SOUTH FLORIDA WATER MANAGEMENT DISTRICT

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Preliminary Report

Hydrogeologic Investigation of the Floridan Aquifer System, R.D. Keene County Park Orange County, Florida

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EXECUTIVE SUMMARY

The Kissimmee Basin Planning Area covers approximately 3,500 square miles, includes portions of Orange, Osceola, Polk, Highlands, Okeechobee and Glades counties, and shares common boundaries with the St. Johns River Water Management District and the Southwest Florida Water Management District. The *2000 Kissimmee Basin Water Supply Plan* (KB Plan) examined the long-term water use conditions for areas located north of Lake Okeechobee within the South Florida Water Management District (SFWMD or District).

The findings of the KB Plan (2000) suggest that the groundwater supplies in portions of Orange, Osceola and Polk counties may not be sufficient to meet the 2020 (1-in-10 drought year) water supply needs. In the Orange, Osceola and Polk County area, the continued use of the Upper Floridan Aquifer (UFA) has been projected to contribute to possible harm to wetlands, reduction in spring flow and may be a factor in the formation of sinkholes. These conclusions however, were predicated on a limited amount of geologic and hydrologic information in the region. In particular, information regarding the interactions between the Surficial Aquifer and UFA is very limited.

A priority recommendation in the KB Plan was to gather additional hydrologic information to better address the uncertainty of the future water use of the UFA and their impact to wetlands and surface water. Towards that end, three Floridan Aquifer System (FAS) exploratory sites were completed in the Kissimmee Basin Planning Area over the past five years. This report summarizes results from one of those sites located at the R.D. Keene County Park in Orange County.

The objective of this work was to construct and test a series of wells that will support the KB Plan and its recommendations. Data collected from the testing and monitoring of the wells at this site will be instrumental in revising the current groundwater model and evaluation of wetland impact constraints. The R.D Keene site is presently part of SFWMD’s long-term water level monitoring network.

The test site described in this report is located in western Orange County within the R.D. Keene County Park (**Figure 1**). Specifically, the test site is located near the Town of Windermere in the northeast quadrant of Section 20, Range 28 East and Township 23 South. Land surface elevation was surveyed at 106.1 feet relative to the National Geodetic Vertical Datum (NGVD) of 1929.

Site preparation and equipment mobilization at the project site began February 20, 2003. The contractor constructed two UFA wells, and three shallow (32 to 92 feet bls) monitor wells to determine the degree of connection between the Surficial Aquifer System (SAS) and the UFA. The UFA wells consisted of one 14-inch diameter test-production well and one 6-inch diameter observation well (identified as ORF-61). In addition, two 2-inch diameter PVC monitor wells were constructed; one completed into the Hawthorn Group (upper confining unit and identified as ORH-1) and one into the SAS (identified as ORS-3) with a corresponding 6-inch diameter test-production well completed in the SAS.

The SFWMD provided technical guidance and oversight of all well construction and testing operations. The Diversified Drilling Corporation (DDC), a Tampa based corporation with a local office in Orlando was responsible for well construction and testing services associated with this project. Daily data collection activities and construction oversight were facilitated by Universal Engineering Sciences (UES). This project was completed on June 10, 2003 at a cost of $225,000.

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

- The top of the FAS was identified at 106 feet below land surface as defined as the first occurrence of vertically persistent, permeable and consolidated, carbonate unit (Tibbals 1990).
- Lithologic data, geophysical logs and aquifer performance test results indicate moderate to good production capacity in UFA.
- Water quality data from the completed monitor wells indicate that chloride and total dissolved solids concentrations in the Surficial Aquifer and UFA meet potable drinking water standards.
- The SAS hydraulic test results yielded a transmissivity of 170 gallons per day per foot of aquifer (gpd/ft) and a dimensionless storativity value of 5.75 x 10 -2.
- The Hawthorn Group (intermediate confining unit) yielded a hydraulic conductivity of 0.038 ft/day.
- Hydraulic testing of the UFA, which included the both Zones A & B yielded a transmissivity of 300,000 gpd/ft, a storage coefficient of 2.40 x 10 -3, a dimensionless r/B value of 0.04 with a calculated leakance value of 7.50 x 10 -2 gpd/ft3.
- Hydraulic test results indicate moderate connectivity between SAS and UFA.

INTRODUCTION

Background

The Kissimmee Basin Planning Area covers approximately 3,500 square miles, includes portions of Orange, Osceola, Polk, Highlands, Okeechobee and Glades counties, and shares common boundaries with the St. Johns River Water Management District and the Southwest Florida Water Management District. The *2000 Kissimmee Basin Water Supply Plan* (KB Plan) examined the long-term water use conditions for areas located north of Lake Okeechobee within the South Florida Water Management District (SFWMD or District).

