH 35% PACKSTONE. TWO TYPES
OF DOLOMITE ARE FOUND IN THE SAMPLE: (1)CRYSTALLINE
DOLOMITE WITH LOW POROSITY (2)GRANULAR DOLOMITE WITH HIGH
POROSITY

1265 - 1295 WACKESTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1295 - 1320	PACKSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 45% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO VERY COARSE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05% FOSSILS: BENTHIC FORAMINIFERA, ECHINOID, CONES
1320 - 1395	WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 15% POROSITY: INTERGRANULAR, INTRAGRANULAR LOW PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 20% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-15% OTHER FEATURES: UNWASHED SAMPLE, DOLOMITIC FOSSILS: BENTHIC FORAMINIFERA, MOLLUSKS
1395 - 1415	PACKSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO VERY COARSE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-15% FOSSILS: BENTHIC FORAMINIFERA
1415 - 1425	GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 25% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 85% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID SAMPLE CONTAINS 10% MUDSTONE

1425 - 1475 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
45% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%, ORGANICS-01%, SPAR-10%
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC
FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
MILIOLIDS, SAMPLE VARIES BETWEEN PACKSTONE AND GRAINSTONE.
DOLOMITE CONTENT INCREASES TO 10%

1475 - 1505 WACKESTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-40%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID

1505 - 1525 WACKESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
FOSSILS: BENTHIC FORAMINIFERA, CONES, BRYOZOA

1525 - 1550 GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%, ORGANICS-07%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1550 - 1560 WACKESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY COARSE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-20%, ORGANICS-02%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1560 - 1600 WACKESTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%
FOSSILS: BENTHIC FORAMINIFERA, CONES

1600 - 1610 WACKESTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
35% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CLAY-07%, DOLOMITE-05%
FOSSILS: MOLLUSKS, BENTHIC FORAMINIFERA, ECHINOID
SAMPLE CONTAINS ~7% OF BLUISH WHITE CLAY CLUMPS

1610 - 1645 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
50% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: DOLOMITE-10%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID

1645 - 1710 DOLOSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY COARSE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-25%, ORGANICS-01%
FOSSILS: CONES
PACKSTONE CONTENT VARIES FROM 30-05%, DOLOMITE RANGES FROM MODERATELY INDURATED, VERY FINE, EUHEDRAL GRAINED TO POORLY INDURATED, COARSE, EUHEDRAL GRAINED DOLOMITE B.H. VIDEO AND CALIPER INDICATE CAVERNOUS, POSSIBLY FRACTURED DOLOMITE FROM 1700-1770 FT, PERSONAL COMMUNICATION W/ MICHAEL BENNETT SFWMD,1998

1710	- 1730	DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE GRAY 15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO VERY COARSE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-07% OTHER FEATURES: SUCROSIC SAMPLE CONTAINS HIGHLY FRACTURED, COARSE DOLOMITE CRYSTALS GROWING ON FRACTURE SURFACES AND IN VUGS, ALSO CONTAINS 5-10% DOLOMITIC LIMESTONE
1730	- 1765	DOLOSTONE; MODERATE DARK GRAY TO MODERATE YELLOWISH BROWN 20% POROSITY: VUGULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; EUHEDRAL GRAIN SIZE: VERY COARSE RANGE: MICROCRYSTALLINE TO VERY COARSE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: ORGANICS-01% OTHER FEATURES: SUCROSIC SAMPLE CONTAINS SUCROSIC MICROCRYSTALLINE DOLOMITE FRAGMENTS WITH COARSER GRAINS GROWING ON OUTER SURFACE AND EUHEDRAL, COARSE -GRAINED DOLOMITE
1765	- 1780	DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE GRAY 15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO VERY COARSE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-10% OTHER FEATURES: SUCROSIC FOSSILS: BRYOZOA SAMPLE CONTAINS ~5% EUHEDRAL, COARSE-GRAINED DOLOMITE, LEPS AND NUMMULITES CAVINGS
1780	- 1790	DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN 15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO FINE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-05%
1790	- 1810	DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE GRAY 15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MICROCRYSTALLINE RANGE: MICROCRYSTALLINE TO VERY COARSE; GOOD INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-05%, LIMONITE-01% OTHER FEATURES: SUCROSIC SAMPLE CONTAINS ~5% EUHEDRAL, COARSE-GRAINED DOLOMITE

1810 - 1875 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-10%
SAMPLE CONTAINS OCALA CAVINGS. INTERVAL VARIES BETWEEN PALE YELLOWISH BROWN AND MEDIUM GRAY/DARK YELLOWISH BROWN DOLOMITE

1875 - 1885 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
15% POROSITY: INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SAMPLE CONTAINS FEW FRACTURE SURFACES

1885 - 1890 WACKESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
10% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: LAMINATED
ACCESSORY MINERALS: DOLOMITE-10%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: BENTHIC FORAMINIFERA, ALGAE

1890 - 1895 DOLOSTONE; DARK YELLOWISH BROWN TO VERY LIGHT ORANGE
15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-15%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: BENTHIC FORAMINIFERA

1895 - 1900 DOLOSTONE; MODERATE YELLOWISH BROWN
15% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-05%

1900 - 1905 MUDSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
10% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE
LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: LAMINATED
ACCESSORY MINERALS: DOLOMITE-20%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: ALGAE

1905 - 1940 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
15% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
10% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: LAMINATED
ACCESSORY MINERALS: DOLOMITE-10%
OTHER FEATURES: UNWASHED SAMPLE
FOSSILS: ALGAE, BRYOZOA, BENTHIC FORAMINIFERA
INTERVAL CONTAINS 25-40% POORLY INDURATED GRAINSTONE
CEMENTED WITH CALCILUTITE MUD, GRAINS CONSIST OF ALGAL
LAMINATED MUDSTONE FRAGMENTS AND DOLOMITE FRAGMENTS

1940 - 1950 DOLOSTONE; DARK YELLOWISH BROWN
15% POROSITY: INTERCRYSTALLINE, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE
RANGE: MICROCRYSTALLINE TO VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-10%
OTHER FEATURES: UNWASHED SAMPLE

1950 - 1955 DOLOSTONE; VERY LIGHT ORANGE TO MODERATE LIGHT GRAY
15% POROSITY: INTERCRYSTALLINE, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-30%
OTHER FEATURES: UNWASHED SAMPLE, MEDIUM RECRYSTALLIZATION
FOSSILS: CONES
SAMPLE CONTAINS VERY DENSE DOLOMITE AND POSSIBLE OOIDS

1955 - 1960	WACKESTONE; VERY LIGHT ORANGE 15% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: CALCILUTITE, BIOGENIC, INTRACLASTS 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: FINE; RANGE: VERY FINE TO VERY COARSE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX SEDIMENTARY STRUCTURES: LAMINATED ACCESSORY MINERALS: DOLOMITE-10% OTHER FEATURES: UNWASHED SAMPLE FOSSILS: BENTHIC FORAMINIFERA
1960 - 1965	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05% OTHER FEATURES: UNWASHED SAMPLE FOSSILS: BENTHIC FORAMINIFERA, CONES
1965 - 1970	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL 50% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: FINE TO GRANULE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT OTHER FEATURES: MEDIUM RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA
1970 - 2005	PACKSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRANULE; RANGE: MEDIUM TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-07% OTHER FEATURES: PLATY FOSSILS: CONES, BENTHIC FORAMINIFERA BEGINNING AT 1985FT SAMPLES BECOME 1/2 PACKSTONE AND 1/2 GRAINSTONE. DOLOMITE CONTENT DECREASES TO 1%

2005 - 2040 GRAINSTONE; VERY LIGHT ORANGE
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: MEDIUM TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
SAMPLE VARIES TO UNCONSOLIDATED

2040 - 2100 PACKSTONE; VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
45% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: LOW RECRYSTALLIZATION
FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID
FOSSIL FRAGMENTS

2100 - 2110 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
23% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-45%
OTHER FEATURES: DOLOMITIC
FOSSILS: BENTHIC FORAMINIFERA, CONES

2110 - 2115 DOLOSTONE; GRAYISH BROWN
20% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-05%

2115 - 2120 DOLOSTONE; GRAYISH BROWN
20% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: LIMESTONE-35%

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2120  - 2130   PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               20% POROSITY: INTERGRANULAR, INTRAGRANULAR
               POSSIBLY HIGH PERMEABILITY
               GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
               45% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE
               POOR INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-20%
               FOSSILS: BENTHIC FORAMINIFERA, CONES

2130  - 2135   PACKSTONE; VERY LIGHT ORANGE
               20% POROSITY: INTERGRANULAR, INTRAGRANULAR
               POSSIBLY HIGH PERMEABILITY
               GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
               45% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRAVEL
               POOR INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-01%
               OTHER FEATURES: MEDIUM RECRYSTALLIZATION
               FOSSILS: BENTHIC FORAMINIFERA, CONES

2135  - 2150   WACKESTONE; VERY LIGHT ORANGE
               15% POROSITY: INTRAGRANULAR, LOW PERMEABILITY
               GRAIN TYPE: CALCILUTITE, BIOGENIC, SKELETAL
               15% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-01%, CLAY-01%
               FOSSILS: FOSSIL MOLDS
               IN LAST 5FT OF INTERVAL, DOLOMITE CONTENT INCREASES TO 15%

2150  - 2220   PACKSTONE; VERY LIGHT ORANGE
               20% POROSITY: INTRAGRANULAR, LOW PERMEABILITY
               GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
               70% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: VERY COARSE; RANGE: VERY FINE TO GRANULE
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
               ACCESSORY MINERALS: CLAY-01%, DOLOMITE-01%
               FOSSILS: CONES, BENTHIC FORAMINIFERA
               SAMPLES FROM 2185-2220FT HAVE ~5% BLUISH WHITE CLAY

2220  - 2230   DOLOSTONE; GRAYISH BROWN
               20% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY
               VUGULAR; 50-90% ALTERED; EUHEDRAL
               GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
               GOOD INDURATION
               CEMENT TYPE(S): DOLOMITE CEMENT
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2230	- 2250	WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 25% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT ACCESSORY MINERALS: DOLOMITE-10% FOSSILS: BENTHIC FORAMINIFERA, CONES
2250	- 2255	PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 20% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 50% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-50% OTHER FEATURES: DOLOMITIC
2255	- 2260	DOLOSTONE; GRAYISH BROWN 20% POROSITY: INTERCRYSTALLINE, POSSIBLY HIGH PERMEABILITY INTERGRANULAR; 50-90% ALTERED; EUHEDRAL GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO VERY COARSE MODERATE INDURATION CEMENT TYPE(S): DOLOMITE CEMENT
2260	- 2325	PACKSTONE; VERY LIGHT ORANGE 25% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 60% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRAVEL POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT ACCESSORY MINERALS: DOLOMITE-02%, CLAY-01% OTHER FEATURES: LOW RECRYSTALLIZATION FOSSILS: BENTHIC FORAMINIFERA, CONES, ECHINOID DOLOMITE CONTENT VARIES FROM 5-40%
2325	- 2365	DOLOSTONE; MODERATE YELLOWISH BROWN 20% POROSITY: INTERCRYSTALLINE, INTERGRANULAR POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM MODERATE INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-05% SUB-EUHEDRAL, DOLOMITE GETS PROGRESSIVELY LIGHTER IN COLOR AS THE INTERVAL INCREASES IN DEPTH. LIMESTONE CONTENT IN SAMPLES 2345-2355FT INCREASES TO 15%

2365	- 2370	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTRAGRANULAR, INTERCRYSTALLINE POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 45% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY COARSE RANGE: MICROCRYSTALLINE TO GRANULE; POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-07%, GYPSUM-01% ANHYDRITE-05% FOSSILS: BENTHIC FORAMINIFERA, CONES, BRYOZOA
2370	- 2375	GRAINSTONE; VERY LIGHT ORANGE 25% POROSITY: INTRAGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: ORGANICS-01%, DOLOMITE-25% FOSSILS: BENTHIC FORAMINIFERA, CONES
2375	- 2390	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTRAGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 40% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-10%, GYPSUM-01% ANHYDRITE-01% FOSSILS: BENTHIC FORAMINIFERA, CONES
2390	- 2400	DOLOSTONE; GRAYISH BROWN 25% POROSITY: INTRAGRANULAR, POSSIBLY HIGH PERMEABILITY 50-90% ALTERED; ANHEDRAL GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO MEDIUM POOR INDURATION CEMENT TYPE(S): DOLOMITE CEMENT ACCESSORY MINERALS: LIMESTONE-40% OTHER FEATURES: CALCAREOUS FOSSILS: ECHINOID, BENTHIC FORAMINIFERA SAMPLE CONTAINS OCALA CAVINGS
2400	- 2445	PACKSTONE; VERY LIGHT ORANGE 20% POROSITY: INTERGRANULAR, INTRAGRANULAR POSSIBLY HIGH PERMEABILITY GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE 70% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO GRANULE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-05%, ANHYDRITE-01% FOSSILS: BENTHIC FORAMINIFERA, CONES

2445 - 2465 GRAINSTONE; VERY LIGHT ORANGE
25% POROSITY: INTERGRANULAR, INTRAGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%, ANHYDRITE-01%
FOSSILS: BENTHIC FORAMINIFERA, CONES
DOLOMITE CONTENT INCREASES TO 20%

2465 - 2485 MUDSTONE; VERY LIGHT GRAY TO VERY LIGHT ORANGE
10% POROSITY: INTRAGRANULAR, LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: ANHYDRITE-05%, DOLOMITE-05%
FOSSILS: BENTHIC FORAMINIFERA
SAMPLE CONTAINS 25% PACKSTONE

2485 - 2500 GRAINSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
20% POROSITY: INTERGRANULAR, INTRAGRANULAR
LOW PERMEABILITY
GRAIN TYPE: BIOGENIC, SKELETAL, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: GRANULE; RANGE: VERY FINE TO GRANULE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-25%, ANHYDRITE-05%
GYPSUM-01%
FOSSILS: BENTHIC FORAMINIFERA, CONES

2500 TOTAL DEPTH

APPENDIX D
PETROPHYSICAL DATA

SOUTH FLORIDA WELL MANAGEMENT DISTRICT
CORE DESCRIPTIONS
LAB-PW
HENDRY COUNTY, FLORIDA

Arcadia Formation

Core Interval: 725.0 to 726.2 feet below land surface.

