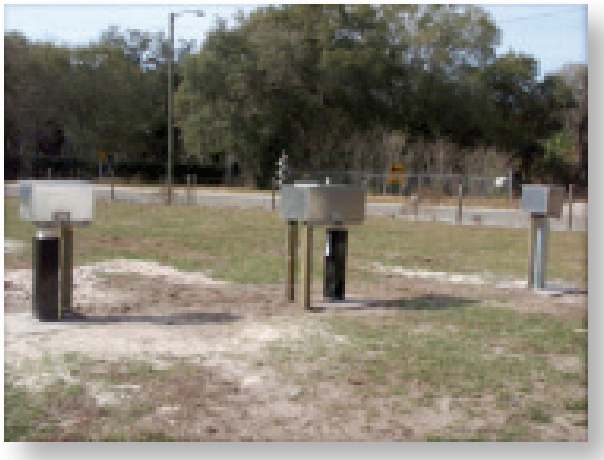
Southwest Florida
Water Management District

Well Construction and Aquifer Performance Testing for the Dover-Plant City Freeze Management Plan in Hillsborough and Polk Counties, Florida



Southwest Florida Water Management District
Geohydrologic Data Section

July 2013

Cover Photos: 1: Contractor constructing wells at the Dover North well site, Hillsborough County, November 2011.
2: Completed monitor wells with water level recorders installed at the Dover North well site, Hillsborough County,
3: Discharge during aquifer performance test at Dover East well site, Hillsborough County, May 2012.

Well Construction and Aquifer Performance Testing for the Dover-Plant City Freeze Management Plan in Hillsborough and Polk Counties, Florida

By Michael T. Gates, P.G.

July 2013

Southwest Florida Water Management District
Geohydrologic Data Section

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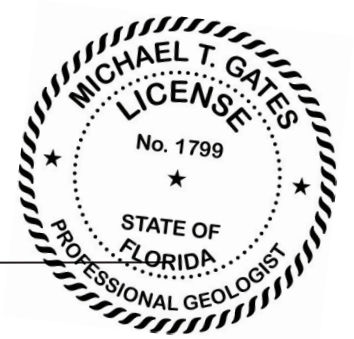
The hydrogeologic evaluations and interpretations contained in the *Well Construction and Aquifer Performance Testing for the Dover-Plant City Freeze Management Plan in Hillsborough and Polk Counties, Florida* have been prepared or approved by a licensed Professional Geologist in the State of Florida, in accordance with Chapter 492, Florida Statutes.



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Date: 7/17/2013

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Conversion Factors and Datums

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)
	Area	
acre	4,047	square meter (m^2)
acre	0.004047	square kilometer (km^2)
square foot (ft^2)	929	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Flow Rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
foot per minute (ft/min)	0.3048	meter per minute (m/min)
foot per day (ft/day)	0.3048	meters per day (m/d)
cubic foot per day (ft^3/s)	0.02832	cubic meters per second (m^3/s)
cubic foot per day (ft^3/d)	0.02832	cubic meters per day (m^3/d)
gallon per minute (gal/min)	0.06309	liters per second (L/s)
gallon per day (gal/d)	0.003785	cubic meter per day (m^3/d)
mile per hour (mi/h)	1.609	kilometer per hour (km/h)

Pressure		
atmosphere, standard (atm)	101.3	kilopascal (kPa)
bar	100	kilopascal (kPa)
Specific Capacity		
gallons per minute per foot [(gal/min)/ft]	0.2070	liter per second per meter [(L/s)/m]
Hydraulic Conductivity		
foot per day (ft/day)	0.00035278	centimeter per second (cm/s)
Transmissivity*		
foot squared per day (ft^2/d)	0.09290	meter squared per day (m^2/day)
Leakance		
foot per day per foot [(ft/day)/ft]	1	meter per day per meter [(m/d)/m]
Temperature		
Celsius(°C)	°F=(1.8 x °C) + 32	Fahrenheit (°F)
Fahrenheit (°F)	°C = (°F – 32) / 1.8	Celsius (°C)

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929).

Elevation, as used in this report, refers to distance above the vertical datum.

*Transmissivity: The standard unit for transmissivity is cubic foot per day per square foot times foot of aquifer thickness [(ft^3/d)/ft^2]ft. In this report, the mathematically reduced form, foot squared per day (ft^2/d), is used for convenience.

Abbreviations

als	above land surface
bls	below land surface
CPS	counts per second
DEG F	degrees Fahrenheit
District	Southwest Florida Water Management District
ft	foot, feet
GEFCO	George E. Failing Company
MV	millivolts
NAVD	North American Vertical Datum of 1988
ohm-m	ohm-meters
PRIM	Peace River Integrated Model
PVC	polyvinyl chloride
RES	single-point resistance
RES(16N)	short (16-inch) normal resistivity
RES(64N)	long (64-inch) normal resistivity
SC08	Saddle Creek site 08
SID#	site identification number
SP COND	specific conductance
SP	spontaneous potential
TEMP	temperature
US	United States
uS/cm	microsiemens per centimeter
o , ‘ , “	degrees, minutes, seconds
oF	degrees Fahrenheit

Well Construction and Aquifer Performance Testing for the Dover-Plant City Freeze Management Plan in Hillsborough and Polk Counties, Florida

By Michael T. Gates, P.G.

Introduction

The Southwest Florida Water Management District's (District) Geohydrologic Data Section constructed 23 permanent monitor wells and conducted two aquifer performance tests (APTs) in the Dover-Plant City area of Hillsborough County, as part of the Dover-Plant City Freeze Management Plan. The Dover-Plant City Freeze Management Plan was developed to address excessive groundwater withdrawals during freeze events in the Dover-Plant City area. The monitor wells were installed in and around the newly established 256 square mile Dover-Plant City Water Use Caution Area (WUCA) shown in figure (fig.1). Between August 2010 and March 2012, 12 new permanent monitor wells were installed at eight existing groundwater monitoring stations and 11 new permanent monitor wells were installed at four new groundwater monitoring stations in the Dover-Plant City area (fig. 1). During May and June 2012, two APTs were conducted at one new monitor well station (Dover East).

The Dover-Plant City area produces the majority of Florida's strawberry crop. More than 7,700 acres of strawberries are permitted for groundwater use in the area. Groundwater is also used for the numerous row crops, citrus groves, berries, nursery ornamentals, and tropical fish farms in the area. For nearly fifty years, farmers in the Dover-Plant City area have used groundwater to protect crops when the ambient temperature drops to below freezing. The Dover-Plant City area experienced an unprecedented 11-day freeze event from January 3–13, 2010. An estimated 2.7 billion gallons of groundwater was pumped from the Upper Floridan aquifer for freeze protection during this 11 day period (Peterson and Rumbaugh, 2012). Upper Floridan aquifer water level declines of more than 70 feet in the study area were estimated from the data collected during the freeze event (fig. 2). The District received nearly 750 dry well complaints and reports of more than 140 sinkholes in the area during the freeze event.

Following the freeze event the District held a series of public workshops and technical work sessions in an effort to develop a groundwater management plan to mitigate the effects of pumping for freeze events in the future. The information gathered from the stakeholders helped the District develop the Dover-Plant City Freeze Management Plan (Plan). The Plan includes:

- Declaring a 256-square-mile water use caution area in the Dover-Plant City area
- Establishing a Minimum Aquifer Level and Minimum Aquifer Level Protection Zone
- Developing a recovery strategy to help meet the Minimum Aquifer Level
- Expanding the Facilitating Agricultural Resource Management Systems (FARMS) program and increasing incentives for alternative frost/freeze protection methods
- Requiring automatic meter reading devices
- Creating a new process for allocating dry well complaints
- Expanding the area where special well construction standards apply
- Enhancing communication for freeze events
- Expanding the data collection network for freeze events

Purpose and Scope

This report presents a summary of the monitor well construction and aquifer performance testing conducted for the Dover-Plant City Freeze Management Plan. The objectives of the projects were to:

- Install additional Upper Floridan aquifer and/or surficial aquifer wells at existing groundwater monitoring stations within the existing Dover Monitor Well Network;
- Install Upper Floridan aquifer, and surficial aquifer monitor wells at four new monitoring stations that will be added to the Dover Monitor Well Network;
- Conduct aquifer performance tests on the Upper Floridan aquifer at one of the four new monitoring stations.