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Project Description

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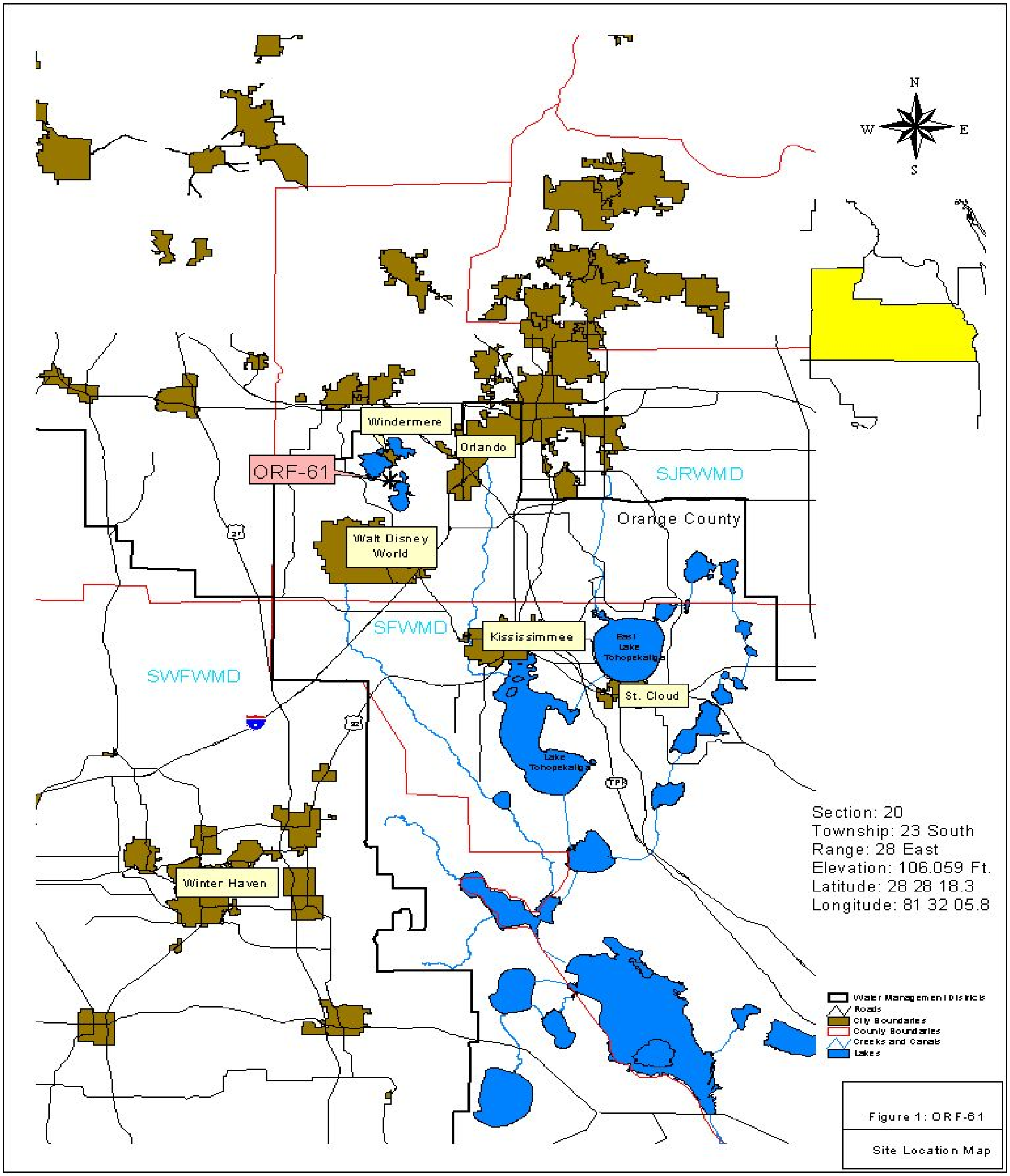


Figure 1. Location Map of R.D. Keene County Park Test Site.

EXPLORATORY DRILLING AND WELL CONSTRUCTION

Floridan Aquifer Test-Production Well (Well No. 1)

During early March 2003, the DDC prepared the site for the first stage of well construction. The first stage drilling commenced on March 17, 2003 with the construction of the 14-inch diameter test-production well. Mud rotary and reverse-air techniques were used during drilling operations. Closed-circulation mud rotary drilling was used to advance a nominal 12-inch diameter pilot hole from land surface to 200 feet bls. The reverse-air, open circulation drilling method was used to complete the 12-inch diameter pilot-hole from 200 feet bls to a total depth of 650 feet bls.

The DDC began drilling operations by advancing a nominal 12-inch diameter pilot hole to a depth of 62 feet bls. It was then over-drilled to a 24-inch diameter borehole to allow installation of the 20-inch diameter surface casing to a depth of 63 feet bls. Once the 20-inch diameter casing was successfully installed, the pilot hole was continued to a depth of 106 feet bls. At this depth, a very hard, but cavernous limestone layer was encountered, which continued to 122 feet bls. This cavernous limestone unit was considered the top of the Floridan Aquifer as defined as the first occurrence of a vertically persistent, permeable and consolidated carbonate unit (Tibbals 1990). Loss circulation material was used to stabilize the borehole and to continue drilling operations via mud rotary. These efforts were successful and the pilot hole was advanced to a depth of 200 feet bls. Once completed, the pilot hole was geophysically logged by Southern Resource Exploration. Based on the lithologic and geophysical log data, the SFWMD selected a casing setting depth of 106 feet bls for the base of the 14-inch diameter production casing. The borehole was then enlarged to 20-inches from 65 feet to 113 feet bls and the 14 inch steel casing was installed and cemented to land surface.

After the production casing was successfully installed, the DDC continued the borehole using the reverse-air, open circulation method to a total depth of 650 feet bls. The DDC completed the test-production well on April 8, 2003. In summary, the test-production well was drilled to a total depth of 650 feet bls and completed with a test-production interval between 106 and 650 feet bls. As part of the land use agreement with Orange County, this well was plugged and abandoned upon completion of testing activities.

Floridan Aquifer Monitor Well (Well No. 2)

Construction activity related to the UFA monitor well at this site started on May 12, 2003. This well had dual purposes; it served as an observation well during aquifer testing and has been incorporated into SFWMD's long-term FAS water level monitoring program.

The DDC advanced a nominal 10-inch pilot hole to a depth of 104 feet bls. After the pilot was completed, the borehole was reamed to allow the installation of 14-inch diameter casing to a depth of 102 feet bls. This casing was then successfully pressured grouted back to land surface. Drilling continued through the cement plug at the bottom of the borehole to a depth of 142 feet bls. During drilling of this section, loss circulation was encountered from 109 feet to 142 feet bls. On Monday May 19, 2003, 8-inch diameter steel casing was installed to a depth of approximately 142 feet bls and subsequently pressured grouted to land surface. The drill operations were converted over to reverse air drilling, the cement plug drilled-out and the borehole advanced to a depth of 322 feet bls. Drilling continued until a total depth of 650 feet bls was reached on May 27, 2003.