Description: Pale yellowish brown colored, very fine to coarse grained, slightly phosphatic, peloidal-foram packstone with good interparticle porosity, and traces of vuggy and foram intraparticle porosity.

Depositional Environment: Open Lagoon.

Core Interval: 726.2 to 726.35 feet below land surface.

Description: Yellowish gray colored, fine to coarse grained, poorly sorted, coquina to gastropod-mollusk-echinoderm packstone. This interval is slightly cemented with overgrowths and has very good interparticle porosity and good moldic porosity.

Depositional Environment: Shoal

Suwannee Limestone

Core Interval: 755.0 to 755.5 feet below land surface.

Description: Pale yellow to white colored, very fine to medium grained, moderately to poorly sorted, mollusk-echinoderm-peliod-foram-packstone This interval is slightly cemented with overgrowths and contains scattered molluscan molds, and a limited number of medium sized vugs.

Depositional Environment: Shoal Flank

Core Interval: 755.5 to 755.7 feet below land surface.

Description: Pale yellow colored, fine to granular size grains, poorly sorted, algal-oncolite boundstone. Possess good interparticle and intraparticle porosity, scattered molluscan molds, and a limited number of medium sized vugs.

Depositional Environment: Algal Mound

Core Interval: 755.7 to 759.1 feet below land surface

Description: This mollusk-foram packstone is yellowish-gray in color with yellowish-gray matrix. It is slightly laminated, fine to coarse size grains, poorly sorted with mollusk shells that range in size between 5 and 20 millimeters. It has fair to good intraparticle, moldic and vuggy porosity. Laminations contain good interparticle porosity ranging between 0.1 and 0.2 millimeters in size.

Depositional Environment: Restricted Marine

Ocala Limestone

Core Interval: 820 to 820.7 feet below land surface

Description: Yellowish-gray, slightly cemented, fine to medium grained, moderately well sorted, echinoderm-pellet grainstone. This interval has numerous grains composed of floating rim and possess good interparticle porosity and trace moldic porosity.

Depositional Environment: Open Lagoon

Core Interval: 820.7 to 821.4 feet below land surface

Description: White to yellowish gray, fine to medium grained, poorly sorted mollusk-interclast-pellet packstone-grainstone.

Depositional Environment: Shoal

Core Interval: 821.4 to 824.2 feet below land surface

Description: This interval is composed of white to yellowish-gray colored, very fine-grained to granular (trace pebbles), poorly sorted mollusk-oncolite-echinoderm-foram packstone and oncolite-interclast packstone-boundstone. Porosity is primarily interparticle but contain minor vugs. This unit contains moderate overgrowth cements and is slightly dolomitic in nature.

Depositional Environment: Mound Shoal

Core Interval: 824.2 to 826.6 feet below land surface

Description: This interval is a red algae oncolite-interclast packstone-boundstone that is poorly sorted with good interparticle and micro porosity development which contains scattered vugs in clasts and large mollusk molds.

Depositional Environment: Mound Shoal

Avon Park Formation

Core Interval: 1,195 to 1,197.4 feet below land surface

Description: Pale yellowish-orange to yellowish-gray colored, medium to coarse grained, moderately sorted, interbedded, pellet-foram-interclastic packstone. This interval is slightly to well cemented, slightly dolomitic with good micro-porosity. Laminations contain good interparticle and fair moldic porosity.

Depositional Environment: Restricted Lagoon/Shoal Flank

Core Interval: 1,295 to 1,298 feet below land surface

Description: This interval is composed of interbedded, very poorly sorted, slightly to very dolomitic, slightly to well cemented, pale-orange to light orange-brown colored, pellet-foram-intraclast packstone. Laminations are slightly wavy to inclined. Intraclasts are fine to pebble sized and subrounded to angular in shape. Good microporosity with only fair moldic, intraparticle, and vuggy porosity. Fair moldic porosity at 1296.7 feet bls with fair intercrystalline, interparticle porosity as scattered vugs and molds at 1,297.3 feet bls.

Depositional Environment: Restricted Lagoon

Core Interval: 1,298 to 1,299.6 feet below land surface

Description: Foram-interclast packstone, pale orange-gray to light brown in color, very fine to coarse grained with some granules, slightly stylolitic, laminated, slightly dolomitic with good interparticle porosity and few scattered molds.

Depositional Environment: Restricted Lagoon

Core Interval: 1,450 to 1,454.7 feet below land surface

Description: Intraclast-lithoclast packstone, pale orange-gray fragments contained in light brown to brown matrix. The fragments are slightly to well laminated, coarse grained to pebble (1mm to 80mm) in size, and subangular to angular in shape. The matrix is dolomitic with poor vuggy porosity development. The lithoclasts has fair but scattered vuggy and moldic porosity.

Depositional Environment: Subaerial/Restricted Lagoon

KEY TO CORE DESCRIPTIONS SPREADSHEET

ROCK TYPE

B	Boundstone
COQ	Coquina
G	Grainstone
P	Packstone
R	Rudstone
W	Wackestone

GRAIN SIZE

C	Coarse
COB	Cobble
F	Fine
G	Granule
M	Medium
P	Pebble
TR	Trace
V	Very

POROSITY VISUAL DOMINANT, POROSITY VISUAL OTHER

F	Fair
G	Good
P	Poor
SCAT	Scattered
TR	Trace
VG	Very Good

POROSITY DOMINANT, POROSITY OTHER

BP	Between Particles
FE	Fenestral
LV	Large Vug
MICOR	Microscopic
MO	Moldic
SH	Shelter
V	Vug
WP	Within Particles

PORE SIZE DOMINANT, PORE SIZE OTHER

C	Coarse
F	Fine
G	Granule
LMO	Large Moldic
LV	Large Vug
M	Medium
MICRO	Microscopic
MO	Moldic
P	Pebble
TR	Trace
VC	Very Coarse
VF	Very Fine

CEMENT

OG	Overgrowth
PART	Partially
REXL	Recrystallization
SL	Slight
TR	Trace
W	Well

LAMINATIONS

INCL	Inclined
MOD	Moderate
SL	Slight
T	Thin
VT	Very Thin

SORTING

M	Medium
MW	Moderately Well
P	Poor
VP	Very Poor
W	Well

GLAUCONITE

SL	Slight
TR	Trace

SAND

S	Some
SL	Slight
V	Very
VSL	Very Slight

DOLOMITE

SL	Slight
TR	Trace

Table 1. Petrologic Summary of Core Sections.

Core Depth	Rock Type	Grain Size	Porosity Visual Dominant	Porosity Dominant	Porosity Visual Other	Porosity Other	Dominant Pore Size	Pore Size Other	Cement	Laminations	Sorting	Glauconite	Sand Content	Dolomite
ARCADIA														
725.0 - 726.2	P	VF-VC	F-G	BP	SCAT	MO-WP	VF	M			MW	TR		
726.2 - 726.3	COQ	F-VC-G	VG	BP	TR	MO	VF-F	M-C	SL OG		VP			
SUWANNEE														
755.0 - 755.5	P	VF-TR C	F	MO	TR	BP			SL OG		M-VP			
755.5 - 755.7	B	F-G	G	BP-V	SCAT	MO-V	M-C	C-VC			VP			
755.7 - 759.1	P	FV-C	F-G	V-MO-MICRO	SCAT	BP	1-12MM	LMO-VC	TR OG	VSL	MW			
OCALA														
820.0 - 820.7	G	F-M	G	BP-WP	TR	V	M-C	C	SL		VP			
820.7 - 821.4	G-P	F-M	VG	BP-MO	TR	V-MO	VF-M	C			VP			
821.4 - 824.2	P-B	VF-G	G	BP	SCAT	V-MO	VF-F	M-VC	10% OG		VP			SL
824.2 - 826.6	P-B	F-VC	G	MICRO-BP	SCAT	V-MO	VF-F	C-VC			VP			SL
AVON PARK														
1195.0 - 1197.3	P	M-C	G	MICRO	F SCAT	V-WP	VF-F	M-C		SL INCL	M			SL
1295.0 - 1298.0	P	VF-P	G	MICRO	F SCAT	FE-BP-V-MO	VF-F	M-VC	PART W	MOD	VP			80%
1298.0 - 1299.6	P	VF-G	G	MICRO	F SCAT	V-BP	VF-F	M-C	SL	SL	VP			SL
1450.0 - 1454.7	P	VF - P	F SCAT	V-MO	F SCAT	WP-V-BP	VF-F	M-VC	W	SL	VP			40-60%

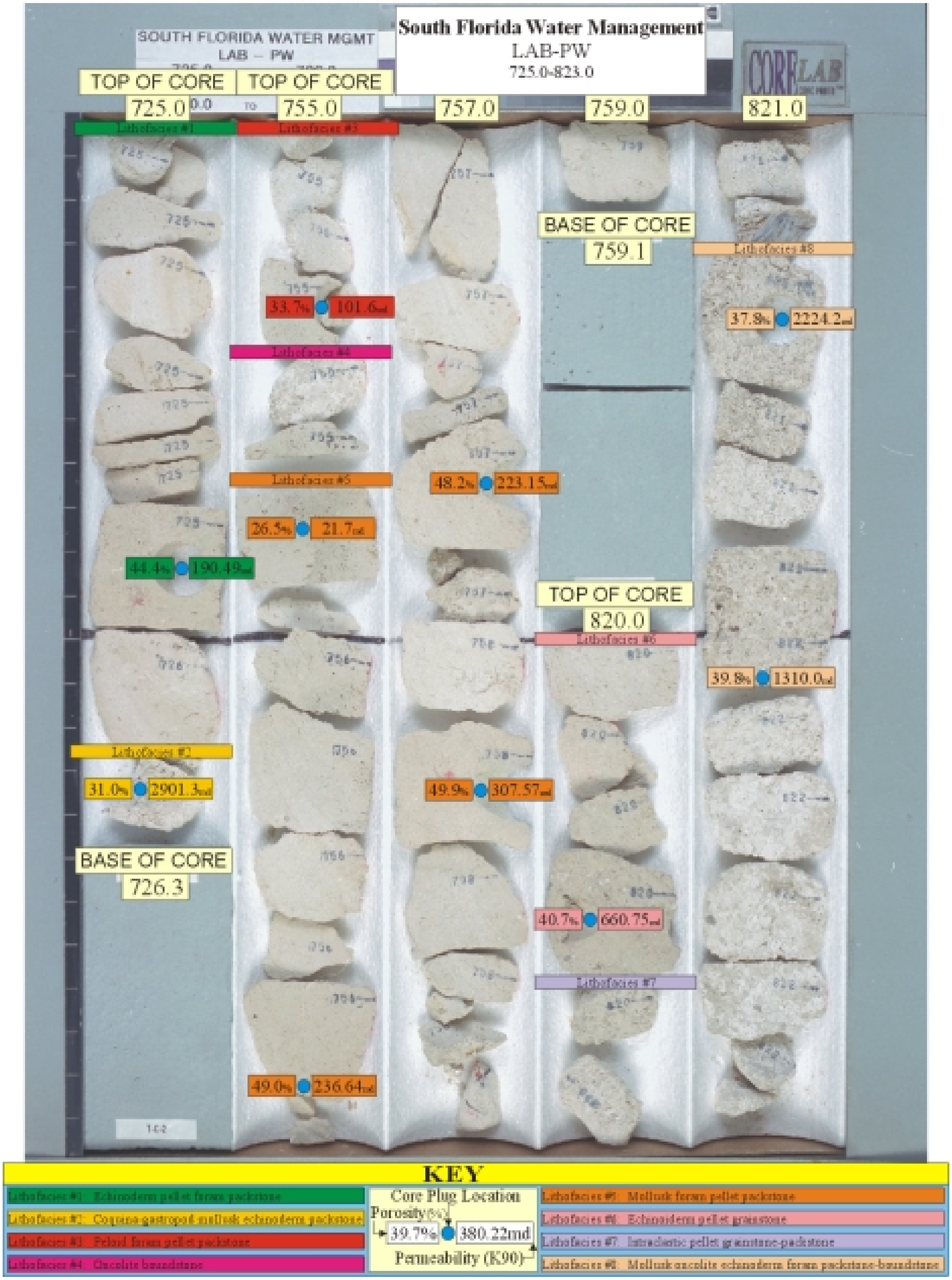
Table 2. Summary of Petrophysical Analyses by Core Laboratories.

