Southwest Florida Water Management District

Hydrogeology, Water Quality, and Well Construction at ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

Southwest Florida Water Management District
Regional Observation and Monitor-well Program

August 2011

Cover Photo: Rainbow River in 2005. Photograph by Richard Gant.

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By Tiffany Horstman

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Foreword

The Regional Observation and Monitor-well Program (ROMP) was started in 1974 in response to the need for hydrogeologic information by the Southwest Florida Water Management District (District). The focus of the ROMP is to quantify the flow characteristics and water quality of the groundwater systems which serve as the primary source of drinking water within southwest Florida. The original design of the ROMP consisted of a ten-mile grid network comprised of 122 well sites and a coastal transect network comprised of 24 coastal monitor transects of two to three wells sites each. Since its inception, the ROMP has taken on many more data collection and well construction activities outside these original two well networks. The broad objectives at each well site are to determine the geology, hydrology, water quality, and hydraulic properties, and install wells for long-term monitoring. The majority of these objectives are achieved by core drilling and testing, which provides data for the hydrogeologic characterization of the well site. The ROMP staff then uses this characterization to ensure the site's monitor wells are properly installed. The hydrologic data of each completed ROMP well site are presented in either an executive summary or report.

Each ROMP well site is given a unique number and a site name. The ten-mile grid network numbering starts in the southern District with ROMP No. 1 and generally increases northward. The coastal transect network numbering starts with ROMP TR 1 in the south and also increases northward.

Jerry L. Mallams
Manager

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Conversion Factors

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Hydraulic Conductivity		
foot per day (ft/d)	0.00035278	centimeter per second (cm/s)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F = (1.8 x °C) + 32

Abbreviations and Acronyms

als	above land surface
AQ	aquifer
bls	below land surface
btoc	below top of casing
$CaSO_4 \cdot 2H_2O$	gypsum
CH 2	core hole 2
CME	Central Mine Equipment
commun.	communication
Dia.	diameter
FLDN	Floridan
ft	feet
ft/d	feet per day
K	horizontal hydraulic conductivity
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
mg/L	milligrams per liter
NDWRAP	Northern District Water Resources Assessment Project
PVC	polyvinyl chloride
ROMP	Regional Observation and Monitor-well Program
SWFWMD	Southwest Florida Water Management District
TDS	total dissolved solids
U	Upper
UFA	Upper Floridan aquifer

Hydrogeology, Water Quality, and Well Construction at ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

By Tiffany Horstman

Introduction

The Southwest Florida Water Management District's (District) Regional Observation and Monitor-well Program (ROMP) obtained the ROMP 128 - Rainbow Springs well site in southwest Marion County, Florida to construct a dedicated groundwater monitoring station (fig. 1).

The ROMP 128 - Rainbow Springs well site was selected to fill a gap in the ROMP network. The ROMP 128 - Rainbow Springs well site is one of various well sites constructed for the Northern District Water Resources Assessment Project (NDWRAP). The NDWRAP was established to assess the impacts of groundwater withdrawals, monitor the freshwater/saltwater interface, identify areas of poor groundwater quality, determine the nature of flow to major springs, and monitor groundwater levels in both the surficial and Upper Floridan aquifers in the northern six-county region of the District. The Northern District encompasses all of Hernando, Citrus, and Sumter Counties and portions of Pasco, Polk, Marion, Lake, and Levy Counties. Additionally, this site was selected to help ascertain the geographic extent of the middle confining unit I and middle confining unit II.

The well site was developed in two phases: (1) shallow exploratory core drilling and testing, and (2) monitor well construction. Permanent monitor wells constructed at this site include three Upper Floridan aquifer wells. The layout for the ROMP 128 - Rainbow Springs well site is presented in figure 2. Phase 1 shallow core drilling and testing was performed from March 2009 to June 2009. Phase 2 monitor well construction was performed from September 2009 to December 2009. The purpose of this report is to present all of the activities performed and the data collected at the ROMP 128 - Rainbow Springs well site.

Site Location

The ROMP 128 - Rainbow Springs well site lies on a parcel of land in southwest Marion County approximately 1 mile east of Highway 41 and was granted by easement agreement from Marion County (fig. 1). The well site is located within the Withlacoochee River Basin in the northeast ¼ of the northwest ¼ of the northwest ¼ of Section 7, Township 16 south, and Range 19 east. The well site coordinates are latitude 29° 6' 43.25" and longitude 82° 25' 57.99". The ROMP 128 - Rainbow Springs well site is located approximately ¾ mile northeast of the head of the Rainbow River and its head spring area. The elevation at the well site is approximately 48 feet above the North American Vertical Datum of 1988 (NAVD 88).

The ROMP 128 - Rainbow Springs well site can be found by heading north on Interstate 75 for approximately 86 miles from Tampa. Take exit 352 for State Highway 40 and turn left toward Dunnellon. Proceed on State Highway 40 for approximately 16 miles. Turn left onto SW 185th Avenue Road and follow for 1 mile. Turn right at SW 77th Place Road. The ROMP 128 - Rainbow Springs well site is approximately half a mile on the right.

The well site is located in the Western Valley physiographic region of west-central Florida (White, 1970). At the well site, the Western Valley lowlands are located between the Brooksville Ridge to the west and the Cotton Plant Ridge to the east. The Withlacoochee River Basin is the dominant physical feature of the valley. The ROMP 128 - Rainbow Springs well site is located in an area that has been extensively modified by karst processes (Jones and others, 1996).

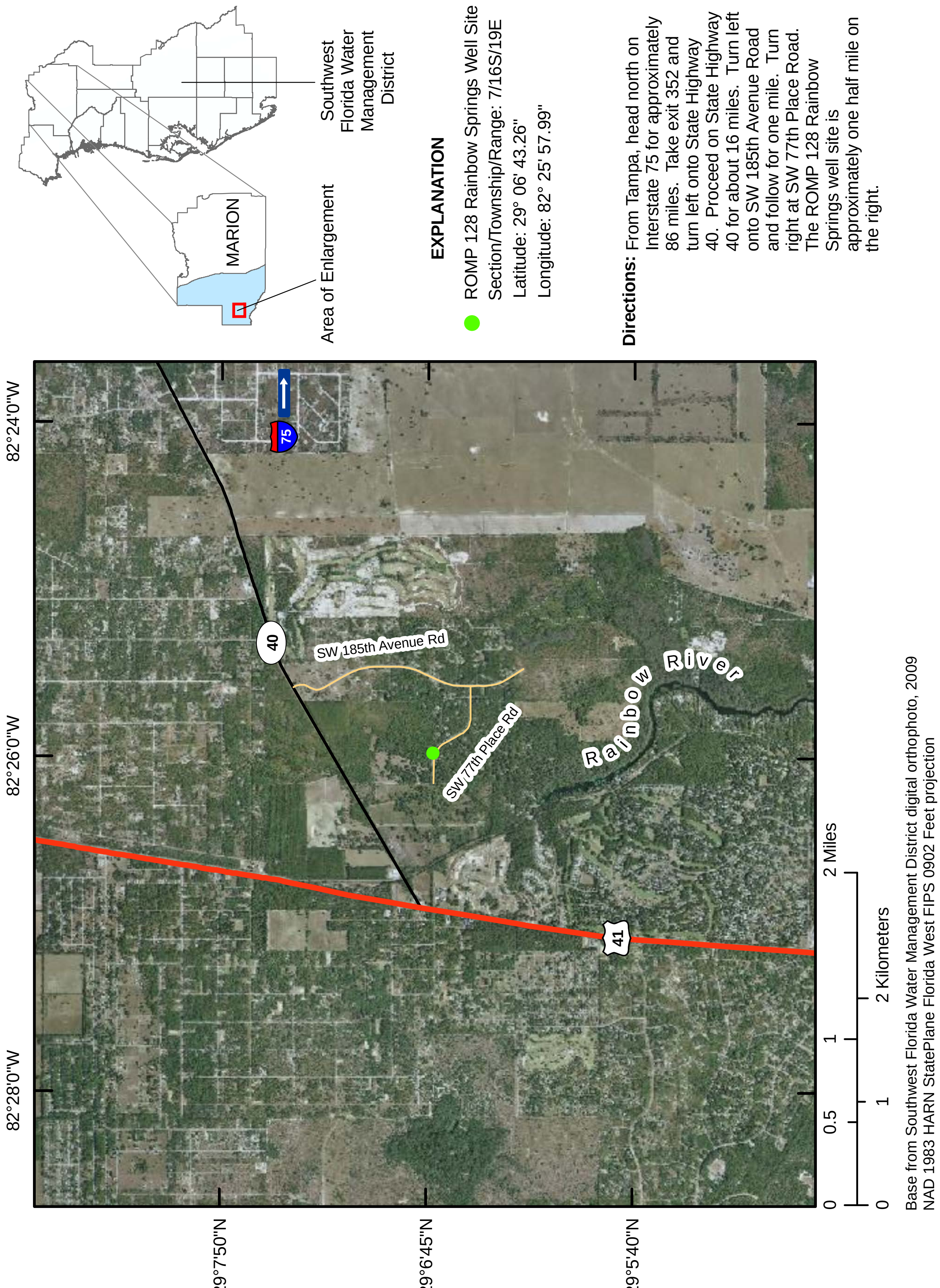


Figure 1. Location of the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

Figure 2. Well site layout for the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

Methods

During construction of each ROMP well site, a variety of hydrogeologic data is collected including lithologic, water level, water quality, and hydraulic data. The data are used to define the hydrogeologic characteristics of the District. The wireline core drilling method was used to collect continuous lithologic samples. Hydraulic data were collected by slug testing borehole intervals isolated with an off-bottom packer or the HW (4-inch inside diameter temporary steel casing) working casing. Water level data were collected almost every day with an electronic water level meter. Rainfall data were collected daily with a digital rain gauge. Water quality samples were collected by pumping borehole intervals isolated with the off-bottom packer or the HW working casing. In addition, geophysical logs were collected at various intervals while coring. After core drilling and testing, monitor wells were constructed by a contract drilling company. A detailed description of the data collection methods is presented in appendix A.

Lithologic Sampling

The District-owned Central Mine Equipment (CME) 85 drill rig was used to perform the shallow core drilling at the ROMP 128 - Rainbow Springs well site to a depth of 660 feet below land surface (bls). The punch shoe core drilling method was used to sample the upper unconsolidated sediments. Wireline core drilling was employed when competent rock was encountered at 18 feet bls. Lithologic sampling from land surface to 80 feet bls was conducted in core hole 1. Because of adverse borehole conditions, the rig was moved a few feet and core drilling was conducted from 40 feet bls to 660 feet bls in core hole 2. Lithologic samples were continuously collected and retrieved in 5-foot intervals. Lithologic samples were boxed, labeled, and described.

Formation Packer Testing

An off-bottom packer assembly, installed through the core rods during wireline core drilling, was used to isolate intervals for discrete water level measurement, discrete hydraulic data collection, and discrete water quality sampling. When feasible, the HW working casing was used in place of the packer assembly.

Hydraulic Testing

Hydraulic properties were collected by performing eight slug tests suites during wireline core drilling from land surface to the total depth of exploratory coring at 660 feet bls. Testing began on core hole 2 after core drilling through the undifferentiated sand and clay deposits and the weathered limestone of the Ocala Limestone.

The off-bottom packer was used to isolate specific intervals of the core hole for slug testing. The packer is typically installed 30 feet off bottom for testing unless borehole conditions necessitate installing the packer at a different interval. With the packer installed, a slug (air, water, or solid) was introduced into the interval raising or lowering the hydraulic head (water level). The water level in the test interval was measured with a pressure transducer and recorded on a datalogger as it returned to static conditions. The slug test data were analyzed to determine the horizontal hydraulic conductivity of the test intervals.

Water Quality Sampling

Eight groundwater samples also were collected while wireline core drilling from land surface to the total depth of exploratory coring. Samples 1 through 7 were collected directly from the discharge point while air-lifting and sample 8 was collected with a nested bailer. The groundwater samples were collected before conducting the slug tests. A portion of each sample was analyzed in the field for temperature, specific conductance, pH, chloride, and sulfate. The remainder of each sample was prepared and delivered to the District's Chemistry Laboratory for additional water quality analyses (SWFWMD, 2009).

Geophysical Logging

Borehole geophysical logs are used to delineate stratigraphic units, identify permeable zones and confining units, characterize water quality, and help determine well casing points and grouting requirements. Geophysical logging was performed three times using the District-owned Century® geophysical logging equipment at the ROMP 128 - Rainbow Springs well site. The first suite of logs was performed on April 13, 2009, on core hole 1 after core drilling ended and before core hole 1 was backplugged. The 8044C multifunction tool and the 9165C caliper/gamma-ray tool were run from land surface to 56 feet bls. On June 25, 2009, the 8143C multifunction tool was run from land surface to 663 feet bls on core hole 2 after core drilling ended. Also, the 9165C caliper/gamma-ray tool was run on core hole 2 from 112 feet bls to 663 feet bls. An obstruction prevented data collection above 112 feet bls. After well construction, geophysical logs were run on the Upper Floridan aquifer sulfate monitor well (U FLDN AQ SULFATE MONITOR) and the Upper Floridan aquifer water level monitor well (U FLDN AQ MONITOR).

Well Construction

The ROMP 128 - Rainbow Springs well site consists of three permanent monitor wells (fig. 2). On February 26, 2009, a 4-inch drilling water supply well was installed by Citrus Well Drilling. The drilling water supply well is open to the Upper Floridan aquifer in the Ocala Limestone and is the permanent nitrate monitor well (U FLDN AQ NITRATE MONITOR). Additional well construction began in September 2009 and ended in December 2009. CAM Well Drilling installed a 6-inch Upper Floridan aquifer sulfate monitor well (U FLDN AQ SULFATE MONITOR) in the Avon Park Formation and modified core hole 2 into a 6-inch Upper Floridan aquifer water level monitor well (U FLDN AQ MONITOR) in the Ocala Limestone. In December 2009, the Upper Floridan aquifer sulfate monitor well was lined and backplugged by District staff. A summary of well construction details is presented in table 1. The well as-built diagrams are presented in appendix B.

Geology

The lithostratigraphy of the ROMP 128 - Rainbow Springs well site is based on the exploratory core drilling that was conducted from land surface to a total depth of 660 feet bls. The geologic formations encountered at the well site include, in ascending order: the Avon Park Formation, Ocala Limestone, residual Hawthorn Group sediments, and undifferentiated sand and clay deposits. The geologic units present at the ROMP 128 - Rainbow Springs well site are presented in figure 3. The lithologic log is presented as appendix C. Digital photographs of the lithologic core samples are presented in appendix D.

Avon Park Formation (Middle Eocene)

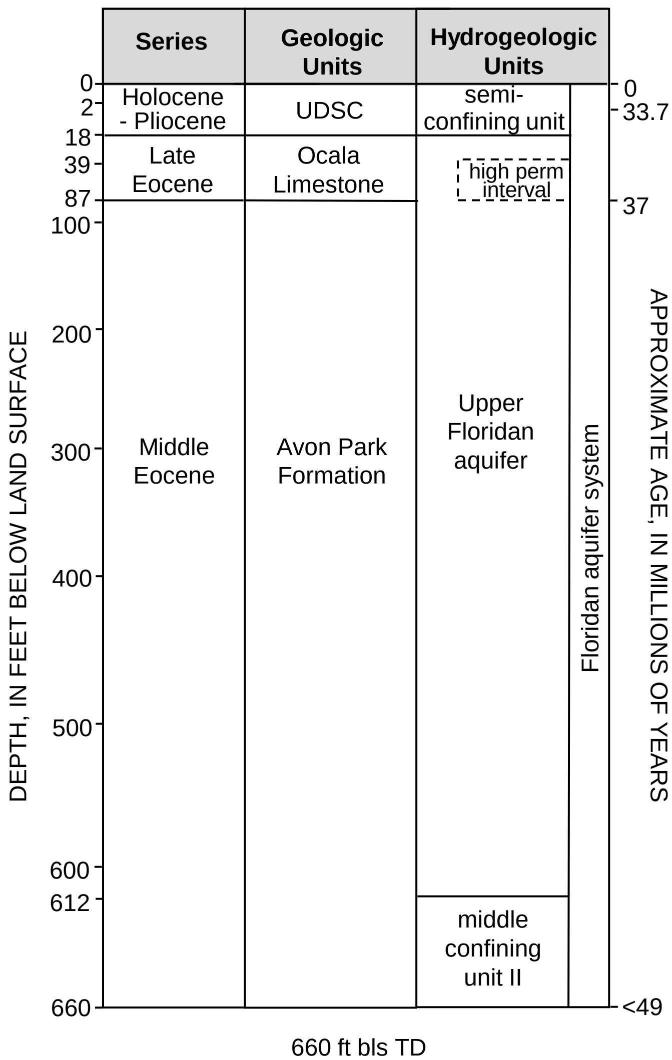
The middle Eocene aged Avon Park Formation extends from 87 feet bls past the total depth of exploration at 660 feet bls. The Avon Park Formation unconformably underlies the Ocala Limestone. The top of the Avon Park Formation is marked by a change in lithology from limestone to dolostone containing the foraminifer *Cushmania americana* (*Dictyoconus americanus*), which is an index fossil characteristic of the Avon Park Formation. In addition, the top of the Avon Park Formation was picked at 87 feet bls because of a corresponding gamma-ray peak and subsequent higher background count rates on the gamma-ray log (appendix E, fig. E2 and E3). The top of the Avon Park Formation is commonly marked by a gamma-ray peak that is attributed to organic material (Arthur and others, 2008; Tihansky and Knochenmus, 2001). Arthur and others (2008) further state that the Avon Park Formation typically has a higher gamma-ray background count rate than the overlying Ocala Limestone. A gamma-ray peak is still apparent on the gamma-ray log, although subdued, even if organic material is not visible in the core because of recrystallization and dolomitization, similar to the core from the ROMP 128 - Rainbow Springs well site (Arthur and others, 2008). A corresponding decrease on the spontaneous potential curve indicates a lithology change that is likely associated with the Ocala Limestone and Avon Park Formation contact (appendix E, fig. E2 and E3).

The Avon Park Formation is predominantly grayish-orange to very pale orange fossiliferous dolostones and

Table 1. Summary of well construction details at the ROMP 128 - Rainbow Springs well site in Marion County, Florida

[ft, feet; bls, below land surface; WCP No., well construction permit number(s), District, Southwest Florida Water Management District; SID, site identification; U, upper; AQ, aquifer; FLDN, Floridan; ROMP, Regional Observation and Monitor-well Program]

Well Name	SID	Alternate Name	Open Interval (ft bls - ft bls)	Constructed By	Start Date (MM/DD/YYYY)	Complete Date (MM/DD/YYYY)	Status	WCP No.
ROMP 128 U FLDN AQ NITRATE MONITOR	738458	DRILLING WATER SUPPLY	61-80	Citrus Well Drilling	02/26/2009	02/26/2009	Active	782109
ROMP 128 U FLDN AQ MONITOR	750199	CORE-HOLE 2	60-87 (0.020-inch slot screen)	District/ CAM Well Drilling	03/25/2009	10/29/2009	Active	782301, 787273
ROMP 128 U FLDN AQ SULFATE MONITOR	750173		150-170	CAM Well Drilling/ District	09/21/2009	12/29/2009	Active	787271, 801654



UDSC, undifferentiated sand and clay; perm, permeable; TD, total depth; <, less than

Figure 3. Stratigraphic column detailing the hydrogeologic setting at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

limestones. The dolostones are more abundant than the variably dolomitized limestones. From 87 feet bls to 163 feet bls, the Avon Park Formation is chiefly composed of grayish-orange to moderate yellowish brown, sucrosic, weathered, fossiliferous, moderately to poorly indurated dolostone with some dolosilt. The fossils within this section include, mollusks, echinoids, and benthic foraminifera, however, only *Cushmania americana* (*Dictyoconus americanus*) is positively identified. The echinoid molds and fragments resemble and presumably are *Neloaganum dalli*. Beds of fissile or biscuit-like dolostone and beds of denser, finely crystalline dolostone occur within this interval. From 118 feet bls to 121 feet bls, grayish-orange to very pale orange, hard, dense, pelletel dolostone and dolomitic grainstone are present. From 87 feet bls to 163 feet bls, the observed porosity is 25 percent and is primarily from intercrystalline, moldic, and pin-point vugular sources. The porosity may increase slightly from 144 feet bls to 157 feet bls where there appears to be some small fractures.

From 163 feet bls to 250 feet bls, the Avon Park Formation chiefly consists of grayish-orange to very pale orange, fossiliferous, crystalline dolostone. The dolostone is predominately medium to coarsely crystalline, weathered, and poorly indurated but is finely crystalline, less weathered, and better indurated in a few areas throughout the section. The dolostones in this section have fewer fossils than the preceding dolostone layers and are mainly in the form of echinoid, foraminifer, mollusk, and coral molds. This section of dolostone is more friable and contains more dolosilt than the previous section. The observed porosity from 163 feet bls to 250 feet bls is 15 percent and is primarily from intercrystalline, moldic, and pin-point vugular sources.

From 250 feet bls to 417 feet bls, the lithology is very pale orange dolostone and dolosilt occasionally intermixed with medium dark gray dolostone and dolosilt. The dolostone is soft, friable, and poorly to moderately indurated. Overall the dolostone is finely crystalline but there are instances of sucrosic texture. Minor amounts of organics are present throughout and probably attribute to the medium dark gray color of some of the dolostone and dolosilt. Gray chert nodules are present as well as gray patches that may be because of partial silicification. Quartz nodules appear at about 365 feet bls and interstitial quartz and quartz crystal lined vugs appear at about 403 feet bls. Fossils observed in this section are mollusks, *Balanus sp*., and coral molds. Sedimentary structures in this section include laminations, mottles, and, to a lesser extent, bioturbation. Burrows and wormholes were noted from 331 feet bls to 417 feet bls. Observed porosity is 15 percent in this section and is mainly from intercrystalline, moldic, and pin-point vugular sources.

During core drilling in the Avon Park Formation from 163 feet bls to 417 feet bls, the drill rods slid down numerous times because the formation was soft and the weight of the rods was sufficient enough to cut through the formation. The caliper log shows many core hole enlargements throughout this section, particularly from about 355 feet bls to about 405 feet bls (appendix E, fig. E2).

From 417 feet bls to 436 feet bls, the lithology is grayish-orange, fossiliferous, finely to coarsely crystalline, soft to hard, poorly to moderately indurated dolostone with abundant organic detritus and laminae. At the very top of the section is a black chert bed with sandstone and organics. Laminations are the only sedimentary structure noted within this section. Observed porosity within this section is 20 percent from molds and vugs.

The Avon Park Formation, from 436 feet bls to 535 feet bls, consists of grayish-orange to very pale orange, poorly to moderately indurated dolomitic limestone and dolostone. The limestone is crystalline to packstone and the dolostone is finely crystalline. This section is very fossiliferous with molds and fragments of mollusks, echinoids, and foraminifera. Beginning at 450 feet bls, interstitial calcite and calcite crystal lined vugs and molds appear. Trace organics are present throughout the section. Rare fractures were noted within this section. Sedimentary structures observed in this section include mottling and bioturbation (wormholes and burrows begin at 513 feet bls). Observed porosity is 25 percent from molds, vugs, and fractures.

From 535 feet bls to 612 feet bls, the lithology is very pale orange to moderate yellowish brown, vuggy, fossiliferous, variably indurated, crystalline dolomitic limestone and finely crystalline dolostone. The dolostone is sucrosic in areas. Quartz and calcite crystals line vugs. Organic detritus, laminae, and interbeds are present throughout this interval. The organics are most likely the cause of high peaks on the gamma-ray log (appendix E, fig. E2). Minor gypsum infill begins at 605 feet bls. Sedimentary structures observed in this section are interbeds, laminations, and mottling. Observed porosity is 20 percent and is from vugs, pin-point vugs, and molds.

From 612 feet bls to the total depth of exploration of 660 feet bls, the lithology is very pale orange to dark yellowish brown, finely crystalline, dense, well indurated dolostone with interstitial and massive gypsum and anhydrite. Few fossil molds were observed in this section. Traces of organics are present throughout this section. Mottling is the only sedimentary structure noted in this section. A substantial drop in porosity and permeability result within this section because of the abundance of pore-filling gypsum and anhydrite. The result is evident as an increase on the resistivity curves (appendix E, fig. E2). Observed porosity is estimated to be below 5 percent. The average core recovery throughout the Avon Park Formation was 85 percent.

Ocala Limestone (Late Eocene)

The late Eocene aged Ocala Limestone extends from 18 feet bls to 87 feet bls at the ROMP 128 - Rainbow Springs well site. The Ocala Limestone unconformably overlies the Avon Park Formation. The top of the Ocala Limestone is marked by a characteristic drop in gamma-ray activity (appendix E, fig. E2 and E3). The Ocala Limestone characteristically has low background count rates and fewer peaks than the underlying Avon Park Formation (Arthur and others, 2008). The muted response remains throughout the Ocala Limestone (appendix E, fig. E2 and E3). Additionally, the top corresponds with a change in lithology to very pale orange packstone with abundant miliolids. Also, a decreasing trend in spontaneous potential just below the delineated contact indicates a lithology change (appendix E, fig. E2). Overlapping core exists from 40 feet bls to 80 feet bls because of drilling two core holes. The lithology of the overlapping cores is similar.

From 18 feet bls to 39 feet bls, the lithology consists of very pale orange, fossiliferous packstone. Overall, the limestone is poorly indurated and friable but there are instances of moderately indurated layers throughout this section. The miliolid foraminifer is the most abundant fossil observed in this section; however, mollusk fragments and molds also are present. No sedimentary structures were noted in this section. The observed porosity is 20 percent and is intergranular. Core recovery for this section was poor at 47 percent because of the soft character of the limestone. From 25 feet bls to 30 feet bls, the core rods pushed through the limestone with the rod weight and no core was retrieved.

From 39 feet bls to 87 feet bls, the lithology changes to grayish-orange to white, crystalline to mudstone, very hard, dense, fossiliferous limestone. The grayish-orange color is likely because of iron-staining. Mollusk, bryozoa, and coral molds and fragments were observed. The limestone is well indurated, however, from 71 feet bls to 80 feet bls, it is less indurated and softer. The limestone appears weathered and karstic and has a “Swiss cheese” character. Large vugs are lined with euhedral calcite crystals. Rare hairline fractures also are filled with calcite. Bioturbation, in the form of wormholes, was the only sedimentary structure noted in this section of the Ocala Limestone. Observed vugular porosity is high at 40 percent and apparent permeability is high because of the abundant solution cavities and weathering. During the core drilling of this Ocala Limestone section, the drill rods dropped two times with the first drop occurring from 57 feet bls to 58 feet bls and the second drop occurring from 78.5 feet bls to 80 feet bls. These rod drops could indicate voids in the limestone. In addition, the rods slid from 75 feet bls to 78 feet bls because of no resistance from the limestone. Limestone gravel was recovered from the airlift discharge, which probably indicates a highly eroded area in the limestone.

Undifferentiated Sand and Clay (Pliocene-Holocene)

The Pliocene to Holocene aged undifferentiated sand and clay unit is the uppermost geologic unit at the ROMP 128 - Rainbow Springs well site and extends from land surface to 18 feet bls. The undifferentiated sand and clay unit unconformably overlies the Ocala Limestone.

From land surface to 2 feet bls, the lithology is dark yellowish brown, medium-grained sand with silt-sized organics and roots and 15 percent clay. The lithology changes to grayish-orange, medium-grained, clayey sand from 2 feet bls to 5 feet bls. Oxidized gray clay is present from land surface to 5 feet bls. From 5 feet bls to 18 feet bls, the lithology consists of grayish-orange to very pale orange, fine to medium grained, iron-stained, very clayey to clayey sand and sandy clay intermixed with rare stringers of dry white clay. The white clay stringers are similar to clays typical of the Hawthorn Group; however, the majority of the sediments are not. Therefore, the unit is considered undifferentiated sand and clay and the white clay stringers are most likely reworked from the Hawthorn Group. Clay content is 5 percent from 2 feet bls to 18 feet bls. No sedimentary structures were noted. Observed intergranular porosity is estimated to range from less than 5 percent to 20 percent from land surface to 18 feet bls. The apparent permeability greatly decreased from 2 feet bls to 18 feet bls because of the high clay content. The average sediment recovery was 63 percent.

Gamma-ray response in the undifferentiated sand and clay unit is highly variable with higher overall background counts than the underlying units and several strong peaks (appendix E). The variableness and intensity of the gamma-ray log likely results because of the residual reworked Hawthorn Group sediments. The peak at the bottom of the unit is commonly attributed to a phosphate lag deposit reworked from Hawthorn Group sediments, however, phosphate was not found at the ROMP 128 - Rainbow Springs well site (Arthur and others, 2008). This high intensity gamma-ray peak may be caused by residual uranium associated with phosphate from reworked Hawthorn Group sediments (Rick Green, Florida Geological Survey, oral commun., 2009).

Hydrogeology

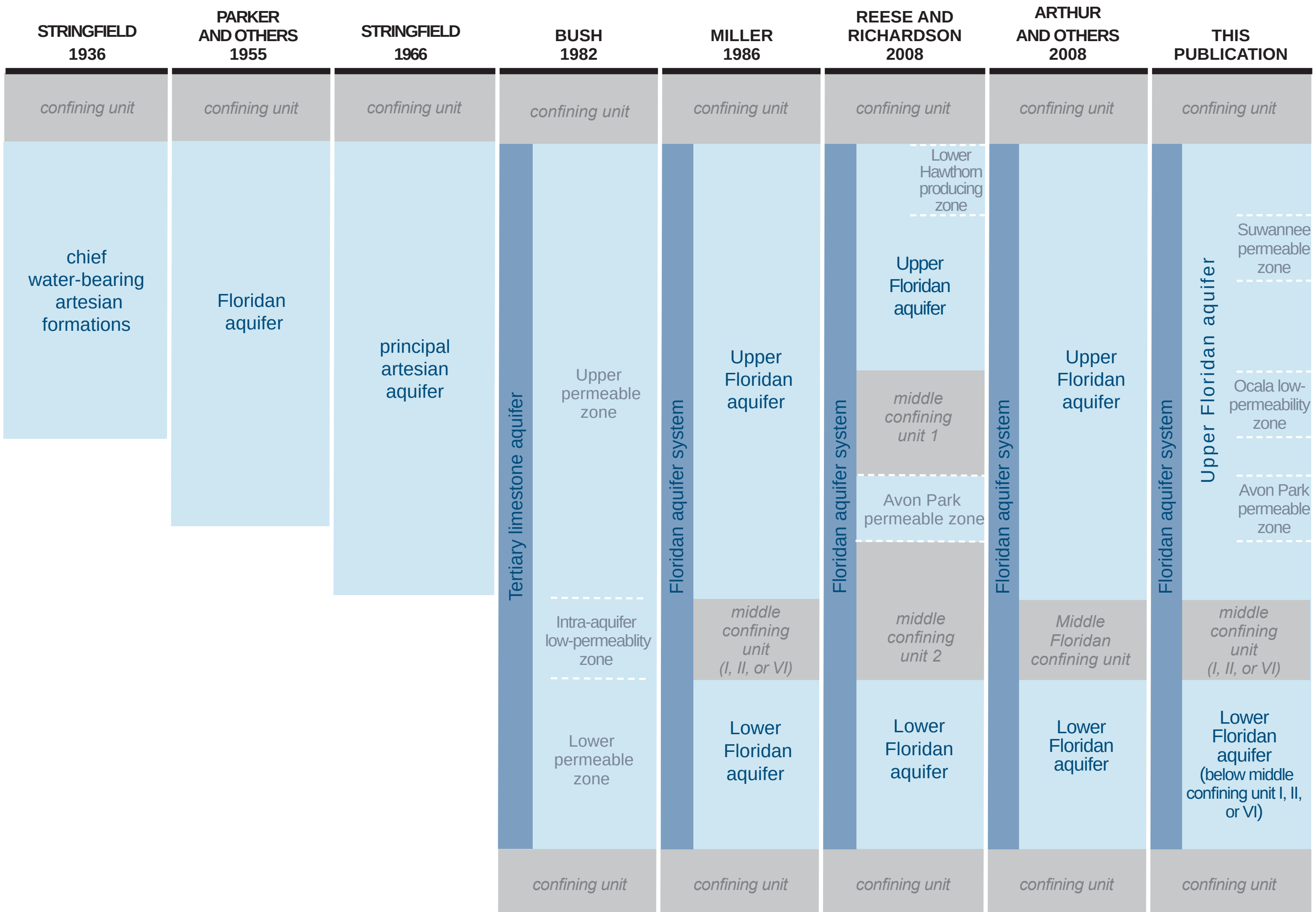
The ROMP 128 - Rainbow Springs well site hydrogeology was defined during exploratory core drilling. Hydrogeologic units primarily were identified from the results of eight slug tests performed throughout the core hole as well as from lithologic descriptions, water levels, water quality data, and geophysical log data. The hydrogeologic units delineated at the ROMP 128 - Rainbow Springs well site include, in descending order: a semi-confining unit, the Upper Floridan aquifer, and the middle confining unit II (fig. 3). The Upper Floridan aquifer contains an interval of higher permeability than the rest of the unit. In this report, the Floridan aquifer system naming convention used is consistent with aquifer nomenclature guidelines proposed by Laney and Davidson (1986) and the North American Stratigraphic Code (2005). A comparison of the nomenclature used in this report and previously published reports is presented in figure 4.

