Hydrogeologic Investigation of the Floridan Aquifer System

Immokalee Water & Sewer District Wastewater Treatment Plant Collier County, Florida Technical Publication WS-14

Title: IWSD-TW Tri-Zone Monitor Well

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EXECUTIVE SUMMARY

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 (LWC) Planning area 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.

This report documents the results of two Floridan aquifer wells constructed and tested under the direction of the SFWMD. These wells are located at the Immokalee Water & Sewer District Wastewater Treatment Plant in Collier County, Florida. This site was selected to augment existing data and to extend knowledge of the geology and hydrogeology of the Floridan aquifer in the SFWMD's Lower West Coast Planning area.

The scope of the investigation consisted of constructing and testing two FAS wells. The first well, a tri-zone monitor well, identified as IWSD-TW was drilled to a total depth of 2,354 feet below land surface (bls). It was completed into three distinct hydrogeologic zones within the upper and lower Floridan aquifer. The second well, identified as IWSD-PW, is located 240 feet west of IWSD-TW and constructed to facilitate aquifer testing of a productive horizon within the upper Floridan aquifer.

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

- The top of the Floridan aquifer, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986), was identified at a depth of approximately 773 feet bls.
- Lithologic and geophysical logs, specific capacity and packer test results, and petrophysical data indicate moderate to good production capacity from the upper Floridan aquifer.
- Water quality data from reverse-air returns and straddle packer tests indicate that chloride and total dissolved solids in the upper Floridan aquifer exceed potable drinking water standards. Chloride and total dissolved solids (TDS) concentrations below 1,160 feet bls range from 1,530 to 4,020 milligrams per liter (mg/L) and 3,410 to 7,150 mg/L, respectively.
- The base of the Underground Source of Drinking Water, those waters having TDS concentrations less than 10,000 milligram per liter, occurs at an approximate depth of 1,950 feet bls.
- The stable isotope results from the Immokalee Water & Sewer District site show that the upper Floridan 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) where $\delta^{18}O = 0\ {}^{0}/_{00}$ and $\delta D = 0\ {}^{0}/_{00},$ consistent with meteoric water.

- Stable isotope results from the IWSD site show that the lower Floridan aquifer waters are similar in both ^{18}O and deuterium as compared to SMOW. The inorganic water quality results from intervals below 2,150 feet bls are brackish to saline in composition and the major ion distribution and stable isotopes indicate that the lower Floridan aquifer has been intruded by seawater.
- The petrophysical data suggest a weak linear relationship between horizontal permeability and porosity with a correlation coefficient (R^2) of 0.524.
- The highest mean horizontal permeability (12,370 millidarcies) corresponds to a cored section at approximately 1,060 feet bls consisting of a peloidal–pelecyod-coquina-packstone. This unit was likely deposited in an open lagoonal shoal environment.
- A productive horizon in the upper Floridan aquifer from 1,040 to 1,160 feet bls, yielded a transmissivity value of 268,000 gallons/day/foot, a storage coefficient of 0.01, and an r/B value of 0.02.
- The average potentiometric heads for the Floridan aquifer monitor intervals are as follows:
  55.4 feet above mean sea level for the 1,060 to 1,140 feet bls monitor interval;
  54.5 feet above mean sea level for the 1,752 to 1,880 feet bls monitor interval;
  11.5 feet above mean sea level for the 2,134 to 2,354 feet bls monitor interval.
- Water levels in the Floridan aquifer respond to external stresses such as tidal loading and barometric pressure variations.

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INTRODUCTION

Background

The Lower West Coast Planning area (LWC) 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 LWC 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.

The first FAS test site completed under this program is located near the SFWMD's G-150 water control structure on the L-2 Canal in eastern Hendry County, Florida (Bennett, 2001a). The second test site is located adjacent to the Big Cypress Basin D2-7 water control structure on the I-75 canal in the Golden Gate Estates area of western Collier County (Bennett, 2001b). The third site, the focus of this report, is located in the Immokalee area of north-central Collier County. This site is located at the Immokalee Water & Sewer District (IWSD) wastewater treatment plant in the northwest quarter of Section 4, Township 47 South, Range 29 East **(Figure 1).**

Purpose

This report documents the hydrogeologic data collected during the SFWMD-initiated Floridan aquifer well drilling, aquifer-testing and monitoring program at the Immokalee Water & Sewer District Wastewater Treatment Plant. The information includes a summary of: 1) well drilling and construction details, 2) geological data 3) hydrogeology, 4) water quality and productive capacity, 5) stable isotope and ^{14}Carbon data, 6) petrophysical and petrologic data, 7) aquifer performance test data and analyses, and 8) long-term potentiometric-head data.

Project Description

Equipment mobilization and site preparation associated with the first FAS well (IWSD-TW) at the Immokalee Water & Sewer District Wastewater Treatment Plant began on May 15, 1995. Two Floridan aquifer wells were constructed at the IWSD Wastewater Treatment Plant. A tri-zone FAS monitor well (IWSD-TW), was completed in three distinct hydrogeologic units. The telescoping style, multi-zone well was drilled to a total depth of 2,354 feet bls and completed to varying depths for aquifer testing and long-term monitoring of the FAS. The final depth of the test-production well (identified as IWSD-PW) was 1,160 feet below land surface (bls) with a 12-inch diameter casing set at 1,050 feet in depth, which corresponds to the uppermost interval of the tri-zone monitor well **(Figure 1).**

SFWMD provided oversight during all well drilling, construction, and testing operations. RST Enterprises (Contractor), a Ft. Myers based firm was the licensed water well contractor responsible for all drilling, construction and testing services associated with the two wells (IWSD-TW and IWSD-PW) under SFWMD Contract C-4172.

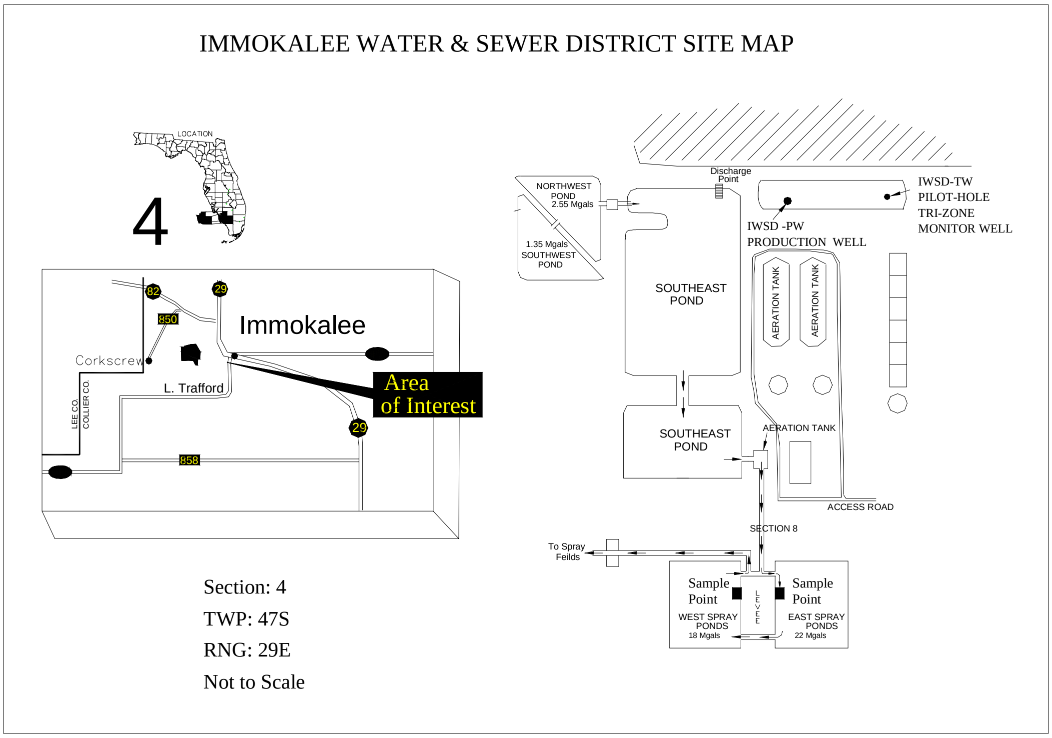


Figure 1. Project Location Map and Site Plan with Detailed Well Locations.

EXPLORATORY DRILLING AND WELL CONSTRUCTION

Immokalee Water & Sewer District Tri-Zone Monitor Well

RST Enterprises mobilized drilling and support equipment to the IWSD wastewater treatment plant on May 15, 1995 to begin drilling and construction of the FAS monitor well (referred to as IWSD-TW). After clearing and rough grading the site, RST lined the ground surface beneath the drill rig and settling tanks with a high-density polyethylene (HDPE) membrane. The Contractor then constructed a 2-foot thick temporary-drilling pad constructed using crushed limestone. Finally, an earthen berm, two feet in height was constructed around the perimeter of the rig and settling tanks to contain drilling fluids and/or formation waters produced during well drilling, testing, and construction activities.

Mud rotary and reverse-air techniques were used during drilling operations. Closed-circulation mud rotary drilling advanced the pilot hole from land surface to 1,270 feet bls. RST Enterprises drilled the remaining portion of the pilot hole from 1,270 to 2,354 feet bls using the reverse-air, open circulation method.

Data from formation samples (well cuttings), packer tests, and geophysical logs were used to determine the actual casing setting depths. The pilot hole was reamed to specified diameters for the selected casing setting. Five concentric steel casings (30-, 24-, 18-, 12-, and 7-inch diameter) were used in the construction of the telescoping style, FAS monitor well. Small diameter, fiberglass tubing was used to construct the lower Floridan aquifer monitor well because of the corrosive nature of the formation water. **Figure 2** shows a completion diagram of the IWSD tri-zone FAS monitor well identified as IWSD-TW.

On June 12, 1995, RST Enterprises drilled a 36-inch diameter borehole to a depth of 35 feet bls. Nominal 30-inch diameter, steel pit casing, (ASTM A53, Grade B) was installed in the nominal 36-inch diameter borehole. The annulus was grouted to land surface using 60 cubic feet (ft^3) of ASTM Type II, neat cement (15.6 lbs./gal).

RST Enterprise drilled the pilot hole by the mud rotary method using a nominal 11-inch diameter drill bit to a depth of 300 feet bls. Based on well cuttings, the bottom of the Surficial Aquifer System (SAS) was identified at approximately 120 feet bls. The Contractor reamed the pilot hole to 305 feet bls using a nominal 29-inch diameter staged bit reamer and installed 24-inch diameter steel surface pipe (ASTM A53, Grade B) to 300 feet bls. The surface casing annulus was grouted to land surface using 523 ft^3 of ASTM Type II neat cement. The purpose of the surface casing is to prevent unconsolidated surface sediments from collapsing into the drilled hole, to isolate the surficial aquifer from brackish water contamination, and to provide drill rig stability during subsequent drilling operations.

With the surface casing installed, RST continued drilling the pilot hole using the closed-circulation mud rotary method through the unconsolidated to semi-consolidated Miocene aged sediments to 862 feet bls. On July 12, 1995, a SFWMD-owned geophysical unit was used to geophysically log the pilot hole from 300 to 862 feet bls. Geophysical log runs included: a 3-arm caliper, natural gamma ray, spontaneous potential (SP), 16/64-inch normal resistivity, and a 6-foot lateral resistivity. Production evaluation logs were not run because of the poorly

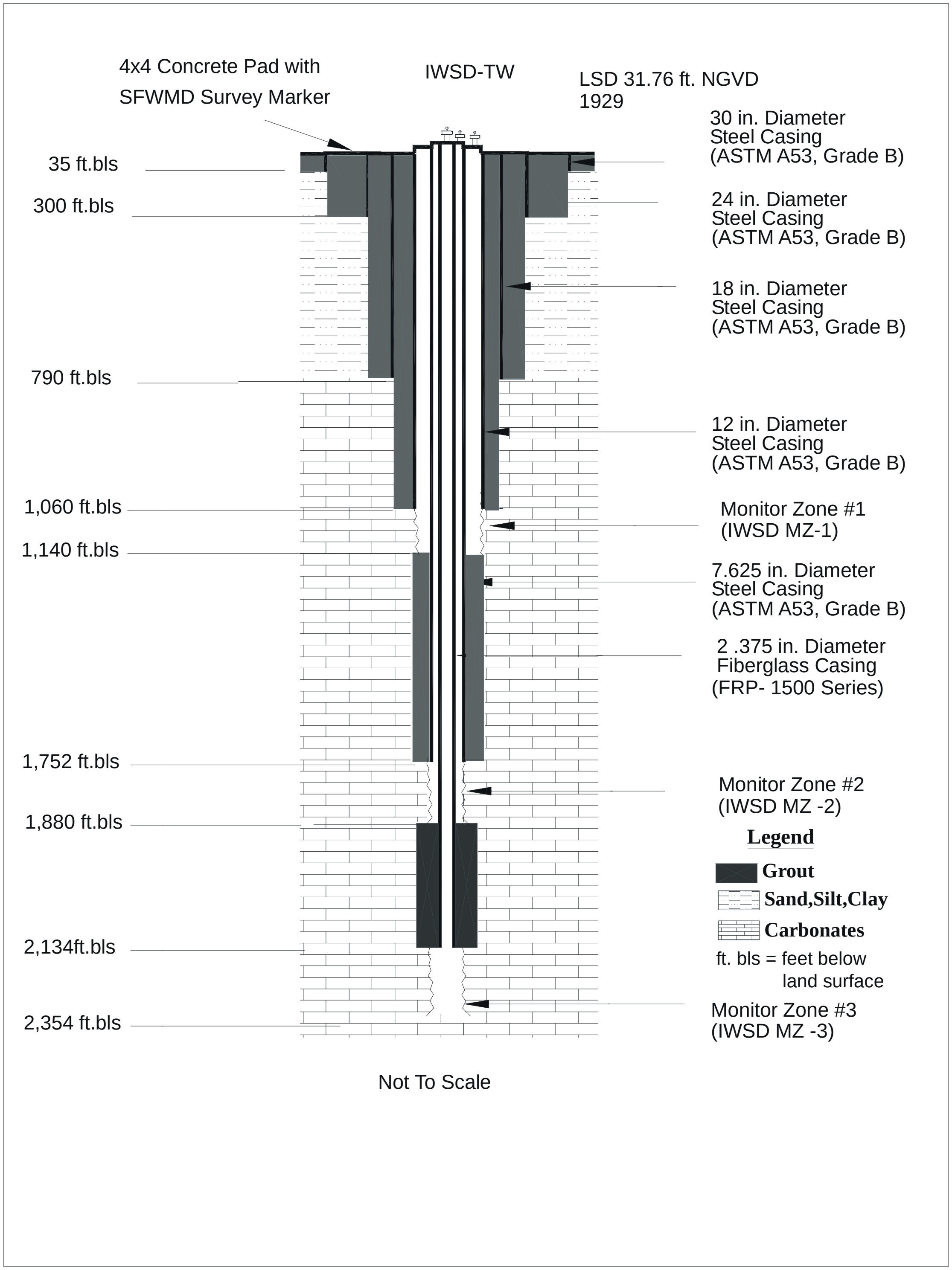


Figure 2. Well Completion Diagram, Tri-Zone Monitor Well IWSD-TW

consolidated nature of the overlying sediments, requiring the drilling fluids to remain in place to insure borehole stability. **Appendix A** contains the individual log traces from IWSD-TW Geophysical Log Run No. 1.

Geophysical and lithologic data collected to this point identified the upper Floridan aquifer at a depth of 773 feet bls. Based on this depth, the Contractor reamed the nominal 11-inch pilot hole to a nominal 23-inch diameter and installed 790 feet of 18-inch diameter steel casing. The 18-inch diameter steel casing (ASTM A53, Grade B) was pressure-grouted using 350 ft^3 of ASTM Type II neat cement. Pressure grouting caused cement to rise within the annulus to an elevation of 540 feet bls. The Contractor used successive cement stages of neat cement to seal the annulus above 540 feet bls via the tremie method with each stage being hard tagged after allowing sufficient time for the cement to harden. During grouting operations, 700 ft^3 of Type II neat cement was used to seal the annulus back to surface. These operations were completed on September 20, 1995.

After setting the casing into the top of the Floridan aquifer, RST Enterprises switched to reverse-air drilling operations. The Contractor drilled out the cement plug from the base of the 18-inch diameter casing, a result of pressure grouting and the temporary fill material used to temporarily back-plug the pilot hole from 790 to 862 feet bls. A nominal 10-inch diameter bit was used to continue the pilot hole from 862 to 891 feet bls. During drilling operations, a moderate-to-well indurated, calcareous sandstone-boundstone unit interbedded with unconsolidated quartz sands was encountered at a depth of 881 feet bls. The unconsolidated sands at this depth caused reverse-air drilling operations to be ineffective due to significant sand dredging. As a result, reverse-air drilling operations ceased, and the pilot hole continued through the Oligocene and upper Eocene aged sediments to 1,270 feet bls, using the closed circulation mud rotary method.

On October 12, 1995, RST Enterprises geophysically logged the nominal 10-inch diameter pilot hole from 790 to 1,270 feet bls. This geophysical logging suite consisted of the following logs: a 3-arm caliper, natural gamma ray, SP, 16/64-inch normal resistivity, and a 6-foot lateral resistivity. Production evaluation logs were not conducted because of the unconsolidated quartz sand encountered from 880 to 890 feet bls, which necessitated that the drilling fluids remain in place to ensure borehole stability. **Appendix A** presents the individual log traces from IWSD-TW Geophysical Log Run No. 2.

The geophysical and lithologic data suggested the presence of a permeable limestone horizon between 1,060 to 1,160 feet bls. This information was taken into consideration during the third phase of monitor well construction. The Contractor reamed the 10-inch diameter pilot hole using a 17-inch staged bit reamer and installed nominal 12-inch steel casing (ASTM A53, Grade B) to a depth of 1,060 feet bls. The casing annulus was then pressure grouted using 400 ft^3 of neat cement (ASTM Type II). The tremie method was used to place additional stages of neat cement with each stage hard tagged after allowing sufficient time for the cement to harden. Successive cement stages were used to complete cement grouting of the 12-inch diameter casing to surface. The Contractor completed the installation of the 12-inch diameter steel casing on November 25, 1995.

The 12-inch diameter casing installed to a depth of 1,060 feet bls isolated the sand unit at 890 feet bls, which stabilized the borehole and allowed reverse-air drilling operations to begin. This drilling method was used to advance the pilot hole through the moderately-to-well indurated wackestones to packstones and dolostones of the Ocala Limestone and Avon Park Formation. The Contractor drilled the pilot hole without significant problems through the Eocene age section from 1,270 to 2,150 feet bls. However, drilling rates slowed considerably from 2,150 to 2,354 feet bls with an increase in drill bit chatter and minor drops in the drill rod indicating potentially fractured horizons within a predominately dolostone sequence. In addition, while drilling through this interval, the reverse-air discharge rates increased and the circulated return fluids began to foam. These two observations indicate that a permeable horizon containing saline water was encountered at between these depths. This permeable dolostone section was identified as the upper portion of the lower Floridan aquifer – meeting the objective of this drilling program. On January 12, 1996 RST Enterprises ceased drilling operations at depth of 2,354 feet bls.

On January 25, 1996, Florida Geophysical Logging Service, Inc. ran the third suite of geophysical logs in the open hole section from 1,060 to 2,354 feet bls. This geophysical logging suite consisted of the following logs: 4-arm caliper, natural gamma, SP, dual induction-laterolog (LL3) combination, compensated neutron and a borehole compensated (BHC) sonic log. Water production evaluation logs included a flowmeter, conducted under artesian flow (dynamic) conditions, a high-resolution temperature log, and a borehole video log. **Appendix A** contains the individual log traces from IWSD-TW Geophysical Log Run No. 3.

Straddle-packer test intervals were selected using the information provided by analysis of the geophysical and lithologic and the first of two tests began on February 22, 1996. The objective of these tests was to characterize the water quality and production capacities of specific intervals within the lower portion of the pilot hole (1,700 to 1,950 feet bls) and to identify intervals having total dissolved solid (TDS) concentrations greater than 10,000 milligrams per liter (mg/L). Intervals having a TDS concentration greater than 10,000 mg/L were excluded from 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) defines an aquifer that contains water with TDS concentrations less than 10,000 mg/L.

The two packer tests were completed on February 26, 1996. The water quality data obtained from the straddle-packer tests in tandem with the geophysical logs identified the base of the USDW at approximately 1,950 feet bls. The "Packer Test" section of this report presents the production capacity and water quality results from the two packer tests.

Following straddle-packer testing, all available information was compiled. This information was used to select the two lower monitor zones. SFWMD selected a depth of 1,752 feet as the casing setting depth for the 7.625-inch outside diameter (OD) steel casing. The Contractor use a nominal 12-inch bit to ream the pilot hole from the base of the 12-inch diameter casing at 1,060 to 1,752 feet bls. The Contractor attached three steel cement baskets to the nominal 7-inch diameter steel casing and cement-grouted the annulus to 1,140 feet bls via the tremie method using multiple stages of neat cement (ASTM Type II). Cement levels at 1,140 feet bls form the base of the first FAS monitor interval from 1,060 feet to 1,140 feet bls (referred to as IWSD MZ-1).

The final casing string consisted of threaded 2.375-inch OD fiberglass reinforced pipe (FRP-Smith Fiberglass, 1500 series), installed to a depth of 2,134 feet bls. The Contractor attached appropriate sized cement baskets to the FRP then cement-grouted the annulus via the tremie method using multiple stages of neat cement (ASTM Type II) bringing cement levels to 1,880 feet bls. Cement levels at 1,880 feet bls, form the base of the second FAS monitor interval from 1,752 to 1,880 feet bls (referred to as IWSD MZ-2). Successful grouting operations also secured the nominal 2-inch FRP in place, completing the lower Floridan aquifer monitor zone. The open-hole interval for the lower Floridan aquifer monitor interval is 2,134 to 2,354 feet bls and is referred to as IWSD MZ-3.

Three, 2-inch inner diameter (ID), stainless steel piezometers equipped with stainless steel ball valves completed the wellhead for the tri-zone FAS monitor well. The piezometers facilitate monitoring of water levels and quality within in the three intervals of the telescoped monitor well. The uppermost monitor zone (IWSD MZ-1) constructed using 12-inch diameter casing, monitors water levels in the upper Floridan aquifer between 1,060 feet to 1,140 feet bls. The intermediate zone (IWSD MZ-2) monitors water levels within a 128-foot section of the middle FAS confining unit above the USDW from 1,752 to 1,880 feet bls. The lowermost zone (IWSD MZ-3) constructed using 2.375-inch OD threaded FRP tubing monitors water levels in the lower Floridan aquifer between 2,134 feet to 2,354 feet bls. **Table 1** lists the monitor intervals and completion methods for the tri-zone FAS monitor well.

Table 1: IWSD-TW Monitor Zones

Identifier	Aquifer	Monitor Interval (feet bls)	Completion Method
IWSD MZ-1	Upper Floridan	1,060 to 1,140	Annular Zone
IWSD MZ-2	Middle Confining Unit	1,752 to 1,880	Annular Zone
IWSD MZ-3	Lower Floridan	2,134 to 2,354	Open-Hole

The Contractor developed the three monitor intervals using reverse-air, pressurized air, and artesian flow techniques until sediment concentrations of the formation water were 15 mg/L or less (using an Imhoff cone). On May 12, 1996, a 5-foot by 5-foot reinforced concrete pad constructed at the surface of the monitor wellhead completed well construction operations related to IWSD-TW.

IWSD Test-Production Well

On May 16, 1996, RST Enterprises moved their drilling and support equipment 240 feet to the west to begin construction of the test-production well at the IWSD site. After minor clearing and rough grading the site, the Contractor lined the ground surface beneath the drill rig and settling tanks with a HDPE membrane and constructed a 2-foot thick temporary drilling pad using crushed limestone. Finally, an earthen berm, 2-feet in height was constructed around the perimeter of the rig and settling tanks to contain drilling fluids and/or formation waters produced during well drilling, testing and well construction.

Construction of the test-production well began during the third week of May 1996. This well would facilitate aquifer testing of a single productive horizon in the upper Floridan aquifer between 1,050 to 1,160 feet bls. **Figure 3** shows a completion diagram of the IWSD Floridan aquifer test-production well identified as IWSD-PW.

Four concentric steel casings (24-, 18-, 12-, and 8-inch diameter) were used in the construction of the Floridan aquifer test-production well. The Contractor installed a 24-inch diameter pit casing (ASTM A53, Grade B) to 30 feet bls. Mud rotary drilling advanced a 24-inch diameter borehole to the base of the poorly consolidated clastic sediments at 310 feet bls. A caliper log was run to evaluate borehole stability and to calculate cement volumes for grouting operations. The Contractor then installed an 18-inch diameter steel pipe (ASTM A53, Grade B) into the nominal 24-inch diameter borehole to 300 feet bls. Once installed, the 18-inch diameter casing was pressure grouted using 490 ft^3 of Type II neat cement resulting in cement returns at surface.

After setting the 18-inch diameter surface casing, a nominal 14-inch diameter bit advanced the borehole to the top of the production interval at 1,050 feet bls and three, 10-foot long, full-diameter rock cores (4-inch diameter) were collected. A caliper log was then run to evaluate borehole stability and to calculate cement volumes for subsequent grouting operations. The third stage of well construction consisted of installing 1,050 feet of production casing using both 8- and 12-inch diameter ASTM A53, Grade B steel pipe. The upper 300 feet consisted of 12-inch diameter steel pipe, then reduced to 8-inch diameter pipe for the remaining 750 feet. The Contractor installed the production casing and sealed the annulus to surface with 857 ft^3 of ASTM Type II neat cement using both pressure and tremie grouting methods. Installation of the combination 8-12-inch diameter, steel production casing was completed on December 10, 1996.

The Contractor then drilled the test interval using a nominal 8-inch bit via the reverse-air method to a total depth of 1,160 feet bls. A total of three, 10-foot long, full-diameter rock cores (4-inch diameter) were obtained from the production interval (1,050 to 1,160 feet bls – Suwannee Limestone). These cores plus the three previously obtained cores from the upper Floridan aquifer were sent to Core Laboratories in Midland, Texas for petrophysical and petrologic analyses (See Petrophysical/Petrologic Section for further information). On December 30, 1996, the Contractor completed drilling of the UFA test interval to a depth of 1,160 feet bls.

The Contractor developed the open-hole section using reverse-air, pressurized air, and artesian flow techniques until the sediment concentration of the formation water was 15 mg/L or less (using an Imhoff cone). Once sufficiently developed, RST geophysically logged the open-hole section (1,050 to 1,160 feet bls). An aquifer performance test (APT) was conducted and completed on February 10, 1997 (see APT section for test details and results).

RST installed a standard 12-inch diameter well head that 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. On February 12, 1997, the Contractor installed a 5-foot by 5-foot reinforced concrete pad at the surface completing construction of the test-production well.

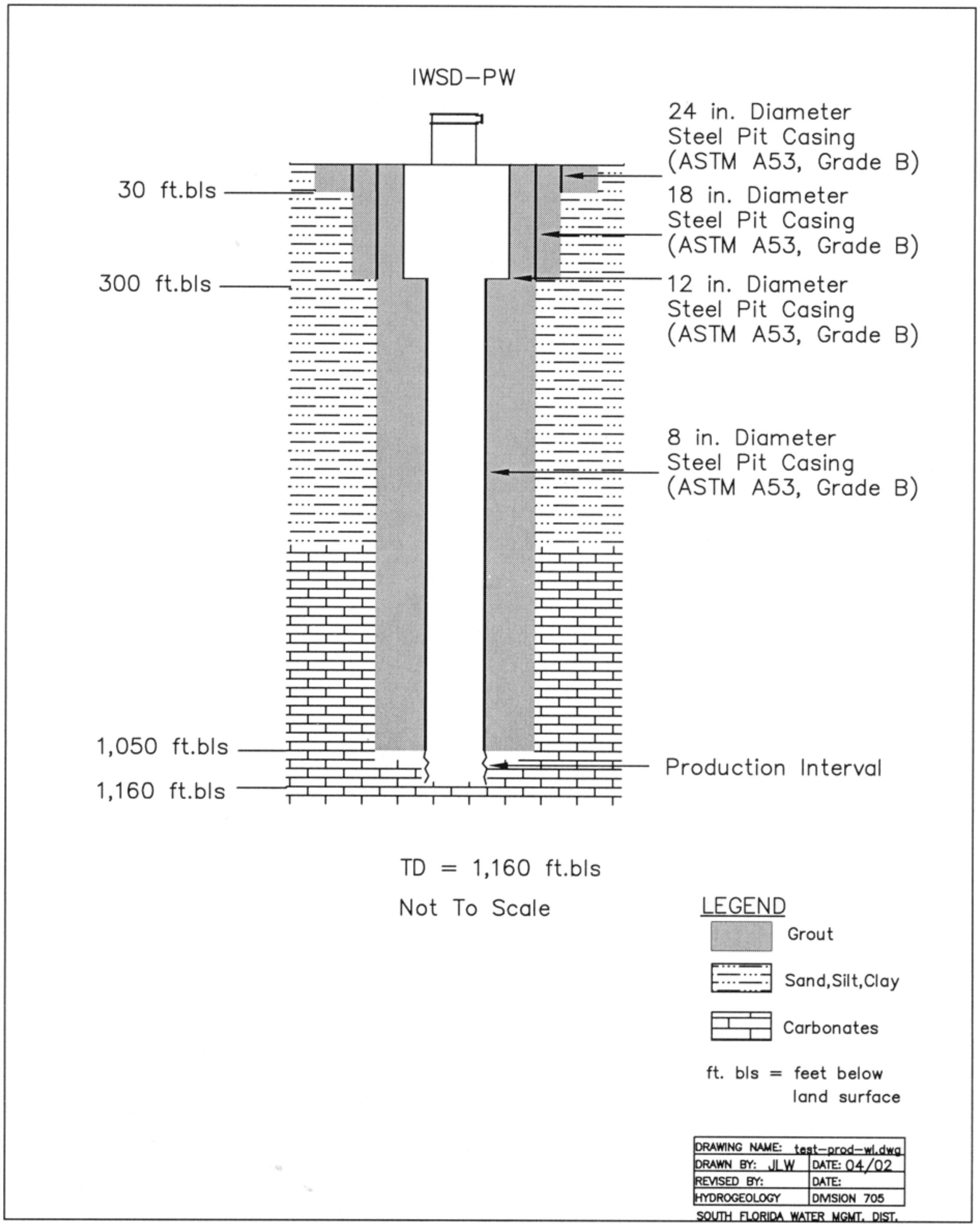


Figure 3. Well Completion Diagram, Test-Production Well IWSD-PW.

STRATIGRAPHIC FRAMEWORK

During the drilling of the pilot hole for the tri-zone monitor well (IWSD-TW), SFWMD collected, washed, and described (using the Dunham, 1962-classification scheme) the geologic formation samples (well cuttings). These formation samples were separated based on their dominant lithologic or textural characteristics, and to a lesser extent color. The representative formation samples were distributed to the SFWMD and the Florida Geological Survey (FGS) for analysis and long-term storage.

Appendix B contains a copy of the FGS's detailed lithologic description for the pilot hole/monitor well IWSD-TW (FGS reference no. W-17391). An electronic version of the lithologic description can be downloaded directly from FGS's Internet site. **Appendix C** contains the original onsite driller's log (lithologic description plus notes related to drilling operations).

Undifferentiated Pliocene-Pleistocene Series

The undifferentiated Pliocene-Pleistocene age sediments occur from land surface to a depth of 120 feet at this site. These sediments consist of unconsolidated, yellowish-gray, very fine to coarse-grained quartz sands and shell fragments.

Miocene-Pliocene Series

Hawthorn Group

The Hawthorn Group is composed of a heterogeneous mixture of silts, clays, calcareous clay, dolosilts, quart sand, phosphate, limestone, and dolomites. It can be subdivided into two lithostratigraphic units. The upper unit is composed of predominantly siliciclastic material referred to as the Peace River Formation. The lower unit composed principally of carbonates is formally referred to as the Arcadia Formation (Scott, 1988). A major regional disconformity separates these two units (Missimer, 1997). The contact between these two units can often be identified by the occurrence of a rubble bed of coarse to pebble size quartz sand and phosphatic sand and gravel. If present, this unit produces a distinctive response ("peak") on the natural gamma ray log.

Peace River Formation

The top of the Peace River formation is indicated by the first appearance of an olive-gray unconsolidated, fine to very coarse-grained quartz sand with a minor greenish-gray clay and phosphate component. These unconsolidated and poorly indurated quartz sands occur at a depth of 120 feet bls and continue to 255 feet bls, where a moderately indurated, light gray, sandy carbonate mudstone is encountered.

Arcadia Formation

The top of the Arcadia Formation was identified at 255 feet bls and extends to a depth of 870 feet bls at this site. The Arcadia Formation is distinguished from the Peace River Formation by a lithologic change from predominately siliciclastic to carbonate rich sediments. A light gray moderately indurated, sandy carbonate mudstone unit occurs from 255 to 383 feet bls. Below this carbonate unit is a dense, non-indurated, medium olive-green to gray colored, clayey-silt-carbonate unit. This low permeability unit is approximately 280 feet thick and extends to a depth of 535 feet bls.

A light gray to tan, moderately indurated limestone (wackestone) occurs from 535 to 621 feet bls. Unconsolidated calcareous muds and poorly indurated mudstones extend from 621 to 773 feet bls. The basal portion of the Arcadia Formation occurs from 773 to 870 feet bls and is composed primarily of light gray, moderately indurated, sandy, phosphatic mudstones and wackestones. The base of the Arcadia Formation is marked by a significant attenuation of natural gamma emissions and by an enlarged borehole that extends to 26 inches in diameter, with a bit size that was 10-inches in diameter (see IWSD-TW Geophysical Log Run No. 2 - **Appendix A).**

Oligocene

Suwannee Limestone

The upper boundary of the Suwannee Limestone was identified at a depth of 870 feet bls. Lithologically, the boundary is marked by a gradual change from white to light gray, sandy, phosphatic mudstones and wackestones of the Arcadia Formation to the medium tan to yellowish gray, phosphate free, grainstone of the upper Suwannee Limestone. The formational contact between the Suwannee Limestone and overlying Arcadia Formation is characterized by an attenuation of the natural gamma activity primarily due to its decrease in phosphate content. Missimer (1997) suggests that the Suwannee Limestone is unconformable with the overlying Arcadia Formation throughout much of south Florida.

Upper Eocene

Ocala Limestone

The boundary between the Suwannee and Ocala Limestones is marked by a change in lithology from a light orangish-tan to light olive gray, well indurated wackestone/packstone to a pale tan to white, moderately indurated, phosphate free, chalky, foraminiferal limestone. The top of the Ocala Limestone is also marked by a significant attenuation of the natural gamma response and abundant <u>Lepidocyclina</u> sp., a diagnostic microfossil and other large forams.

The Ocala Limestone occurs from 1,152 to 1,459 feet bls. It consists primarily of light orange to beige, poorly to moderately indurated mudstones and wackestones. These limestones exhibit a broad range of textural fabrics ranging from calcareous muds to foramineral grainstones. The allochemical constituents consist primarily of larger benthic foraminiferal tests such as <u>Lepidocyclina</u> sp., and <u>Nummulites</u> sp.

Middle Eocene

Avon Park Formation

The Avon Park Formation consists of beige to light brown, moderately to well indurated packstone to grainstone with intermittent brown to gray, well indurated dolostones. The Avon Park Formation was identified at a depth of 1,459 feet bls, based on a slight lithologic change, the occurrence of the diagnostic microfossil <u>Dictyoconus</u> sp., along with a minor increase in natural gamma activity. The minor difference in lithologic character between the overlying Ocala Limestone and the Avon Park Formation may signify a continuous or similar depositional environment.

Moderately indurated, tan to gray packstones and grainstones with minor recrystallized limestone is predominant in the upper Avon Park Formation. A significant change in lithology occurs at 2,150 feet bls and continues to the total depth of the borehole at 2,354 feet bls. Well indurated, crystalline (euhedral to subhedral) dolostones are dominant in this interval with minor stringers of moderately indurated mudstone and wackestone units being present. The induction, neutron porosity, sonic, and caliper logs all note the change in lithology as seen in their individual log traces recorded during IWSD-TW Geophysical Log Run No. 3 (**see Appendix A**).

Lower Eocene

Oldsmar Formation

The top of the Oldsmar Formation is often difficult to identify because of a lack of diagnostic microfossils, which are generally obliterated by diagenetic effects or a lithologic character similar to the overlying Avon Park Formation. The top of the Oldsmar in south Florida is often identified based on the presence of a dolostone unit that occurs below a depth of 2,000 feet bls. This unit is discerned on geophysical logs by increased gamma ray counts and resistivity values and decreased sonic travel times. If these criteria are used, the Oldsmar Formation could be identified at 2,150 feet bls which corresponds to the occurrence of a well indurated, crystalline (euhedral to subhedral) dolostone. Based on lithologic criteria defined by Miller (1986), the lack of a glauconite marker bed used by Duncan et al., (1994), and the absence of Early Eocene index fossils such as Helicostegina gyralis (Chen, 1965), the Oldsmar Formation was not encountered at this site.

HYDROGEOLOGIC FRAMEWORK

Three major aquifer systems underlie this site, the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Floridan Aquifer System (FAS) with the FAS being the focus of this test well program. These aquifer systems are composed of multiple, discrete aquifers separated by low permeability "confining" units that occur throughout the Tertiary/Quaternary-aged sequence. **Figure 4** shows a generalized lithologic and hydrogeologic section underlying the IWSD site.

Surficial Aquifer System

The SAS extends from land surface to a depth of 120 feet bls. It consists of Pliocene to Pleistocene-aged sediments. The undifferentiated Pliocene-Pleistocene sediments occur from land surface to a depth of 120 feet bls, and consist of unconsolidated orange to light gray, very fine to coarse grained quartz sands and shell fragments. The finer grained, low permeability siliciclastic sediments of the Peace River Formation were used to delineate the base of the SAS.