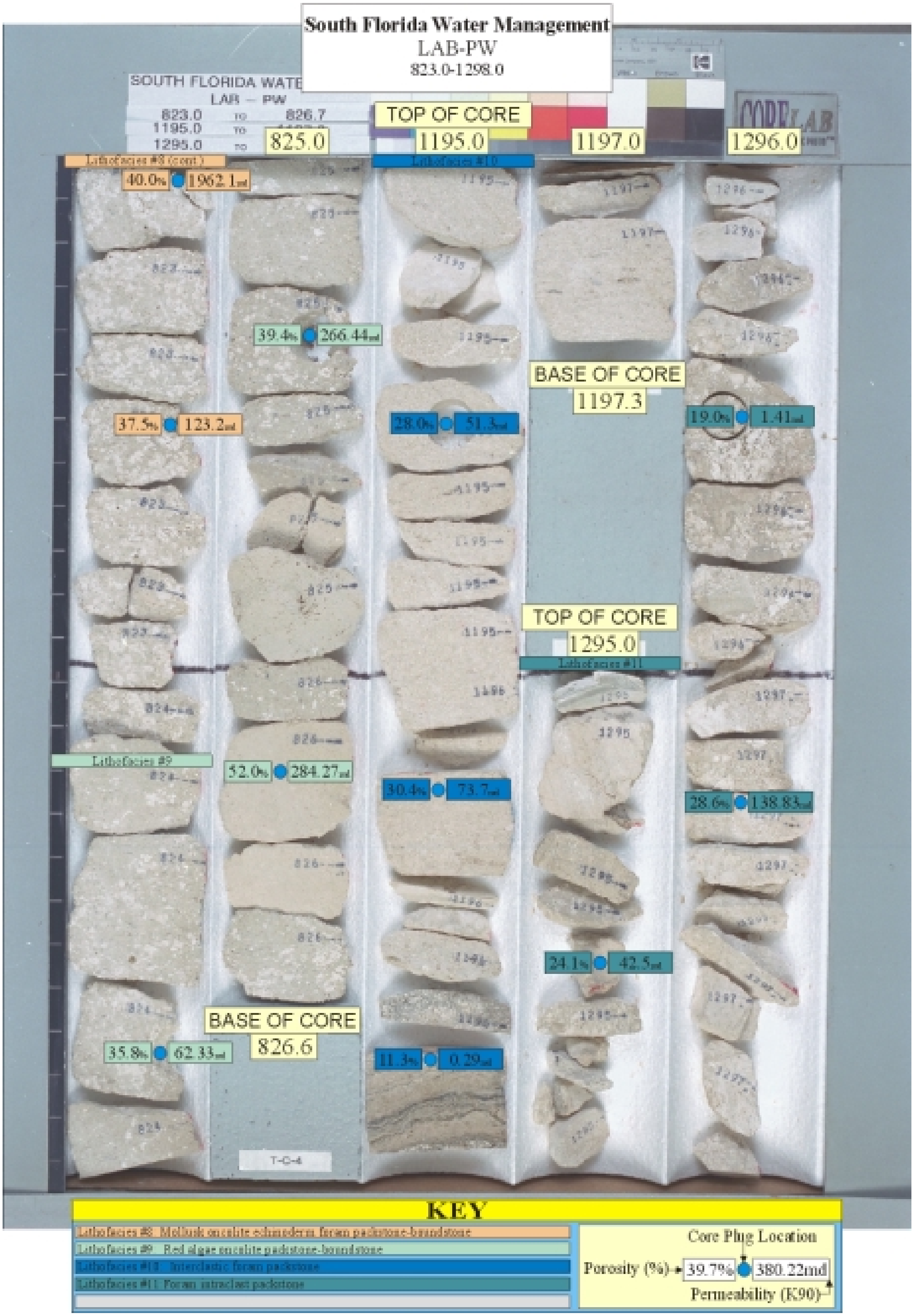
Core No.	Sample No.	Depth (ft. bls)	Horizontal Permeability (md)	Porosity Helium (%)	Grain Density (g/cm^3)	Description
1	1	725.8	190.49	44.4	2.72	Lim, pp
	2	726.3	2901.33	31.0	2.72	Lim, vug
		Mean	**1545.9**	**37.7**	**2.72**	
2	3	755.4	101.60	33.7	2.72	Lim, vug, foss
	4	755.7	21.70	26.5	2.71	Lim, vug, foss
	5	756.9	236.64	49.0	2.71	Lim, vug, foss
	6	757.8	223.15	48.2	2.72	Lim, vug, foss
	7	758.4	307.57	49.9	2.72	Lim, vug, foss
		Mean	**178.1**	**41.5**	**2.72**	
		Stand. Dev	**114.60**	**10.69**	**0.01**	
3	8	820.4	660.75	40.7	2.72	Lim, vug
	9	821.4	2224.19	37.8	2.72	Lim, vug, foss
	10	822.0	1309.97	39.8	2.72	Lim, vug
	11	823.0	1962.07	40.3	2.72	Lim, vug
	12	823.5	123.10	37.5	2.72	Lim, vug
	13	824.8	62.33	35.8	2.72	Lim, vug
	14	825.4	266.44	39.4	2.72	Lim, vug
	15	826.2	284.27	51.7	2.71	Lim, vug
		Mean	**861.6**	**40.4**	**2.72**	
		Stand. Dev:	**860.30**	**4.86**	**0.00**	
4	16	1194.4	51.30	28.0	2.72	Lim, vug
*	17	1196.2	73.70	30.4	2.72	Lim, foss, vug
*	18	1196.7	0.29	11.3	2.80	Lim, hvy min, sl vug
		Mean	**41.8**	**23.2**	**2.75**	
		Stand. Dev:	**37.62**	**10.40**	**0.05**	
5	19	1295.7	42.50	24.1	2.72	Lim, vug
	20	1296.5	1.41	18.9	2.80	Lim, hvy min, sl vug
	21	1297.3	138.83	28.6	2.75	Lim, vug
	22	1298.0	28.62	31.8	2.72	Lim, vug
	23	1298.7	123.41	34.7	2.71	Lim, vug
		Mean	**67.0**	**27.6**	**2.74**	
		Stand. Dev:	**60.66**	**6.26**	**0.04**	
6	24	1450.7	24.59	26.5	2.71	Lim, sl vug, brec
	25	1451.5	28.59	25.5	2.71	Lim, sl vug, brec
	26	1452.9	2.54	20.0	2.72	Lim, sl vug, brec
	27	1453.7	8.15	25.8	2.72	Lim, sl vug, brec
*	28	1454.2	2.10	24.3	2.71	Lim, sl vug, brec
		Mean	**13.2**	**24.4**	**2.71**	
		Stand. Dev:	**12.54**	**2.60**	**0.01**	

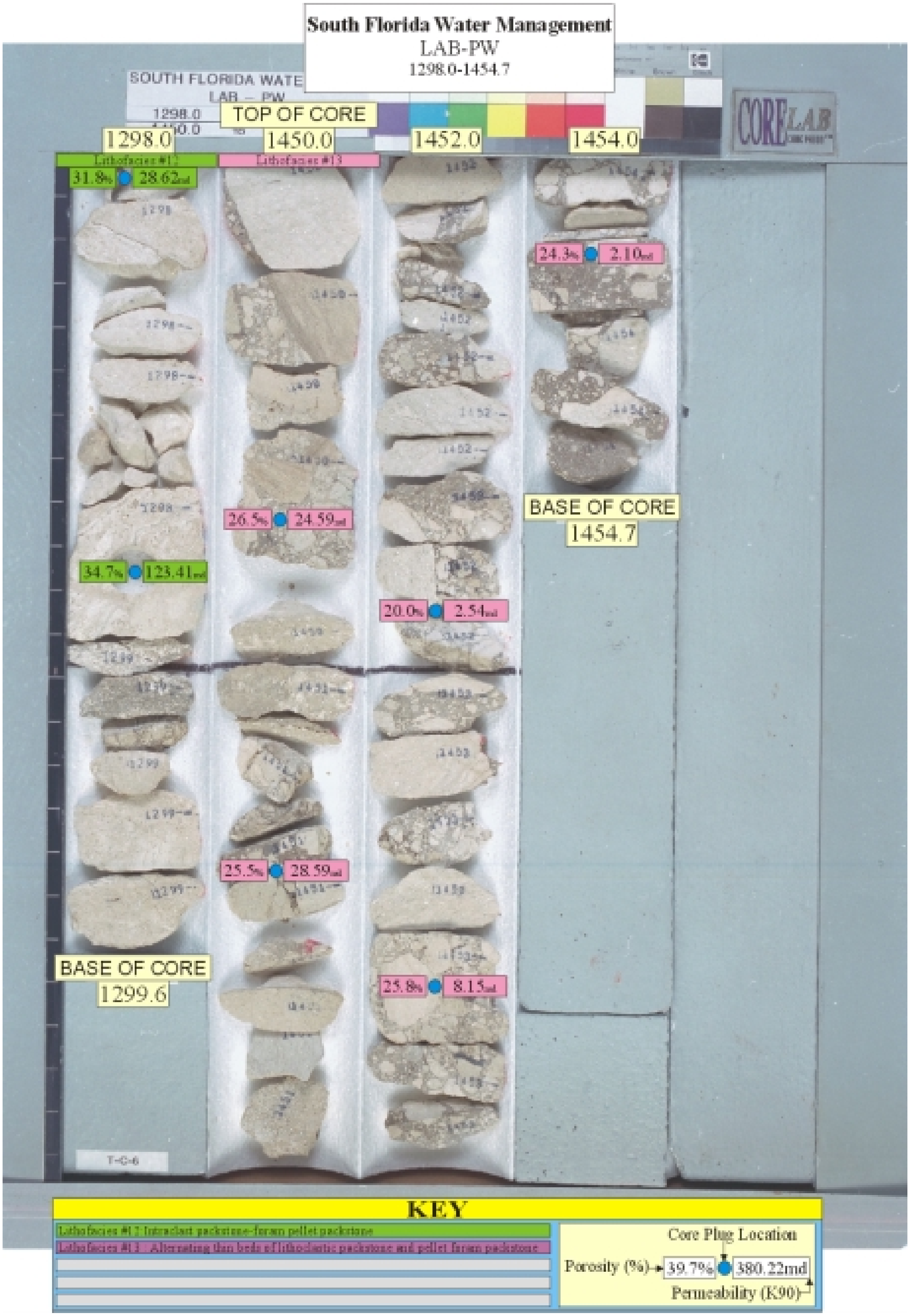
ft. bls = feet below land surfacel
md = millidarcy
% = percent
brec = breccia
hvy min = heavy minerals
g/cm^3 = grams per cubic centimeter
Lim = Limestone
vug = vug (gy)
foss = fossil (-iferous)
***** indicates full diameter analyses

Table 3. Summary of Petrologic Analyses by Collier Consulting, Inc.