The addition of the new monitor wells to the network and the data from APTs will provide faster reporting of changes in aquifer levels during freeze events, better define areas impacted

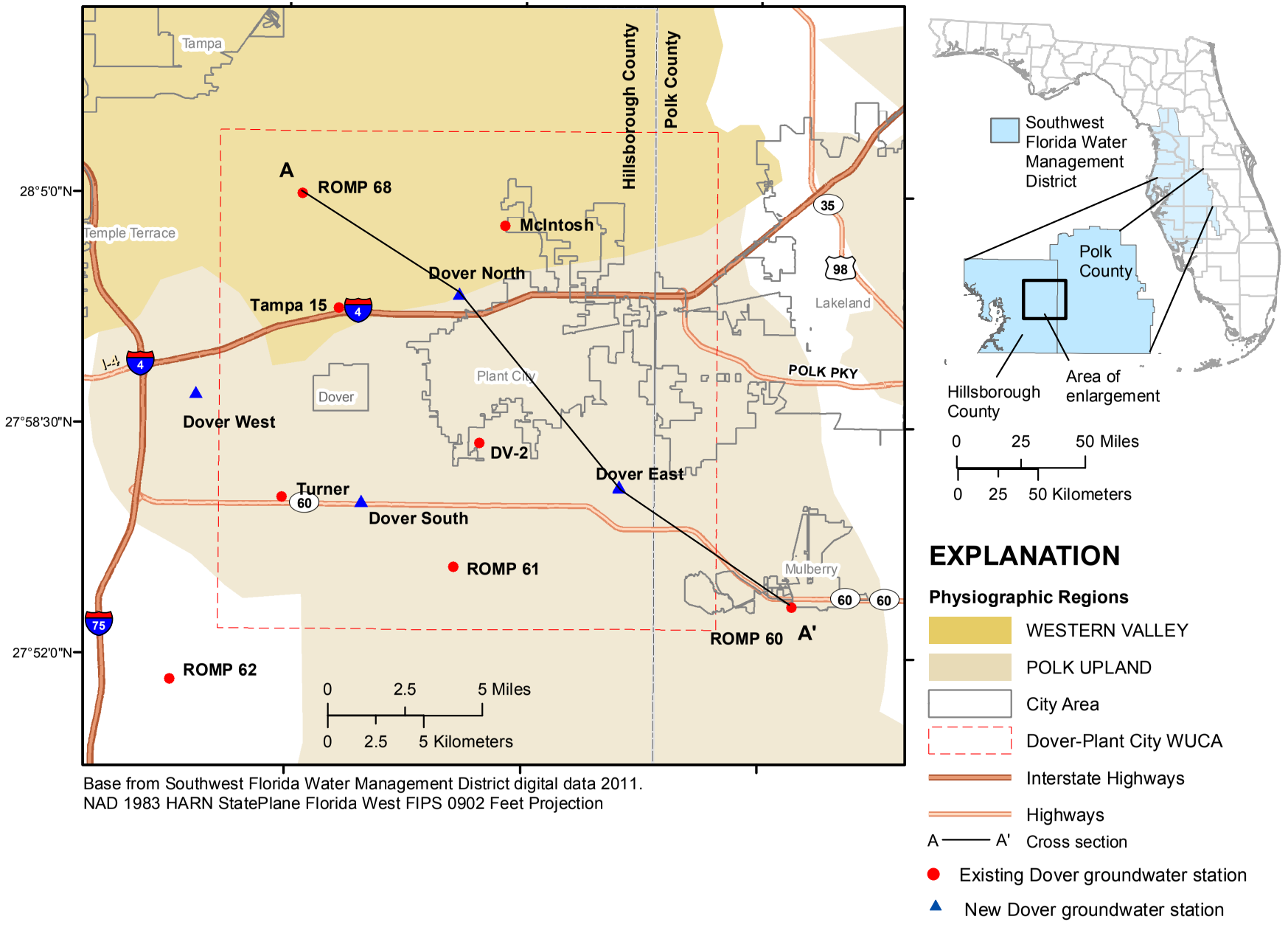
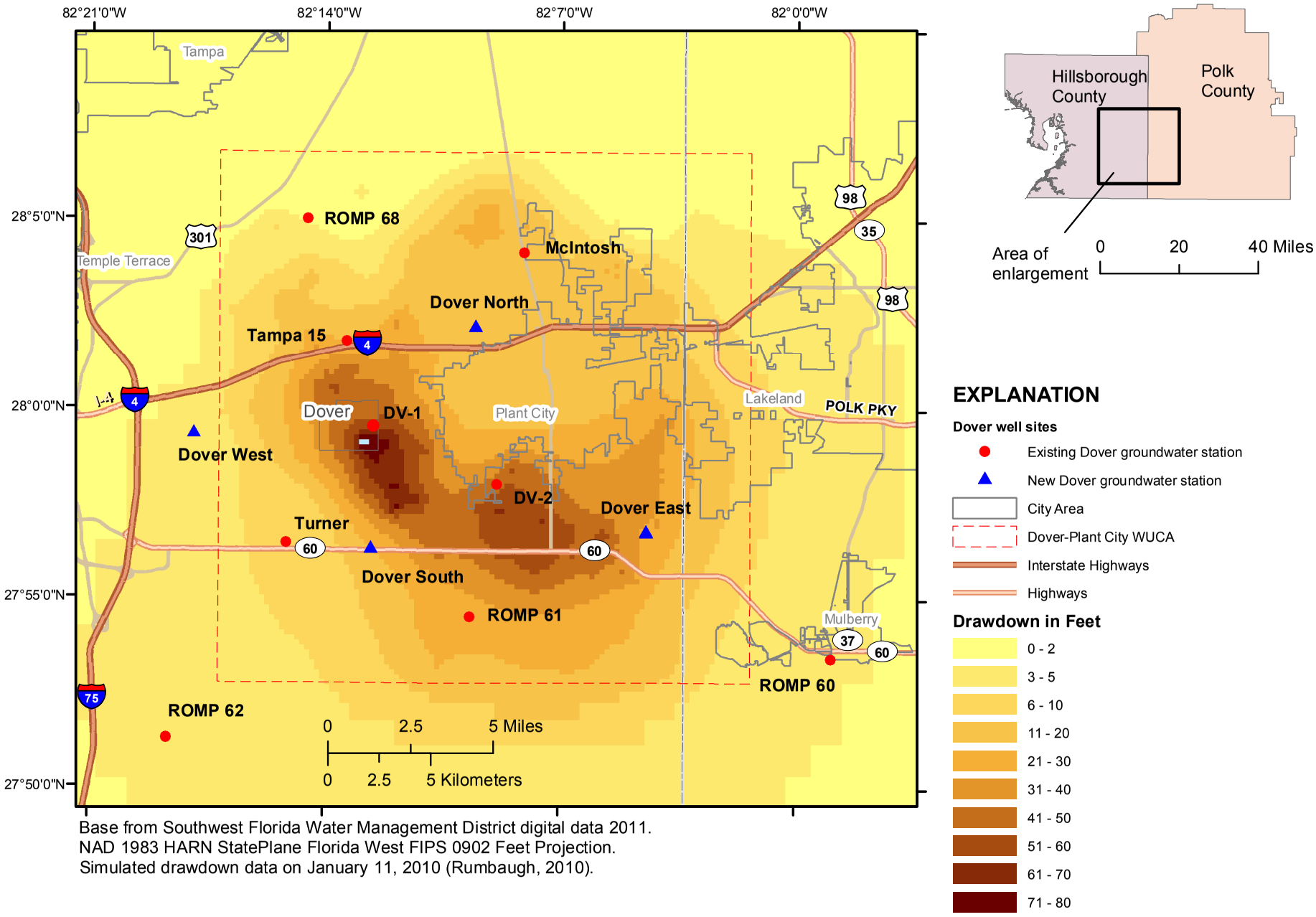


Figure 1. Location of the Dover-Plant City study area and Water Use Caution Area in Hillsborough and Polk Counties, Florida.



Base from Southwest Florida Water Management District digital data 2011.
NAD 1983 HARN StatePlane Florida West FIPS 0902 Feet Projection.
Simulated drawdown data on January 11, 2010 (Rumbaugh, 2010).

Figure 2. Estimated drawdown of the Upper Floridan aquifer in the Dover-Plant City study area on January 11, 2010.

by drawdown in the area, and provide hydrogeologic data that can be used to update groundwater models.

Location

The Dover-Plant City study area is located in eastern Hillsborough County and the extreme western edge of Polk County in west-central Florida (fig. 1). The study area lies within the Western Valley and Polk Upland physiographic provinces (White, 1970). Land surface elevations in the area range from 40 feet to 140 feet above the National Geodetic Vertical Datum (NGVD). The highest land surface elevations are found in the Western Valley physiographic province north of Interstate 4 (Peterson and Rumbaugh, 2012).

Methods

A variety of methods were employed by the District's Geohydrologic Data Section to collect hydrogeologic data during well construction. Split-spoon samples and drill cuttings were collected to help with lithologic interpretation. Borehole geophysical logs were collected periodically to provide additional hydrogeologic data during well construction. Groundwater levels were measured with electronic water level meters and pressure transducers. Hydraulic data and groundwater quality samples were collected from select monitor wells during the APTs. A detailed description of the data collection methods can be found in appendix A.

Lithologic Sampling

The District contracted private-sector drilling firms to construct the new monitor wells for the project. Lithologic samples were collected during split-spoon sampling and rotary drilling. Unconsolidated surficial sediments were collected with a split-spoon sampler at two-foot intervals until reaching the top of limestone or refusal. Drill cuttings of the carbonate rocks and sediments were collected from select wells during mud-rotary and reverse-air rotary drilling. The split spoon samples and drill cuttings collected were used for lithologic description and to help determine aquifer and formation boundaries.