Intermediate Aquifer System

The IAS lies below the SAS and extends from 120 to 773 feet bls. The Peace River sediments from 120 feet to 255 feet bls, consist primarily of light gray to medium gray, unconsolidated fine to coarse grained quartz sand with minor fine-grained sandstone stringers (moderate to good permeability). A tan to light gray, moderately to well indurated limestone (20% coarse quartz sand) of moderate permeability occurs from 255 to 287 feet bls is considered as the carbonate facies of the Sandstone aquifer (Smith and Adams, 1988). A light blue-gray, poorly to non-indurated, low permeability calcilutite (mudstone) unit at 287 feet bls defines the base of the Sandstone aquifer at this site.

The IAS contains multiple productive horizons separated by low permeability inter-aquifer confining units. The Arcadia Formation of the Miocene aged Hawthorn Group (Scott, 1988) acts as a semi-confining unit separating the Floridan aquifer from the SAS. Low permeability arenaceous mudstones and non-indurated silty clays from 287 to 535 feet bls form a confining unit within the IAS. A second moderately productive unit occurs from 535 to 620 feet bls. It consists of moderately indurated biogenic limestone (75% allochems consisting of mollusks and coral) with minor phosphatic sands and is identified as the mid-Hawthorn aquifer (Wedderburn et al., 1982). Through this interval, the natural gamma log readings range between 10 to 20 counts per second (cps), and the 16/64-inch resistivity readings increase from 10 to 15 ohm-meters (ohm-m). Below this semi-productive interval is a relatively thick, low permeability carbonate unit (good confinement) from 620 to 773 feet bls. This unit consists of low permeability, light gray to medium gray, non-indurated lime mud (mudstone) with minor biogenic limestone stringers. A portion of this interval (620 to 750 feet bls) correlates to the "Marker Unit" as identified by Reese, 2000. The natural gamma log signature, identified this unit as a result of its characteristic thin, intermittent, high gamma radiation peaks, associated primarily with intervals of high phosphatic sand/silt content below a depth of 620 feet bls. The Marker Unit and other low permeability sediments form the lower boundary of the IAS at 773 feet bls.

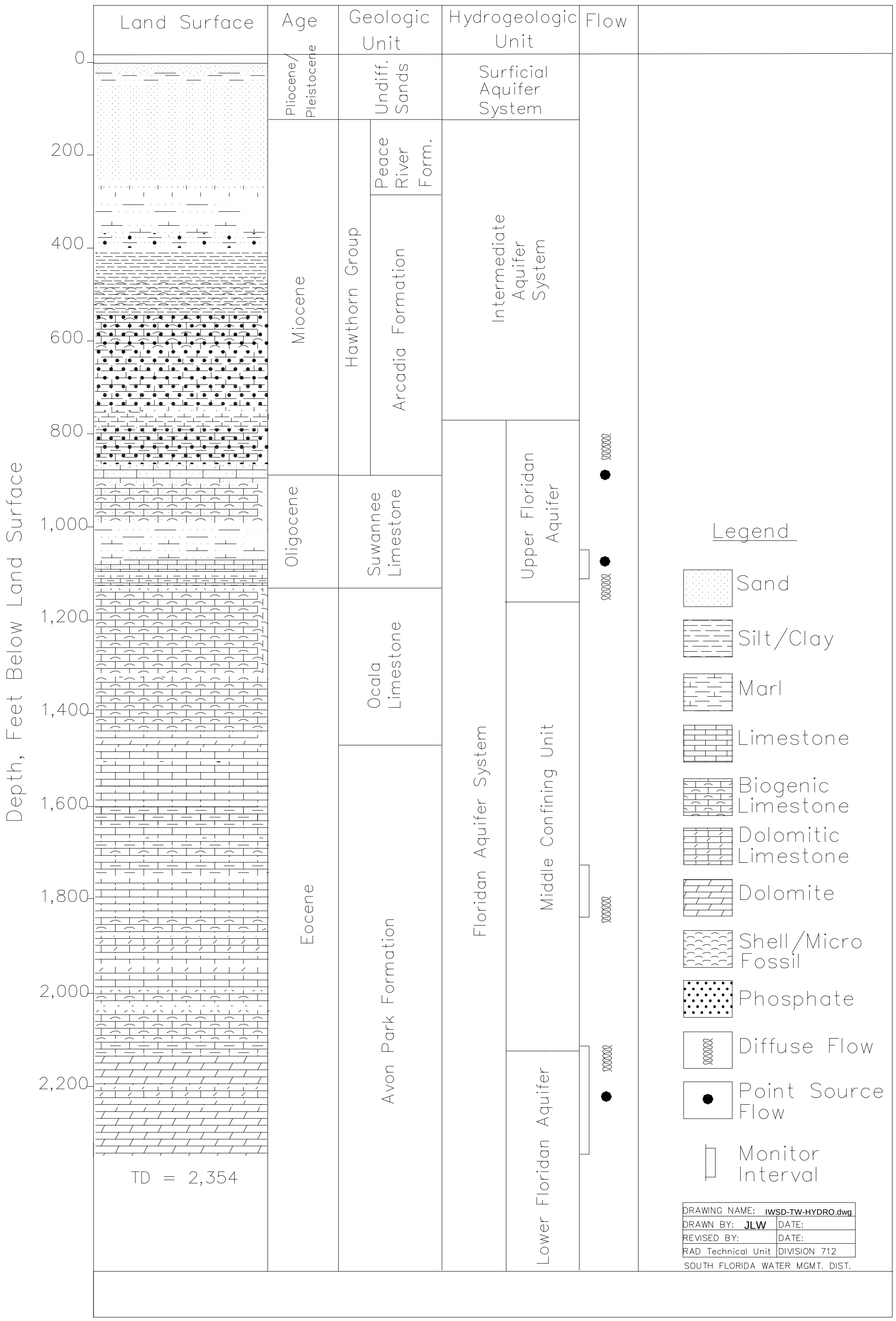


Figure 4. Lithologic and Hydrogeologic Section for the IWSD Site.

Floridan Aquifer System

The FAS consists of a series Tertiary Age limestone and dolostone units. The system includes permeable sediments of the lower Arcadia Formation, Suwannee Limestone, Ocala Limestone, Avon Park Formation, and the Oldsmar Formation. The evaporitic gypsum and anhydrite beds of the Paleocene age Cedar Keys Formation form the lower boundary of the FAS (Miller, 1986).

Upper Floridan Aquifer

The top of the FAS, as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986), coincides with the top of a vertically continuous permeable carbonate sequence. The upper Floridan aquifer consists of thin, high permeability, water-bearing horizons interspersed within thick, low permeability units of early Miocene to middle Eocene aged sediments, including the basal Arcadia Formation, Suwannee and Ocala Limestones. At this site, the top of the FAS occurs at a depth of 773 feet bls, which coincides with the lower portion of the Arcadia Formation, the Basal Hawthorn Unit (Reese, 2000).

Generally, two predominant permeable zones exist within the UFA with the uppermost 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 horizon at the IWSD site includes the lower portion of the basal Hawthorn unit (Reese, 2000) and upper Suwannee Limestone; which occurs from 773 to 910 feet bls. This transmissive unit (773 to 870 feet bls) is composed of tan to light gray, moderately indurated wackestones with moderate to good permeability. Moderate drilling fluid losses were observed and noted in the on-site drilling log from 800 to 831 feet bls, indicative of a permeable horizon.

A tan to medium brown, moderately indurated arenaceous limestone (grainstone to boundstone), inter-bedded with well indurated crystalline limestone and unconsolidated quartz sands, extends from 870 to 889 feet bls. This change in lithology was used to identify the upper boundary of the Suwannee Limestone.

This formation boundary coincides with a decrease in natural gamma activity and an enlarged borehole indicated by the caliper log (see IWSD-TW Geophysical Log Run No. 2 - **Appendix A)**. A light brown moderately indurated sandstone to well indurated boundstone unit with excellent secondary porosity development (moldic and pinhole porosity) occurs from 889 to 896 feet bls. The base of this productive horizon terminates within the upper portion of the Suwannee Limestone at a depth of 910 bls. This productive horizon (773 to 910 feet bls) correlates with the lower Hawthorn/Suwannee aquifer (Knapp et. al., 1986) present within this area and identified as the uppermost portion of the Floridan aquifer at this site.

Below the lower Hawthorn/Suwannee aquifer, a relatively thick, low permeability, inter-aquifer semi-confining carbonate unit consisting of poorly to moderately indurated sandy mudstones and wackestones. This confining unit extends from 910 to 1,052 feet bls. A second productive interval in the UFA (lower Suwannee/upper Ocala Limestones) was identified from 1,052 to 1,160 feet bls based on lithologic data and significant drilling fluid losses. Lithologically, this interval consists of well indurated grainstones with stringers of boundstone and crystalline limestones with well developed secondary porosity (e.g., vugular and channel porosity). During mud rotary drilling operations, significant drilling fluids losses (10,000 gallons) occurred between 1,100 to 1,115 feet bls, indicative of a transmissive horizon.

Middle Floridan Confining Unit

The Ocala Limestone from 1,160 to 1,440 feet bls, acts as an inter-aquifer confining unit within the FAS at this site. This interval consists of low permeable, poorly to moderately indurated mudstones and wackestones. Formation samples from this interval show no evidence of large-scale secondary porosity development. In addition, the production type geophysical logs (e.g., temperature and flowmeter logs from Geophysical Log Run No. 3 – **Appendix A**) indicate limited production horizons, which supports the overall confining nature of this interval.

Moderate to high permeability intervals have been documented within the middle confining unit ranging in depth from 1,400 to 1,600 feet bls (Miller, 1986). Within this inter-aquifer confining unit a minor flow zone is present within a moderately indurated wackestone, inter-bedded with well indurated (euhedral) dolostones from 1,440 to 1,497 feet bls. This inter-bedded wackestone unit was identified on the geophysical logs (see Geophysical Log Run No. 3 – **Appendix A**) by a relatively gauged caliper (similar to bit size) and a shift noted on both the resistivity and sonic log traces. Minor water production occurs throughout this interval indicated by deflections in the flowmeter log trace and visual verification by a borehole video survey. A flow zone at a similar depth (1,481 to 1,500 feet bls) within a medium-brown to olive-gray crystalline dolomite unit was identified at a site located near Naples, Florida which yielded 15.13 gallons per minute/foot (gpm/ft) of drawdown (Bennett, 2001b). However, a packer test could not be conducted at the IWSD site to quantify its production capacity due to the interval's borehole rugosity. In addition, the borehole diameter above and below the potential test interval exceeded the expansion limits of the packers, which prohibited testing operations (see caliper log from Geophysical Log Run No 3 **– Appendix A).**

The upper portion of the Avon Park Formation is generally confining in nature. It is characterized by moderately indurated packstones to grainstones, interbedded with minor crystalline limestones and dolostones from 1,497 to 1,740 feet bls. These limestone units show evidence of varying degrees of pinhole porosity development within the crystalline limestone and dolostone stringers being slightly vuggy in nature. However, a well-defined flow zone is not evident, as indicated by both the temperature and flowmeter logs (see log traces from Geophysical Log Run No. 3 **– Appendix A**).

Well-indurated dolomitic packstones to grainstones (allochems consist primarily of the foraminifer <u>Dictyoconus sp</u>, and irregular echinoids) inter-bedded with moderately indurated wackestones are found from 1,740 to 1,800 feet bls. This interval is easily identified from the geophysical logs by shifts in both the dual induction and sonic log traces (see Geophysical Log Run No. 3 **– Appendix A**). Minor water production from discrete zones within this interval was noted by the flowmeter log and observed in the borehole video survey, but yielded only 0.43 gpm/ft of drawdown during Packer Test No.2 (1,700 to 1,774 feet bls). This interval produced slightly brackish waters based on water samples obtained from Packer Test No. 2. The results of the water quality analysis of these samples yielded a chloride and TDS concentration of 1,162 and 3,062 mg/L, respectively.

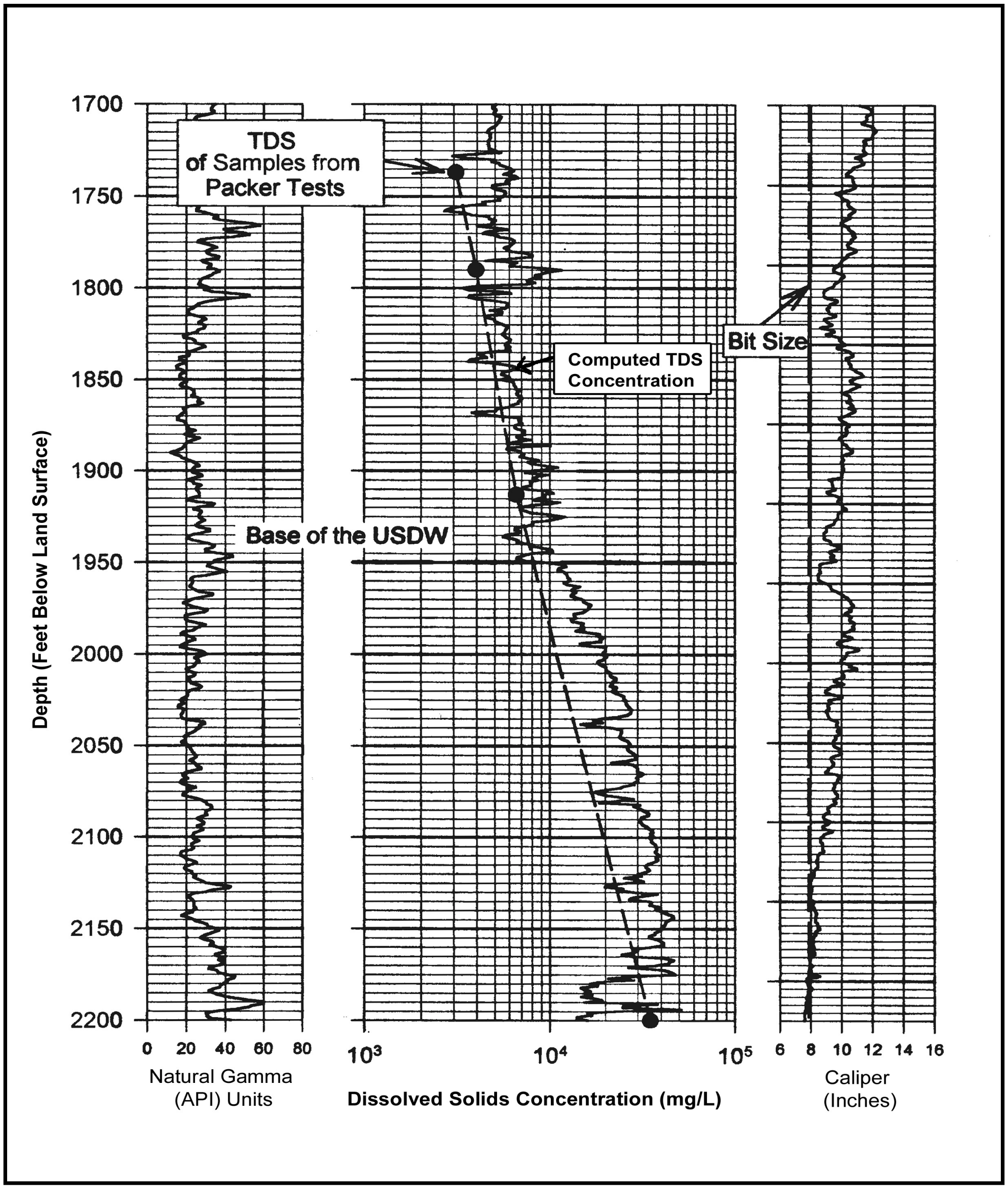
Deep induction log values begin to decrease from 30 ohm-meter at 1,800 feet bls to 4 ohm-m at 2,000 feet bls with very little change in lithology or porosity (as noted in the well cuttings and neutron and sonic porosity curves). The low deep induction readings (resistivity less than 5 ohm-m, reported by Reese, 2000) coupled with the water quality results from straddle packer tests initially identified the base of the USDW (waters with less than 10,000 mg/L TDS) at approximately 1,950 feet bls. A formation water resistivity log was generated using Archie's equation (Archie, 1942), which employs the deep induction and sonic porosity log data. The results generated from Archie's equation was used in a linear regression analyses (Reese, 2000) to generate a formation water quality profile (TDS) for a portion of the wellbore from 1,700 to 2,200 feet bls. This analysis also verified the base of the USDW occurs at approximately 1,950 feet bls. **Figure 5** shows the calculated formation water TDS log compared to measured TDS concentrations of water samples taken from the packer tests and completed monitor zones at this site.

The lower portion of the middle confining unit is characterized by moderate to well indurated packstones to grainstones, interbedded with minor dolostone units that occur from 1,800 to 2,150 feet bls. These limestone units show evidence of varying degrees of pinhole and moldic porosity development with the dolostones being slightly surcrosic in nature. A well-defined flow zone is evident from 1,880 to 1,910 feet bls, as indicated by sharp deflection in the temperature log trace and significant upward flow observed on the borehole video log (see Geophysical Log Run No. 3 – **Appendix A).** Straddle Packer Test No. 1 (1,876 to 1,950 feet bls) was conducted to isolate this flow zone. This flow zone generated a specific capacity of 15.3 gpm/ft of drawdown stressed at 103 gpm. Similar production data (13.49 gpm/ft at a pumping rate of 102 gpm) with corresponding depths (1,850 to 1,901 feet bls) was noted in a Floridan test well (referred to as I75-TW) located near Naples, Florida (Bennett, 2001b).

Miller (1986) observed that portions of the lower Avon Park Formation are fine-grained and have low permeability, thereby acting as inter-aquifer confining units within the FAS. Based on well cuttings, well indurated, low porosity mudstone to packstone units with intermittent brown to gray dolostones and crystalline limestones occur in the subsurface from 1,950 to 2,150 feet bls. Significant lithologic changes from limestone to predominately well-indurated dolostones occur at 2,150 feet bls.

Lower Floridan Aquifer

Below the confining unit identified between 1,950 feet and 2,150 feet bls, thin, moderately to highly permeable, fractured, and cavernous dolostones occur interspersed within less permeable dolostone and limestone units. A significant lithologic change occurs at a depth of 2,150 feet bls and continues to the total depth of the borehole at 2,354 feet. Well indurated, crystalline (euhedral to subhedral) dolostones dominate this interval with only minor stringers of wackestone and packstone units. A change in lithology was noted by the caliper log that measured a relatively gauged borehole – similar to drill bit diameter, an increase in resistivity, and a decrease in sonic travel times (see Geophysical Log Run No. 3 – **Appendix A**). A minor flow zone was discerned by a significant increase in water production near the top of this dolostone sequence noted during reverse-air drilling. A deflection in the temperature log trace and information from the borehole video log confirmed its productive nature. Based on information provided by Meyer (1989) and Reese (2000), the interval from 2,150 to 2,210 feet bls was identified as the uppermost dolostone unit of the lower Floridan aquifer. The pilot hole extends into the upper dolostone units of the lower Floridan to a total depth of 2,354 feet bls. Consequently, this interval was identified for long-term water level and water quality monitoring (IWSD MZ-3), meeting the objectives of the test well program.



$F = a/\phi^m$ m=1.95, a=0.883
F = Formation Factor
a = Tortuosity Factor
ϕ = Porosity in decimal form derived from sonic log
^{m} = Cementation Exponent

$R_o = F \times R_w$
R_o = Resistivity in ohm-meters of the formation 100% water saturated
F = Formation factor, a proportionality constant
R_w = Resistivity in ohm-meters of the water saturating the formation

RILD = Rt
RILD = Deep Induction Log Value
Rt = Formation Resistivity

Figure 5. Calculated Formation TDS Concentration – IWSD-TW (1,700-2,200' bls)

HYDROGEOLOGIC TESTING

Specific information was collected during the drilling program to determine the lithologic, hydraulic, and water quality characteristics of the FAS at this site. These data were used to design 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.

Formation Fluid Sampling

During reverse-air drilling of the tri-zone monitor well (IWSD-TW), samples were taken from circulated return fluids (composite formation water) at 30-foot intervals (average length of drill rod) from 1,270 feet bls to the total depth of the pilot hole at 2,354 feet bls. A Hydrolab® multi-parameter probe measured field parameters on each sample, which included temperature, specific conductance, and pH. A field titration method (Hach® Kit) determined chloride concentrations. **Figure 6** shows field determined specific conductance values and chloride concentrations with respect to depth. Between 1,270 feet to 1,862 feet bls, specific conductance values and chloride concentrations average 4,700 micromhos per centimeter (umhos/cm) and 1,200 mg/L, respectively. Between 1,862 feet and 2,172 feet bls, specific conductance, and chloride concentrations gradually increase to about 13,900 umhos/cm and 4,400 mg/L, respectively. At 2,202 feet bls, specific conductance and chloride values show marked increases; saline waters (chloride concentrations in excess of 10,000 mg/L) occur at this depth and continue to the total depth of the well at 2,354 feet bls.

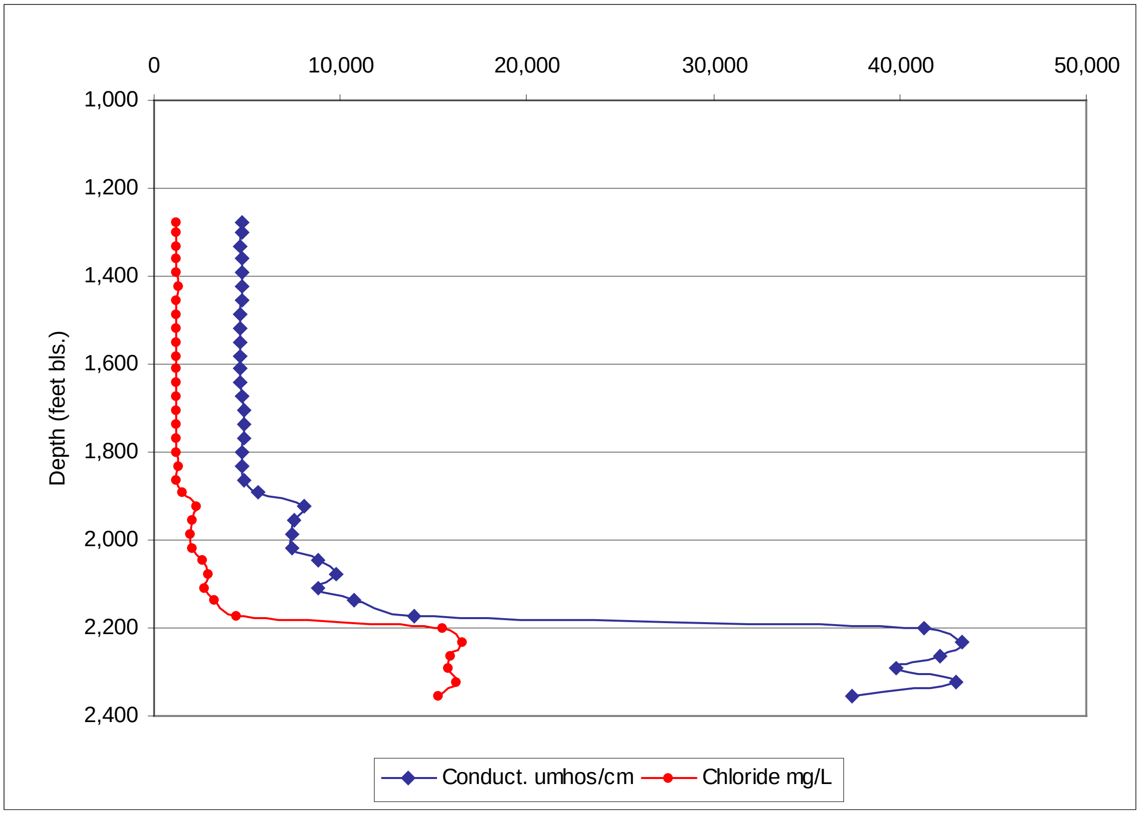


Figure 6. Water Quality with Depth – Reverse-Air Fluid Returns

Geophysical Logging

Geophysical logging was conducted in the pilot holes after each stage of drilling and prior to casing installations. The resulting logs provide a continuous record of the physical properties of the subsurface formations and their contained fluids. These logs assisted in the interpretation of lithology, provided estimates of permeability, porosity, bulk density, and resistivity of the aquifer, and determined the resistivity profile of the ground water using Archie's equation (Archie, 1942). In addition, the extent of confinement of discrete intervals and identification of permeable zones can be discerned from the individual logs. Florida Geophysical Inc. downloaded all geophysical log data directly from the onsite logging processor in log ASCII standard (LAS) version 1.2 or 2.0 format. The SFWMD and RST Enterprise provided slim-line geophysical logging services. **Appendix A** contains the geophysical log traces from log runs 1, 2, and 3 for well IWSD-TW. The original geophysical logs and video surveys are archived and available for review at the SFWMD's headquarters in West Palm Beach, Florida. **Table 2** summarizes the geophysical logging program at this site.

Table 2: Summary of Geophysical Logging Operations

Run #	Date	Logging Company	Measuring Point Elevation feet NGVD 1929	Logged Interval feet (bls)	Caliper	Natural Gamma Ray	SP	Resistivity 16"/64" 6-ft Lateral	Dual Induction	Sonic	Neutron	Flow-Meter	Temp	Video
1	07/12/95	SFWMD	31.76	300-862	x	x	x	x						
2	10/12/95	RST Enterprise	31.76	790-1270	x	x	x	x						
3	01/25/96	Fla. Geophysical	31.76	1050-2354	x	x	x		x	x	x	x	x	x

Straddle Packer Tests

Two straddle-packer tests were conducted in the middle portion of the FAS (1,700 to 1,950 feet bls) in well IWSD-TW at this site. The purpose of these tests was to gain water quality and production capacity data on discrete intervals (approximately 75 feet in length) and to establish the depth of the 10,000 mg/L TDS interface.

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

1) Lower packer assembly to the interval selected for testing based on geophysical and lithologic log data.
2) Set and inflate packers and open the ports between the packers to the test interval.
3) Install a submersible pump from a depth of 60 feet to 120 feet below the drill floor with a pumping capacity of 200 gpm.
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 water quality parameters (e.g., temperature, specific conductance, and pH) from the purged formation water until stable. The water quality parameters and transducer readings were used to determine the quality of isolation of the "packed-off" interval.
7) Perform constant rate drawdown test once the interval was effectively isolated.

8) Collect formation water samples for laboratory water quality analyses per SFWMD's QA/QC sampling protocol.
9) Record recovery data until water levels return to static conditions.

Before ground water sampling, the packer intervals were purged until three drill stem volumes were evacuated or until field parameters of samples collected from the discharge pipe had stabilized. A limit of +/-5% variation in consecutive field parameter readings was used to determine chemical stability. A Hydrolab® multi-parameter probe measured the field parameters including temperature, specific conductance, and pH on each sample. Chloride concentrations were determined using a field titration method (Hach® Kit). The flow of water from the discharge point was adjusted to minimize the aeration and disturbance of the water to be sampled. SFWMD personnel collected unfiltered and filtered water directly from the discharge point into a Teflon bailer. The bailer was then placed on a bailer stand where the sample bottles were filled slowly to minimize aeration. Duplicate samples were collected from consecutive bailers, whereas split-samples were taken from the same bailer.

SFWMD personnel preserved and immediately placed the individual samples on ice in a closed container and transported them to the SFWMD's water quality laboratory. The samples were then analyzed by SFWMD's water quality laboratory for major cation and anions using EPA and/or Standard Method Procedures (SFWMD, Comprehensive Quality Assurance Plan, 1995).

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 collected from straddle packer tests because they generally involve partial penetration, significant friction loss in small pipe, and short pumping period, which violate the various analytical method's basic assumptions.

Packer Test No. 1 (1,876 to 1,950 feet bls):

The purpose of this packer test was to determine the hydraulic properties and water quality characteristics of a productive interval within the middle Floridan confining unit and to help approximate the base of the USDW at this site. The dual packer assembly isolated an interval between 1,876 and 1,950 feet bls. A drawdown/recovery test was conducted on February 22, 1996. During the 80 minutes drawdown test, this interval produced 19.29 feet of drawdown of at a pumping rate 108 gpm. A specific capacity of 15.3 gpm/ft of drawdown was calculated correcting for friction loss of 11.97 feet. At the end of the recovery phase, the static water level rose to 52.63 feet NGVD, (1929) (density corrected to a freshwater equivalent head of 60.22 feet NGVD, 1929).

The productive nature of this interval enabled it to respond almost instantaneously to the limited applied pumping stress. The rapid reduction or addition of water within the standpipe (caused by the starting or stopping of the pump) induced a pressure wave. **Figure 7** shows the response to this pressure wave, which masks true recovery response of the formation.

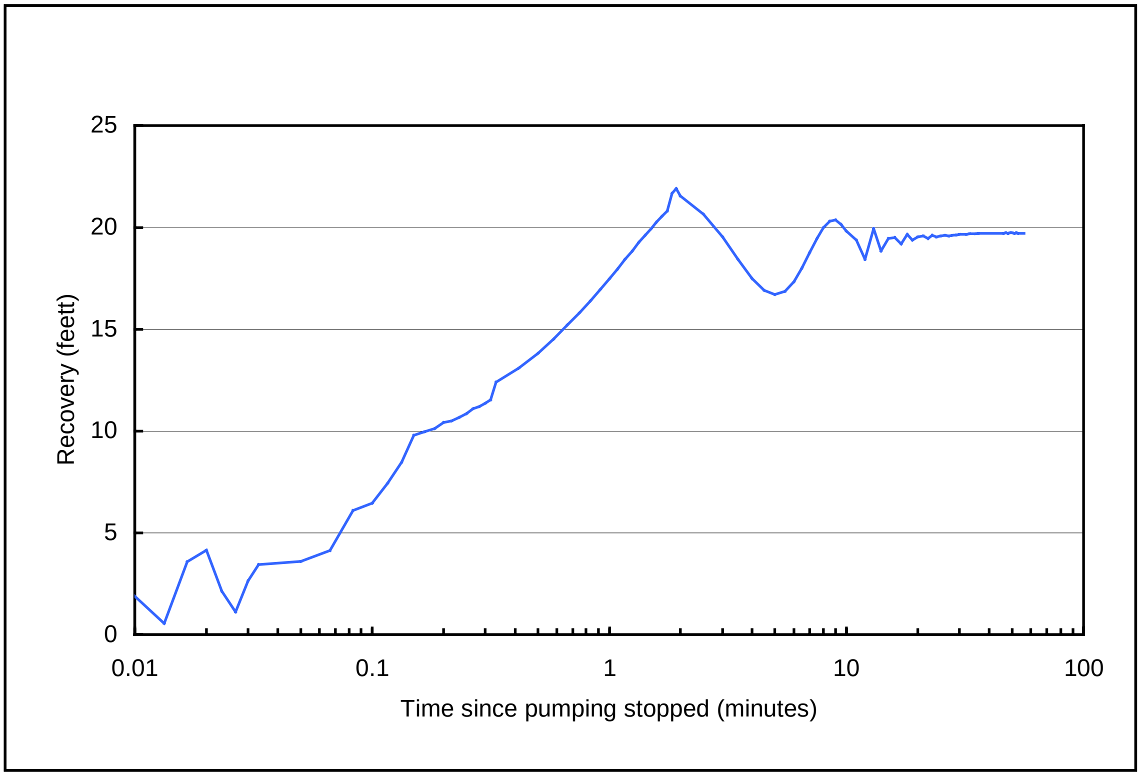


Figure 7. Semi-Log Plot of Recovery Data from Packer Test No. 1

Shortly before the end of the drawdown phase, a composite water sample was taken from the discharge point and field water quality parameters measured. The field determined water quality results are as follows: temperature, 31.04 degrees Celsius; specific conductance, 10,700 microseimens (umhos/cm); and pH 7.33. The SFWMD's Water Quality Laboratory conducted major cation-anion-TDS analysis on the composite water samples. **Table 3** lists the analytical results.

Packer Test No. 2 (1,700 to 1,774 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 FAS confining unit at this site. The dual packer set-up isolated an interval between 1,700 and 1,774 feet bls. A 135-minute drawdown test conducted on February 26, 1996 produced a maximum-recorded drawdown of 77.66 feet at a pumping rate of 32 gpm. The friction-loss-corrected drawdown produced a specific capacity 0.43 gpm/ft. The static water level measured at the end of the recovery phase was 56.12 feet NGVD (density corrected to 58.69 feet NGVD, 1929). **Figure 8** shows a semi-log time series plot of the recovery data.

SFWMD personnel took a composite water sample from the discharge point near the end of the drawdown phase. The field determined water quality results are as follows: temperature, 30.33 degrees Celsius; specific conductance, 5,000 umhos/cm; and pH, 7.45. The SFWMD's Water Quality Laboratory also conducted major cation-anion-TDS analysis on the composite water samples. **Table 3** lists the analytical results for each of the Packer Tests.

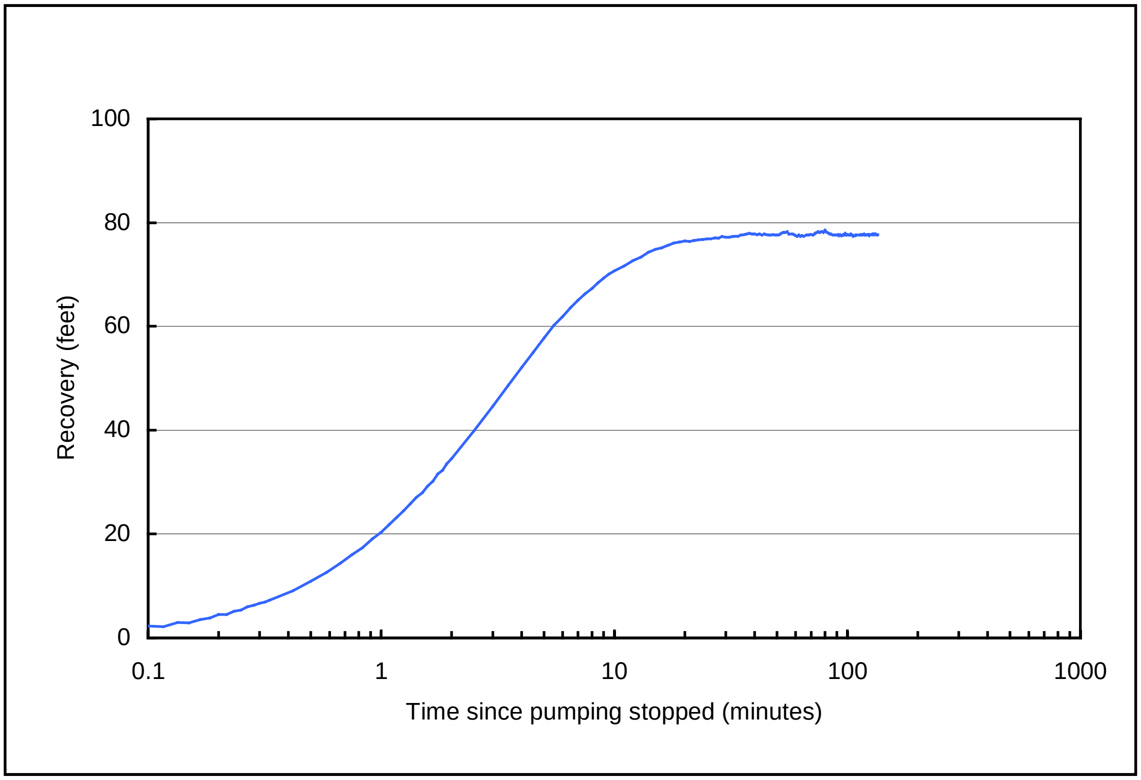


Figure 8. Semi-Log Plot of Recovery Data from Packer Test No. 2

			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	TDS mg/L	Specific Conduct. umhos/cm	Temp ^oC	pH s.u.
IWSD PT-2	1700-1774	02/26/96	784	44	137	129	1,162	115	616	3,090	5,000	30.33	7.45
IWSD PT-1	1876-1950	02/22/96	1,882	101	244	286	3,075	111	1,025	6,570	10,700	31.04	7.33

ft. bls = feet below land surface
mg/L = milligrams per liter
Alka as CaCO3 = Alkalinity as Calcium Carbonate
umhos/cm - micromhos per centimeter
^{o}C = degree Celsius
s.u. = standard unit

Table 3. Packer Test Water Quality Data from IWSD-TW, Collier County, Florida.

Stable Isotope and ^{14}Carbon Data

The acquisition of isotopic data complements inorganic geochemistry and physical hydrogeology investigations. The data collected at this site will be used in a regional investigation (Kaufmann and Bennett, in review) to better understand the ground water circulation patterns (Kohout, 1965, 1967) and to identify recharge and discharge areas within the FAS. If an interval has a particular isotopic signature, it may help to identify and assist in the mapping of aquifer storage and recovery (ASR) and reverse osmosis (RO) horizons within the upper Floridan aquifer. Radiocarbon dating of ground water can also be used to estimate regional flow velocities within the Floridan aquifer (Hanshaw, et.al, 1964).

Water samples collected during packer tests and from monitor intervals from well IWSD-TW were sent to the University of Waterloo for stable isotope determinations. The analytical services included the determination of the stable isotope compositions for the following parameters: $\delta^{18}O$, 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). The hydrogen compositions were determined using the methods of Coleman et al. (1982) and Drimmie et al. (1991). $\delta^{13}C$ values were performed on carbon dioxide produced from dissolved inorganic carbon (DIC) treated with phosphoric acid using methods described by Drimmie et al. (1990). 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) using procedures outlined in Stuiver and Polach (1977). **Table 4** summarizes the stable isotope and ^{14}C results for the IWSD site.

Table 4: Summary of Isotope and ^{14}Carbon Analyses.