As discussed in appendix A, the horizontal hydraulic conductivities derived from the slug tests may be underestimated because of unavoidable testing errors and limitations of the analysis. Consequently, the values should be used as an approximation of the relative differences between the aquifer units. The ROMP 128 - Rainbow Springs well site slug test results are presented in table 2. All the horizontal hydraulic conductivity estimates are within expected ranges for the lithology types encountered at the ROMP 128 - Rainbow Springs well site (Freeze and Cherry, 1979). A graph of the horizontal hydraulic conductivity estimates and core hole depth is presented in figure 5. The slug test data acquisition sheets are shown in appendix F and the curve-match analyses are given in appendix G.

Water level data were collected almost daily during exploratory core drilling in the core holes and the drilling water supply well (appendix H). Additionally, core hole water level data were recorded during isolated test intervals and should be representative of how the water level varied with depth and within the Upper Floridan aquifer, including the highly permeable intervals, and the middle confining unit II. The composite and test interval core hole water level data recorded during exploratory core drilling from March 2009 to June 2009 are shown in figure 5.

Semi-Confining Unit

The surficial aquifer is considered absent at the ROMP 128 - Rainbow Springs well site because the undifferentiated sand and clay unit was dry at the time of exploratory core drilling and testing. Additionally, the clay content in the unit, which ranges from 5 percent to 15 percent, suggests the sediments have decreased permeability and likely do not effectively yield an appreciable amount of water. However, redoximorphic features observed from land surface to 5 feet bls suggest periodic saturated periods above 5 feet bls.



[Terms shown are for hydrogeologic units present within the Southwest Florida Water Management District]

Figure 4. Nomenclature of the Floridan aquifer system used for the ROMP 128 - Rainbow Springs well site compared to names in previous reports.

The clay content in the undifferentiated sand and clay unit is 15 percent from land surface to 2 feet bls and 5 percent from 2 feet bls to 18 feet bls, which is sufficient to slow downward flow of water to the underlying Upper Floridan aquifer. The lateral extent of this unit beyond the well site is unclear. In the region of the well site, breaches in the confining unit allow direct infiltration of water into the Upper Floridan aquifer (Jones and others, 1996). However, at the site-specific scale of this investigation, the presence of these lower permeability sediments implies some local restriction of vertical flow that creates at least partial confinement of the Upper Floridan aquifer. It is likely that buried karst features perforate these lower permeability sediments creating preferential pathways for flow as is typical for this region. This could result in a semi-confining unit that may only slow recharge for brief periods following rainfall events. This was observed by the draining of the discharge pit. The air-lift discharge pit that was approximately 5 feet deep by 10 feet wide drained overnight after each discharge period.

Upper Floridan Aquifer

At the ROMP 128 - Rainbow Springs well site, the Upper Floridan aquifer of the Floridan aquifer system is the only aquifer identified because the clayey to very clayey sand of the undifferentiated sand and clay unit was dry at the time of exploratory core drilling and testing. The Upper Floridan aquifer at the ROMP 128 - Rainbow Springs well site is considered semi-confined as discussed in the Semi-Confining Unit section. However, according to Jones and others (1996), the area around the well site is generally unconfined. Conversely, the presence of discharging springs in the area, such as the Rainbow Springs Complex, implies some degree of confinement. The Upper Floridan aquifer includes all the Ocala Limestone and the upper part of the Avon Park Formation. The Upper Floridan aquifer extends from the top of the Ocala Limestone at 18 feet bls to 612 feet bls where the low permeability middle confining unit II begins.

Table 2. Summary of the core hole slug test results performed at the ROMP 128 - Rainbow Springs well site in Marion County, Florida

[No., number; ft., feet; bls, below land surface; CH 2, core hole 2; UFA, Upper Floridan aquifer; d, day; All slug tests are pneumatic rising head except where otherwise noted. All slug test intervals are isolated with a packer assembly except where otherwise noted. Hydraulic conductivity values are underestimated for higher K zones when using NQ packer assembly]

Slug Test No.	Date (M/DD/YYYY)	Test Interval (ft bls)	Visual Lithologic Characterization	Geologic/ Hydrogeologic Unit	Analytical Method	Horizontal Hydraulic Conductivity (K) (ft/d)	Comments
1	4/23/2009	41-60	Karstic Crystalline Limestone	Ocala/UFA	Butler (1998)	7,500	CH 2; Tested on HW casing, no packer.
2	5/5/2009	94-135	Sucrosic Dolostone and Dolosilt	Avon Park/UFA	Butler (1998)	730	CH-2; Tested on HW casing, no packer.
3	5/7/2009	189-245	Weathered Crystalline Dolostone	Avon Park/UFA	McElwee-Zenner (1998)	9	CH 2.
4	5/14/2009	327-370	Crystalline Dolostone and Dolosilt	Avon Park/UFA	Butler (1998)	28	CH 2.
5	5/28/2009	420-455	Crystalline Dolostone with Chert and Organics	Avon Park/UFA	Butler (1998)	83	CH 2.
6	6/4/2009	500-535	Dolomitic Limestone and Crystalline Dolostone	Avon Park/UFA	Butler (1998)	100	CH 2.
7	6/10/2009	560-615	Dolomitic Limestone and Crystalline Dolostone	Avon Park/UFA	Butler (1998)	28	CH 2.
8	6/23/2009	612-660	Gypsiferous Dolostone	Avon Park/MCU II[1]	Cooper et al (1967)	0.001	CH 2; water slug, falling head.

[1]MCU II refers to the middle confining unit II as defined by Miller (1986).

Drilling circulation was lost at the top of rock at 18 feet bls during core drilling, which typically indicates the top of a permeable zone. It appeared as though water was not encountered until the top of rock was penetrated and that the water level rose to approximately 15 feet bls the following day, which could indicate some degree of confinement. However, the drilling mud used while core drilling through the unconsolidated sediments could have masked or depressed the water level until the core hole was cleaned. The top of rock was encountered at 23 feet bls in the drilling water supply well and the water level was approximately 16 feet bls.

The Upper Floridan aquifer is a single aquifer. At the ROMP 128 - Rainbow Springs well site, there is an interval of higher permeability within the Upper Floridan aquifer that is not characteristic of the entire aquifer. This interval of higher permeability is within the Ocala Limestone. This permeable interval is referred to as an interval and not a zone because the regional extent of this interval is unknown. This permeable interval extends from 39 feet bls to 87 feet bls based on the lithology. There are two intervals of higher permeability within the Avon Park Formation; the first extending from approximately 87 feet bls to 163 feet bls and the second extending from approximately 425 feet bls to 612 feet bls. However, their horizontal hydraulic conductivity estimates are an order of magnitude lower than the permeable interval within the Ocala Limestone and they make up over half of the Upper Floridan aquifer within the Avon Park Formation, therefore, they are not subdivided in this report.

One slug test was performed in the permeable interval within the Ocala Limestone from 41 feet bls to 60 feet bls. The horizontal hydraulic conductivity estimate is 7,500 feet per day (ft/d). This slug test was performed without a packer assembly. Therefore, the horizontal hydraulic conductivity estimate for this interval is a better representative value because of no packer orifice restriction. However, this result also contributes to a larger disparity between subsequent horizontal hydraulic conductivity estimates because of the need to use the packer assembly in the subsequent slug tests.

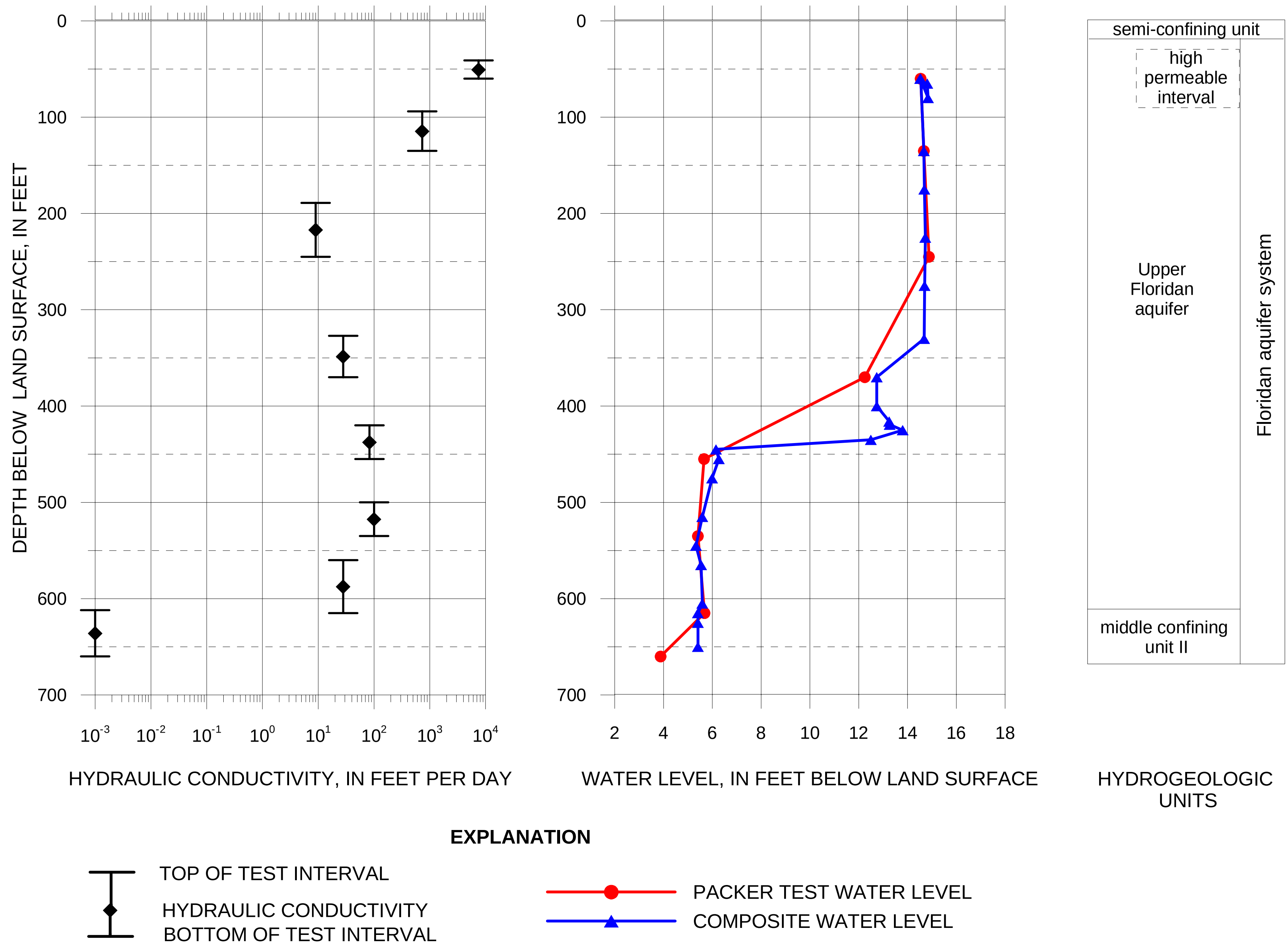


Figure 5. Horizontal hydraulic conductivity estimates and static water levels collected during core drilling at the ROMP 128 - Rainbow Springs well site.

According to Faulkner (1973), most of the groundwater flow to Rainbow Springs is derived from the upper part of the Upper Floridan aquifer that is coincident with the Ocala Limestone. As previously mentioned, the area around the ROMP 128 - Rainbow Springs well site has undergone substantial changes because of karst processes. The high horizontal hydraulic conductivity value in the permeable interval within the Ocala Limestone indicates the Ocala Limestone has indeed been affected by karst processes. The "Swiss cheese" appearance of the Ocala Limestone also implies a mature karst terrain. The extensive dissolution of the limestone associated with mature karst causes enlarged interconnected cavities that facilitate rapid movement of large amounts of water (Faulkner, 1973). Moreover, the ROMP 128 - Rainbow Springs well site lies along a northeastern trending photolineament, which is a surface expression of a subsurface fracture (appendix I). The photolineament was previously identified by aligning karst features including springs and sinkholes, and straight stream segments (Jones and others, 1996; ERM, 1999). This finding further supports that the permeable interval within the Ocala Limestone has a high horizontal hydraulic conductivity and likely is the major contributor of groundwater flow to Rainbow Springs. Also, resistivity is lowest from 39 feet bls to 87 feet bls indicating a more permeable lithology (appendix E, fig. E2). The extensive karst in the Ocala Limestone also suggests that the undifferentiated sand and clay may only slow the downward movement of water and the unit is breached.

Six additional slug tests were conducted in the Upper Floridan aquifer. The horizontal hydraulic conductivity decreased to 730 ft/d below the permeable interval within the Ocala Limestone as indicated by slug test 2 conducted from 94 feet bls to 135 feet bls (table 2). Although this horizontal hydraulic conductivity estimate can still be considered high, it is an order of magnitude lower than the previous estimate in the permeable interval within the Ocala Limestone. Slug test 2 also was performed without a packer assembly; therefore, this horizontal hydraulic conductivity estimate also is a better representative value because of no packer orifice restriction. The decrease in horizontal hydraulic conductivity from slug test 1 to slug test 2 is likely a valid decrease and could be attributed to the change in lithology from karstic limestone to dolostone and dolosilt. Porosity and permeability within the dolostone is not as substantial as in the limestone likely because dolostone is less soluble than limestone and not as susceptible to dissolution. According to Faulkner (1973), the upper part of the Avon Park Formation is substantially less permeable than the Ocala Limestone. A substantial increase in resistivity supports that the decrease in horizontal hydraulic conductivity results, in part, because of a change to a less permeable lithology (appendix E, fig. E2).

The remaining five slug tests yielded horizontal hydraulic conductivity estimates ranging from 9 ft/d to 100 ft/d with a geometric mean of 36 ft/d (table 2 and fig. 5). Slug test 3 (conducted from 189 feet bls to 245 feet bls) and slug test 4 (conducted from 327 feet bls to 370 feet bls) indicate the horizontal hydraulic conductivity decreases further with estimates of 9 ft/d and 28 ft/d, respectively (table 2). This decrease in horizontal hydraulic conductivity could be attributed to the use of a packer assembly but it is also likely because of the change in lithology from dolostone and dolosilt to weathered dolostone and dolosilt. The horizontal hydraulic conductivity estimates from slug test 6 (conducted from 420 feet bls to 455 feet bls) and slug test 7 (conducted from 500 feet bls to 535 feet bls) are 83 ft/d and 100 ft/d, respectively. The increase in horizontal hydraulic conductivity is most likely because of the few minor fractures noted in the lithology from 436 feet bls to 535 feet bls within the Avon Park Formation. The last slug test performed in the Upper Floridan aquifer, from 560 feet bls to 615 feet bls, yielded a horizontal hydraulic conductivity estimate of 28 ft/d. The slug test penetrated 3 feet into the middle confining unit II, but it is unlikely that the test was affected by this unit.

The water level generally rose (nearly 10 feet in total) with depth during core drilling at the ROMP 128 - Rainbow Springs well site. An increase in water level with depth indicates a discharging system (Faulkner, 1973). In the core hole, the water levels ranged from 14.84 feet bls (in April 2009) to 5.33 feet bls (in June 2009). At the end of May 2009, while core drilling from 435 feet bls to 445 feet bls, the water level rose over 6 feet (fig. 5 and appendix H). The permeability appears to increase as indicated by slug test 6 as previously discussed. The recovery was poor from 430 feet bls to 445 feet bls and averaged 35 percent. Chert beds are interspersed from about 417 feet bls to 426 feet bls, which likely acts as a confining layer. The cause of the substantial water level rise is unclear, however, it could be attributed to a confining layer that was not observed. From May 18, 2009 to May 21, 2009, the core hole water level averaged 34 feet NAVD 88, which is similar to the U.S. Geological Survey's May 2009 Upper Floridan aquifer potentiometric surface of 34 feet NGVD 29 (approximately 33 feet NAVD 88) during the same period for the area around the ROMP 128 - Rainbow Springs well site.

The water level in the drilling water supply well ranged from 16.16 feet bls to 16.60 feet bls (appendix H). The drilling water supply well is open (from 61 feet bls to 80 feet bls) to the permeable interval within the Ocala Limestone. Local rainfall is the major source of recharge to the Upper Floridan aquifer in the area around the ROMP 128 - Rainbow Springs well site, especially where the Ocala Limestone is at or near the surface and the overlying sediments allow infiltration (Faulkner, 1973). The water level in the drilling water supply well generally declined until the middle of May 2009, and then the water level generally rose until core drilling ended at the end of June 2009. This rise in water level appeared to coincide with an increase in rainfall at the ROMP 128 - Rainbow Springs well site. Substantial rainfall (about 10 inches) was measured during May 2009 (appendix H). Core drilling operations were performed during the rainy season and did not span long enough to observe seasonal fluctuations at the ROMP 128 - Rainbow Springs well site.

Middle Confining Unit

The lower section of the Avon Park Formation contains lower permeability carbonates with interstitial evaporite minerals that decrease the permeability of the formation. The first appearance of persistent gypsum and a substantial decrease in permeability mark the top of the middle confining unit II as defined by Miller (1986). At the ROMP 128 - Rainbow Springs well site, the middle confining unit II extends from 612 feet bls past the total depth of exploration of 660 feet bls.

One drop slug test was performed in the middle confining unit II. The test was performed from 612 feet bls to 660 feet bls. The horizontal hydraulic conductivity estimate is 0.001 ft/d (table 2). The increase in resistivity also suggests a less permeable unit (appendix E, fig. E2). There was about a 1.5-foot rise in water level between the Upper Floridan aquifer and the middle confining unit II, when comparing discrete interval water levels. The water level was 3.88 feet bls in the middle confining unit II after a packer was set for 3 days. The composite water level was steady at 5.41 feet bls for the 3 days of water level measurements that were recorded during core drilling and prior to setting the packer in the middle confining unit II. Rainfall was nearly 3 inches while core drilling in the middle confining unit II (appendix H).

Groundwater Quality

One objective of the ROMP 128 - Rainbow Springs well site was to assess groundwater characteristics from the Upper Floridan aquifer. The groundwater quality characterization is based on results from eight discrete groundwater samples that were collected from 41 feet bls to 660 feet bls. No sampling occurred above 41 feet bls because of the unconsolidated nature of the sediments. The field and laboratory analyses are presented in appendix J.

The secondary drinking water standards for total dissolved solids, sulfate, chloride, and iron are 500 milligrams per liter (mg/L), 250 mg/L, 250 mg/L, and 0.3 mg/L (300 micrograms per liter, µg/L), respectively (Hem, 1985; U.S. EPA, 2009). Iron concentration values typically are underestimated when aerated samples are collected from the air-lift discharge as opposed to samples collected from a bailer. Field pH was used in analyses because it is more likely to represent the actual conditions in the water because pH is sensitive to environmental changes (Driscoll, 1986; Fetter, 2001). Additionally, total alkalinity was used as bicarbonate concentration because hydroxyl ions generally are insignificant in natural groundwater and carbonate ions typically are not present in groundwater with a pH less than 8.3 (Fetter, 2001).

The groundwater at the ROMP 128 - Rainbow Springs well site is fresh to some depth above 189 feet bls. Below 189 feet, the water quality samples indicate the water quality quickly degrades because total dissolved solids (TDS) and sulfate exceed secondary drinking water standards (fig. 6 and appendix J). The first water quality sample to exceed secondary drinking water standards for iron is sample 7 (collected from 560 feet bls to 615 feet bls) with a value of 389 µg/L (appendix J).

Generally, the major ion concentrations increase with depth (fig. 6 and appendix J). The equivalent weights, percent equivalent weights, and water type for each sample are presented in table 3. The primary cations observed throughout the core hole are calcium and magnesium, and the principal anions are bicarbonate and sulfate. The water type from 41 feet bls to 135 feet bls is calcium bicarbonate. The dominant water type changes to calcium sulfate at some depth between 135 feet bls and 189 feet bls. Specific conductance increases with depth (appendix J2). The pH of the water quality samples generally decrease with depth and range from 7.62 to 8.23 (appendix J1). The pH values are within the typical groundwater range from 6 to 8.5 (Hem, 1985).

Select molar ratios were calculated to investigate the water quality changes with depth (table 4 and fig. 7). The evaporite track illustrates the interaction between fresh water and evaporites. The dolomite track identifies fresh water affected by dolomite. The sodium chloride track depicts effects from connate or sea water. The most notable change in water quality is the substantial increase in sulfate concentration at a relatively shallow depth. Also, calcium concentration substantially increases with depth and magnesium concentration increases in the lower part of the Upper Floridan aquifer and the middle confining unit II.

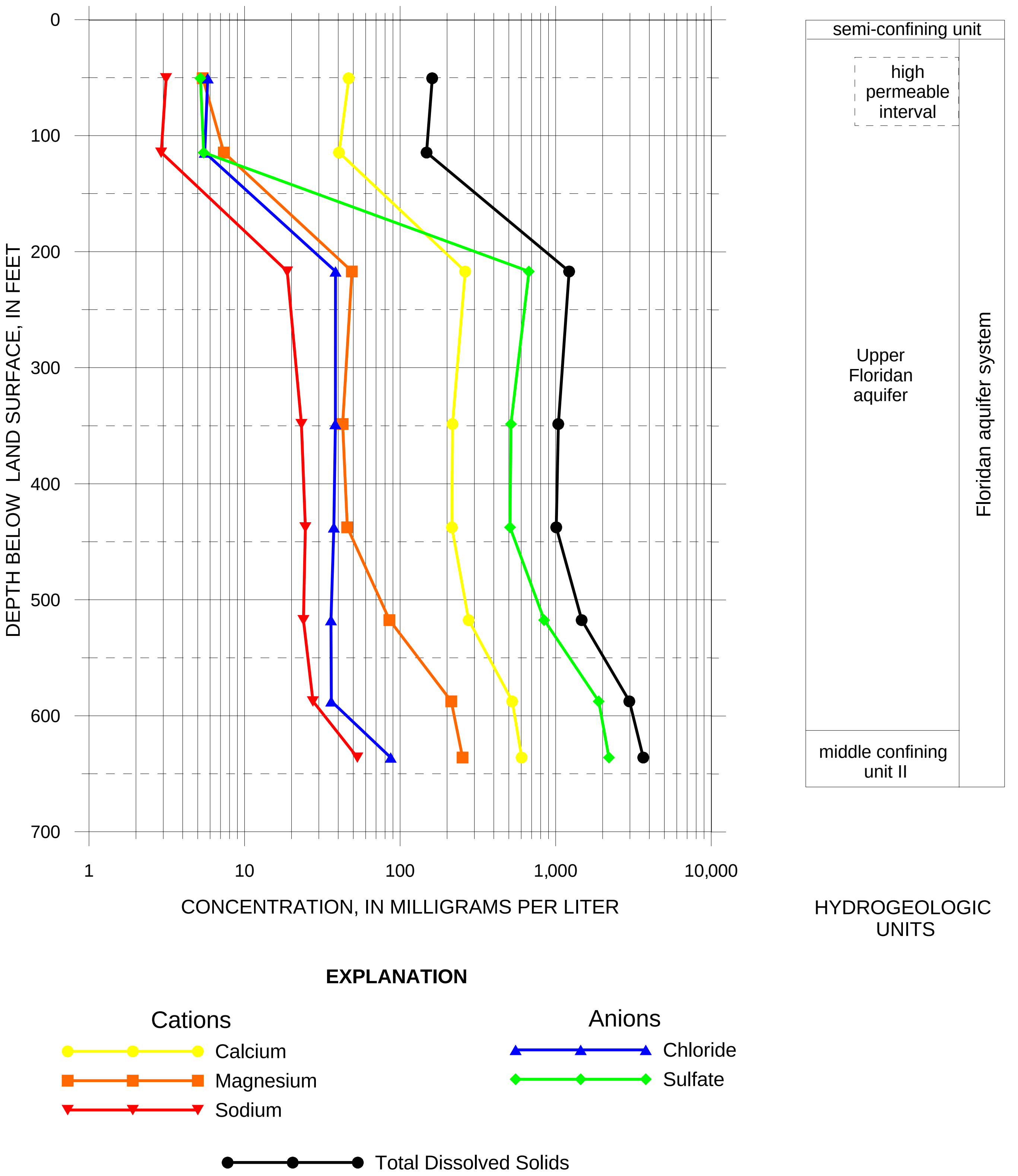


Figure 6. Select cations and anions, and total dissolved solids concentrations for groundwater samples from the ROMP 128 - Rainbow Springs well site in Marion County, Florida. Depth represents the middle of the discrete open interval at the time of sampling.

Table 3. The equivalent weight and percent equivalent weight for select ions and the water type for each water quality sample collected at the ROMP 128 - Rainbow Springs well site

[No., number; ft, feet; bls, below land surface; meq/L, milliequivalent per liter; %, percent; total alkalinity is used as HCO_3^{1-} because it is assumed CO_3^{2-} and H_2CO_3 are negligible based on groundwater pH at this site because hydroxyl ions are insignifcant in groundwater and carbonate ions are typically not present if pH is less than 8.3 standard units (SU)]

Water Quality Sample No.	Open Interval (ft bls)	CATIONS						ANIONS						Water Type
		Ca2+		Mg^{2+}		Na^{1+}		HCO_3^{1-}		Cl^{1-}		SO_4^{2-}		
		meq/L	%	meq/L	%	meq/L	%	meq/L	%	meq/L	%	meq/L	%	
1	41-60	2.33	79.9	0.443	15.2	0.14	4.7	2.044	88.26	0.16	7.1	0.11	4.7	Calcium Bicarbonate.
2	94-135	2.02	73.3	0.606	22	0.13	4.6	1.950	87.83	0.16	7.1	0.11	5.1	Calcium Bicarbonate.
3	189-245	13.1	72.7	4.0	22.4	0.817	4.54	2.027	11.85	1.084	6.334	14.00	81.82	Calcium Sulfate.
4	327-370	10.8	70.2	3.51	22.8	1.01	6.54	2.734	18.78	1.08	7.42	10.7	73.8	Calcium Sulfate.
5	420-455	10.7	68.6	3.76	24.1	1.07	6.84	3.130	21.17	1.06	7.15	10.6	71.7	Calcium Sulfate.
6	500-535	13.8	62.8	7.03	32.0	1.04	4.74	2.819	13.18	1.01	4.74	17.6	82.1	Calcium Sulfate.
7	560-615	26.2	58.2	17.5	38.9	1.20	2.65	2.314	5.422	1.01	2.39	39.35	92.19	Calcium Sulfate.
8	612-660	30.1	56.4	20.7	38.8	2.31	4.32	2.989	5.833	2.45	90.2	45.80	89.38	Calcium Sulfate.