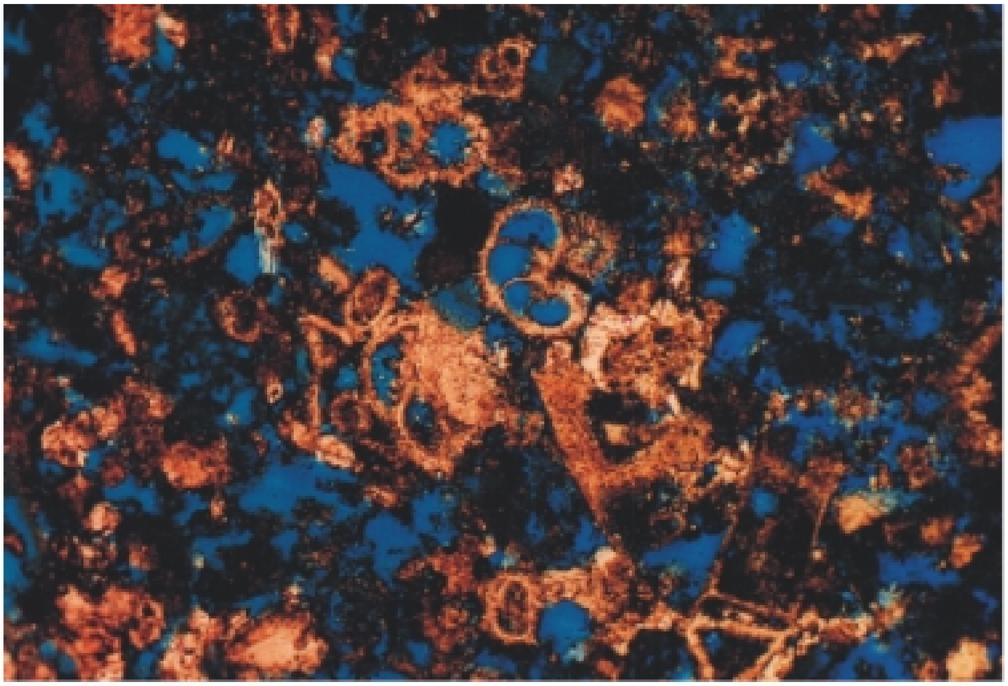
Core Depth	Lithofacies	Depositional Environment	Depth of Measurement (ft. bls)	Horizontal Permeability (md)	Porosity Helium (%)
ARCADIA					
725.0 - 726.2	ECHINODERM-PELLET-FORAM-PACKSTONE	OPEN LAGOON	725.8	190.49	44.4
726.2 - 726.3	COQUINA-GASTROPOD-MOLLUSK-ECHINODERM PACKSTONE	SHOAL	726.3	2901.33	31.0
SUWANNEE					
755.0 - 755.5	PELOID-FORAM-PELLET PACKSTONE	SHOAL FLANK	755.4	101.60	33.7
755.5 - 755.7	ONCOLITE BOUNDSTONE	MOUND	755.7	21.70	26.5
755.7 - 759.1	MOLLUSK-FORAM-PELLET PACKSTONE	RESTRICED MARINE	756.9	236.64	49.0
			757.8	223.15	48.2
			758.4	307.57	49.9
			Mean	**178.1**	**41.5**
OCALA					
820.0 - 820.7	ECHINOD-PELLET GRAINSTONE	OPEN LAGOON	820.4	660.75	40.7
820.7 - 821.4	INTRACLAST-PELLET GRAINSTONE-PACKSTONE	SHOAL	821.4	2224.19	37.8
821.4 - 824.2	MOLLUSK-ONCOLITE-ECHINODERM-FORAM PACKSTONE-BOUNDSTONE	MOUND SHOAL	822.0	1309.97	39.8
			823.0	1962.07	40.3
			823.5	123.10	37.5
			Mean	**1256.0**	**39.2**
824.2 - 826.6	RED ALGAE-ONCOLITE PACKSTONE-BOUNDSTONE	MOUND SHOAL	824.8	62.33	35.8
			825.4	266.44	39.4
			826.2	284.27	51.7
			Mean	**204.3**	**40.4**
AVON PARK					
1194.7 - 1197.3	INTERCLAST-FORAM PACKSTONE	REST. LAGOON/SHOAL FLANK	1194.4	51.30	28.0
			1196.2	73.70	30.4
			1196.7	0.29	11.3
			Mean	**41.8**	**23.2**
1295.0 - 1298.0	FORAM-INTRACLAST PACKSTONE	RESTRICTED LAGOON	1295.7	42.50	24.1
			1296.5	1.41	18.9
			1297.3	138.83	28.6
			Mean	**60.9**	**23.9**
1298.0 - 1299.6	INTRACLAST PACKSTONE-FORAM PELLET PACKSTONE	RESTRICTED LAGOON	1298.0	28.62	31.8
			1298.7	123.41	34.7
			Mean	**76.0**	**33.3**
1450.0 - 1454.7	THIN INTERBEDDED LITHOCLASTIC AND PELLET-FORAM PACKSTONE	SUBAERIAL/RESTRICTED LAGOON	1450.7	24.59	26.5
			1451.5	28.59	25.5
			1452.9	2.54	20.0
			1453.7	8.15	25.8
			1454.2	2.10	24.3
			Mean	**13.2**	**24.4**


South Florida Water Management
LAB-PW
725.0-823.0
SOUTH FLORIDA WATER MGMT
LAB – PW
TOP OF CORE
725.0
TOP OF CORE
755.0
757.0
759.0
821.0
Lithofacies #1
Lithofacies #3
Lithofacies #4
Lithofacies #5
Lithofacies #2
Lithofacies #6
Lithofacies #7
Lithofacies #8
33.7% 101.6md
26.5% 21.7md
44.4% 190.49md
31.0% 2901.3md
49.0% 236.64md
48.2% 223.15md
49.9% 307.57md
37.8% 2224.2md
39.8% 1310.0md
40.7% 660.75md
BASE OF CORE
759.1
TOP OF CORE
820.0
BASE OF CORE
726.3
KEY
Lithofacies #1: Echinoderm pellet foram packstone
Lithofacies #2: Coquina-gastropod mollusk echinoderm packstone
Lithofacies #3: Peloid foram pellet packstone
Lithofacies #4: Oncolite boundstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)
Lithofacies #5: Mollusk foram pellet packstone
Lithofacies #6: Echinoderm pellet grainstone
Lithofacies #7: Intraclastic pellet grainstone-packstone
Lithofacies #8: Mollusk oncolite echinoderm foram packstone-boundstone


South Florida Water Management
LAB-PW
823.0-1298.0
TOP OF CORE
825.0
1195.0
1197.0
1296.0
Lithofacies #8 (cont.)
Lithofacies #10
40.0%
1962.1md
39.4%
266.44md
37.5%
123.2md
28.0%
51.3md
BASE OF CORE
1197.3
19.0%
1.41md
TOP OF CORE
1295.0
Lithofacies #11
Lithofacies #9
52.0%
284.27md
30.4%
73.7md
28.6%
138.83md
24.1%
42.5md
BASE OF CORE
826.6
35.8%
62.33md
11.3%
0.29md
T-C-4
KEY
Lithofacies #8 Mollusk oncolite echinoderm foram packstone-boundstone
Lithofacies #9 Red algae oncolite packstone-boundstone
Lithofacies #10 Interclastic foram packstone
Lithofacies #11 Foram intraclast packstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)

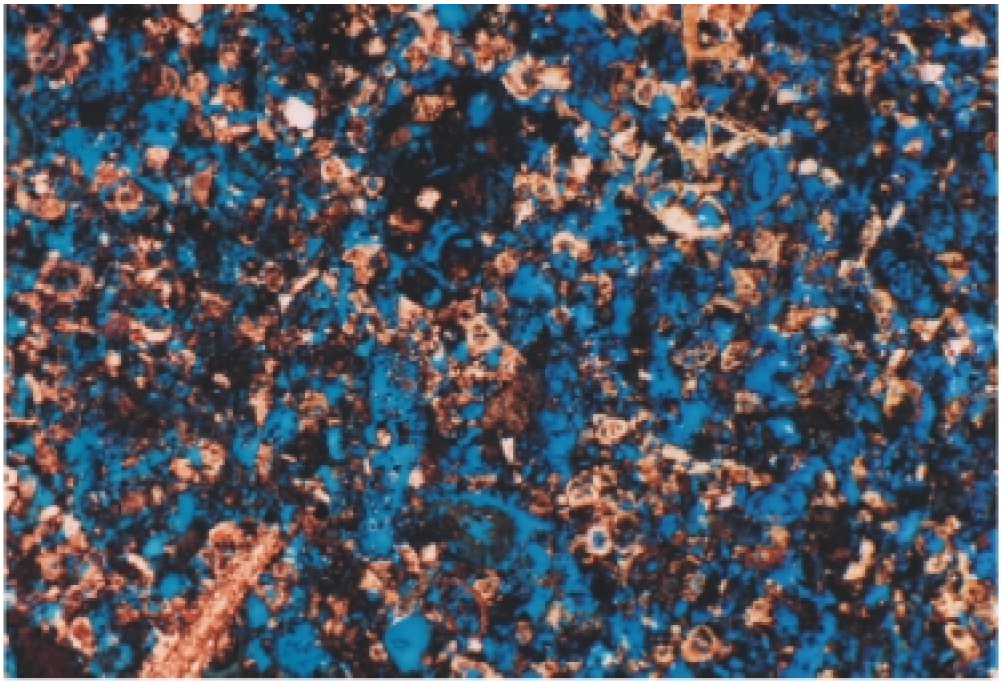

South Florida Water Management
LAB-PW
1298.0-1454.7
TOP OF CORE
1298.0
1450.0
1452.0
1454.0
Lithofacies #12
Lithofacies #13
31.8% 28.62md
34.7% 123.41md
26.5% 24.59md
25.5% 28.59md
20.0% 2.54md
25.8% 8.15md
24.3% 2.10md
BASE OF CORE
1299.6
BASE OF CORE
1454.7
CORE LAB
KEY
Lithofacies #12: Intraclast packstone-foram pellet packstone
Lithofacies #13 : Alternating thin beds of lithoclastic packstone and pellet foram packstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)

APPENDIX E
PHOTOMICROGRAPHS



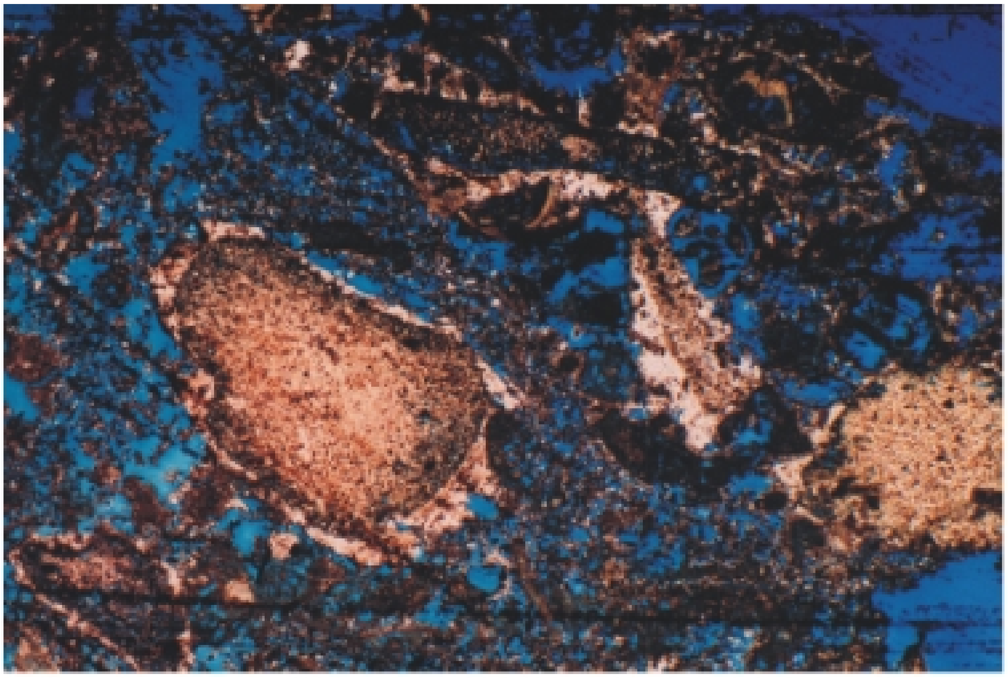
WELL: LAB-TW
DEPTH: 725.8
MAGNIFICATION: X40

Photomicrograph of thin section of pellet - foram packstone showing good interparticle porosity with fair vuggy intraparticle porosity and scattered glauconitic occlusions.



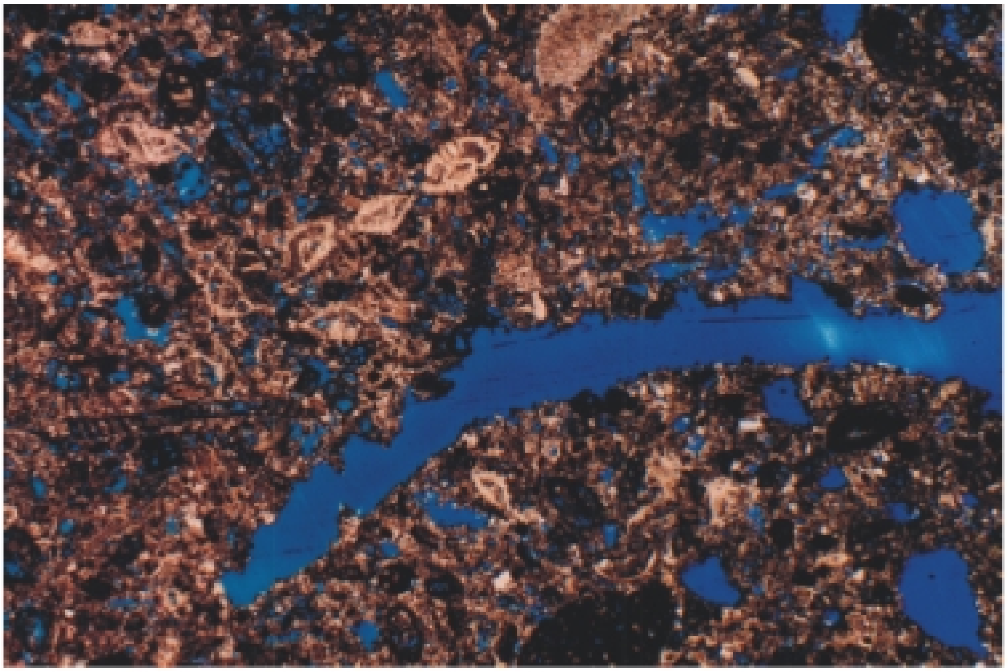
WELL: LAB-PW
DEPTH: 725.8
MAGNIFICATION: X20

Photomicrograph of thin section showing good interparticle porosity with fair vuggy and moldic porosity.