Identifier	Aquifer	Sample Interval ft. bls	Sample Date	$\delta^{18}O$ $^0/_{00}$ SMOW	$\delta^{2}H$ $^0/_{00}$ SMOW	$\delta^{37}Cl$ $^0/_{00}$ SMOC	$\delta^{13}C$ $^0/_{00}$ PDB	$\delta^{34}S$ $^0/_{00}$ CDT	$\delta^{14}C$ $^0/_{00}$	^{14}C pmC	Reported ^{14}C Yr. B.P	Corrected ^{14}C Yr. B.P
IWSD MZ-1	UFA	1060-1140	06/25/96	-1.69	-4.72	ND	-2.73	21.32	-988.3	1.11	36,080	21,477
IWSD PT-2	MCU	1700-1774	02/26/96	-1.44	-6.04	-0.27	-1.62	21.16				
IWSD MZ-2	MCU	1752-1880	06/25/96	-1.59	-7.90	ND	-2.31	21.34	-989.6	0.99	37,000	21,624
IWSD PT-1	MCU	1876-1950	02/22/96	-1.35	-6.42	-0.14	-1.13	20.80				
IWSD MZ-3	LFA	2134-2354	06/25/96	0.12	3.72	0.01	-2.88	20.78	-948.8	4.92	24,150	10,125

ft. bls - feet below land surface
$^0/_{00}$ - per mil
SMOW - Standard Mean Ocean Water Standard
SMOC - Standard Mean Ocean Chloride Standard
PDB - Pee Dee Belemnitella Standard
CDT- Canon Diablo Meteorite Standard
pmC - percent modern carbon
Yr. B.P. - Years Before Present
MZ = Monitor Zone
PT = Packer Test
UFA = Upper Floridan Aquifer
MCU = Middle Confining Unit
LFA = Lower Floridan Aquifer
* Corrected Age using Pearson & Hanshaw Method, 13 C Correction for Closed System

The stable isotopic results from IWSD-TW show that the UFA and middle confining unit waters are depleted in both $\delta^{18}O$ and δD as compared to the reference standard referred to as Standard Mean Ocean Water (SMOW), where $\delta^{18}O = 0\ ^0/_{00}$ and $\delta D = 0\ ^0/_{00}$. **Figure 9** shows the isotopic composition of UFA and middle confining unit waters deviates slightly from the global meteoric water line (GMWL) (Craig, 1961) and mean isotopic composition of recent Everglades rainfall ($\delta^{18}O = -2.2^0/_{00}$; $\delta D = -7.6\ ^0/_{00}$, Meyers et al., 1993). The occurrence of $\delta^{18}O$ and δD values near the GWML indicate that these waters are likely meteoric in origin.

Stable isotope results from the IWSD site show that lower Floridan aquifer waters are similar in both $\delta^{18}O$ and δD as compared to SMOW. The inorganic water quality results from intervals below 2,150 feet bls (IWSD MZ-3) are saline in composition, suggesting that the lower Floridan aquifer has been intruded by seawater. Stable isotope results from other locations in south Florida (Meyer, 1989, Bennett, 2001a, and 2001b, Kaufmann and Bennett, in review) show that waters within the upper Floridan aquifer are depleted while lower Floridan waters are slightly enriched and plot near SMOW.

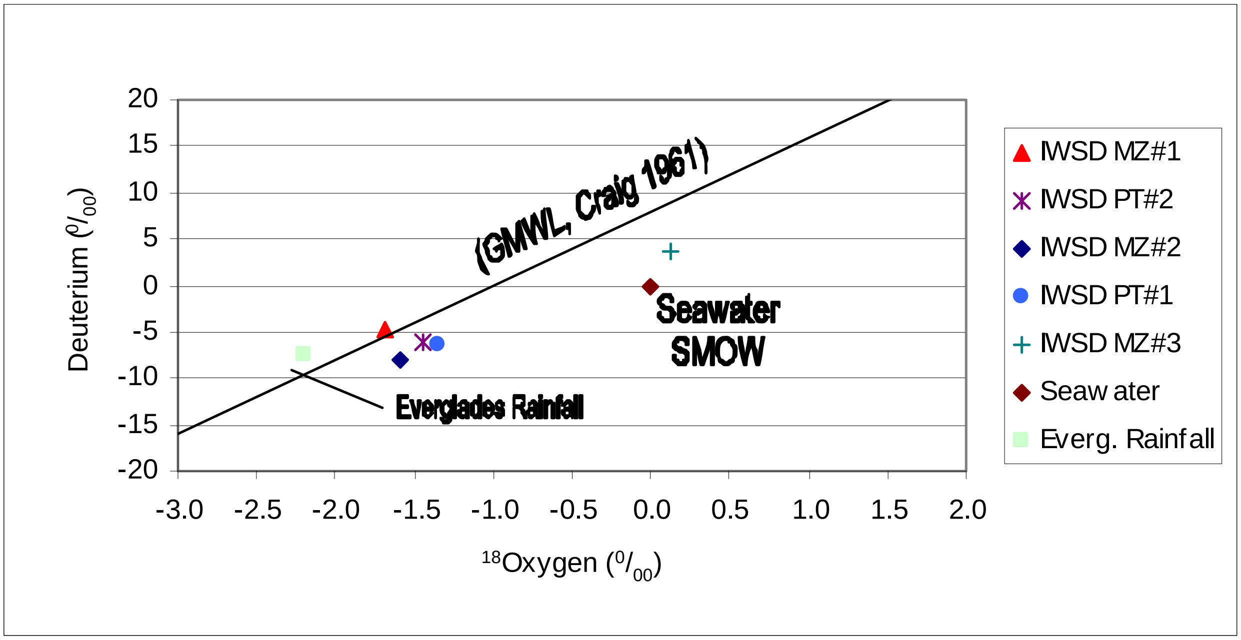


Figure 9. Relationship Between Stable Isotopes Deuterium and ^{18}Oxygen.

The ^{14}C activities or pmC values listed in **Table 4** are absolute percent of modern, relative to the National Bureau of Standards (NBS) oxalic acid standard (HOxI) corrected for decay since 1950. The ^{14}C activity of a ground water sample from the UFA (1,060 to 1,140 feet bls) and middle confining unit (1,752 to 1,880 feet bls) produced values of 1.11 and 0.99 pmC, respectively. The reported radiocarbon ages from the UFA and middle confining unit is approximately the same with radiocarbon ages 36,080 and 37,000 years before present (bp), respectively. In order to be meaningful, the reported radiocarbon ages where corrected using the Pearson and Hanshaw method (Person and Hanshaw, 1976), which uses a ^{13}C correction for a closed system. The corrected radiocarbon ages from the UFA and middle confining unit are 21,977 and 21,624 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 UFA and middle confining unit occurred during the late Pleistocene.

The ^{14}C activities of ground water samples from the lower Floridan aquifer (IWSD MZ-3; 2,134 to 2,354 feet bls) generated a value of 4.92 pmC. The reported radiocarbon age for this interval was approximately 24,150 years bp age, corrected to 10,125 years bp. The significant differences in the δ^{18}O and δD values, ^{14}C activities, and reported/corrected radiocarbon ages between the UFA and middle confining unit to the lower Floridan aquifer suggest two different water masses may be present. The upper Floridan waters being meteoric in origin. The lower Floridan waters appear to be younger intruded seawater that may have entered somewhere along the Florida Straits. That water moved inland through the "Boulder Zone" (or other highly permeable rock units of the lower Floridan aquifer) to its present position some 10,000 years bp.

Petrophysical and Petrologic Data

During drilling of the test-production well (IWSD-PW), the Contractor obtained conventional cores using a 4-inch diameter, 10-foot long, diamond-tipped core barrel. Six rock cores of various lengths were recovered from the UFA between 882 and 1,098 feet bls with core recoveries of 20 to 90 percent. The six cores were then sent to Core Laboratories located in Midland, Texas to determine the following parameters: horizontal and vertical permeability, porosity, grain density, and lithologic character.

Upon arrival, Core Laboratories recorded a core spectral gamma log for downhole correlation. Full diameter and plug samples (when core conditions necessitated) were then selected for core analyses and fluid removal was achieved by convection oven drying.

Core Laboratories determines full diameter porosity by direct pore volume measurement using the Boyle's Law Helium Expansion. Once the samples were cleaned and dried, bulk volume was measured by Archimedes Principle. Grain density was calculated from the dry weight, bulk volume and pore volume measurements using Equation No.1 (American Petroleum Institute, 1998).

Grain Density = Dry Weight / (Bulk Volume – Pore Volume) *(Equation 1)*

Porosity as a percent was calculated using bulk volume and grain volume measurements using Equation No. 2.

Porosity = ((Bulk Volume – Grain Volume)/ Bulk Volume) x 100 *(Equation 2)*

The 1-inch diameter plugs had direct grain volume measured using Boyle's Law Helium Expansion Method. After cleaning, bulk volume was measured by Archimedes Principle on the individual plug samples. Equation No. 2 calculates porosity using the bulk volume and grain volume data. Two plug samples from a core obtained from 956 (sample no. 10) and 1,089 (sample no. 35) feet bls were selected for stressed pore volume measurements at a confining pressure of 400 pounds-per-square-inch (psi) to determine overburden pressure effects on porosity. The stressed pore volume data indicates minimal to no pore volume reductions **(Table 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.

The cores were slabbed and boxed after analysis, then photographed under natural and ultraviolet light. Negatives of the slabbed cores were scanned and stored on a compact disc and reproduced in Figures 1 to 6 listed in **Appendix D**. The results of the petrophysical analyses are listed in **Appendix D, Table 2.** Horizontal to vertical permeability and horizontal permeability (K_{90}/K_{max}) anisotropy ratios were not calculated due to the limited number of values. **Figure 10** shows a semi-log cross-plot of laboratory derived horizontal permeability versus (helium) porosity. The scattered data points suggest a weak linear relationship between horizontal permeability and porosity defined by the equation log (y) = 0.1242 * (x) – 1.0927 with a correlation coefficient (R^2) of 0.524 (a value of 1 indicates a strong positive relationship).

Table 5: Summary of Net Overburden Pressure Effects on Porosity

Sample No.	Depth (ft. bls)	Data Source	Horizontal Permeability (md)	Porosity Helium (%)	Grain Density (g/cm^3)	Description
10	956.3	Original ambient porosity		34.7	2.69	Lim , pp.
10	956.3	Second ambient porosity		34.8	2.69	
10	956.3	400 N.O.B. porosity	3,744	34.6	2.69	
35	1,088.9	Original ambient porosity		34.2	2.71	Lim , sli vug.
35	1,088.9	Second ambient porosity		34.2	2.71	
35	1,088.9	400 N.O.B. porosity	281	34.5	2.71	

ft. bls = feet below land surface
md = millidarcy
% = percent
g/cm3 = grams per cubic centimeter
Lim = Limestone
sli vug = slightly vug (gy)
pp = pin point porosity
400 N.O.B = 400 pounds per square inch net overburden

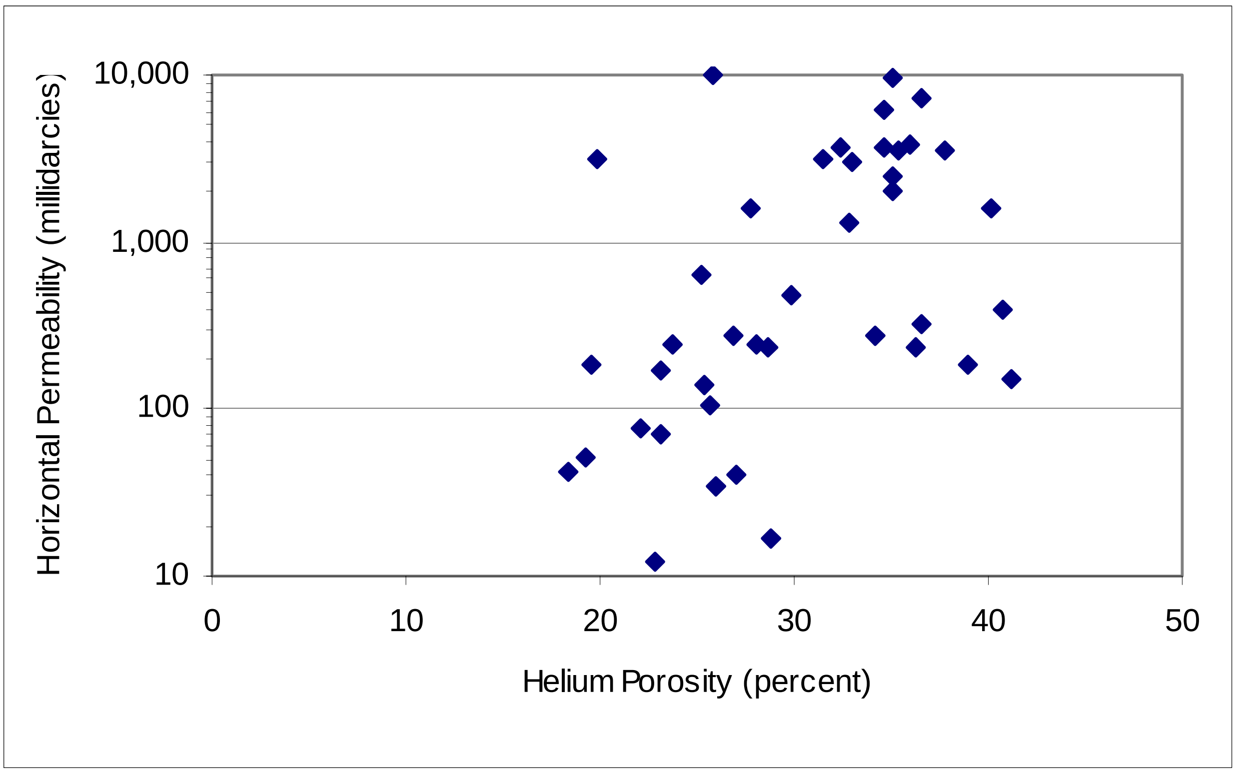


Figure 10. Relationship Between Laboratory Derived Horizontal Permeability and Porosity.

Once the cores were slabbed, a petrologic study was conducted on the cores. This study provides preliminary data on the gross reservoir heterogeneity and depositional environmental (facies) controls on porosity and permeability development within the Floridan aquifer.

Dr. Hughbert Collier of Collier Consulting, Inc., Stephensville, Texas examined and described the slabbed cores. 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. A petrologic summary for each core section, generated by Collier Consulting Inc. is listed in **Appendix D**, **Table 3**. Individual photomicrographs of selected cores are reproduced in **Appendix D.** The petrologic analyses combined with the petrophysical data indicate variations in horizontal permeability and porosity based on lithofacies and corresponding depositional environment. The highest mean horizontal permeability (12,370 millidarcies) corresponds to a cored section at approximately 1,060 feet bls consisting of a peloidal–pelecyod-coquina-packstone, likely deposited in an open lagoonal shoal environment. Petrologic analyses of two other SFWMD-owned Floridan aquifer wells, one located in eastern Hendry County (L2-TW) and the other in western Collier County (I75-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).

Aquifer Performance Testing

An aquifer performance test (APT) was conducted to determine the hydraulic performance of a section (1,050 to 1,160 feet bls) of the upper Floridan aquifer (Suwannee/Ocala Limestones) at the IWSD site. **Figure 11** shows the well configuration of the tri-zone monitor well (IWSD-TW) and test-production well (IWSD-PW) used in the aquifer performance test. The principle factors of aquifer performance, such as transmissivity and storage coefficients, can be calculated from drawdown and/or recovery data obtained from a proximal monitor well completed in the same interval. If the aquifer tested is semi-confined, the hydraulic parameter, then the leakance of the semi-confining layer(s) can also be determined.

A 71.6-hour constant-rate discharge test was conducted on an interval from 1,050 to 1,160 feet bls. The drawdown phase was followed by a 69.5-hour recovery period, where water levels returned to background condition.

On January 30, 1997, RST Enterprises installed a 10-inch diameter submersible pump in the test-production well, with the pumping bowl set at 120 feet bls. This depth was chosen based on preliminary data, which 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 10-inch diameter PVC discharge line was connected to the wellhead. A 12-inch diameter circular orifice weir with a 6-inch diameter orifice plate was used to measure discharge rates during pumping, verified by an in-line flowmeter. A pressure transducer was installed on the orifice weir to record discharge rates during the pump test at 5-minute intervals. Additional pressure transducers were installed on/in the test-production well and all three-monitor zone of IWSD-TW and connected to a Hermit® 2000 (Insitu, Inc.) data logger via electronic cables. The transducers and data logger were used to measure and record water-level changes at pre-determined intervals during testing operations.

On February 1, 1997, a step-drawdown test was conducted to determine the most efficient pump rate for the planned 72-hour drawdown test. The step-drawdown test yielded a specific capacity of 12.1 gpm/ft of drawdown at a pump rate of 1,100 gpm. Once completed, water levels were allowed to recover to static condition. Later that day (February 1, 1997), the drawdown phase of the APT was started by initiating pumping of the test-production well (IWSD-PW) located 240 feet west of the tri-zone monitor well (IWSD-TW) at 1,100 gpm. During the drawdown phase, water levels, and pump rates were continuously measured and recorded by the installed electronic instruments. Pumping continued for approximately 24 hours before an electrical problem caused pumping to cease. The Contractor removed, repaired, and re-installed the 10-inch diameter submersible pump to continue the APT. The drawdown phase of the APT was restarted with an average pumping rate of 1,100 gpm on February 4, 1997. It continued uninterrupted for 71.6 hours ending on February 7, 1997. **Figure 12** shows a semi-log plot of the drawdown data for the monitor well (IWSD MZ-1) located in the pumped horizon. **Figure 13 and Figure 14** shows time-series plots of water-level fluctuations during the drawdown phase of the APT for the lower two monitor zones, IWSD MZ-2 (1,752 to 1,880 feet bls) and IWSD MZ-3 (2,134 to 2,354 feet bls).

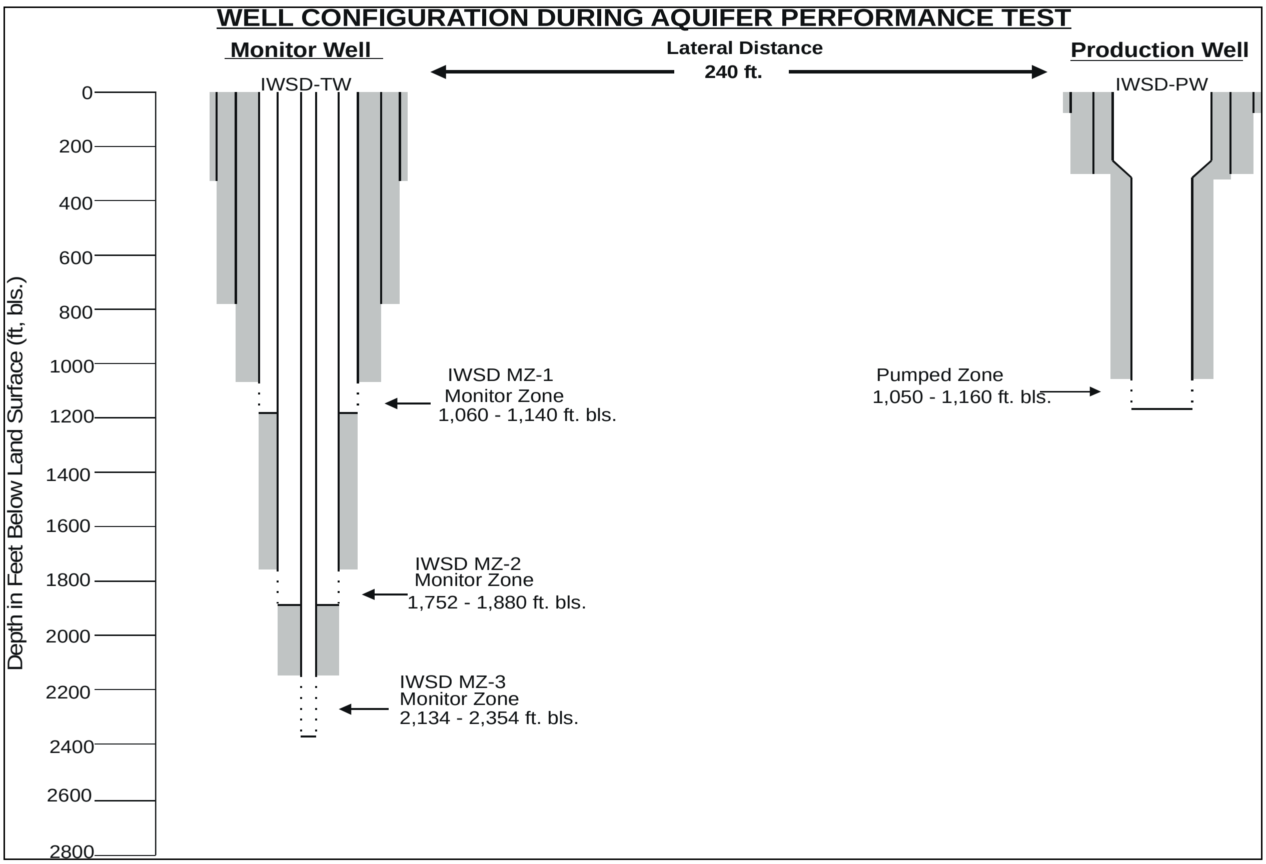


Figure 11. Aquifer Performance Test – Well Configuration.

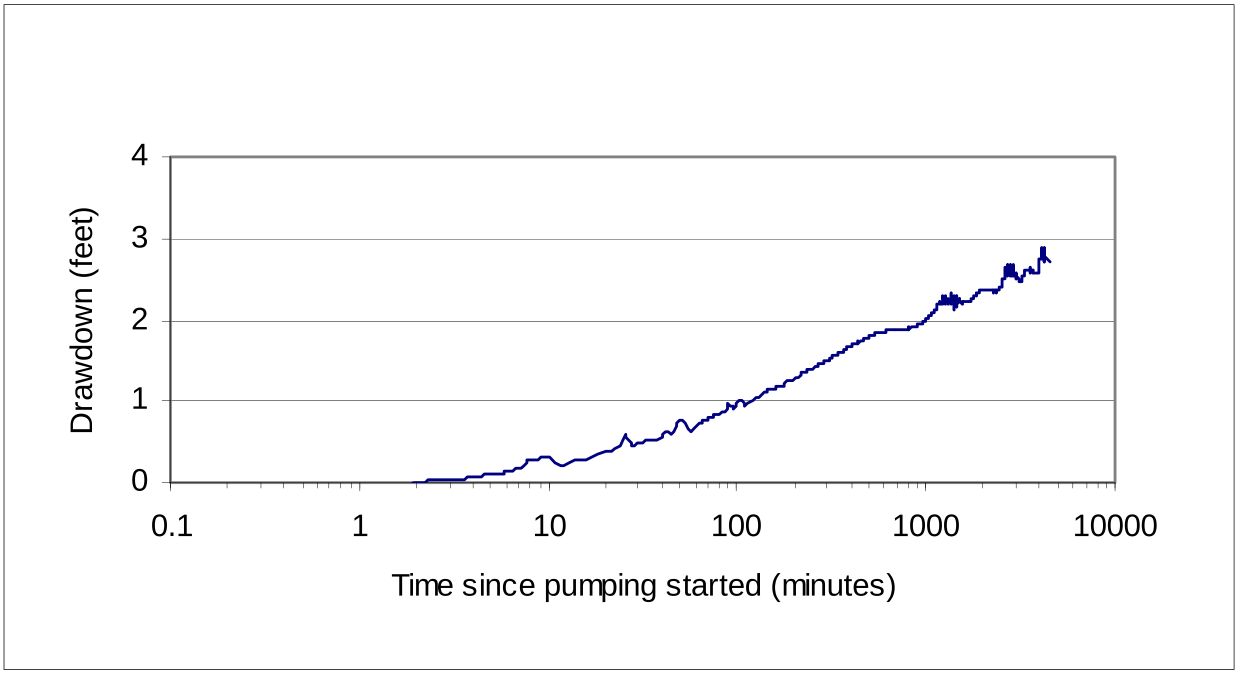


Figure 12. Time Series Plot of Drawdown from IWSD MZ-1 - Long Term APT

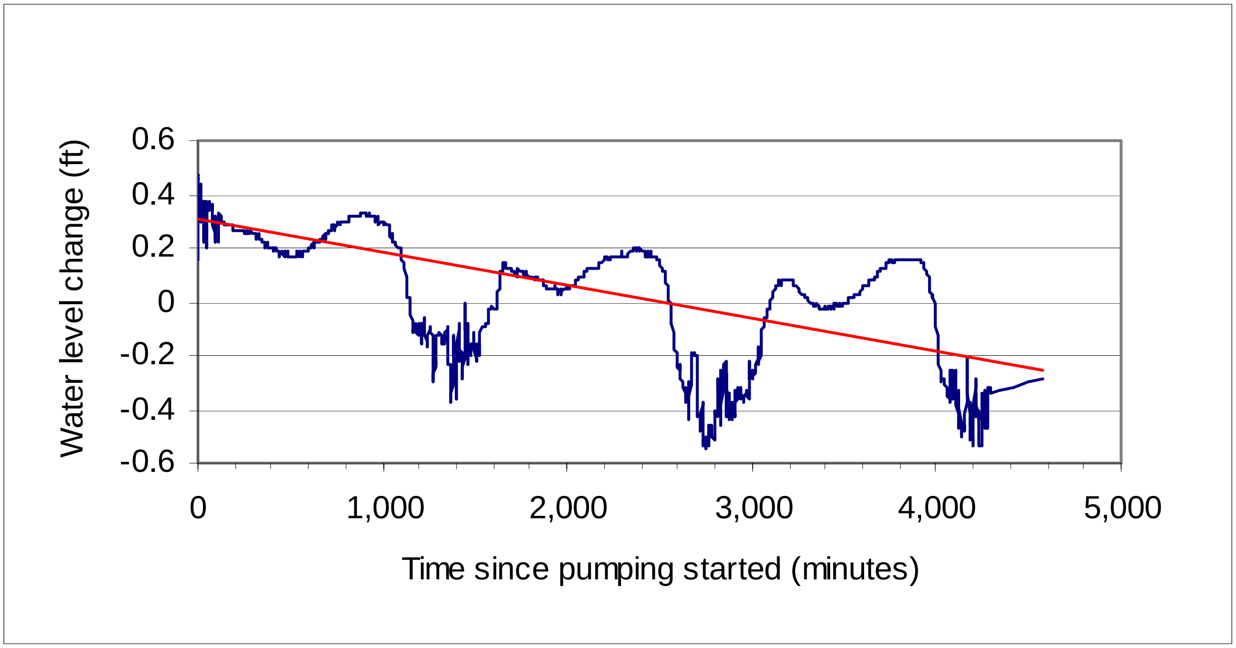


Figure 13: Time Series Plot of Water Levels from IWSD MZ-2 During Pumping Phase of APT

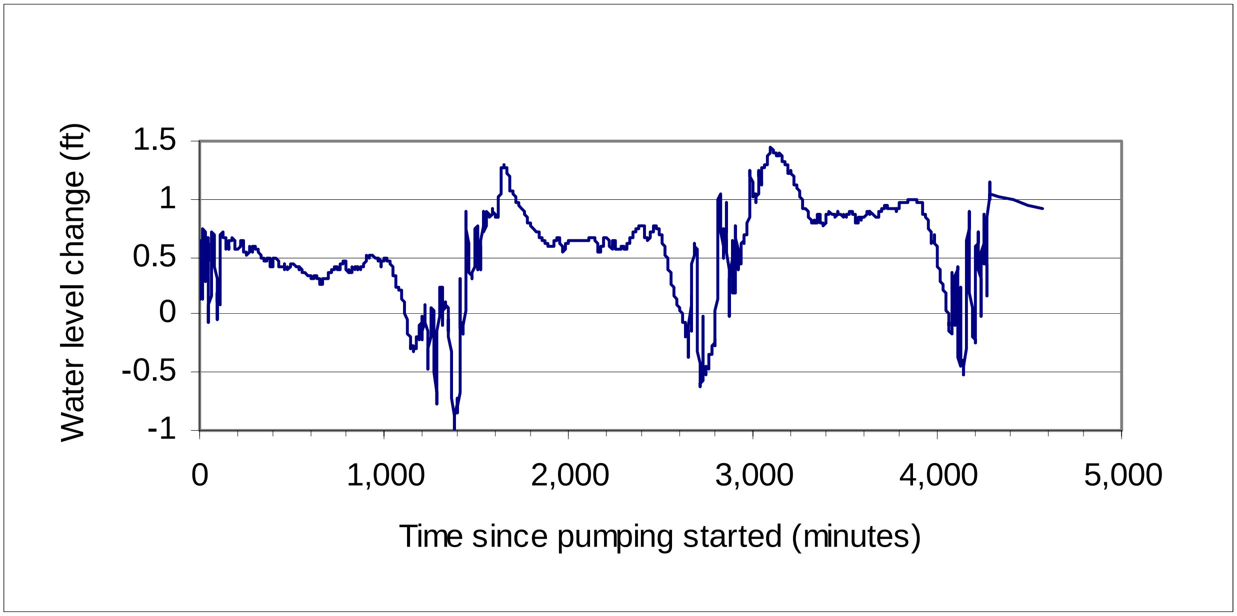


Figure 14: Time Series Plot of Water Levels from IWSD MZ-3 During Pumping Phase of APT

Figure 15 contains discharge data from the 12-inch diameter, circular orifice weir acquired during the pumping phase of the APT**. Figure 15** also identifies 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, but can be seen by a slight offset in drawdown from the pump monitor interval IWSD MZ-1 **(Figure 12)** in the first 10 minutes of the test.

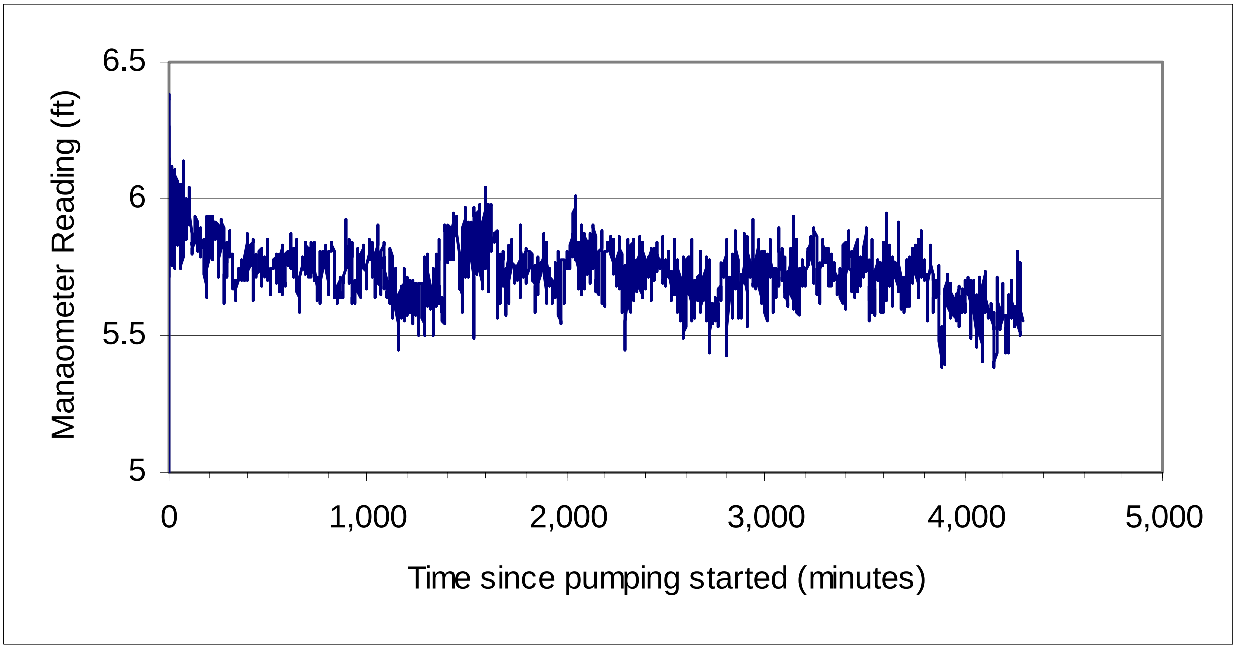


Figure 15: Time Series Plot of Manometer Readings from Discharge Orifice Weir – APT

Before pumping stopped, SFWMD staff reconfigured the data loggers to record the recovery data. The Contractor stopped the submersible pump and water levels recovered to static condition. The recovery phase of the APT continued for 69.5 hours, ending on February 10, 1997. **Figure 16** shows a semi-log plot of the recovery data for the pumped monitor zone (IWSD MZ-1). **Figure 17** is a time series plot of the lower monitor intervals (IWSD MZ-2 and IWSD MZ-3) during recovery. 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.

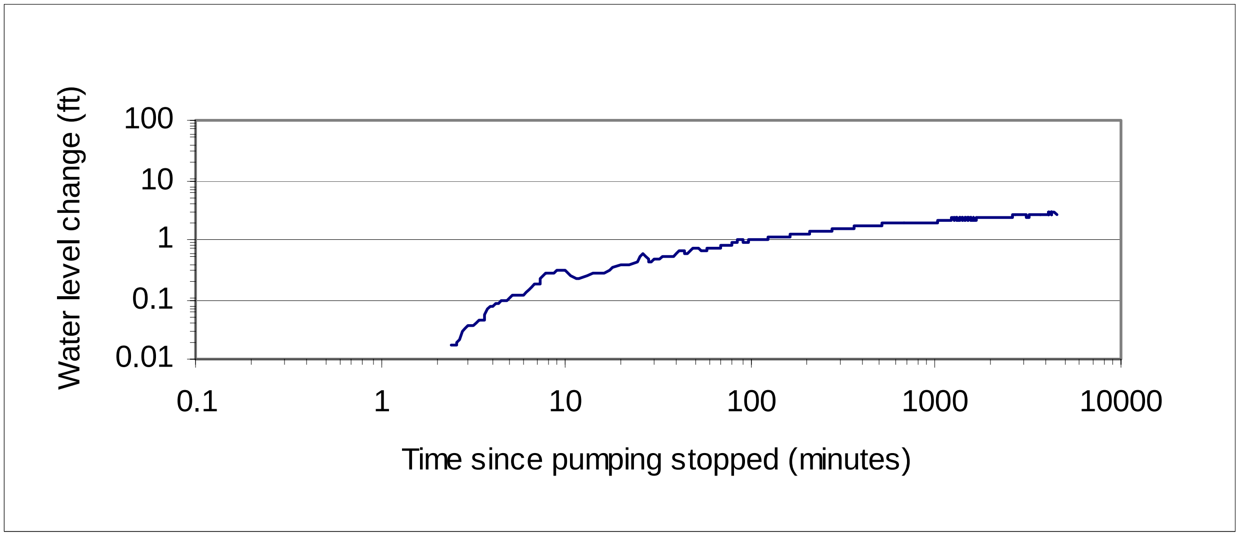


Figure 16: Time Series Plot of Recovery Data from IWSD MZ-1 – Long Term APT

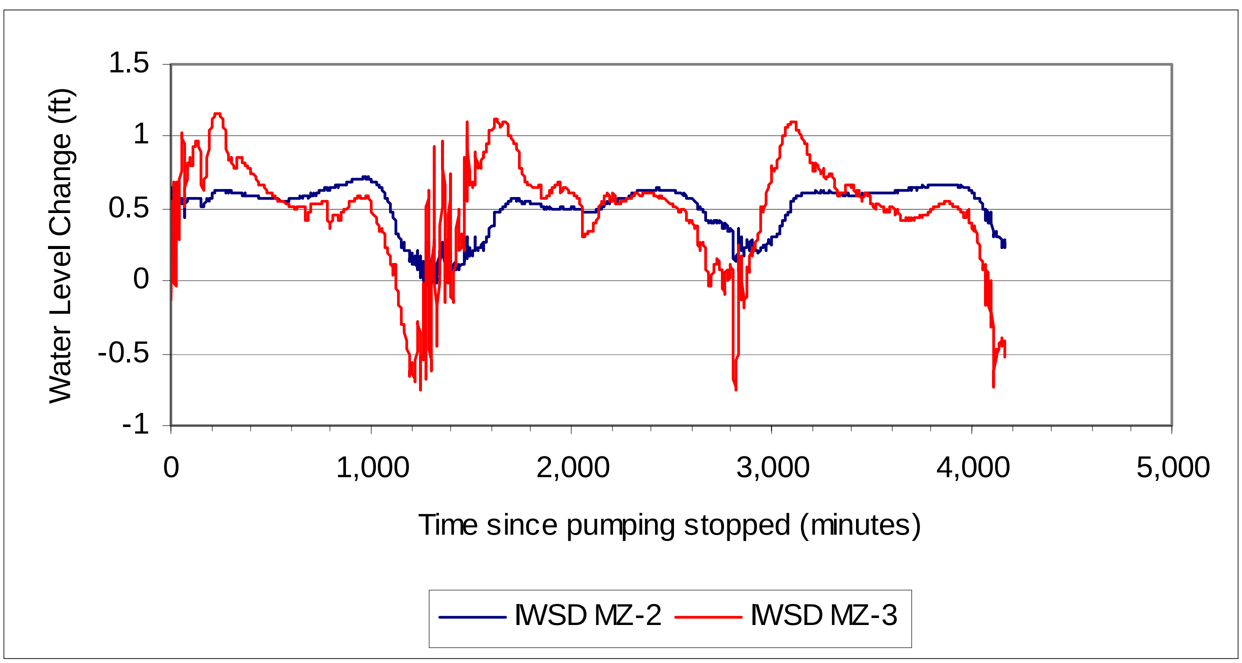


Figure 17. Time Series Plot of Water Level Responses for IWSD MW-2 and IWSD MZ-3 During Recovery Phase of APT.

Figure 18 is a log/log plot of drawdown versus time for the pumped interval (1,060 to 1,140 feet bls; IWSD MZ-1). Various analytical models were applied to the drawdown data collected during the APT to determine the hydraulic properties of the aquifer and aquitard(s) at this site. The analytical methods included both confined and semi-confined "leaky" solutions. The confined transient analytical solutions were 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 (see original articles for assumptions). **Table 6** list results generated by the various analytical methods. Analyses of the recovery data from this APT produced similar hydraulic results as compared to the drawdown analysis. 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 and do not provide a unique match to the data set.