Table 4. Select molar ratios for the water quality at the ROMP 128 - Rainbow Springs well site

[No., number; ft, feet; bls, below land surface; total alkalinity is used as HCO_3^{1-} because it is assumed CO_3^{2-} and H_2CO_3 are negligible based on groundwater pH at this site because hydroxyl ions are insignifcant in groundwater and carbonate ions are typically not present if pH is less than 8.3 standard units (SU)]

Water Quality Sample No.	Open Interval (ft bls)	Cl^{1-}:SO_4^{2-}	Ca^{2+}:HCO_3^{1-}	Ca^{2+}:Mg^{2+}	Cl^{1-}:HCO_3^{1-}	Na^{1+}:HCO_3^{1-}	Na^{1+}:Cl^{1-}	SO_4^{2-}:HCO_3^{1-}
1	41-60	3.0	0.570	5.26	0.080	0.067	0.83	0.026
2	94-135	2.8	0.518	3.34	0.080	0.065	0.81	0.029
3	189-245	0.155	3.22	3.2	0.5347	0.403	0.754	3.454
4	327-370	0.201	1.98	3.08	0.395	0.369	0.933	1.97
5	420-455	0.200	1.71	2.85	0.338	0.342	1.01	1.69
6	500-535	0.115	2.44	1.96	0.359	0.369	1.03	3.11
7	560-615	0.0518	5.67	1.50	0.440	0.517	1.17	8.502
8	612-660	0.107	5.04	1.45	0.821	0.772	0.941	7.661

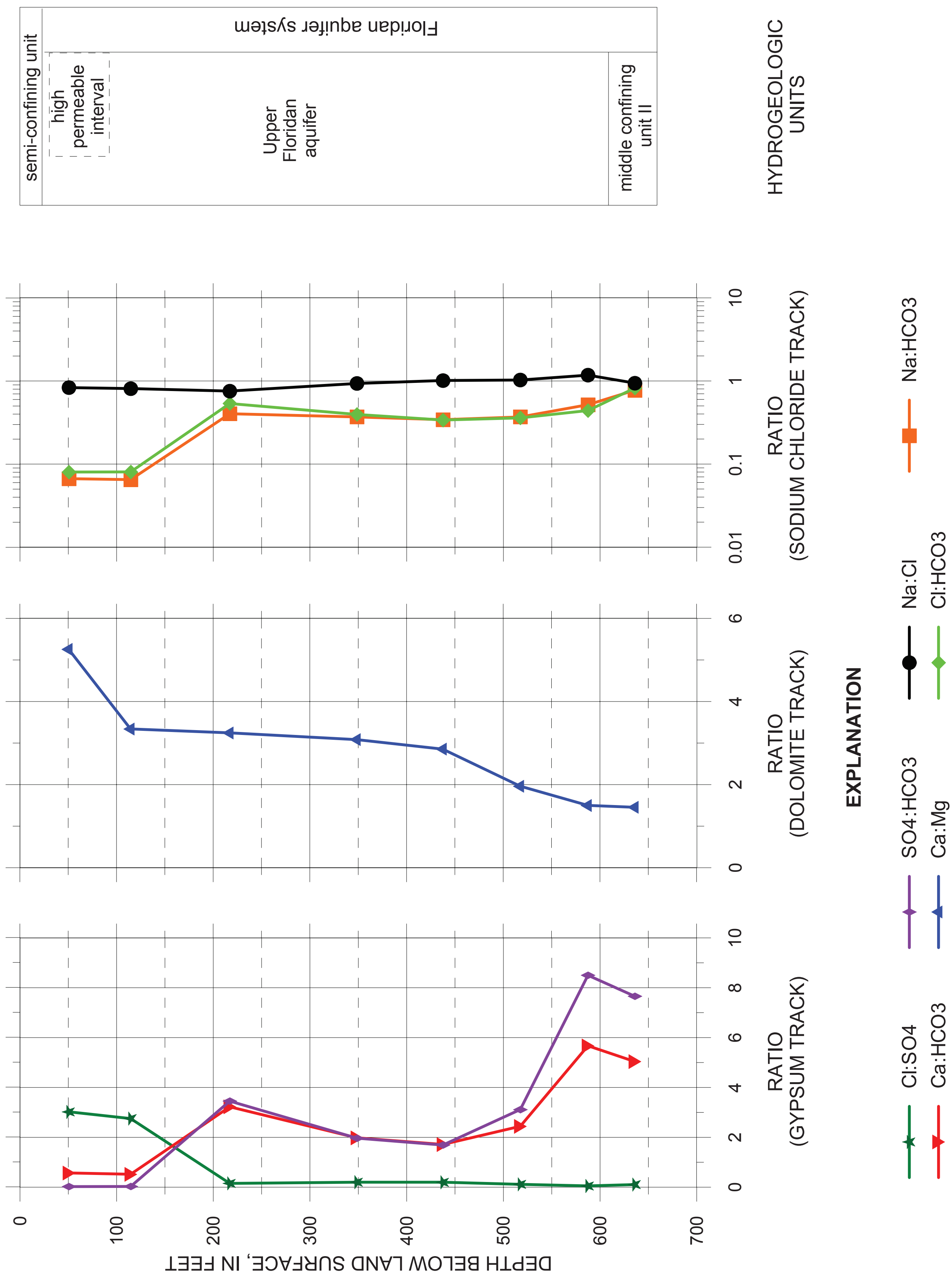


Figure 7. Select molar ratios with depth for water quality data at the ROMP 128 - Rainbow Springs well site. Depth represents the middle of the discrete open interval at the time of sampling.

Upper Floridan Aquifer

Seven water quality samples were collected within the Upper Floridan aquifer during exploratory core drilling (appendix J). One sample was collected from 41 feet bls to 60 feet bls, within the highly permeable interval in the Ocala Limestone and the results indicate the water is fresh with a TDS value of 161 mg/L, a sulfate concentration of 5.2 mg/L, and a chloride concentration of 5.8 mg/L. Specific conductance for water quality sample 1 is 266 micromhos per centimeter (µmhos/cm). The water quality within the highly permeable interval within the Ocala Limestone probably remains fresh because of rapid groundwater flow, short residence time, and direct recharge from rainfall.

Six water quality samples were collected from the Upper Floridan aquifer below the highly permeable interval within the Ocala Limestone. The laboratory results indicate the water is fresh to a depth somewhere between 135 feet bls and 189 feet bls. The results from water quality sample 2, collected from 94 feet bls to 135 feet bls, are similar to water quality sample 1. Rapid groundwater flow, short residence time, and rainfall recharge also are probably responsible for the good water quality. Water quality sample 3, collected from 189 feet bls to 245 feet bls is the first sample to exceed secondary drinking water standards. Sulfate concentration increases from 5.5 mg/L to 672.59 mg/L and TDS increases from 148 mg/L to 1,220 mg/L from water quality sample 2 to water quality sample 3 (appendix J). During exploratory core drilling in core hole 2, hydrogen sulfide odor was noted after coring to 155 feet bls, which likely indicates an increase in sulfate concentration. The specific conductance curve in appendix E, fig. E2 shows an increase around 105 feet bls, but it is believed that the upper part of the water column in the core hole was disturbed while performing the geophysical log because there was no other evidence of an increase at this depth. The specific conductance curve for the U FLDN AQ SULFATE MONITOR well shows an increase from 252 µmhos/cm to 1,200 µmhos/cm beginning around 174 feet bls (appendix E, fig. E3). This well was developed and logged approximately 10 days later to allow the water column to stratify. Therefore, the depth at which water quality exceeds secondary drinking water standards is probably 174 feet bls. The shallow degradation of water quality at the ROMP 128 - Rainbow Springs well site likely results because of upwelling of deeper water probably because the well site lies along a fracture trace (as discussed in the Hydrogeology section).

Calcium concentration increased more than six-fold from 40.5 mg/L to 262 mg/L between water quality sample 2 (interval 94 to 135 feet bls) and water quality sample 3 (interval 189 to 245 feet bls) (appendix J). The extra calcium, as well as sulfate, likely results because of the dissolution of gypsum ($CaSO_4 \cdot 2H_2O$) within the middle confining unit II. Although the middle confining unit II begins at 612 feet bls, the effect on water quality is seen at shallower depths. Chloride concentration increases from 5.6 mg/L to 38.43 mg/L from water quality sample 2 to water quality sample 3, however, it is still below secondary drinking water standards. Magnesium concentration increases more than six-fold from 7.36 mg/L to 49 mg/L. The additional magnesium probably results because of a change in lithology from dolostone and limestone to dolostone and because of a substantial decrease in groundwater flow. This decrease in flow allows more time for ions to precipitate. Silica concentration more than doubled from 6.1 mg/L to 14.0 mg/L probably because of the effect from the chert and quartz found just below the sample interval. Sodium, potassium, iron, and strontium concentrations also increased from water quality sample 2 to water quality sample 3. The major cause of the increases is probably the decrease in groundwater flow. The water quality results from water quality sample 4 (interval 327 to 370 feet bls) and 5 (interval 420 to 455 feet bls) are relatively the same as the results from water quality sample 3.

Water quality sample 6, collected from 500 feet bls to 535 feet bls, results indicate the specific conductance increased to 1,750 µmhos/cm, sulfate concentration increased to 843 mg/L, magnesium concentration nearly doubled to 84.4 mg/L, iron concentration more than tripled to 181 µg/L, and TDS increased to 1,470 mg/L. These increases result probably because of the effects from deeper, mineralized water.

Water quality sample 7 (interval 560 to 615 feet bls) is the last water quality sample collected from the Upper Floridan aquifer but penetrates 3 feet into the middle confining unit II. Sulfate concentration more than doubles from 843 mg/L to 1,890 mg/L, which indicates a major effect from gypsum. Calcium concentration nearly doubles increasing from 276 mg/L to 526 mg/L, which also can be attributed to gypsum. Magnesium concentration more than doubles from 85.4 mg/L to 213 mg/L. For the first time, iron exceeds secondary drinking water standards with a value of 389 µg/L.

The water type within the Upper Floridan aquifer to approximately 174 feet bls is calcium bicarbonate, which is typical for a karstic carbonate aquifer (table 3). Below about 174 feet bls to the total depth of exploration, the water type changes from calcium bicarbonate to calcium sulfate (table 3). The increase in sulfate relative to bicarbonate is illustrated on the gypsum track of molar ratios (fig. 7). The increase in the sulfate to bicarbonate ratio indicates an effect of gypsum on water quality. The molar ratio of calcium to magnesium decreases with depth. Although magnesium replaces some calcium because of dolomitization, the substantial increase in calcium concentration from gypsum dissolution allows calcium to predominate magnesium concentration (fig. 7 and table 3). The calcium to bicarbonate molar ratio also indicates an increase in calcium concentration.

The trends of the relative abundances of each major cation and anion species observed in the water quality samples collected at the ROMP 128 - Rainbow Springs well site are presented on a Piper (1944) diagram in figure 8 as percent milliequivalents. It is apparent that the water sample collected from the highly permeable interval within the Ocala Limestone is calcium bicarbonate (fig. 8). Water quality sample 2 plots close to water quality sample 1 because they are chemically similar. Water quality samples 3 to 7 clearly are calcium sulfate and plot along the freshwater/deepwater mixing line. This result indicates the water has been affected by calcium and sulfate that is representative of a deepwater source that is upwelling and mixing with the freshwater (Tihansky, 2005) (appendix J). The calcium and sulfate

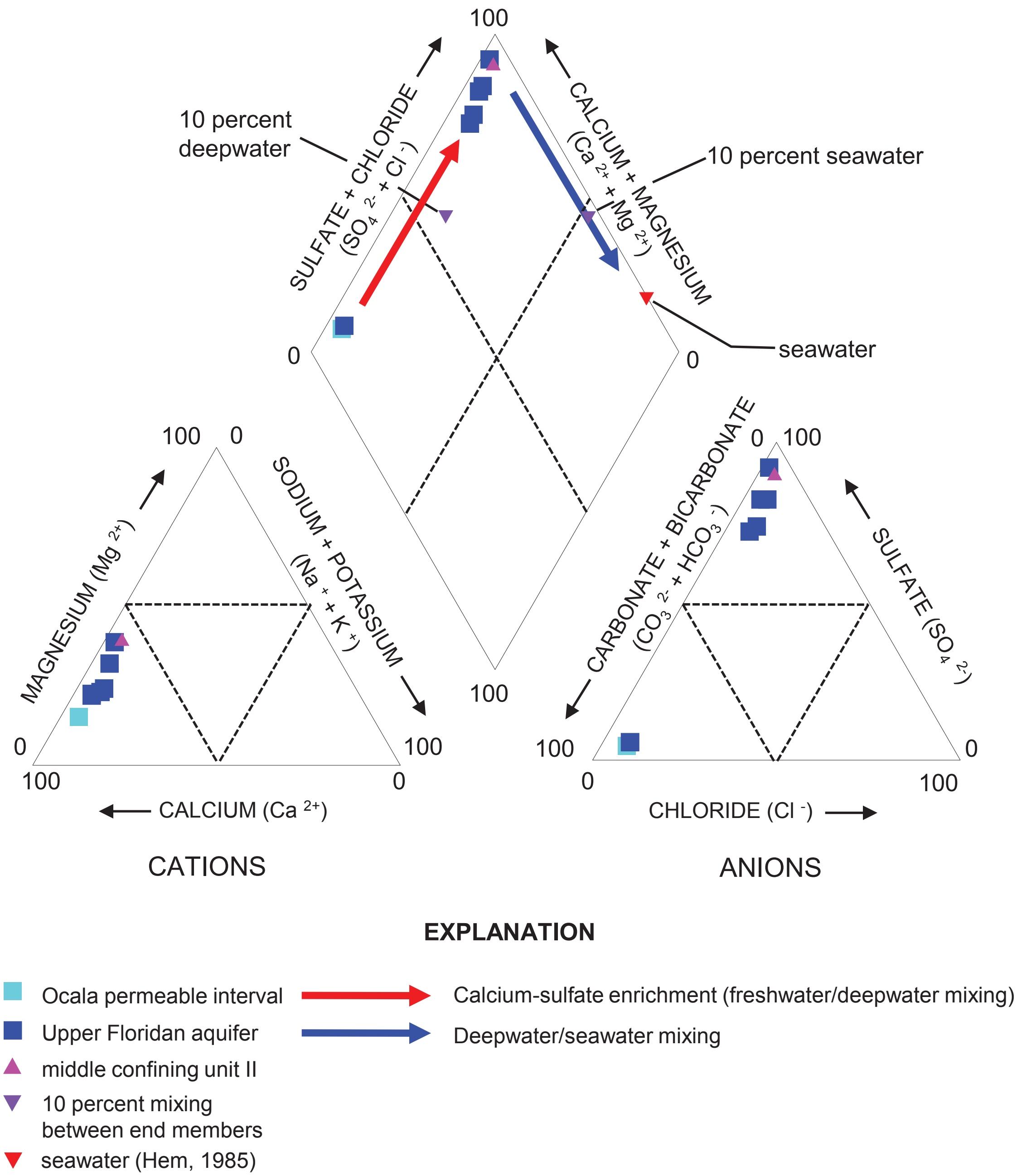


Figure 8. Piper diagram displaying the laboratory data from the water quality samples collected at the ROMP 128 - Rainbow Springs well site.

rich water is typically associated with the middle confining unit II, and as stated earlier, the effect on water quality is occurring at relatively shallow depths (below approximately 174 feet bls).

Middle Confining Unit

One water quality sample was collected from the middle confining unit II from 612 feet bls to 660 feet bls. The TDS increased from 2,980 mg/L to 3,660 mg/L. Chloride and potassium concentrations more than doubled from 36.1 mg/L to 87.0 mg/L and from 4.8 mg/L to 10.1 mg/L, respectively. Iron continues to exceed secondary drinking water standards with a concentration of 361 µg/L. The water type remains calcium sulfate and plots at the top of the quadrilateral field on the piper diagram (fig. 8). Sodium concentration increases from 27.5 mg/L to 53.1 mg/L in the middle confining unit II, but this increase does not change the water type. The molar ratio of sodium to chloride remains close to one throughout exploratory core drilling and sodium and chloride concentrations remain relatively low. This low molar ratio indicates sodium and chloride do not greatly affect water quality and that there is little to no effect from connate or sea water (table 4 and figs. 6 and 7). The chloride to sulfate ratio generally decreases with depth because sulfate concentration increases more than chloride concentration increases (table 4 and fig. 7). Moreover, the sodium to bicarbonate and chloride to bicarbonate molar ratios generally increase with depth and are highest within the middle confining unit II, indicating sodium and chloride concentrations increase with depth and are highest within the middle confining unit II. This result suggests that there is little to no effect from connate or sea water on the water quality at the ROMP 128 - Rainbow Springs well site (appendix K).

Summary

Exploratory core drilling and testing to 660 feet bls was performed from March 2009 to June 2009 at the ROMP 128 - Rainbow Springs well site located in southwestern Marion County, Florida. The ROMP 128 - Rainbow Springs well site was selected to fill data gaps in the ROMP network and help ascertain the geographic extent of the middle confining unit I and middle confining unit II. Three permanent monitor wells were constructed and include the U FLDN AQ SULFATE MONITOR, U FLDN AQ NITRATE MONITOR, and U FLDN AQ WATER LEVEL MONITOR.

The geologic formations encountered at the ROMP 128 - Rainbow Springs well site, in ascending order, are: the Avon Park Formation, the Ocala Limestone, and the undifferentiated sand and clay deposits. The Avon Park Formation extends from 87 feet to the total depth of exploration and is composed of limestone, variably dolomitic limestone, and fossiliferous dolostone with occurrences of organics, chert, quartz, and gypsum. The Ocala Limestone extends from 18 feet bls to 87 feet bls. From 18 feet bls to 39 feet bls, the Ocala Limestone consists of friable limestone. From 39 feet bls to 87 feet bls, the Ocala Limestone is karstic and has a “Swiss cheese” appearance. The undifferentiated sand and clay deposits consist of variably clayey sand from land surface to 18 feet bls.

The hydrogeologic units encountered at the ROMP 128 - Rainbow Springs well site, in descending order, are: a semi-confining unit, the Upper Floridan aquifer, and the middle confining unit II. The clay content of the undifferentiated sand and clay unit is sufficient to slow the downward movement of water creating a local semi-confining unit. Regionally, breaches in the undifferentiated sand and clay unit allow direct infiltration of water suggesting an unconfined system, however, springs like the Rainbow Springs Complex indicate some confinement. The extensive karst in the Ocala Limestone further supports that the undifferentiated sand and clay unit slows but does not effectively restrict the downward movement of water. Therefore, the Upper Floridan aquifer is considered semi-confined at the ROMP 128 - Rainbow Springs well site. The Upper Floridan aquifer includes a highly permeable interval within the Ocala Limestone (from 39 feet bls to 87 feet bls) that has a horizontal hydraulic conductivity estimate of 7,500 ft/d and probably contributes the majority of the flow to Rainbow Springs. The horizontal hydraulic conductivity estimates within the Upper Floridan aquifer from 87 feet bls to 612 feet bls range from 9 ft/d to 730 ft/d. The middle confining unit II extends from 612 feet bls past the total depth of exploration of 660 feet bls and has a horizontal hydraulic conductivity estimate of 0.001 ft/d. Water levels generally increased with depth and as rainfall increased. The water level in the core hole rose nearly 10 feet in total and with depth, indicating a discharging system. The water level in the drilling water supply well rose as rainfall increased.

Eight water quality samples were collected at the ROMP 128 - Rainbow Springs well site. The water quality exceeded secondary drinking water standards at approximately 174 feet bls because of a substantial increase in sulfate concentration and TDS. Calcium concentrations also substantially increase. The increase in sulfate and calcium concentrations are likely from the dissolution of gypsum within the middle confining unit II that is affecting the water quality at shallow depths. The water quality samples plot along the freshwater/deepwater mixing line, which also indicates the water quality is affected by deepwater typical of the middle confining unit II. The water type is calcium bicarbonate until approximately 174 feet bls and changes to calcium sulfate below.

Selected References

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Appendix A. Methods of the Regional Observation and Monitor-well Program

The Southwest Florida Water Management District (District) collects the majority of the hydrogeologic data during the exploratory core drilling phase of the project. Lithologic samples will be collected during the core drilling process. Hydraulic and water quality data are collected primarily during packer tests as the core hole is advanced. Geophysical logging will be conducted on the core hole providing additional hydrogeologic data. After well construction, an aquifer pumping test (APT) will be conducted on each of the major freshwater aquifers or producing zones encountered at the project site. These data will be uploaded into the District's Water Management Information System (WMIS).

Collection of Lithologic Samples

The District conducts hydraulic rotary core drilling, referred to as diamond drilling, with a Central Mining Equipment (CME) 85 core drilling rig and the Universal Drilling Rigs (UDR) 200D LS. The basic techniques involved in hydraulic rotary core drilling are the same as in hydraulic rotary drilling (Shuter and Teasdale, 1989). The District applies a combination of HW and NW gauge working casings along with NQ core drilling rods, associated bits, and reaming shells from Boart Longyear®. The HW and NW working casings are set and advanced as necessary to maintain a competent core hole. The NQ size core bits produce a nominal 3-inch hole. The HW and NW working casings and NQ coring rods are removed at the end of the project. Details on the core drilling activities are recorded on daily drilling logs completed by the District's drilling crew and hydrologists.

Recovery of the core samples is accomplished using a wireline recovery system (fig. A1). The District's drilling crew uses the Boart Longyear® NQ wireline inner barrel assembly. This system allows a 1.87-inch by 5-foot section and a 1.99-inch by 10-foot section of core to be retrieved with the CME 85 rig and UDR 200D LS rig, respectively. The core is retrieved without having to remove the core rods from the core hole. Grab samples of core hole cuttings are collected and bagged where poor core recovery occurs because of drilling conditions or where the formation is unconsolidated or poorly indurated. The core samples are placed in core boxes, depths marked, and recovery estimates calculated. Core descriptions are made in the field using standard description procedures. Rock color names are taken from the "Rock-Color Chart" of the National Research Council

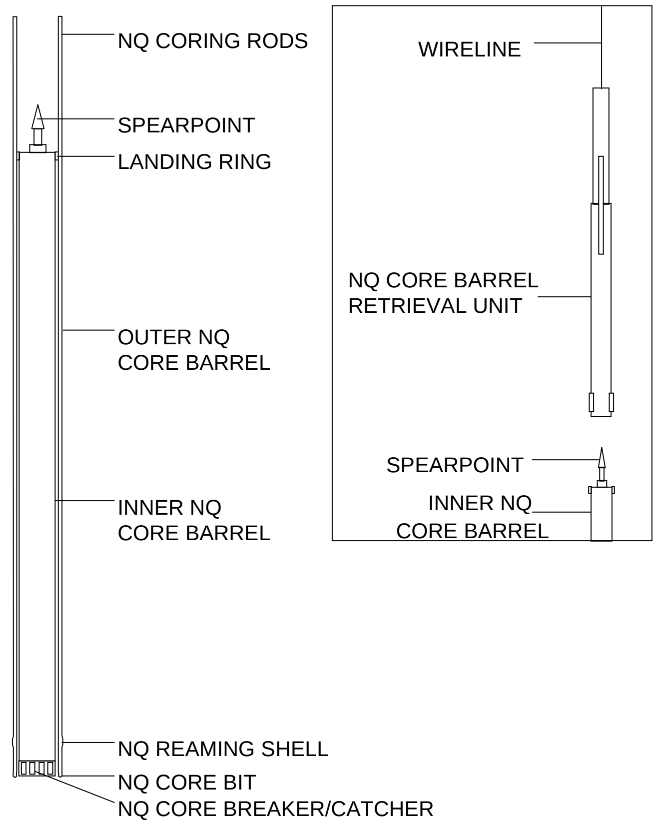


Figure A1. Boart Longyear® NQ Wireline Coring Apparatus.

(Goddard and others, 1948). The textural terms used to characterize carbonate rocks are based on the classification system of Dunham (1962). The core samples are shipped to the Florida Geological Survey for detailed lithologic descriptions of core, cuttings, and unconsolidated sediments. All lithologic samples will be archived at the Florida Geological Survey in Tallahassee, Florida.

Unconsolidated Coring

Various methods exist for obtaining core of unconsolidated material, which is extremely difficult as compared to rock coring (Shuter and Teasdale, 1989). To ensure maximum sample recovery, the District drilling crew utilizes a punch shoe adapter on the bottom of the inner barrel along with an unconsolidated core catcher. The punch shoe extends the inner barrel beyond the bit allowing collection of the sample prior to disturbance by the bit or drilling fluid. A variety of bottom-discharge bits are used during unconsolidated coring. A thin bentonite mud may be used to help stabilize the unconsolidated material.

Rock Coring

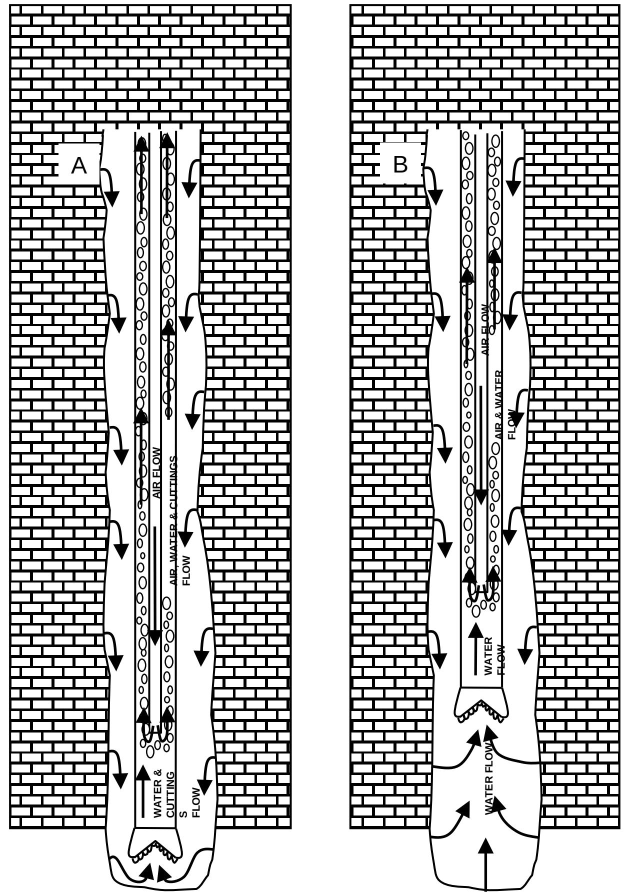
During rock coring, the District drilling crew utilizes HW and NW working casings as well as permanent casings to stabilize the core hole. NQ core drilling rods and associated products are employed during the core drilling process. Core drilling is conducted by direct-circulation rotary methods using fresh water for drilling fluid. Direct water is not effective in removing the cuttings from the core hole, therefore, a reverse-air (air-lift) discharge method (fig. A2) is used to develop the core hole every 20 feet or as necessary. The District typically uses face-discharge bits for well indurated rock core drilling.

Formation Packer Testing

Formation (off-bottom) packer testing allows discrete testing of water levels, water quality, and hydraulic parameters. A competent core hole is necessary for packer testing, meaning unconsolidated sediments and some of the shallow weathered limestone cannot be tested using this technique. The packer assembly (fig. A3) is employed by raising the NQ coring rods to a predetermined point, lowering the packer to the bottom of the rods by using a combination cable/air inflation line, and inflating the packer with nitrogen gas. This process isolates the test interval, which extends from the packer to the total depth of the core hole. Sometimes, the working casing may be used in place of the packer assembly. Test intervals are selected based on a regular routine of testing or at any distinct hydrogeologic change that warrants testing.

Collection of Water Level Data

Water level data is collected daily before core drilling. Additionally, water levels are recorded during each formation packer test after the necessary equilibration time. Equilibration is determined when the change in water level per unit time is negligible. Water levels are measured using a Solinst® water level meter. The water level is measured relative to an arbitrary datum near land surface which is maintained throughout the project. These data provide a depiction of water level with core hole depth. However, these data are normally collected over several months and will include temporal variation.



Reverse-air drilling and water sampling procedure: Reverse-air drilling allows cuttings to be removed without introduction of man-made drilling fluids. As air bubbles leave the airline and move up inside the rods, they expand and draw water with them, creating a suction at the bit. The water, which serves as the drilling fluid, comes from up-hole permeable zones and is natural formation water. Suction at the bit draws water and drill cuttings up the rods to be discharged at the surface (A). After cuttings are cleaned from the hole and the water clears up, a reverse-air discharge water quality sample can be collected at the surface. If a bottom-hole bailer (non-aerated) sample is desired, the rods are raised the length of a drill rod in preparation for adding another rod and airlifting is continued. This draws water from the lower portion of the hole into the wellbore (B). Airlifting is ceased and the drill rods are lowered back to bottom, filling the lower rod with bottom-hole water. After the airline is removed, the bailer is lowered inside the rods by wireline to the bottom to collect, theoretically, a bottom-hole water sample.

Figure A2. Reverse-air drilling and water sampling procedure.

Collection of Water Quality Data

Water quality samples are collected during each formation packer test. Sampling methods are consistent with the "Standard Operating Procedures for the Collection of Water Quality Samples" (Water Quality Monitoring Program, 2009). The procedure involves isolating the test interval with the off-bottom packer (fig. A3) as explained above, and air-lifting the water in the NQ coring rods. To ensure a representative sample is collected, three core hole volumes of water are removed and temperature, pH, and specific conductance are monitored for stabilization using a YSI® multi-parameter meter. Samples are collected either directly from the air-lift discharge point, with a wireline retrievable stainless steel bailer (fig. A4), or with a nested bailer. When sampling a poorly producing interval, the purge time may be substantial. The nested bailer is an alternative that is attached directly to the packer orifice thereby reducing the volume of water to be evacuated from the core hole because it collects water directly from the isolated interval through the orifice. Bailers may also be used to obtain non-aerated samples because aerated samples may have elevated pH and consequently iron precipitation.

Once the water samples are at the surface, they are transferred into a clean polypropylene beaker. A portion of the sample is bottled according to standard District procedure for laboratory analysis (SWFWMD, 2009). Two bottles, one 250 ml and one 500 ml, are filled with water filtered through a 0.45-micron filter. Another 500 ml bottle is filled with unfiltered water. A Masterflex® console pump is used to dispense the water into the bottles. The sample in the 250 ml bottle is acidified with nitric acid to a pH of 2 in order to preserve metals for analysis. The remainder is used to collect field parameters including specific conductance, temperature, pH, and chloride and sulfate concentrations. Temperature and specific conductance are measured using a YSI® multi-parameter handheld meter. Chloride and sulfate concentrations, and pH are analyzed with a YSI® 9000 photometer. The samples are delivered to the District's environmental chemistry laboratory for additional analysis. A "Standard Complete" analysis that includes pH, calcium, chloride, ion balance, iron, magnesium, potassium, silica, sodium, strontium, specific conductance, sulfate, total dissolved solids (TDS), and total alkalinity is performed on each set of samples (SWFWMD, 2009). Chain of Custody forms are used to track the samples.