Water Quality Sampling

Water quality samples were collected from the Upper Floridan aquifer wells at the Dover East (Bealsville) well site during the aquifer performance tests. Two groundwater samples were collected from the pumped well while pumping the Tampa Member/Suwannee Limestone (Tampa/Suwannee) portion of the Upper Floridan aquifer. Two groundwater samples were also collected from the pumped well while pumping the Avon Park permeable zone section of the Upper Floridan aquifer. A portion of each sample was analyzed in the field for temperature, specific conductance, and pH; the remainder of the sample was bottled and delivered to the District Environmental Chemistry Laboratory for more extensive analysis. The groundwater samples were collected in accordance with established protocols (Southwest Florida Water Management District, 2009). Additional groundwater samples will be collected periodically from the wells in the study area by the District's Water Quality Monitoring Program (WQMP). The water quality results for the samples collected from the wells can be accessed from the District's Water Management Information System (WMIS) database: *http://www18.swfwmd.state.fl.us/Res-Data/Search/ExtDefault.aspx/. Accessed July 24, 2013.*

Geophysical Logging

Borehole geophysical logs were collected during and after well construction to help delineate stratigraphic boundaries, identify confining units and permeable zones, determine casing points, and determine grout requirements. Caliper logs were run on all completed wells to verify the construction and integrity of the wells prior to final payment for well construction services. All logs were collected using the District-owned Century® digital geophysical logging equipment. Table 1 lists geophysical logging details for all logs collected during the project.

Aquifer Performance Testing

Two Upper Floridan aquifer APTs were conducted at the Dover East (Bealsville) well site (fig. 3). The APTs were conducted on the Tampa/Suwannee section of the Upper Floridan aquifer and the Avon Park permeable zone section of the Upper Floridan aquifer. A pumped well and an observation well were installed into both the Tampa/Suwannee section of the Upper Floridan aquifer and the Avon Park permeable zone section of the Upper Floridan aquifer. Discharge from each pumped well was conveyed through 10-inch aluminum discharge pipe 500 feet north to Howell Branch Creek, a tributary of the Alafia River. Backgroundwater levels were recorded in all on-site wells from May 1, 2012 to June 18, 2012. Background data indicated the Upper Floridan aquifer water level was declining at a rate of 0.19 feet per day (1.3×10^{-4} feet per minute) prior to the drawdown phase of the Tampa/Suwannee APT. The Upper Floridan aquifer water level was rising at a rate of 0.42 feet per day (2.9×10^{-4} feet per minute) prior to the drawdown phase of the Avon Park permeable zone APT. The backgroundwater level trend was removed from each of the data sets before analysis. AQTESOLV® software (Duffield, 2007) was used to determine the aquifer and confining unit hydraulic parameters.

Table 1. Summary of borehole geophysical logs collected from wells installed in the Dover-Plant City study area, Hillsborough and Polk Counties, Florida.

[AVPK PZ, Avon Park permeable zone; BLS, below land surface; DV, Dover; Mulit, multifunction tool; ROMP, Regional Observation and Monitor-well Program; U FLDN AQ , Upper Floridan aqufier; zone; SWNN, Suwannee; TEMP, temporary]

Date	Well Station	Well	Geophysical tool number	Geophysical Logs	Borehole Diameter (inches)	Casing Depth (feet BLS)	Total Depth (feet BLS)	Notes	Appendix
11/17/10	ROMP 60	U FLDN AQ MONITOR	9165C	Caliper/gamma	10	237	710	Inspect well before lining	C-1
11/17/10	ROMP 60	U FLDN AQ MONITOR	8144C	Multi[1]	10	237	710		
5/19/11	ROMP 60	AVPK PZ MONITOR	9165C	Caliper/gama	6	470	710	Final logs run at total depth	C-2
5/19/11	ROMP 60	SWNN PZ MONITOR	9165C	Caliper/gama	6	235	310	Final logs run at total depth	C-3
1/11/11	McIntosh	AVPK PZ MONITOR	9074C	Caliper/gamma	6	537	855	Final logs run at total depth	C-4
1/11/11	McIntosh	AVPK PZ MONITOR	8044C	Multi	6	537	855		
1/20/11	DV-2	AVPK PZ MONITOR	9165C	Caliper/gamma	6	565	850	Final logs run at total depth	C-5
1/20/11	DV-2	AVPK PZ MONITOR	8143C	Multi	6	565	850		
5/19/11	TAMPA 15	AVPK PZ MONITOR	9165C	Caliper/gamma	12	210	550	Borehole inspection	C-6
5/19/11	TAMPA 15	AVPK PZ MONITOR	8144C	Multi	12	210	550		
6/9/11	TAMPA 15	AVPK PZ MONITOR	9165C	Caliper/gamma	6	548	850	Final logs run at total depth	C-7
6/9/11	TAMPA 15	AVPK PZ MONITOR	8144C	Multi	6	548	850		
9/20/11	ROMP 62	SWNN MONITOR	9165C	Caliper/gamma	6	218	300	Final logs run at total depth	D-8
9/20/11	ROMP 62	SWNN MONITOR	8144C	Multi	6	218	300		
10/3/11	Dover East	DRILLING WATER SUPPLY TEMP	9064A	Caliper	4	212	300	Final logs run at total depth	C-9
10/3/11	Dover East	DRILLING WATER SUPPLY TEMP	8144C	Multi	4	212	300		
12/15/11	Dover East	SWNN MONITOR	9165C	Caliper/gamma	6	180	300	Final logs run at total depth	C-10
12/2/11	Dover East	AVPK PZ MONITOR	9165C	Caliper/gamma	6	530	850	Final logs run at total depth	C-11
12/2/11	Dover East	AVPK PZ MONITOR	8144C	Multi	6	530	850		
1/17/12	Dover East	AVPK PZ PRODUCTION TEMP	9165C	Caliper/gamma	20	204	530	Inspect well before casing set	C-12
10/4/11	Dover North	DRILLING WATER SUPPLY TEMP	9064A	Caliper	4	215	300	Final logs run at total depth	C-13
10/4/11	Dover North	DRILLING WATER SUPPLY TEMP	8144c	Multi	4	215	300		
1/5/12	Dover North	SWNN MONITOR	9165C	Caliper/gamma	6	195	300	Final logs run at total depth	C-14
1/5/12	Dover North	AVPK PZ MONITOR	9165C	Caliper/gamma	6	470	510	Inspect borehole	C-15
1/18/12	Dover North	AVPK PZ MONITOR	9165C	Caliper/gamma	6	470	800	Final logs run at total depth	C-16
1/18/12	Dover West	SWNN MONITOR	9165C	Caliper/gamma	6	180	300	Final logs run at total depth	C-17
1/18/12	Dover West	AVPK PZ MONITOR	9165C	Caliper/gamma	6	530	842	Final logs run at total depth	C-18
1/18/12	Dover West	AVPK PZ MONITOR	8143C	Multi	6	530	842		
3/8/12	Dover South	AVPK PZ MONITOR	9165C	Caliper/gamma	6	530	842	Final logs run at total depth	C-19
3/8/12	Dover South	AVPK PZ MONITOR	8144C	Multi	6	530	842		

[1] Multi - includes natural gamma, short normal (16-inch) resistivity, long normal (64-inch) resistivity, fluid resistivity, lateral resistivity, spontenous potential, single point resistance, temperature and delta temperature logs