Hawthorn Confining Unit Monitor Well (Well No. 3)

The third well was constructed as a monitor well located in the Hawthorn Group, which serves as the upper confining unit separating the FAS from the SAS. The primary purpose of this and the shallow wells was to determine the interconnectivity between the SAS and the UFA when water is pumped from the UFA. The DDC started well construction by drilling a nominal 10-inch diameter borehole via mud rotary to a depth of 92 feet bls. After the borehole was completed, a combination of 6-inch diameter PVC (schedule 40) casing and well screen were used to construct this monitor well. Specifically, the DDC used 32 feet of 6-inch diameter PVC well screen (20 slot) and 60 feet of 6-inch diameter PVC well casing. The DDC installed a gravel pack around the well screen consisting of silica sand (6–20 grade). The gravel pack extended 2 feet above the well screen and was capped by fine silica sand (1-foot thick) with the remaining portion of the annulus cemented to land surface using ASTM Type I neat cement.

Surficial Aquifer System Test-Production Well (Well No. 4)

The fourth well was constructed into the SAS as a test-production well. The DDC employed the mud rotary technique to drill the 10-inch diameter borehole to 54 feet bls. Six-inch diameter, PVC casing and well screen (20 slot) were used to construct this well. The screen interval is located from 32 to 52 feet bls with a gravel pack consisting of silica sand (6–20 grade) extending 2 feet above the well screen capped by fine silica sand (1-foot thick). The remaining portion of the annulus was cemented to land surface using ASTM Type I cement.

Surficial Aquifer System Monitor Well (Well No. 5)

The fifth well was constructed complementary to the SAS test well (Well No.4) using the same type of material, but completed as a 2-inch diameter well. The borehole was drilled using mud rotary to 53 feet bls. The DDC installed 52 feet of 2-inch PVC casing and screen with a monitor interval of 32 to 52 feet bls. A gravel pack was installed around the screen that consisted of silica sand (6–20 grade), capped using 1-foot of fine sand then cemented to surface.

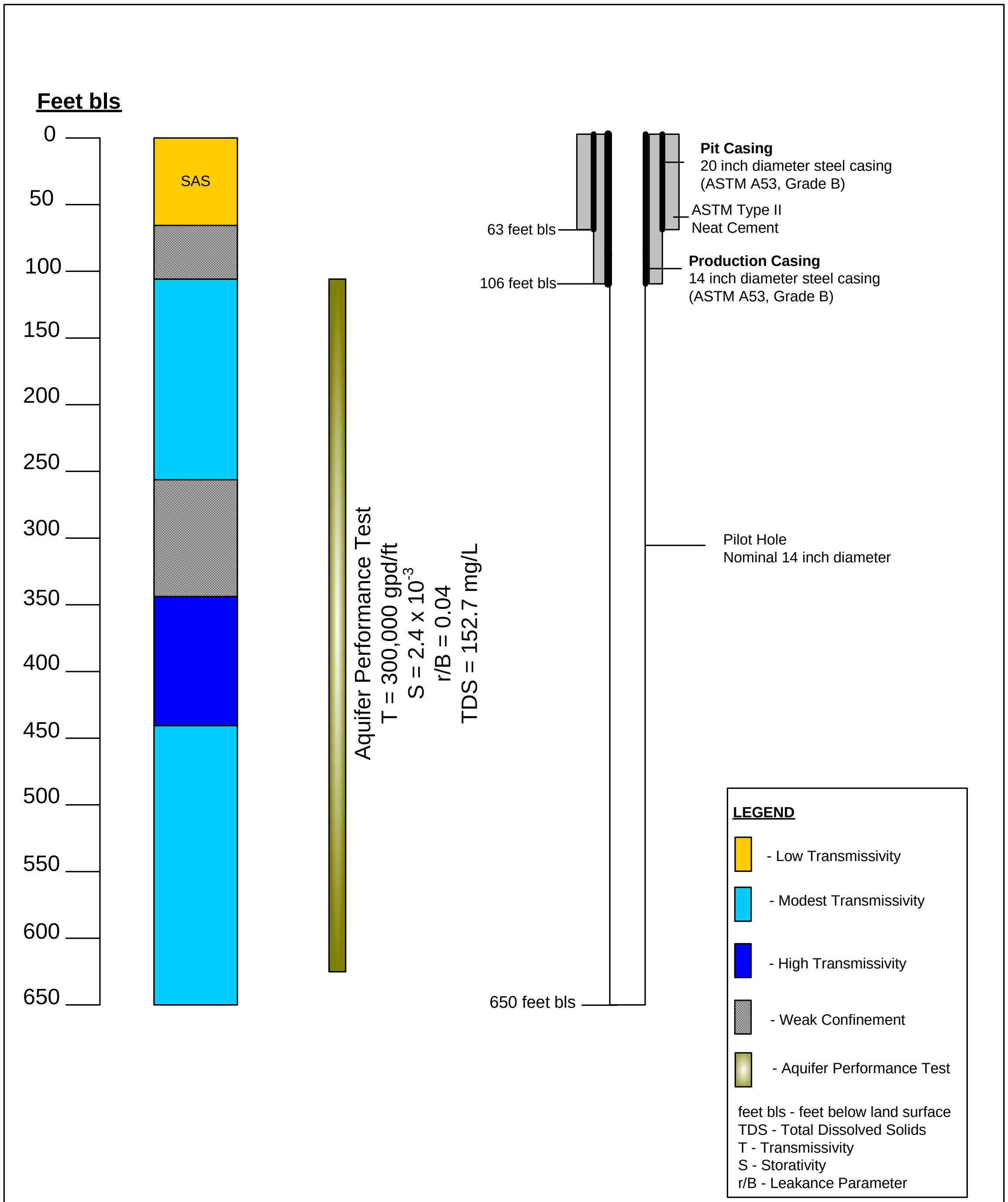
Table 1 is a summary of the test and monitor wells installed, the test/monitor intervals and the completion methods for the R.D. Keene Park Site.