The analysis of the water quality data includes the evaluation of relative ion abundance and ion or molar ratios, and the determination of water type(s). The laboratory data are used to calculate milliequivalents per liter (meq/L) and percent meq/L. Using the criteria of 50 percent or greater of relative abundance of cations and anions, the water type for each sample is determined (Hem, 1985). The data is plotted on a Piper diagram to give a graphical depiction of the relative abundance of

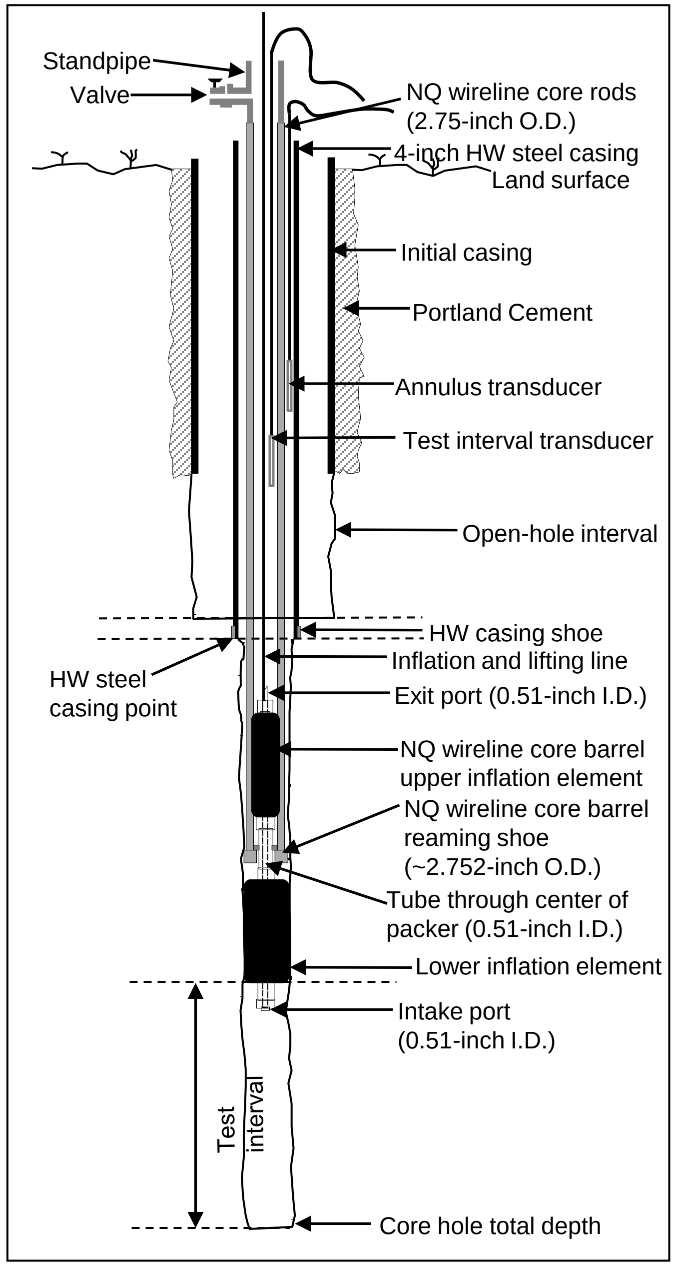


Figure A3. Formation (off-bottom) packer assembly deployed in the core hole.

ions in an individual sample (Domenico and Schwartz, 1998) as well as how the individual samples compare to each other. Select ion ratios are calculated for each sample to further evaluate chemical similarities or differences among waters and to help explain why certain ions change with depth. Field pH is used in analyses because it is more likely to represent the actual conditions in the water since pH is sensitive to environmental changes (Driscolll, 1986; Fetter, 2001). Additionally, total alkalinity is used as bicarbonate concentration because hydroxyl ions generally are insignificant in natural

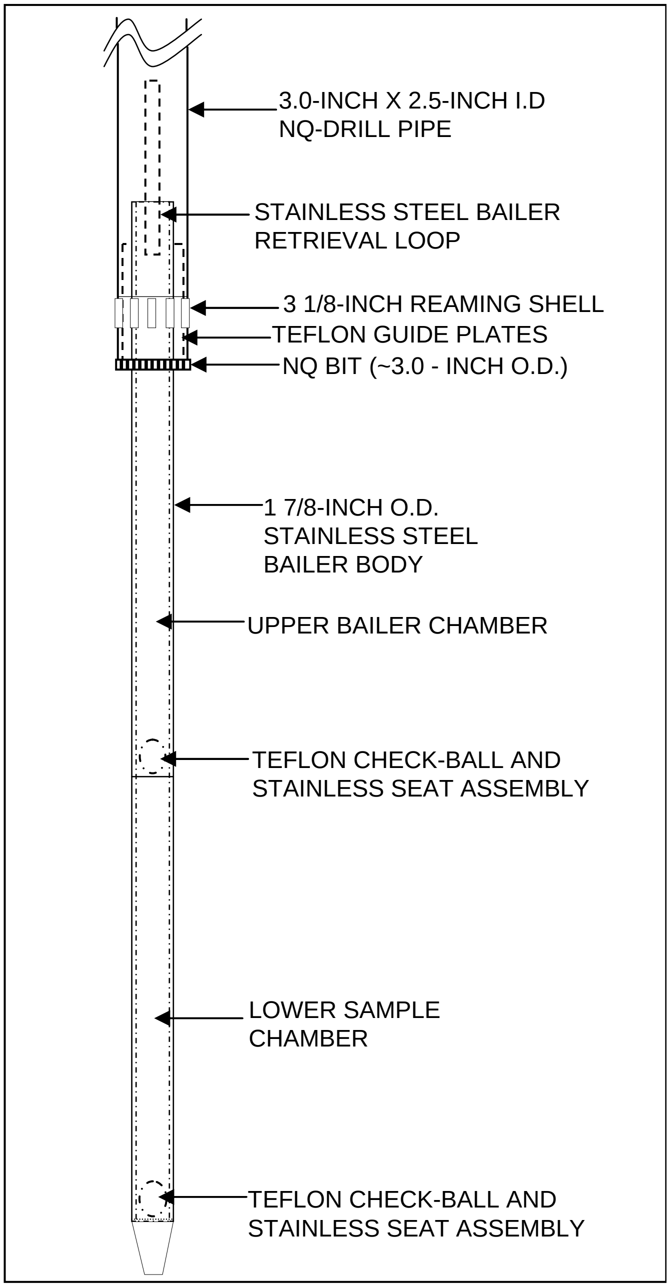


Figure A4. Diagram of the wireline retrievable bailer.

groundwater and carbonate ions typically are not present in groundwater with a pH less than 8.3 (Fetter, 2001).

Collection of Slug Test Data

Some hydraulic properties can be estimated by conducting a series of slug tests. During slug tests, the static water level in the test interval is suddenly displaced, either up or down, and the water level response is recorded as it returns to a static state. Typically, the slug tests are conducted using the off-bottom packer assembly to isolate test intervals as the core hole is advanced. KPSI® pressure transducers are used to measure the water level changes in the test interval and the annulus between the HW casing and the NQ coring rods. The annulus pressure transducer is used as a quality control device to detect water level changes indicative of a poorly seated packer or physical connection (i.e. fractures or very permeable rocks) within the formation. A third pressure transducer is used to measure air pressure during pneumatic slug testing. All pressure transducer output is recorded on a Campbell Scientific, Inc CR800 datalogger. Prior to all slug tests, the test interval is thoroughly developed.

Slug tests can be initiated several ways. The primary methods used by the District are the pneumatic slug method and the drop slug method. Core hole conditions and apparent formation properties dictate which method is used. The pneumatic slug method is used for moderate to high hydraulic conductivity formations due to the near instantaneous slug initiation. The pneumatic slug method uses a NQ rod modified to include a pressure gauge and regulator, and an electronic or manual valve. The opening is sealed with compression fittings. Air pressure is used to depress the static water level. The water level is monitored for equilibration and once it returns to the initial static water level the test is initiated. The electronic or manual valve is opened to release the air pressure causing the water level to rise (rising head test). The water level is recorded until it reaches the initial static water level. The drop slug method is used for low hydraulic conductivity formations due to the slow slug initiation. This test initiation method is slower than the pneumatic method because the water has to travel down the core hole before reaching the test interval. The drop slug method involves adding a predetermined volume of water into the NQ rods raising the static water level. A specially designed PVC funnel fitted with a ball valve placed over the NQ rods is used to deliver the water. The valve is opened releasing the water causing the water level to rise. The water level is recorded until the raised level falls (falling head test) back to static level.

Several quality assurance tests are conducted in the field in order to identify any potential sources of error in the slug test data. The quality assurance tests include evaluation of the discrepancy between the expected and observed initial displacements (Butler, 1998), evaluation of the normalized plots for head dependence and evolving skin effects, and the evaluation of the annulus water level for movement. Lastly, estimates of the hydraulic conductivity values are made based on the slug test data using AQTESOLVE® (Duffield, 2007) software by applying the appropriate analytical solution.

Slug tests in which the formation packer assembly is used all have one common source of error resulting from the orifice restriction (fig. A3). The water during the slug tests moves through NQ coring rods with an inner diameter of 2.38-inches, the orifice on the packer assembly that has an inner diameter of 0.75-inch, and the core hole that has a diameter of approximately 3-inches. The error associated with this restriction is evident as head dependence in the response data of multiple tests conducted on the same test interval with varying initial displacements. The error associated with the orifice restriction will result in an underestimation of the hydraulic conductivity values. In order to reduce the error associated with the orifice restriction, the District inserts a spacer within the zone of water level fluctuation thereby reducing the effective casing radius from 1.19 inches to 0.81 inch. A second technique used to minimize the effects caused by the orifice restrict is the use of initial displacements (slugs) of less than 1.5-feet in height. Also, if the working casing is used instead of the packer, the error is eliminated.

Geophysical Logging

Geophysical logs are useful in determining subsurface geologic and groundwater characteristics (Fetter, 2001). Geophysical logs provide three major types of information from water wells: hydrologic (water quality, aquifer characteristics, porosity, and flow zone detection), geologic (lithology, formation delineation), and physical characteristics (depth, diameter, casing depth, texture of well bore, packer points, and integrity of well construction).

Geophysical logging entails lowering the geophysical tool into the monitor well on a wireline and measuring the tool's response to the formations and water quality in and near the core hole during retrieval. Core hole geophysical logs are run during various stages of core drilling. When feasible, geophysical logs are run prior to casing advancements, while the core hole is still open to the formation.

The District uses Century® geophysical logging equipment. The three types of geophysical probes used are the caliper/gamma, induction, and multifunction. The multifunction tool measures natural gamma-ray [GAM (NAT)], spontaneous potential (SP), single-point resistivity (RES), short [RES(16N)], long [RES(64N)] normal resistivity, fluid temperature (TEMP) and fluid specific conductance (SP COND). Each log type is explained below.

Caliper (CAL)

Caliper logs are used to measure the diameter of the borehole. This log can identify deviations from the nominal borehole diameter and, in turn, locate cavities, washouts, and build-up. This log is useful for determining packer and casing placement because competent, well-indurated layers can be located.

Gamma [GAM(NAT)]

Natural gamma logs measure the amount of natural radiation emitted by rocks in the borehole. Radioactive elements present in certain types of geologic materials emit natural gamma radiation, thus specific rock materials can be identified from the log. Typically, clays contain high amounts of radioactive isotopes in contrast to more stable rock materials like carbonates and sands, therefore, can be identified easily. One advantage using natural gamma radiation is that it can be measured through PVC and steel casing, although it is subdued slightly by steel casing. Gamma is used chiefly to identify rock lithology and correlate stratigraphic units because it can be measured through casing and is relatively consistent.

Spontaneous Potential (SP)

Spontaneous potential logs measure the electrical potential (voltages) that result from chemical and physical changes at the contacts between different types of geological materials (Driscoll, 1986). They must be run in fluid-filled, uncased boreholes. They are useful in identifying contacts between different lithologies and stratigraphic correlation.

Single-Point Resistance (RES)

Single-point resistance logs measures the electrical resistance from rocks and fluids in the borehole to a point at land surface. Electrical resistance of the borehole materials is a measure of the current drop between the current electrode in the borehole and the electrode at land surface. The log must be run in a fluid-filled, uncased borehole.

Short-Normal [RES (16N)] and Long-Normal [RES (64N)]

Short-normal and long-normal resistivity logs measure the electrical resistivity of the borehole materials and the surrounding rocks and water by using two electrodes. The 16 and 64 refers to the space, in inches, between the potential electrodes on the logging probe.

The short-normal curve indicates the resistivity of the zone close to the borehole and the long-normal has more spacing between the electrodes, therefore measures the resistivity of materials further away from the borehole (Fetter, 2001). Short-normal and long-normal logs are useful in locating highly resistive geologic materials such as limestone, dolostone, and pure, homogenous sand and low resistivity materials like clay or clayey, silty sand. Also, the logs indicate water quality changes because fresh water has high resistivity whereas poor quality water has low resistivity. Resistivity logs must be run in fluid-filled, open boreholes.

Temperature (TEMP)

Temperature logs record the water temperature in the borehole. Temperature variations may indicate water entering or exiting the borehole from different aquifers. Thus, the log is useful in locating permeable zones. The log must be run in fluid-filled boreholes.

Specific Conductance (SP COND)

Specific Conductance logs measure the capacity of borehole fluid to conduct an electrical current with depth. The log indicates the total dissolved solids concentration of the borehole fluid. The specific conductance log may be useful in determining permeable zones because zones of increased inflow or outflow may show a change in water quality.

Aquifer Pumping Tests

An APT is a controlled field experiment conducted to determine the hydraulic properties of water-bearing (aquifers) units (Stallman, 1976). APTs can be either single-well or multi-well and may partially or fully penetrate the aquifer. An APT involves pumping the aquifer at a known rate and monitoring the water level response. The general procedure, applied by the District, for conducting an APT involves design, field observation, and data analysis. Test design is based on the geologic and hydraulic setting of the site, such as knowledge of the aquifer thickness, probable range in transmissivity and storage, the presence of uncontrolled boundaries (sources/sinks), and any practical limitations imposed by equipment. Field observations of the discharge and water levels are recorded to ensure a successful test. The District measures the discharge rate using an impeller meter and circular orifice weir. The District measures water levels using pressure transducers and an electric tape. All the recording devices are calibrated and traceable to the National Institute of Standards and Technology.

Data analysis includes first making estimates of drawdown observed during the test and then using analytical and numerical methods to estimate hydraulic properties of the aquifer and adjacent confining units. Diagnostic radial flow plots and derivative analyses of APT data are utilized and are valuable tools in characterizing the type of aquifer present and specific boundary conditions that may be acting on the system during an APT.

Single-Well Aquifer Pumping Test

Single-well APTs includes one test (pumped) well within the production zone used for both pumping and monitoring the water level response. A single-well APT may include monitoring the background water level in the test well for a duration of at least twice the pumping period (Stallman, 1976). Background data collection may not be necessary if the duration of the single-well test is short and the on-site hydrogeologist does not consider background data necessary. After background data collection is complete and it is determined that a successful test can be accomplished, pumping is started. During the test, the discharge rate is monitored and controlled to less than 10 percent fluctuation to ensure a constant rate test. The water level is recorded in the test well during the drawdown (pumping) and recovery phases. Other wells outside of the production zone may be monitored in order to provide additional information on the flow system. The response data are used to estimate drawdown and then analyzed using analytical methods to estimate the hydraulic properties of the aquifer and adjacent confining units. Typically, response data is analyzed using AQTESOLVE® (Duffield, 2007) software by applying the appropriate analytical solution.

Multi-Well Aquifer Pumping Test

Multi-well APTs involve a test (pumped) well and at least one observation well for monitoring the water level response in the production zone. Background water level data is collected for a period of at least twice the planned pumping period (Stallman, 1976). The background data allows for the determination of whether a successful test can be conducted and permits the estimation of drawdown. After the background data collection period is complete and it is determined that a successful test can be completed, pumping is started. During the test, the discharge rate is monitored and controlled to less than 10 percent fluctuation. The water level response is recorded in both the test well and the observation well(s) during the drawdown (pumping) and recovery phases. Other wells outside of the production zone may be monitored in order to provide additional information on the flow system. The response data are used to estimate drawdown and then analyzed using analytical or numerical methods to estimate the hydraulic properties of the aquifer and adjacent confining units. Typically, response data is analyzed using AQTESOLVE® (Duffield, 2007) software by applying the appropriate analytical solution.

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Appendix B. Well As-Built Diagrams for the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

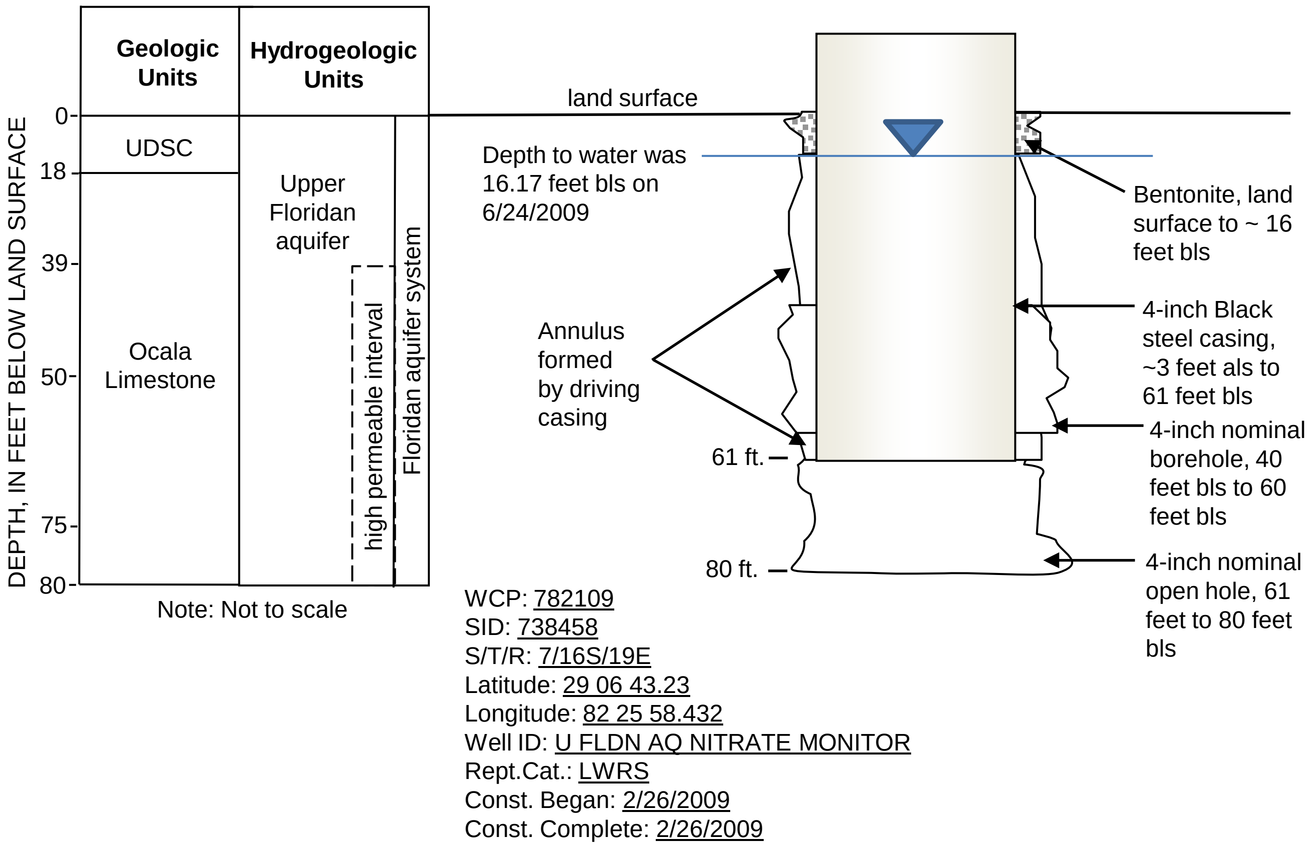


Figure B1. Well as-built diagram for the Upper Floridan aquifer nitrate monitor well constructed at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

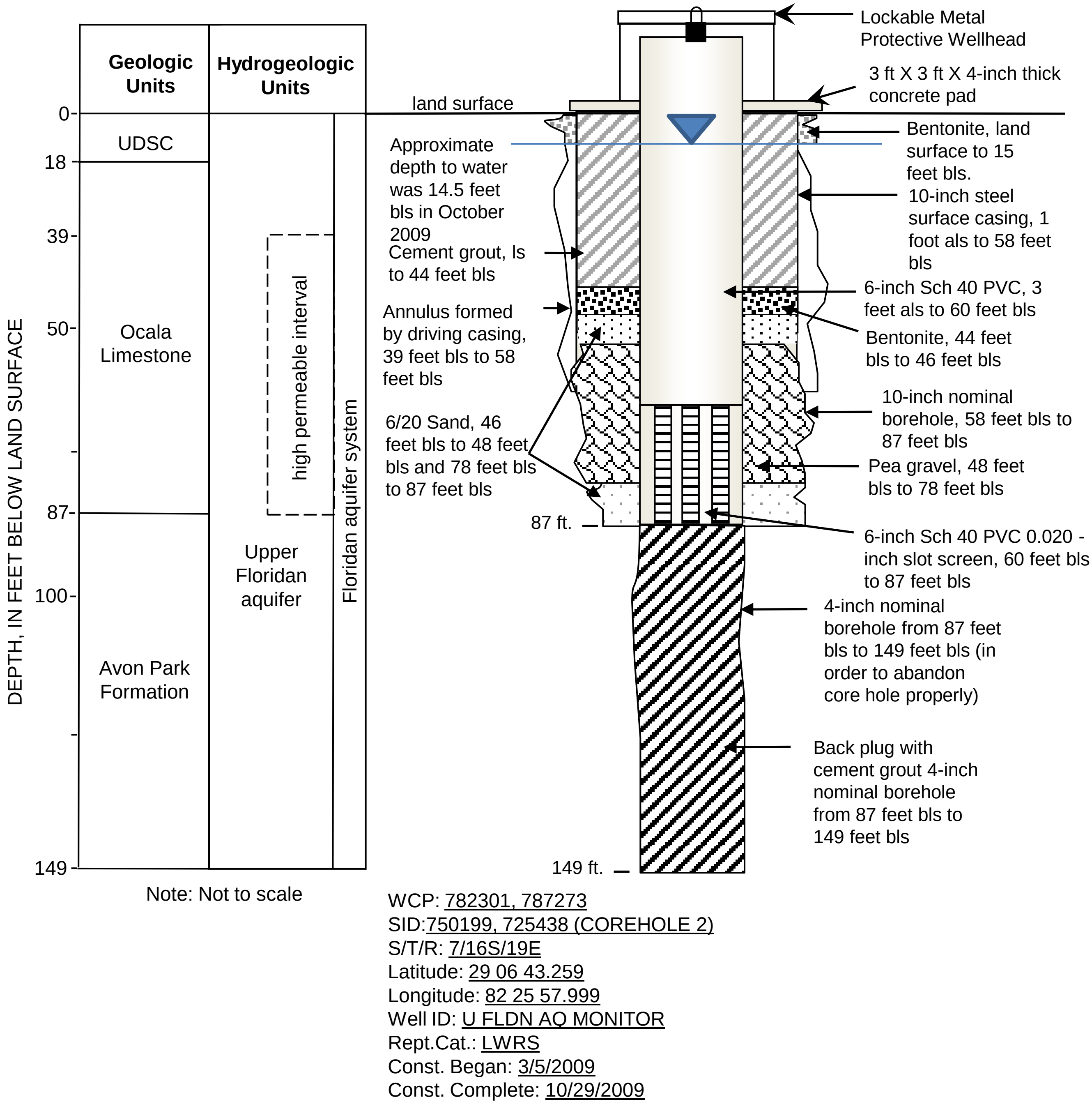
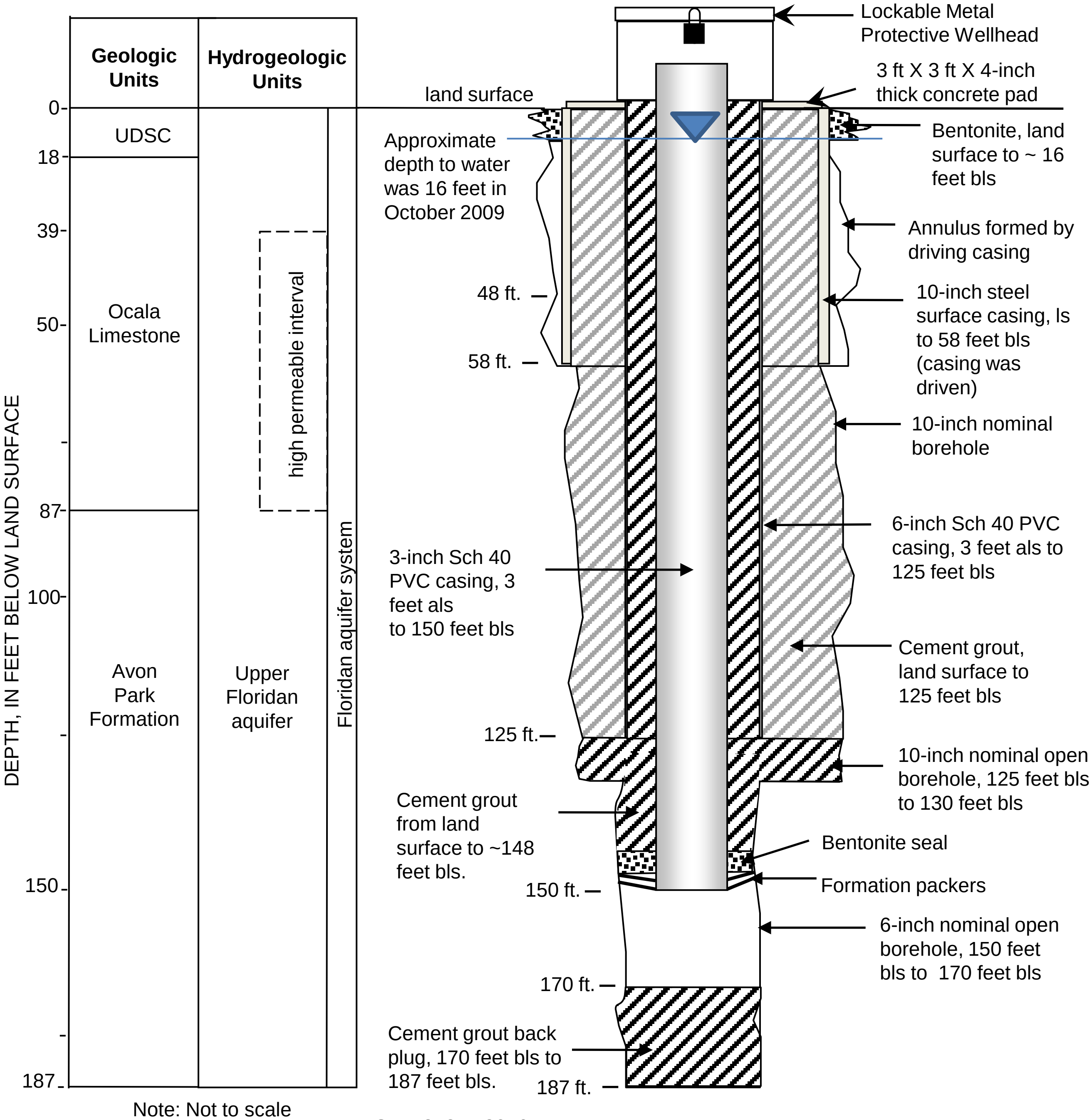


Figure B2. Well as-built diagram for the Upper Floridan aquifer water level monitor well constructed at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.



WCP: 787271,801654
SID: 750173
S/T/R: 7/16S/19E
Latitude: 29 06 43.276
Longitude: 82 25 58.157
Well ID: U FLDN AQ SULFATE MONITOR
Rept.Cat.: LWRS
Const. Began: 9/21/2009
Const. Complete: 12/29/2009

Figure B3. Well as-built diagram for the Upper Floridan aquifer sulfate monitor well constructed at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

Appendix C. Lithologic Log for Core Hole 1 and 2 at the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

LITHOLOGIC WELL LOG PRINTOUT SOURCE - FGS

WELL NUMBER: W-19230 COUNTY - MARION
TOTAL DEPTH: 660 FT. LOCATION: T.16S R.19E S. 7
SAMPLES - NONE LAT = 29D 06M 43S
LON = 82D 25M 58S
COMPLETION DATE: N/A ELEVATION: 48 FT
OTHER TYPES OF LOGS AVAILABLE - GAMMA, ELECTRIC, CALIPER, TEMPERATURE

OWNER/DRILLER:ROMP 128-Rainbow Springs

WORKED BY:Description by Michelle Ladle
Started 02/03/11; Completed 03/15/11

0.0 - 18.0 090UDSC UNDIFFERENTIATED SAND AND CLAY
18.0 - 87.0 124OCAL OCALA GROUP
87.0 - TD. 124AVPK AVON PARK FM.

0 - 2.5 SAND; LIGHT YELLOWISH ORANGE TO MODERATE GRAY
20% POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX, IRON CEMENT, ORGANIC MATRIX
ACCESSORY MINERALS: CLAY-15%, ORGANICS-05%
Presence of roots and plant material; oxidized gray clay

2.5- 18.0 SAND; VERY LIGHT ORANGE TO LIGHT YELLOWISH ORANGE
20% POROSITY: INTERGRANULAR
GRAIN SIZE: FINE; RANGE: VERY FINE TO MEDIUM
ROUNDNESS: ANGULAR TO SUB-ROUNDED; MEDIUM SPHERICITY
POOR INDURATION
CEMENT TYPE(S): CLAY MATRIX, IRON CEMENT, ORGANIC MATRIX
ACCESSORY MINERALS: CLAY-05%, HEAVY MINERALS-<1%
Less oxidized gray clay with depth until 5.0’ Decrease in iron becoming lighter in color with depth A few layers of white clay; 12’ of recovery in top 20’ of core (due probably to shrinkage); half inch bed or lense of sandy micrite at 17’

18.0- 25 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, VUGULAR
GRAIN TYPE: SKELETAL, INTRACLASTS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, CLAY MATRIX
IRON CEMENT
ACCESSORY MINERALS: QUARTZ SAND-15%, CLAY-05%
OTHER FEATURES: LOW RECRYSTALLIZATION
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, MILIOLIDS
Only 15” of Recovery; Top of Ocala

25 - 30 NO SAMPLES
No Recovery 25-30’

30 - 34.8 GRAINSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
25% POROSITY: INTERGRANULAR, VUGULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: SKELETAL, INTRACLASTS, CRYSTALS
95% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: MICROCRYSTALLINE TO VERY COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
IRON CEMENT
ACCESSORY MINERALS: QUARTZ SAND-05%
OTHER FEATURES: LOW RECRYSTALLIZATION, FOSSILIFEROUS
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
MILIOLIDS
Nummulites sp. at ~33'; Increase in calcite sands and
increased induration with depth; End of interval: decrease
in grain size and increase in micrite to packstone.

34.8- 36.3 PACKSTONE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: INTERGRANULAR, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
85% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, BENTHIC FORAMINIFERA
MILIOLIDS
Dissolved grain boundaries where recrystallization is high
Less recrystallization with more micrite in lower portion
Lepidocyclina ocalana? (hard to id due to
recrystallization); only 3' of Recovery 35.0-39.0'.

36.3- 37.7 GRAINSTONE; WHITE TO VERY LIGHT ORANGE
20% POROSITY: INTERGRANULAR, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: SKELETAL, CRYSTALS, CALCILUTITE
92% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: COARSE; RANGE: MICROCRYSTALLINE TO VERY COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, MILIOLIDS

37.7- 38.4 WACKESTONE; WHITE TO VERY LIGHT ORANGE
05% POROSITY: INTERGRANULAR, PIN POINT VUGS
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
25% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC

38.4- 39.5 GRAINSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: INTERGRANULAR, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, SKELETAL, SKELTAL CAST
92% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MEDIUM; RANGE: CRYPTOCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILIFEROUS
FOSSILS: FOSSIL FRAGMENTS, MOLLUSKS, MILIOLIDS
FOSSIL MOLDS

39.5- 41 MUDSTONE; MODERATE YELLOWISH BROWN TO GRAYISH BROWN
30% POROSITY: MOLDIC, VUGULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Recrystallized dolomitic limestone precipitant with large
molds

41 - 42 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
05% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE, MOLDIC
GRAIN TYPE: CRYSTALS, CALCILUTITE
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
OTHER FEATURES: HIGH RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
Very fine calcite crystals in vugs; Increase in
recrystallization with depth

42 - 59.5 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
15% POROSITY: MOLDIC, VUGULAR, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
IRON CEMENT
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS, MILIOLIDS
Only 8.5’ of recovery 45-60’; Large amount of rubble; Signs
of dissolution 50.0-59.5’

59.5- 60 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: MOLDIC, VUGULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC

60 - 61 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
30% POROSITY: MOLDIC, VUGULAR, LOW PERMEABILITY

GRAIN TYPE: CRYSTALS, CALCILUTITE
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC

61 - 62.5 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
15% POROSITY: MOLDIC, VUGULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
Calcite filled fractures

62.5- 71 MUDSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
20% POROSITY: MOLDIC, VUGULAR, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE
02% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
SEDIMENTARY STRUCTURES: NODULAR
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
VARIEGATED
Calcite lined/filled fractures; Large vugs evidence of
dissolution; Iron decreasing with depth; 34” of recovery
65-70’; 7” of recovery 70-71’

71 - 75 MUDSTONE; WHITE TO VERY LIGHT ORANGE
POROSITY: INTERCRYSTALLINE, PIN POINT VUGS, MOLDIC
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, FOSSILIFEROUS
FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA, MILIOLIDS
More vuggy and recrystallized than above interval.