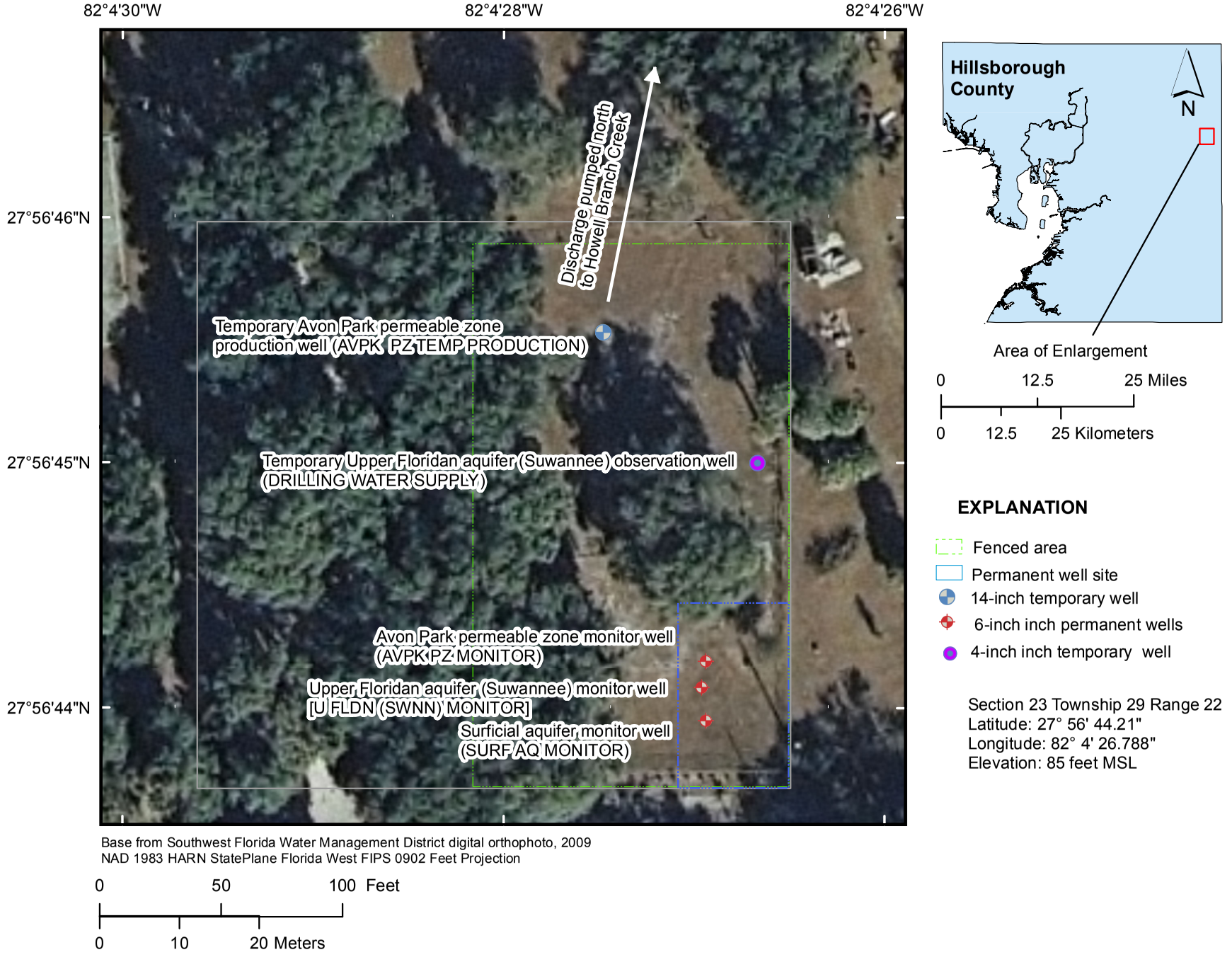


Figure 3. Map of the Dover East (Bealsville) well site, Hillsborough County, Florida.

Well Construction

The District contracted Applied Drilling Engineering, Inc., David Cannon Well Drilling, Inc., Fourqurean Well Drilling, and Huss Drilling, Inc. to construct the new surficial aquifer and Upper Floridan aquifer monitor wells for the Dover-Plant City Freeze Management Plan. Surficial aquifer wells were constructed using the hollow-stem auger method and Upper Floridan aquifer wells were constructed using mud-rotary and/or reverse-air methods.

A total of 23 new permanent monitor wells and three temporary wells were constructed between August 12, 2010 and March 15, 2012 as part of the Dover-Plant City Freeze Management Plan. Ten permanent surficial aquifer wells and 13 Upper Floridan aquifer wells were installed. Twelve new permanent wells were installed at eight existing monitoring well stations and 11 new permanent wells were installed at four new monitoring well stations. Two of the three temporary wells were constructed at the new Dover North and Dover East monitor well stations to supply water during the construction phase. The temporary well at the Dover East monitoring well station was also used as an observation well during the Tampa/ Suwannee APT at the site. These two temporary wells were plugged and abandoned when the monitor well construction was complete. One temporary well was constructed as an Avon Park permeable zone Upper Floridan aquifer production

Table 2. Summary of well construction details for monitor wells installed in the Dover-Plant City study area, Hillsborough Polk Counties, Florida.

[AQ, aquifer; AVPK, Avon Park; bls, below land surface; BTOC, below top of casing; deg, degree; DV, Dover; min, minutes; NM, not measured; NAVD, North American Vertical Datum of 1988; NGVD, National Geodetic Vertical Datum of 1929; PZ, permeable zone; sec, seconds; SF, shelter floor; SID, site identification; SWNN, Suwannee; SURF, surficial; TMPA. Tampa; TEMP; temporary; TOC, top of casing; U FLDN, Upper Floridan aquifer; WCP, well construction permit;° degree; ', minute; ", seconds)]

Existing Well Sites

Well Name	SID	WCP	Aquifer Monitored	Monitored Interval (size and type)	Casing Depth (feet bls)	Total Depth (feet bls)	SF (Feet NGVD29)	SF (Feet NAVD88)	Trimble Latitude (deg min sec)	Trimble Longitude (deg min sec)	Appendix
DV-2 AVPK PZ MONITOR	770770	809065	Upper Floridan	6-inch open hole	565	850	109.25	NM	27° 58' 00.21"	82° 08' 53.49"	B-1
McIntosh AVPK PZ MONITOR	768554	807839	Upper Floridan	6-inch open hole	537	855	109.28	NM	28° 04' 07.65"	82° 08' 07.98"	B-2
ROMP 60 Mulberry AVPK PZ MONITOR	777757	811817	Upper Floridan	10-inch open hole	470	710	103.71	102.82	27° 53' 27.27"	81° 58' 56.71"	B-3
ROMP 60 Mulberry SURF AQ MONITOR	768709	807699	Surficial	6-inch screened	9	24	103.64	102.75	27° 53' 27.20"	81° 58' 56.60"	B-4
ROMP 60 Mulberry U FLDN AQ (SWNN) MONITOR	777756	811804	Upper Floridan	6-inch open hole	235	310	103.4	102.51	27° 53' 27.25"	81° 58' 56.59"	B-5
ROMP 61 Medard SURF AQ MONITOR	763305	806746	Surficial	6-inch screened	5.5	20.5	75.64	NM	27° 54' 30.80"	82° 09' 40.68"	B-6
ROMP 62 Christina SURF AQ MONITOR	784219	815630	Surficial	6-inch screened	13	28	71.45	NM	27° 51' 16.91"	82° 18' 39.17"	B-7
ROMP 62 Christina UFLDN AQ (SWNN) MONITOR	784222	815319	Upper Floridan	6-inch open hole	218	300	71.3	NM	27° 51' 17.20"	82° 18' 39.30"	B-8
ROMP 68 Antioch SURF AQ MONITOR	777749	812780	Surficial	6-inch screened	6	41	59.38	58.52	28° 05' 01.26"	82° 14' 34.45"	B-9
Turner SURF AQ MONITOR	777750	811365	Surficial	6-inch screened	2	10	37.68	NM	27° 56' 26.92"	82° 15' 08.70"	B-10
Tampa 15 AVPK PZ MONITOR	780106	812279	Upper Floridan	6-inch open hole	548	850	73.72	72.85	28° 01' 47.26"	82° 13' 23.18"	B-11
Tampa 15 SURF AQ MONITOR	780114	813344	Surficial	6-inch open hole	4	24	73.7	72.83	28° 01' 47.24"	82° 13' 23.09"	B-12

New Well Sites

Well Name	SID	WCP	Aquifer Monitored	Well Type	Casing Depth (feet bls)	Total Depth (feet bls)	SF (Feet NGVD29)	SF (Feet NAVD88)	Trimble Latitude (deg min sec)	Trimble Longitude (deg min sec)	Appendix
Dover North (Cork Prairie) DRILLING WATER SUPPLY TEMP	782755	815536	Upper Floridan	4-inch open hole	206	300	NM	NM	28° 02' 09.32"	82° 09' 32.55"	B-13
Dover North (Cork Prairie) AVPK PZ MONITOR	788472	815920	Upper Floridan	6-inch open hole	470	800	112.26	NM	28° 02' 09.38"	82° 09' 33.89"	B-14
Dover North (Cork Prairie) U FLDN AQ (SWNN) MONITOR	788471	817282	Upper Floridan	6-inch open hole	200	300	112.30	NM	28° 02' 09.47"	82° 09' 33.87"	B-15
Dover North (Cork Prairie) SURF AQ MONITOR	790045	818255	Surficial	6-inch screened	5	25	112.68	NM	28° 02' 09.57"	82° 09' 33.87"	B-16
Dover East (Bealsville) DRILLING WATER SUPPLY TEMP	798551	815535	Upper Floridan	4-inch open hole	212	300	NM	NM	27° 56' 44.09"	82° 04' 26.83"	B-17
Dover East (Bealsville) AVPK PZ MONITOR	798549	816307	Upper Floridan	6-inch open hole	530	850	93.95	93.07	27° 56' 44.19"	82° 04' 26.79"	B-18
Dover East (Bealsville) UFLDN AQ (SWNN) MONITOR	784813	816312	Upper Floridan	6-inch open hole	195	300	93.99	93.11	27° 56' 43.91"	82° 04' 26.87"	B-19
Dover East (Bealsville) AVPK PZ PRODUCTION TEMP	784815	816316	Upper Floridan	14-inch open hole	530	850	NM	NM	27° 56' 45.98"	82° 04' 27.03"	B-20
Dover East (Bealsville) SURF AQ MONITOR	798550	819338	Surficial	6-inch screened	2	20	93.81	92.93	27° 56' 43.95"	82° 04' 26.91"	B-21
Dover West (Mango) AVPK PZ MONITOR	789584	817014	Upper Floridan	6-inch open hole	530	842	71.36	NM	27° 59' 18.93"	82° 17' 54.60	B-22
Dover West (Mango) U FLDN AQ (SWNN) MONITOR	790056	817878	Upper Floridan	6-inch open hole	180	300	112.30	NM	27° 59' 18.99"	82° 17' 54.76"	B-23
Dover West (Mango) SURF AQ MONITOR	790057	818256	Surficial	6-inch screened	2	27	112.68	NM	27° 59' 18.95"	82° 17' 54.45"	B-24
Dover South (Sydney Trails) AVPK PZ MONITOR	793066	818274	Upper Floridan	6-inch open hole	530	843	75.90	NM	27° 56' 17.69"	82° 12' 37.95"	B-25
Dover South (Sydney Trails) SURF AQ MONITOR	793079	819339	Surficial	6-inch screened	7	24	75.90	NM	27° 56' 17.81"	82° 12' 37.94"	B-26

well to accommodate a pump during the APT at the new Dover East monitoring station. This well was plugged and abandoned following the APT in October 2012. Caliper logs were run on all wells to verify construction specifications and the integrity of the well casing. Following well construction and testing, all permanent wells were equipped with water level recorders for long-term groundwater level monitoring by the District's Hydrologic Data Section. A summary of well construction details is presented in table 2 and locations of the monitoring well stations are presented in figure 1. Well construction diagrams are presented in appendix B and geophysical logs run in the wells are presented in appendix C.