Table 1. Summary of Completed Test/Monitor Wells – R.D. Keene Site.

Identifier	**Test/Monitor Interval (feet bls)**	***Completion Method***
Well No. 1	110 to 650	*Open Hole*
Well No. 2 (ORF-61)	142 to 650	*Open Hole*
Well No. 3 (ORH-1)	60 to 92	*Screened*
Well No. 4	32 to 52	*Screened*
Well No. 5 (ORS-3)	*32 to 52*	*Screened*

HYDROSTRATIGRAPHIC FRAMEWORK

The hydrogeologic setting for this site includes the SAS, the intermediate confining unit and the FAS. The FAS consists of the UFA, the middle semi-confining unit and the Lower Floridan Aquifer (LFA). **Figure 2** shows a generalized lithostratigraphic and hydrogeologic sequence that underlies the R.D. Keene site.



South Florida Water Mamagement District 3301 Gun Club Road West Palm Beach, Florida 33406	R. D. Keene Site	**Construction Details & Hydrostratigraphy**

Figure 2. Generalized Lithostratigraphic and Hydrogeologic Section – R.D. Keene Site.

Surficial Aquifer System

In Orange County, the SAS is generally unconfined (under atmospheric conditions) and consists of fine-to-medium-grained quartz sand with varying amounts of silt, clay and crushed shell material. Thickness of the SAS varies from less than 10 feet to greater than 150 feet along the high ridge area of western Orange County. At the R.D Keene site, the SAS was approximately 60 feet thick and consisted of silt to fine grain quartz sand, which slowly graded into a well indurated, gray colored siltstone with depth. At approximately 70 feet bls, shark teeth were present, indicating a transition into the Hawthorn Group (intermediate confining unit). As part of this study, an aquifer performance test (APT) was conducted to determine the hydraulic character of the SAS at this location. Analysis of the test data yielded a transmissivity of 170 gallon per day per foot with a dimensionless storativity value of 5.75×10^{-2}. These values are in line with expectations for aquifers composed of silt to fine-grained sediments.

Intermediate Confining Unit

The intermediate confining unit separates the SAS and FAS and restricts the vertical movement of water between these two aquifer systems. This unit includes all sediments of late-to-middle Miocene age (Hawthorn Group) and low permeability beds of early Pliocene age (Miller 1986). At the R.D Keene site, the intermediate confining unit consists of interbedded sands, calcareous silts and clays, shells and phosphatic limestone and dolomite that occur from 60 feet to 95 feet bls. A slug test was performed on the 60 to 95 foot interval whereby the entire well bore was displaced with water and allowed to return to static conditions. Analysis of the slug test data yielded a hydraulic conductivity of 0.038 feet per day.

Floridan Aquifer System

The Floridan Aquifer System (SAS) is considered the primary source of potable water within Orange County and is composed of highly permeable carbonate rocks of Eocene to Late Paleocene age. The aquifer system includes stratigraphic units of the Eocene aged Ocala Limestone (if present), Avon Park Formation and the Oldsmar Formation and the Paleocene aged Cedar Keys Formation. At this site only the Ocala Limestone and Avon Park Formation were encountered at depth.

In general, the FAS contain two major permeable zones, the Upper and Lower Floridan aquifers, separated by a less permeable zone considered as the middle semi-confining unit. The UFA includes the Ocala Limestone (if present) and upper portion of the Avon Park Formation. Within this study area, the top of the UFA is approximately 100 to 150 feet bls. At this site, it was encountered at 106 ft. bls, marked by a lost circulation horizon.

Two discrete zones were identified in the UFA, separated by a semi-confining unit. These two productive horizons are designated as “Zone A and Zone B” consistent with nomenclature used in O’Reilly et al., 2002. Zone A corresponds to about the upper one-thirds of the aquifer. Zone A was encountered at 106 feet bls and the lower extent was determined by the first occurrence of dark brown mudstone/dolostone at 235 feet bls.

An intervening semi-confining unit separates Zone A from Zone B in the UFA. At this site it is composed of competent, well-indurated, low permeability, crystalline dolostone unit interbedded with moderately indurated, tan colored, grainstones and crystalline limestones extending from 235 to 340 feet bls.

The top of Zone B was encountered at 340 feet bls, identified by a distinct response on the various geophysical logs. A fractured and cavernous dolostone unit from 340 to 450 feet bls was the major production zone within this test well. Significant water production occurs at 340 feet bls with minor production at 450 feet bls, as indicated by the flowmeter and temperature logs (see Geophysical Log Run No. 2–**Appendix B**). Smaller, less productive intervals continue from 500 to 650 feet bls through poorly to moderately indurated wackestone/packstone units as evident in the flowmeter or temperature log traces and seen on the borehole video log. An APT was performed on the entire Upper Floridan Aquifer (including both Zone A and B) from 106 feet to 650 feet bls. Analysis of the test data yielded a transmissivity of 300,000 gpd/ft, a storage coefficient of 2.40 x 10^{-3}, an r/B value of 0.04 with a calculated leakance value of 7.50 x 10^{-2} gpd/ft^3.

HYDROGEOLOGIC TESTING

The SFWMD collected information during the test program to determine the lithologic, hydraulic and water-quality characteristics of the Surficial and Floridan Aquifer systems at this site. These data were used in the final design of the various test and monitor wells for use in site-specific aquifer tests, and in the long-term water-level monitoring program. **Figure 3** summarizes the well construction for the 14-inch diameter test-production well, as well as the test results from R.D. Keene site.