75 - 80 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
POROSITY: INTERCRYSTALLINE, VUGULAR, MOLDIC
GRAIN TYPE: CRYSTALS; 05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: HEAVY MINERALS-10%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE

End of Channel 1 at 80.0’

Start of Channel 2 at 40.0’

40 - 42 MUDSTONE; WHITE TO VERY LIGHT ORANGE
20% POROSITY: VUGULAR, MOLDIC
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
08% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: HEAVY MINERALS-03%
OTHER FEATURES: HIGH RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS, MILIOLIDS

42 - 58.8 DOLOSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
05% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: NODULAR
ACCESSORY MINERALS: LIMESTONE-30%, HEAVY MINERALS-03%
IRON STAIN-10%
OTHER FEATURES: CALCAREOUS, CRYSTALLINE
FOSSILS: FOSSIL MOLDS
Multiple mollusk molds; Nummulites sp.; Calcite filed
Fractures; Nodules of recrystallized mudstone; Large vugs
evidence of dissolution; Only 2’ of recovery 52-59’

58.8- 60 WACKESTONE; WHITE TO VERY LIGHT ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
45% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
ACCESSORY MINERALS: HEAVY MINERALS-03%
OTHER FEATURES: HIGH RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA
Calcite lined vugs; large vugs from dissolution; Dissolved
grain boundaries

60 - 63.5 LIMESTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
SEDIMENTARY STRUCTURES: MOTTLED, NODULAR
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
Dense calcite/dolomite with nodules of recrystallized

mudstone; variable amounts of Fe and Mg (dolomitization)
Areas of mudstone appear to be more dissolved than
surrounding matrix.

63.5- 71 MUDSTONE; VERY LIGHT ORANGE
25% POROSITY: VUGULAR, INTERCRYSTALLINE, PIN POINT VUGS
GRAIN TYPE: CRYSTALS, SKELTAL CAST
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
Dense crystalline LS with nodules of recrystallized
wackestone; Large vugs evidence of dissolution (of primarily
the less indurated nodules); Recovery: 9” for 65-68’; 10”
for 69-70’; 2.2’ for 70-75’

71 - 72 WACKESTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: CHALKY, LOW RECRYSTALLIZATION
FOSSILS: MILIOLIDS, BENTHIC FORAMINIFERA
2’ of recovery 70-75’; Increase in grain size with depth
Top of interval: micritic/chalky

72 - 75 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, SKELTAL CAST
35% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
Similar to 63.5-71.0 but increased allochems (dense
crystalline LS mottled with vuggy recrystallized packstone
with dissolved grain boundaries); forams difficult to id
due to recrystallization.

75 - 87.5 MUDSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
30% POROSITY: VUGULAR, MOLDIC, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS, SKELTAL CAST
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
Similar to 63.5-71.0’; Dense calcite with nodules of
recrystallized mudstone; Recovery: 2’ for 75-80’; 2’ for

80-85’; 2.7’ for 85-90’; Largely rubble; large vugs
evidence of dissolution; Areas of iron minerals.

87.5- 88.5 MUDSTONE; VERY LIGHT ORANGE
20% POROSITY: INTERCRYSTALLINE, MOLDIC
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CRYSTALS; 01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
FOSSILS: FOSSIL MOLDS
Molds may be from Dictyoconus sp. but hard to id. Increase
in dolomite with depth; 2.7’ recovery 85-90’

88.5- 92 LIMESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
IRON CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
Only 2.3’ of recovery 90-95’; Rubble; Possible cave-in?
Similar to 75.0-87.5’.

92 - 94 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
30% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: SUCROSIC, CRYSTALLINE
FOSSILS: FOSSIL MOLDS
Induration increase with depth; Bryozoa molds

94 - 97 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS, ECHINOID

97 - 102.8 DOLOSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
30% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT

OTHER FEATURES: SUCROSIC, CRYSTALLINE
FOSSILS: FOSSIL MOLDS
At 102.0’: Layers of large echinoid fragments

102.8- 111 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS, ECHINOID
Only 39” of recovery 110-114’

111 - 112.3 DOLOSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
35% POROSITY: VUGULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO VERY COARSE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: CALCAREOUS
Possibly reworked

112.3- 116.2 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: MOLDIC, INTERCRYSTALLINE; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: SUCROSIC
FOSSILS: FOSSIL MOLDS, ECHINOID
Moderate permeability; Increased indured induration with depth; Echinoid at 113.9’: can see dorsal structure from inside; round; 6cm diam; pattern similar to Periarchus; At 114.5: Triangular mold

116.2- 116.8 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS, BRYOZOA, ECHINOID

116.8- 118.1 WACKESTONE; VERY LIGHT ORANGE
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS; 40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
FOSSILS: FOSSIL MOLDS
Top 2”: Non-permeable, zero porosity

118.1- 118.3 MUDSTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE
GRAIN SIZE: MICROCRYSTALLINE

RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION
Calcite filled fractures

118.3- 123.8 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: VUGULAR, INTERCRYSTALLINE, INTERGRANULAR
GRAIN TYPE: SKELTAL CAST, BIOGENIC, CRYSTALS
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC, FOSSILIFEROUS
FOSSILS: BENTHIC FORAMINIFERA, MILIOLIDS, FOSSIL FRAGMENTS
ECHINOID
Vuggy fossiliferous packstone/grainstone interbedded with
low porosity mudstone; Upper 6”; large vugs; increase in
dolomitization with depth; At 123.7’: flat round fossil
(lep or Archais?)

123.8- 130.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
15% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS, FOSSIL FRAGMENTS
At 125.3’: Echinoid mold with preserved outer texture

130.5- 134.1 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
08% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: IRON STAIN-03%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
Fewer molds; increased compaction; Dense calcareous
dolomite interbedded with dolomitic crystalline mudstone
and moldic (more porous) dolomite.

134.1- 137 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
30% POROSITY: MOLDIC, VUGULAR, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: SUCROSIC
FOSSILS: FOSSIL MOLDS
Moderate permeability; Only 40” of recovery 135-140’; Molds
shaped more like Dictyconus sp. or Fabiana cubensis

Possibly some echinoid casts and molds

137 - 140.5 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
10% POROSITY: PIN POINT VUGS, MOLDIC, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: IRON STAIN-02%
OTHER FEATURES: SUCROSIC
FOSSILS: FOSSIL MOLDS
End of interval (~1’): Dense compact fine DS; possibly some
silica present (intergranular)

140.5- 145.5 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
15% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: CRYPTOCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
ACCESSORY MINERALS: CHERT-03%
FOSSILS: FOSSIL MOLDS
Increase in chert with depth

145.5- 146.5 DOLOSTONE;
POROSITY: NOT OBSERVED, LOW PERMEABILITY; 50-90% ALTERED
ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
ACCESSORY MINERALS: CHERT-25%
Dense silicified DS

146.5- 150.7 DOLOSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE
10% POROSITY: MOLDIC, INTERCRYSTALLINE; 90-100% ALTERED
SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: SUCROSIC
FOSSILS: FOSSIL MOLDS
Only 37” of recovery 146-150

150.7- 151.3 DOLOSTONE; GRAYISH BROWN TO MODERATE LIGHT GRAY
POROSITY: NOT OBSERVED, LOW PERMEABILITY; 50-90% ALTERED
ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
ACCESSORY MINERALS: CHERT-20%, HEAVY MINERALS-01%

151.3- 153.4 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
05% POROSITY: MOLDIC, LOW PERMEABILITY; 50-90% ALTERED

ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%

153.4- 154.1 DOLOSTONE; GRAYISH ORANGE TO MODERATE YELLOWISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: SUCROSIC
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS

154.1- 157 DOLOSTONE; LIGHT GRAY TO GRAYISH BROWN
10% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
ACCESSORY MINERALS: CHERT-15%
FOSSILS: FOSSIL MOLDS
Mollusk molds; Increase in silica with depth

157 - 162.8 DOLOSTONE; GRAYISH ORANGE TO MODERATE YELLOWISH BROWN
25% POROSITY: MOLDIC, VUGULAR, INTERCRYSTALLINE
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS
Good Permeability; 158-158.2’: Silicified DS; 161.0’:
Lighter in color; increased induration

162.8- 164 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
15% POROSITY: MOLDIC, PIN POINT VUGS
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS, FOSSIL FRAGMENTS

164 - 168.1 WACKESTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, INTERGRANULAR
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CALCILUTITE, SKELETAL, BIOGENIC
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%, ORGANICS-01%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA
Echinoid and mollusk molds; Some silicification @ 167.5 and

168.0'; Peloids and/or miliolids present

168.1- 168.7 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: NOT OBSERVED, LOW PERMEABILITY; 50-90% ALTERED ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: CALCAREOUS

168.7- 170.2 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, POSSIBLY HIGH PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: CLAY-02%, IRON STAIN-02%
OTHER FEATURES: CALCAREOUS, SUCROSIC
FOSSILS: FOSSIL MOLDS
Mottled clay layer at 168.8': shows signs of flow; Increase induration and recrystallization with depth

170.2- 173 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: PIN POINT VUGS, INTERGRANULAR
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE; RANGE: CRYPTOCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE

173 - 179.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: MOLDIC, VUGULAR, POSSIBLY HIGH PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: FISSILE
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
CALCAREOUS
FOSSILS: FOSSIL MOLDS
Dolomitized and recrystallized packstone/wackestone
Decrease in dolomitization and recrystallization with depth

179.5- 187.3 MUDSTONE; VERY LIGHT ORANGE
08% POROSITY: MOLDIC, PIN POINT VUGS
GRAIN TYPE: CALCILUTITE, INTRACLASTS, CRYSTALS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED

OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Interbedded with less indurated wackestone and less porous crystalline dolomitic mudstone; Only 4' of recovery 180-185'; At 180': Rubble

187.3- 197 MUDSTONE; VERY LIGHT ORANGE
03% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, INTRACLASTS, CRYSTALS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: HIGH RECRYSTALLIZATION
Interbedded with recrystallized wackestone (less indurated good permeability); Multiple areas of rubble; Recovery: 25" for 187-190'; 22" for 190-195'; 38" for 195-200'.

197 - 202 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
80% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS
BENTHIC FORAMINIFERA, MOLLUSKS, ECHINOID
Area ~198': some silicification present; At 201': Dense recrystallized mudstone/dolomite; 30" of recovery 200-205'

202 - 212 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, SKELETAL, CALCILUTITE
25% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS, MOLLUSKS
BENTHIC FORAMINIFERA
Recovery: 31" for 205-210'; 24" for 210-215'

212 - 221.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL FRAGMENTS, FOSSIL MOLDS
At 215': Area of fossiliferous dolomitized grainstone
Recovery: 45" for 215-220'; 22" for 220-223; Mollusks and

miliolids present

221.5- 232.5 PACKSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
30% POROSITY: VUGULAR, MOLDIC, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELETAL
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
IRON CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Recovery: 14” for 223-225’; 31” for 225-230’; 4’ for
230-235’; Aliz. Red-purple; Dolomitic packstone/ wackestone
interbedded with dense cryptocrystalline DS; 225.0-232.5’:
Less dolomitization and recrystallization; Interbedded with
dolomitic chalk.

232.5- 235.2 WACKESTONE; VERY LIGHT ORANGE
10% POROSITY: VUGULAR, MOLDIC, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CRYSTALS, INTRACLASTS, CALCILUTITE
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: CRYPTOCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
23” of recovery 235-240’

235.2- 243 MUDSTONE; VERY LIGHT ORANGE
10% POROSITY: VUGULAR, PIN POINT VUGS
POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
DOLOMITIC
FOSSILS: FOSSIL MOLDS
Interbedded with dolomitic wackestone; 43” of recovery
240-245’.

243 - 249.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
15% POROSITY: VUGULAR, MOLDIC, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
FOSSILS: FOSSIL MOLDS
28” of recovery 245-250’; Some areas dense and less porous

249.5- 252 DOLOSTONE; VERY LIGHT ORANGE TO LIGHT GRAY

30% POROSITY: VUGULAR, INTERGRANULAR; 50-90% ALTERED
ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: MOTTLED
ACCESSORY MINERALS: LIMESTONE-25%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
Reworked dolomite mottled with crystalline calcarenite

252 - 255 WACKESTONE; VERY LIGHT ORANGE
20% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS

255 - 260 WACKESTONE; VERY LIGHT ORANGE
15% POROSITY: VUGULAR, PIN POINT VUGS, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC
21” of recovery 255-260’; Less porosity than above; High
permeability; End of interval: recrystallized mudstone
(lower permeability)

260 - 265.6 MUDSTONE; VERY LIGHT ORANGE TO VERY LIGHT GRAY
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: MOTTLED
ACCESSORY MINERALS: CLAY-10%, ORGANICS-02%
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC
Largely rubble, but good recovery

265.6- 267.9 WACKESTONE; VERY LIGHT ORANGE TO VERY LIGHT GRAY
05% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; MODERATE INDURATION

CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED, MOTTLED
ACCESSORY MINERALS: PYRITE-03%, CLAY-10%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Interbedded with dolomitic recrystallized mudstone; Organic
clays are somewhat dolomitized.

267.9- 271.1 PACKSTONE; VERY LIGHT ORANGE TO LIGHT GRAY
15% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: SKELETAL, CALCILUTITE, CRYSTALS
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: MOTTLED
ACCESSORY MINERALS: CLAY-10%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Variable recrystallization; highly permeable

271.1- 275 DOLOSTONE; VERY LIGHT ORANGE
10% POROSITY: MOLDIC, INTERCRYSTALLINE, PIN POINT VUGS
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
CALCILUTITE MATRIX
SEDIMENTARY STRUCTURES: MOTTLED
ACCESSORY MINERALS: HEAVY MINERALS-03%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
274-275’: Less dolomitic and mottled with wackestone
Rubble

275 - 280.1 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
10% POROSITY: MOLDIC, INTERCRYSTALLINE, PIN POINT VUGS
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: MOTTLED
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Increase in molds and allochems (v.f. calcarenite) with
depth and becoming less indurated; Mottled texture-
variable dolomitization; 5” of recovery 279-280’

280.1- 285 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
15% POROSITY: MOLDIC, VUGULAR, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, INTRACLASTS, CRYSTALS
30% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
Remnant grain boundaries

285 - 290.1 MUDSTONE; VERY LIGHT ORANGE
POROSITY: PIN POINT VUGS, MOLDIC
GRAIN TYPE: CALCILUTITE, INTRACLASTS, CRYSTALS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
SILICIC CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
10” of recovery 285-290’; Rubble; Some areas of silicified
DS/chert

290.1- 292 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, INTRACLASTS, CALCILUTITE
70% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Interbedded with dolomite

292 - 295 MUDSTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
Remnant grain boundaries; Highly permeable

295 - 305 PACKSTONE; VERY LIGHT ORANGE
30% POROSITY: VUGULAR, MOLDIC
GRAIN TYPE: CRYSTALS, INTRACLASTS, SKELTAL CAST
75% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
Interbedded with thin beds of dolomite and recrystallized
wackestone with remnant grain boundaries; Recovery: 28”
for 295-300’; 24” for 300-305’

305 - 310 MUDSTONE; VERY LIGHT ORANGE TO VERY LIGHT GRAY
10% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELTAL CAST
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
14” of recovery 305-310’

310 - 311.7 CHALK; VERY LIGHT ORANGE
02% POROSITY: PIN POINT VUGS, INTERGRANULAR
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION

311.7- 317.9 WACKESTONE; VERY LIGHT ORANGE
08% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
35% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%, CHERT-<1%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
FOSSILS: FOSSIL MOLDS, BENTHIC FORAMINIFERA
Remnant grain boundaries

317.9- 320 MUDSTONE; VERY LIGHT ORANGE
02% POROSITY: PIN POINT VUGS, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
DOLOMITIC
Dolomite crystals increasing with depth to 320’

320 - 323.1 WACKESTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
DOLOMITIC
FOSSILS: FOSSIL MOLDS

323.1- 328.4 PACKSTONE; LIGHT GREENISH GRAY
02% POROSITY: PIN POINT VUGS, INTERGRANULAR

GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: STREAKED
ACCESSORY MINERALS: CHERT-<1%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
FOSSILS: FOSSIL MOLDS
Streaks of silicification; Increased recrystallization with depth

328.4- 333.1 WACKESTONE; VERY LIGHT ORANGE
15% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS, WORM TRACES

333.1- 334.8 MUDSTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE, MOLDIC
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: STREAKED
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS, WORM TRACES, MILIOLIDS
Light gray streaks: possibly silica

334.8- 342 WACKESTONE; VERY LIGHT ORANGE
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
40% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
Remnant grain boundaries; Variable amount of visible allochems and recrystallization; Interbedded with less porous chalky recrystallized mudstone.

342 - 347 MUDSTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
02% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE

RANGE: CRYPTOCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: FISSILE
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, CHALKY
DOLOMITIC
FOSSILS: FOSSIL MOLDS
4’ of recovery 345-350’

347 - 350.1 WACKESTONE; VERY LIGHT ORANGE
15% POROSITY: VUGULAR, MOLDIC, POSSIBLY HIGH PERMEABILITY
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Porosity varies 10-20%; Some regions largely moldic and
vuggy; Variable visible allochems; Remnant grain
boundaries

350.1- 351 MUDSTONE; VERY LIGHT ORANGE
08% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS

351 - 352.7 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
30% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS

352.7- 359.5 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
30% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS, MOLLUSKS
Remnant grains; Recrystallized packstone; Interbedded with

dolomitic mudstone; 355.3-356.0’: Area of higher
recrystallization and dolomitization

359.5- 361.5 MUDSTONE; VERY LIGHT ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC, CHALKY
FOSSILS: FOSSIL MOLDS, WORM TRACES
359.5-360.1’: Higher recrystallization and dolomitization

361.5- 364 PACKSTONE; VERY LIGHT ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, INTRACLASTS
60% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: VERY FINE; RANGE: CRYPTOCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
V. fine calcerenitic sized reworked recrystallized LS; Some
areas more of a wackestone

364 - 365 WACKESTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
364-364.5’: Higher recrystallization and dolomitization
(similar to 359.5-360.1’)

365 - 370 WACKESTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
10% POROSITY: MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-<1%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Only 2’ of recovery 365-370’; Top 6”: quartz crystals
Recrystallized; Reworked

370 - 376.8 MUDSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
03% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR

GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%, IRON STAIN-<1%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
4’ of recovery 370-375’; Top 4” of recovery: rubble with
amounts of dolomite and iron

376.8- 385.7 MUDSTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
CHALKY
FOSSILS: FOSSIL MOLDS
Less porosity and allochems with depth; Recovery: 6” for
380-385’; 4’ for 385-390’

385.7- 388 WACKESTONE; VERY LIGHT ORANGE
15% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, SKELTAL CAST
15% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-03%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Variable amounts of allochems

388 - 389 MUDSTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, SKELTAL CAST
08% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
CHALKY

389 - 390.1 MUDSTONE; VERY LIGHT ORANGE
03% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, CRYSTALS
03% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-<1%, ORGANICS-<1%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC, CHALKY

390.1- 392.9 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: MOLDIC, VUGULAR, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
OTHER FEATURES: CALCAREOUS
Remnant grain boundaries visible

392.9- 395 MUDSTONE; VERY LIGHT ORANGE
03% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
01% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-<1%, CHERT-<1%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC, CHALKY
Some remnant grains; Similar to 389.0-390.1’; End of
interval (1”): Up to 35% allochems and 15% porosity
(largely moldic)

395 - 400.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
05% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
ACCESSORY MINERALS: HEAVY MINERALS-<1%, ORGANICS-01%
OTHER FEATURES: CALCAREOUS, CHALKY
Some visible remnant grain boundaries; Organic laminae at
end of interval

400.5- 405 CHALK; VERY LIGHT ORANGE
03% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE, VUGULAR
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: QUARTZ-01%, CHERT-01%
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC
Quartz crystals within vugs at ~403’; Chert streaks
Variable recrystallization; 4’ of recovery 400-405’; Area of
rubble ~401-402’.

405 - 408.6 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: MOLDIC, VUGULAR, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE

GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS

408.6- 410 CHALK; VERY LIGHT ORANGE TO GRAYISH ORANGE
03% POROSITY: MOLDIC, PIN POINT VUGS; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: QUARTZ-01%, CLAY-08%
OTHER FEATURES: DOLOMITIC
FOSSILS: FOSSIL MOLDS
408.6-408.7’: Layer of clays and gypsum; Quartz crystals in
some molds/vugs

410 - 416 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
03% POROSITY: MOLDIC, FRACTURE, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%, ORGANICS-01%
CLAY-02%, GYPSUM-01%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
Some areas less dolomitizated (dolomitic chalk/mudstone)
Decrease in permeability and increase in dolomite with
depth; 32” of recovery 410-415’; At ~413.5-413.8’: Layers
of clay, gypsum, and quartz; At 415’ and 416’: Broken
chunks of dolomitic chalk and quartz crystals

416 - 418 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
<1% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-01%, ORGANICS-01%
~417.5-418’: Less dolomitized, quartz and white cubic
crystals in vugs; vuggy rubble; 13” of recovery 417-420’

418 - 420 CHERT; DARK GRAY TO GRAYISH BROWN
POROSITY: NOT OBSERVED, LOW PERMEABILITY
ACCESSORY MINERALS: DOLOMITE-10%

420 - 425 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
05% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: CHERT-25%, HEAVY MINERALS-01%
Layers of black chert at ~420.5-451, ~452.2-252.8, and

~453.4-454; 38” of recovery 420-425’; Reworked dolosilt
Remnant layers visible

425 - 435 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
10% POROSITY: PIN POINT VUGS, VUGULAR, MOLDIC
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, ORGANIC MATRIX
ACCESSORY MINERALS: ORGANICS-10%, QUARTZ-03%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
Organic laminae throughout; Increase in vugs and becoming
more recrystallized with depth; Layers of less dolomitized
recrystallized vuggy LS present; Layer of chert at 435.0’

435 - 439.5 DOLOSTONE; VERY LIGHT ORANGE
10% POROSITY: VUGULAR, INTERCRYSTALLINE, MOLDIC
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-02%
17” of recovery 435-440’

439.5- 446.5 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
05% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SILICIC CEMENT
IRON CEMENT
SEDIMENTARY STRUCTURES: MASSIVE
ACCESSORY MINERALS: IRON STAIN-03%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION
18” of recovery 440-445’

446.5- 447 DOLOSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
05% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, IRON CEMENT
Good permeability

447 - 450.2 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
05% POROSITY: VUGULAR, MOLDIC, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: HEAVY MINERALS-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
Crystals in vugs: quartz and/or gypsum, some prismatic
some fibrous (at 417.0’); Some areas more of a wackestone

End of interval: nodular in crystalline dolomite (brown
translucent) matrix

450.2- 457 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: CALCAREOUS
V. fine sand-size dolomite interbedded with vuggy
microcrystalline DS; Low permeability; Vugs lined with
large dolomite crystals after 454’.

457 - 459.3 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: CRYSTALLINE
FOSSILS: FOSSIL MOLDS

459.3- 463.1 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: VUGULAR, MOLDIC; 90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
FOSSILS: FOSSIL MOLDS
Smaller vugs/molds filled with crystalline dolomite (larger
vugs lined); Mudstone-like texture

463.1- 465.1 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
OTHER FEATURES: CRYSTALLINE
FOSSILS: FOSSIL MOLDS
Presence of gypsum crystals in vugs/molds

465.1- 469.8 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: VUGULAR, PIN POINT VUGS; 90-100% ALTERED
ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
CALCILUTITE MATRIX
OTHER FEATURES: CALCAREOUS
Mudstone-like texture with large vugs lined with dolomite
crystals; Main rock becoming a mudstone (less dolomitic)
with large areas of precipitated dolomite.

469.8- 478 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED, MOTTLED
ACCESSORY MINERALS: ORGANICS-<1%
OTHER FEATURES: CALCAREOUS, CRYSTALLINE
MEDIUM RECRYSTALLIZATION
FOSSILS: FOSSIL MOLDS
Calcite and dolomite crystals in vugs/molds; Fractures in
rock; good permeability; Less porous after 475’
472.5-472.7’: Less recrystallized and less vuggy
Interbedded with recrystallized dolomitic LS; 39” of
recovery 475-480’.

478 - 485 MUDSTONE; VERY LIGHT ORANGE TO TRANSPARENT
5V% POROSITY: INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-20%
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC, CHALKY
Large dolomite crystals

485 - 492.4 MUDSTONE; VERY LIGHT ORANGE
05% POROSITY: PIN POINT VUGS, INTERGRANULAR
INTERCRYSTALLINE
ACCESSORY MINERALS: DOLOMITE-10%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
Variable recrystallization; Dolomite crystals; Increased
dolomitization with depth

492.4- 500 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
08% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, CALCILUTITE MATRIX
SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
Interbedded with dolomitic mudstone (less indurated); At
495.4’: organic laminae

500 - 503.7 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
15% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE

RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED, MOTTLED
OTHER FEATURES: CALCAREOUS, CRYSTALLINE
FOSSILS: FOSSIL MOLDS
Interbedded with recrystallized dolomitic wackestone.

503.7- 505 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
05% POROSITY: PIN POINT VUGS, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: NODULAR
OTHER FEATURES: LOW RECRYSTALLIZATION, CHALKY, DOLOMITIC

505 - 506.1 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
20% POROSITY: VUGULAR, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: CRYSTALLINE, CALCAREOUS
FOSSILS: FOSSIL MOLDS

506.1- 509.7 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
10% POROSITY: PIN POINT VUGS, INTERGRANULAR, VUGULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-30%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
CHALKY
Dolomite crystals in micritic matrix

509.7- 515.7 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: CRYSTALLINE, CALCAREOUS
FOSSILS: FOSSIL MOLDS, WORM TRACES

515.7- 520 MUDSTONE; VERY LIGHT ORANGE
03% POROSITY: PIN POINT VUGS, INTERGRANULAR
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
02% ALLOCHEMICAL CONSTITUENTS

GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO FINE; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
CHALKY
At 519.3: Poorly indurated with low recrystallization
Organic laminae throughout

520 - 521.2 DOLOSTONE; VERY LIGHT ORANGE
10% POROSITY: VUGULAR, MOLDIC; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
CALCILUTITE MATRIX
ACCESSORY MINERALS: LIMESTONE-30%
OTHER FEATURES: CALCAREOUS
Increased dolomitization with depth

521.2- 526.5 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
OTHER FEATURES: CALCAREOUS
Organic laminae; Variable porosity (Increase with depth)

526.5- 530 WACKESTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, INTERGRANULAR, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; POOR INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, DOLOMITE CEMENT
OTHER FEATURES: LOW RECRYSTALLIZATION, DOLOMITIC

530 - 535.6 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ORGANIC MATRIX
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: LIMESTONE-20%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS, WORM TRACES, CONES
Interbedded with dolomitic wackestone/mudstone (less porous), organic laminae, and crystalline dolomite (translucent and precipitated?); 533.5-533.8': Poorly indurated dolomitic mudstone (silt-size); Cross-sections of recrystallized cones present

535.6- 541 MUDSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH ORANGE

10% POROSITY: PIN POINT VUGS, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: CALCILUTITE, CRYSTALS, INTRACLASTS
03% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-20%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Vugs and fractures lined with large dolomite crystals and
gypsum/anhydrite crystals; Signs of dissolution; Increase
in recrystallization with depth; Variable dolomitization
Some dissolved grain boundaries

541 - 542.9 WACKESTONE; VERY LIGHT ORANGE
10% POROSITY: PIN POINT VUGS, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
20% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; MODERATE INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-25%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC

542.9- 543.9 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
08% POROSITY: VUGULAR, MOLDIC, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
FOSSILS: FOSSIL MOLDS

543.9- 546 WACKESTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
10% POROSITY: VUGULAR, MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
25% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: MICROCRYSTALLINE TO MEDIUM; MODERATE INDURATION
CEMENT TYPE(S): CALCILUTITE MATRIX, SPARRY CALCITE CEMENT
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: MOTTLED, BRECCIATED
ACCESSORY MINERALS: DOLOMITE-20%, ORGANICS-10%
OTHER FEATURES: MEDIUM RECRYSTALLIZATION, DOLOMITIC
FOSSILS: FOSSIL MOLDS
Vugs and fractures lined with dolomite crystals; Increase
in recrystallization at 545’.

546 - 553 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
15% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT

SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: ORGANICS-03%
FOSSILS: FOSSIL MOLDS
Interbedded with dolomitic recrystallized wackestone (see above); Nodules of anhydrite; Decrease in porosity with depth; Evidence of dissolution; Organic laminae

553 - 561.5 MUDSTONE; VERY LIGHT ORANGE
03% POROSITY: MOLDIC, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
02% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MEDIUM; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: NODULAR, MOTTLED
ACCESSORY MINERALS: ORGANICS-05%, HEAVY MINERALS-02%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC, CHALKY
Nodules of vuggy dolomite; mottled with organics (increasing with depth); Coarse dolomite crystals throughout; increase in recrystallization and color change at 558.0-558.7’

561.5- 565 DOLOSTONE; VERY LIGHT ORANGE TO DARK YELLOWISH BROWN
10% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: PEAT-30%
OTHER FEATURES: CALCAREOUS
FOSSILS: PLANT REMAINS, FOSSIL MOLDS
Increase in dolomitization and coarse dolomite rhombs with depth; Increase in vugs and molds

565 - 566.2 MUDSTONE; VERY LIGHT ORANGE TO MODERATE YELLOWISH BROWN
05% POROSITY: MOLDIC, VUGULAR, INTERCRYSTALLINE
GRAIN TYPE: CRYSTALS, CALCILUTITE, INTRACLASTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, CALCILUTITE MATRIX
DOLOMITE CEMENT
ACCESSORY MINERALS: DOLOMITE-35%
OTHER FEATURES: HIGH RECRYSTALLIZATION, DOLOMITIC
Brecciated dolomitic LS in dolomite matrix

566.2- 568.5 DOLOSTONE; MODERATE YELLOWISH BROWN
10% POROSITY: MOLDIC, PIN POINT VUGS, INTERCRYSTALLINE
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: LIMESTONE-03%, PEAT-15%
OTHER FEATURES: CALCAREOUS
Larger rhombs in larger vugs

568.5- 570 DOLOSTONE; GRAYISH BROWN TO DARK YELLOWISH BROWN
20% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO COARSE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: LIMESTONE-20%, PEAT-10%
OTHER FEATURES: CALCAREOUS
Larger vugs from dissolution lined with coarse rhombs

570 - 573.9 DOLOSTONE; MODERATE YELLOWISH BROWN
10% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: PEAT-03%

573.9- 577 DOLOSTONE; MODERATE YELLOWISH BROWN TO DARK YELLOWISH BROWN
20% POROSITY: VUGULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: GYPSUM-02%, HEAVY MINERALS-<1%
ORGANICS-01%
FOSSILS: FOSSIL MOLDS

577 - 579 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
10% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: GYPSUM-01%

579 - 580 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
20% POROSITY: VUGULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: LIMESTONE-35%, GYPSUM-03%
OTHER FEATURES: CALCAREOUS
FOSSILS: FOSSIL MOLDS
Upper end of interval: highly recrystallized dolomitic LS
Recrystallized casts present

580 - 583 DOLOSTONE; GRAYISH ORANGE TO MODERATE YELLOWISH BROWN
05% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: PEAT-10%

Organic/Peat Layers throughout.