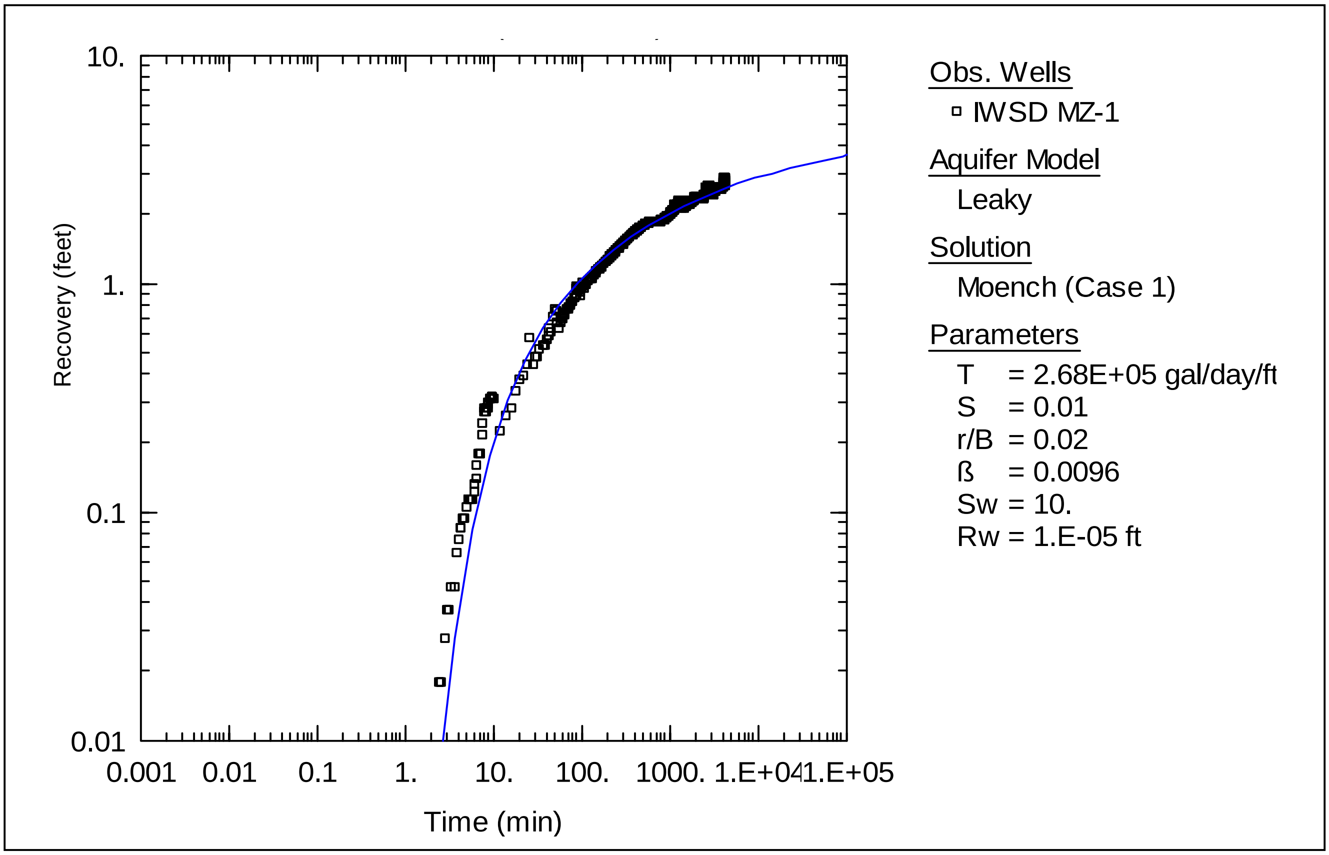


Figure 18. Log/Log Plot of Drawdown vs. Time for Monitor Well IWSD MZ-1.

Table 6. Summary of Analytical Model Results for APT.

Summary of Analytical Solutions				
Analytical Method	**Transmissivity (gal/day/ft)**	**Storativity**	**β (beta)**	**r/B**
Theis (Confined)	271,700	1.215E-02	NA	NA
Cooper-Jacob (Confined)	287,200	1.000E-02	NA	NA
Hantush (Leaky)	268,000	1.000E-02	9.60E-04	NA
Hantush-Jacob (Leaky)	268,000	1.000E-02	NA	2.00E-02
Moench (Leaky)	268,000	1.000E-02	9.60E-04	2.00E-02

β = aquitard storage factor
NA = not applicable

The site-specific lithologic data indicate that the lithologic units overlying and underlying the pumped interval units are composed of porous (25% to 45% porosity) mudstones to wackestones. These units have the potential to transmit water and supply additional water released from storage to the pumping well. A proximal FAS monitor well, completed above the test interval of 1,050 to 1,160 feet bls, that could have quantified the relative contribution of the overlying semi-confining unit was not available for monitoring during the APT. However, the FAS monitor zone identified as IWSD MZ-2 was completed below the test interval from 1,752 to 1,880 feet bls. During the APT, water levels in IWSD MZ-2 declined 0.5 feet and showed a discernable negative trend **(Figure 13)**.

Moench (1985) derived an analytical solution for predicting water-level displacements in response to pumping a large diameter well (well bore storage in a leaky confined aquifer assuming storage in the aquitard(s) and wellbore skin). 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 268,000 gpd/ft, a storage coefficient of 1.0 x 10^{-2}, and an r/B value of 0.02. The dimensionless parameter r/B characterizes the leakage across the aquitard(s) to the pumped aquifer.

Long-Term Ground Water Level/Quality Monitoring Program

Shortly after the construction of the tri-zone Floridan aquifer monitor well (IWSD-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 7** summarizes the analytical results.

Table 7. Composite Water Quality Data from IWSD-TW, Collier County, Florida.

			Cations				Anions				Field Parameters		
Identifier	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	TDS mg/L	Specific Conduct. umhos/cm	Temp °C	pH s.u.
IWSD MZ-1	1060-1140	06/25/96	636	31	129	111	1,173	112	636	2,750	4,810	31.14	7.53
IWSD MZ-2	1752-1880	06/25/96	873	42	167	160	1,697	117	704	3,980	6,750	31.37	7.98
IWSD MZ-3	2134-2354	06/25/96	10,140	459	1,418	1,348	18,155	113	4,322	35,100	50,060	30.94	7.68

ft. bls = feet below land surface
mg/L = milligrams per liter
Alka as CaCO3 = Alkalinity as Calcium Carbonate
umhos/cm - micromhos per centimeter
° C = degree Celsius
s.u. = standard unit

In addition, SFWMD established a monthly potentiometric-head monitoring program. A 30-psig transducer and a Hermit 3000 (Insitu, Inc.) data logger recorded pressures from the various monitor zones once a month. On November 24, 1997, SFWMD installed automated pressure recorders (Insitu® Troll 4000) on the FAS tri-zone monitor well (IWSD-TW). The sample frequencies were set to hourly readings to identify short- and long-term stresses to the FAS.

All pressure readings are converted to equivalent heads in feet using a conversion factor of 2.31 feet of head per psig. Once the pressures are converted, they were added to the surveyed measuring point elevation to obtain a potentiometric head referenced to the National Geodetic Vertical Datum (NGVD) of 1929.

Figure 19 illustrates the long-term hourly water level data for two of the FAS monitor intervals and barometric pressure data. **Table 8** lists the monitor intervals within the FAS, average recorded potentiometric head, and degree of variation. The hydrographs for the UFA and middle-confining unit were generated using hourly readings. The hydrographs show water level fluctuations that may be attributed to tidal loading and changes in atmospheric pressure (i.e., barometric effect).

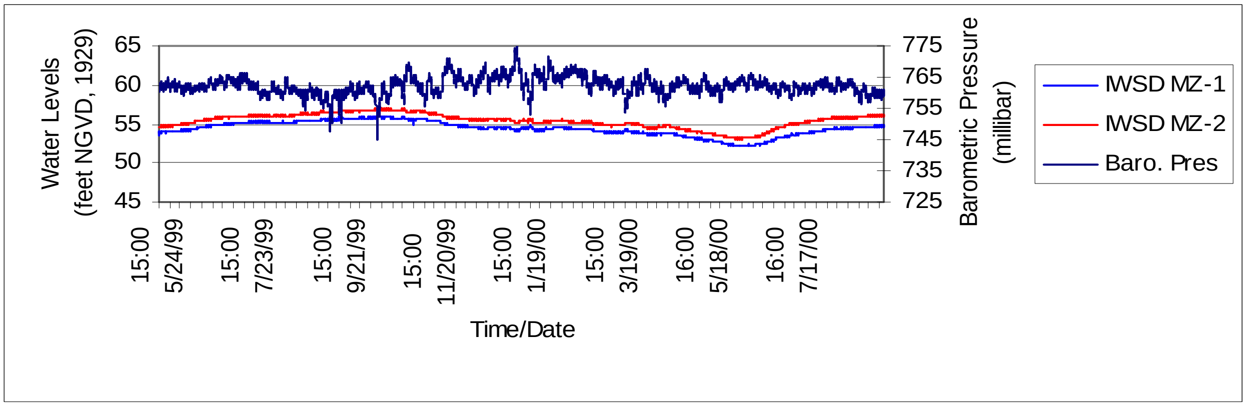


Figure 19. Time Series Plot of Water Levels for IWSD MZ-1 and IWSD MZ-2 and Barometric Pressure Data

Table 8: Average FAS Potentiometric Head Data from Tri-Zone Monitor Well

Identifier	Monitor Interval (feet bls)	Average Measured Water Levels (feet NGVD, 1929)	Standard Deviation
IWSD MZ-1	1,060 to 1,140	55.4	0.933
IWSD MZ-2	1,752 to 1,880	54.5	0.926
IWSD MZ-3	2,134 to 2,354	11.5	

Period of Record from 5/99 to 9/00

SUMMARY

1. The top of the Floridan aquifer as defined by the Southeastern Geological Society AdHoc Committee on Florida Hydrostratigraphic Unit Definition (1986) was identified at a depth of approximately 773 feet below land surface.
2. Lithologic and geophysical logs, specific capacity and packer test results, and petrophysical data indicate moderate to good production capacity of the upper Floridan aquifer.
3. Water quality data from reverse-air returns and straddle packer tests indicate that chloride and total dissolved solid concentrations in the upper Floridan aquifer exceed potable drinking water standards. Chloride and total dissolved solids concentrations below 1,160 feet bls range from 1,530 to 4,020 mg/L and 3,410 to 7,150 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 1,950 feet below land surface.
5. The stable isotope results from the Immokalee Water & Sewer District site show that the upper Floridan and middle confining unit waters are depleted in both ^{18}O and deuterium as compared to the reference standard of SMOW were $\delta^{18}O = 0\ ^0/_{00}$ and $\delta D = 0\ ^0/_{00,}$ consistent with meteoric water.
6. Stable isotope results from the IWSD site show that the lower Floridan aquifer waters are slightly enriched in both ^{18}O and deuterium as compared to SMOW. The inorganic water quality results from intervals below 2,150 feet bls is saline in composition. This data suggests the lower Floridan aquifer may have been intruded by seawater.
7. The petrophyscial data suggest no linear relationship between horizontal permeability and porosity with a correlation coefficient (R^2) of 0.524.
8. The highest mean horizontal permeability (12,370 millidarcies) corresponds to a cored section at approximately 1,060 feet bls consisting of a peloidal–pelecyod-coquina-packstone. This unit was likely deposited in an open lagoonal shoal environment.
9. A productive horizon in the upper Floridan aquifer from 1,050 to 1,160 feet bls, yielded a transmissivity value of 268,000 gallons/day/foot, a storage coefficient of 1.0×10^{-2}, and an r/B value of 0.02.
10. The average measured potentiometric heads for the Floridan monitoring intervals are as follows:

    55.4 feet above mean sea level for the 1,060 to 1,140 feet bls monitor interval;
    54.5 feet above mean sea level for the 1,752 to 1,880 feet bls monitor interval;
    11.5 feet above mean sea level for the 2,134 to 2,354feet bls monitor interval.
11. Water levels in the Floridan aquifer respond to external stresses such as tidal loading and barometric pressure variations.

REFERENCES

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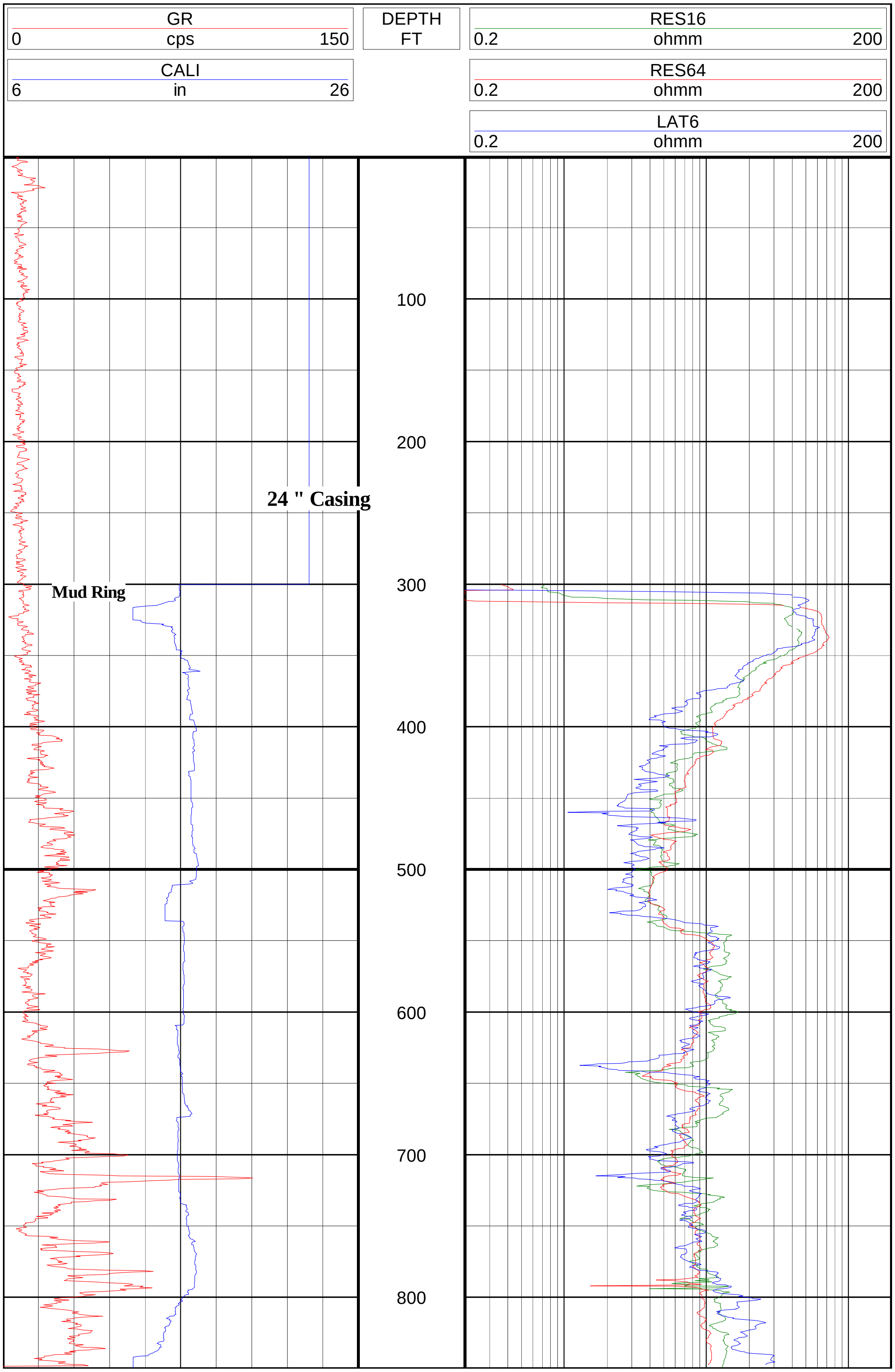
APPENDIX A

GEOPHYSICAL LOG RUNS

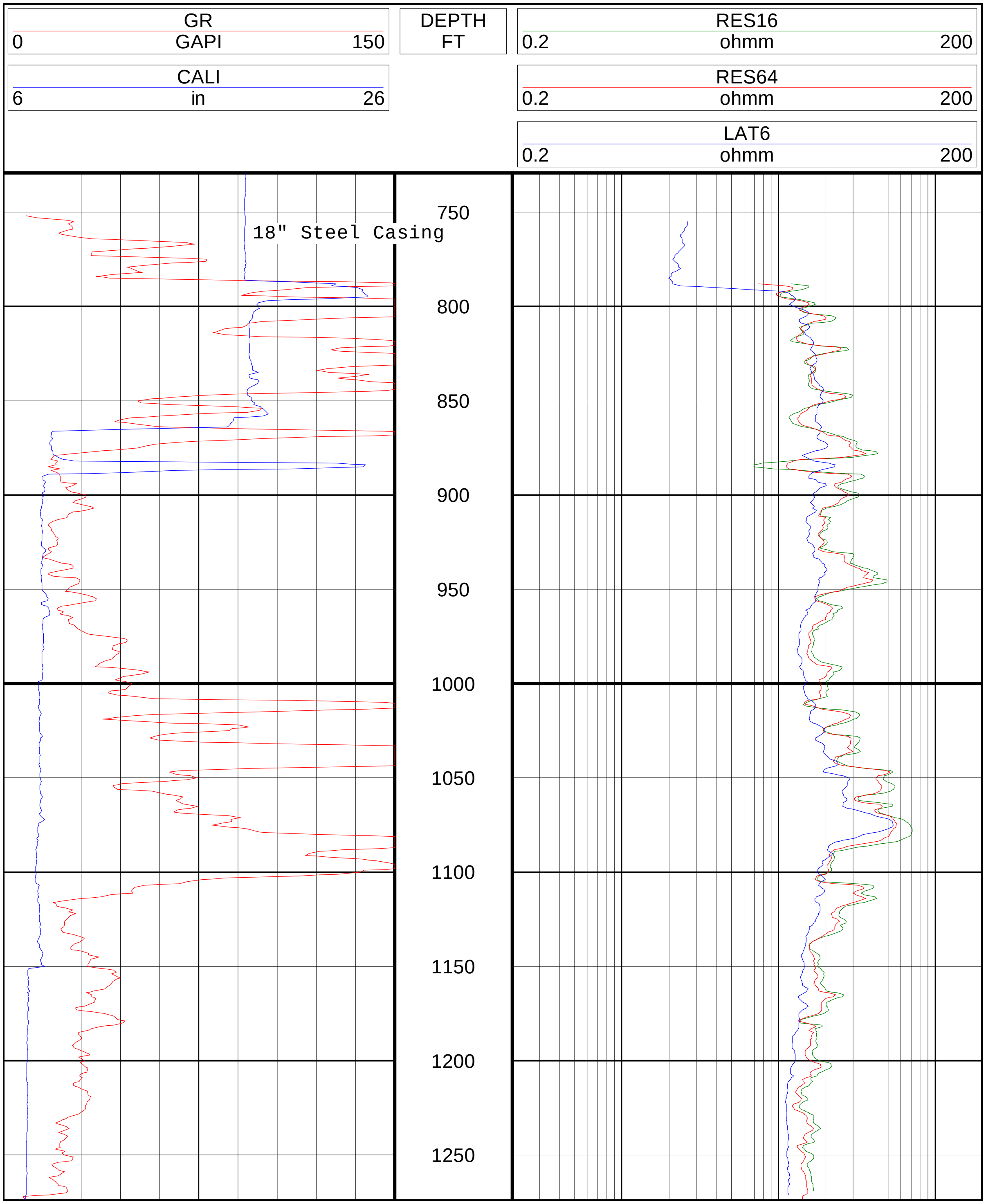
Legend for Geophysical Log Traces

CALI	**caliper**
cps	**counts per second**
dec	**decimal fraction**
DegF	**degrees Fahrenheit**
DT	**delta transient time**
FLOWD	**flowmeter dynamic**
FT	**feet**
API	**gamma American Petroleum Institute units**
GR	**gamma ray**
RILD	**deep induction log**
RILM	**medium induction log**
in	**inches**
LAT6	**lateral – 6-foot resistivity**
NPHI	**neutron porosity**
OHMM	**ohm-meters**
RES16	**normal resistivity (16-inch)**
RES64	**normal resistivity (64-inch)**
RLL3	**shallow focused resistivity**
TEMPG	**temperature gradient**
USEC	**microseconds per foot**
XCAL	**x-caliper**
YCAL	**y-caliper**

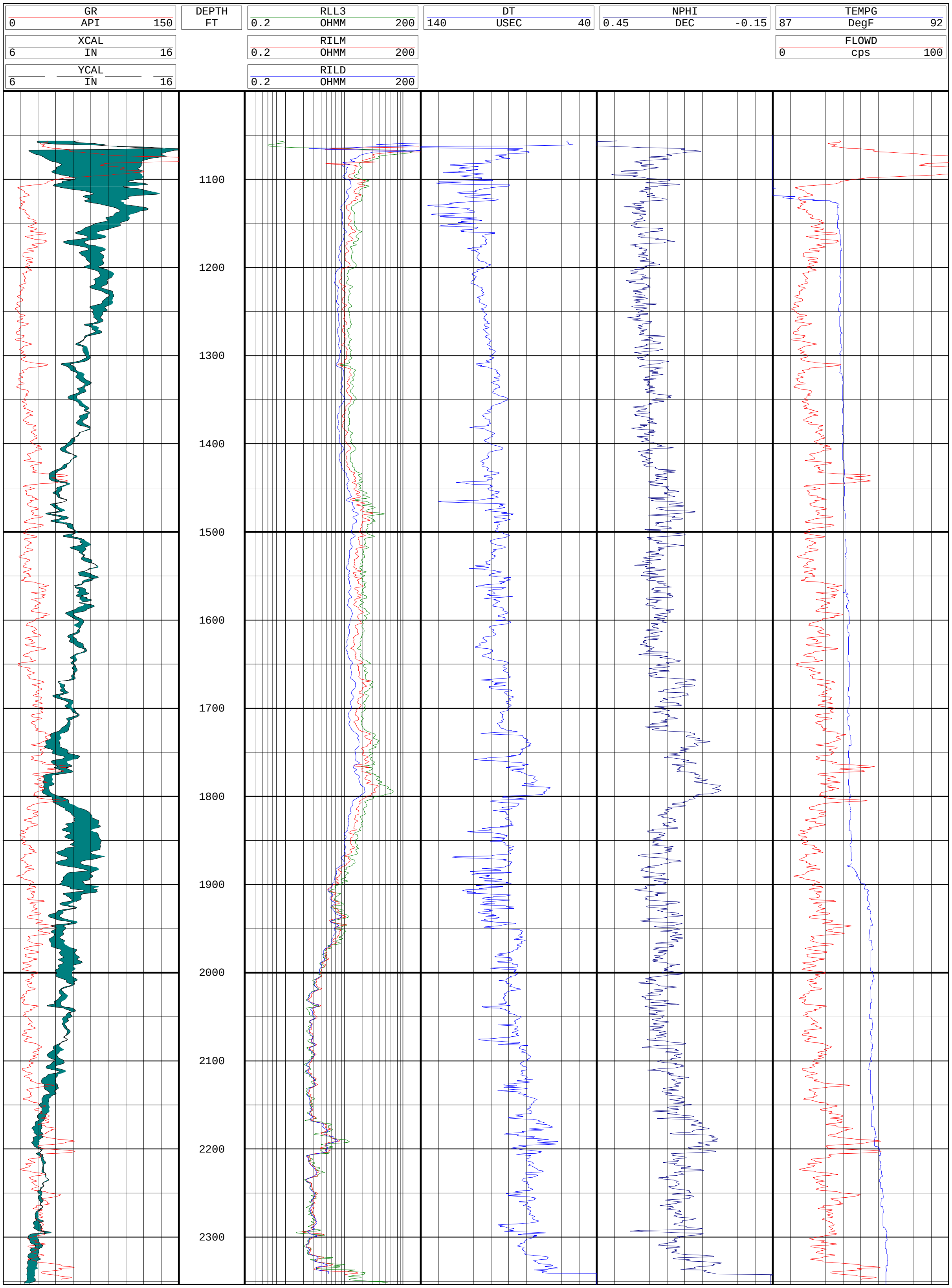
IWSD-TW Geophysical Log Run No. 1



IWSD-TW Geophysical Log Run No. 2



IWSD-TW Geophysical Log Run No. 3



APPENDIX B

FLORIDA GEOLOGICAL SURVEY

LITHOLOGIC DESCRIPTIONS

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LITHOLOGIC WELL LOG PRINTOUT                    SOURCE - FGS

WELL NUMBER:   W-17391                          COUNTY -   COLLIER
TOTAL DEPTH:    2354  FT.                       LOCATION:  T.47S R.29E S.04
301 SAMPLES FROM 5 TO 2354 FT.                             LAT = 26D 24M 48S
                                                           LON = 81D 25M 24S
COMPLETION DATE: 96/12/01                       ELEVATION: 30 FT
OTHER TYPES OF LOGS AVAILABLE - Y, ELECTRIC, SONIC

OWNER/DRILLER:RST (SFWMD)

WORKED BY:__MARTIN BALINSKY (8/1/96)
QUAD ZONE MONITOR WELL
SFWMD ID# FOR CUTTINGS IS 021-00009
WELL IS LOCATED IN NW 1/4, SW 1/4 OF SEC 4, T47S, R29E
IMMOKALEE 7.5' QUADRANGLE, COLLIER COUNTY
PLANAR X=756151; PLANAR Y=358704, ZONE 7
0      5  000NOSM  NO SAMPLES
5    245  121PCPC  PLIO-PLEISTOCENE UNITS
245    831  122HTRN  HAWTHORN GROUP
831   2252  124OCAL  OCALA LIMESTONE
2252         124AVPK  AVON PARK FORMATION
1000   1010  000NOSM  NO SAMPLES
NOTE: PICKS ABOVE ARE M. BALINSKY'S ORIGINAL PICKS. PICKS LISTED BELOW ARE FR
RICK GREEN 06/01. (TOP OF HAWTHORN GROUP TENTATIVE...SAMPLES ARE POOR QUALITY

    0.    -  120.   121PCPC   PLIOCENE-PLEISTOCENE
  120.    -  870.   122HTRN   HAWTHORN GROUP
  870.    - 1152.   123SWNN   SUWANNEE LIMESTONE
 1152.    - 1459.   124OCAL   OCALA GROUP
 1459.    -   TD.   124AVPK   AVON PARK FM.

    0  -    5    NO SAMPLES

    5  -   20   SAND; YELLOWISH GRAY
                30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; HIGH SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: PHOSPHATIC SAND-02%
                OTHER FEATURES: MEDIUM RECRYSTALLIZATION
                CONSISTS OF LARGE MOLLUSK SHELLS, MOSTLY SCALLOPS

   20  -   30   SAND; LIGHT OLIVE GRAY TO GRAYISH ORANGE
                30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: MEDIUM; RANGE: FINE TO MEDIUM; HIGH SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: PHOSPHATIC SAND-02%
                OTHER FEATURES: MEDIUM RECRYSTALLIZATION
                GASTROPODS