Geology

The stratigraphy of the Dover-Plant City area was delineated from previously published reports in the study area and from rotary drill cuttings and geophysical logs collected while drilling the new monitor wells. The geologic units encountered include in ascending order: the Avon Park Formation, Ocala Limestone, Suwannee Limestone, Hawthorn Group, and undifferentiated sand and clays. A diagram of the general stratigraphy and hydrogeology underlying the study area is shown in figure 4 and a cross-section from northwest to southeast across the site is shown in figure 5.

Avon Park Formation

The Middle Eocene age Avon Park Formation was the deepest formation encountered while drilling and constructing the new monitor wells. In the study area the top of the Avon Park Formation ranges from about -300 feet mean sea level (msl) in the North to nearly -600 feet msl in the South (Arthur and others, 2008). The thickness of the Avon Park Formation is greater than 1,000 feet in the study area (Arthur and others, 2008). The Avon Park Formation consists of yellowish gray to very light orange limestone and light brown to olive brown dolostone. An area of highly fractured dolostone was encountered below -300 feet NGVD in the study area. These highly fractured dolostone intervals can be seen as areas of an enlarged borehole on the caliper logs run at the Dover East, Dover North, and Dover West well sites (appendix C., fig. C-11, fig. C-16, and fig. C-18). This interval is referred to as the Avon Park permeable zone.

Ocala Limestone

The Ocala Limestone is Late Eocene in age and overlies the Avon Park Formation. In the study area the top of the Ocala Limestone ranges from about -150 feet msl to -300 feet msl and is approximately 150 feet thick (Arthur and others, 2008). The lithology is packstone or grainstone ranging from white to yellowish gray in color. Numerous fossils are common including miliolids, foraminifera, and echinoids (Southwest Florida Water Management District, 1978).

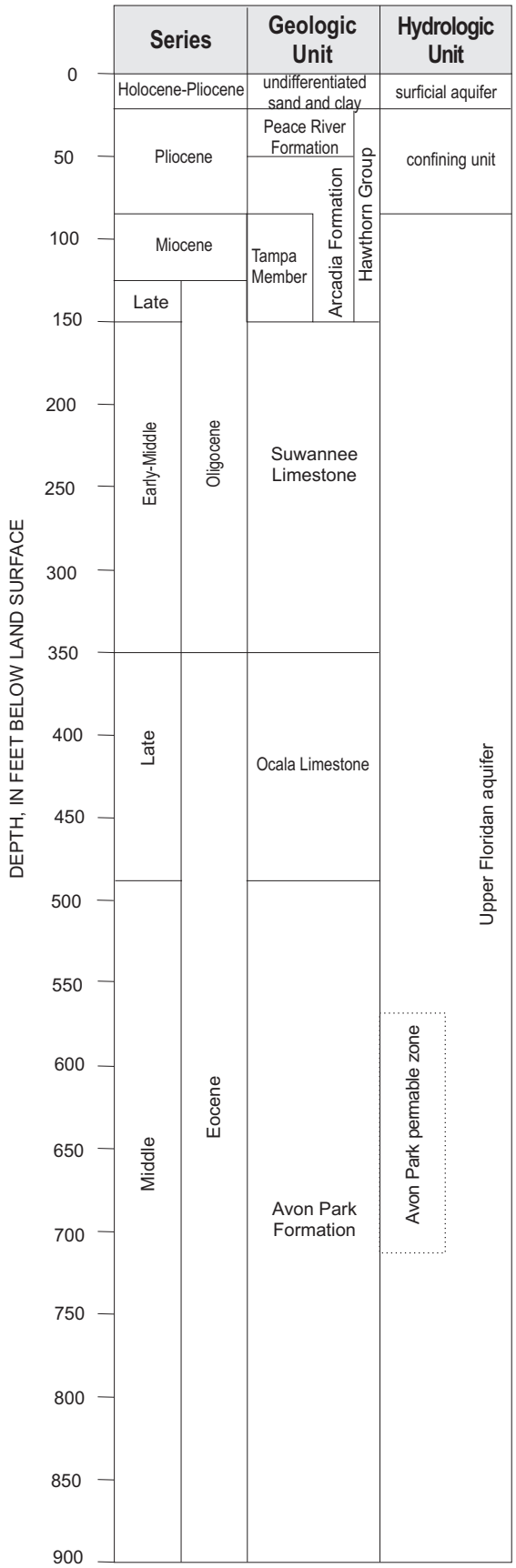


Figure 4. Hydrogeologic setting in the Dover-Plant City study area.

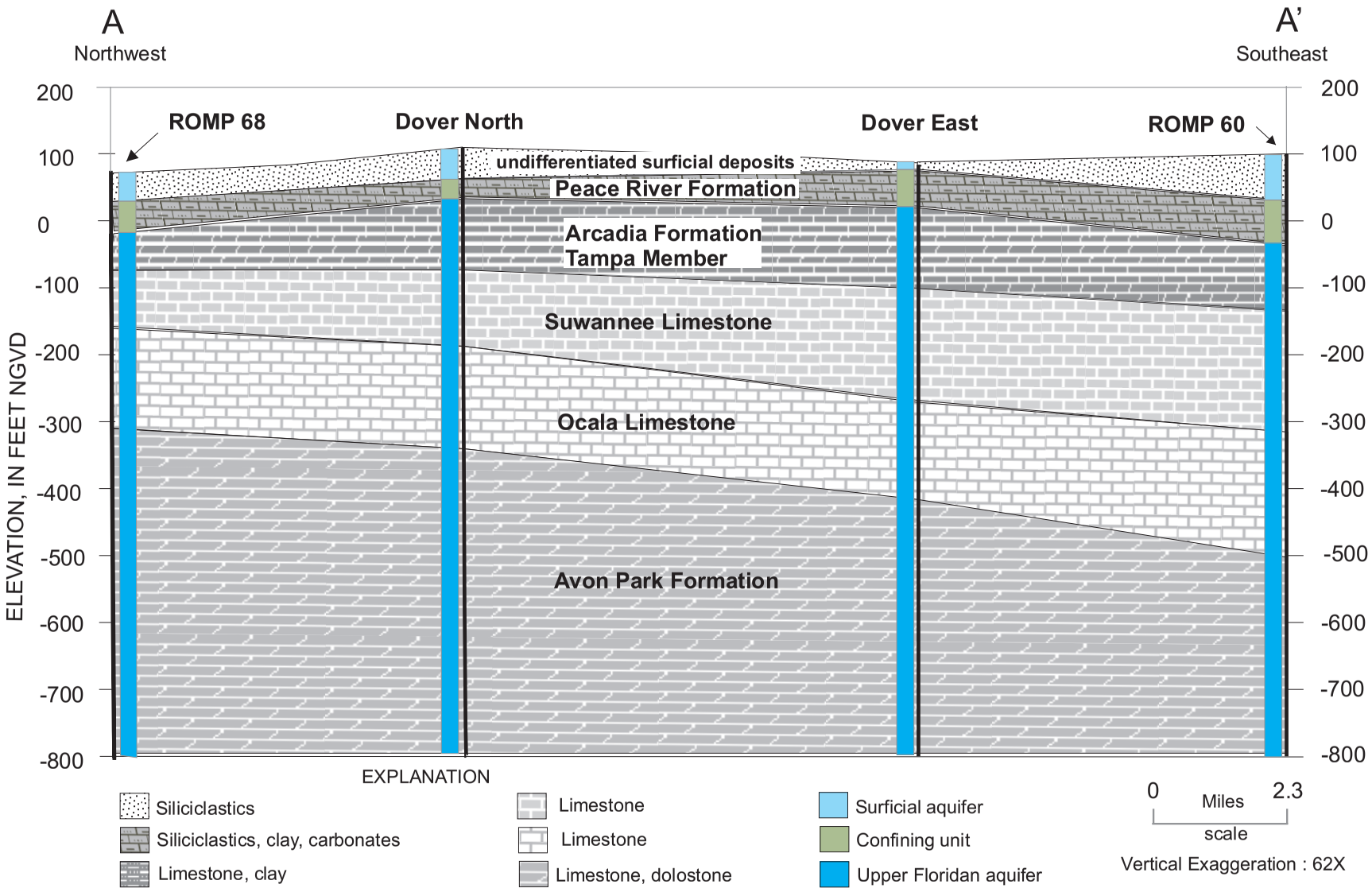


Figure 5. Hydrogeologic cross-section of the Dover-Plant City study area. See figure 1 for A - A' section location.