583 - 587 DOLOSTONE; MODERATE YELLOWISH BROWN TO MODERATE GRAY
03% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ORGANIC MATRIX
SEDIMENTARY STRUCTURES: INTERBEDDED, MOTTLED, BRECCIATED
ACCESSORY MINERALS: PEAT-20%
OTHER FEATURES: CALCAREOUS
V. fine dolarenite mottled and interbedded with
microcrystalline DS and peat layers; Breccias of
recrystallized LS

587 - 591.5 DOLOSTONE; MODERATE YELLOWISH BROWN TO DARK YELLOWISH BROWN
03% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ORGANIC MATRIX
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: PEAT-30%
OTHER FEATURES: CALCAREOUS
Interbedded with peat layers

591.5- 594.2 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
25% POROSITY: VUGULAR, MOLDIC, POSSIBLY HIGH PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO MEDIUM
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: INTERBEDDED
ACCESSORY MINERALS: GYPSUM-05%, PEAT-10%
Interbedded with peat and gypsum; Thick layer of peat at
594.1’

594.2- 602.5 DOLOSTONE; WHITE TO MODERATE YELLOWISH BROWN
25% POROSITY: VUGULAR, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: FINE; RANGE: MICROCRYSTALLINE TO COARSE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, ORGANIC MATRIX
GYPSUM CEMENT
ACCESSORY MINERALS: GYPSUM-05%, ORGANICS-01%
FOSSILS: FOSSIL MOLDS
Anhydrite/gypsum and large coarse dolomite rhombs in large
dissolved vugs; Semi-dissolved nodules of gypsum

602.5- 607.3 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
20% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION

CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
ACCESSORY MINERALS: GYPSUM-05%
FOSSILS: FOSSIL MOLDS
Anhydrite/gypsum nodules

607.3- 608.9 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
10% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE, MOLDIC
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
ORGANIC MATRIX
ACCESSORY MINERALS: GYPSUM-03%, PEAT-05%

608.9- 612 DOLOSTONE; MODERATE YELLOWISH BROWN TO DARK YELLOWISH BROWN
15% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MEDIUM; RANGE: MICROCRYSTALLINE TO COARSE
MODERATE INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
ORGANIC MATRIX
ACCESSORY MINERALS: GYPSUM-20%
Some areas more vuggy with porosity up to 25%; Large
gypsum/anhydrite nodules (>2” diam.)

612 - 618 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
02% POROSITY: VUGULAR, MOLDIC, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
SEDIMENTARY STRUCTURES: MASSIVE
ACCESSORY MINERALS: GYPSUM-15%, PEAT-02%
Some layers of peat at top of interval

618 - 620 DOLOSTONE; GRAYISH BROWN
01% POROSITY: PIN POINT VUGS, MOLDIC, INTERCRYSTALLINE
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
GYPSUM CEMENT
ACCESSORY MINERALS: GYPSUM-20%
OTHER FEATURES: CALCAREOUS, CHALKY
Brecciated gypsum/anhydrite nodules; large nodule
618.2-618.8; Vugs and fractures infilled with gypsum

620 - 631.3 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
01% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
GYPSUM CEMENT

SEDIMENTARY STRUCTURES: MASSIVE
ACCESSORY MINERALS: GYPSUM-40%, LIMESTONE-03%
OTHER FEATURES: CALCAREOUS
Brecciated gypsum and anhydrite nodules; filled vugs and
fractures (brecciated 621.9-622.6); Large nodules:
624.5-625.5, 625.7-626.4, 627.0-627.6, 628.3-628.8
Variable amounts of iron; small nodules of LS; 622.9-623.4:
increase in porosity (vugs)

631.3- 637.6 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
02% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
SEDIMENTARY STRUCTURES: MASSIVE, BRECCIATED
ACCESSORY MINERALS: GYPSUM-35%

637.6- 639.7 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
05% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
SEDIMENTARY STRUCTURES: MOTTLED
ACCESSORY MINERALS: ORGANICS-10%, GYPSUM-02%
OTHER FEATURES: CALCAREOUS
Organic laminae

639.7- 645.6 DOLOSTONE; GRAYISH BROWN TO GRAYISH ORANGE
05% POROSITY: MOLDIC, INTERCRYSTALLINE
POSSIBLY HIGH PERMEABILITY; 50-90% ALTERED; ANHEDRAL
GRAIN SIZE: VERY FINE; RANGE: MICROCRYSTALLINE TO FINE
GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: GYPSUM-05%, ORGANICS-03%
OTHER FEATURES: CALCAREOUS

645.6- 648 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
<1% POROSITY: MOLDIC, LOW PERMEABILITY; 90-100% ALTERED
ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: LITHOGRAPHIC TO MICROCRYSTALLINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
ACCESSORY MINERALS: GYPSUM-15%
Gypsum layers/nodules at 646.9 and 647.4 (~2”)

648 - 650.5 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
03% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
SPARRY CALCITE CEMENT

ACCESSORY MINERALS: GYPSUM-15%
Molds filled with gypsum; layer at 649.1-649.4; Remnant
grain boundaries visible

650.5- 653 MUDSTONE; VERY LIGHT ORANGE TO GRAYISH BROWN
03% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
GRAIN TYPE: CRYSTALS; 05% ALLOCHEMICAL CONSTITUENTS
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): SPARRY CALCITE CEMENT, DOLOMITE CEMENT
GYPSUM CEMENT
SEDIMENTARY STRUCTURES: BRECCIATED
ACCESSORY MINERALS: GYPSUM-05%
OTHER FEATURES: HIGH RECRYSTALLIZATION, CRYSTALLINE
DOLOMITIC
Remnant grain boundaries; Molds and vugs filled with
gypsum

653 - 654 DOLOSTONE; VERY LIGHT ORANGE TO GRAYISH ORANGE
01% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; SUBHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, SPARRY CALCITE CEMENT
ACCESSORY MINERALS: GYPSUM-10%
OTHER FEATURES: CALCAREOUS
Gypsum nodule at 653.1’

654 - 655 DOLOSTONE; GRAYISH ORANGE TO GRAYISH BROWN
03% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: GYPSUM-02%

655 - 657.3 DOLOSTONE; VERY LIGHT ORANGE TO LIGHT GRAY
<1% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
50-90% ALTERED; ANHEDRAL
GRAIN SIZE: CRYPTOCRYSTALLINE
RANGE: LITHOGRAPHIC TO MICROCRYSTALLINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, GYPSUM CEMENT
SEDIMENTARY STRUCTURES: BRECCIATED
ACCESSORY MINERALS: GYPSUM-10%
OTHER FEATURES: CALCAREOUS
Brecciated where gypsum nodules are

657.3- 658.1 GYPSUM; WHITE TO VERY LIGHT GRAY
POROSITY: NOT OBSERVED, LOW PERMEABILITY; GOOD INDURATION
CEMENT TYPE(S): GYPSUM CEMENT, ANHYDRITE CEMENT

658.1- 658.5 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
01% POROSITY: PIN POINT VUGS, INTERCRYSTALLINE
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO MICROCRYSTALLINE

GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT, ORGANIC MATRIX
ACCESSORY MINERALS: ORGANICS-<1%, GYPSUM-<1%
Flecks of organics

658.5- 660 DOLOSTONE; GRAYISH BROWN TO MODERATE YELLOWISH BROWN
05% POROSITY: MOLDIC, INTERCRYSTALLINE, LOW PERMEABILITY
90-100% ALTERED; ANHEDRAL
GRAIN SIZE: MICROCRYSTALLINE
RANGE: CRYPTOCRYSTALLINE TO VERY FINE; GOOD INDURATION
CEMENT TYPE(S): DOLOMITE CEMENT
ACCESSORY MINERALS: GYPSUM-<1%

660 TOTAL DEPTH

Appendix D. Digital Photographs of Core Samples Retrieved from Core Hole 1 and 2 at the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

Core Hole 1

Core Hole 1

Core Hole 1

Core Hole 1

Core Hole 2

Core Hole 1

Core Hole 2

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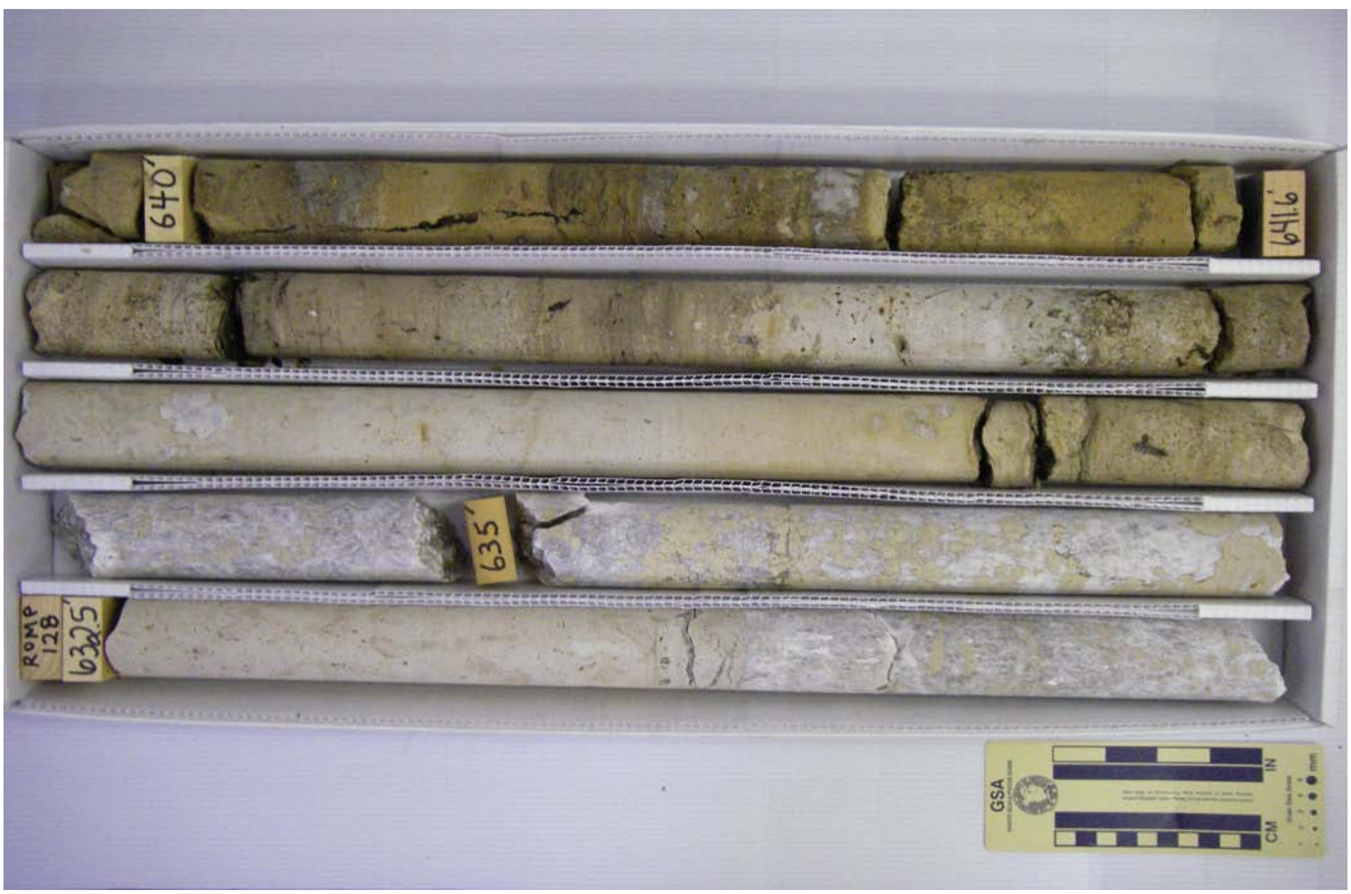


Core Hole 2

Core Hole 2

Appendix E. Geophysical Log Suites for the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

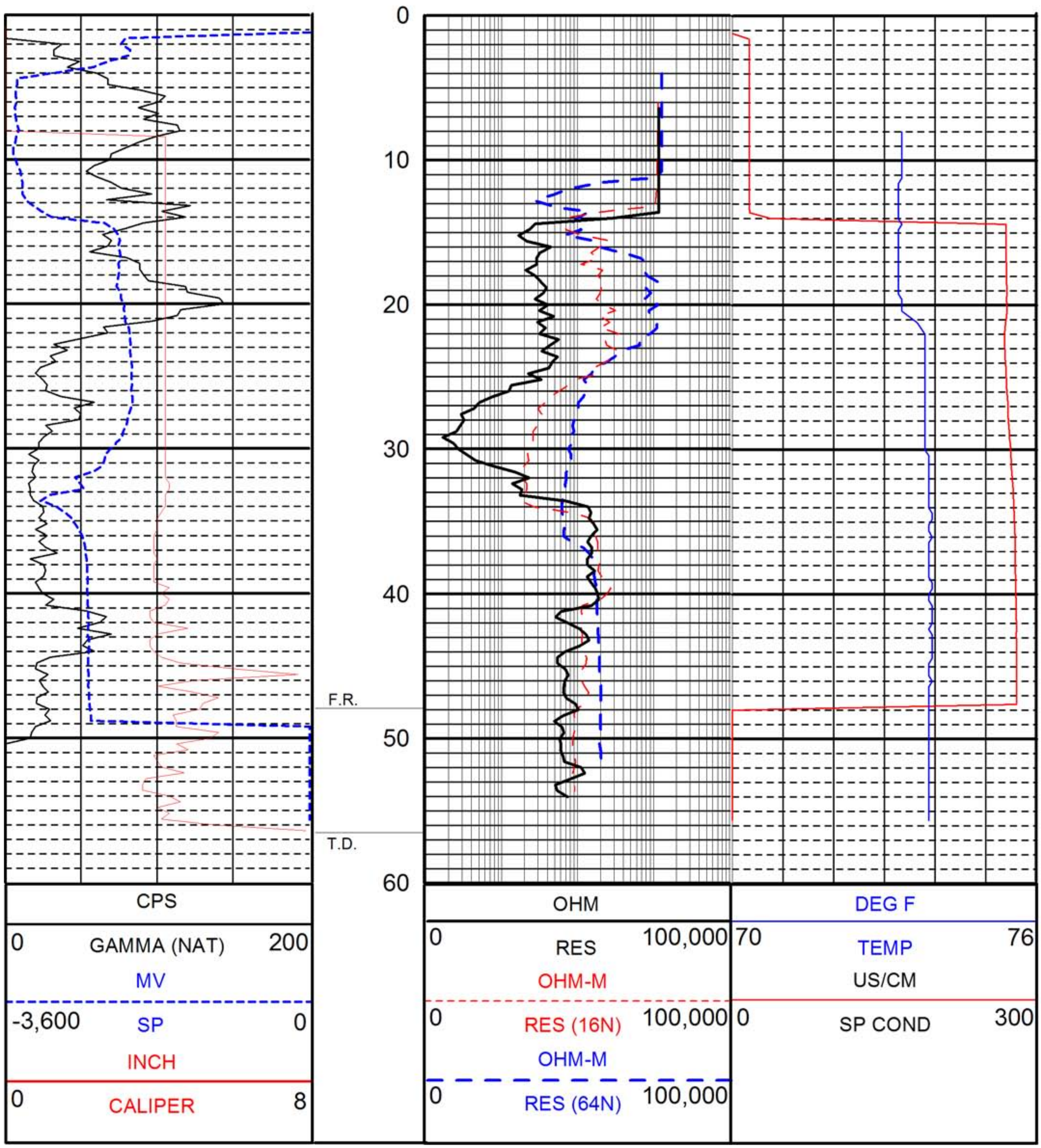


Figure E1. Geophysical log suite for core hole 1 from land surface to 56 feet below land surface conducted at the ROMP 128 - Rainbow Springs well site in Marion County, Florida. The log was performed on April 13, 2009, using the 9165C (caliper/gamma-ray) and 8044C (multifunction) tools. The casing depth at time of logging was 33 feet below land surface. The log scale is 1 inch per 10 feet. Tracks 1 and 3 are linearly scaled and track 2 is in logarithmic scale.

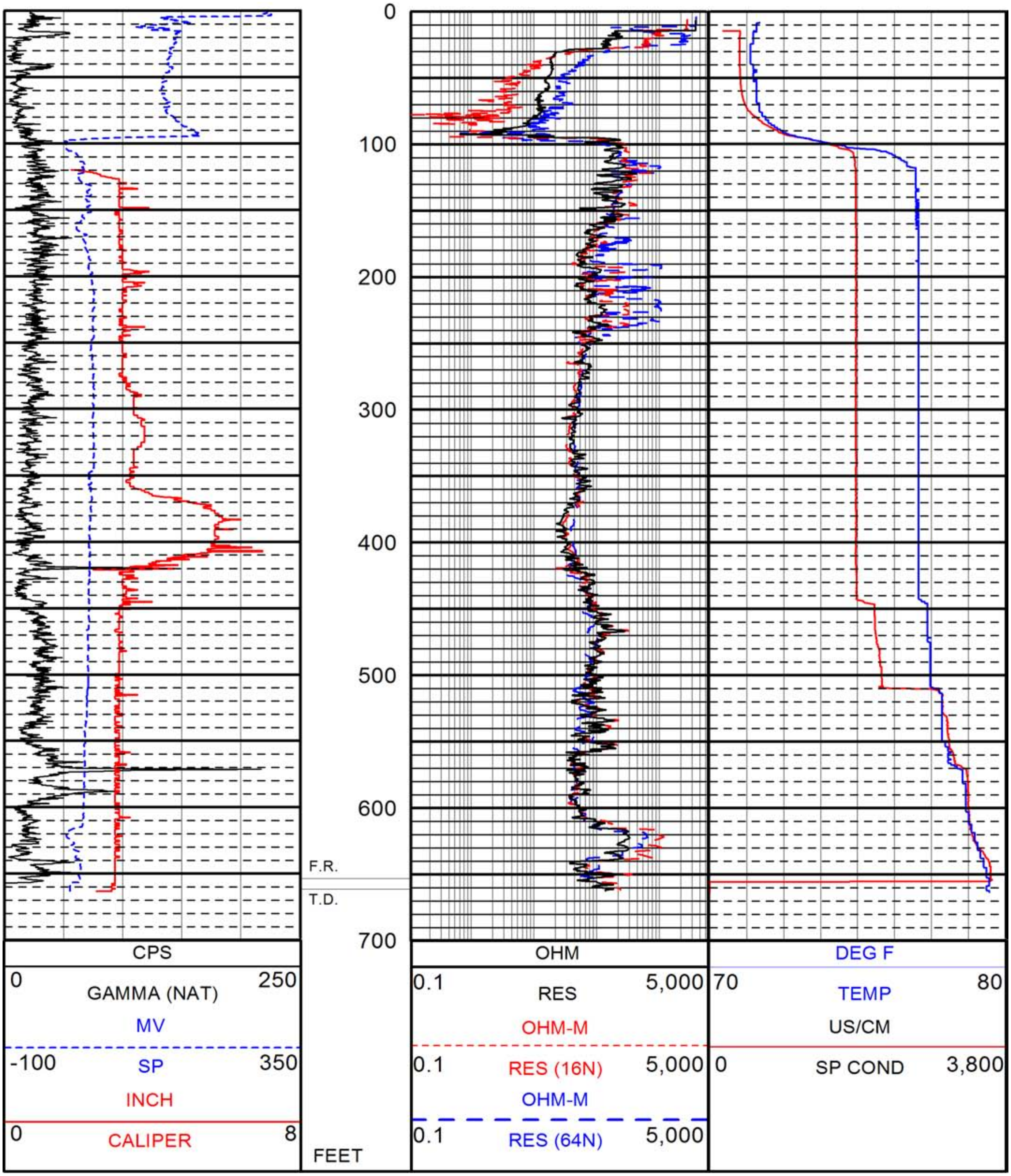


Figure E2. Geophysical log suite for core hole 2 from land surface to 663.2 feet below land surface conducted at the ROMP 128 - Rainbow Springs well site in Marion County, Florida. The log was performed on June 25, 2009, using the 9165C (caliper/gamma-ray) and 8143C (multifunction) tools. The casing depth at time of logging was 33 feet below land surface. The log scale is 1 inch per 100 feet. Tracks 1 and 3 are linearly scaled and track 2 is in logarithmic scale. An obstruction prevented caliper data collection above 112 feet bls while logging with the 9165C tool.

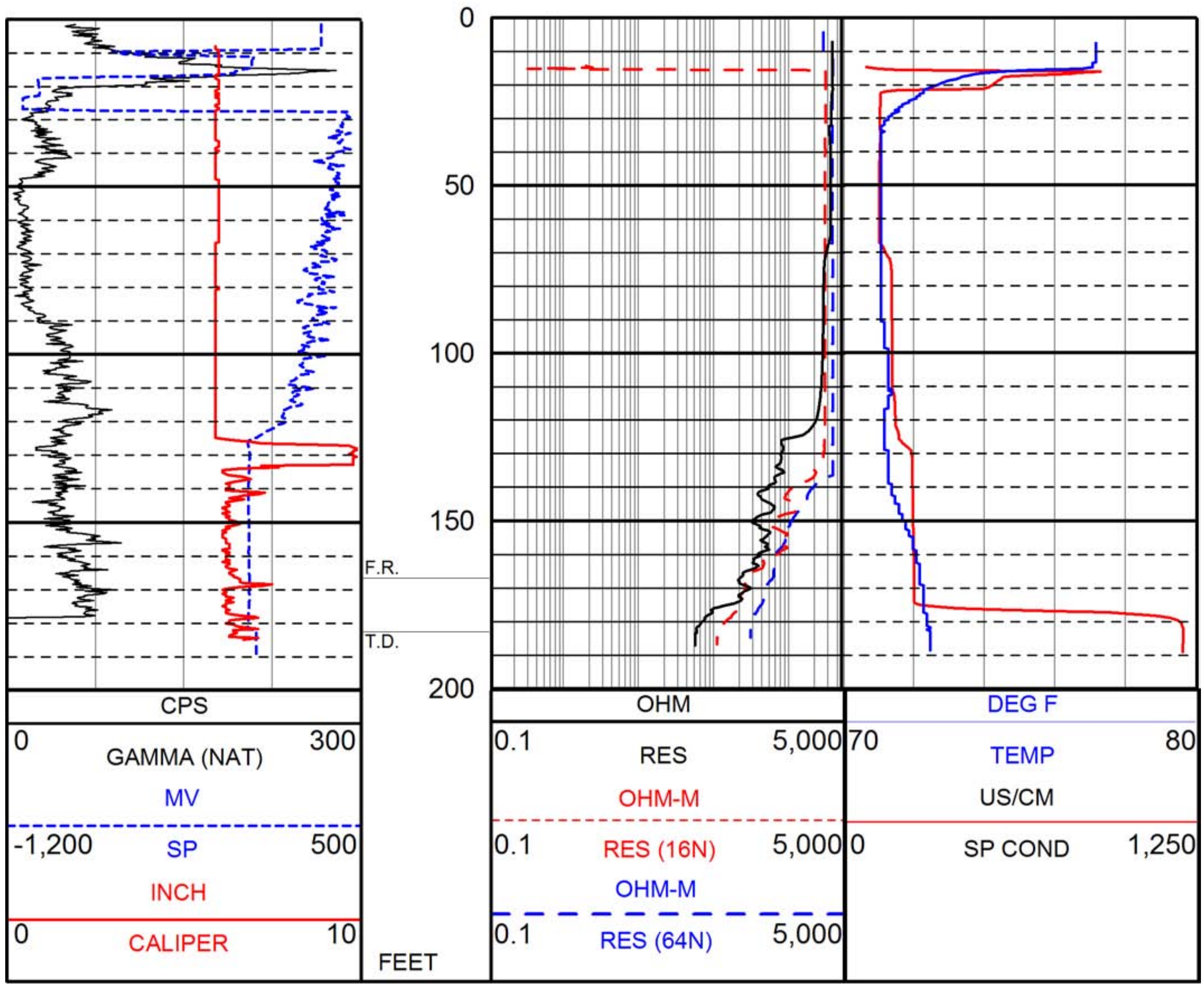


Figure E3. Geophysical log suite for the Upper Floridan aquifer sulfate monitor well from land surface to 188.8 feet below land surface conducted at the ROMP 128 - Rainbow Springs well site in Marion County, Florida. The log was performed on November 9, 2009, using the 9074C (caliper/gamma-ray) and 8143C (multifunction) tools. The casing depth at time of logging was 125 feet below land surface. The log scale is 1 inch per 50 feet. Tracks 1 and 3 are linearly scaled and track 2 is in logarithmic scale.

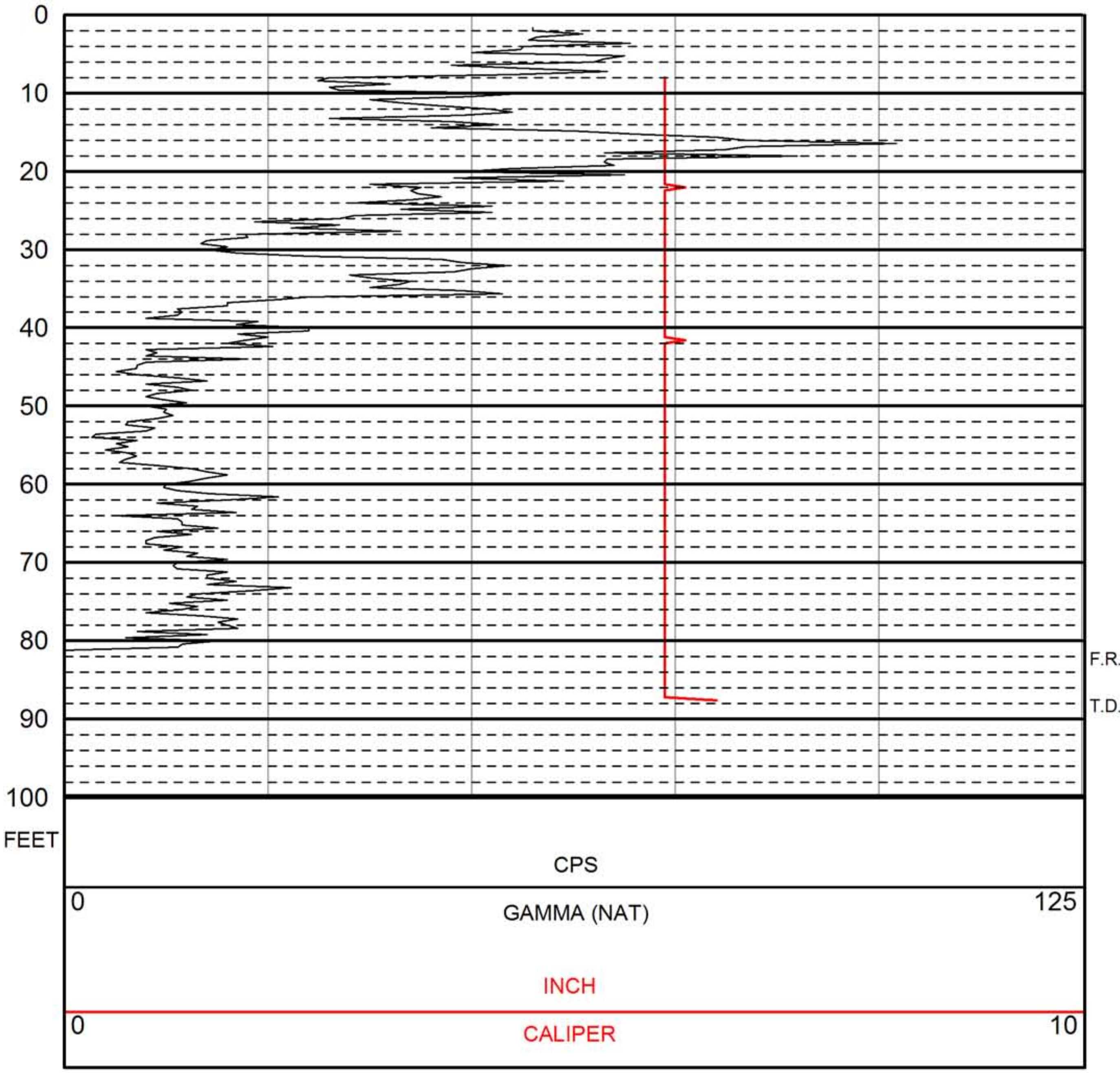


Figure E4. Geophysical log suite for the Upper Floridan aquifer water level monitor well from land surface to 87.6 feet below land surface conducted at the ROMP 128 - Rainbow Springs well site in Marion County, Florida. The log was performed on November 9, 2009, using the 9074C (caliper/gamma-ray) tool. The casing depth at time of logging was 60 feet below land surface. The log scale is 5 inches per 100 feet. The log track is linearly scaled.

Appendix F. Slug Test Data Acquisition Sheets for the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

Slug Test No. 1

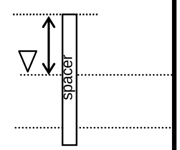
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	4/23/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	60	Test Interval (ft - ft bls)	41-60
Test Casing Height (ft als)	4.18	Date of Last Development	4/23/2009
Test Casing Diameter (in)	4	Initial Static WL (ft btoc)	18.72
Test Casing Type	HW	Final Static WL (ft btoc)	NR
Test Interval Length (ft)	19	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	0608164	22	Test Casing	0.01	3.28/3.19
CH 2 (Red)	15 psi	0603325		Surface Pressure	0	
CH 3 (Yellow)	15 psi	NA	NA	Annulus	NA	NA

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	NA	Spacer Placement (ft above static WL)	NA
Spacer OD.	NA		



Displaced WL (maybe +/-static WL)

Comments: Testing on 4-inch HW casing, therefore, no spacer necessary. There is some fall-in from 56 feet to 60 feet bls.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude	1.5	0.581	0.283	1.5
Initiation method	Pneumatic	Pneumatic	Pneumatic	Pneumatic
Rising/Falling head	Rising	Rising	Rising	Rising
Pre-test Sub. #1	3.19	3.2	3.2	3.2
Pre-test Sub. #2	NA	NA	NA	NA
Expected Displacement (ft)	1.47	0.587	0.312	1.493
Observed Displacement (ft)	1.509	0.566	0.333	1.385
Slug Discrepancy (%)	3%	4%	7%	7%
Max Rebound above Static	1.139	0.464	0.232	1.145
Post-test Sub. #1	3.19	3.2	3.2	3.2
Residual Dev. from H_o (%)	0	0	0	0
Data Logger File Name	R128_ST1_41-60_A	R128_ST1_41-60_B	R128_ST1_41-60_C	R128_ST1_41-60_D
Specific Conductance (uS)	284.3	284.3	284.3	284.3
Lithology	Karstic Crystalline Limestone (Ocala Limestone)			
Other	Upper Floridan Aquifer			
K_h (feet/day)	7500			

Comments

Core hole radius is 0.161458 because it was reamed out with a 3 $^{7}/_{8}$ - inch bit.