   30  -  120   SAND; YELLOWISH GRAY
                30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY
                GRAIN SIZE: COARSE; RANGE: FINE TO COARSE
                ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
                UNCONSOLIDATED
                ACCESSORY MINERALS: PHOSPHATIC SAND-  %
```

120 - 210	SAND; LIGHT OLIVE GRAY TO YELLOWISH GRAY 30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE UNCONSOLIDATED ACCESSORY MINERALS: PHOSPHATIC SAND-01% DOMINANTLY MILKY QUARTZ	M
210 - 245	SAND; LIGHT OLIVE GRAY TO MODERATE GRAY 30% POROSITY: INTERGRANULAR, POSSIBLY HIGH PERMEABILITY GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE ROUNDNESS: SUB-ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY UNCONSOLIDATED ACCESSORY MINERALS: CALCILUTITE-05%, SHELL-05% FOSSILS: MOLLUSKS	
245 - 382	MUDSTONE; LIGHT GRAY TO WHITE POROSITY: LOW PERMEABILITY, INTERGRANULAR GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELETAL 15% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: SPAR-05% FOSSILS: MOLLUSKS CHANGE OF LITHOLOGY POSSIBLY INDICATIVE OF TOP OF HAWTHORN FORMATION.	
382 - 535	SILT; LIGHT OLIVE GRAY TO WHITE 17% POROSITY: INTERGRANULAR; MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS	
535 - 621	GRAINSTONE; LIGHT OLIVE GRAY TO YELLOWISH GRAY 20% POROSITY: INTERGRANULAR GRAIN TYPE: SKELETAL, CALCILUTITE 75% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE POOR INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-04% FOSSILS: MOLLUSKS, CORAL	
621 - 652	WACKESTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY 15% POROSITY: LOW PERMEABILITY, INTERGRANULAR GRAIN TYPE: CALCILUTITE, SKELETAL 30% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: PHOSPHATIC SAND-02%, SILT-05% FOSSILS: MOLLUSKS	

652 - 698 MUDSTONE; YELLOWISH GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-01%
FOSSILS: MOLLUSKS

698 - 711 WACKESTONE; LIGHT OLIVE GRAY TO WHITE
18% POROSITY: INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%
FOSSILS: MOLLUSKS

711 - 720 MUDSTONE; YELLOWISH GRAY TO GREENISH GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%, SILT-35%
PHOSPHATIC GRAVEL-02%
FOSSILS: MOLLUSKS

720 - 728 WACKESTONE; YELLOWISH GRAY TO WHITE
20% POROSITY: INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO GRAVEL
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%
FOSSILS: MOLLUSKS, CORAL

728 - 760 MUDSTONE; YELLOWISH GRAY
POROSITY: INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%
FOSSILS: MOLLUSKS

760 - 773 MUDSTONE; YELLOWISH GRAY TO LIGHT OLIVE GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: SILT-02%, PHOSPHATIC SAND-01%
SILT-05%, QUARTZ SAND- %
FOSSILS: MOLLUSKS

773 - 831 MUDSTONE; WHITE TO YELLOWISH GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
08% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND- %
FOSSILS: MOLLUSKS

831 - 862 WACKESTONE; WHITE TO VERY LIGHT ORANGE
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
12% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: PHOSPHATIC SAND-02%, SPAR-02%
FOSSILS: MOLLUSKS
CALCILUTITE IS STRONGLY CEMENTED. NO PHOSPHATE.
LITHOLOGIC CHANGE POSSIBLY INDICATIVE OF TOP OF OLIGOCENE
SUWANNEE LIMESTONE.

862 - 870 NO SAMPLES

870 - 880 LIMESTONE; YELLOWISH GRAY TO BROWNISH GRAY
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELETAL
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
MOSTLY RECRYSTALLIZED. DIFFICULT TO TELL WHAT PERCENTAGE
WERE ORIGINAL ALLOCHEMS

880 - 896 LIMESTONE; YELLOWISH GRAY TO WHITE
11% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: CALCILUTITE-30%
FOSSILS: MOLLUSKS
EXTENSIVE RECRYSTALLIZATION MAKES IT DIFFICULT TO DETERMINE
ORIGINAL ALLOCHEM PERCENTAGE

896 - 1028 GRAINSTONE; YELLOWISH GRAY
14% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: BIOGENIC, CALCILUTITE
90% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX

1028 - 1125 LIMESTONE; MODERATE LIGHT GRAY TO YELLOWISH GRAY
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: ECHINOID
GASTROPODS. DIFFICULT TO TELL ALLOCHEM PERCENTAGE. CHANGE IN LITHOLOGY POSSIBLY INDICATIVE OF TOP OF LATE EOCENE OCALA LIMESTONE

1125 - 1177 WACKESTONE; YELLOWISH GRAY TO VERY LIGHT ORANGE
15% POROSITY: LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, , SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, ECHINOID
GASTROPODS

1177 - 1218 PACKSTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY
15% POROSITY: LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, , SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS
CHANGE IN LITHOLOGY POSSIBLY INDICATIVE OF TOP OF MIDDLE EOCENE AVON PARK FORMATION

1218 - 1317 WACKESTONE; YELLOWISH GRAY TO WHITE
15% POROSITY: LOW PERMEABILITY
GRAIN TYPE: CALCILUTITE, SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS
DICTYOCONUS

1317 - 1437 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH YELLOW
15% POROSITY: LOW PERMEABILITY
GRAIN TYPE: SKELETAL, CALCILUTITE
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS

1437	- 1459	WACKESTONE; GRAYISH YELLOW TO MODERATE OLIVE BROWN 10% POROSITY: LOW PERMEABILITY GRAIN TYPE: CALCILUTITE, CRYSTALS 35% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE GOOD INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: ECHINOID, MOLLUSKS
1459	- 1468	DOLOSTONE; DARK GRAYISH YELLOW TO WHITE 50-90% ALTERED; EUHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: SHELL-30%, CALCILUTITE-15% FOSSILS: ECHINOID, MOLLUSKS SAND DOLLARS PRESENT. WHITE SHELLS IN A MATRIX OF BROWN DOLOMITE CRYSTALS
1468	- 1476	WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN 10% POROSITY: LOW PERMEABILITY GRAIN TYPE: CALCILUTITE, SKELETAL 15% ALLOCHEMICAL CONSTITUENTS GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-10% FOSSILS: MOLLUSKS DICTYOCONUS
1476	- 1479	DOLOSTONE; GRAYISH ORANGE TO WHITE 10% POROSITY: LOW PERMEABILITY; 50-90% ALTERED; EUHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE GOOD INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: DOLOMITE-20%, SHELL-03% FOSSILS: MOLLUSKS
1479	- 1497	DOLOSTONE; GRAYISH ORANGE TO WHITE 10% POROSITY: LOW PERMEABILITY; 50-90% ALTERED; EUHEDRAL GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE GOOD INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX ACCESSORY MINERALS: CALCILUTITE-30% FOSSILS: MOLLUSKS NUMMULITES
1497	- 1518	LIMESTONE; GRAYISH ORANGE TO VERY LIGHT ORANGE 15% POROSITY: LOW PERMEABILITY, INTERGRANULAR GRAIN TYPE: CRYSTALS, CALCILUTITE GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE MODERATE INDURATION CEMENT TYPE(S): CALCILUTITE MATRIX FOSSILS: MOLLUSKS EXTENSIVE RECRYTALLIZATION (DIFFICULT TO TELL ALLOCHEM PERCENTAGE)

1518 - 1556 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, , SKELETAL
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS
GASTROPODS ABOUT 20%

1556 - 1663 GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: SKELETAL, , CRYSTALS
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, ECHINOID
EXTENSIVE RECRYSTALLIZATION

1663 - 1750 PACKSTONE; GRAYISH YELLOW TO VERY LIGHT ORANGE
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR, VUGULAR
GRAIN TYPE: SKELETAL, , CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS, ECHINOID
FINELY CRYSTALLINE CLACITE LINES VUGS. EXTENSIVE
RECRYSTALLIZATION (FINELY CRYSTALLINE) GASTROPODS

1750 - 1761 PACKSTONE; YELLOWISH GRAY
15% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, , CRYSTALS
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

1761 - 1784 PACKSTONE; GRAYISH BROWN TO GRAYISH ORANGE PINK
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, , CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

1784 - 1799 LIMESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR, VUGULAR
GRAIN TYPE: CRYSTALS, SKELETAL
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
FOSSILS: MOLLUSKS

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1799  - 1823   LIMESTONE; MODERATE BROWN
               10% POROSITY: LOW PERMEABILITY, INTERGRANULAR, VUGULAR
               GRAIN TYPE: CRYSTALS, , CALCILUTITE
               80% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
               GOOD INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX

1823  - 1882   MUDSTONE; VERY LIGHT ORANGE
               15% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CALCILUTITE, SKELETAL
               05% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO MEDIUM
               GOOD INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               FOSSILS: MOLLUSKS

1882  - 1944   LIMESTONE; GRAYISH ORANGE
               13% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               INTERCRYSTALLINE
               GRAIN TYPE: CRYSTALS, CALCILUTITE
               10% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
               GOOD INDURATION
               CEMENT TYPE(S): SPARRY CALCITE CEMENT
               FOSSILS: MOLLUSKS
               RECRYSTALLIZED TO DOMINANTLY FINELY CRYSTALLINE LIMESTONE

1944  - 1964   LIMESTONE; GRAYISH ORANGE
               13% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               INTERCRYSTALLINE
               GRAIN TYPE: CALCILUTITE, ; 80% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               FOSSILS: MOLLUSKS
               PARTIALLY RECRYSTALLIZED

1964  - 1971   LIMESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
               15% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CALCILUTITE, CRYSTALS
               GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
               ACCESSORY MINERALS: DOLOMITE-05%
               FOSSILS: BRACHIOPOD
               EXTENSIVE RECRYSTALLIZATION.  SOME DOLOMITE INTERBEDDED
               WITH LIMESTONE.  RECRYSTALLIZATION MAKES IT TOUGH TO TELL
               ALLOCHEM PERCENTAGE

1971  - 2036   LIMESTONE; VERY LIGHT ORANGE
               12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CALCILUTITE, CRYSTALS
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO FINE
               MODERATE INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               MICROCRYSTALLINE RECRYSTALLIZED LIMESTONE.  AGAIN DIFFICULT
               TO TELL ORIGINAL ALLOCHEM PERCENTAGE.  DICTYOCONUS
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2036 - 2039 DOLOSTONE; DARK YELLOWISH BROWN TO WHITE
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
INTERCRYSTALLINE; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: QUARTZ SAND-10%, CALCILUTITE-10%
SOME REMNANT CALCILUTITE AND DICTYOCONUS SHELLS

2039 - 2070 PACKSTONE; VERY LIGHT ORANGE TO YELLOWISH GRAY
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL,
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%
FOSSILS: BRACHIOPOD
MINOR DOLOMITE, INTERBEDDED WITH THE CALCILUTITE.
LIMESTONE IS PARTIALLY RECRYSTALLIZED

2070 - 2096 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, ; 70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
FOSSILS: BRACHIOPOD
EXTENSIVE RECRYSTALLIZED DOLOMITE INTERBEDDED WITH
CALCILUTITE

2096 - 2123 WACKESTONE; WHITE TO GRAYISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, , SKELETAL
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-05%
OTHER FEATURES: DOLOMITIC
DICTYOCONUS. SOME RECRYSTALLIZED. DOLOMITE IS INTERBEDDED
WITH CALCILUTITE

2123 - 2128 DOLOSTONE; OLIVE GRAY TO WHITE
POROSITY: LOW PERMEABILITY, INTERGRANULAR, VUGULAR
50-90% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-20%
OTHER FEATURES: CALCAREOUS
CALCILUTITE INTERBEDDED WITH THE DOLOMITE. EXTENSIVE VUGS
LINED WITH EUHEDRAL CRYSTALS. DOLOMITE IS ABOUT 70%
EUHEDRALA AND 30% SUBHEDRAL

2128 - 2145 LIMESTONE; GRAYISH ORANGE
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELETAL
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-15%
OTHER FEATURES: DOLOMITIC
RECRYSTALLIZED LIMESTONE, WITH REMNANT CALCILUTITE

2145 - 2147 DOLOSTONE; MODERATE YELLOWISH BROWN TO WHITE
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
INTERCRYSTALLINE; 50-90% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-40%
OTHER FEATURES: CALCAREOUS
CALCILUTITE EXISTS BOTH AS REMNANT AMONG DOLOSTONE AND INTERBEDDED WITH IT

2147 - 2149 MUDSTONE; WHITE TO GRAYISH ORANGE
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
ACCESSORY MINERALS: DOLOMITE-03%
OTHER FEATURES: DOLOMITIC
DOMINANTLY WHITE CALCILUTITE. SOME DOLOMITE IS INTERBEDDED WITH IT.

2149 - 2155 PACKSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
OTHER FEATURES: DOLOMITIC
EUHEDRAL DOLOMITE CRYSTALS ARE INTERBEDDED WITH PACKSTONE AND ON SURFACES OF ROCKS

2155 - 2158 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
INTERGRANULAR; 90-100% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-05%
OTHER FEATURES: CALCAREOUS
CALCILUTITE INTERBEDDED WITH DOLOMITE

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2158  - 2160   MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
                POROSITY: LOW PERMEABILITY, INTERGRANULAR
                GRAIN TYPE: CALCILUTITE, SKELETAL
                02% ALLOCHEMICAL CONSTITUENTS
                GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
                GOOD INDURATION
                CEMENT TYPE(S): DOLOMITE CEMENT
                ACCESSORY MINERALS: DOLOMITE-02%
                OTHER FEATURES: DOLOMITIC
                MINOR DOLOMITE INTERBEDDED WITH CALCILUTITE

2160  - 2162   DOLOSTONE; MODERATE BROWN TO VERY LIGHT ORANGE
                15% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
                INTERGRANULAR; 90-100% ALTERED; EUHEDRAL
                GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
                MODERATE INDURATION
                CEMENT TYPE(S): DOLOMITE CEMENT
                ACCESSORY MINERALS: CALCILUTITE-07%
                OTHER FEATURES: CALCAREOUS
                CALCILUTITE EXISTS BOTH AS REMNANT AMONG DOLOMITE AND
                INTERBEDDED WITH IT

2162  - 2164   GRAINSTONE; VERY LIGHT ORANGE TO WHITE
                14% POROSITY: LOW PERMEABILITY, INTERGRANULAR
                GRAIN TYPE: , SKELETAL; 95% ALLOCHEMICAL CONSTITUENTS
                GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
                MODERATE INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX
                ACCESSORY MINERALS: DOLOMITE-01%
                OTHER FEATURES: DOLOMITIC

2164  - 2169   DOLOSTONE; DARK YELLOWISH BROWN TO GRAYISH ORANGE
                12% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
                90-100% ALTERED; EUHEDRAL
                GRAIN SIZE: FINE; RANGE: VERY FINE TO FINE
                GOOD INDURATION
                CEMENT TYPE(S): DOLOMITE CEMENT
                ACCESSORY MINERALS: CALCILUTITE-03%
                SOME REMNANT CALCILUTITE.  TWO TYPES OF FRAGMENTS ARE
                PRESENT: DARKER UNIT CONSISTS OF DOMINANTLY SUBHEDRAL
                CRYSTALS AND LIGHTER UNIT CONSISTS OF DOMINANTLY EUHEDRAL
                CRYSTALS

2169  - 2177   WACKESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
                15% POROSITY: LOW PERMEABILITY, INTERGRANULAR
                GRAIN TYPE: , SKELETAL, CALCILUTITE
                40% ALLOCHEMICAL CONSTITUENTS
                GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
                GOOD INDURATION
                CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
                ACCESSORY MINERALS: DOLOMITE-20%
                ABOUT 5% OF THE DOLOMITE IS INTERBEDDED WITH CALCILUTITE
                BUT THE REST EXISTS AMONG CALCILUTITE FRAGMENTS AS THEY
                HAVE BEEN PARTIALLY DOLOMITIZED
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2177 - 2180 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE BROWN
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
INTERCRYSTALLINE; 90-100% ALTERED; EUHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT

2180 - 2182 MUDSTONE; VERY LIGHT ORANGE TO LIGHT OLIVE GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, ; 01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-30%
OTHER FEATURES: DOLOMITIC
EUHEDRAL DOLOMITE IS INTERBEDDED WITH CALCILUTITE

2182 - 2195 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
12% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ABOUT 80% OF THE DOLOMITE IS SUBHEDRAL, AND ABOUT 20% IS ANHEDRAL

2195 - 2201 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, ; 05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-40%
OTHER FEATURES: DOLOMITIC
CALCILUTITE IS INTERBEDDED WITH DOLOMITE. ABOUT 30% FINE TO MEDIUM SIZED EUHEDRAL CRYSTALS, AND ABOUT 70% ANHEDRAL

2201 - 2204 DOLOSTONE; DARK YELLOWISH BROWN TO DARK YELLOWISH BROWN
12% POROSITY: LOW PERMEABILITY, INTERGRANULAR
INTERCRYSTALLINE; 90-100% ALTERED; ANHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-02%
CALCILUTITE IS INTERBEDDED WITH DOLOMITE. ABOUT 30% IS COMPOSED OF FINE TO MEDIUM GRAINED EUHEDRAL CRYSTALS, AND 70% ANHEDRAL

2204 - 2205 MUDSTONE; WHITE TO LIGHT OLIVE GRAY
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, ; 01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-15%
OTHER FEATURES: DOLOMITIC
DOLOMITE INTERBEDDED WITH CALCILUTITE

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2205  - 2208   DOLOSTONE; MODERATE YELLOWISH BROWN TO WHITE
               11% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               INTERCRYSTALLINE; 50-90% ALTERED; EUHEDRAL
               GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
               GOOD INDURATION
               CEMENT TYPE(S): DOLOMITE CEMENT
               ACCESSORY MINERALS: CALCILUTITE-45%
               OTHER FEATURES: CALCAREOUS
               TWO LITHOLOGIES INTERBEDDED--DOLOMITE AND CALCILUTITE
               ALMOST EQUAL IN PERCENTAGE. OF THE DOLOMITE, APPROXIMATELY
               60% IS EUHEDRAL, AND 40% SUBHEDRAL

2208  - 2226   LIMESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CRYSTALS, CALCILUTITE,
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
               GOOD INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
               ACCESSORY MINERALS: CALCILUTITE-10%
               OTHER FEATURES: CALCAREOUS
               RECRYSTALLIZED LIMESTONE.  DIFFICULT TO TELL WHAT THE
               ORIGINAL ALLOCHEM PERCENTAGE IS.

2226  - 2247   PACKSTONE; VERY LIGHT ORANGE TO WHITE
               10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CALCILUTITE, ; 80% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
               GOOD INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               ACCESSORY MINERALS: DOLOMITE-01%, CALCILUTITE-20%
               CALCILUTITE IS INTERBEDDED WITH DOLOMITE

2247  - 2252   DOLOSTONE; MODERATE YELLOWISH BROWN TO WHITE
               12% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
               INTERGRANULAR; 50-90% ALTERED; EUHEDRAL
               GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
               GOOD INDURATION
               CEMENT TYPE(S): DOLOMITE CEMENT
               ACCESSORY MINERALS: CALCILUTITE-20%
               APPROXIMATELY 70% EUHEDRAL CRYSTALS, 30% ANHEDRAL

2252  - 2258   MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
               POROSITY: LOW PERMEABILITY, INTERGRANULAR
               GRAIN TYPE: CALCILUTITE, ; 05% ALLOCHEMICAL CONSTITUENTS
               GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
               GOOD INDURATION
               CEMENT TYPE(S): CALCILUTITE MATRIX
               CALCILUTITE IS INTERBEDDED WITH DOLOMITE.  CHANGE IN
               LITHOLOGY POSSIBLY INDICATIVE OF TOP OF OLDSMAR FORMATION
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2258 - 2273 MUDSTONE; VERY LIGHT ORANGE TO WHITE
POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-10%
OTHER FEATURES: DOLOMITIC
DOLOMITE IS INTERBEDDED WITH CALCILUTITE

2273 - 2283 LIMESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, SKELETAL
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-15%
OTHER FEATURES: DOLOMITIC
DOLOMITE (EUHEDRAL) IS INTERBEDDED WITH CALCILUTITE. EXTENSIVE RECRYSTALLIZATION MAKES IT DIFFICULT TO TELL ALLOCHEM PERCENTAGE

2283 - 2291 LIMESTONE; VERY LIGHT ORANGE
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
PARTIALLY (60%) RECRYSTALLIZED CALCILUTITE. DIFFICULT TO TELL ORIGINAL ALLOCHEM PERCENTAGE.

2291 - 2293 DOLOSTONE; DARK BROWN TO MODERATE YELLOWISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE
INTERGRANULAR; 90-100% ALTERED; EUHEDRAL
GRAIN SIZE: COARSE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-05%
OTHER FEATURES: CALCAREOUS
CALCILUTITE EXISTS AS REMNANT AMONG DOLOMITE

2293 - 2349 MUDSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
10% POROSITY: LOW PERMEABILITY, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, ; 01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX
ACCESSORY MINERALS: DOLOMITE-01%
MINOR DOLOMITE INTERBEDDED WITH CALCILUTITE. ABOUT 70% ANHEDRAL CRYSTALS, ABOUT 10% SUBHEDRAL AND 20% EUHEDRAL. EUHEDRAL CRYSTALS EXIST ON THE SURFACE OF ROCKS AND AS VUG LINERS. FRAGMENTS ARE LARGE WITH SMOOTH FACES. MINOR CALCILUTITE INTERBEDDED WITH DOLOMITE

2349 - 2350 DOLOSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
13% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE, VUGULAR
90-100% ALTERED; EUHEDRAL
GRAIN SIZE: MEDIUM; RANGE: VERY FINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-01%

2350 - 2354 DOLOSTONE; DARK YELLOWISH BROWN TO MODERATE YELLOWISH BROWN
12% POROSITY: LOW PERMEABILITY, INTERCRYSTALLINE, VUGULAR
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CALCILUTITE-04%
OTHER FEATURES: CALCAREOUS
DOMINANTLY SUBHEDRAL, EUHEDRAL CRYSTALS LINE VUGS

2354 TOTAL DEPTH

APPENDIX C

SFWMD ON-SITE DRILLER'S LOG

FORM RP-59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT Lake Floridan WELL NO. IWSD-TW DATE 6-12-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
0 – 5	Missing (Dug 5' hole w/ Back-hoe to set 30' steel surface
	casing :
5' - 20'	Lt to medium gray fine-grained to medium grained Frosted Qtz
	sand w/ minor amount of organic material interspersed within
	the Qtz sand, unconsolidated, 1% heavy minerals
20 - 30	Lt gray silty clay w/ minor or clayey silt component of fine grained
	Qtz sand, unconsolidated; sample taken from Kelly no sample obtained from the shaker but color change of discharge noted @ 20'
	Kelly down @ 1955 hrs
Next Day 6-13-95	Started next Rod @ ~~2005~~ hrs 0800 6-13-95
30 – 60	Lt gray, unconsolidated ~~fine to~~ medium to coarse, frosted grained Qtz sand
	w/ minor amount of organic material; s/ minor component of
	fine ~~coarse~~-grained Qtz sand'. characteristic of "Beach sands". (Miocene coarse clastics")
NOTE:	Drilling w/ a 10 3/4" tooth Bit
	Kelly down @ 0840 hrs
	Started next Rod @ 0930 hrs
60 - 75'	Lt gray, unconsolidated medium to coarse grained Qtz sand
	(Miocene coarse clastics) possibly high permeability (primarily a medium sand)
75' - 90'	"Same As Above" possibly high permeability
	Kelly down to -90 bls @ 0950 hrs (stopped to re-mix additional muds)
	Started NEXT Rod @ 1105
90 - 100	Same As Above (possibly High permeability)
100 - 120	Lt-gray, fine to coarse grained unconsolidated Quartz sand
	this interval is slightly finer-grained than the interval from 30 to 100'
	(good permeability) ~~The~~
NOTE:	The formation continues to take drilling fluids
	Kelly down @ 1140 hrs @ -120' bls, continue to clean-out borehole
~~120~~	Started NEXT Rod @ 12
~~120~~ –	NOTE: stopped drilling after this Rod due to slumping-caving
	of the Bore-hole - Remixing of drilling muds from 1200hr to 1600hr. and Re-circulation to Build up mudcake to stop caving.
–	NOTE: Drilling stopped for the day due to Burned-OUT Air
	Filter on the mud pump.

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FORM RP-59
July 1979

WELL DRILLER'S LOG

[illegible] FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC F[illegible] WELL NO. IWSD-TW DATE 6-14-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	started drilling @ 1143hr @ -120 bls
120-135	Lt-gray, unconsolidated fine to very coarse Qtz sand
	w/ minor heavy mineral component (phosphate) 1 to 2% (Miocene Coarse Clastics)
	good permeability (moderate to good sorting)
135-150	"Same As Above"
	Kelly down @ 1210hrs to -150' bls
	Started next rod @ 1225hrs
150-165	"Same As Above"
165-180	"Same As Above"
	Kelly down @ 1243hrs to depth of -180' bls
	Started next Rod @ 1255hr
180'-195	Lt-gray, unconsolidated fine to coarse Qtz sand w/
	1 to 2% fine to medium grained phosphate (good permeability)
195'-210'	"Same As Above"
	Kelly down @ 1320hrs to a depth of 210' bls.
	Started next rod @ 1330hrs.
210-230	Medium gray, unconsolidated fine to coarse-grain Qtz sand
	w/ 2 to 3% medium grained phosphate (good permeability)
230-240	medium gray unconsolidated fine to coarse-grained Qtz sand
	w/ 2 to 3% medium grained - to coarse phosphate w/ a stringer of moderate
	indurated tan sandstone from 230-235' good permeability
	Kelly down 1355hr. to depth of -240 bls; let mud circulate
	for 15 min to clean out bore-hole
	started next rod @ 1415hrs.
240-245	"Same As Above" (1% coarse grained phosphate)
245-255	moderately indurated tan colored fine-grained
	Sandstone w/ 30-35% coarse-grained Quartz sand (moderate to good perm)
~~255-270~~	Calcilutite matrix possibly for the sandy Limestone? May have minor stringer of Lt-gray micritic mud interspersed?
255-270	moderately to well indurated sandy Limestone tan to Lt
	gray in color; contain approx 20% coarse-grained Qtz sands
	(significant bit chatter through this interval (Sandstone Aquifer?)
	Kelly down 1735hrs to a depth of -270' bls.

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FORM RP-59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Floridan WELL NO. IWSD-TW DATE 6-14-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
270-280	medium tan to Lt-gray well indurated Limestone
	(good permeability) "Sandstone Aquifer" no visible Qtz within Interval
280-287	"Same As Above"
287-300	Lt-bluish gray, poorly to non indurated Lime mud "Micrite" w/
	few stringer of moderately indurated tan Limestone (good confinement)
	Low permeability
	Kelly down @ 2015hrs to depth of 300'
	Ended Drilling for the Day.
*	Date: 7-5-95 Wednesday
300-305	No sample taken due to mixture of sample from cement plug
	and material that had into and around the bottom of the 6H while
	running in the 24" steel casing.
305-315	Lt-gray poorly to non indurated Lime mud "Micrite" w/
	10% fine to coarse grained Qtz sand interspersed within this
	interval; few stringer of orangish-Tan poorly indurated mudstone
	Low permeability; good confinement (fast Drill Rate)
315-324	"Same As Above"
324-335	Lt-gray poorly to Moderately indurated sandy mudstone
	10% fine to coarse-grained Qtz sands; few mollusk internal
	molds & casts; This interval is interspersed w/ modest Amount of
	Lt-gray Lime mud; Low permeability
	Kelly down @ 1600 hRs
	Started next Rod 1620hRs
335-343	Lt-gray poorly indurated Sandstone/Sand w/ calcilute matrix
	w/ stringer of sandy Limestone, soft Abundant micrite matrix
	Qtz sand range from fine to coarse-grained. Low permeability
	due to abundant matrix)
343-357	Lt-gray poorly to nonindurated mudstone/micrite w/ 10 to 15%
	fine to coarse grained sandstone Low permeability
357-367	Lt-gray poorly indurated Limy Sandstone, Matrix consist
	of Lt-gray micrite interspersed w/ fine to pebble size Qtz
	sands (fast drilling) moderate permeability.

Kelly down 1700 hrs.

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FORM RP-59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT ______ WELL NO. IWSD TW DATE 7-5-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
367-375	Lt gray poorly indurated sandstone to non-indurated sand w/ abundant Lt-gray micrite matrix; Qtz sand range from fine to coarse-grained w/ some pebbles; few stringers of Lt-gray poorly indurated mudstone. (moderate to Low permeability)
375-382	"Same as above"
382-390	medium olive-greenish gray poorly to non-indurated sandy-lime mud (clay) w/ fine-grained phosphate "micrite" - plastic in nature - very low permeability good confinement; This interval appears to be the first good example of Hawthorn Lithology. The upper interval appears to contain no phosphate and abundant fine to pebble size Qtz grains
390-398	"Same as above"
	Kelly down @ 1800hrs. to a depth 398' bls
	Started next rod @ 1815hr (minor clogging problem within this 30 interval