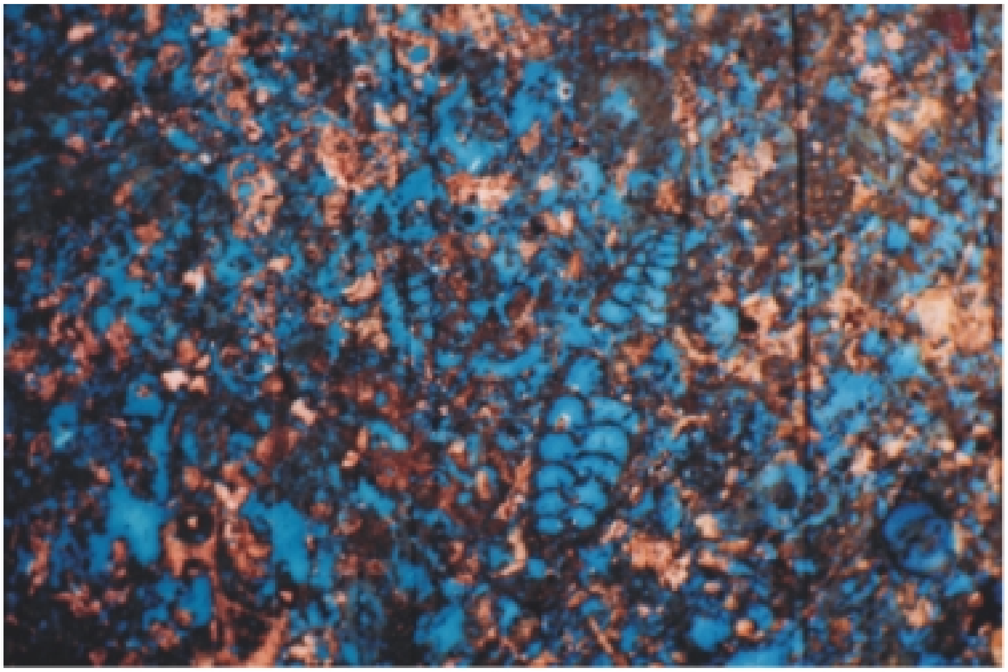
WELL: LAB-PW
DEPTH: 726.3
MAGNIFICATION: X40

Photomicrograph of thin section of echinoderm-pellet-foram packstone with scattered slightly overgrowth cement and good vuggy interparticle porosity.

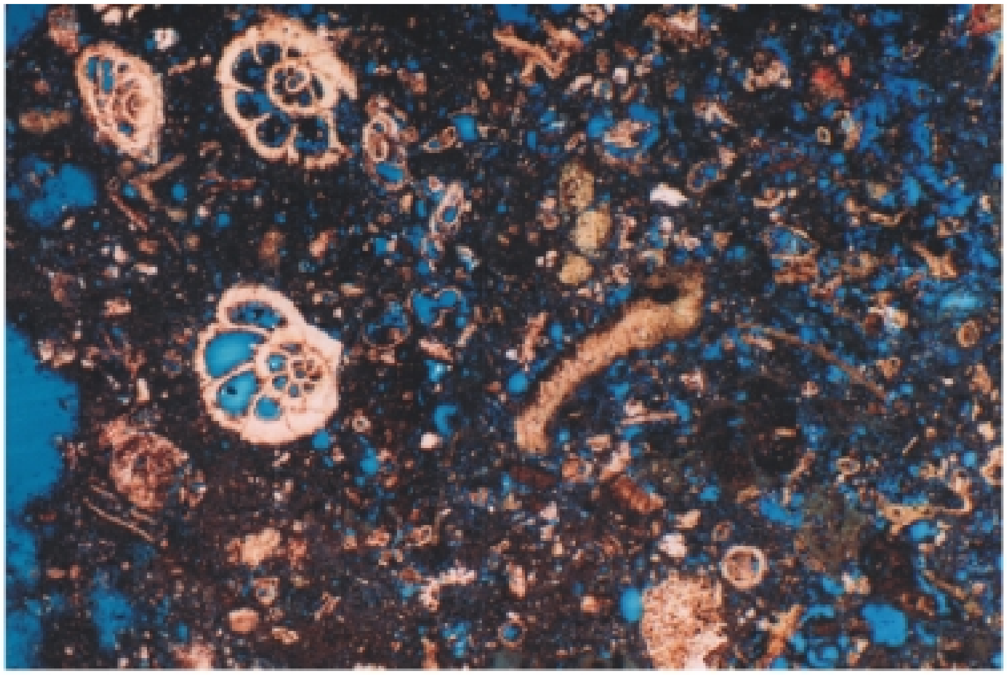


WELL: LAB-PW
DEPTH: 755.4
MAGNIFICATION: X20

Photomicrograph of thin section of mollusk-echinoderm-peloid-foram-pellet packstone with good interparticle-vuggy porosity and scattered large mollusk molds.

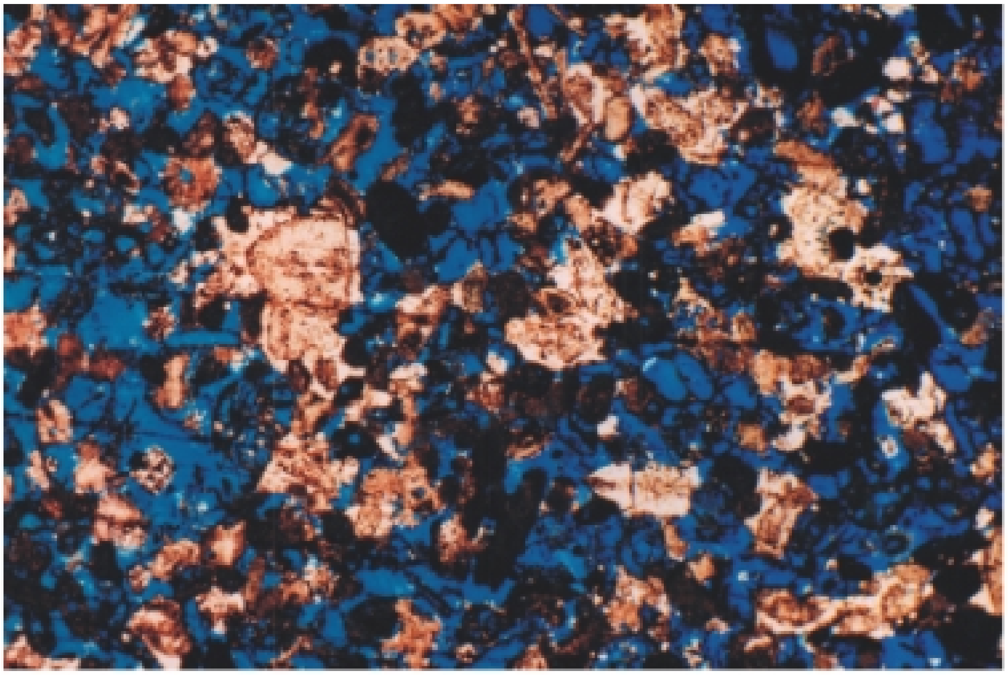


WELL: LAB-PW
DEPTH: 756.9
MAGNIFICATION: X20
Photomicrograph of thin section of foram-pellet packstone with scattered foram-intraparticle and good vuggy-interparticle porosity.



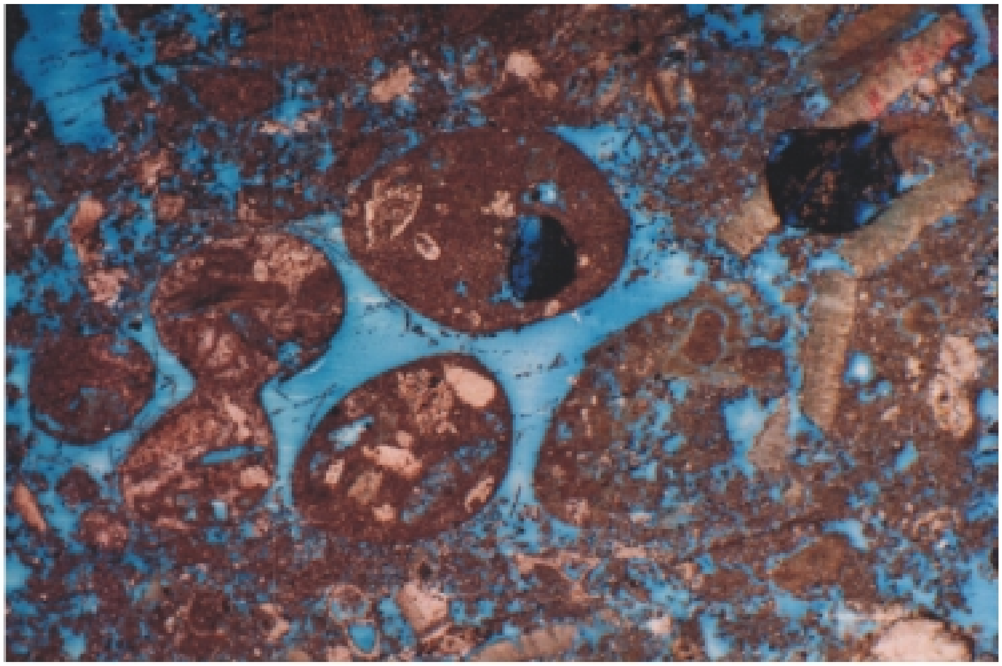
WELL: LAB-PW
DEPTH: 757.8
MAGNIFICATION: X20

Photomicrograph of thin section showing mollusk-foram packstone with traces of glauconite and good microporosity, vuggy porosity, scattered moldic, and fair interparticle porosity.



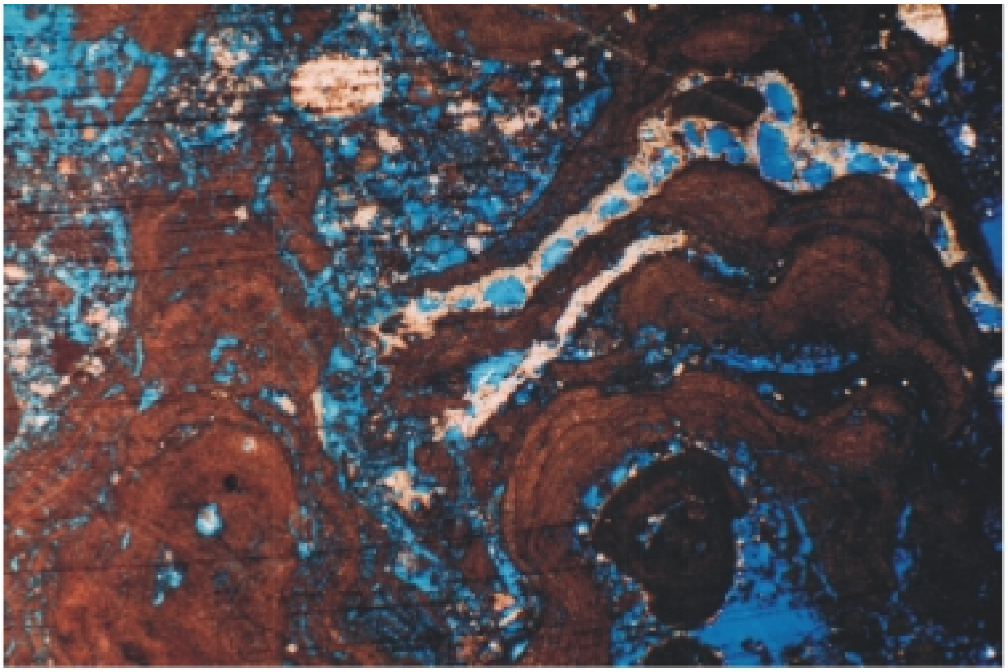
WELL: LAB-PW
DEPTH: 820.6
MAGNIFICATION: X20

Photomicrograph of thin section showing very good interparticle and moldic porosity with floating grain rims in a echinoderm-pellet-grainstone. The grainstone is slightly cemented with scattered overgrowth cement.