Formation Sampling

During drilling operations, the onsite geologist took formation samples (well cuttings) at 5-foot intervals. These samples were washed then described using the Dunham (1962) classification scheme. The onsite lithologic descriptions produced by UES are summarized in **Appendix A.** Once well construction activities were completed, the SFWMD sent the formation samples to the Florida Geological Survey (FGS) for further analysis and long-term storage.

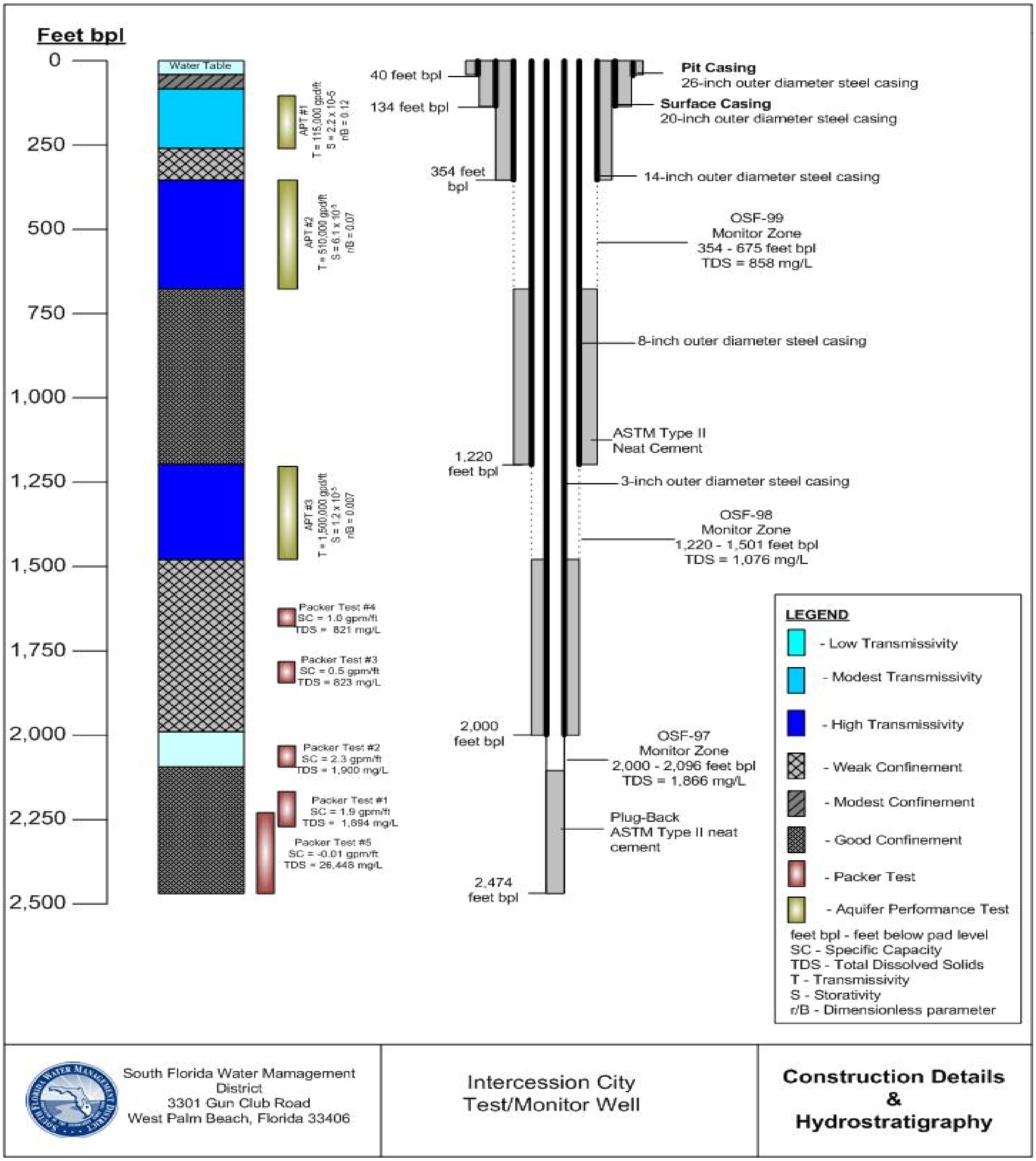


Figure 3. Well Construction and Testing Summary – R.D. Keene Site.

Formation Fluid Sampling

During reverse-air drilling of the pilot-hole, samples were taken from circulated return fluids (composite formation water) at 30-foot intervals (average length of drill rod) from 250 feet bls to 1,350 feet bls. Water quality measurements on the reverse-air returns were not taken below 1,350 feet bls due to equipment availability. A Hydrolab® multiparameter probe was used to measure field parameters on each sample, which included temperature, specific conductance and pH. **Figure 4** shows field determined specific conductance values and calculated total dissolved solids (TDS) concentrations with respect to depth using the following equation; TDS = Specific Conductance * 0.57 (Hem 1994).