398-410	medium gray to olive green non-indurated clay; very plastic in nature minor amount of fine grained phosphate (very good confinement; very low permeability; very slow drilling
410-420	"Same as above"
420-428	"Same as above". extremely slow drilling through the Last __ ft. very minor amount of fine grained material
	Kelly down @ 19__ hr to total depth of -428' bls.
	Stopped drilling for the day 7-5-95
*	Thursday 7-6-95
	Started drilling @ 0950 hrs @ depth of -428' bls
428-435	medium gray to olive-green non-indurated clay, very plastic sticky; minor amount of silt to fine sand size phosphate; w/ minor amount what appears to be moderately indurated Limestone (Shell Hash interbedded. (very good confinement))
435-448	"Same as above" (very good confinement)
448-459	medium to Dark olive gray; non to poorly indurated clay/claystone very sticky and plastic in nature; slightly more silt to fine-grained sand size phosphate 3 to 4%; interval contains few stringers of moderately indurated Biogenic Limestone w/ few mollusk casts. (very good confinement)
	Kelley down @ 1141 hr to depth of 459' bls
NOTE:	2 hours of drill time to penetrate this 30' interval.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 7-6-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started Next Rod @ 12
459-467	medium gray to olive green non-indurated clay; sticky somewhat
	soupy in nature; 1 to 2% silt to fine-grain sand size phosphate minor
	shell fragments. (very Low permeability)
467-480	medium gray to olive green non to poorly indurated clay/claystone/siltstone
Bit chatter @ 467-469	w/ few stringer of moderately indurated siltstone & Biogenic Limestone
	mollusk shell fragment present; the clay is stiff in nature NOT AS
	soupy as above; contains 2 to 4% silt to medium phosphate (very Low permeability; good confinement
480-490	medium gray to olive green, non-indurated clay (dolsilt) sticky
	somewhat soupy in nature; contain 1 to 3% silt to fine grained
	phosphate (very Low permeability; good confinement; rather soft
	from 486-490' - faster drilling. some biogenic Limestone fragments
	Stopped drilling @ 1400hrs @ 490' bls.
	Next Rod @ 1430hrs.
490-498	medium gray to olive-green non-indurated clay (dolosilt) w/
	stringer of shell Hash interbedded; biogenic Limestone fragments. 5 to 7%
	silt to medium grained phosphate (Low permeability)
498-510	medium gray to olive-green non-indurated clay (dolosilt)
	contains 5 to 7% fine grained phosphate, minor Amount
	of shell fragments (soupy in nature) very Low permeability
	good confinement; minor Amount of marly clay.
510-523	"Same as above"
	Kelly down @ 1550hrs. to depth of -523 bls.
	Started Next Rod @ 1820 hr. Broken mud Line repair.
523-535	medium gray to olive-green non-consolidated; non indurated clay
	dolosilt w/ Approx 1 to 2% silt to fine sand size phosphate. This
Mid Hawthorn.	interval is very soupy in nature (very good confinement) (Low permeability
535-545	Lt-gray to medium tan; poorly indurated biogenic Limestone
	containing mollusk & bryozoan fragments; somewhat clayey probably
	due to mixing w/ clay cuttings in Annulus (This interval took drilling fluids
	Moderate to... good. permeability depending on true clay content.?
545-555	"Same As Above
	Kelly down to -52 @ 2000 hrs.
	Stopped drilling for the day

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT Lwc Floridan WELL NO. IWSD-TW DATE 7-7-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started Drilling @ 0915 hrs. @ a depth 553' BLS
555-525	medium tan/beige to Lt-gray poorly to moderately indurated Biogenic
	Limestone ("Biogenic grainstone) calcarenite matrix, contains 10 to 15%
	mollusk shell fragment; 5 to 7% fine-grained phosphate
	(good permeability)
565-575	"Same as above"
575-585	"Same as Above" (minor bit chatter @ 583' to 585'
	Kelly down @ 0950 hr circulated fluids to 1030 hrs. Approx 22 min delay in cuttings Return
	Started next rod @ 1055 hrs
585 to 595	"Same as above"
595-605	"Same as Above"
KD 1141 1230 605-615	"Same as Above"
	Kelly Down @ 1141 hr. circulated fluids to 1230 hr. : approx 23 min delay in cutting return.
	Started next rod @ 1237 hrs.
615-621	" Same as above
621-632	Lt-gray non indurated Lime mud interlayer w/ poorly indurated
	tan packestone; the majority of this interval is a calcareous clay
	1 to 2% silt size to fine-grained phosphate (Low permeability)
	The calcareous clay is very sticky in nature (good confinement)
632-647	medium tan (beige) to Lt-gray nonindurate Lime mud
	interlayer w/ tan packestone; the majority of the interval
	is composed of the calcareous clay; 1 to 2 fine-grained phosphate
	minor shell fragments; The calcareous clay is very sticky in
	nature (Low permeability) good confinement)
	Kelly down @ 1337; circulated fluid to 1415 hrs.
	Started next rod @ 1430 hrs.
647-652	medium-gray non-indurated micrite (calcalutite) w/ stringers
	of moderately indurated Limestone 1 to 3% fine grained phosphate
	the micrite is very sticky, plastic in nature (very low permeability)
KP 1337	(good confinement.)
652-665	Lt-gray non-indurated micrite (calcalutite) w/ stringers
678 653	of moderately indurated Limestone 1 to 4% fine-grained phosphate
	the micrite is very sticky, plastic in nature (very low permeability)

good confinement.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 7-7-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
665-678	"Same As Above"
	Kelly down @ 1537 hr; circulated fluid to 1600 hrs
	Started next rod @ 1610 hrs
678-688	" Same As Above" (Low permeability) (very good confinement)
688-698	" Same As Above"
698-708	" Same As Above"
	Kelly down @ 1735 hr. circulated fluids to 1800 hrs.
	Started Next Rod @ 1815 hrs.
708-711	Same As Above
711-720	medium-gray to olive-green non indurated lime mud "micrite"
	w/ minor Limestone lens interbedded; 5 to 7% phosphate ranging
	from fine to coarse-grained; The calculutite is very sticky
	and plastic (good confinement) very low permeability
720-728	Lt-gray to Lt olive-green non-indurated micrite w/ minor
	Limestone lenses interbedded 3 to 5% fine-grained phosphatic;
	Also contains dark grayish-olive green dolosilt
	(Low permeability) good confinement
728-738	Lt-gray non-indurated micrite w/ minor limestone lenses
	interbedded toward base of interval 1 to 3% fine-grained
	phosphate minor amount of grayish-olive green dolosilt within
	the interval.
	Kelly Down @ 1947 hrs to depth of ~738' bls.
*	Ended Drilling for the day @ 2010 hrs.
***	7-10-95 Monday
	Started Next Rod @ 0830 hrs
738-750	Lt-gray non-indurated micrite (calculutite) w/ minor lenses
	interbedded w/ Lt-gray to tan color Limestone; Minor amount of grayish
	olive-green dolosilt, 1% fine-grained to coarse-grained phosphate. (micrite is
	very sticky in nature (very good confinement Low permeability ↔ ↕
750-760	"Same As Above"
760-770	Same As Above
	Kelly down @ 0935 hr; circulated muds until 1010 hr to clean drill cuttings.

KD 0935 hr

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 7-10-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started next rod @ 10 hr
770-773	"Same as above"
* 773-783	Lt-tan to Buff colored, moderately indurated Limestone,
Lower Hawthorn Aquifer	(wackestone) containing minor amount of white micrite, ~~limestone~~
	contains 1 to 2% silt to fine-grained sand phosphate,
	fast drilling through interval; minor molluscian and sponge spicules
	present (moderate to good permeability)
783-800	Lt-tan to ~~medium gray~~, moderately indurated Limestone
	wackestone ... grainstone, contains 5 to 7% fine-grained sand size to coarse phosphate, minor amount of well indurated dolostone / mudstone
	minor amount of molluscian shell fragment (moderate to good
	permeability.
	Kelly down @ 1110 hr; circulated mud to 1200 hrs
	Started next rod @ 1217 hrs.
800-807	medium tannish-gray, moderately indurated Limestone
	wackestone; contains fine to coarse-grained phosphate
	Minor molluscian shell fragments (good permeability)
807-820	Lt-gray, poorly to moderately indurated Limestone (mudstone
	to wackestone, interbedded w/ fine-grained moderately indurated
	sandstone, contains moderate volume of shell fragments and
	internal molds of Gastropods, contain minor amount of Lt-gray
	poorly indurated micrite, contain fine to coarse grained phosphate
	(moderate to good permeability) Interval took significant volume
	of drilling fluids.
820-831	"same as above"
	Kelly down @ 1250 to depth of 831' bls.
	Started next rod 1438 hr
831-841	Lt-gray poorly to moderately indurated Limestone (mudstone to
	wackestone, interbedded w/ white non to poorly indurated micrite
	interval contains 5 to 7% fine-grained phosphate in the limestone
	; moderate volume of molluscian shell fragments and gastropod internal
	molds (moderate permeability due to micrite content. minor pin-hole & moldic porosity development.
841-852	"Same as above"
852-863	Same as above

Kelly down @ 1510 hr. circulated drilling fluids to 1605 hrs.
stopped Drilling for the Day!!

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 9-22-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	started drilling @ 1012 hr @ a depth of -870 w/ Reverse-air
	open-circulation Borehole interval 862-870 lost when drilling out
	fill material
870-880	medium tan to Lt-brown moderately indurated grainstone (sandy
	Limestone w/ 45 to 50% fine to medium Qtz sand matrix interbedded
	w/ well indurated medium brown crystalline dolostone … dolomitic Limestone
	Minor Amount of pin-hole & moldic porosity development (moderate to
	good permeability
880 – 889	moderately to well indurated Lt tan colored Limy sandstone; fine
	grained in nature intermixed w/ mollusk shell fragment; interbedded
	w/ fine-grained, unconsolidated Qtz sand; shell fragments; starting
	@ Approx 881 rapid drill rates occurred w/ the bit proceeding to -887
	w/ Approx 1 min subsequently clogging the drill pipe w/ sand and larger
	cuttings of Qtz sandstone; sand is probably depositional in nature
	significant dredging occurring to void this zone; the majority
	of this interval seems to be the unconsolidated sand; hard to tell due
	to dredging of Borehole (stopped @ 1900 hr @ 889; still dredging)
9-23-95 889-896	Lt Brown; moderately indurated sandstone / grainstone interval
	w/ well indurated boundstone intervals; good moldic and pin-hole
	porosity development within this interval; contain 5 to 10% fine
	Qtz sand maybe in-falling from above / good to excellent secondary permeability
	development; minor amount of mollusk shell fragment & casts, possibly
	good interparticle porosity. few sponge spicules
	Stopped drilling for the day @ 1227 hrs
*Note	Due to the sand pouring into the borehole; the borehole will be
	Mudded up and interval squeezed w/ cement to seal it off.
	Time Temp Cond pH Redox Chloride
	1240 29.25°C 4650us 7.25 189 1120mg/L

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT ~~Sw~~ Florida WELL NO. IWSD-TW DATE 10-4-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
NOTE :	started drilling @ 1110hr @ a depth of -896.5' bls
	by closed circulation mud Rotary using a 8 3/4" Roller Bit
896-910	Lt-gray to Lt organish Tan moderately indurated limestone (wackestone to grainstone)
	w/ stringer sandy Limestone @ 898-900' corresponding to very fast drilling
	through this interval Allochems comprise approx 10% of Limestone consisting
	of molluskian shell fragment & sponge spicles; moderate pin-Hole porosity
	development & minor moldic also visible due to small cutting fragments
	(good permeability) fine-grained Qtz content within LS range 10 to 25%
	also few stringer of Sandstone, possibly nonindurated sands? Lost in drilling mud
910-927	same as above; slightly more fine to medim grained sandstone stringer through interval
	especially toward base of this interval (good permeability).
	Kelly down @ -927 @ Approx 1335hrs. consistent drilling Rate through interval
	Next rod started @ 1410 hrs
927-940	Lt-gray to Lt organish Tan moderately indurated Limestone wackestone
	to grainstone; containing 5 to 10% Qtz sand within matrix (Sandy
	Limestone (minor pin-hole porosity) Allochem 5 to 10% consisting of primarily
	molluscian shell fragment minor moldic porosity based on fragments,
	moderate to good permeability) formation is only taking minor
	amount of drilling fluids, consistent drilling rate through 38' interval
	from 927-958' bls. few stringer of well indurated Limestone
940-958	"Same as Above"
	Kelly down @ 1508 Let mud circulate to 1620hr to clean
	drill cutting - depth 958' bls.
	Next Rod started @ 1635hr.
958-968	Lt-gray to organish tan; moderately indurated Limestone (packestone
	to grainstone; grainy texture through this interval; very consistent
	Lithology; 5 to 10% Qtz sand within matrix; possibly minor stringer
	of Calcific Sandstones. (minor pin-hole porosity) Allochems primarily
	molluscian shell fragments (moderate to good permeability; consistent
	drilling speed through interval "Suwanee type Lithology
968-978	"Same as above"
978-989	"Same as above"

Kelly down @ 1715hr; circulated drilling fluids to clean cuttings to 1825hr

10

896.5
9'
910

959

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

KD 40min
1021
circulated 1:05hr.

PROJECT LWC Floridan WELL NO. IWSD-TW DATE 10-6-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started drilling @1145 hr @ a depth of ~989.5' bls.
989-1001	Lt-organish Tan; moderately indurated Sandy Limestone (grainstone)
	interbedded w/ Lt gray moderately indurated fine to medium grained
	Calcic-Sandstone; no visible pin-hole porosity or secondary permeability
	development; minor amount of molluscian shell fragments (moderate to
	low permeability)
1001-1010	Lt to medium gray moderately indurated fine to medium grained Qtz
	Calcic-Sandstone interbedded w/ non-indurated Lt-gray carbonate clay
	micrite and moderately indurated Sandy Limestone; minor amount of
	molluscian shell fragments (no visible pin-hole porosity or secondary permeability
	development (low permeability due to carbonate clay content)
1010-1021	Lt-organish-tan moderately indurated Sandy Limestone (grainstone)
	interbedded w/ moderately indurated Lt-gray fine-grained calcic-Qtz sandstone
	no visible pin-hole porosity or secondary permeability development; minor molluscian
	shell fragments (this interval could be classified as either a very sandy
	limestone (packstone) or calcic Qtz sandstone
NOTE:	variable drilling rates through interval seemed to be a bit harder from
	1010-1021 due to slower drilling rates; approx 40 min drilling time
	through interval; circulated drilling muds for 1:05hr to clean cuttings
	Low volume of drill cuttings from 1001 to 1021 may indicate a higher
	volume of silt and fine sands be suspended in drilling muds; The
	drilling fluids seem to get a bit thicker after circulating through
	interval. KD @ 1340 hrs.
	Started next rod @ 1415 hrs.
1021-1028	Lt-organish tan; moderately indurated Limestone (grainstone) interbedded
	w/ minor stringers Calcic-Sandstone; no visible signs of pin-hole porosity or secondary
	permeability development; consistent drill through this interval moderate
~~1028~~	to low permeability)
1028-1040	Lt-organish tan; moderately to well indurated Limestone (grainstone)
	interbedded w/ Lt to medium gray moderately to well indurated Qtz
	Sandstone and lt gray to buff colored carbonate mud (micrite)
	micrite content approx 10 to 15% very minor pin-hole porosity; minor
	molluscian shell fragment content. clay: silt content may be higher

30min
1.11hr.

52

than 10 to 15% but content lost in drilling fluid. (Low permeability)
due to micrite (silt micrite) content.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT Lwc Florida WELL NO. IWSD-TW DATE 10-6-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1040. 1052	"Same as above" slightly harder toward base.
	Kelly down @ 1502 hr to depth of 1052' bls. circulated mud for 1:11 hrs
NOTE.	No significant drilling fluid Loss; primarily due to volume of B.H.
	Started NEXT ROD @ 1630 hrs.
1052 - 1064	Lt. organish tan moderately indurated Limestone (grainstone) interbedded
	w/ well indurated medium gray wackestone to grainstone (sandy Limestone)
	minor pin-hole porosity development in the gray LS. Also contain 10 to 15%
	Non-indurated - Lt gray carbonate mud (micrite) irregular drilling
	through this interval well indurated Layer / soft zones
	minor amount of Lt tan sandstone (?) (Low permeability) due to
	interbedded nature and carbonate clay content
1064 - 1074	Lt - organish tan moderately indurated Limestone (wackestone to grainstone)
	interbedded w/ well indurated medium gray grainstone (sandy limestone) approx 50/50
	between the moderately & well indurated Limestone units. minor pin-hole
	and vugular porosity development. minor molluscan shell fragment.
	2 to 3% non-indurated Lt-gray carbonate mud (micrite) better
	permeability probably within the well indurated gray Limestone
	moderate permeability (somewhat more consistent drilling rate through this interval.
1074 - 1083	"Same As Above"
	Drill time 1:00 hr through this interval; circulated drilling
	fluids for approx 1:10 hr
	Stopped drilling @ 1845 hrs.

101
1:10 hr
8

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 10-10-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started drilling @ 0945hr @ depth of -1083'bls
NOTE:	consistent drilling rate for the 1st 20' Interval w/ only slight irregularities
	Approx 20 to 25 mins to drill through this interval w/ minor bit chatter.
	Approx @ -1108'bls significant bit chatter started and persisted to end of
	drill rod. Hard interval from -1105'bls to -1115'bls approx 40 mins to
	drill this 10' interval, From -1105 the formation started to take
	drilling fluids. Drilling rate for 30' interval 1 hr 1 min Recirculated
	muds for approx 50 mins then the drilling fluids drop below mud
	pump intake port, ceased drilling @ this Time ; Took approx 20,000 gal of drilling fluids.
1083 - 1093	Lt organish tan to Lt olive gray moderately indurated packstone to
	grainstone; minor molluscian shell fragments, minor pin-Hole; moldic
	porosity development slight calcic-sandstone or Sandy Limestone content
	Qtz. silt or fine sand content within Limestone difficult to determine (1 to 2% carbonate mud)
	moderate permeability
1093 - 1103'	" same as above " slightly better pin-hole porosity development within this
	interval. (moderate to good permeability)
1103 - 1115'	Lt organish tan to Lt olive gray well indurated packstone to grainstone
	Moderate pin-hole, moldic and vugular porosity development; minor molluscian shell
	fragments few internal molds. Appears to contain minor volume of boundstone.
	and medium gray crystalline Limestone; calcite (Excellent permeability)
	good secondary permeability development. Crystalline LS. consist of large
	irregularly shaped fragment indicating possible channel porosity
	minor Calcic-Sandstone Content.
	Mixed new batch of drilling fluids.
	Started drilling next rod @ 1405 hrs.
1115 - 1125'	Lt organish-Tan to Lt olive gray moderately indurated packstone to
	grainstone; moderate pin-hole and moldic porosity development; moderate
	volume of molluscian shell fragments; few internal molds ; replaced
	Shell fragments 1 to 2% non indurated Lt gray micrite (moderate to

EP. 11 min circulate 30 min - Take DF FT = 1146

Good permeability (moldic porosity development in the better indurated medium gray wackestone to packstone.)

next rod started @ 1102 hr

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSA-TW DATE 10-10-98

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1125 - 1135	"Same as Above" (moderate to good permeability?)
1135 - 1146	"Same as Above"
NOTE:	Consistant drill rate through this 30' interval; interval
	Appear to be somewhat soft due to the ease of drilling;
	17 minutes to drill this 30' section; recirculated drilling fluids
	for Approx 30 min before changing rods due to formation taking
	drilling fluids. No observed micro-fossils.
	Started NEXT Rod
1146 - 1152	Lt-organish tan to white colored; moderately indurated wackestone to
	packstone; moderate pin-hole & moldic porosity development. 10-15 Allochem
	of molluscan shell fragments; interbedded well indurated medium gray
	wackestone moldic and pin-hole better development in the white &
	medium gray LS contained within this interval; better induration than
	Above 30' section; Moderate to good permeability This interval contains
	2 to 5% non-indurated Lt-gray carbonate mud; possibly lower perm. potential
1152 - 1163	Lt-organish tan to Lt gray colored; moderately indurated packstone
	to grainstone minor pin-hole & moldic porosity development 5 to 10%
	Allochem of molluscan shell fragments 2 to 3% nonindurated Lt-gray
	micrite (moderate permeability)
1163 - 1184	"Same as Above" decrease micrite content 1 to 2%; Slightly better
	pin-hole & moldic porosity development; slower the last 5' of this
	interval from 1169-1174. moderate permeability (possible LSP?)
	KD After 29 minutes of drilling; circulated drilling fluids for
	Approx 1hr 30 min to clean cuttings.
	Stopped drill @ 1740 hrs
	Observation made during washing of cuttings
	Suwannee transition to Ocala 1135 to 1146 ft bls.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

KD: 29 min
Circ. 1:25 hr.

PROJECT LWC Floridan WELL NO. IWSD-TW DATE 10-11-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started Drilling @ 0821 hr @ depth of -1174' bls
NOTE	consistent drilling speed through 30 interval from -1177 to 1208
	bls. Drilling Time 29 min for 30' section; circulated mud for
	1 hr 25 mins; minimal fluid Loss excluding B.H volume Loss.
1178-1188	pale organish Tan; moderately indurated Limestone (packstone to
	grainstone interbedded w/ white, moderately indurate mudstone &
	medium gray boundstone, minor pin-hole & moldic porosity development
	Allochem consist primarily of molluscian shell fragments; few replaced
	~~shell~~ molluscian shell; few internal gastropod ~~molds~~ & clam internal
	molds. (Ocala Type lithology; few spicules present NO visible phosphate
	(moderate to Low? permeability) very Little fluid loss : few Leps present
1188-1198	"Same As Above"
1198-1208	"Same As Above"
	Started Next Rod @ 1029 hr.
1208-1218	pale organish Tan; moderately indurated Limestone (packstone to
	grainstone interbedded w/ white, moderately indurate mudstone to wackestone.
	minor tan colored boundstone minor pin-hole porosity - moldic porosity; Allochem consist of molluscian
	shell fragments and microfossils (forams) few internal molds.
	No Phosphate (few replaced shells) Low permeability No fluid Loss
1218-1228	pale organish tan; moderately indurated Limestone (wackestone to packstone)
	Allochems ~~ ~~ consist primarily of microfossils (Leps) w/ few molluscian
	shell fragment (small drill cutting fragments over the majority of this
	interval) very minor pin-hole porosity development visible only on
	few of the larger fragments (Low permeability) No fluid Loss
	No phosphate (Ocala Lithology)
1228-1238.5	"Same As Above"
	Kelly down @ 1100 hrs; circulated mud for approx 1.5 hrs to
	clean cutting NO Apparent fluid Loss over this interval.
	Started Next Rod @ 1245 hrs.

27 min
KD
circ. 1.5

1270

~~1268~~

15

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 10-11-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1238.-1248	pale orangish-Tan poorly to moderately indurated Limestone (wackestone to packestone) Allochems consist Almost exclusively of microfossil (Leps) comprise approx 35% of Rock volume; This interval could Also be classified As a biomicrite According to Folks classification (very minor pin-hole porosity development); minor external mollusca casts; chalky in nature, has a cornmeal Texture; minor 2 to 3% volume of nonindurated white to tan colored micrite interperse within this interval (Low permeability)
1248-1258	"Same As Above"
1258-1270	"Same As Above"
NOTE	consistent but rapid drill rate through this 30' section; Drill time 18 mins. The drilling fluids thicken slightly due to carbonate clay & silt fraction contributed by the 30' section of B.H. Also causing a slight change in color in the drilling fluid to slight olive-tan color. Kelly down 1307 hrs to depth 1270' bls. End drilling via mud Rotary method; well within the ocala to Hopefully Avoiding any Significant sand intervals.

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 12-28-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started drilling @ 0745 hr @ a depth -1270' bls.
1270 - 1282	pale-organish tan poorly to moderately indurated limestone
	wackestone: Allochems consist primarily of Leps w/ minor sponge spicules.
	No visible pin-hole porosity development, significant fine in discharge
	waters "Low permeability"
1282 - 1292	pale-organish tan to lt-gray poorly to moderately indurated limestone
	mudstone to wackestone: allochems consist of Lepidocyclina; few fragment
	of microcrystalline calcite, no visible pin-hole porosity development
1292 - 1294	Lt-gray non-indurated to poorly indurated limestone (micrite to mudstone) low permeability
1294 - 1299	pale-organish tan poorly to moderately indurated limestone (wackestone
	allochems consist primarily of Leps; no visible pin-hole porosity development.
	signif. fine in discharge water (Low permeability) Allochem approx 20-25%
	Kelly down @ 0845 hr to a depth of -1299.04'
	Started next rod @ 0925 hrs.
1299 - 1310	Same as above
1310 - 1314	Lt to medium gray non to poorly indurated mudstone ("micrite")
	very clayey in nature; slower drilling rates through this interval very low perm
1314 - 1317	Lt-gray to pale-organish tan; moderately to poorly indurated limestone
	mudstone to wackestone, no visible signs of porosity development
	20% Allochems consisting primarily of Leps.
1317 - 1330	Lt-pale organish tan; poorly to moderately indurated limestone
	wackestone to packestone; sample consists primarily of Lepidocyclinas 60-70%
	w/ minor sponge spicule; could be classified as a fossiliferous limestone
	maybe grain support by large % of Allochems; no visible signs of porosity
	development; Low permeability
	Kelly down @ 1025 hr. to depth of -1330' bls.
	Started next rod @ 1050 hr.
1330 - 1340	"Same as above"
1340 - 1350	Lt-pale organish tan poorly to moderately indurated limestone (wackestone
	to packestone: grainy texture Allochems consists primarily of Leps but represent
	Approx 10-15%, minor fragments of medium tan to lt brown boundstone;
	no visible porosity development (low permeability) minor o/o of what
	Appears to be a medium gray ~~silty clay~~ siltstone (cement?)

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FORM RP-59
July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida **WELL NO.** IWSD-TW **DATE** 12-28-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1350- 1356	Lt-pale orangish tan; poorly indurated Limestone (wackestone) Allochems
	consist primarily of Leps; minor stringers of packstone; minor phosphate?
	Content; no visible porosity development (Low permeability
1356- 1361	Lt-pale orangish tan; poorly to moderately indurated Limestone (packstone
	to grainstone); Allochem represent approx 5% and consist primarily of Lep
	minor moderately indurated - dark gray dolosilt; very minor pin-Hole porosity
	development; discharge consistently milky white through this 30' section
	Kelly down @ 1200 hr @ a depth -1361'
	started next rod @ 1225hr.
1361-1366	Lt-pale orangish tan poorly indurated Limestone (wackestone to
	packstone; Allochems consist primarily of Lep representing approx 60-70%
	of sample; minor phosphate content (check Gamma Log) This interval
	could be classified as a biomicrite or fossiliferous Limestone no visible
	porosity development (Low permeability)
1366- 1376	Lt-pale orangish tan; poorly to moderately indurated Limestone (wackestone
	to packestone; Allochems consist primarily of Leps; better indurated packestone
	show minor pin-hole porosity development; Note if there is any change
	in the sonic or density Log; Allochems represent approx 40% by volume.
	(Low permeability... maybe moderate due to better induration
1376- 1386	"Same As Above"
1386- 1393	"Same As Above"
	Kelly down @ 1345hrs @ a depth of -1393' bls
	Started Next Rod @ 1410hrs
1393 — 1403	Lt to medium tan poorly indurated Limestone (wackestone.)
	Allochems consist primarily of Leps representing about 10% minor
	stringer of dark gray dolosilt @ approx 1397' bls. few fragment of
	white ~~[illegible]~~ sparry calcite; no visible porosity development (Low permeability)
1403- 1413	'Same as Above'