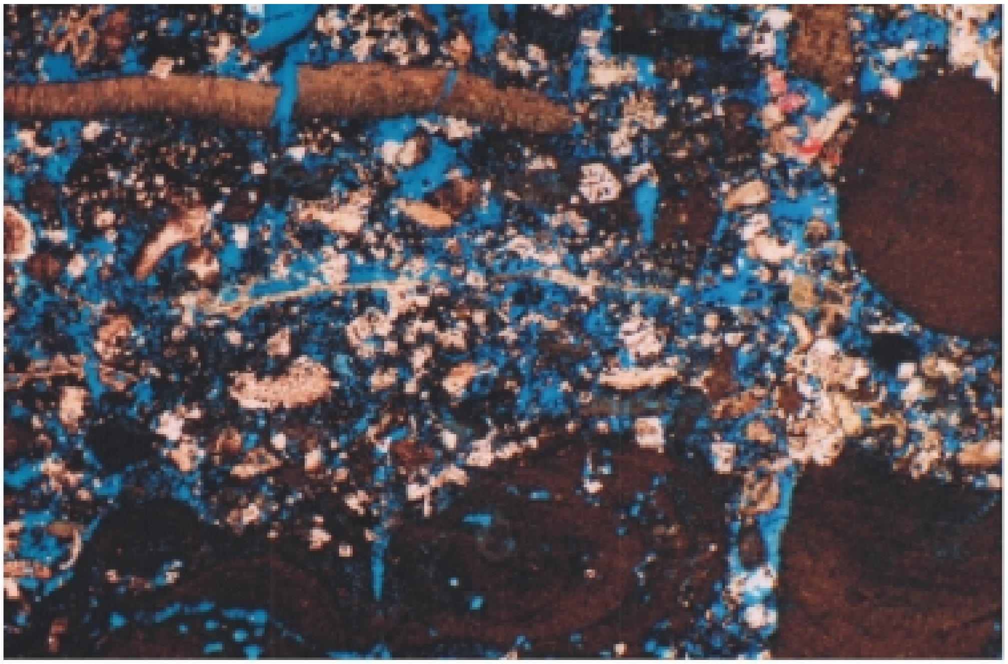
WELL: LAB-PW
DEPTH: 821.4
MAGNIFICATION: X40

Photomicrograph of thin section showing mollusk-intraclast-pellet packstone with good interparticle porosity and fair scattered vuggy porosity.



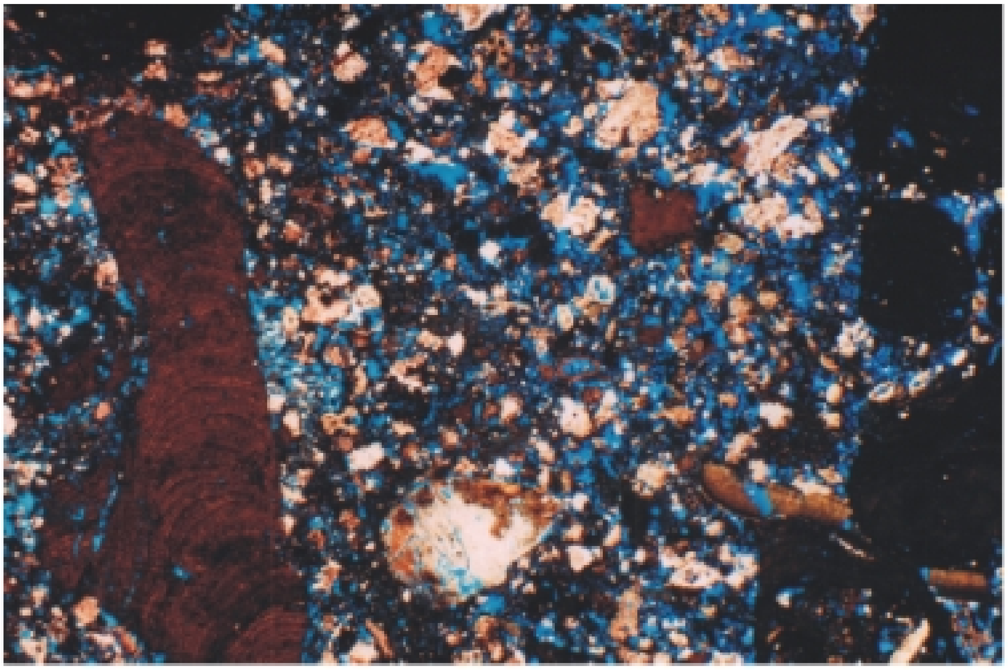
WELL: LAB-PW
DEPTH: 822.4
MAGNIFICATION: X20

Photomicrograph of thin section showing algal stromatolite with good interparticle porosity and fair intraparticle, vuggy, and moldic porosity.



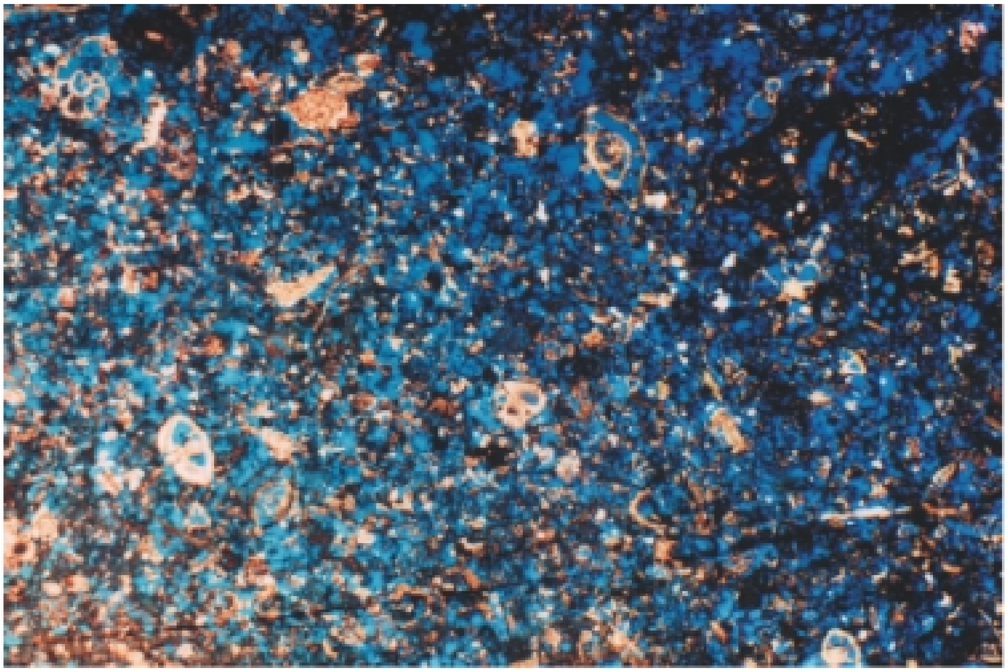
WELL: LAB-PW
DEPTH: 823.5
MAGNIFICATION: X20

Photomicrograph of thin section showing slightly dolomitic intraclast-oncolite packstone with good intraparticle and vuggy porosity.



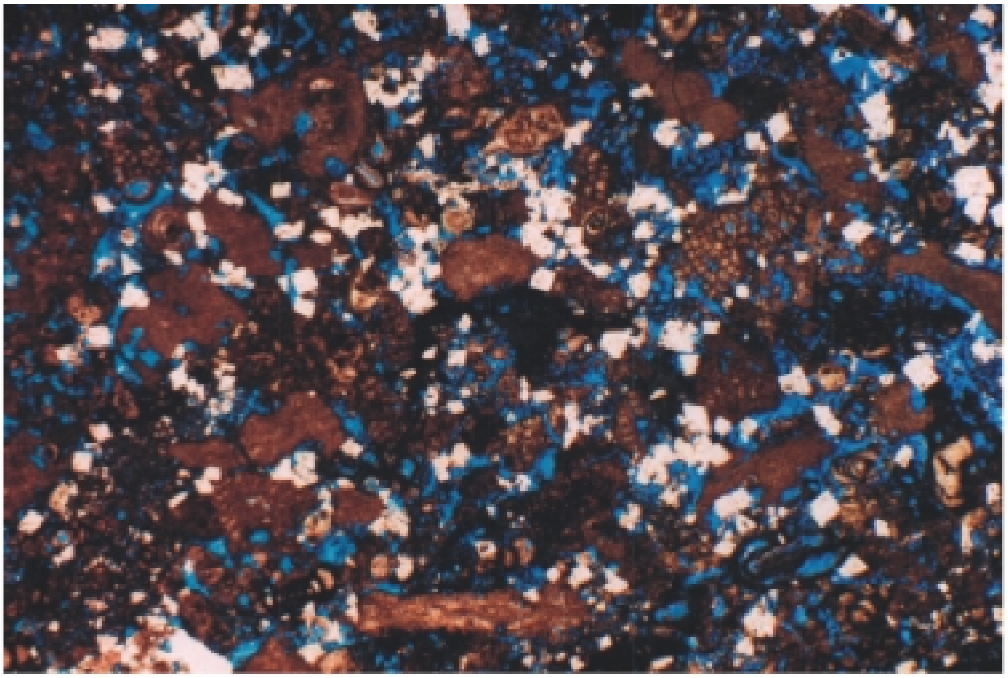
WELL: LAB-PW
DEPTH: 825.4
MAGNIFICATION: X20

Photomicrograph of thin section showing slightly dolomitic, very poorly sorted, red algae-oncolite-intraclast-echinoderm-foram packstone with some echinoderm overgrowth cement and good porosity.



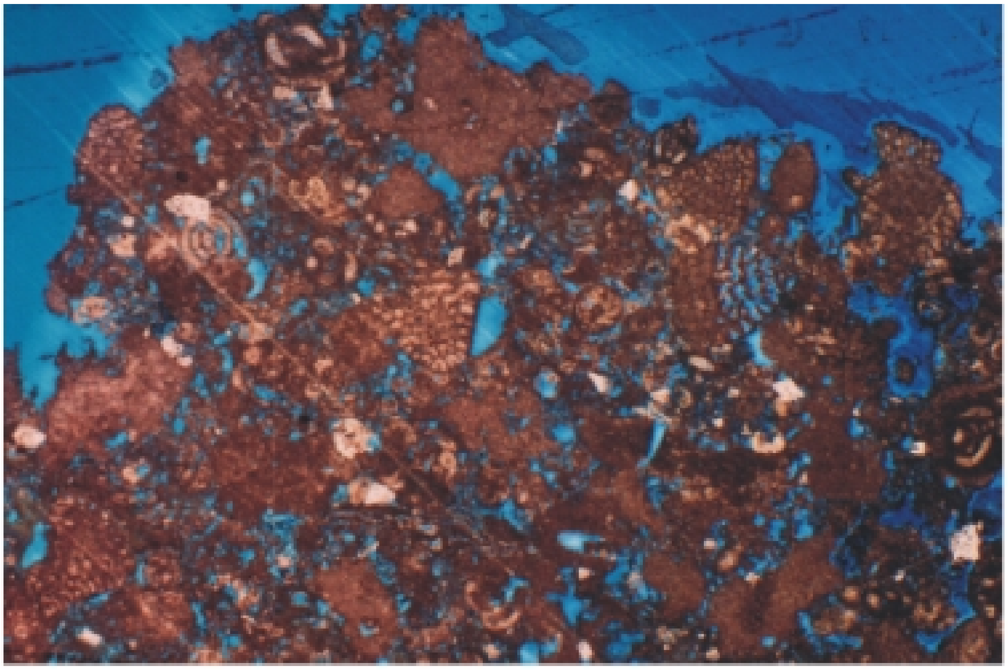
WELL: LAB-PW
DEPTH: 826.2
MAGNIFICATION: X20

Photomicrograph of thin section showing very fine to fine grained foram-pellet grainstone with very good intraparticle and microporosity, scattered intraparticle, vug, and moldic porosity.



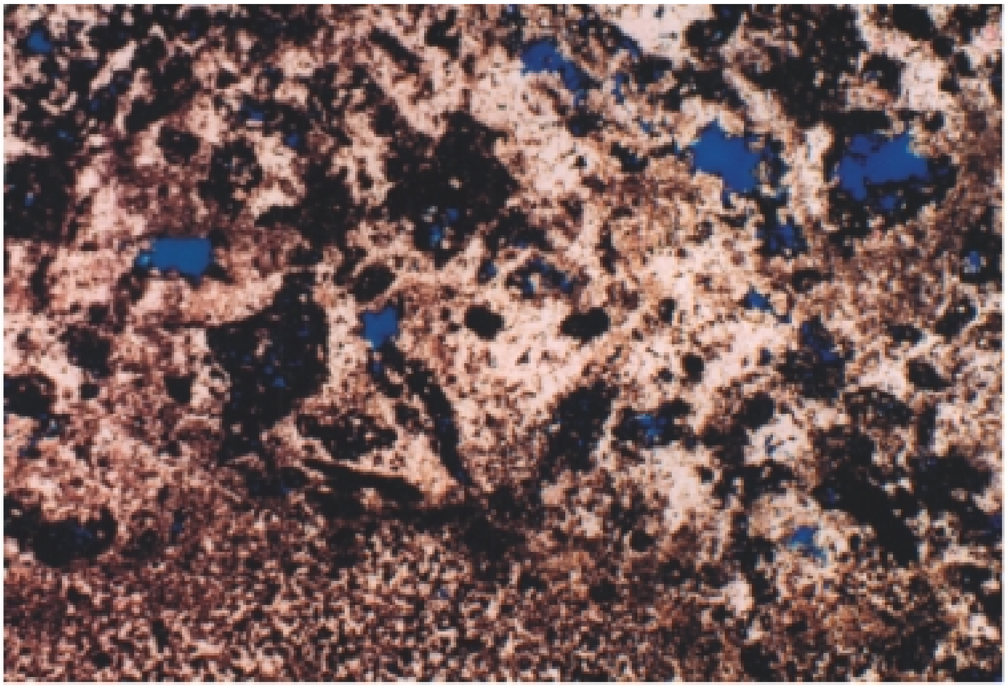
WELL: LAB-PW
DEPTH: 1195.4
MAGNIFICATION: X20

Photomicrograph of thin section showing slightly dolomitic pellet-foram-intraclast packstone with good microporosity and fair vuggy, intraparticle, and interparticle porosity.