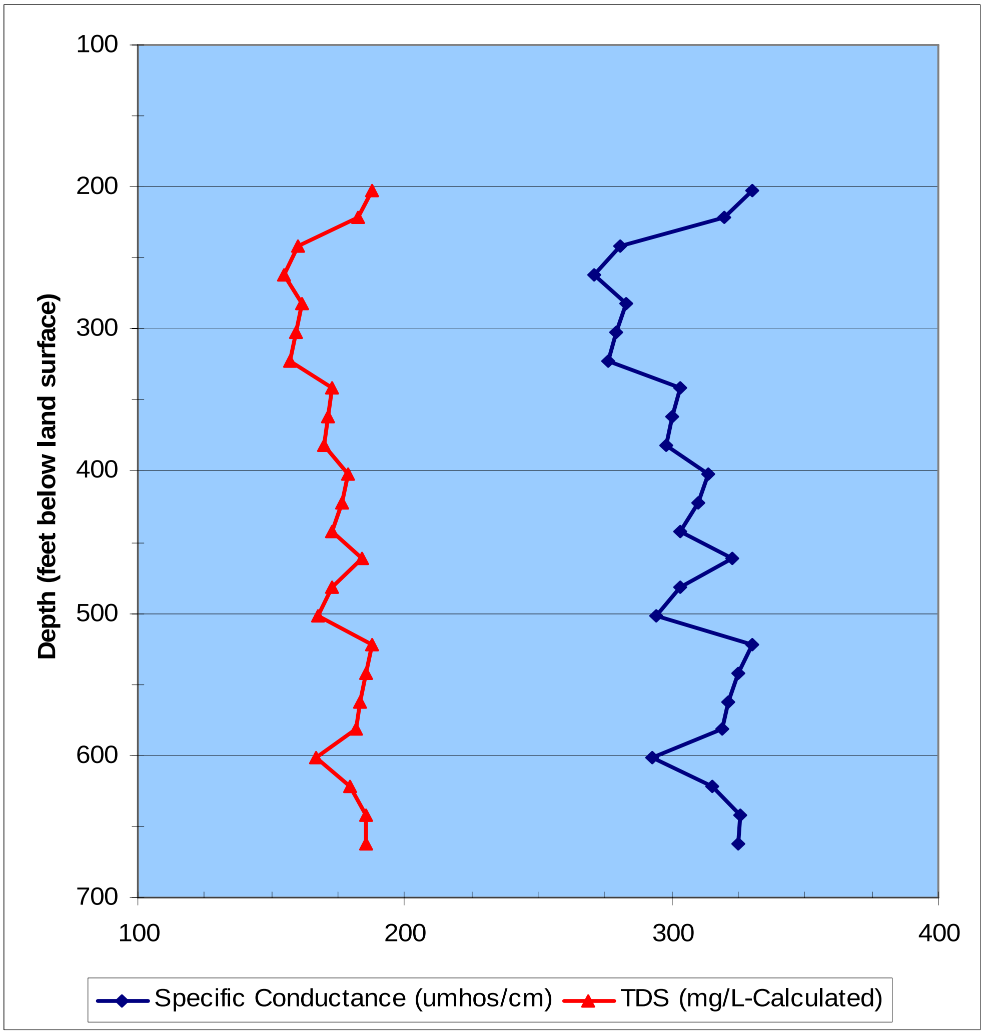


Figure 4. Water Quality with Depth – Reverse Air Returns Geophysical Logging.

Geophysical Logging

Geophysical logging was conducted in the pilot hole for the test-production well at various stages of drilling and construction. The geophysical logs provided a continuous record of the physical properties of the subsurface formations and their respective fluids. Geophysical log data were captured directly from the onsite logging processor (digital) using log ASCII standard. The geophysical log traces from the 14-inch diameter test-production well are displayed in **Appendix B.**

The first set of geophysical log surveys conducted included the 4-arm caliper, natural gamma ray, spontaneous potential and a dual-induction/laterlog-3 resistivity log. These surveys were run in the upper 200 feet of the nominal 12-inch diameter mud filled pilot hole. These logs provide a continuous record of borehole conditions, which allows the onsite geologist to determine the best depth to install the well casing.

The second series of geophysical logs were conducted in two parts. The formation evaluation-type surveys consisted of a 4-arm caliper, natural gamma ray, spontaneous potential (SP), dual induction and sonic log. The production-type surveys consisted of a flow meter, temperature and fluid resistivity logs conducted under both static and dynamic (pumped) conditions. This approach helps to identify where water enters or exits the borehole. These logs are archived in the SFWMD's DBHYDRO hydrogeologic database under the permanent well identifier ORF-61. In addition, hard copies of these logs can be reviewed at the SFWMD headquarters in West Palm Beach, Florida. **Table 2** is a summary of the geophysical logging program conducted at this site.

Table 2. Summary of Geophysical Logging Activities at the R.D. Keene Site.

Run #	Date	Logging Company	Logged Interval (ft. bls)	Caliper	Natural Gamma Ray	SP	Dual Induct	Sonic	Flow-Meter	Temp	Fluid Resistivity	Video
1	03/26/03	SRE	0 - 202	x	x	x	x					
2	04/10/03	SRE	2 - 650	x	x	x	x	x	x	x	x	x

SRE = Southern Resource Exploration

Measuring Point Elevation is Land Surface at 106.1 feet NGVD, 1929

Groundwater Quality

Water quality in the Floridan Aquifer within Orange County has remained fairly constant over time. Some water quality variations occur where sinkholes provide a direct or near-direct surface hydraulic connection to the UFA (Tibbals 1990). Water quality in the UFA is affected by contact with the aquifer material or as a result of residence time. UFA waters in western and central Orange County have the lowest total dissolved solid concentrations. This is a result of recharge to the aquifer from rainfall through portions of the intermediate confining unit where it is thin, permeable or breached.

Water quality samples were taken from the UFA, intermediate confining unit (Hawthorn Confining Unit) and the SAS. Analytical results from these water samples were use to establish baseline water quality conditions for these three long-term monitoring stations. Unfiltered and filtered water samples were taken directly from the discharge point of the peristaltic sample pump for the SAS and Hawthorn well samples with the UFA sample taken during the APT. As part of the SFWMD's water quality sampling protocol, duplicate samples were collected under the same sampling conditions. After the samples are collected and labeled, they were preserved on ice in a closed container and transported directly to the SFWMD water quality laboratory. The samples were received and analyses completed within the required holding times for each parameter. The water quality samples were analyzed using Standard Method procedures developed under the SFWMD, Comprehensive Quality Assurance Plan, 2000. The analytical results are summarized in **Table 3**.

Table 3. Composite Water Quality Data – Completed Monitor Zone.