1413- 1424	Lt to medium olive tan poorly indurated Limestone (mudstone to wackestone)
	Allochem consist primarily of Leo representing about 2 to 5% of sample minor
	stringer of dark-gray dolosilt?; discharge very turbid through this interval
	no visible porosity development (Low permeability)
	Kelly down @ 1515 hrs to depth of 1424' bls.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

18/31

PROJECT LWC Florida WELL NO. IWSD-TW DATE 12-28-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1424-1434	Lt to medium tan poorly to moderately indurated Limestone
	(mudstone: wackestone) No visible Leprodiocyclinas Minor Amount
	of nonindurated white to medium tan dolomicrite Approx 1 to 3% No visible
	porosity development (low permeability)
1434-1444	medium tan to medium brown moderately to well indurated
	Limestone (mudstone) interbedded w/ Lt-gray to olive gray non-indurated
	micrite Approx 30% non-indurated Micrite; no visible Allochems present
Ocala Grp ? Avon Park	No visible porosity development; (Low permeability)
1444-1455	Lt-tan moderately to well indurated Limestone (wackestone
	to grainstone; golden colored sparry calcite primarily from recrystallized
	echinoid (regular echinoderm) present @ approx 15%; Allochem consist predominately
	of echinoids shells & fragments (fast drilling through this Interval -
	possible Ocala - Avon Park Fm Contact? minor stringer of Lt-gray micrite
	poorly indurated @ 1453') possibly moderate to good permeability?
	Check temperature & Flow Logs for this contact.
	Kelly down @ 1700 hrs to depth of 1455' bls.
	Stopped drilling for the day 12-28-95
	Friday 12-29-95
1455-1487	Started drilling @ 0724 hr @ a depth of ~1 5
	Ended first Rod @ 0829 hr Total drilling time 1.05 mins
	This 30' section was highly variable in composition interlayered
	w/ Unconsolidated micrite to crystalline dolomitic Limestone and dolostone
	w/ beds of wackestone to grainstone Limestone
	Discharge Last 7' became more turbid.
1487-1518	Started Next Rod @ 0904 hrs total drilling time 47.5 mins
	This 30' section was more consistent primarily consisting of pale orangish
	tan to Lt brown packestone to grainstone.
1518-1548	Started Next rod @ 1025 hrs
	- very uniform; consistent grainstone through the entire 30' section
	uniform drilling rate; moderately indurated Check geophysical Logs
	for flow & permeability data; Look @ borehole camera video
	possibly good permeability Appeared to have increased flow from discharge

Line during changing of the rods

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Floridan WELL NO. IWSD-TW DATE 12-29-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started next rod @ 1200 hrs. total drilling time: 71 mins
1548-1580	This 30' section was slightly variable in Lithology Ranging from
	a wackestone to the primary component of a grainstone w/
	minor color variations (poorly to moderately indurated) moderate
	permeability due to grainstone texture; no truely visible sign
	of porosity development
1580-1611	Started next rod 1350 hrs Total drilling time 73 min's
	moderately indurated grainstone from 1580-1592
	1592-1595- variable Lithology medium gray to brown wackestone to packestone
	1595-1611 poorly to moderately indurate wackestone to packestone
	minor grainstone
1611-1642	Started Next rod @ 1530 hrs Total drilling time 68 mins.
	poorly to well indurated packestone to grainstone w/ minor stringers
	of wackestone; minor Amount of non-indurated lt-greenish gray clay
	in 1616 to 1621 interval; minor allochems some echinoids present.
	(moderate permeability)

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Floridan WELL NO. IWSP-TW DATE -2-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	started drilling @ 0750hrs @ a depth of -1642' bls
1642-1649	Lt pale orangish tan to Lt-gray; poorly to moderately indurated
	grainstones; Allochem consists of dictyonconus Americanus? & echnoid shells & fragment minor pin-Hole
	porosity development (Moderate Permeability)
1649-1654	Lt tan moderately to well indurated packestone to grainstone, minor
	Allochems; minor pin-Hole porosity; some plucked fragment from better
	indurated fragments. (Low to moderate permeability)
1654-1663	Lt brown to pale orangish tan; moderately to well indurated
	grainstone; Allochems consist of dictyonconous & Echnoids
	moderate permeability; somewhat better indurated from 1660-1663
1663-1668	Lt brown to medium gray; moderately to well indurated packestone
	to grainstone; allochems consists of dictyonconus minor pin-Hole & moldic
	porosity development (moderate permeability)
1668-1670	Lt to medium gray; well indurated mudstone to wackestone
	better pin-Hole porosity than above; minor Lt brown grainstone
	stringer; (good permeability)
1670-1678	Lt-gray to buff colored; moderately to well indurated wackestone
	interlayered w/ Lt brown grainstone minor pinHole porosity development
	(moderate permeability) NOTE: Discharge Less turbid from 1668; Less fines better induration
	stopped drilling @ 0905hr to depth of -1673' bls
	Started next rod @ 0940 hr.
1678-1679	Tan to Lt brown; moderately to well indurated grainstone w/ stringers
	of Buff colored; well indurated wackestone; minor pin-Hole porosity
	allochems consist primarily of Dictyoconus Americanus (moderate permeability)
1679-1681	Dark gray; poorly to moderately indurated wackestone to packestone
	no visible porosity development (Low permeability)
1681-1683	Tan colored; moderately indurated grainstone; minor allochems
	present no visible porosity development but good grainstone texture
	(moderate to Low permeability)
1683-1688	Lt-gray; moderately indurated mudstone to wackestone w/ approx
	20% Lt-gray non-indurated carbonate clay (micrite) slow drilling through
	this interval (Low permeability)

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Floridan WELL NO. IWSD-TW DATE 1-2-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1688-1693	Lt to medium brown moderately indurated grainstone Allochems
	consist of dictyconus americanus & minor echinoids; minor pin-hole
	porosity development (moderate permeability)
1693-1698	Tan colored moderately to well indurated packestone; to grainstone
	minor % of unconsolidated carbonate clay present Allochem consist
	primarily of dictyconus Americanus; very minor pin-hole porosity develop
	low to moderate permeability
1698-1706	Lt tan to grayish Lt brown moderately indurated (limestone) grainstone
	Allochems consist primarily of Dictyconus ... minor pin-hole porosity
	development (moderate permeability)
	Ended drilling @ 1115hr total drilling time of 1hr 36mins
	Started drilling next rod @ 1200hr.
1706-1716	Lt tan to Lt-gray moderately indurated Limestone packestone
	to grainstone; primarily a grainstone; minor allochems, minor
	pin-hole porosity development; minor thinly layered packestone
	(moderate permeability)
1716-1727	"Same As Above"
1727-1737	Lt to medium brown; well indurated Limestone packestone to
	grainstone; minor allochem consisting of dictyconus; minor
	echinod shell fragments; minor pin-Hole & moldic porosity
	development; minor well indurated medium gray dolostone or dolomitic limestone
	(moderate to good permeability) slow drilling through this interval.
	stopped drilling @ 1330hr. to depth of -1737 bls.
	started next rod @ 1353hr
1737-1742	Lt brownish-gray; moderately indurated Limestone (packestone
	to grainstone; primarily a packestone; minor pin-hole porosity
	contain approx 5 to 10% non-indurated - Lt gray carbonate mud micrite
	moderate to low permeability due to micrite content
1742-1750	Lt-grayish brown to tan colored; moderately indurated Limestone
	grainstone; w/ well indurated Lt-gray mudstone to wackestone from 1742-1744
	Also contain some fragment of thinly bedded packestone to grainstone
	and medium gray grainstone; highly variable in color.
	minor pin-Hole porosity development (moderate permeability)

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC-Florida WELL NO. IWSA-TW DATE 1-2-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1750-1754	medium brown; moderately indurated Limestone (grainstone)
	minor pin-Hole porosity development; interlayer w/ stringer of
	medium gray wackestone (moderate permeability)
1754-1761	Lt tan moderately to well indurated Limestone (wackestone to
	packestone w/ stringer of grainstone; very minor pin-hole porosity
	development (moderate to low permeability
1761-1768	Lt brown Moderately to well indurated Limestone (packestone to grainstone)
	interbedded w/ non-indurated Lt gray to olive tan colored carbonate clay
	Micrite approx 10% minor-pin-Hole porosity development (minor stringer of well
	indurated dolomitic wackestone or dolostone (moderate to Low due to
	Micrite content.
	stopped drilling @ 1548 hrs @ a depth of -1768' bls
	due to Lack of additional drill rod.
	Thursday 1-4-96
	started drilling @ 0742 hr
1768-1772	medium grayish brown moderately indurated packestone to grainstone
	contains approx 5 to 7% unconsolidated medium gray micrite w/ stringers
	of well indurated Lt brown to medium gray cryptocrystalline Limestone/dolostone.
	minor porosity development in well indurated rock fragments (moderate permeability)
1772-1778	Tan to Lt brown moderately to well indurated packestone to grainstone
	to crystalline Limestone; stringer of tan color microcrystalline Limestone
	w/ moderate porosity development (moderate to good permeability)
1778-1782	Same As Above
1782-1784	medium to dark gray moderately indurated packestone to wackestone
	interbedded w/ well indurated crystalline Limestone / dolostone; very
	minor porosity development
1784-1788	Tan colored well indurated crystalline to microcrystalline Limestone
	w/ minor stringer of Lt tan wackestone to packestone; minor pin-Hole porosity
	development (moderate permeability development may be higher based on
	secondary permeability development (eg. fractures)
1788-1793	"Same As Above"
1793-1799	"Same As Above
	Kelly down @ 0942 hr to depth of -1799' bls; Total drilling Time

2 hr for this 30' section; extremely slow drilling the last 20'

1750-1880

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 1-4-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started next rod @ 1024 hr
1799-1801	Lt to medium gray well indurated grainstone w/ approx 5 to 7%
	Lt gray nonconsolidated micrite interbedded very minor pin-hole porosity.
	(Low to moderate permeability due to micrite content
1801-1804	Lt to medium brown moderately to well indurated grainstone w/
	Approx 10% Lt brown non-indurated carbonate clay micrite; Last
	foot 1803-1804 primarily micrite (Low permeability,
1804-1807	Lt gray to buff colored well indurated mudstone; no visible
	porosity development (Low permeability)
1807-1809	Lt to medium brown moderately indurated packstone to grainstone
	minor pin-hole porosity development (moderate permeability
1809-1815	Lt-gray moderately to well indurated wackestone to packstone
	Allochem consist of dictyconus Americanus (minor pin-hole porosity development
1815-1823	medium grayish brown moderately indurated grainstone w/ very minor
	allochem present; minor pin-hole porosity development (moderate permeability)
	minor fragment of medium gray well indurated dolostone w/ better porosity
	development
1823-1831	Lt-gray to tan colored moderately to well indurated packstone to
	grainstone w/ few fragment of well indurated crystalline limestone (mudstone?)
	allochem consist primarily of dictyconus; few in number (minor pin-hole
	porosity development (moderate permeability)
	Kelly down @ 1142 hr Total drilling time 1 hr 24 min
	Started next rod @ 1225 hr.
1831-1841	Lt-gray to tan colored moderately to well indurated packstone
	to grainstone; minor allochems, primarily consisting of dictyconus
	moderate drilling rate from 1831-1836) Low to moderate permeability
1841-1851	"Same as above"
1851-1862	"Same as above"
	Kelly down @ 1557 hr Total drilling time 1 hr 31 mins
	Started next rod @ 1630 hrs
1862-1868	Lt tan to Lt brown poorly to moderately indurated mudstone to
	wackestone w/ 2 to 3% Lt gray non-indurated carbonate clay micrite
	minor pin-hole porosity development (Low to moderate permeability

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 1-4-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
1868-1873	tan to Lt brown; moderately to well indurated grainstone, very grainy
	texture; friable; good pin-hole porosity development (good permeability)
	NOTE check this interval on flow & Temp logs
1873-1875	Lt-gray & buff colored well indurated mudstone to wackestone
	very minor pin-hole porosity develop. (Low permeability)
1875-1882	Lt brown to grayish Tan; well indurated grainstone; friable; stringer of
	crystalline dolomitic LS or dolostones show vuggy porosity development.
	good to excellent pin-hole porosity development (good to very good permeability)
1882-1886	"Same As Above"
1886-1892	Tan to Lt brown; well indurated packstone to sub crystalline Limestone
	moderate pin-hole porosity development (good permeability)
	NOTE: changes in conductivity & chlorides @ this interval. chloride
	↑ from 1224 to 1470 mg/L
	Kelly down @ 1614 hr total drilling Time 1 hr 45 mins
	started NEXT Rod @ 1645 hrs
1892-1897	Lt-Tan to Med brown; well indurated grainstone w/ micro to
	crystalline dolomitic Limestone; moderate pin-Hole porosity development
	minor vugular porosity development within the crystalline Limestone fragments
	moderate to good permeability (Excellent cuttings)
1897-1902	"Same As Above"
	Stopped drilling for the day @ 1725 hrs. to depth of 1902' bls
1-5-95	Started drilling @ 0719 hrs @ depth of 1902' bls.
1902-1910	Tan to Lt to medium brown; well indurated packstone to grainstone
	w/ stringer of well indurated micro to crystalline Limestone / dolostone
	minor pin-Hole porosity development (Low to moderate permeability
1910-1918	medium brown to medium gray moderately to well indurated grainstone;
	moderate pin hole porosity development; granular Texture smaller cutting
	fragment (friable)
1918-1920	Tan colored well indurated packstone to grainstone to crystalline Limestone
	minor pin Hole porosity development (Low to moderate permeability)
1920-1923	medium to dark brown; well indurated crystalline to microcrystalline Limestone / dolostone
	minor grainstone texture minor pin-hole porosity development
	(Low to moderate permeability) ↑ conductivity & chloride concentrations

Kelly down 0830 hrs.

change in RH WQ CL ↑ 250 mg/L

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT Lwc Florida WELL NO. IWSA-MW DATE 1-5-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started drilling Next Rod @ ~~0800~~ 1007 hrs. : Repair of broken Air Line 65 min delay.
1923 - 1928	Tan to Lt brown moderately to well indurated grainstone ; rapid
	drill through this interval ; possibly fractured darkened surface on rock fragment
	face ; minor pin-hole porosity development. (Low to moderate perm)
1928 - 1934	Lt brown to medium Brown ; well indurated packstone to grainstone
	Interlayered w/ stringers of micro crystalline dolostone ; minor pin-hole porosity
	develop. (Low to moderate permeability)
1934 - 1937	Tan to Lt brown well indurated packstone interlayered w/ white crystalline
	Limestone ; good pin-hole & minor vugular porosity develop. in the crystalline Limestone
1937 - 1944	Lt brown to medium brown moderately to well indurated packstone to
	grainstone ; interlayered w/ crypto crystalline black dolostone
	minor pin-hole porosity (Low to moderate permeability) fast drilling from
	1938 - 1943
1944 - 1949	Lt-grayish tan well indurated wackestone to packestone ; minor pin-hole
	porosity development ; minor stringers of black granular dolostone - Black - Tan
	indicating some kind of contact.
1949 - 1954	Tan to Lt brown well indurated grainstone ; moderate pin-hole
	porosity development ; Allochems consist of dictyoconus. (moderate
	permeability ; minor stringers of crystalline Lmstne/dolostone.
	Kelly down @ 1148hrs total drilling time 1hr 37 mins
	Started Next Rod @ 1225 hr
1954 - 1964	Lt brown moderate to well indurated wackestone to packstone ; minor
	stringers of grainstone ; very minor pin-hole porosity ; (Low permeability)
1964 - 1967	Grayish Brown ; moderately indurated grainstone ; interbedded w/
	w/ white to Buff colored crystalline Limestone ; crystalline LS shows
	minor sucrosic texture ; moderate pin-hole porosity ; minor vugular porosity.
	(moderate to good permeability)
1967 - 1971	Lt Brown to medium brown ; moderately indurated packstone to grainstone
	no visible pin-hole porosity in the packstone ; minor pin-hole porosity in the
	grainstone (Low to moderate perm)
1971 - 1980	Lt-Tan colored ; moderately indurated grainstone w/ stringer Allochems consists of Dictyoconus Americanus
	of packstone ; moderate pin-hole porosity develop. (moderate ... good? perm)
1980 - 1985	Lt brown ; well indurated packestone to grainstone ; minor

pin-hole porosity development (Low to moderate permeability).
Kelly down @ 1642 Total Drilling Time 1hr 44 mins.

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO: IWSD-TW DATE 1-5-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started next rod @ 1500hr.
1985-1997	Tan colored; poorly to moderately indurated grainstone
	Allochem consist exclusively of dictyoconus Americanus approx 30 to 35%.
	Allochems: fast drilling through this interval; very minor visible
	pin-hole porosity development (Low to moderate perm?)
1997-2000	grayish-medium brown poorly to moderately indurated grainstone
	Allochems of Dictyoconus 5 to 7%; minor pin-Hole porosity development
2000-2005	Lt Tan to Lt brown well indurated packstone to grainstone
	minor stringer of crystalline limestone; minor pin-hole porosity develop
	better from 2003-2005' (Low to moderate?)
2005-2010	Tan colored; moderately indurated packstone to grainstone; primarily
	a grainstone; minor pin-hole porosity develop; no visible Allochems
	(Low to moderate permeability)
2010-2016	"Same as above"
	Kelly down @ 1632hrs @ depth of ~2016' bls Total
	drilling Time 1hr 32mins
	Stopped drilling for the day
1-8-96	Started drilling @ 1107hrs @ depth ~2016
2016-2020	Tan to Lt brown moderately to well indurated wackestone to packstone
	no visible Allochems minor pin-hole porosity development
	(Low permeability)
2020-2026	Tan colored moderately to well indurated packstone to grainstone
	no visible Allochems; minor to moderate pin-Hole porosity development
	(Low; maybe moderate perm due to better pin-Hole porosity develop.
2026-2033	"Same as above"
2033-2036	Tan colored well indurated wackestone to packstone; no visible
	Allochems present; no visible pin-hole porosity development (Low permeability)
2036-2039	medium to dark brown; very well indurated crystalline dolostone;
	No visible secondary porosity or permeability; seem to show 90% dolomitization
	Low permeability
2039-2046	Tan to Lt brown moderately indurated grainstone; minor to
	moderate pin-hole porosity develop. Allochems present consisting of dictyoconus
	americanus; ~~[illegible]~~ fast drilling rate through this interval.

1325 Kelly down @ 1258hrs – 1hr 46min drilling Time
Started next rod 1325hr

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July 1979

WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-IW DATE 1-8-95

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started NEXT ROD @ 1325
2046 – 2051	Tan to light brown; moderately indurated grainstone; Allochems present
	consisting of Dictyoconus Americanus, approx 20 to 30% Allochems; moderate
	pin-hole porosity development; granular texture; friable. (moderate permeability)
2051 – 2059	Lt tan to Lt brown; poorly to moderately indurated grainstone
	Allochems present consisting of Dictyoconus Americanus, 30 to 40% Allochems
	moderate pin-hole porosity development; minor stringer of dark gray to dark
	grainstone from 2062-2063; (moderate permeability)
2059 - 2062	Tan colored moderately to well indurated wackestone to packstone;
	some crystalline well indurated Limestone; very minor pin-hole porosity
	development (Low permeability)
2062 - 2070	Tan to Lt gray; poorly to moderately indurated packstone to grainstone
	Allochems present consisting of Dictyoconus Americanus; approx 20 to 30% Allochems
	very minor vugular porosity develop. minor pin-hole porosity, moderate
	permeability (grainy texture) friable
2070 - 2072	tan to medium brown to dark grayish black wackestone to dolostone to
	crystalline Limestone; very highly variable in composition, color & texture
	No Allochems present (Low permeability)
2072 - 2076	Tan to Lt brown; moderately indurated packstone to grainstone; Allochems
	present consisting of Dictyoconus Americanus, minor pin-hole porosity development
	granular Texture; friable in nature; Low to moderate permeability.
	Kelly down @ 1510hr Total Drilling Time 1hr 44 mins
	Started NEXT ROD @ ~~1010~~ 0918 hr hrs 1-10-95
2076 - 2081	Tan to Lt brown; moderately indurated packstone to grain; Allochems
	present consisting of D. Americanus, minor pin-hole porosity; partial
	Dolomitized dolomitic grainstone to dolostone; moderate to low permeability
2081 - 2083	medium to dark brown moderately indurated dolomitic ~~Limestone~~ crystalline / crystalline
	dolostone; minor pin-hole; very minor vugular porosity development
	(Low to moderate permeability)
2083 - 2091	Lt brown to Lt gray; moderately indurated grainstone; minor pin-hole
	porosity develop. Allochems present consisting of D. Americanus, approx
	5% Allochems
2091 - 2096	Tan to Lt brown moderately to well indurated packstone to grainstone;
	to subcrystalline Limestone; minor stringer of chocolate brown crystalline

dolomite from 2094-2095, very minor pin-hole porosity development. good grainstone interval from 2095 to 2096 (Low permeability).

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WELL DRILLER'S LOG

PROJECT LWC-Florida WELL NO. IWSD-TW DATE 1-10-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
2096 - 2102	Tan colored; well indurated packstone, minor pin-hole porosity minor stringers of tan to white crystalline limestone and chocolate brown sub to crystalline dolostone (Low permeability)
2102 - 2107	Lt-gray to tan colored; moderately to well indurated mudstone to wackestone; minor grainstone; very minor pin-hole porosity development minor crystalline limestone fragments (Low permeability)
	Kelly down @ 1118 hr Total drilling time 2.0 hrs.
	note: this 30' interval was highly variable in lithology; color; thin layers of dolomitic limestone / dolostone and crystalline dolomite present; this interval could have been segmented into much smaller sample intervals
	Started next rod @ 1207 hrs.
2107 - 2114	Buff colored to Lt tan moderately indurated wackestone to packstone & medium to chocolate brown crystalline dolostone @ 2112-2114'; minor to moderate pin-hole porosity; minor vugular porosity develop. fast drilling through this interval. (moderate to good permeability) better porosity development in the crystalline dolomite; no visible allochems.
2114-2119	Tan to Lt brown moderately indurated packstone to grainstone; primarily a grainstone; no visible allochems; minor pin-hole porosity development granular texture; friable (Low to moderate?)
2119-2123	Tan to medium brown; well indurated micro to crystalline dolostone w/ stringers of well indurated packstone to crystalline limestone; minor pin hole porosity in the dolostone (Low to moderate?)
2123-2128	Chocolate brown to brownish black very well indurated dolostone / dolomite micro to crystalline in nature; somewhat sucrosic in the chocolate brown dolomite; moderate pin-hole porosity; minor vugular porosity (moderate to good permeability; check flow & temp log through this interval to see is any ↑ flow potential.
2128-2138	Tan to Lt gray; moderately to well indurated wackestone to grainstone w/ stringers of crystalline dolomitic limestone and dolostone; minor pin-hole porosity develop. minor vugular porosity; fast drill through this interval (Low to moderate permeability) no visible allochems.
	Kelly down @ 1347 Total drilling Time 1hr 40mins

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC Florida WELL NO. IWSD-TW DATE 1-10-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started next Rod @ 1430 hrs
2139-2145	Tan to Lt brown; moderately to well indurated grainstone; no visible Allochems, very minor pin-hole porosity development; granular Texture. friable in nature (Low to moderate permeability)
2145-2147	Lt to medium brown; well indurated crystalline dolostone & Limestone interbedded w/ moderately indurated mudstone to wackestone; Appear that the mudstone is partially dolomitized; very minor pin-hole porosity (Low perm)
2147-2149	Buff colored; moderately indurated mudstone to wackestone; no visible Allochems, ~~[illegible]~~ no visible secondary porosity development (Low permeability)
2149-2155	Tan to Lt brown; moderately to well indurated packstone / dolomitic crystalline Limestone or dolostone; no visible Allochems; the Limestone appears to be partial dolomitized w/ crystalline & non crystalline fragment Adjacent
2155-2158	Dark chocolate brown to brownish black; very well indurated crystalline dolostone / dolomite; good pin-hole porosity develop; moderate vugular porosity, sucrosic in Texture (good permeability).
2158-2160	Tan to medium gray; moderately indurated wackestone to crystalline dolomitic Limestone or dolostone; no visible Allochem; no visible pin hole porosity development. (Low permeability)
2160-2162	medium brown; ~~very~~ well indurated crystalline dolostone w/ golden brown moderately indurated sucrosic dolomite; minor pin-hole porosity develop. (moderate permeability)
2162-2164	Tan to Lt brown; moderately indurated packstone to packstone; No visible Allochems; minor crystalline Limestone / dolostone; very minor pin-hole porosity development (Low permeability)
2164-2169	golden brown to brownish black; well indurated to very well indurated micro to crystalline dolostone; sucrosic in nature the golden brown dolostone while the brownish black dolostone is microcrystalline nature; moderate pin-hole porosity; minor vugular porosity $\frac{\text{sucrosic}}{\text{crystalline}}$ (moderate to good permeability (check flow & temp log through this interval.
2169-2171	medium grayish; well indurated; packstone to cryptocrystalline dolomitic Limestone or dolostone; moderate vugular porosity in the cryptocrystalline dolostone; (moderate permeability)

kelly down @ 1635 hr; Total drilling time 2 hrs 5 mins
stopped for the day

Upper Dolostone Unit

2171

2131 / 2155

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

KD=1016hr

PROJECT Lwr Florida WELL NO. IWSD-IW DATE 1-11-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
	Started drilling @ 0755 hr.
2171-2173	Lt to medium gray moderately to well indurated dolomitic Limestone/
dolostone	granular to crystalline in nature; some fragments are cryptocrystalline
	in nature; very minor pin-hole porosity develop. (Low permeability)
2173-2177	Golden brown; moderately indurated crystalline dolostone/dolomite
	sucrosic in nature; good pin-hole and vugular porosity development
	(good permeability)
2177-2180	golden brown to brownish-black very well indurated crystalline dolostone/
	dolomite; sucrosic to crystalline in nature; minor pin-hole & vugular porosity
	development (moderate to good permeability)
2180-2182	Lt to medium gray; moderately to well indurated dolomitic Limestone
	to dolostone; granular to crystalline in nature; Appears to be partially
	dolomitized; some fragment of dolostone are micro to cryptocrystalline
2182-2185	golden to medium brown; very well indurated; crystalline dolostone/dolomite
	sucrosic to micro crystalline in nature; moderate vugular porosity development in
	sucrosic dolomite; minor pin-hole porosity in micro to crystalline dolostone,
	(moderate permeability)
2185-2195	medium brown to brownish black very well indurated microcrystalline to
	crystalline dolostone/dolomite; very minor pin-hole porosity; very
	Little water discharge when penetrating this interval; good confinement
	(very Low to Low permeability
2195-2201	Lt gray to medium grayish brown; well indurated dolomitic Limestone to
	dolostone; granular to crystalline in nature; This interval Appears to
	partial dolomitized or recrystallized; very minor pin-hole porosity development
	minor stringer of medium Light brown crystalline dolostone @ 2196
~~2201~~ -	Kelly down @ 1016 hr Total drilling Time 2 hr 27 mins