Suwannee Limestone

The Suwannee Limestone is Oligocene in age and overlies the Ocala Limestone. The top of the Suwannee Limestone ranges from about -70 feet msl to -150 feet msl and is approximately 200 feet thick in the study area (Arthur and others, 2008). The top of the Suwannee Limestone occurs at approximately 200 feet bls at the Dover East well site and is indicated by the decrease in the counts per second (CPS) on the natural gamma (GAMMA(NAT) log (appendix C, fig. C-10). The formation varies in color from very light gray to very light orange and the texture ranges from packstone to grainstone. Common fossils include foraminifera and mollusks (Campbell, 1984).

Hawthorn Group

The Hawthorn Group is mid-Oligocene to Early Pliocene in age and unconformably overlies the Suwannee Limestone. The top of the Hawthorn Group ranges from about 50 feet msl to -100 feet msl and is approximately 150 feet thick in the study area (Arthur and others, 2008). The Hawthorn Group comprises the Peace River Formation and the Arcadia Formation in the Dover-Plant City area. Formational members that have been identified in boreholes from the area include the Bone Valley Member of the Peace River Formation and the Tampa Member of the Arcadia Formation (Clayton, 1991). The Hawthorn Group consists of a complex assemblage of quartz sand, phosphatic sand and gravel, clay and carbonates (Scott, 1988). The top of the Hawthorn Group occurs at approximately 25 feet bls at the Dover North well site and is indicated by the very high CPS counts on the natural gamma log (appendix C, fig. C-14).

Undifferentiated Sand and Clay Deposits

The undifferentiated sand and clay deposits are Pliocene to Holocene in age and extend from land surface to 25 feet bls in the study area (Arthur and others, 2008). The unit consists of very pale orange to pale yellowish brown, fine to coarse grained, quartz sand and sandy clay.

Hydrogeology

The hydrogeology of the study area was delineated from previously published reports, well completion reports of wells in the study area, geophysical logs, and water level data collected while drilling. Hydrogeologic units in the area include in descending order: the surficial aquifer, a confining unit, and the Upper Floridan aquifer.

Surficial Aquifer

The surficial aquifer is the uppermost hydrologic unit in the study area and ranges from 0 to about 40 feet in thickness. Where present, the aquifer is comprised of unconsolidated quartz sand, and sandy clay. The base of the aquifer is formed by low permeability clays of the Hawthorn Group. The water level in the surficial aquifer generally conforms to the surface topography (Arthur and others, 2008).

Confining Unit

The Hawthorn Group sediments lie predominantly between the surficial aquifer and the Upper Floridan aquifer. In Southern West-Central Florida, the Hawthorn Group may contain one or more aquifers of varying lateral continuity separated by low permeability confining beds (Basso and Hood, 2005). This hydrologic unit has been widely referred to as the intermediate aquifer system/confining unit (Southeastern Geological Society, 1986). DeWitt and Mallams (2007) proposed the name Hawthorn aquifer system to describe the unit when aquifers are present. This naming convention is consistent with the North American Stratigraphic Code (2005). The hydrologic unit is simply referred to as a confining unit if no aquifers are present (D. DeWitt, personal communication). Southern Hillsborough County and Central Polk County mark the northern extent of the aquifers present in the Hawthorn Group sediments (Peterson and Rumbaugh, 2012). In the Dover-Plant City study area most of the Hawthorn Group forms a confining unit separating the overlying surficial aquifer from the underlying Upper Floridan aquifer. The Tampa Member of the Arcadia Formation is the exception. The sandy carbonates of the Tampa Member are moderately productive and are hydraulically connected to the Upper Floridan aquifer in most of the study area (Arthur and others, 2008, Clayton, 1991 and Tihansky, 2005).

Upper Floridan Aquifer

Within the study area, the Upper Floridan aquifer is composed of Middle Eocene to Early Miocene age carbonates. The top of the Upper Floridan aquifer is generally coincident with the Tampa Member of the Arcadia Formation and ranges from -30 feet to 50 feet msl in the study area (fig. 5). The Upper Floridan aquifer in the Dover area comprises the Tampa Member of the Arcadia Formation, the Suwannee Limestone, the Ocala Limestone, and the Avon Park Formation. The thickness of the Upper Floridan aquifer is around 1,100 feet in the Dover area (Miller, 1986). The most productive units within Upper Floridan aquifer occur within the Avon Park Formation (Arthur and others, 2008). The moderately productive Tampa member and Suwannee Limestone units overlay the lower permeability granular carbonates of the Ocala Formation. The Avon Park permeable formation is found within the Avon Park Formation and is usually located in the part of the formation characterized by fractured dolostone (figure 4).

An APT was conducted on the Tampa /Suwannee portion of the Upper Floridan aquifer at the Dover Bealsville well site in May 2012. The static water level in the in the 6-inch Upper Floridan aquifer/Suwannee monitor well [U FLDN

(SWNN) MONITOR] was 51.50 feet above the North American Vertical Datum of 1988 (NAVD) prior to starting the drawdown phase of the APT on May 14, 2012. This well was pumped at a discharge rate of 106 gallons per minute (gpm) for 74 hours starting at 12:07 p.m. on May 14, 2012. The maximum drawdown in the 6-inch Upper Floridan aquifer/Suwannee monitor well was 10.16 feet. The 4-inch temporary drilling water supply well (DRILLING WATER SUPPLY TEMP) was used as the observation well for the Tampa/Suwannee APT. Maximum drawdown in the 4-inch temporary observation well located 80 feet from the pumped well was 3.2 feet. Both of these wells are open to only to the Suwannee Limestone portion of the Upper Floridan aquifer. The water level in the surficial aquifer well (SURF AQ MONITOR) and Avon Park permeable zone well (AV PK PZ MONITOR) showed little response to pumping the Tampa/Suwannee portion of the Upper Floridan aquifer (fig. 6). The oscillations in the Upper Floridan aquifer level shown in figure 6 are caused by regional pumping from wells in the surrounding area.

Drawdown and recovery water levels from the 4-inch Suwannee observation well were analyzed using the Hantush-Jacob (1955) and Theis (1935) methods, respectively (appendix D, figure D-1 and D-2). The calculated transmissivity values for the drawdown and recovery phases were 3.7×10^{3} feet^2/day and 3.2×10^{3} feet^2/day, respectively. The geometric mean value for transmissivity is 3.4×10^{3} feet^2/day, the storativity is 9.1×10^{-4}; and the value for leakance is 3.6×10^{-2} foot/day/foot (days-1). The results of the aquifer performance tests are presented in table 3.

An APT was conducted on the Avon Park Formation portion of the Upper Floridan aquifer at the Dover Bealsville well site from May to June 2012. The open hole intervals of both the Avon Park permeable zone pumped well (AVPK PZ TEMP PRODUCTION) and the Avon Park permeable zone observation well extend from 530 feet bls to 850 feet bls. The water level in the 14-inch Avon Park permeable zone monitor well was 53.82 feet NAVD prior to the drawdown phase of the aquifer test on May 29, 2012. The well was pumped at a discharge rate of 2,405 gpm for 68 hours starting at 1:52 p.m. on May 29, 2012. The maximum drawdown in the 14-inch pumped well (not including a downward surge in water level immediately following the start of the pump) was 13.69 feet (fig. 7). The maximum drawdown in the 6-inch Avon Park permeable zone observation well located 140 feet from the pumped well was 4.4 feet. The maximum drawdown in the 6-inch Upper Floridan aquifer/Suwannee monitor well, located 150 feet from the Avon Park temporary production well was 3.8 feet. The drawdown in the Tampa/Suwannee portion of the Upper Floridan aquifer during the test is indicative of leakage across lower permeability Ocala Limestone unit. No appreciable drawdown was observed in the 6-inch surficial aquifer monitor well, located approximately 140 feet from the Avon Park temporary production well (fig. 7). The affect of numerous agricultural and residential wells pumping from the Upper Floridan aquifer in the region can be seen in the hydrograph in figure 7.

Table 3. Results of the aquifer performance tests conducted at the Dover East (Bealsville) well site in Hillsborough County, Florida.