Inorganic Water Quality Data from R.D Keene Drill Site, Orange County, Florida.												
		Cat ions				Anions				Field Parameters		
Identifier	Depth Interval (ft. bls)	Na^{+} mg/L	K^{+} mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	Cl^{-} mg/L	Alka as $CaCO_3$ mg/L	SO_4^{2-} mg/L	TDS mg/L	Specific Conduct. umhos/cm	Temp ^{o}C	pH s.u.
ORS-3	32-52	3.9	13.0	26.9	9.7	9.9	27.3	68.6	180	286	26.5	5.6
ORH-1	60-92	37.5	30.6	35.4	3.5	26.1	138.7	46.9	278	376	25.6	9.3
ORF-61	106-650	6.9	4.4	33.3	7.2	10.4	103.2	13.0	153	240	24.5	8.0

ft. bls = feet below land surface o C = degree Celsius
mg/L = milligrams per liter Alka as $CaCO_3$ = Alkalinity as Calcium Carbonate
umhos/cm = microumhos per centimeter s.u. = standard unit

Groundwater Level Monitoring Program

The various monitor wells at this site were outfitted with Rittmeyer (Model MPx) pressure transducers connected to a Campbell Scientific CR10 data logger as part of SFWMD’s long-term groundwater level monitoring program. The data recorder was installed to determine long-term water level fluctuations as result of natural and induced stresses for use in calibrating groundwater models. The individual pressure transducers are rated at 15 pounds per square inch (psi) and set approximately 10 feet below static water level in each monitor well. A water level reading is collected every 15 minutes and stored in the data logger’s storage module. The water level recorders are connected to a telemetry system that transmits the data to the SFWMD headquarters in West Palm Beach on a daily basis. This data is reviewed then entered into the SFWMD DBHYDRO environmental database. Water level data is not presently available for this site.

SUMMARY

1. The top of the FAS was determined at 106 feet below land surface as defined as the first occurrence of vertically persistent, permeable and consolidated, carbonate unit (Tibbals 1990).
2. Lithologic data, geophysical logs and APT results indicate moderate production capacity in Zone A of the UFA and good production in Zone B of the UFA.
3. Water quality data from the completed monitor wells indicate that chloride and total dissolved solids in the Surficial Aquifer and Upper Floridan Aquifer meet potable drinking water standards.
4. The SAS hydraulic test results yielded a transmissivity of 170 gallons per day per foot of aquifer (gpd/ft) and a dimensionless storativity value of 5.75×10^{-2}.
5. The Hawthorn Group (intermediate confining unit) yielded a hydraulic conductivity of 0.038 ft/day.
6. Hydraulic testing in the UFA, which included the both Zones A & B yielded a transmissivity of 300,000 gpd/ft, a storage coefficient of 2.40×10^{-3}, a dimensionless r/B value of 0.04 with a calculated leakance value of 7.50×10^{-2} gpd/ft^3.
7. Hydraulic test results indicate moderate connectivity between the SAS and UFA.

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APPENDIX A
Lithologic Description

Table A-1. Lithologic Description – R.D. Keene FAS Test.

Lithologic Log - ORF-61 R.D. Keene County Park Orange County, Florida		
Depth in Feet (bls)		**Lithologic Description ORF-61**
From	**To**	
0	10	Gray/tan, well sorted medium quartz sand, good permeability
10	20	Dark brown, medium to coarse sand, organic material
20	30	Light brown, fine quartz sand, trace of clay
30	40	Light brown, fine grain silty sand, trace of clay
40	50	Gray, fine grain sand with trace of clay
50	60	Gray, fine sand with clay
60	85	Gray siltstone, well indurated, some poorly sorted quartz sand, broken shark tooth
85	90	Gray sandy clay with well indurated quartz sand
90	100	Gray siltstone/mudstone with quartz sand
100	106	Gray mudstone
106	120	Void, no samples
120	130	Light tan, packstone with broken shell
130	150	Light tan, pachstone with shell fragments
150	155	Light tan wackestone with shell and gray siltstone
155	165	Light gray lime mudstone,
165	170	Light gray to tan wackestone
170	180	Light gray mudstone with fossils
180	200	Light gray to tan wackestone with increasing fossil fragments

Table A-1. Lithologic Description – R.D. Keene Site (Continued).

Lithologic Log - ORF-61 R.D. Keene County Park Orange County, Florida		
Depth in Feet (bls)		**Lithologic Description ORF-61**
From	**To**	
200	215	Light brown packestone, moldic porosity
215	235	Tan mudstone with broken echinoid fossils
235	240	Brown to dark brown dolostone with voids, moldic porosity
240	250	Light brown packestone with voids
250	260	Brown packestone with voids
260	275	Light brown packestone skeletal matter visible, fossils not identified, effervesces with 10% HCl.
275	285	Light brown grainstone, echinoid fragments, moldic porosity
285	310	Light brown packestone, echinoid fragments, friable
310	315	Light brown packestone with cone shape(possible dictyoconus) fossils
315	320	Light brown grainstone, fossil fragments
320	335	Light brown mudstone with fossil fragments
335	340	Tan grainstone with fossil frags(dictyoconus)
340	350	Light brown grainstone, fossil fragments with brown dolomite present
350	360	Light brown grainstone, fossil fragments(dictyoconus) less dolomite
360	365	Brown dolomite, hard
365	375	Tan lime mudstone,
375	390	Cream-colored grainstone, friable, moldic and intergranular porosity
390	500	Samples missing

Table A-1. Lithologic Description – R.D. Keen Site (Continued).