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 2

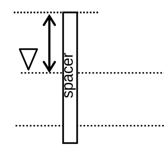
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	5/5/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	135	Test Interval (ft - ft bls)	94-135
Test Casing Height (ft als)	4.25	Date of Last Development	5/5/2009
Test Casing Diameter (in)	4	Initial Static WL (ft btoc)	18.92
Test Casing Type	HW	Final Static WL (ft btoc)	NR
Test Interval Length (ft)	41	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	0608164	22	Test Casing	-0.02	3.08/3.01
CH 2 (Red)	15 psi	0603325		Surface Pressure	0	
CH 3 (Yellow)	15 psi	NA	NA	Annulus	NA	NA

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	NA	Spacer Placement (ft above static WL)	NA
Spacer OD.	NA		



Displaced WL
(maybe +/-static WL)

Comments: Testing on 4-inch HW casing, therefore, no spacer necessary.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude	1.5	0.77	1.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1	3.01	3.01	3.02	
Pre-test Sub. #2	NA	NA	NA	
Expected Displacement (ft)	1.494	0.776	1.508	
Observed Displacement (ft)	1.501	0.87	1.479	
Slug Discrepancy (%)	0.5%	12%	2%	
Max Rebound above Static	1.182	0.631	1.182	
Post-test Sub. #1	3.01	3.01	3.02	
Residual Dev. from H_o (%)	0	0	0	
Data Logger File Name	R128_ST2_94-135_A	R128_ST2_94-135_B	R128_ST2_94-135_C	
Specific Conductance (uS)	267.5	267.5	267.5	
Lithology	Sucrosic Dolostone and Dolosilt (Avon Park Formation)			
Other	Upper Floridan Aquifer			
K_h (feet/day)	730			

Comments

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 3

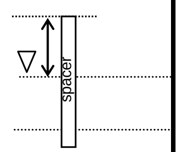
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	5/7/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	245	Test Interval (ft - ft bls)	189-245
Test Casing Height (ft als)	4.11	Date of Last Development	5/7/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	18.99
Test Casing Type	NQ	Final Static WL (ft btoc)	18.94
Test Interval Length (ft)	56	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	Spacer	22	Test Casing	0.02	3.01/2.95
CH 2 (Red)	15 psi	0603325		Surface Pressure	-0.02	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.06	2.76/2.84

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	5 feet	Spacer Placement (ft above static WL)	1.99
Spacer OD.	1.625		



Displaced WL
(maybe +/-static WL)

Comments: Used packer and spacer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	0.5	1	0.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1 (ft)	2.94	2.96	2.97	
Pre-test Sub. #2 (ft)	2.84	2.84	2.84	
Expected Displacement (ft)	0.58	1.087	0.594	
Observed Displacement (ft)	0.602	0.979	0.609	
Slug Discrepancy (%)	4%	10%	3%	
Max Rebound above Static	0.702	0.065	0.065	
Post-test Sub. #1 (ft)	2.94	2.97	2.97	
Residual Dev. from H_o (%)	0	0.3%	0	
Data Logger File Name	R128_ST3_189-245_A	R128_ST3_189-245_B	R128_ST3_189-245_C	
Specific Conductance (uS)	1473	1473	1473	
Lithology	Weathered Crystalline Dolostone			
Other	Upper Floridan Aquifer			
K_h (feet/day)	9			

Comments slight head dependence with different magnitudes

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 4

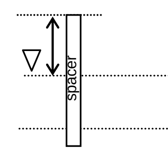
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	5/14/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	370	Test Interval (ft - ft bls)	327-370
Test Casing Height (ft als)	4.30	Date of Last Development	5/13/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	16.55
Test Casing Type	NQ	Final Static WL (ft btoc)	16.57
Test Interval Length (ft)	43	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	Spacer	19	Test Casing	0.03	2.45/2.46
CH 2 (Red)	15 psi	0603325		Surface Pressure	-0.01	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.07	2.71/2.78

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	5 feet	Spacer Placement (ft above static WL)	2.55
Spacer OD.	1.625		



Displaced WL
(maybe +/-static WL)

Comments: Used packer and spacer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	0.5	1	0.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1 (ft)	2.45	2.46	2.46	
Pre-test Sub. #2 (ft)	2.78	2.78	2.78	
Expected Displacement (ft)	0.5	1.015	0.5	
Observed Displacement (ft)	0.493	1.153	0.566	
Slug Discrepancy (%)	1%	14%	13%	
Max Rebound above Static	0.225	0.37	0.232	
Post-test Sub. #1 (ft)	2.46	2.46	2.46	
Residual Dev. from H_o (%)	0.3%	0%	0%	
Data Logger File Name	R128_ST4_327-370_A	R128_ST4_327-370_B	R128_ST4_327-370_C	
Specific Conductance (uS)	1319	1319	1319	
Lithology	Crystalline Dolostone and Dolosilt			
Other	Upper Floridan Aquifer			
K_h (feet/day)	28			

Comments: slight head dependence

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 5

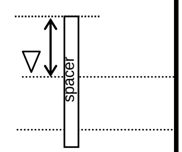
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	5/28/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	455	Test Interval (ft - ft bls)	420-455
Test Casing Height (ft als)	4.56	Date of Last Development	5/28/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	10.22
Test Casing Type	NQ	Final Static WL (ft btoc)	10.15
Test Interval Length (ft)	35	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	Spacer	13.5	Test Casing	0.01	3.28/3.21
CH 2 (Red)	15 psi	0603325		Surface Pressure	-0.04	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.05	2.89/2.98

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	5 feet	Spacer Placement (ft above static WL)	1.72
Spacer OD.	1.625		



Displaced WL
(maybe +/-static WL)

Comments: Used packer and spacer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	1.5	0.841	1.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1 (ft)	3.21	3.22	3.23	
Pre-test Sub. #2 (ft)	2.98	2.98	3.00	
Expected Displacement (ft)	1.566	0.892	1.559	
Observed Displacement (ft)	1.552	1.088	1.632	
Slug Discrepancy (%)	0.9%	22%	5%	
Max Rebound above Static	0.841	0.558	0.827	
Post-test Sub. #1 (ft)	3.21	3.23	3.24	
Residual Dev. from H_o (%)	0%	0.3%	0.3%	
Data Logger File Name	R128_ST5_420-455_A	R128_ST5_420-455_B	R128_ST5_420-455_C	
Specific Conductance (uS)	1318	1318	1318	
Lithology	Crystalline Dolostone with Chert and Organics			
Other	Upper Floridan Aquifer			
K_h (feet/day)		83		

Comments: no significant head dependence

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 6

General Information

Site Name: ROMP 128 Rainbow Springs — Date: 6/4/2009

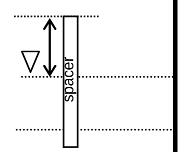
Well: CH-2 — Performed by: T.Horstman

Well Depth (ft bls)	535	Test Interval (ft - ft bls)	500-535
Test Casing Height (ft als)	4.31	Date of Last Development	6/3/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	9.72
Test Casing Type	NQ	Final Static WL (ft btoc)	9.71
Test Interval Length (ft)	35	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	Spacer	13	Test Casing	0.03	3.28/3.24
CH 2 (Red)	15 psi	0603325		Surface Pressure	-0.01	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.08	2.94/3.02

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	5 feet	Spacer Placement (ft above static WL)	1.72
Spacer OD.	1.625		



Displaced WL
(maybe +/-static WL)

Comments: Used packer and spacer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	1.5	0.5	1.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1 (ft)	3.24	3.24	3.22	
Pre-test Sub. #2 (ft)	3.02	3.02	3.02	
Expected Displacement (ft)	1.465	0.522	1.494	
Observed Displacement (ft)	1.581	0.508	1.501	
Slug Discrepancy (%)	8%	3%	0.5%	
Max Rebound above Static	0.87	0.384	0.878	
Post-test Sub. #1 (ft)	3.24	3.24	3.22	
Residual Dev. from H_o (%)	0%	0%	0%	
Data Logger File Name	R128_ST6_500-535_A	R128_ST6_500-535_B	R128_ST6_500-535_C	
Specific Conductance (uS)	1749	1749	1749	
Lithology	Dolomitic Limestone and Crystalline Dolostone			
Other	Upper Floridan Aquifer			
K_h (feet/day)		100		
Comments				

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 7

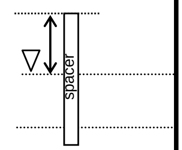
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	6/10/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	615	Test Interval (ft - ft bls)	560-615
Test Casing Height (ft als)	4.23	Date of Last Development	6/10/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	9.91
Test Casing Type	NQ	Final Static WL (ft btoc)	NR
Test Interval Length (ft)	55	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	Spacer	13	Test Casing	-0.01	3.09/3.07
CH 2 (Red)	15 psi	0603325		Surface Pressure	-0.05	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.03	3.09/3.06

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	5 feet	Spacer Placement (ft above static WL)	1.91
Spacer OD.	1.625		Displaced WL (maybe +/-static WL)



Comments: Used packer and spacer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	1.5	0.645	1.5	
Initiation method	Pneumatic	Pneumatic	Pneumatic	
Rising/Falling head	Rising	Rising	Rising	
Pre-test Sub. #1 (ft)	3.05	3.05	3.11	
Pre-test Sub. #2 (ft)	3.10	3.12	3.13	
Expected Displacement (ft)	1.53	0.718	1.53	
Observed Displacement (ft)	1.472	0.66	1.53	
Slug Discrepancy (%)	4%	8%	0%	
Max Rebound above Static	0.645	0.384	0.66	
Post-test Sub. #1 (ft)	3.05	3.11	3.08	
Residual Dev. from H_o (%)	0%	2%	1%	
Data Logger File Name	R128_ST7_560-615_A	R128_ST7_560-615_B	R128_ST76_560-615_C	
Specific Conductance (uS)	3035	3035	3035	
Lithology	Dolomitic Limestone and Crystalline Dolostone			
Other	Upper Floridan Aquifer			
K_h (feet/day)	28			

Comments

Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Slug Test No. 8

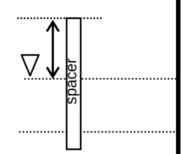
General Information

Site Name:	ROMP 128 Rainbow Springs	Date:	6/23/2009
Well:	CH-2	Performed by:	T.Horstman
Well Depth (ft bls)	660	Test Interval (ft - ft bls)	612-660
Test Casing Height (ft als)	4.40	Date of Last Development	6/17/2009
Test Casing Diameter (in)	2.38	Initial Static WL (ft btoc)	8.37
Test Casing Type	NQ	Final Static WL (ft btoc)	8.28
Test Interval Length (ft)	48	Slot Size & Filter Pack Type	NA

Set-up Information

Transducer	Type	Serial No.	Depth (ft)	Purpose	Reading in Air (ft)	Exp/Obsvd Sub (ft)
CH 1 (Blue)	15 psi	060864	10.4	Test Casing	-0.04	2.03/1.96
CH 2 (Red)	15 psi	NA		Surface Pressure	NA	
CH 3 (Yellow)	15 psi	0603300	19	Annulus	0.04	3.14/3.19

Data Logger	Campbell CR 800	Pressure Display Mode	Deviation from static
Logging schedule	Step	Level Reference	0
Time Interval (sec)	Step 1 = 0.1; Step 2 = 1; Step 3 = 5	Reference Read Time	Start of Test
Spacer Length	NA	Spacer Placement (ft above static WL)	NA
Spacer OD.	NA		



Displaced WL
(maybe +/-static WL)

Comments: Used packer.

Note: Reading in Air of the Transducer should be < +/-1% of the Full Scale of the Transducer

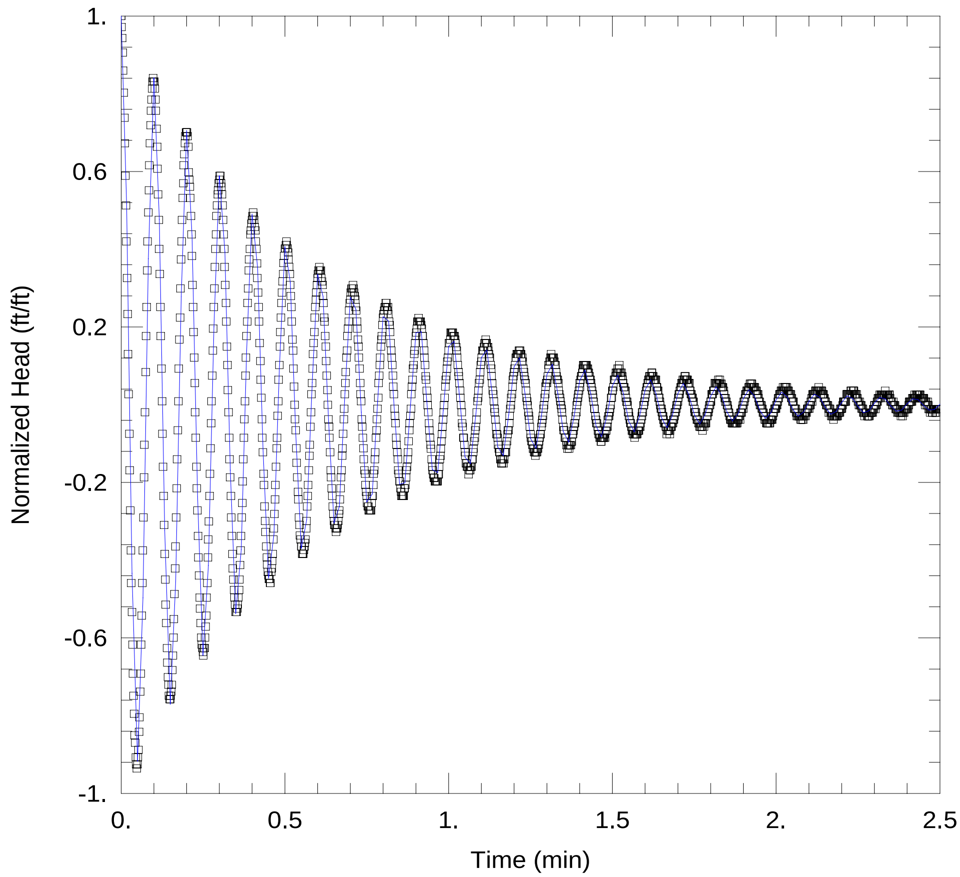
Test Data

	Test A	Test B	Test C	Test D
Slug Magnitude (ft)	0.5	0.5	0.5	
Initiation method	Drop/Water	Drop/Water	Drop/Water	
Rising/Falling head	Falling	Falling	Falling	
Pre-test Sub. #1 (ft)	1.7	1.36	1.96	
Pre-test Sub. #2 (ft)	3.17	3.19	3.19	
Expected Displacement (ft)	0.5	0.5	0.5	
Observed Displacement (ft)	0.515	0.421	0.471	
Slug Discrepancy (%)	3%	16%	6%	
Max Rebound above Static	NA	NA	NA	
Post-test Sub. #1 (ft)	3.16	1.96	2.05	
Residual Dev. from H_o (%)	46%	44%	3%	
Data Logger File Name	R128_ST8_612-660_A	R128_ST8_612-660_B	R128_ST8_612-660_C	
Specific Conductance (uS)	3608	3608	3608	
Lithology	Gypsiferous Dolostone			
Other	middle confining unit II			
K_h (feet/day)			0.001	

Comments Test A started on 6/17/2009 but water level was still rising. Test not good. Started Test B on 6/22/2009 but water level was still rising. Re-ran as Test C on 6/23/2009. Water level rose slightly, however, seems good. All general information and set-up information pertains to Test C.

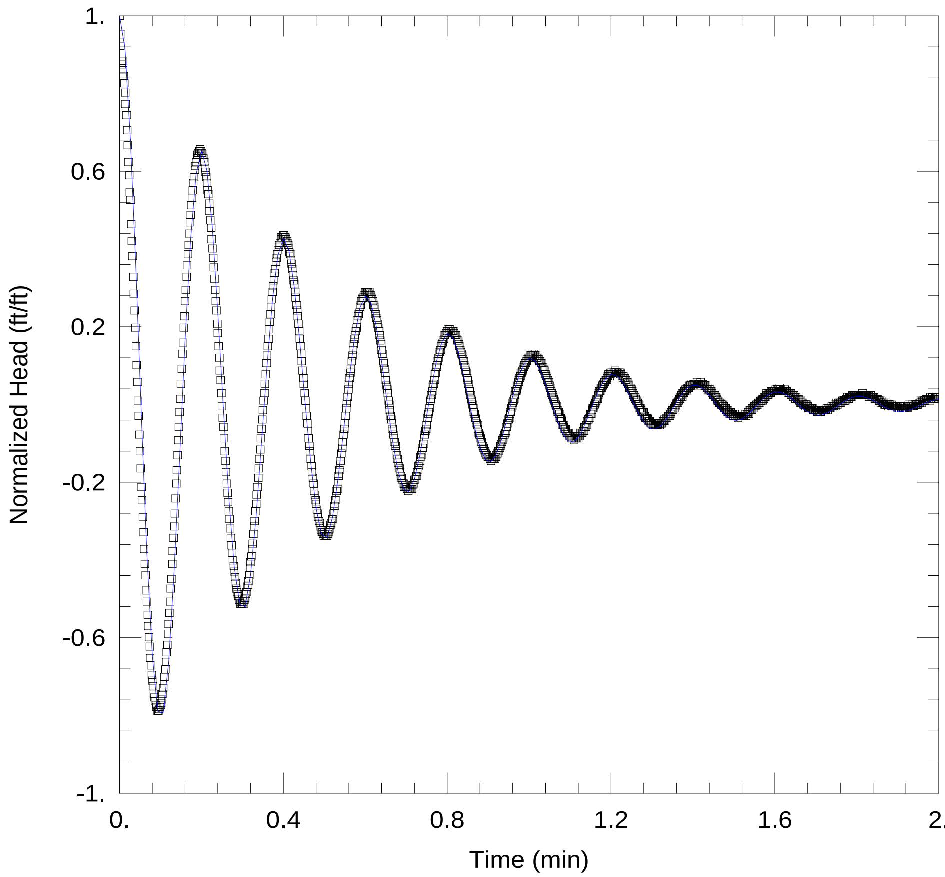
Notes: Slug Discrepancy <10%; Residual Deviation from H_o < 5%; and Maximum Rebound < Spacer Placement above Static

Appendix G. Slug Test Curve Match Analyses for the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida



SLUG TEST ANALYSIS	
Data Set: D:\...\R128_ST1_A_41-60_Butler_translated_3rd peak.aqt	
Date: 03/17/11	Time: 14:20:34
PROJECT INFORMATION	
Company: SWFWMD	
Project: ROMP 128	
Location: Marion County	
Test Well: Core hole 2	
Test Date: 4/23/2009	
AQUIFER DATA	
Saturated Thickness: 48. ft	Anisotropy Ratio (Kz/Kr): 0.5
WELL DATA (R128_ST1_A_41-60)	
Initial Displacement: 0.776 ft	Static Water Column Height: 45.46 ft
Total Well Penetration Depth: 19. ft	Screen Length: 19. ft
Casing Radius: 0.1664 ft	Well Radius: 0.1615 ft
SOLUTION	
Aquifer Model: Confined	Solution Method: Butler
K = 7460.4 ft/day	Le = 29.87 ft

Figure G1. Slug test analysis curve match for slug test 1 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS

Data Set: D:\My Documents\ROMP 128\Slug Tests\ST 2\test for report\R128_ST2_A_94-135_Butler.aqt
Date: 03/17/11 Time: 14:23:50

PROJECT INFORMATION

Company: SWFWMD
Project: ROMP 128
Location: Marion County
Test Well: Core hole 2
Test Date: 05/05/2009

AQUIFER DATA

Saturated Thickness: 525. ft Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (R128_ST2_A_94-135)

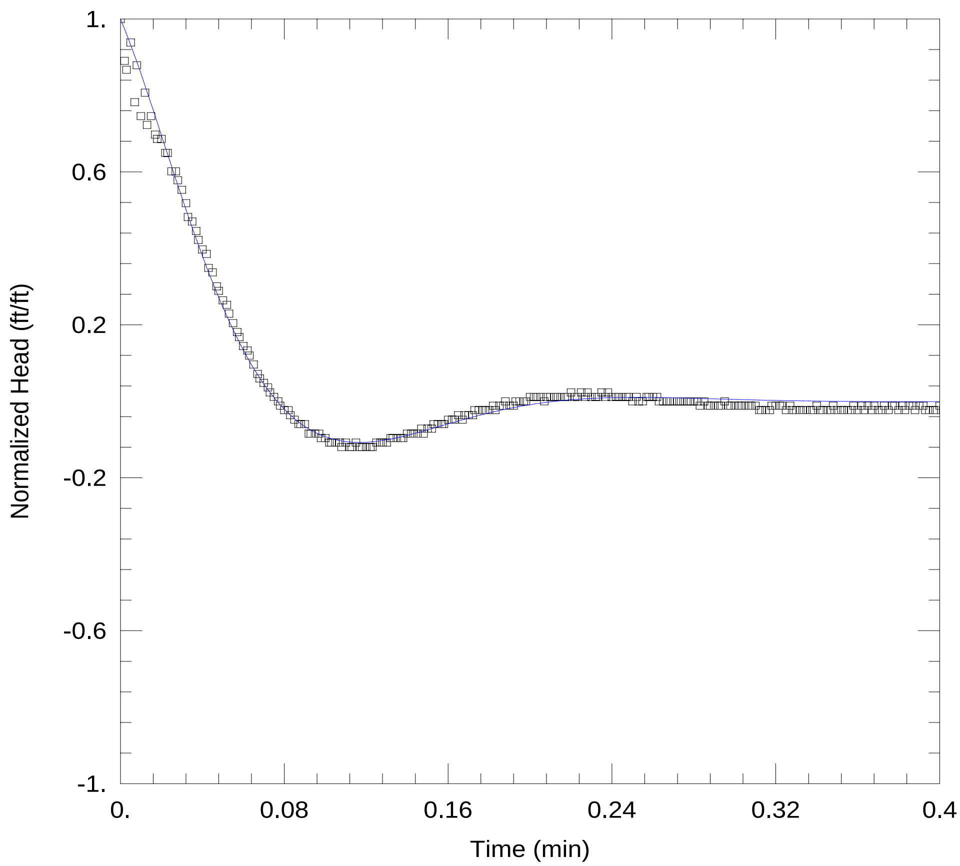
Initial Displacement: -1.501 ft Static Water Column Height: 120.3 ft
Total Well Penetration Depth: 48. ft Screen Length: 41. ft
Casing Radius: 0.1664 ft Well Radius: 0.1263 ft

SOLUTION

Aquifer Model: Confined Solution Method: Butler

K = 729.8 ft/day Le = 117.5 ft

Figure G2. Slug test analysis curve match for slug test 2 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS

Data Set: D:\My Documents\ROMP 128\Slug Tests\ST 3\test for report\R128_ST3_A_189-245_McElwee.aqt
Date: 05/04/10 Time: 12:50:48

PROJECT INFORMATION

Company: SWFWMD
Project: ROMP 128
Location: Marion County
Test Well: Core hole 2
Test Date: 05/07/2009

AQUIFER DATA

Saturated Thickness: 525. ft Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (R128_ST3_A_189-245)

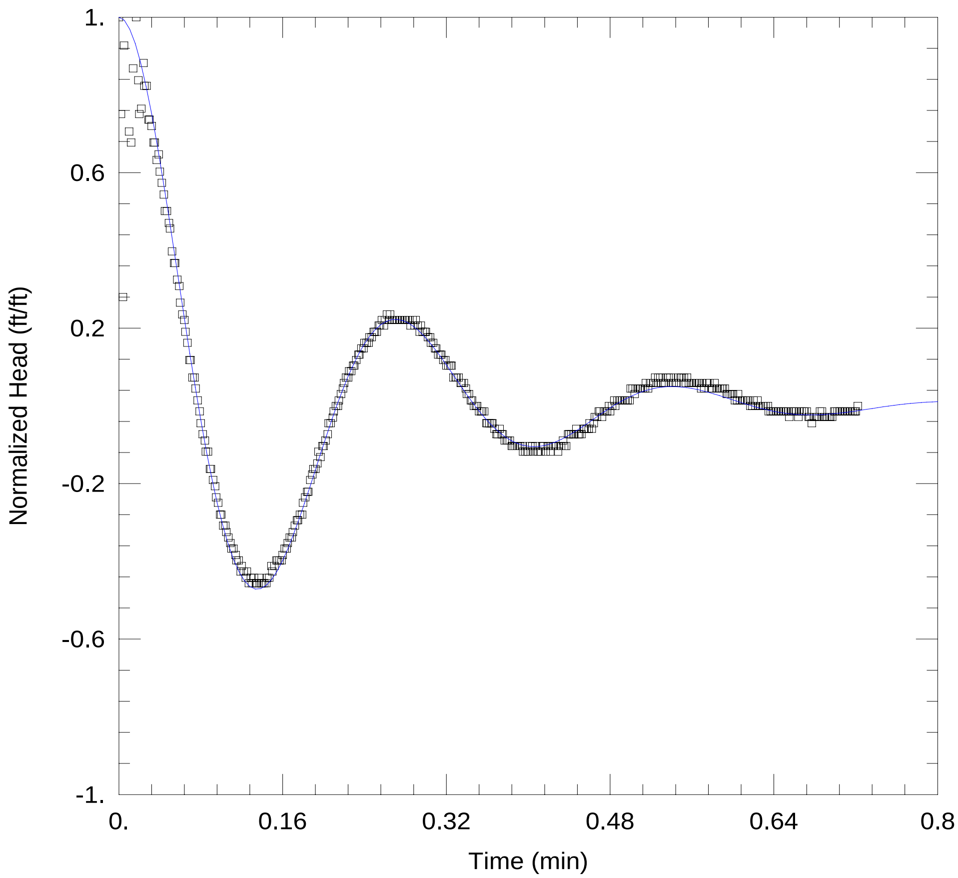
Initial Displacement: -0.602 ft Static Water Column Height: 230.1 ft
Total Well Penetration Depth: 158. ft Screen Length: 56. ft
Casing Radius: 0.06684 ft Well Radius: 0.1263 ft

SOLUTION

Aquifer Model: Confined Solution Method: McElwee-Zenner

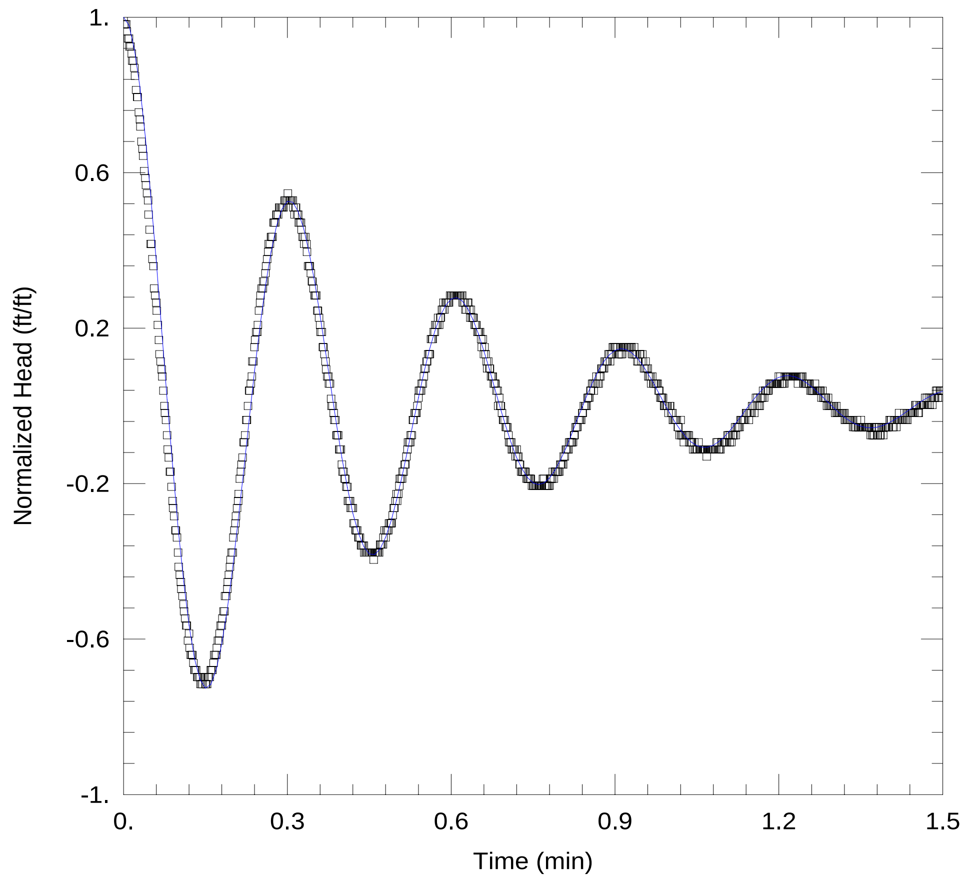
K = 9.401 ft/day ß = -91.93 ft
A = 0. v(0) = 7.626 ft/day

Figure G3. Slug test analysis curve match for slug test 3 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



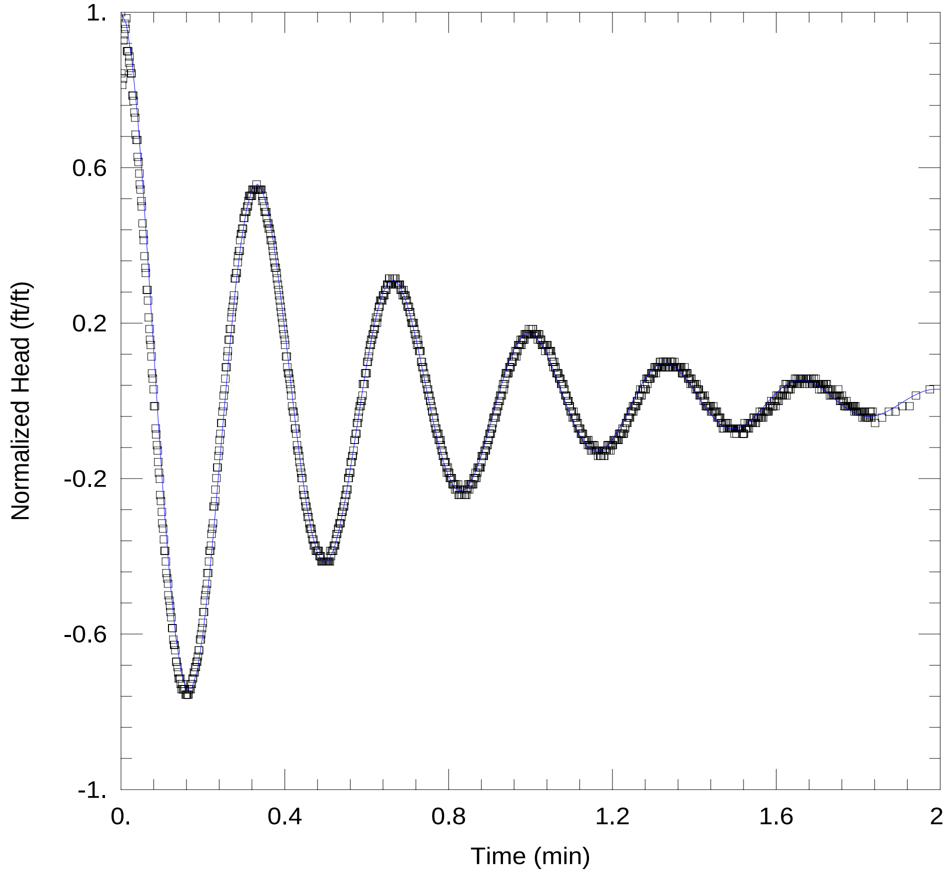
SLUG TEST ANALYSIS	
Data Set: D:\My Documents\ROMP 128\Slug Tests\ST 4\test for report\R128_ST4_A_327-370_Butler.aqt	
Date: 05/04/10	Time: 12:47:37
PROJECT INFORMATION	
Company: SWFWMD	
Project: ROMP 128	
Location: Marion County	
Test Well: Core hole 2	
Test Date: 05/14/2009	
AQUIFER DATA	
Saturated Thickness: 525. ft	Anisotropy Ratio (Kz/Kr): 0.5
WELL DATA (R128_ST4_A_327-370)	
Initial Displacement: -0.493 ft	Static Water Column Height: 357.8 ft
Total Well Penetration Depth: 283. ft	Screen Length: 43. ft
Casing Radius: 0.06684 ft	Well Radius: 0.1263 ft
SOLUTION	
Aquifer Model: Confined	Solution Method: Butler
K = 27.91 ft/day	Le = 202.8 ft