* 2202 *** NOTE	Chloride & conductivity value increased significantly after this interval
	Chloride went from 4400 mg/L to 15,500 mg/L & conductivity from 13000
	to 41,280 microsiemens.
	Started NEUTRON @ 1113 hrs.
2201-2204	Dark Brownish Black; very well indurated crystalline dolostone;
	minor pin-hole porosity development, moderate vugular porosity development
	(Low to moderate) depends on secondary perm development
2204-2205	Lt-gray moderately indurated mudstone to wackestone
	no visible allochems; no visible porosity development (Low permeab.
2205-2208 -	medium golden brown; moderately indurated crystalline dolostone
	Sucrosic in nature interbedded w/ Lt-gray moderate indurated mudstone

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1332

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

2232

PROJECT LWC Florida WELL NO. IWSD-TW DATE 1-11-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
2208-2215	Lt-gray moderately indurated mudstone to wackestone; no visible
	Allochems; no visible porosity development (low permeability)
2215-2226	Tan to Lt brown moderately to well indurated packstone to grainstone
	primarily a grainstone; minor to moderate pin-hole porosity develop
	in thin Layers; granular Texture; friable (moderate permeability
2226-2229	dark brown to golden brown to white; well indurated microcrystalline
	to crystalline dolostone; minor vugular porosity in sucrosic dolomite
	interbedded w/ minor tan colored grainstone (moderate .. good? permeability)
2229-2232	Tan to Lt brown; moderately to well indurated packstone to grainstone
	minor crystalline Limestone fragment; no visible Allochems minor
	pin-hole porosity development (Low to moderate permeability
	Kelly down 1332 hr Total drilling Time 1hr 52 mins
	Started Next Rod @ 1345hrs.
2232-2235	Lt-gray; moderately indurated mudstone to wackestone; minor
	pin-Hole porosity development (Low permeability) no visible Allochems
2235-2247	Tan to Lt brown; moderately indurated grainstone minor pin-Hole
	and vugular porosity development; some section are partially crystallized
	Minor wackestone stringer @ base of interval contain minor black dolostone.
2247-2252	medium to dark brown; very well indurated crystalline dolostone
	dolomite; good pin-hole & vugular porosity development; sucrosic in
	nature (good to very good permeability)
2252-2258	Lt-gray; moderately indurate wackestone to packstone interbedded
	golden brown well indurated sucrosic crystalline dolostone: This
	interval could be either a Limestone or dolostone, moderate pin-hole & vugular
	porosity develop. in sucrosic dolostone (moderate to good due to sucrosic dolomite
2258-2263	Lt-gray to Lt tannish brown; moderately to well indurated
1600	packstone to grainstone; minor Lens of mudstone & non indurated
	Micrite @ 2260-2261; no visible Allochems; minor pin-hole porosity
	development (Low to moderate)
	Kelly down @ Total drilling time 1hr 37mins
	Started next rod @ 1600hrs.
2263-2273	Lt-gray; well indurated packstone to grainstone; primarily a grainstone
	Minor stringer of sucrosic crystalline dolostone @ 2268'-2269' (2264-2265), good

vugular porosity development in the Thin sucrosic dolostone. minor pin-hole porosity development in the grayish grainstone (Low to moderate permeability 32

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

2297

PROJECT LWC Florida WELL NO. IWSD-IW DATE 1-11-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
2273-2278	Lt gray moderately to well indurated wackestone to packstone; no
	visible allochems; very minor pin-hole porosity development; Thin
	Layers of sucrosic dolostone @ 2273 & 2275; good vugular porosity
	in the sucrosic dolostone (Low to moderate permeability depending on
	the dolostone layer.
2278-2283	Lt-gray to Buff colored moderately indurated mudstone to packstone,
	interbedded w/ dark brown sucrosic dolomite and crystalline dolomitic Limestone
	No visible Allochems, very minor pin-hole porosity in the granular Limestone
	moderate pin-hole & vugular porosity development in the sucrosic dolomite.
	(Low to moderate depending on permeability of dolostone layers.
	stopped drilling for the day @ 1742hr. Total drilling 1hr 42min / 20 foot
	1-12-96 Started drilling @ 0733 hrs.
2283-2289	golden brown to dark chocolate brown moderately to well indurated
	crystalline dolostone interbedded w/ well indurated partially dolomitized
	packstone/dolostone; Thin Layer of granular to partially crystallized dolostone
	occur @ 2283 & 2287; Approx 0.5 to 1.0 thick. The crystalline dolomite
	is sucrosic and has moderate to good vugular porosity develop.
	(good permeability)
2289-2291	Medium tan to lt brown; well indurated granular to partially
	recrystallized dolomitic Limestone or dolostone; No visible allochem; No
	visible porosity development (Low permeability)
2291-2293	golden brown to brownish-Black crystalline dolostone; very
	well to moderately indurated; sucrosic; Moderate vugular porosity develop
	Thin crystalline to microcrystalline dolostone w/ Lower permeability.
	Kelly down @ 0830hr. Total Drilling Time Approx 2hr 15mins 30' foot
	Started NEXT Rod @ 855hrs
2293-2302	Lt Gray to ~~lt brown~~ Tan colored; moderately to well indurated wackestone
	to grainstone/dolostone to partially dolomitized/crystalline dolostone; No visible Allochems; very minor pin-hole
	porosity development; primarily granular in texture; Low permeability
2302-2312	Lt gray to tan colored; moderately to well indurated packstone to
	grainstone; minor stringer of partially crystalline to crystalline dolostone
	However primary a grainstone/dolostone?; minor pin-hole porosity develop
	Low to moderate permeability; no visible allochems,
2312-2318	same as above

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WELL DRILLER'S LOG

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

PROJECT LWC-Florida WELL NO. IWSD-TW DATE 1-12-96

DEPTH	DESCRIPTION – ROCK TYPE, COLOR, HARDNESS, OTHER
2318-2321	medium gray; well indurated crystalline dolostone, crystalline
	to microcrystalline in nature; minor pin-hole & vugular porosity
	development; (moderate permeability)
2321-2327	white to lt ~~brown~~ gray; moderately indurated; granular to crystalline
	dolostone / grainstone; minor pin-hole porosity; Low to moderate permeability
24	partially crystalline / granular nature; small dolomite rhombs observed
	Kelly down @ 1200hr probably a dolostone.
2327-2331	medium to dark chocolate brown; cryptocrystalline to crystalline dolostone
	very well indurated approx 1:00hr through this interval; moderate pin-hole
	and vugular porosity @ base of interval 2330-2331; no porosity develop conchoidal fracturing
	in the cryptocrystalline (Low to good permeability): Soun Gas odor observed
2331-2334	medium gray; very well indurated crystalline dolostone; slight bit
	drop through this interval; good pin-hole & vugular porosity development
	(good permeability to excellent permeability
2334-2339	Tan to medium brown to medium gray; well indurated crystalline to
	microcrystalline Dolomite; good pin-hole porosity; moderate vugular porosity development
	(excellent permeability)
2339-2344	light brown to medium gray; very well indurated crystalline dolostone/
	Dolomite; good pin-hole porosity; good to excellent vugular porosity develop
	minor sucrosic texture; bit drop through this interval (excellent permeability)
2344-2346	Dmk to medium Tanish brown; well indurated crystalline dolostone; good
	pin-hole porosity; sucrosic to microcrystalline; minor vugular porosity
	good permeability
2346-2349	medium gray to lt brown; moderately indurated crystalline to microcrystalline
	dolostone; good to excellent pin-hole & vugular porosity development; fast drilling through this
	interval; (excellent permeability)
2349-2350	Lt brown; moderately indurated; crystalline dolostone; very sucrosic
	excellent pin-hole & vugular porosity development; very fast drilling
	(excellent permeability)
2350-2354	medium brown; very well indurated crystalline dolostone; minor pin-hole
	porosity development; very crystalline in nature; moderate permeability
	very slow drilling through this interval; ** Lost 0.5 to 1.0 went back into the * granular to partially crystalline Dolostone.
	Kelly down @ 1715hrs Total drilling Time 4. hrs
	Ending Drilling of IWSD TW @ -2354 feet

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APPENDIX D

PETROLOGIC DATA

SOUTH FLORIDA WELL MANAGEMENT DISTRICT
CORE DESCRIPTIONS
IWSD-PW
COLLIER COUNTY, FLORIDA

Suwannee Limestone

Core Interval: 882.0 to 882.7 feet below land surface.

Description: Light gray to yellow gray colored, peloidal-coated quartz sand-intraclastic packstone with sandy, intraclastic rudstone from 882.2-882.4 feet below land surface.

Depositional Environment: Open lagoon shoal-back bank.

Core Interval: 882.7 to 887.5 feet below land surface.

Description: Yellowish gray to pale orange colored, very sandy-skeletal-peloidal packstone. The quartz sand component is moderately to well sorted with subangular to angular grains. This interval has fair scattered interparticle porosity with some scattered vugs.

Depositional Environment: Open lagoon shoal-algal mound

Core Interval: 887.5 to 888.7 feet below land surface.

Description: Pale yellow to yellowish gray colored, slightly laminated, sandy-intraclastic-peloidal packstone with algal laminations and scattered algal balls; fair to poor interparticle and scattered vug porosity. At interlaminated algae with scattered vugs and microporosity, small patches of microcrystalline to very fine crystalline dolomite with in interconnected vugs and traces of rudstone occur from 887.5 to 887.7 feet bls.

Depositional Environment: Restrictive lagoon

Core Interval: 888.7 to 889.4 feet below land surface.

Description: Skeletal-peloidal-intraclastic packstone, 5-30 mm rounded pebble size intraclasts, fair bivalve moldic porosity, (3-10 mm molds) with scattered .5 mm molds. At 888.9 feet bls are coated quartz sand grains.

Depositional Environment: Restrictive lagoon

Core Interval: 955 to 962.1 feet below land surface

Description: Yellowish-gray colored, moderately sorted skeletal phylloid algal-coated grain-peloidal packstone, slightly laminated with abundant echinoids. Good moldic interparticle porosity with scattered algal molds and secondary vugs.

At 957.8 feet bls

Sandy-peloidal-echinoid grainstone, slightly cemented echinoid overgrowths, very good interparticle porosity with trace of intraparticle (foram) porosity.

At 960.7 feet bls
Sandy echinoid-bryozoan grainstone, abundant secondary vugs and floating grains with very good vuggy and interparticle porosity.

At 961.4 feet bls
Peloidal-echinoid grainstone, slightly recrystallized and dolomitized, with minor quartz sand content, very good vuggy porosity with traces of dolomite rim cement.

Depositional Environment: Open lagoon shoal flank-backbank

Core Interval: 1,040 to 1,041 feet below land surface
Description: Yellowish-gray, sandy coquina, friable, very fine to fine grained quartz sand, minor pelecypod wackestone, poor vuggy porosity development.

Depositional Environment: Open lagoon shoal flank-shoal

Core Interval: 1,041 to 1,044 feet below land surface
Description: Yellowish gray, sandy, intraclastic-ostracod-pelecypod-peloidal wackestone with scattered moldic porosity, poor vuggy and interparticle porosity development.

Depositional Environment: Open lagoon

Core Interval: 1,044 to 1,049.7 feet below land surface
Description: Grayish orange to yellowish gray brown, moderately to well sorted sandy peloidal, coquina. This interval has very good vuggy and pelecypod moldic porosity with scattered oversized vugs, parts of which are occluded by secondary calcite cement.

Depositional Environment: Open lagoon-shoal

Core Interval: 1,060 to 1,062.2 feet below land surface
Description: Gastropod-peloidal-pelecypod wackestone-packstone with fair scattered moldic porosity, some interparticle porosity, trace intraparticle, good interconnected molds.

Depositional Environment: Open lagoon-shoal

Core Interval: 1,080 to 1,089.1 feet below land surface
Description: Yellowish gray colored with very light gray intraclasts, gastropod-echinoid-pelecypod-foram peloidal packstone. This interval has good interparticle porosity and fair intraparticle to moldic porosity, contains scattered large molds (molds 0.5 to 2.5 mm in size), with few intraclasts (2.5 to 8 cm in size).

Depositional Environment: Back bank

Core Interval: 1,090 to 1,096 feet below land surface

Description: Yellowish gray colored, foram-peloidal packstone, fair very fine-fine size interparticle porosity, poor interparticle porosity at 1093 feet bls. This interval contains scattered intraparticle porosity and minor moldic porosity with traces of molluscan and scattered bryozoan fragments.

Description: Open lagoon-shoal

Core Interval: 1,096 to 1,098 feet below land surface

Description: Yellowish gray colored, bryozoan-foram-peloidal grainstone which is highly burrowed. This interval possess very good interparticle porosity and a trace of moldic porosity. At 1097.7 feet bls there is slightly cemented, patchy interparticle and intraparticle porosity with a trace of dolomite and crystalline rim cement.

Description: Open lagoon shoal-back bank

KEY TO CORE DESCRIPTIONS

Rock Type

COQ	Coquina
G	Grainstone
P	Packstone
R	Rudstone
W	Wackestone

Grain Size

C	Coarse
F	Fine
G	Granule
M	Medium
P	Pebble
VF	Very Fine

Porosity Visual Dominant, Porosity Visual Other

F	Fair
G	Good
P	Poor
VG	Very Good

Porosity Dominant, Porosity Other

BP	Between Particles
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

REXL	Recrystallization
SL	Slight
TR	Trace
W	Well

Laminations

INCL	Inclined
SL	Slight
T	Thin
VT	Very Thin

Sorting

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

Glauconite

SL	Slight

Sand

S	Some
SL	Slight
V	Very
VSL	Very Slight

Dolomite

SL	Slight
TR	Trace

Table 1. Petrologic Summary for 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	Sand Content	Dolomite
882.0 - 882.7	P-R	VF-G	F	BP-V	TR	WP	F-C	LV-VC	TR		VP	S	
882.7 - 887.5	P-R	F-VC-P	F	BP	F	V	F-M	TR C-VC			MW	V	
887.5 - 888.7	P-R	F-P	F	BP	F	V	VF-F	C-VC		SL	VP	SL	PATCH
888.7 - 889.4	R	P	F	MO			MO 3-10MM	TR VC	W		P	V	
955.0 - 962.1	P		G	MO-BP	F	V	F-M	C-VC	TR	SL	M	V	TR RIM
1040.0 - 1041.0	COQ	VF-F-P	P	V			F-M		TR		P	VSL	
1041.0 - 1044.0	W	VF-P	F	MO	P	V-BP	VF-F	C-VC			VP		
1044.0 - 1049.7	COQ	F-P	VG	V-MO	F	LV-MO	VF-P	F	SL		MW	SL	
1060.0 - 1062.2	P	VF-G	F	MO	F	BP-WP	VC-P	P			VP	SL	
1080.0 - 1089.1	P	VF-C-P	G	BP	F	WP-MO-LV	VF-F	5% C-G			P	VSL	TR RIM
1090.0 - 1096.0	P	F-M	P	BP	F	WP-MO	VF-F	C-VC			W		
1096.0 - 1098.0	P	F-M	VG	BP	TR	MO	F-M	C-VC	5%		W		TR RIM

Table 2. Summary of Petrophysical Analyses.

Core No.	Sample Number	Depth feet (bls)	Horizontal Permeability millidacy	Vertical Permeability millidarcy	Porosity Helium percent	Grain Density g/cm3
1	1H-V	882.9	185.4	115.0	19.5	2.70
	2H-V	883.7	171.2	97.3	23.1	2.70
	3H-V	884.5	76.2	44.8	22.1	2.69
	4H-V	885.2	316.0	18.2	19.8	2.70
	5H-V	886.4	42.2	37.4	18.4	2.69
		Mean	**158.2**	**62.5**	**20.6**	**2.70**
		Standard Deviation	**171.2**	**44.8**	**19.8**	**2.70**
1	6H-V	887.8	52.1	24.5	19.3	2.70
	7H-V	888.3	69.4	32.1	23.2	2.70
	8H	889.1	1296.0		32.9	2.71
		Mean	**472.5**	**28.3**	**25.1**	**2.70**
		Standard Deviation	**69.4**	**28.3**	**23.2**	**2.70**
2	9H	955.1	240.5		23.7	2.69
	10H	956.3	3744.0		34.7	2.69
	11H-V	957.0	2046.6	1733.0	35.0	2.71
	12H	958.4	2492.1		35.1	2.69
	13H	959.5	3523.5		35.4	2.69
	14H	961.0	3902.2		35.9	2.69
	15H	961.6	13507.0		39.1	2.70
		Mean	**4208.0**		**34.1**	**2.69**
		Standard Deviation	**3523.5**		**35.1**	**2.69**
3	16H	1040.9	633.4		25.2	2.70
3	17H-V	1041.5	1041.0	141.8	25.3	2.68
	18H-V	1042.7	483.8	301.0	29.8	2.70
	19H-V	1043.6	3088.3	1899.0	31.5	2.74
		Mean	**1537.7**	**780.6**	**28.9**	**2.71**
		Standard Deviation	**1041.0**	**301.0**	**29.8**	**2.70**
3	20H-V	1044.2	6132.6	4123.0	34.7	2.78
	21H-V	1045.5	3043.1	944.0	33.0	2.79
	22H-V	1046.5	3720.0	721.0	32.4	2.80
	23H-V	1047.7	3546.4	1955.0	37.8	2.83
	24H-V	1048.3	7179.9	1342.0	36.6	2.82
	25H-V	1049.2	9539.0	1255.0	35.0	2.85
		Mean	**5526.8**	**1723.3**	**34.9**	**2.81**
		Standard Deviation	**4926.3**	**1298.5**	**34.9**	**2.81**
4	26H	1060.8	14720.0		26.3	2.72
	27H	1061.5	10018.0		25.8	2.71
		Mean	**12369.0**		**26.1**	**2.72**
5	28H-V	1080.7	1621.1	387.0	27.7	2.73
	29H-V	1081.6	12.4	1.2	22.9	2.71
	30H-V	1082.5	844.0	16.9	28.8	2.79
	31H-V	1084.0	241.3	9.3	28.1	2.72
	32H-V	1085.0	237.0	25.0	28.7	2.70
	33H-V	1086.7	34.8	21.9	26.0	2.71
	34H-V	1087.8	41.0	42.6	27.0	2.71
	35H	1088.9	280.5		34.2	2.71
		Mean	**414.0**	**72.0**	**27.9**	**2.72**
		Standard Deviation	**239.2**	**21.9**	**27.9**	**2.71**
6	36H	1090.2	106.5		25.7	2.72
	37H-V	1091.4	230.5	158.0	36.2	2.69
	38H-V	1092.7	386.8	394.0	40.7	2.69
	39H-V	1093.6	182.1	162.0	39.0	2.69
	40H-V	1094.5	149.7	146.0	41.2	2.69
	41H-V	1095.7	321.7	327.0	36.5	2.70
		Mean	**229.5**	**237.4**	**36.6**	**2.70**
		Standard Deviation	**206.3**	**162.0**	**37.8**	**2.69**
	42H-V	1096.6	270.2	228.0	26.8	2.70
	43H	1097.5	1581.3		40.2	2.72
		Mean	**925.7**		**33.5**	**2.71**

feet bls = feet below land surface
g/cm^3 = grams per cubic centimeter

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

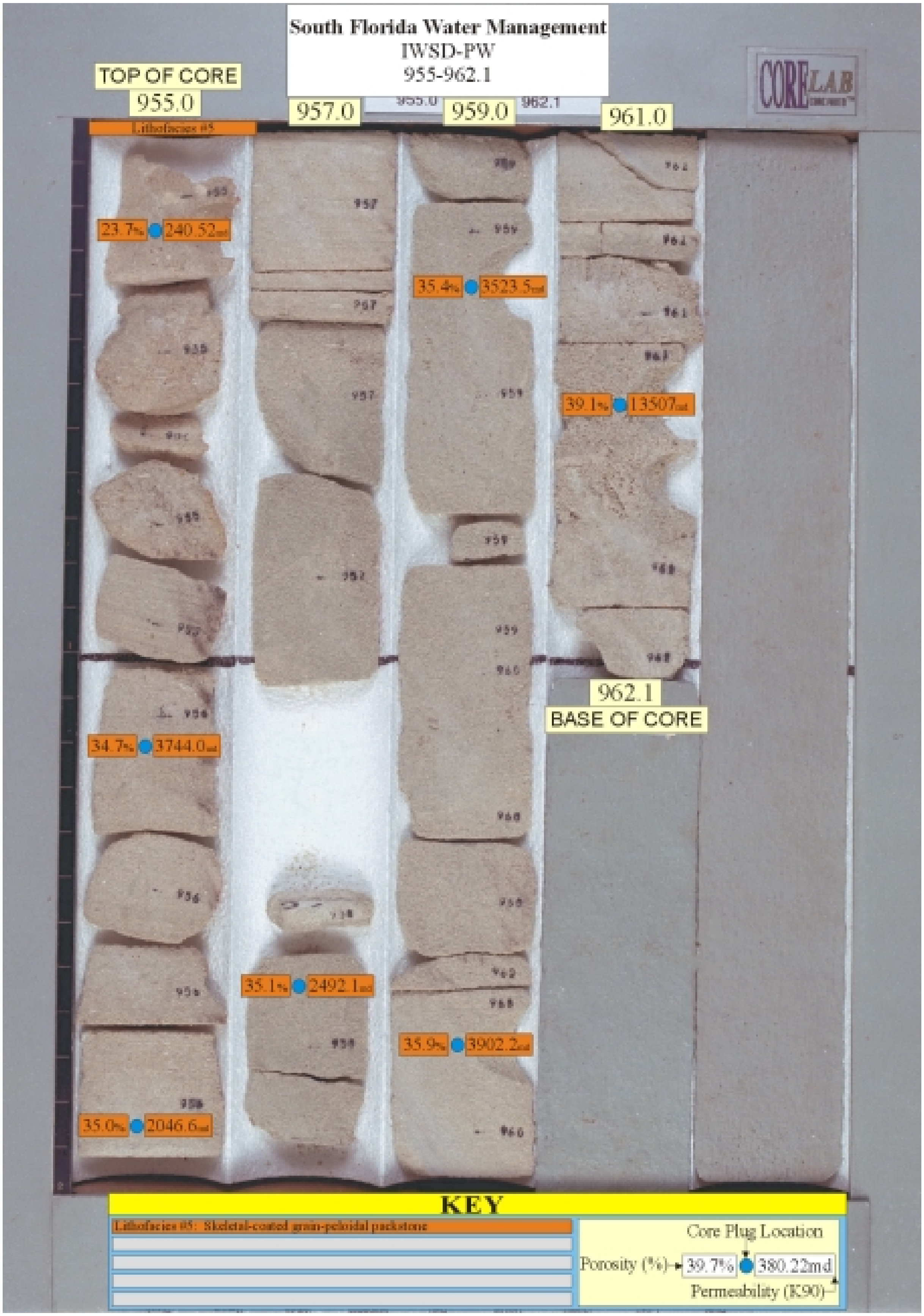
Core No.	Sample Number	Depth feet (bls)	Lithofacies	Depositional Environment	Horizontal Permeability millidacy	Vertical Permeability millidarcy	Porosity Helium percent	Grain Density g/cm3
1	1H-V	882.9	Sandy skeletal-peloidal packstone	Open Lagoon Shoal-Algal Mound	185.4	115.0	19.5	2.70
	2H-V	883.7	Sandy skeletal-peloidal packstone	Open Lagoon Shoal-Algal Mound	171.2	97.3	23.1	2.70
	3H-V	884.5	Sandy skeletal-peloidal packstone	Open Lagoon Shoal-Algal Mound	76.2	44.8	22.1	2.69
	4H-V	885.2	Sandy skeletal-peloidal packstone	Open Lagoon Shoal-Algal Mound	316.0	18.2	19.8	2.70
	5H-V	886.4	Sandy skeletal-peloidal packstone	Open Lagoon Shoal-Algal Mound	42.2	37.4	18.4	2.69
				Mean	**158.2**	**62.5**	**20.6**	**2.70**
				Median	**171.2**	**44.8**	**19.8**	**2.70**
1	6H-V	887.8	Sandy-peloidal packstone-boundstone	Restrictive Lagoon	52.1	24.5	19.3	2.70
	7H-V	888.3	Sandy-peloidal packstone-boundstone	Restrictive Lagoon	69.4	32.1	23.2	2.70
	8H	889.1	Skeletal-peloidal intraclastic-packstone	Restrictive Lagoon	1296.0		32.9	2.71
				Mean	**472.5**	**28.3**	**25.1**	**2.70**
				Median	**69.4**	**28.3**	**23.2**	**2.70**
2	9H	955.1	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	240.5		23.7	2.69
	10H	956.3	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	3744.0		34.7	2.69
	11H-V	957.0	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	2046.6	1733.0	35.0	2.71
	12H	958.4	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	2492.1		35.1	2.69
	13H	959.5	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	3523.5		35.4	2.69
	14H	961.0	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	3902.2		35.9	2.69
	15H	961.6	Sketetal-pelodial packstone	Open Lagoon Shoal Flank	13507.0		39.1	2.70
				Mean	**4208.0**		**34.1**	**2.69**
				Median	**3523.5**		**35.1**	**2.69**
3	16H	1040.9	Pelecypod-coquina wackestone	Open Lagoon Shoal Flank	633.4		25.2	2.70
3	17H-V	1041.5	S-ostracod-pelecypod-peloidal wackestone	Open Lagoon	1041.0	141.8	25.3	2.68
	18H-V	1042.7	S-ostracod-pelecypod-peloidal wackestone	Open Lagoon	483.8	301.0	29.8	2.70
	19H-V	1043.6	S-ostracod-pelecypod-peloidal wackestone	Open Lagoon	3088.3	1899.0	31.5	2.74
				Mean	**1537.7**	**780.6**	**28.9**	**2.71**
				Median	**1041.0**	**301.0**	**29.8**	**2.70**
3	20H-V	1044.2	Peloidal-pelecypod coquina	Open Lagoon-Shoal	6132.6	4123.0	34.7	2.78
	21H-V	1045.5	Peloidal-pelecypod coquina	Open Lagoon-Shoal	3043.1	944.0	33.0	2.79
	22H-V	1046.5	Peloidal-pelecypod coquina	Open Lagoon-Shoal	3720.0	721.0	32.4	2.80
	23H-V	1047.7	Peloidal-pelecypod coquina	Open Lagoon-Shoal	3546.4	1955.0	37.8	2.83
	24H-V	1048.3	Peloidal-pelecypod coquina	Open Lagoon-Shoal	7179.9	1342.0	36.6	2.82

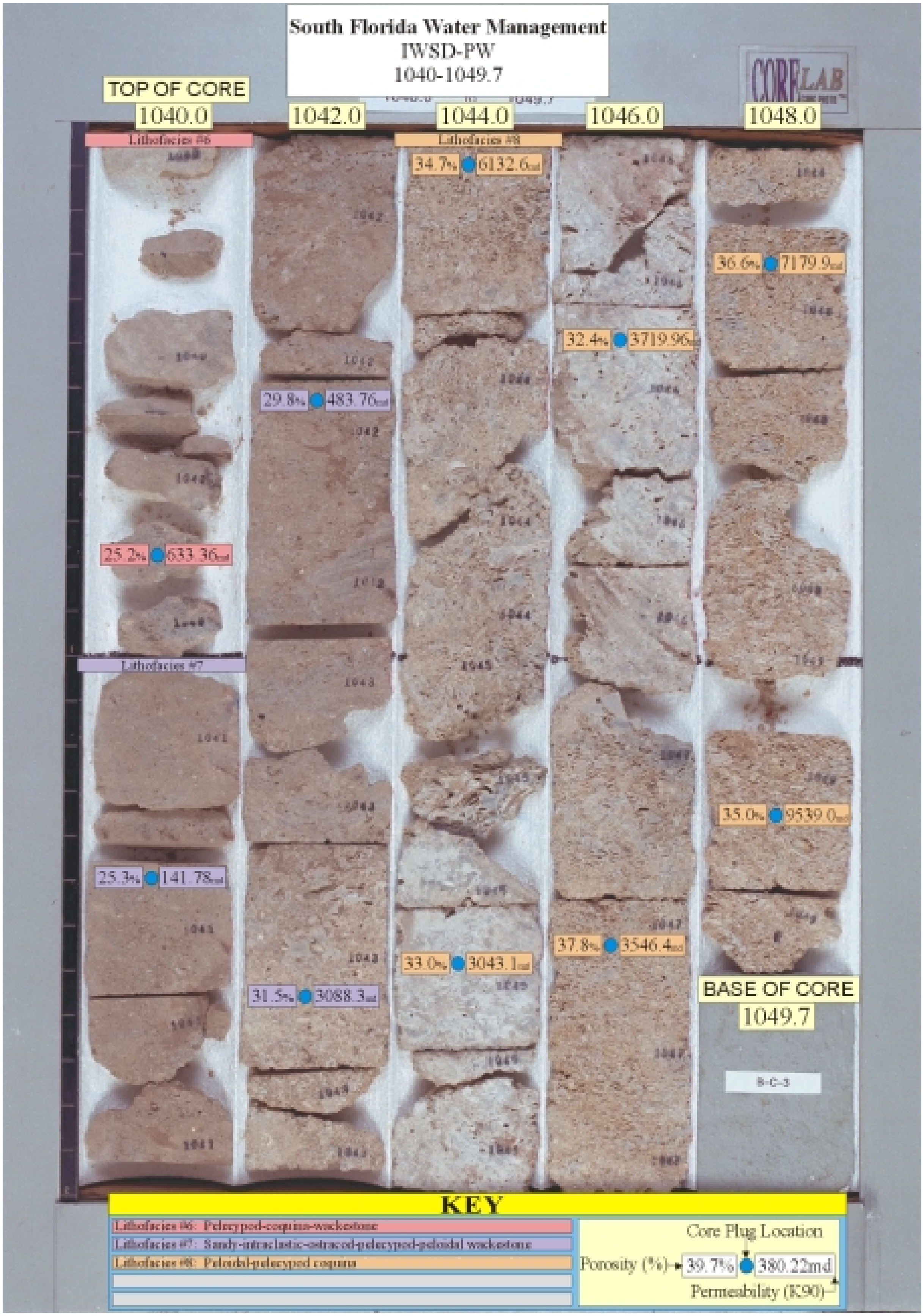
Core No.	Sample Number	Depth feet (bls)	Lithofacies	Depositional Environment	Horizontal Permeability millidacy	Vertical Permeability millidarcy	Porosity Helium percent	Grain Density g/cm3
	25H-V	1049.2	Peloidal-pelecypod coquina	Open Lagoon-Shoal	9539.0	1255.0	35.0	2.85
				Mean	**5526.8**	**1723.3**	**34.9**	**2.81**
				Median	**4926.3**	**1298.5**	**34.9**	**2.81**
4	26H	1060.8	Pelodial-pelecyod-wackestone-packstone	Open Lagoon-Shoal	14720.0		26.3	2.72
	27H	1061.5	Pelodial-pelecyod-wackestone-packstone	Open Lagoon-Shoal	10018.0		25.8	2.71
				Mean	**12369.0**		**26.1**	**2.72**
5	28H-V	1080.7	Intraclastic-echnoid-peleypod-foram packstone	Backbank	1621.1	387.0	27.7	2.73
	29H-V	1081.6	Intraclastic-echnoid-peleypod-foram packstone	Backbank	12.4	1.2	22.9	2.71
	30H-V	1082.5	Intraclastic-echnoid-peleypod-foram packstone	Backbank	844.0	16.9	28.8	2.79
	31H-V	1084.0	Intraclastic-echnoid-peleypod-foram packstone	Backbank	241.3	9.3	28.1	2.72
	32H-V	1085.0	Intraclastic-echnoid-peleypod-foram packstone	Backbank	237.0	25.0	28.7	2.70
	33H-V	1086.7	Intraclastic-echnoid-peleypod-foram packstone	Backbank	34.8	21.9	26.0	2.71
	34H-V	1087.8	Intraclastic-echnoid-peleypod-foram packstone	Backbank	41.0	42.6	27.0	2.71
	35H	1088.9	Intraclastic-echnoid-peleypod-foram packstone	Backbank	280.5		34.2	2.71
				Mean	**414.0**	**72.0**	**27.9**	**2.72**
				Median	**239.2**	**21.9**	**27.9**	**2.71**
6	36H	1090.2	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	106.5		25.7	2.72
	37H-V	1091.4	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	230.5	158.0	36.2	2.69
	38H-V	1092.7	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	386.8	394.0	40.7	2.69
	39H-V	1093.6	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	182.1	162.0	39.0	2.69
	40H-V	1094.5	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	149.7	146.0	41.2	2.69
	41H-V	1095.7	Foram-peloidal-packstone-grainstone	Open Lagoon-Shoal	321.7	327.0	36.5	2.70
				Mean	**229.5**	**237.4**	**36.6**	**2.70**
				Median	**206.3**	**162.0**	**37.8**	**2.69**
	42H-V	1096.6	Bryozoan-foram-peloidal grainstone	Open Lagoon-Shoal-Backbank	270.2	228.0	26.8	2.70
	43H	1097.5	Bryozoan-foram-peloidal grainstone	Open Lagoon-Shoal-Backbank	1581.3		40.2	2.72
				Mean	**925.7**		**33.5**	**2.71**

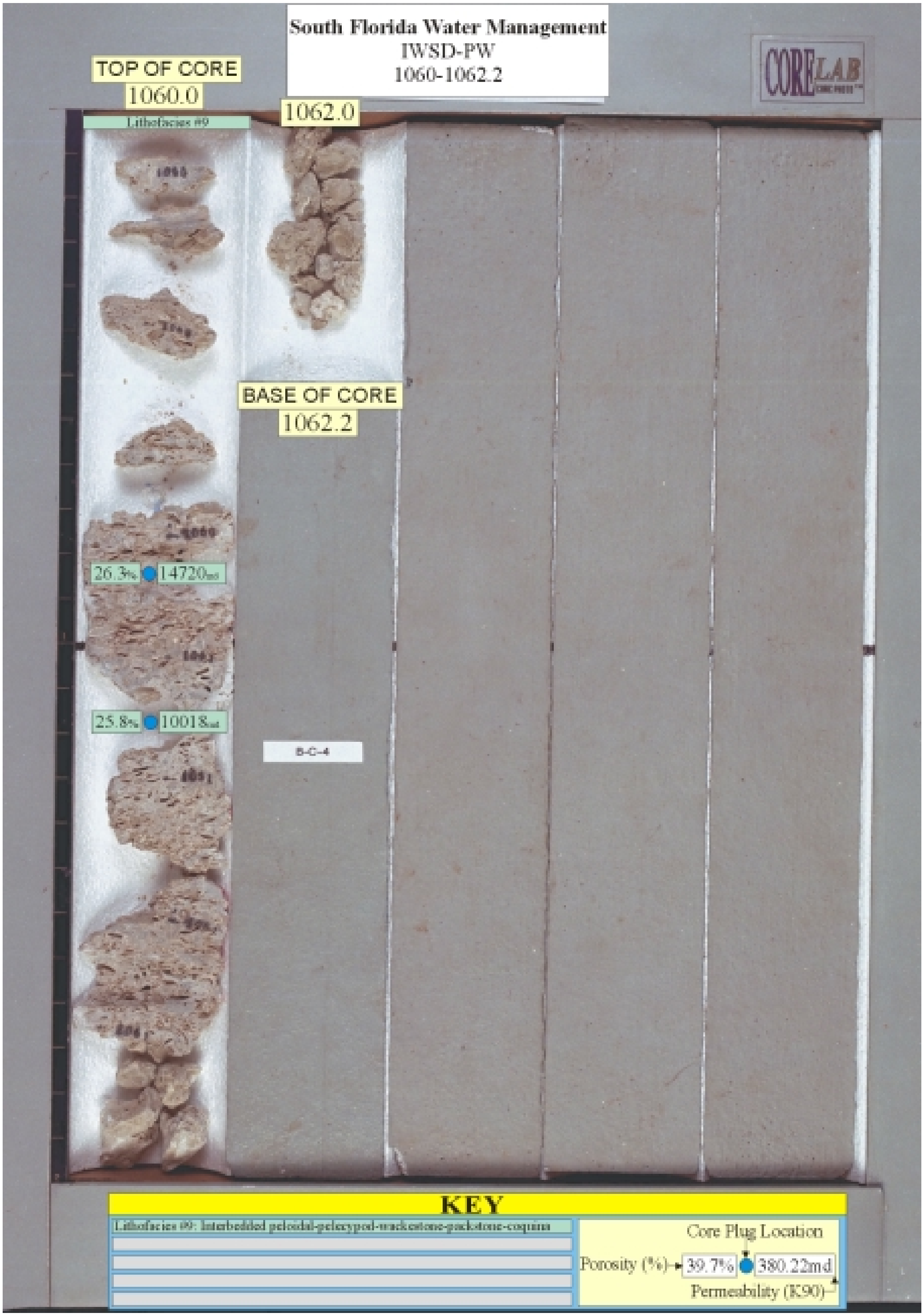
feet bls = feet below land surface

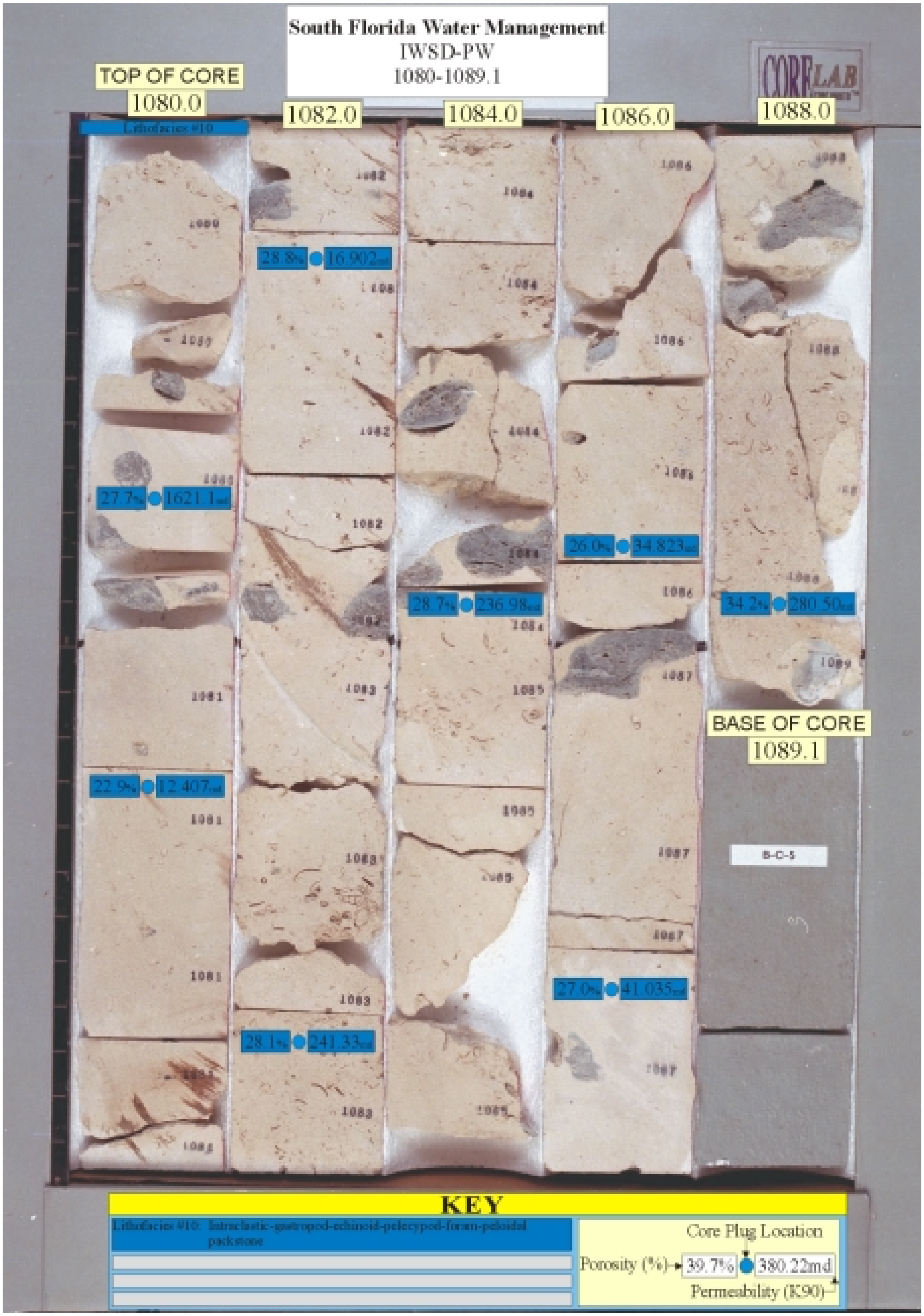
g/cm^3 = grams per cubic centimeter


South Florida Water Management
IWSD-PW
882-889.4
TOP OF CORE
882.0
884.0
886.0
888.0
Lithofacies #1
Lithofacies #2
Lithofacies #3
Lithofacies #4
19.5% 185.42md
23.1% 171.22md
22.1% 76.249md
19.8% 3160.6md
18.4% 42.164md
19.3% 52.090md
23.2% 69.448md
32.9% 1295.6md
889.4
BASE OF CORE
KEY
Lithofacies #1: Peloidal-coated quartz-intraclastic packstone
Lithofacies #2: Very sandy skeletal-intraclastic-peloidal packstone
Lithofacies #3: Slightly sandy-intraclastic peloidal packstone w/algal boundstone
Lithofacies #4: Skeletal-peloidal-intraclastic packstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)


South Florida Water Management
IWSD-PW
955-962.1
TOP OF CORE
955.0
957.0
959.0
961.0
Lithofacies #5
23.7% 240.52md
35.4% 3523.5md
39.1% 13507md
962.1
BASE OF CORE
34.7% 3744.0md
35.1% 2492.1md
35.9% 3902.2md
35.0% 2046.6md
KEY
Lithofacies #5: Skeletal-coated grain-peloidal packstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)


South Florida Water Management
IWSD-PW
1040-1049.7
TOP OF CORE
1040.0
1042.0
1044.0
1046.0
1048.0
Lithofacies #6
Lithofacies #7
Lithofacies #8
34.7% 6132.6md
36.6% 7179.9md
32.4% 3719.96md
29.8% 483.76md
25.2% 633.36md
35.0% 9539.0md
25.3% 141.78md
37.8% 3546.4md
33.0% 3043.1md
31.5% 3088.3md
BASE OF CORE
1049.7
KEY
Lithofacies #6: Pelecypod-coquina-wackestone
Lithofacies #7: Sandy-intraclastic-ostracod-pelecypod-peloidal wackestone
Lithofacies #8: Peloidal-pelecypod coquina
Core Plug Location
Porosity (%) 39.7% 380.22md
Permeability (K90)

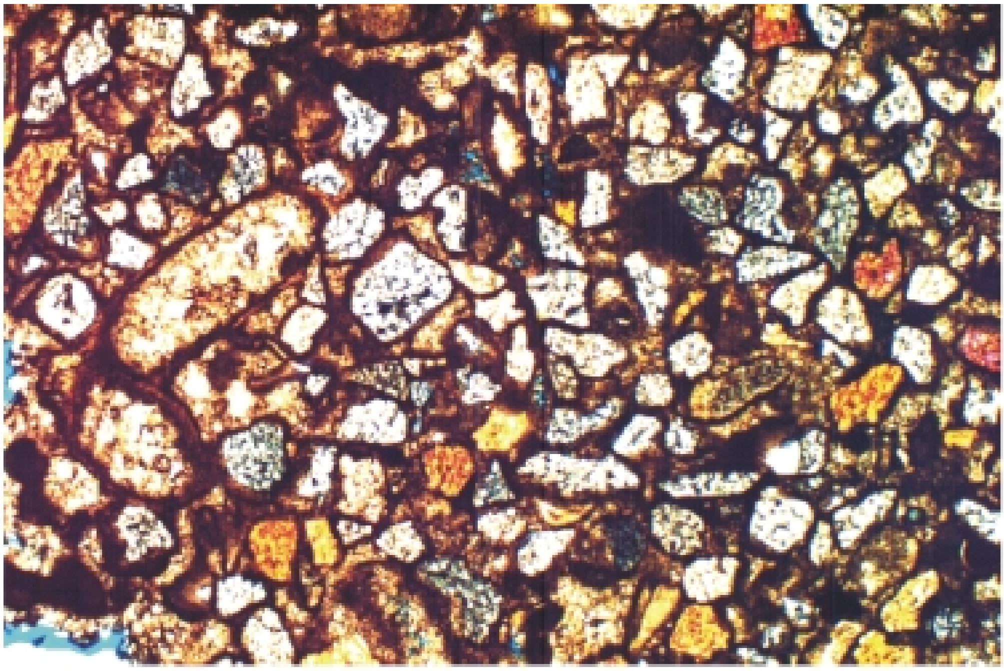

South Florida Water Management
IWSD-PW
1060-1062.2
TOP OF CORE
1060.0
Lithofacies #9
1062.0
BASE OF CORE
1062.2
26.3%
14720md
25.8%
10018md
B-C-4
KEY
Lithofacies #9: Interbedded peloidal-pelecypod-wackestone-packstone-coquina
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)


South Florida Water Management
IWSD-PW
1080-1089.1
TOP OF CORE
1080.0
1082.0
1084.0
1086.0
1088.0
Lithofacies #10
28.8% 16.902md
27.7% 1621.1md
26.0% 34.823md
28.7% 236.98md
34.2% 280.50md
22.9% 12.407md
27.0% 41.035md
28.1% 241.33md
BASE OF CORE
1089.1
KEY
Lithofacies #10: Intraclastic-gastropod-echinoid-pelecypod-foram-peloidal packstone
Core Plug Location
Porosity (%) 39.7% 380.22md
Permeability (K90)


South Florida Water Management
IWSD-PW
1090-1098
TOP OF CORE
1090.0
1092.0
1094.0
1096.0
1098.0
BASE OF CORE
Lithofacies #11
Lithofacies #12
25.7% 106.45md
36.2% 230.52md
40.7% 386.75md
39.0% 182.14md
41.2% 149.74md
36.5% 321.69md
26.8% 270.17md
40.2% 1581.3md
KEY
Lithofacies #11: Foram-peloidal packstone-grainstone
Lithofacies #12: Bryozoan-foram-peloidal grainstone
Core Plug Location
Porosity (%)
39.7%
380.22md
Permeability (K90)

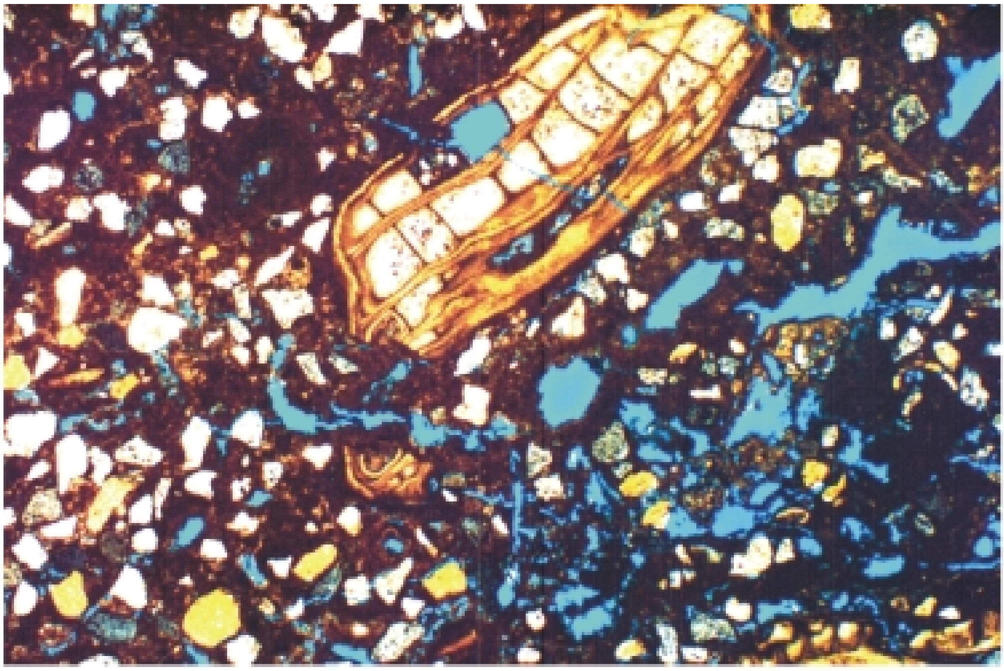
APPENDIX E

PHOTOMICROGRAPHS



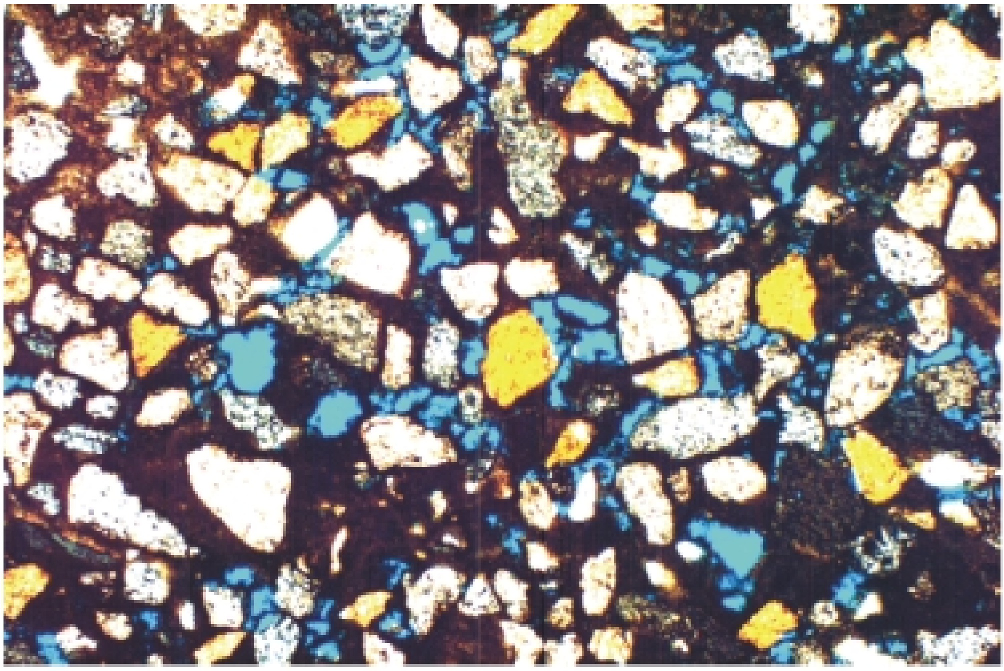
WELL: IWSD-PW
DEPTH: 882.2
MAGNIFICATION: X40

LITHOFACIES: PELOIDAL COATED SAND PACKSTONE WITH TRACES OF INTERPARTICLE POROSITY



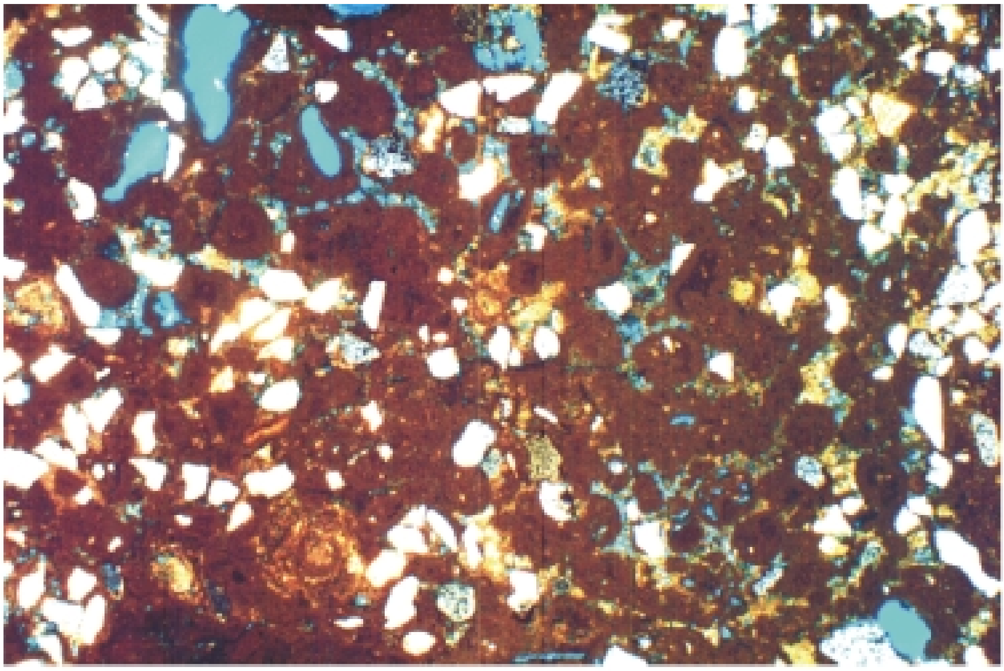
WELL: IWSD-PW
DEPTH: 882.9
MAGNIFICATION: X20

LITHOFACIES: COATED SAND INTRACLASTIC PELOIDAL PACKSTONE WITH FAIR VUGGY INTERPARTICLE POROSITY. LARGE BRYOZOAN FRAGMENT CONTAINS BLOCKY CALCITE CEMENT.



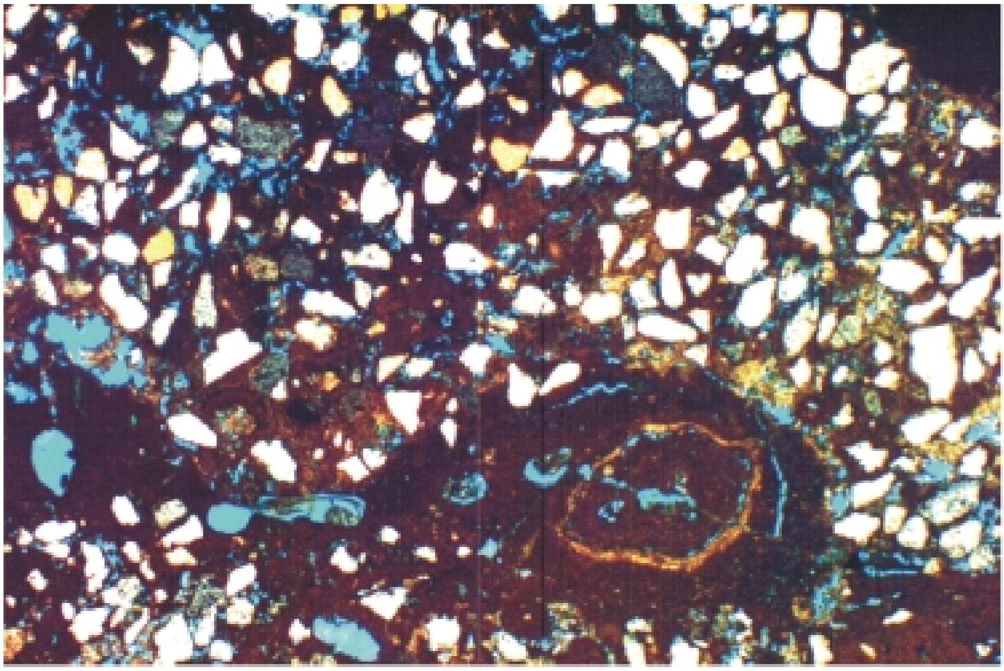
WELL: IWSD-PW
DEPTH: 886.1
MAGNIFICATION: X20, CROSS NICHOLS

LITHOFACIES: VERY SANDY-PELOIDAL PACKSTONE WITH FAIR INTERPARTICLE AND VUGGY POROSITY



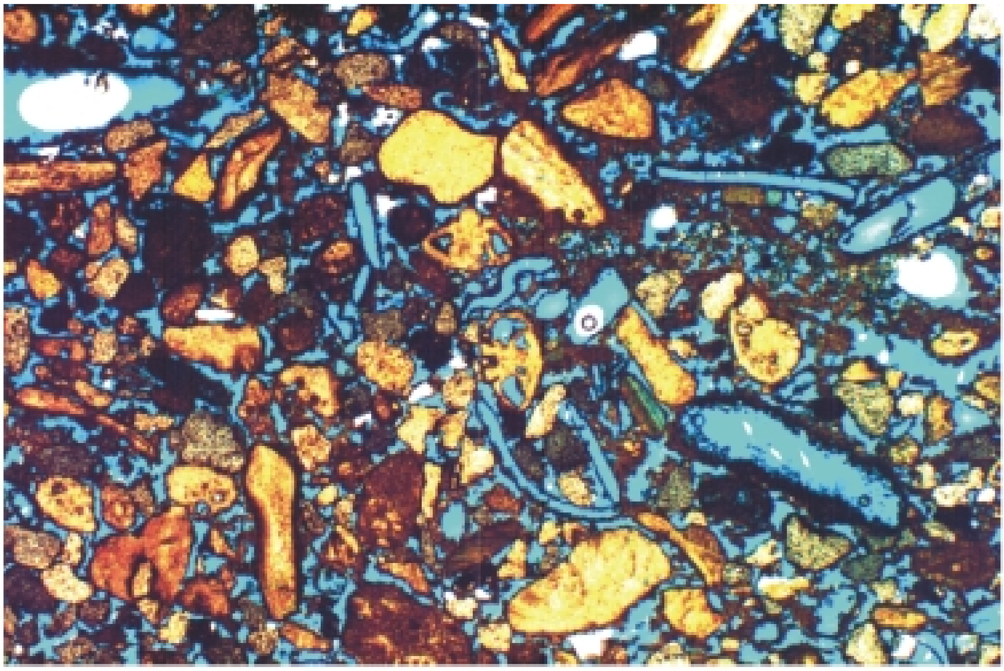
WELL: IWSD-PW
DEPTH: 887.6
MAGNIFICATION: X20, CROSS NICHOLS

LITHOFACIES: SLIGHTLY SANDY PELOIDAL PACKSTONE WITH FAIR INTERPARTICLE VUGGY POROSITY



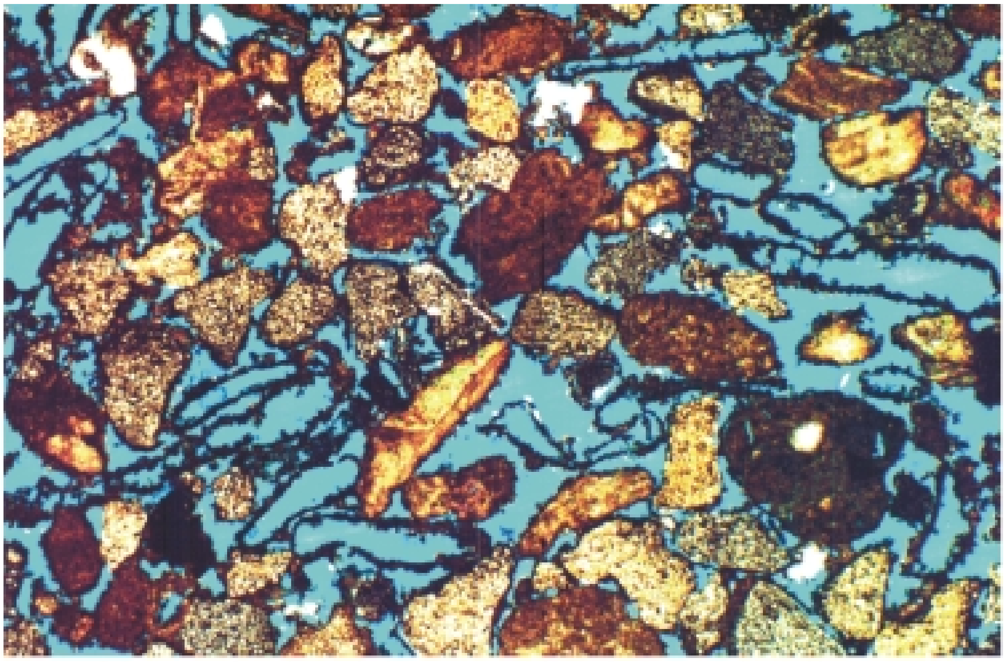
WELL: IWSD-PW
DEPTH: 887.6
MAGNIFICATION: X20, CROSS NICHOLS

LITHOFACIES: INTERLAMINATED SANDY PELOIDAL PACKSTONE AND PELOIDAL ALGAL BOUNDSTONE WITH FAIR INTERPARTICLE VUGGY POROSITY



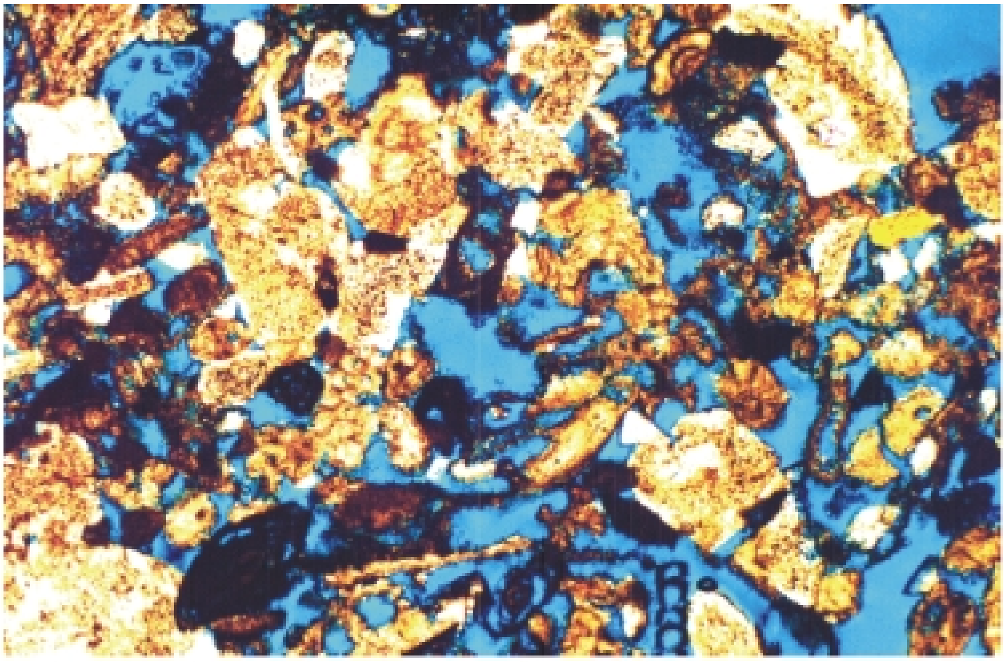
WELL: IWSD-PW
DEPTH: 955.4
MAGNIFICATION: X20, CROSS NICHOLS

LITHOFACIES: SKELETAL-COATED GRAIN-PELOIDAL PACKSTONE WITH GOOD INTERPARTICLE AND MOLDIC POROSITY



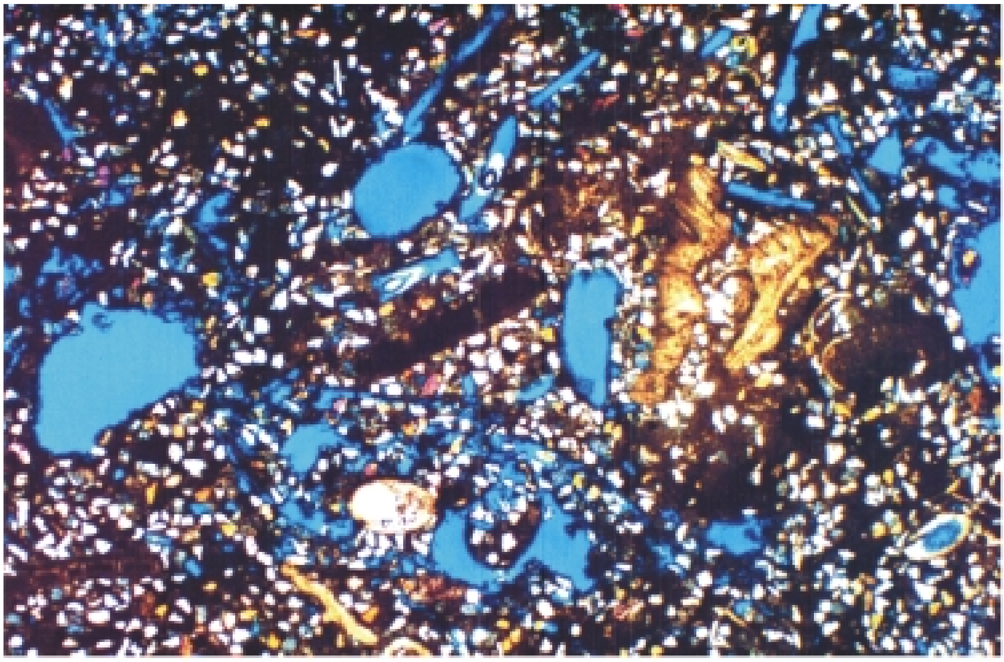
WELL: IWSD-PW
DEPTH: 955.4
MAGNIFICATION: X40, CROSS NICHOLS

LITHOFACIES: COATED SAND, COATED GRAIN PELOIDAL PACKSTONE WITH GOOD INTERPARTICLE AND MOLDIC POROSITY
NOTE: FLOATING COATING IS INDICATIVE OF A LATE STAGE OF LEACHING



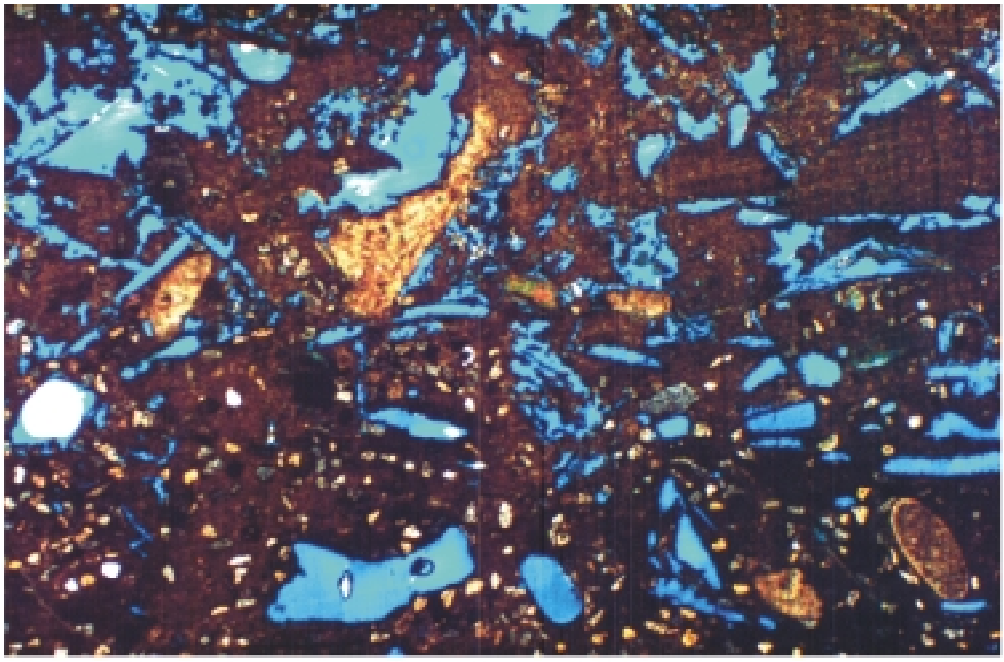
WELL: IWSD-PW
DEPTH: 957.8
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH SHOWING MINOR OVERGROWTH ON ECHINODERM FRAGMENTS AND GOOD INTERPARTICLE AND VUGGY POROSITY



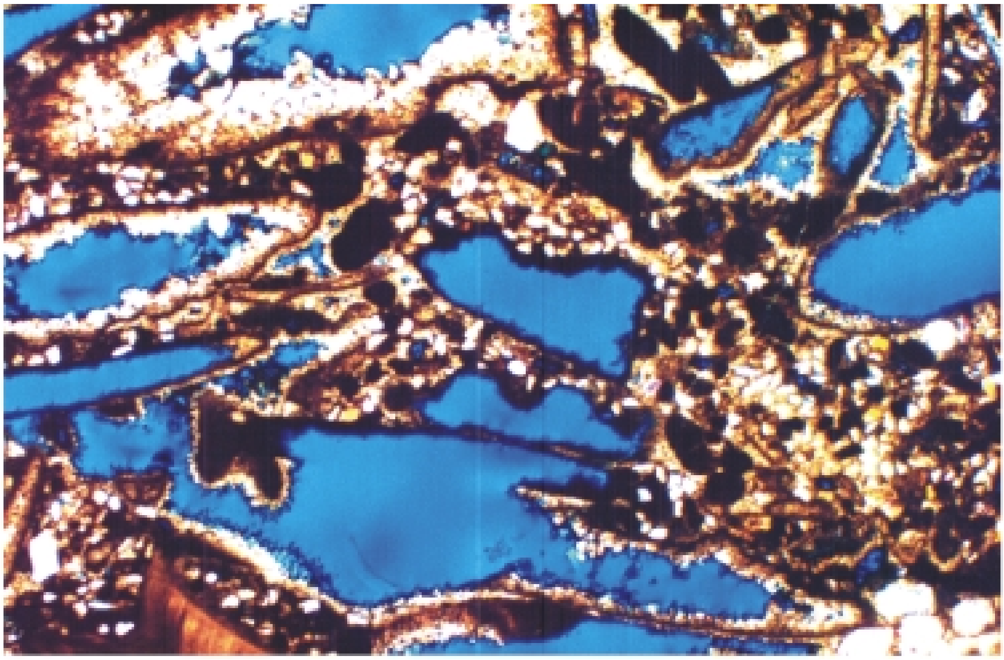
WELL: IWSD-PW
DEPTH: 1041.2
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF VERY SANDY INTRACLASTIC-PELECYPOD-PELOIDAL PACKSTONE WITH FAIR MOLDIC VUGGY POROSITY



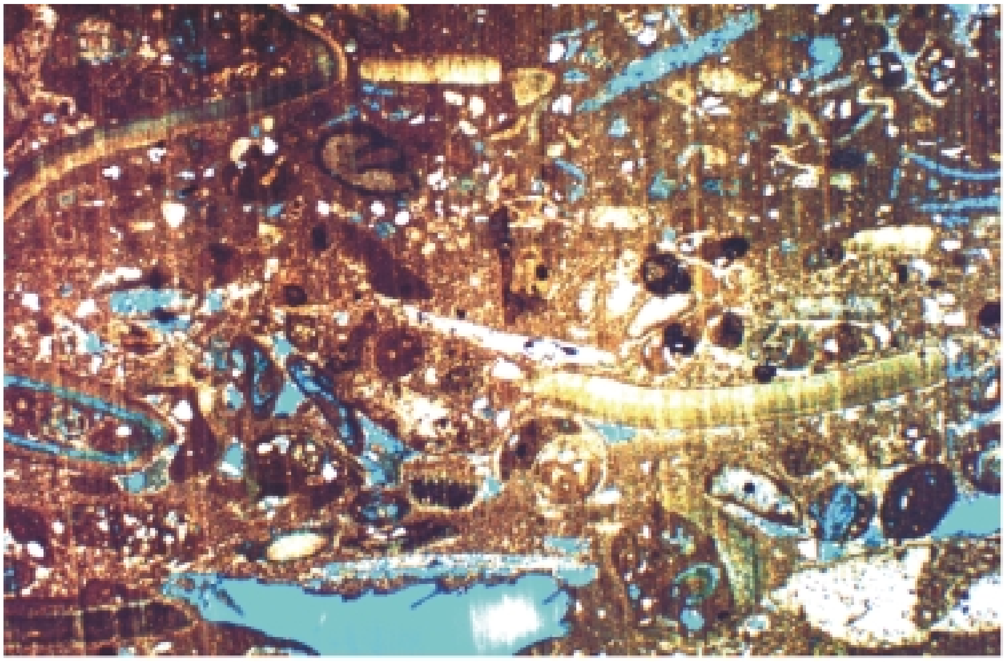
WELL: IWSD-PW
DEPTH: 1043.6
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF SLIGHTLY SANDY INTRACLASTIC-PELECYPOD-PELOIDAL WACKESTONE WITH FAIR MOLDIC POROSITY AND SOME VUGGY INTERPARTICLE POROSITY



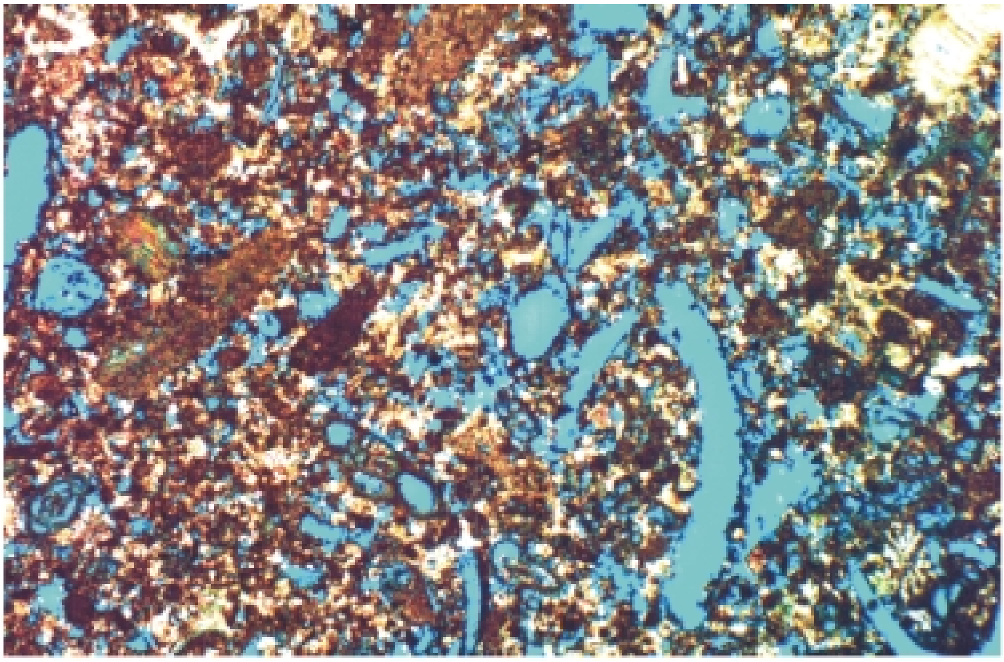
WELL: IWSD-PW
DEPTH: 1045.4
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF SLIGHTLY SANDY PELOIDAL-PELECYPOD COQUINA WITH GOOD SHELL MOLDIC AND VUG POROSITY. MOLDS ARE PARTLY OCCLUDED BY CALCITE RIM AND BLOCKY CALCITE CEMENTS.



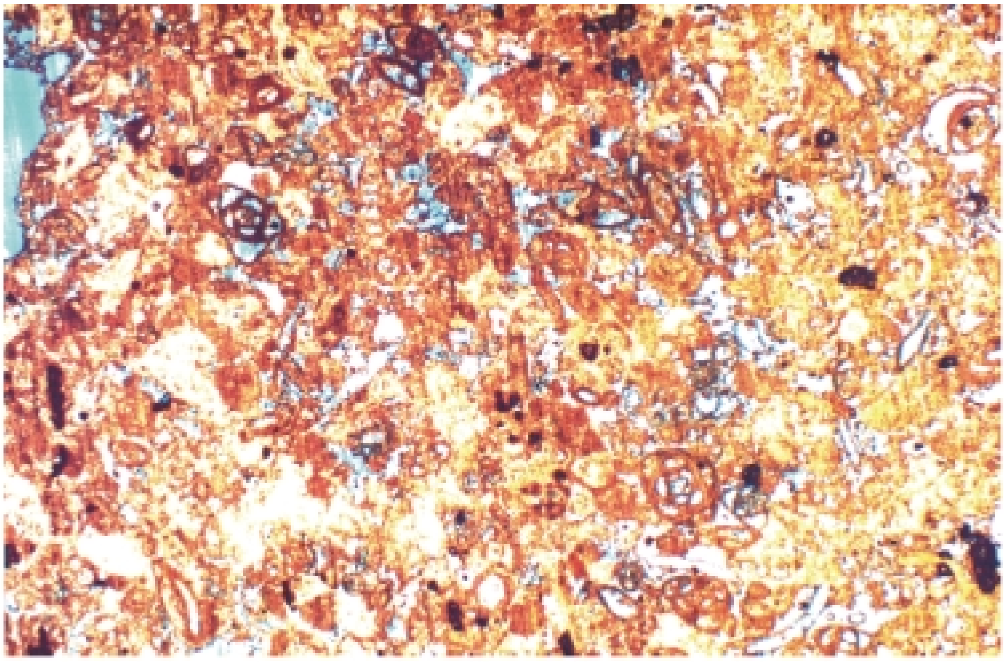
WELL: IWSD-PW
DEPTH: 1060.8
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF PELOIDAL PELECYPOD WACKESTONE PACKSTONE WITH FAIR MOLDIC, INTRAPARTICLE, AND INTERPARTICLE POROSITY.



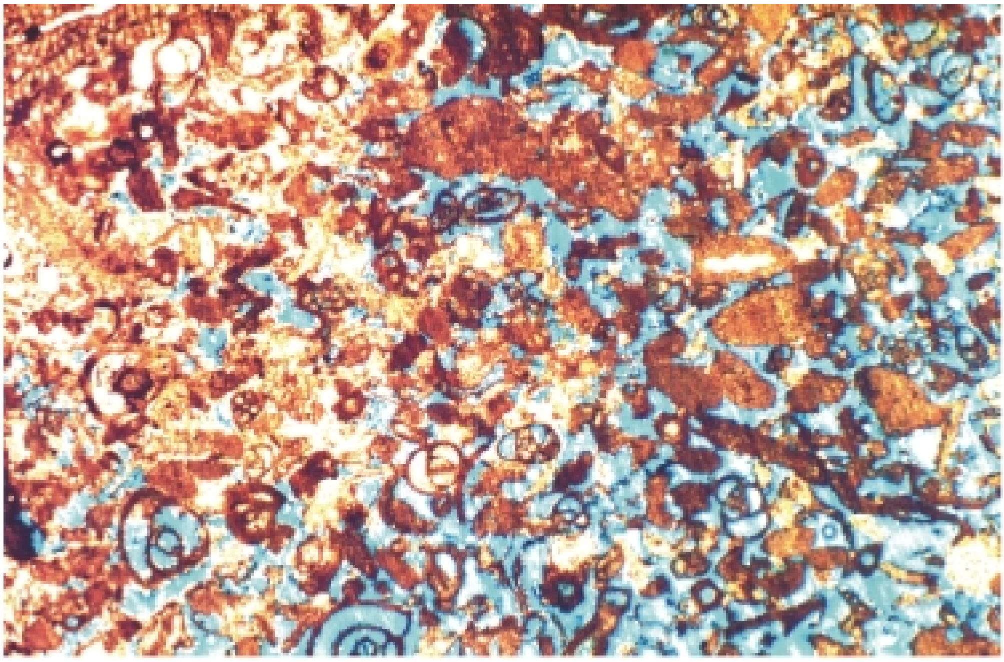
WELL: IWSD-PW
DEPTH: 1083.95
MAGNIFICATION: X20, CROSS NICHOLS

LITHOFACIES: INTRACLASTIC MOLLUSCAN FORAM PELOIDAL PACKSTONE WITH GOOD INTERPARTICLE AND MOLDIC POROSITY.



WELL: IWSD-PW
DEPTH: 1090.3
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF ECHINODERM-FORAM-PELOIDAL PACKSTONE WITH POOR INTERPARTICLE, AND FAIR FORAM INTRAPARTICLE POROSITY.



WELL: IWSD-PW
DEPTH: 1097.7
MAGNIFICATION: X20

LITHOFACIES: PHOTOMICROGRAPH OF FORAM-PELOIDAL PACKSTONE-GRAINSTONE WITH VERY GOOD INTERPARTICLE POROSITY, SOME FORAM INTRAPARTICLE , SCATTERED CEMENT OVERGROWTHS, AND RECRYSTALLIZATION