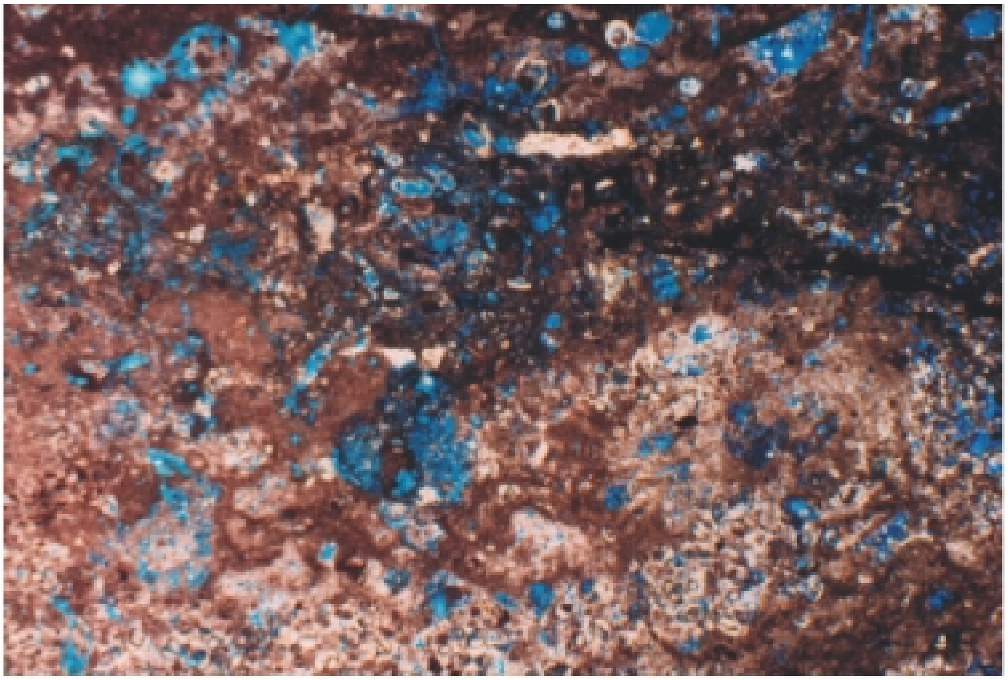
WELL: LAB-PW
DEPTH: 1196.2
MAGNIFICATION: X20

Photomicrograph of thin section showing pellet-foram-intraclast packstone with fair interparticle, intraparticle, and vuggy porosity.



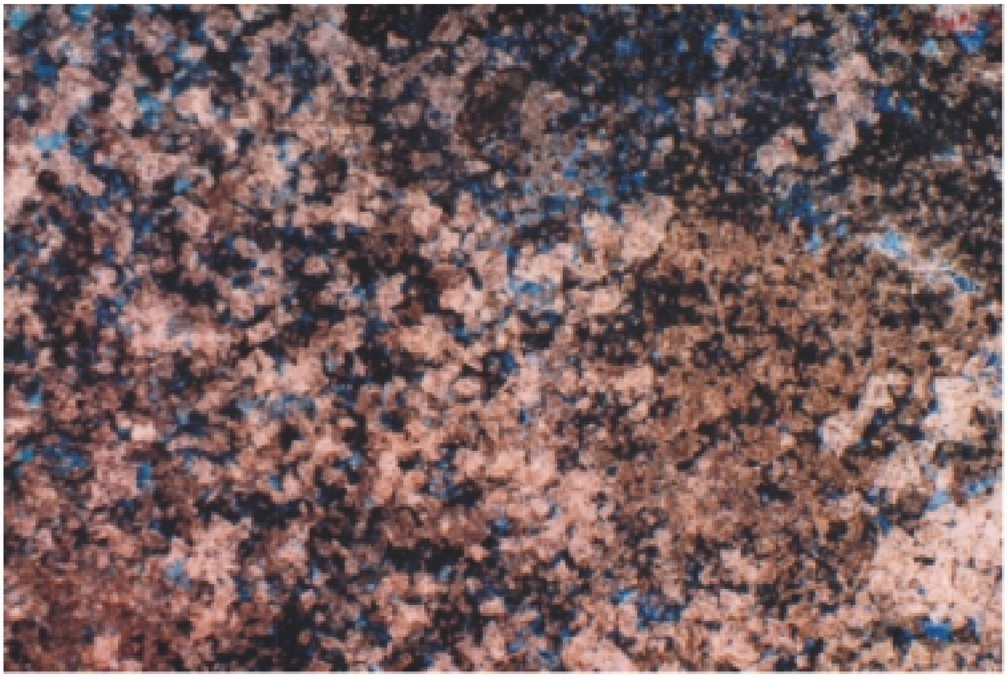
WELL: LAB-PW
DEPTH: 1196.7
MAGNIFICATION: X20

Photomicrograph of thin section showing well cemented intraclast-foram-pellet packstone with poor vuggy and intercrystalline porosity.



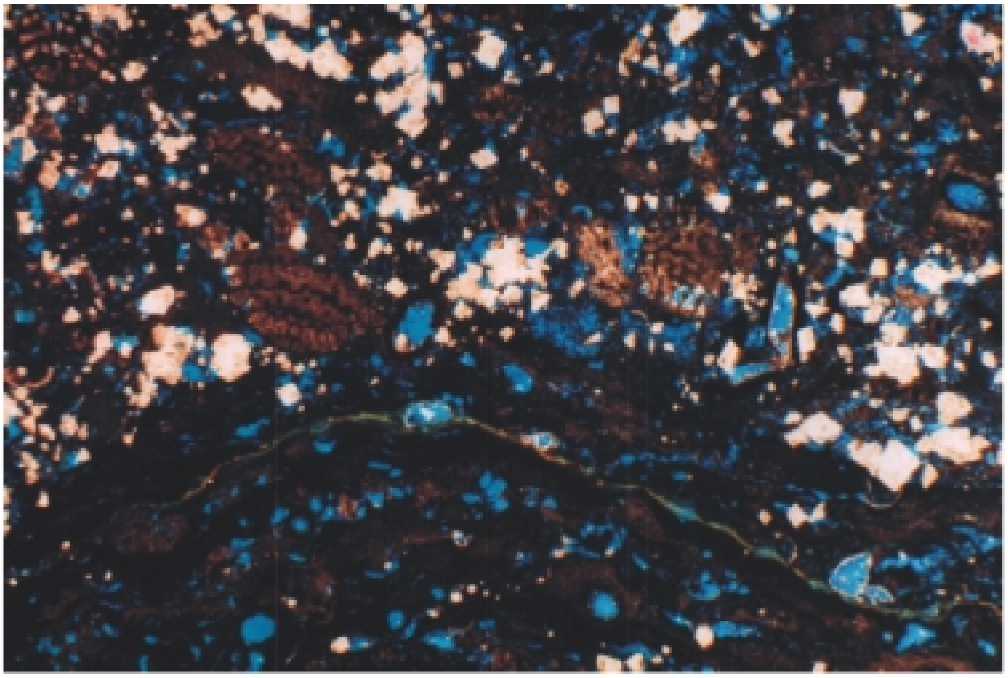
WELL: LAB-PW
DEPTH: 1295.7
MAGNIFICATION: X20

Photomicrograph of thin section showing partly well cemented pellet-foram-intraclast packstone with good microporosity and fair intercrystalline, vuggy, and moldic porosity.



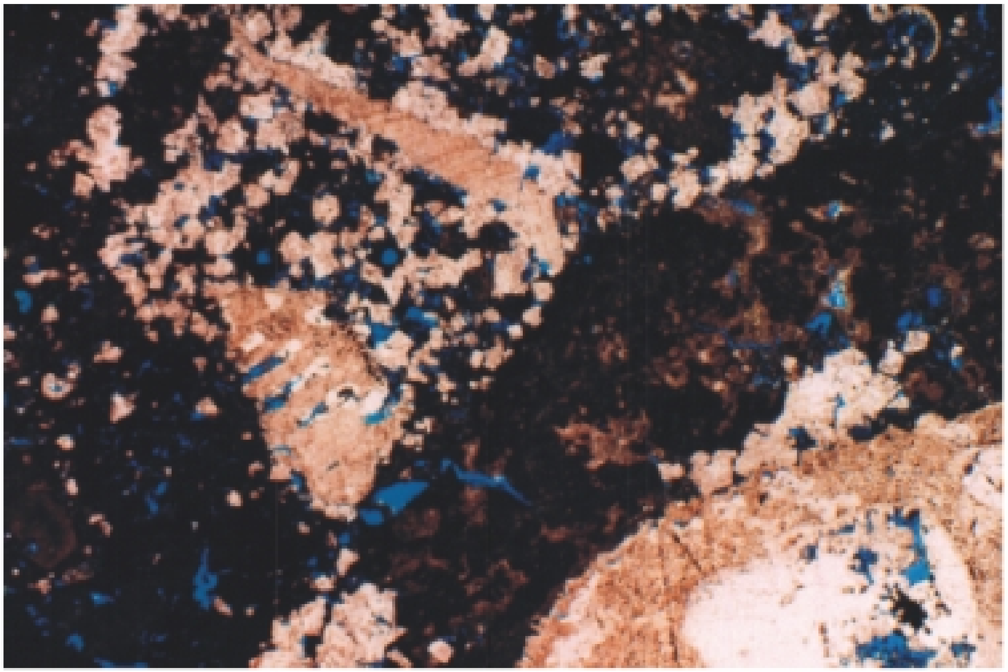
WELL: LAB-PW
DEPTH: 1296.5
MAGNIFICATION: X20

Photomicrograph of thin section showing very dolomitic foram-pellet packstone with good microporosity and fair intercrystalline porosity.



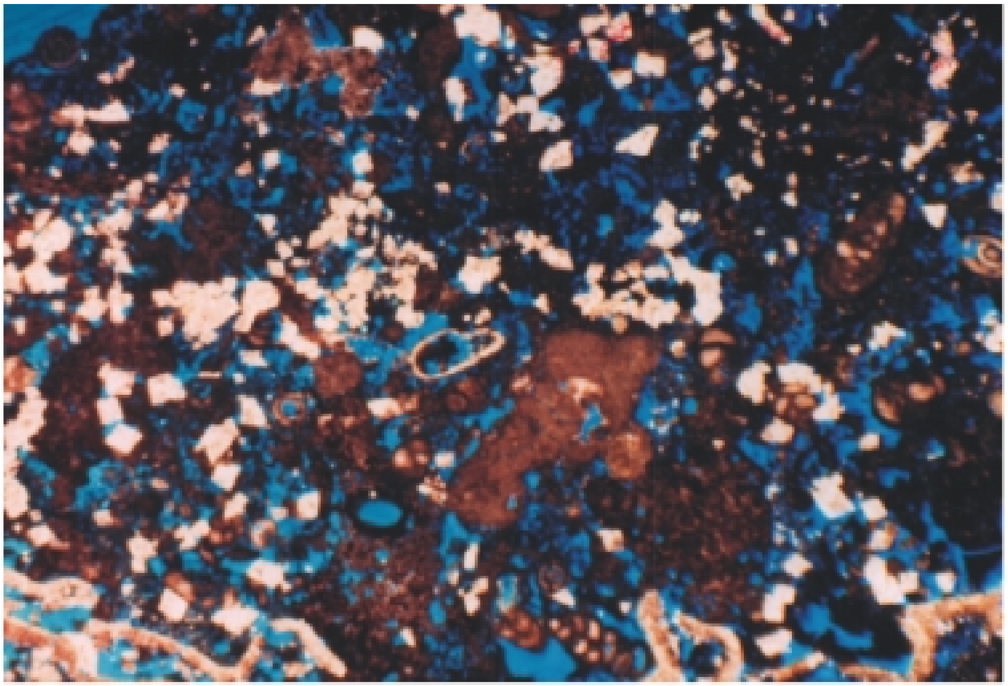
WELL: LAB-PW
DEPTH: 1298
MAGNIFICATION: X20

Photomicrograph of thin section showing slightly dolomitic inter-laminated pellet-algal boundstone and intraclast-foram packstone with fair intraparticle, moldic, and vuggy porosity.