Figure G4. Slug test analysis curve match for slug test 4 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS	
Data Set: D:\...\R128_ST5_B_420-455_Butler_translated 2nd trough.aqt	
Date: 05/04/10	Time: 12:55:45
PROJECT INFORMATION	
Company: SWFWMD	
Project: ROMP 128	
Location: Marion County	
Test Well: Core hole 2	
Test Date: 05/28/2009	
AQUIFER DATA	
Saturated Thickness: 525. ft	Anisotropy Ratio (Kz/Kr): 0.5
WELL DATA (R128_ST5_B_420-455)	
Initial Displacement: -0.384 ft	Static Water Column Height: 449.3 ft
Total Well Penetration Depth: 192. ft	Screen Length: 35. ft
Casing Radius: 0.06684 ft	Well Radius: 0.1263 ft
SOLUTION	
Aquifer Model: Confined	Solution Method: Butler
K = 91.65 ft/day	Le = 268.3 ft

Figure G5. Slug test analysis curve match for slug test 5 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS

Data Set: D:\My Documents\ROMP 128\Slug Tests\ST 6\test for report\R128_ST6_B_500-535_Butler.aqt
Date: 05/04/10 Time: 13:01:17

PROJECT INFORMATION

Company: SWFWMD
Project: ROMP 128
Location: Marion County
Test Well: Core hole 2
Test Date: 06/04/2009

AQUIFER DATA

Saturated Thickness: 525. ft Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (R128_ST6_B_500-535)

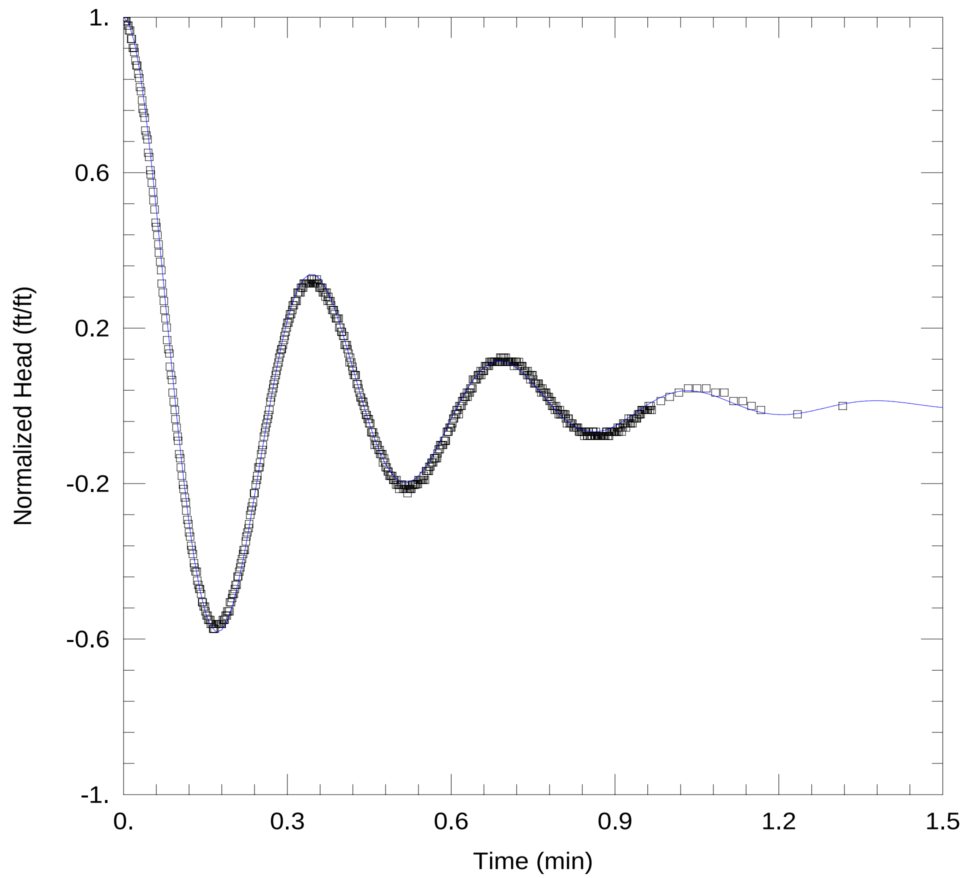
Initial Displacement: -0.508 ft
Total Well Penetration Depth: 112. ft
Casing Radius: 0.06684 ft
Static Water Column Height: 529.6 ft
Screen Length: 35. ft
Well Radius: 0.1263 ft

SOLUTION

Aquifer Model: Confined Solution Method: Butler

K = 104.3 ft/day Le = 320.6 ft

Figure G6. Slug test analysis curve match for slug test 6 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS

Data Set: D:\...\R128_ST7_A_560-615_Butler_translated 1st peak.aqt
Date: 05/04/10 Time: 13:03:18

PROJECT INFORMATION

Company: SWFWMD
Project: ROMP 128
Location: Marion County
Test Well: Core hole 2
Test Date: 06/10/2009

AQUIFER DATA

Saturated Thickness: 525. ft
Anisotropy Ratio (Kz/Kr): 0.5

WELL DATA (R128_ST7_A_555-615)

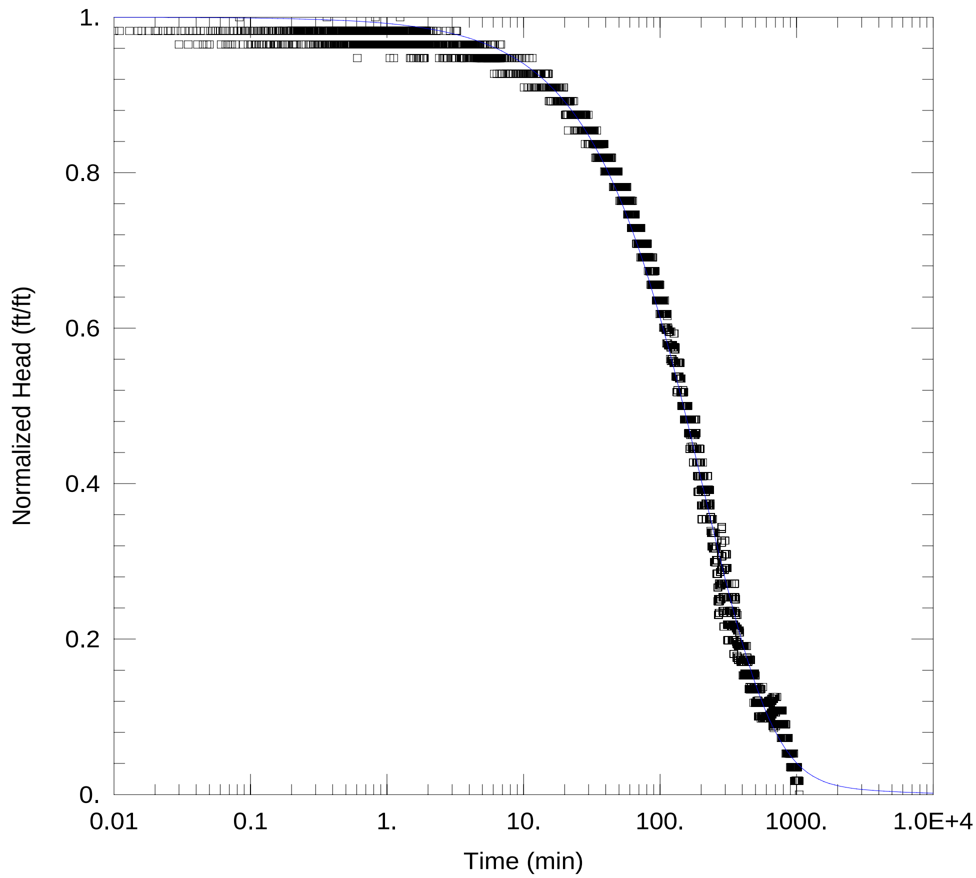
Initial Displacement: 0.645 ft
Total Well Penetration Depth: 58. ft
Casing Radius: 0.06684 ft
Static Water Column Height: 609.3 ft
Screen Length: 55. ft
Well Radius: 0.1263 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Butler

K = 27.98 ft/day
Le = 338.1 ft

Figure G7. Slug test analysis curve match for slug test 7 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.



SLUG TEST ANALYSIS	
Data Set: D:\...\R128_ST8_C_612-660_cooper_corrected to zero.aqt	
Date: 05/04/10	Time: 13:28:07
PROJECT INFORMATION	
Company: SWFWMD	
Project: ROMP 128	
Location: Marion County	
Test Well: Core hole 2	
Test Date: 06/23/2009	
AQUIFER DATA	
Saturated Thickness: 200. ft	Anisotropy Ratio (Kz/Kr): 0.001
WELL DATA (R128_ST8_C_612-660)	
Initial Displacement: 0.398 ft	Static Water Column Height: 656. ft
Total Well Penetration Depth: 48. ft	Screen Length: 48. ft
Casing Radius: 0.09514 ft	Well Radius: 0.1263 ft
SOLUTION	
Aquifer Model: Confined	Solution Method: Cooper-Bredehoeft-Papadopulos
T = 0.1924 ft^2/day	S = 5.417E-6

Figure G8. Slug test analysis curve match for slug test 8 performed at ROMP 128 - Rainbow Springs well site in Marion County, Florida.

Appendix H. Daily Water Levels for the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

Appendix H. Daily water levels for the ROMP 128 - Rainbow Springs well site.

[ft, feet; bls, below land surface; NAVD 88, North American Vertical Datum of 1988; NR, not recorded; csg, casing; MP, measuring point]

Date	Time	Deepest Casing Depth (ft bls)	Core hole Total Depth (ft bls)	Core Hole Static Water Level (ft bls)	Core Hole Static Water Level (ft NAVD 88)	Water Supply Well Static Water Level (ft bls)	Water Supply Well Static Water Level (ft NAVD 88)	HW Static Water Level (ft bls)	HW Static Water Level (ft NAVD 88)	Rain Gauge (inches)	Comments
3/30/2009	10:30	NR	NR	NR	NR	16.20	31.64	NR	NR	NR	core hole 1.
3/31/2009	7:30	22	22	NR	NR	16.21	31.63	NR	NR	0	
4/1/2009	6:30	22	50	NR	NR	16.20	31.64	NR	NR	0.3	
4/2/2009	7:25	33	50	NR	NR	16.20	31.64	NR	NR	0	
4/7/2009	11:10	33	65	14.81	31.74	16.24	31.60	14.85	31.70	0.3	
4/8/2009	7:00	33	80	14.84	31.71	16.26	31.58	14.87	31.68	0	obstruction at 56 ft bls.
4/9/2009	6:40	33	80	NR	NR	16.28	31.56	NR	NR	0	obstruction at 55 ft bls.
4/13/2009	10:05	33	80	NR	NR	16.33	31.51	NR	NR	0	Abandoning core hole 1.
4/14/2009	7:25	NR	NR	NR	NR	16.32	31.52	NR	NR	0.62	HW csg set to 41 ft bls in core hole 2
4/15/2009	6:40	41	NR	NR	NR	16.32	31.52	NR	NR	0	Begin core hole 2.
4/16/2009	7:00	41	60	NR	NR	16.33	31.51	14.50	32.05	0	HW inside PW .35 ft; MP on PW.
4/21/2009	9:10	41	60	14.52	32.03	16.37	31.47	14.55	32.00	0	HW MP now 1.25 ft higher; MP = 1.6.
4/22/2009	6:50	41	60	14.53	32.02	16.38	31.46	14.55	32.00	0	NQ measured from 10 inch steel csg.
4/23/2009	6:40	41	60	14.54	32.01	16.39	31.45	14.55	32.00	0	
4/27/2009	10:05	41	60	NR	NR	16.43	31.41	NR	NR	0	Advancing HW.
4/28/2009	6:40	59	65	NR	NR	16.43	31.41	14.61	31.94	0	
4/29/2009	6:20	81	82	NR	NR	16.44	31.40	14.61	31.94	0	
4/30/2009	6:30	81	90	NR	NR	16.47	31.37	14.63	31.92	0	

Appendix H. (Continued) Daily water levels for the ROMP 128 - Rainbow Springs well site.

[ft, feet; bls, below land surface; NAVD 88, North American Vertical Datum of 1988; NR, not recorded; csg, casing; MP, measuring point]

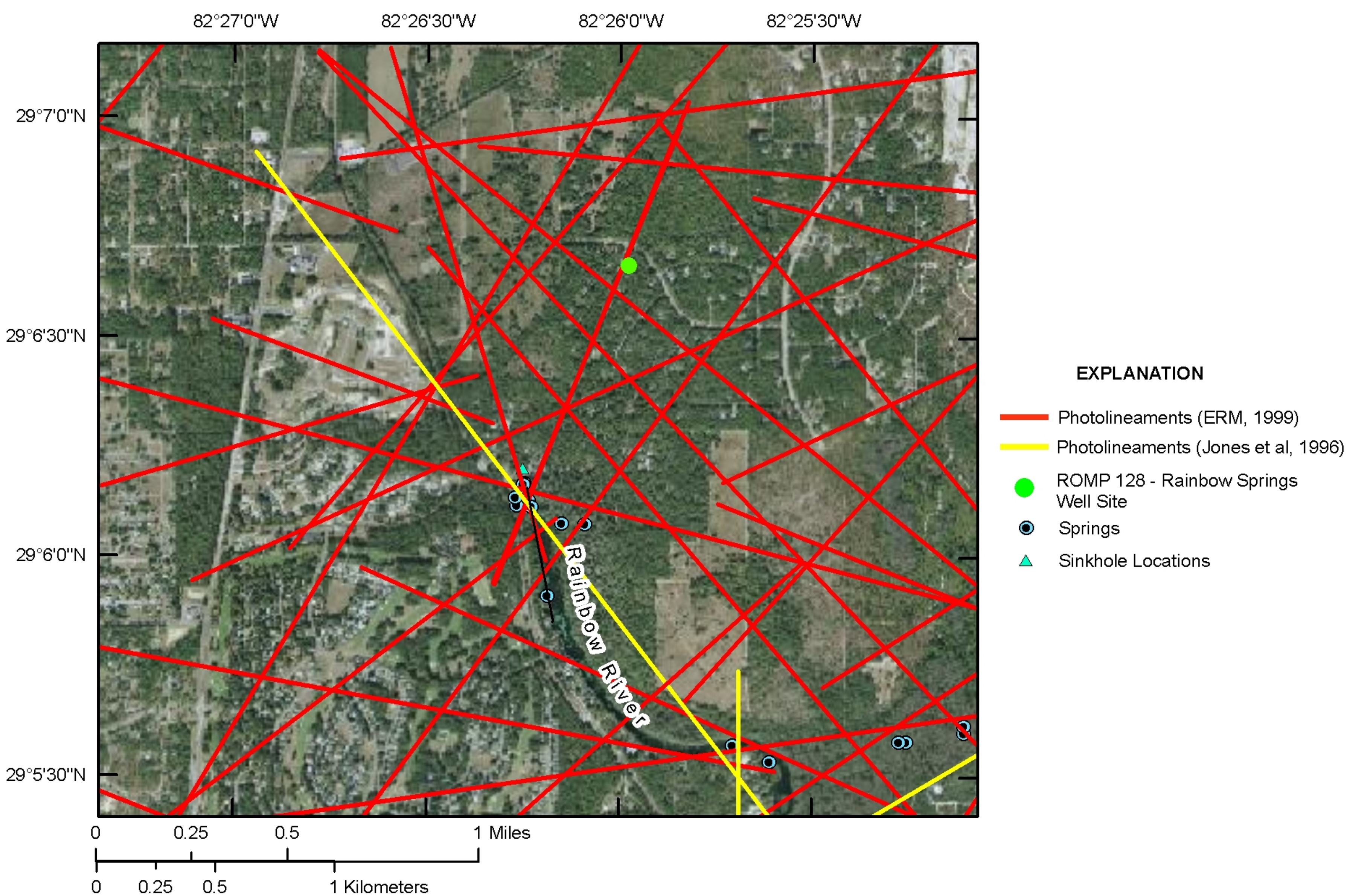
Date	Time	Deepest Casing Depth (ft bls)	Core hole Total Depth (ft bls)	Core Hole Static Water Level (ft bls)	Core Hole Static Water Level (ft NAVD 88)	Water Supply Well Static Water Level (ft bls)	Water Supply Well Static Water Level (ft NAVD 88)	HW Static Water Level (ft bls)	HW Static Water Level (ft NAVD 88)	Rain Gauge (inches)	Comments
5/4/2009	9:55	94	95	NR	NR	16.51	31.33	NR	NR	0	
5/5/2009	6:15	94	135	14.67	31.88	16.52	31.32	14.65	31.90	0	
5/6/2009	6:15	94	175	14.69	31.86	16.52	31.32	14.62	31.93	0	
5/7/2009	7:15	94	225	14.73	31.82	16.52	31.32	14.65	31.90	0	
5/11/2009	10:10	94	245	NR	NR	16.59	31.25	14.70	31.85	0	20 feet of NQ rods tripped out.
5/12/2009	6:40	94	275	14.70	31.85	16.59	31.25	14.74	31.81	0	
5/13/2009	6:55	94	330	14.68	31.87	16.60	31.24	14.73	31.82	0	
5/14/2009	6:30	94	370	12.25	34.01	16.57	31.27	14.69	31.89	0.34	Packer was set.
5/18/2009	10:30	94	370	12.74	33.81	16.54	31.30	14.68	31.87	3.28	
5/19/2009	6:25	94	400	12.74	33.81	16.54	31.30	14.70	31.85	0.5	
5/20/2009	6:50	94	416	13.25	33.30	16.55	31.29	14.60	31.95	1.65	
5/21/2009	6:30	94	419.3	13.27	33.28	16.50	31.34	14.64	31.91	1.52	
5/26/2009	10:00	94	425	13.80	32.75	16.46	31.38	14.59	31.96	1.85	
5/27/2009	6:15	94	435	12.50	34.05	16.44	31.40	14.57	31.98	0.54	
5/28/2009	6:20	94	445	6.15	40.40	16.45	31.39	14.59	31.96	0.26	
6/1/2009	10:30	94	455	6.27	40.28	16.35	31.49	14.50	32.05	0	
6/2/2009	6:15	94	475	5.99	40.56	16.35	31.49	14.49	32.06	0	
6/3/2009	6:45	94	515	5.59	40.96	16.34	31.50	14.48	32.07	0.12	

Appendix H. (Continued) Daily water levels for the ROMP 128 - Rainbow Springs well site.

[ft, feet; bls, below land surface; NAVD 88, North American Vertical Datum of 1988; NR, not recorded; csg, casing; MP, measuring point]

Date	Time	Deepest Casing Depth (ft bls)	Core hole Total Depth (ft bls)	Core Hole Static Water Level (ft bls)	Core Hole Static Water Level (ft NAVD 88)	Water Supply Well Static Water Level (ft bls)	Water Supply Well Static Water Level (ft NAVD 88)	HW Static Water Level (ft bls)	HW Static Water Level (ft NAVD 88)	Rain Gauge (inches)	Comments
6/4/2009	6:20	94	535	5.39	41.16	16.34	31.50	14.48	32.07	0.38	Packer was set.
6/8/2009	9:25	94	545	5.33	41.22	16.22	31.62	14.37	32.18	1.25	
6/9/2009	6:20	94	565	5.54	41.01	16.22	31.62	14.34	32.21	0	
6/10/2009	6:20	94	605	5.59	40.96	16.22	31.62	14.37	32.18	0	
6/15/2009	13:10	94	615	5.41	41.14	16.18	31.66	14.28	32.27	1.25	
6/16/2009	6:20	94	625	5.41	41.14	16.20	31.64	14.32	32.23	0.14	
6/17/2009	6:25	94	650	5.41	41.14	16.20	31.64	14.32	32.23	0	
6/18/2009	12:10	94	660	4.85	41.70	16.16	31.68	14.30	32.25	0.66	Packer was set.
6/22/2009	8:45	94	660	5.04	41.51	16.16	31.68	14.29	32.26	0.76	Packer was set.
6/23/2009	9:10	94	660	3.97	42.58	16.17	31.67	14.28	32.27	0	Packer was set.
6/24/2009	8:10	94	660	3.88	42.67	16.17	31.67	14.29	32.26	0.03	Packer was set.

Appendix I. Photolineaments in the Area Around the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida



Base from Southwest Florida Water Management District digital orthophoto, 2009
NAD 1983 HARN StatePlane Florida West FIPS 0902 Feet projection
Photolineaments modified from report by ERM, 1999, Hydrologic Evaluation Priest Property, Dunellon, Florida
and georeferenced to Southwest Florida Water Management District's NAVTEQ Streets in the SWFWMD, 2009

Appendix J. Field and Laboratory Data for the Water Quality Samples Collected at the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida

Appendix J1. Field analyses results of the water quality samples collected during exploratory core drilling at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

[No., number; bls, below land surface; ft, feet; °C, degrees Celsius; CH, core hole; SU, standard units; SID,Site identification; µmmhos/cm, micromhos per centimeter; mg/L, milligrams per Liter; WQ, water quality)

Water Quality Sample No.	Monitor Well SID No.	Date (MM/DD/YYYY)	Time (HH:MM)	Sample Interval (ft bls)	Temperature (°C)	pH (SU)	Specific Conductance (µmhos/cm)	Major Anions		Sample Collection Method/ Remarks
								Cl^{1-} (mg/L)	SO_4^{2-} (mg/L)	
1	725438 (CH 2)	04/23/2009	10:00	41-60	22.1	8.21	284.3	6.5	9	Slug Test 1 (41-60 ft bls). Airlift discharge sample.
2	725438 (CH 2)	05/05/2009	9:45	94-135	22.8	8.23	267.5	8.4	0	Slug Test 2 (94-135 ft bls). Airlift discharge sample.
3	725438 (CH 2)	05/07/2009	13:15	189-245	23.8	8.06	1473	26.0	870	Slug Test 3 (189-245 ft bls). Airlift discharge sample.
4	725438 (CH 2)	05/14/2009	16:45	327-370	24.2	8.04	1319	34.0	638	Slug Test 4 (327-370 ft bls). Airlift discharge sample.
5	725438 (CH 2)	05/28/2009	16:50	420-455	25.2	8.04	1318	34.0	624	Slug Test 5 (420-455 ft bls). Airlift discharge sample.
6	728438 (CH-2)	06/04/2009	10:30	500-535	25.2	8.00	1749	175.5	1204	Slug Test 6 (500-535 ft bls). Airlift discharge sample.
7	725438 (CH 2)	06/10/2009	16:15	560-615	25.9	7.91	3035	40.0	2167	Slug Test 7 (560-615 ft bls). Airlift discharge sample.
8	728438 (CH-2)	06/24/2009	14:15	612-660	25.6	7.62	3608	80.9	2472	Slug Test 8 (612-660 ft bls). Nested bailer sample.

Appendix J2. Laboratory analyses results of the water quality samples collected during exploratory core drilling at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

[No., number; bls, below land surface; ft, feet; CH, core hole; SU, standard units; SID,Site identification; µmmhos/cm, micromhos per centimeter; mg/L, milligrams per Liter; WQ, water quality)

							Major Anions		Major Cations				
Water Quality Sample No.	Monitor Well SID No.	Date (MM/DD/YYYY)	Time (HH:MM)	Sample Interval (ft bls)	pH^{Q} (SU)	Specific Conductance (µmhos/cm)	Cl^{1-} (mg/L)	SO_4^{2-} (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^{+} (mg/L)	K^{+} (mg/L)	Fe^{2+} (µg/L)
1	725438 (CH 2)	04/23/2009	10:00	41-60	8.23	266	5.8	5.2	46.7	5.39	3.1	$0.24^{U,I}$	<2.5U
2	725438 (CH 2)	05/05/2009	9:45	94-135	8.26	268	5.6	5.5	40.5	7.36	2.9	$0.21^{U,I}$	12.5I
3	725438 (CH 2)	05/07/2009	13:15	189-245	7.93	1480	38.43	672.59^{Q}	262	49	18.8	2.82	88.1
4	725438 (CH 2)	05/14/2009	16:45	327-370	7.98	1320	38.3^{Q}	516^{Q}	217	42.7	23.2	2.78	60.2
5	725438 (CH 2)	05/28/2009	16:50	420-455	8.15	1320	37.5	509	215	45.7	24.6	2.86	52.4
6	725438 (CH 2)	06/04/2009	10:30	500-535	8.01	1750	35.9	843	276	85.4	23.9	3.31	181
7	725438 (CH 2)	06/10/2009	16:15	560-615	7.97	3060	36.1	1890	526	213	27.5	4.8	389
8	725438 (CH 2)	06/24/2009	14:15	612-660	7.72	3640	87.0	2200	604	252	53.1	10.1	361

Appendix J2. (Continued) Laboratory analyses results of the water quality samples collected during exploratory core drilling at the ROMP 128 - Rainbow Springs well site in Marion County, Florida.

[No., number; bls, below land surface; ft, feet; CH, core hole; SU, standard units; SID,Site identification; μmmhos/cm, micromhos per centimeter; mg/L, milligrams per Liter; WQ, water quality)

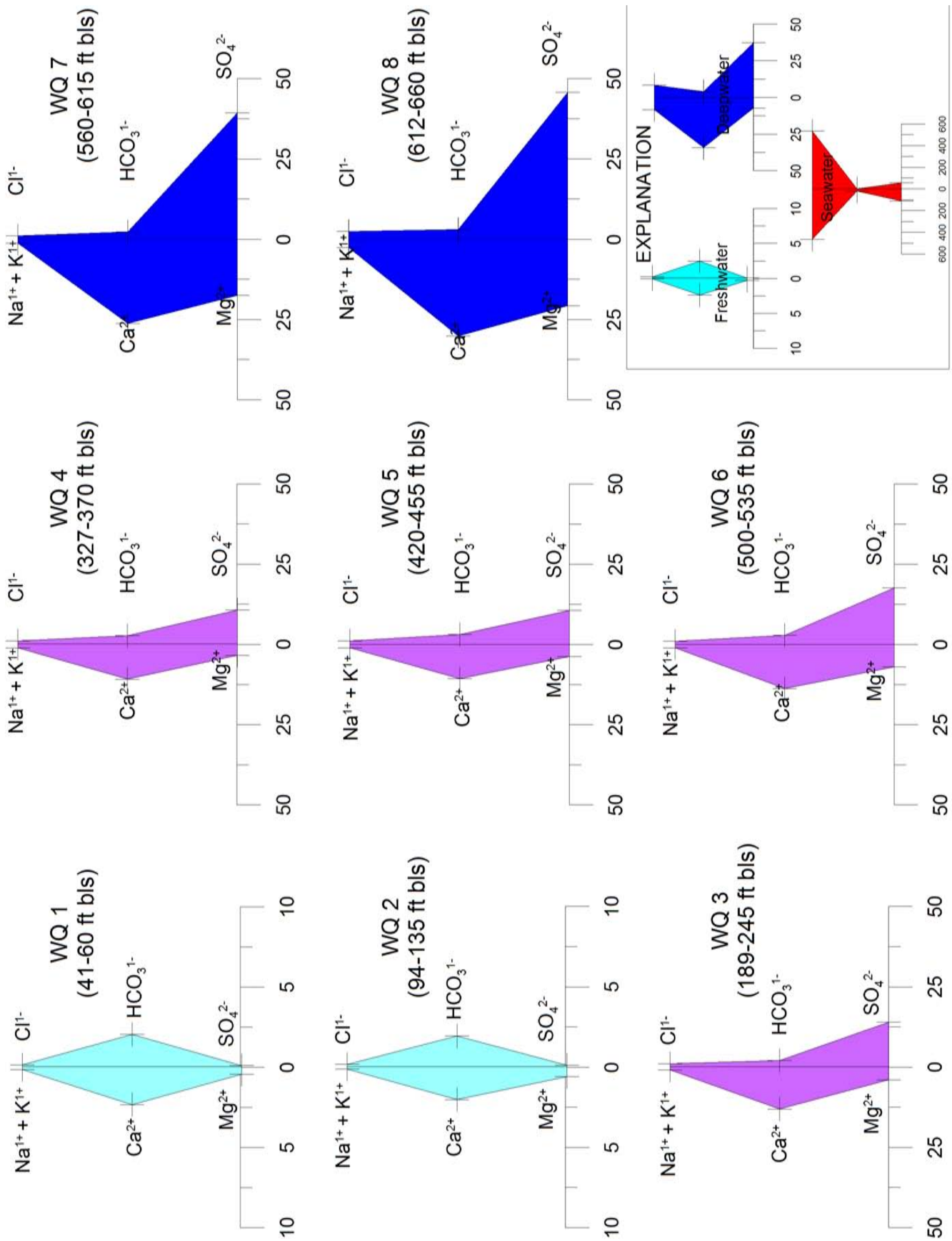
Major Cations				
Sr^{2+} (mg/L)	Si as SiO_2 (mg/L)	Total Dissolved Solids (mg/L)	Total Alkalinity $CaCO_3$ (mg/L)	Sample Collection Method/ Remarks
0.1[U,I]	6.1	161	124.7[Q]	Slug Test 1 (41-60 ft bls). Airlift discharge sample.
0.09[U,I]	6.1	148	119.0	Slug Test 2 (94-135 ft bls). Airlift discharge sample .
5.89	14.0	1220	123.7[Q]	Slug Test 3 (189-245 ft bls). Airlift discharge sample.
5.37	17.6	1040	166.8[Q]	Slug Test 4 (327-370 ft bls). Airlift discharge sample.
5.58	16.3	1010	191.0	Slug Test 5 (420-455 ft bls). Airlift discharge sample.
6.67	16.3	1470	172.0[Q]	Slug Test 6 (500-535 ft bls). Airlift discharge sample.
9.03	16.5	2980	141.2[Q]	Slug Test 7 (560-615 ft bls). Airlift discharge sample.
10.5	22.9854	3660	182.4	Slug Test 8 (612-660 ft bls). Nested bailer sample.

[U] The ion was analyzed for but not detected. Value is reported as the method detection limit.

[Q] Sample was held beyond holding time. Field pH is used in analyses due to a 15 minute holding time.

[I] Value is between the method detection limit and the practical quantitation limit, which is four times the detection limit.

Appendix K. Stiff Diagrams for the Water Quality Samples Collected at the ROMP 128 - Rainbow Springs Well Site in Marion County, Florida


WQ 1
(41-60 ft bls)
WQ 2
(94-135 ft bls)
WQ 3
(189-245 ft bls)
WQ 4
(327-370 ft bls)
WQ 5
(420-455 ft bls)
WQ 6
(500-535 ft bls)
WQ 7
(560-615 ft bls)
WQ 8
(612-660 ft bls)
$Na^{1+} + K^{1+}$
Ca^{2+}
Mg^{2+}
Cl^{1-}
HCO_3^{1-}
SO_4^{2-}
EXPLANATION
Freshwater
Seawater
Deepwater

Southwest Florida
Water Management District