[AVPK PZ, Avon Park permeable zone; days^{-1} inverse days; OB, observation well; feet^2/day, feet squared per day; r/B, leakage parameter of the confining unit; SWNN, Suwannee; NA, not applicable; U FLDN AQ, Upper Floridan aquifer]

Aquifer tested	Aquifer thickness	Overlying confining unit thickness	Well analyzed	OB well distance from pumped well	Test phase	Analytical method	Horizontal hydraulic conductivity	Storativity	r/B	Vertical hydraulic conductivity of overlying confining unit	Leakance	Transmissivity
	(feet)	(feet)		(feet)			(feet/day)	dimensionless		(feet/day)	(days-1)	(feet^2/day)
Upper Floridan aquifer/Tampa-Suwannee	290	58	SWNN MONITOR	80	Drawdown	Hantush-Jacob (1955)	13	9.1E-04	2.5E-01	2.1E+00	3.6E-02	3.7E+03
					Recovery	Theis (1935)	11	NA	NA	NA	NA	3.2E+03
						geometric mean	**12**				**geometric mean**	**3.4E+03**
Upper Floridan aquifer/Avon Park Permeable Zone	490	150	AVPK PZ MONITOR	140	Drawdown	Hantush (1960)	75	8.2E-04	1.E-02	2.8E-02	1.9E-04	3.7E+04
					Recovery	Theis (1935)	137	NA	NA	NA	NA	6.7E+04
						geometric mean	**101**				**geometric mean**	**5.0E+04**

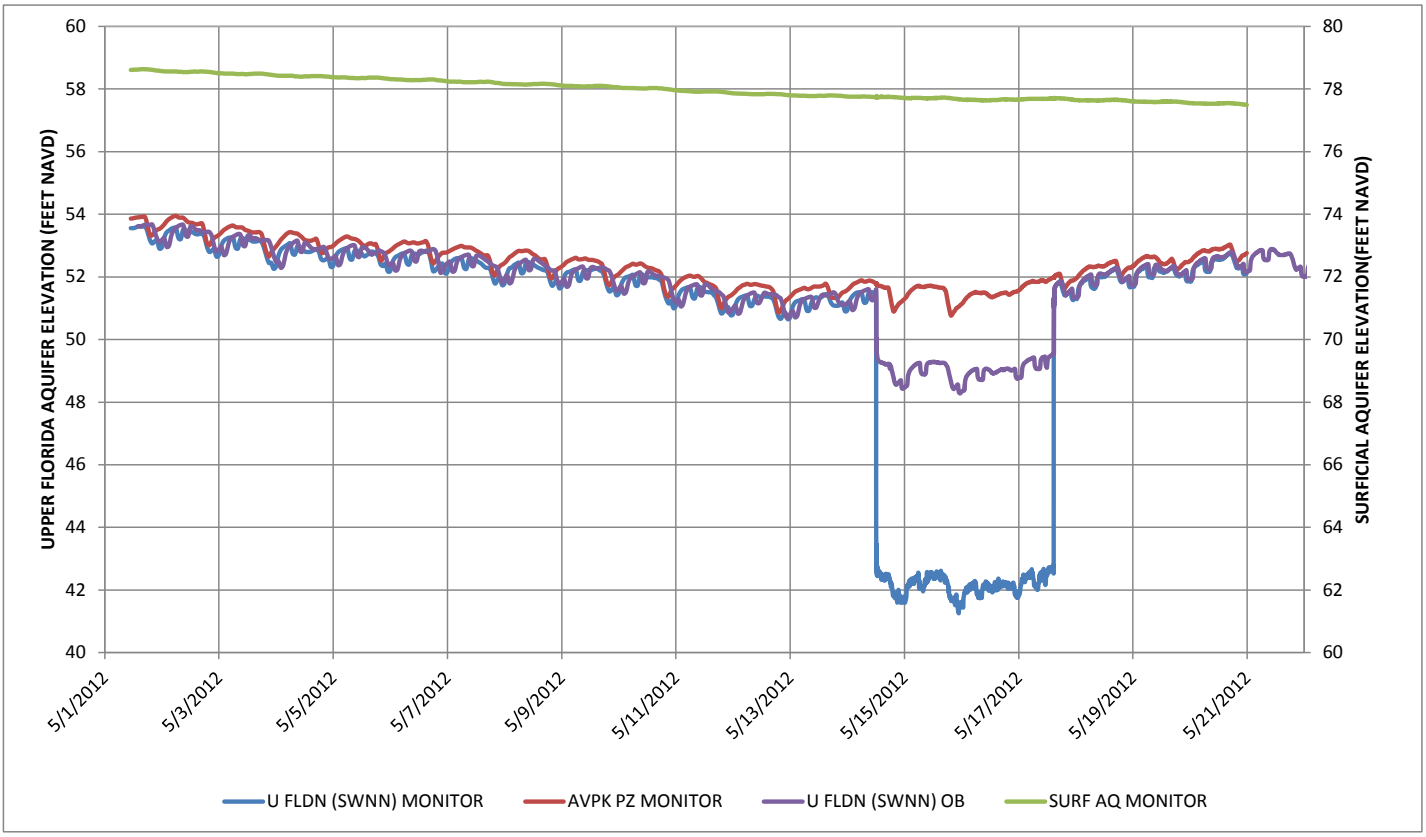


Figure 6. Hydrograph showing the aquifer performance test conducted on the Tampa/Suwannee part of the Upper Floridan aquifer in the Dover-Plant City study area, Hillsborough County, Florida.

Drawdown and recovery water levels from the 6-inch Avon Park permeable zone observation well were analyzed using the Hantush (1960) and Theis (1935) methods, respectively (appendix D, fig. D-3 and D-4). The calculated transmissivity for the drawdown and recovery phases were 3.7×10^4 feet^2/day and 6.7×10^4 feet^2/day, respectively. The geometric mean for transmissivity is 5.0×10^4 feet^2/day, the value for storativity is 8.2×10^{-4} and the value for leakance is 1.9×10^{-4} foot/day/foot (days-1). The APT results are presented in table 3.

Four groundwater samples were collected from the Upper Floridan aquifer while conducting APTs at the Dover Bealsville well station. Two groundwater samples were collected during the drawdown phase of the Tampa/Suwannee APT. The first sample was collected at the beginning of the drawdown phase (May 14, 2012). The second sample was collected near the end of the drawdown phase (May 14, 2012). These samples were collected to note any changes in water quality during pumping. Results of the sample analyses show little change in water quality constituent levels between the two sampling events. The chloride, sulfate, total dissolved solids (TDS), and iron concentrations for the groundwater samples collected on May 14, 2012 were 8.9 milligrams per liter (mg/L), 5.8 mg/L, 209 mg/L, and 0.007 mg/L, respectively. The chloride, sulfate, TDS, and iron concentrations for the groundwater sample collected on May 17, 2012 were 8.9 mg/L, 9.6 mg/L, 200 mg/L, and 0.004 mg/L, respectively. All water quality constituents were within secondary drinking water standards. The secondary drinking water standards for TDS, sulfate, chloride, and iron are 500 mg/L, 250 mg/L, 250 mg/L, and 0.3 mg/L, respectively (United States Environmental Protection Agency, 2013).

Two groundwater samples were also collected from the Avon Park production well during the Avon Park APT. The first sample was collected near the beginning of the drawdown phase on May 29, 2012 and the second sample was collected about 48 hours after the start of pumping on May 31, 2012. Results of the sample analyses show all water quality constituent levels were within secondary drinking water standards. The chloride, sulfate, TDS, and iron concentrations for the groundwater sample collected on May 29, 2012 were 9.7 mg/L, 8.5 mg/L, 210 mg/L, and 0.012 mg/L, respectively. The chloride, sulfate, TDS, and iron concentrations for the groundwater sample collected on May 31, 2012 were 9.7 mg/L, 7.5 mg/L, 208 mg/L, and 0.012 mg/L, respectively. Table 4 presents the laboratory results of the groundwater samples.

Summary

The District constructed 23 new permanent monitor wells in the newly designated 256-square-mile Dover-Plant City Water Use Caution Area in response to the January 2010 freeze

Figure 7. Hydrograph showing the aquifer performance test conducted on the Avon Park permeable zone of the Upper Floridan aquifer in the Dover-Plant City study area, Hillsborough County, Florida.

event in the Dover-Plant City area. From August 2010 to March 2012, 10 new permanent surficial aquifer monitor wells and 13 new permanent Upper Floridan aquifer wells were constructed to augment the existing Dover-Plant City monitor well network. The Dover-Plant City monitor well network now includes 12 groundwater monitoring stations and a total of 37 monitor wells.

Borehole geophysical logs were collected at various stages during construction of the Upper Floridan aquifer wells. Two APTs were conducted to determine the hydraulic parameters of the permeable zones and confining units of the Upper Floridan aquifer. The addition of new monitor wells to the network and the data provided from the APTs will allow faster reporting of changes in aquifer levels during freeze events, better define areas impacted by drawdown in the area, and provide hydraulic data that can be used to update groundwater models.

The geologic and hydrologic units of the Dover area were described based on review of previous studies of the area and new data collected during construction and testing of the new monitor wells. The geologic units present in the Dover area include in ascending order: the Avon Park Formation, Ocala Limestone, Suwannee Limestone, Hawthorn Group, and undifferentiated sand and clay deposits. The hydrologic units present in descending order include: the surficial aquifer, a confining unit, and the Upper Florida aquifer. The surficial aquifer consists of quartz sands of the undifferentiated sand and clay deposits. The confining unit consists of clay and low permeability carbonates of the Hawthorn Group. The Upper Floridan aquifer is composed of carbonates within the Tampa Member of the Arcadia Formation, the Suwannee and Ocala Limestones and the Avon Park Formation.