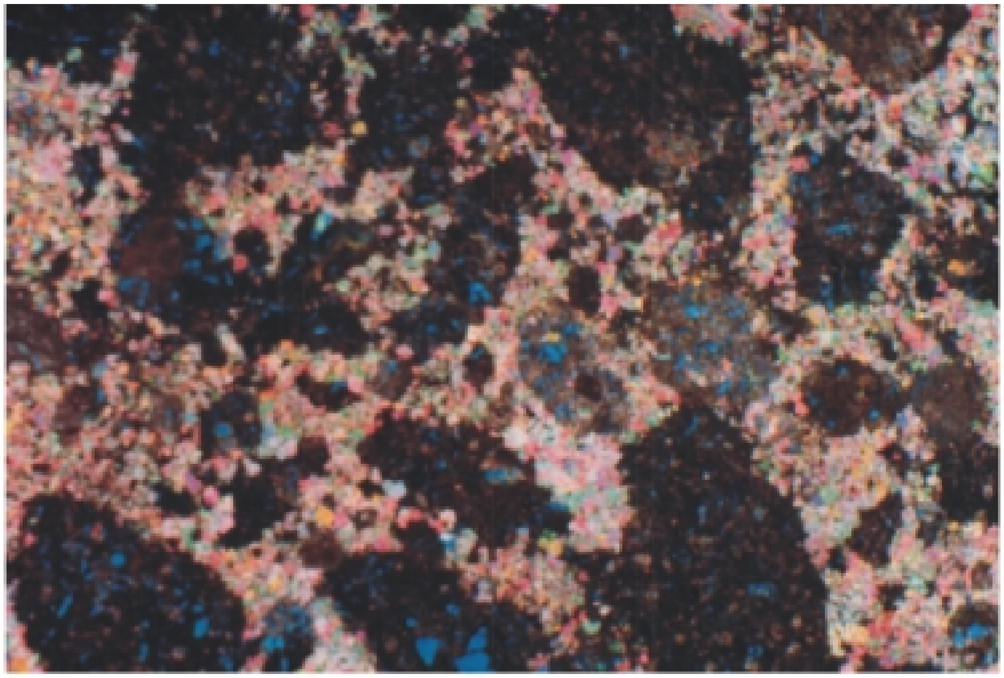
WELL: LAB-PW
DEPTH: 1298
MAGNIFICATION: X40

Photomicrograph of thin section showing partly dolomitized echinoderm-foram-pellet-intraclast packstone with fair vuggy, moldic, and intercrystalline porosity. Note the overgrowth cement on the echinoderm in the lower right corner of the photograph.



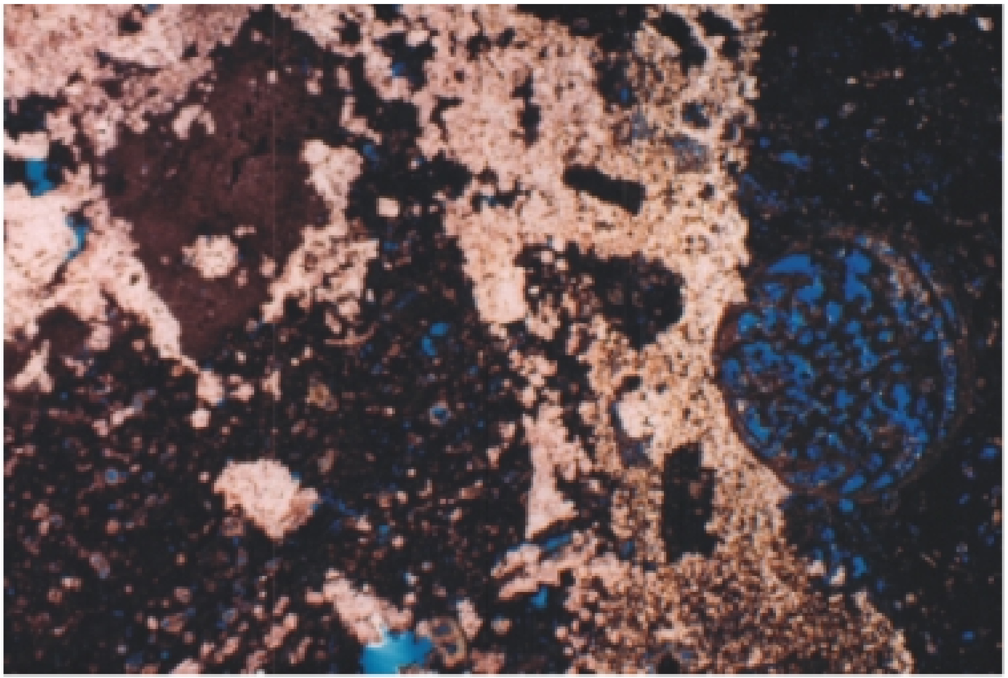
WELL: LAB-PW
DEPTH: 1298.7
MAGNIFICATION: X20

Photomicrograph of thin section showing slightly dolomitized pellet-foram-intraclast packstone with good microporosity and fair vuggy, intraparticle, and interparticle porosity.



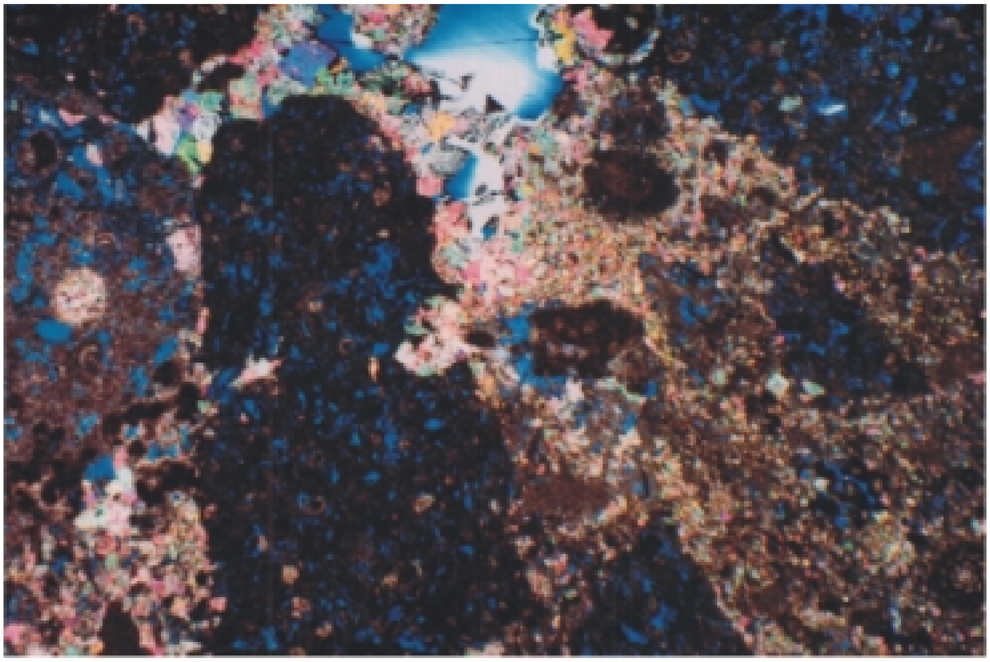
WELL: LAB-PW
DEPTH: 1453.7
MAGNIFICATION: X20

Photomicrograph of this section showing very dolomitized lithoclast packstone with fair vuggy and moldic porosity in lithoclasts.



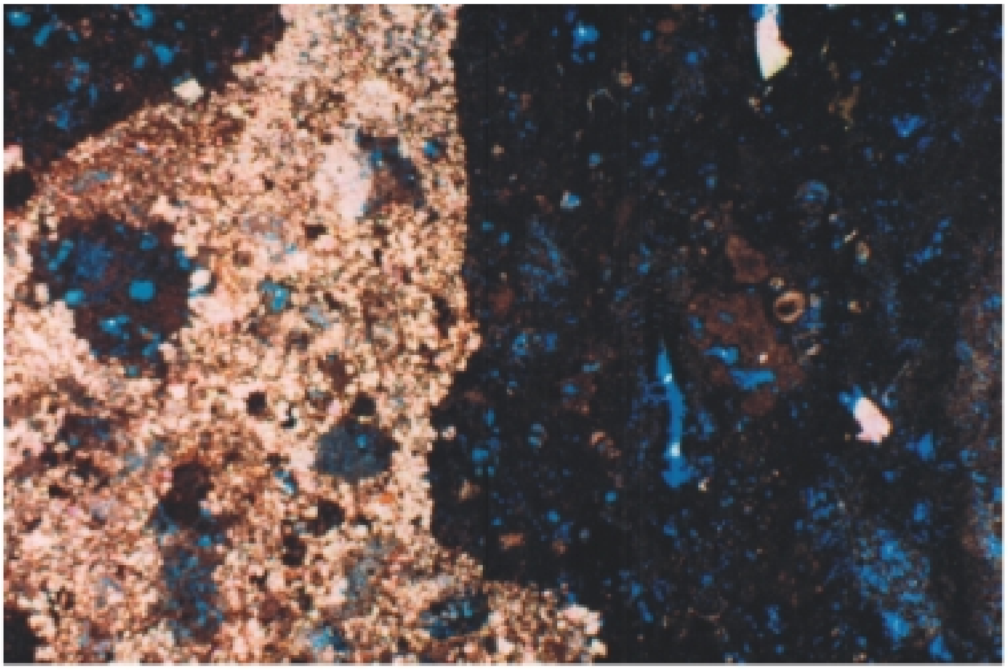
WELL: LAB-PW
DEPTH: 1452.9
MAGNIFICATION: X40

Photomicrograph of thin section showing well cemented dolomitized lithoclast packstone with fair vuggy, moldic, and intraparticle porosity within the lithoclasts.



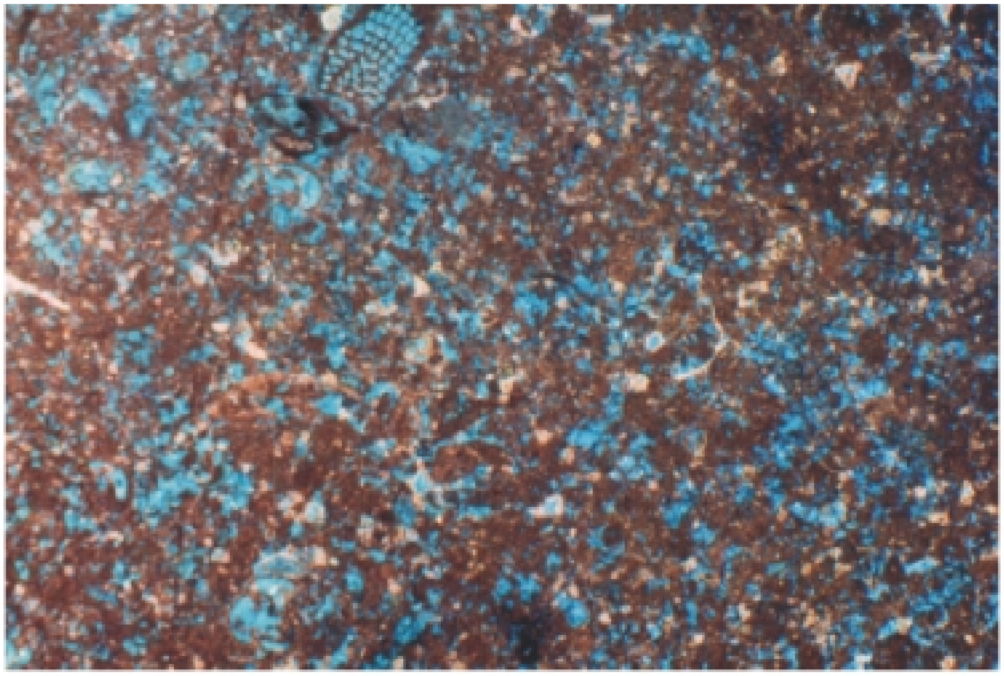
WELL: LAB-PW
DEPTH: 1451.5
MAGNIFICATION: X20

Photomicrograph of thin section showing intraclast-foram-pellet bearing lithoclast packstone with very fine size fair vuggy-moldic porosity in lithoclast and poor intercrystalline-vuggy porosity in matrix.



WELL: LAB-PW
DEPTH: 1454.2
MAGNIFICATION: X100

Photomicrograph of thin section showing a closeup of a partly dolomitized lithoclast and the matrix. Note the fair vuggy-moldic porosity in the lithoclast and the poor vuggy-intercrystalline porosity in the matrix.



WELL: LAB-PW
DEPTH: 1453.7
MAGNIFICATION: X20

Photomicrograph of thin section showing interbedded, slightly dolomitic, moderately well sorted, foram-pellet-intraclast packstone with good interparticle, vuggy, and moldic porosity.