Lithologic Log - ORF-61 R.D. Keene County Park Orange County, Florida		
Depth in Feet (bls)		**Lithologic Description ORF-61**
From	**To**	
500	525	Tan wackestone with small voids present
525	535	Tan mudstone
535	540	Tan mudstone
540	545	Tan packstone, fossil fragments, effervesces with 10%HCl
545	555	Light brown dolostone/mudstone
555	560	Brown wackestone
560	565	Light brown dolostone /wackestone with small solution voids
565	580	Tan mudstone, vuggy and moldic porosity
580	605	Brown dolostone/wackestone with solution voids
605	620	Dark brown dolostone/wackestone with solution voids
620	625	Light brown mudstone with gray well indurated siltstone
625	650	Brown dolostone/wackestone with solution voids visible

APPENDIX B
Geophysical Logs

AHT10	Shallow Induction
AHT30	Medium Induction
AHT90	Deep Induction
CNCF	Calculated porosity
CPS	Count per Second
DDTMP	Dynamic Delta Temperature
DFRES	Dynamic Fluid Resistivity
DPHZ	Density Porosity
DTMP	Dynamic Temperature Gradient
degF	Degrees Fahrenheit
DT	delta transient time
DTMP	delta temperature
DTCO	delta transient time – Compression Wave
DTSM	delta transient time – Shear Wave
FLOWN	Flow-meter - Dynamic
FLOWNS	Flow-meter - Static
FT	feet
Ft/min	feet per minute
FRES	Fluid Resistivity
GAPI	gamma American Petroleum Institute units
GR	gamma ray
g/c^3	grams per cubic centimeter
HCAL	density caliper
in	inches
LSPD	Line Speed - downward
MV	Millivolts
OHMM	ohm-meters

PEFZ	photoelectric effect
QFlown	Corrected Flowmeter
RILD	deep induction log
RILM	medium induction log
RLL3	shallow focused resistivity
SP	spontaneous potential
TEMP	temperature gradient
Usec/ft	microseconds per foot
VCL	Volume - Clay
VCLC	Volume - Limestone
VDOL	Volume – Dolomite
VP/VS	Velocity Primary vs. Velocity Secondary
XCAL	x-caliper
YCAL	y-caliper

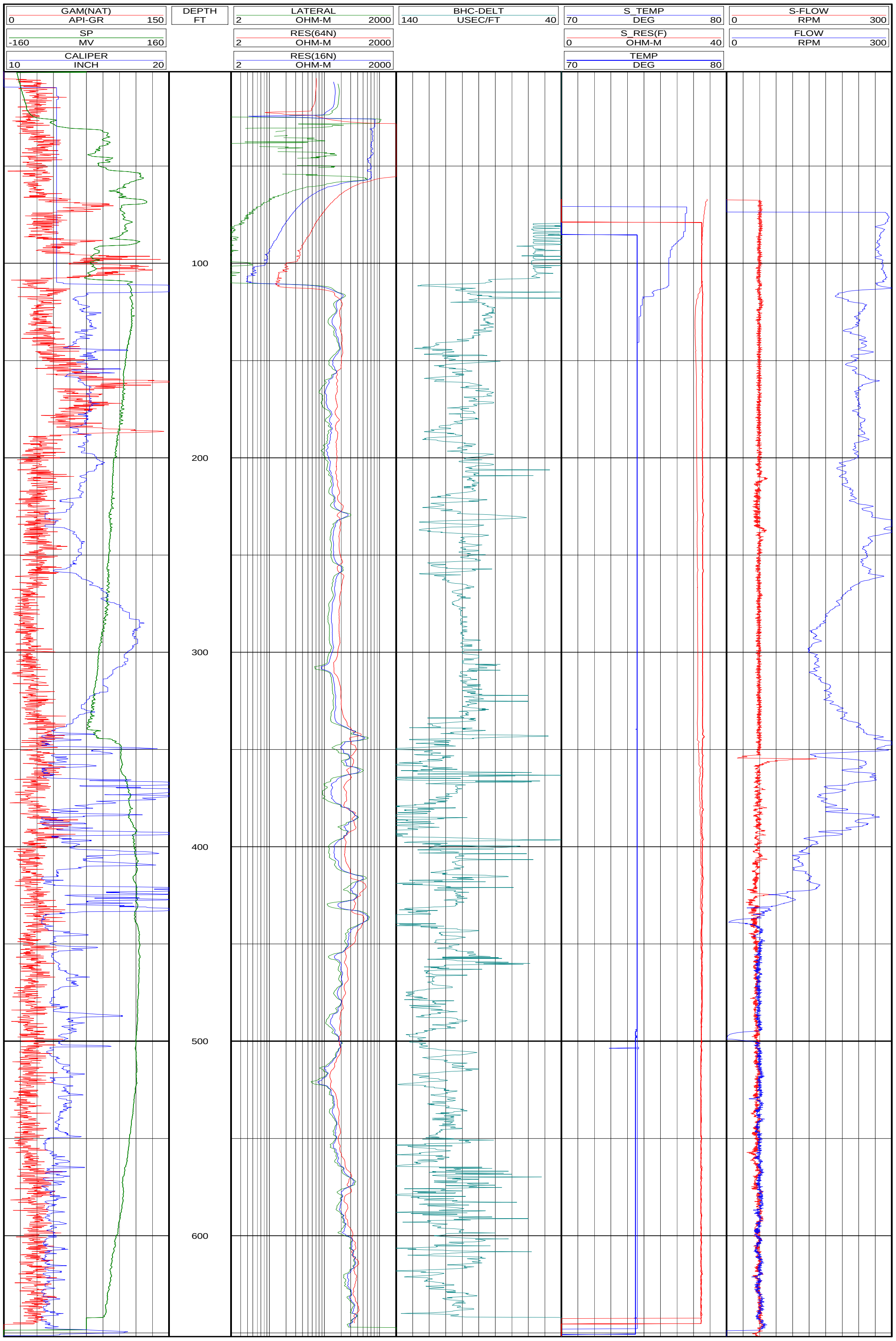

Figure B-1. Geophysical Logs for ORF-61.