APTs were conducted on the Tampa/Suwannee and Avon Park permeable intervals of the Upper Floridan aquifer. A geometric mean for transmissivity of 3.4×10^3 feet^2/day was calculated for the drawdown and recovery phases of the Tampa/Suwannee APT. The geometric mean for transmissivity calculated for the drawdown and recovery phase of the Avon Park APT was 5.0×10^4 feet^2/day. Groundwater samples collected during the APTs indicate that water quality constituents are within secondary drinking standards for both the Tampa/Suwannee and the Avon Park permeable sections of the Upper Floridan aquifer. The water samples showed no appreciable change in quality during pumping.

Table 4. Results of the laboratory analyzed groundwater samples collected during the aquifer performance tests at the Dover East (Bealsville) well site in Hillsborough C

[AVPK PZ, Avon Park Permable Zone; bls, below land surface; Ca^{2+}, calcium ion; Cl^{1-}, chloride ion; Fe^{2+}, iron ion; K^{1+}, potassium ion; Mg^{2+}, magnesium ion; mg/L, milligrams per liter; Na^{1+}, No., number; pH, hydrogen ion; sodium ion; Si, silica ion; SO_4^{2-}, sulfate ion; Sr^{2+}, strontium ion; SWNN, Suwannee; TDS, total dissolved solids; ! mhos/cm, micromhos per centimeter; U FLDN, Upper Floridan; %, 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 insignificant in groundwater and carbonate ions are typically not present if pH is leass than 8.3 standard units (SU)]

Water Quality Sample No.	Date	Time	Sampe Interval (feet bls)	Hydrogeologic Unit	pH	Specific Conductance	CATIONS						ANIONS		Si	TDS	Alkalinity
							Ca^{2+}	Mg^{2+}	Na^{1+}	K^{1+}	Fe^{2+}	Sr^{2+}	Cl^{1-}	SO_4^{2-}			
						(! mhos/cm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
1	5/14/12	15:12	195-300	UFLDN (SWNN)	8.2	325	41.0	10.6	9.4	1.7	0.007	0.5	8.9	5.8	22.5	209.0	147.8
2	5/17/12	14:00	195-300	U FLDN (SWNN)	8.21	331	41.4	10.7	9.0	1.1	0.004	0.5	8.9	9.6	22.5	200.0	151.9
3	5/29/12	15:05	530-850	AVPK PZ	8.13	341	43.9	11.1	9.4	0.9	0.012	0.5	9.7	8.5	23.1	210.0	156.3
4	5/31/12	13:50	530-850	AVPK PZ	8.11	338	42.5	10.8	9.1	0.9	0.012	0.5	9.7	7.5	22.7	208.0	156.4

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Appendix A: Data Collection Methods for the Dover-Plant City Freeze Management Plan

Collection of Lithologic Samples

Mud-rotary and reverse-air drilling methods were used to drill and construct the monitor wells. Lithologic samples (drill cuttings) are collected periodically while drilling for lithologic description. Lithologic 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 (Goddard and others, 1948). The textural terms used to characterize carbonate rocks are based on the classification system of Dunham (1962).

Details on the drilling activities are recorded on daily drilling logs completed by the District's drilling crew and hydrologists.

Samples from the unconsolidated sand and clay deposits were collected using a hollow-stem auger and split-barrel (split-spoon) sampler. The hollow-stem augers are rotated into the ground in 5-feet lengths and a split-spoon sampler is driven inside the auger at 2-feet intervals. The undisturbed samples are then retrieved from the split-spoon sampler for description.

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, although they are normally collected over several months and will include temporal variation.

Collection of Water Quality Data

Water quality samples were collected during aquifer performance tests (APT)s. Sampling methods are consistent with the "Standard Operating Procedures for the Collection of Water Quality Samples" (Water Quality Monitoring Program, 2009). To ensure a representative sample is collected, a minimum of three well volumes of water are removed and temperature, pH, and specific conductance are monitored for stabilization using a YSI® multi-parameter meter.

The water quality sample is collected using 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 milliliter and one 500 milliliter, are filled with water filtered through a 0.45-micron filter. Another 500 milliliter bottle is filled with unfiltered water. A Masterflex® console pump is used to dispense the water into the bottles. The sample in the 250 milliliter bottle is acidified with nitric acid to a pH of 2 in order to preserve metals for analysis. The remainder of the sample is used to measure 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.

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, porosity, and flow zone detection), geologic (lithology, formation delineation), and physical characteristics (depth, diameter, casing depth, texture of well bore, and integrity of well construction).

Geophysical logging entails lowering the geophysical tool into the borehole or monitor well on a wireline, and measuring the tool's response to the formation and water quality as the tool is moved up the hole. Borehole geophysical logs are run during various stages of drilling. When feasible, geophysical logs are run prior to casing advancements, while the borehole 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 tool is 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 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. Natural gamma 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 of 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 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 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 farther 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 Performance Tests

An APT is a controlled field experiment conducted to determine the hydraulic properties of water-bearing 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 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. 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.

Single-Well Aquifer Performance Test

Single-well APTs are conducted on one well within the production zone which is used for both pumping and monitoring the water level response. Background water level in the test well is collected for a time period twice as long as the pumping period (Stallman, 1976). Background water level 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. During pumping, 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 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 Performance Test

Multi-well APTs are conducted with a 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 time period at least twice the pumping period (Stallman, 1976). During pumping, 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 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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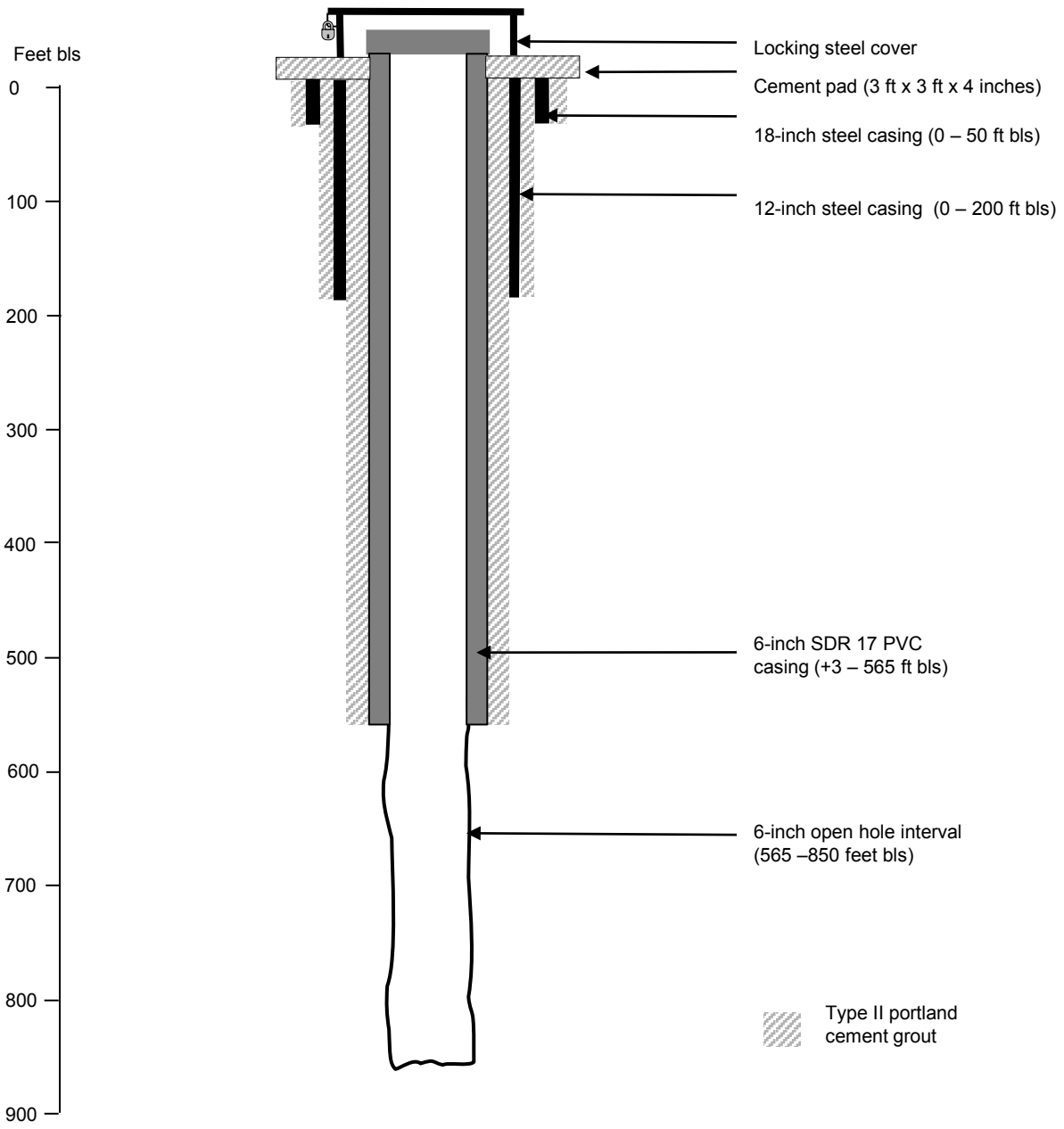
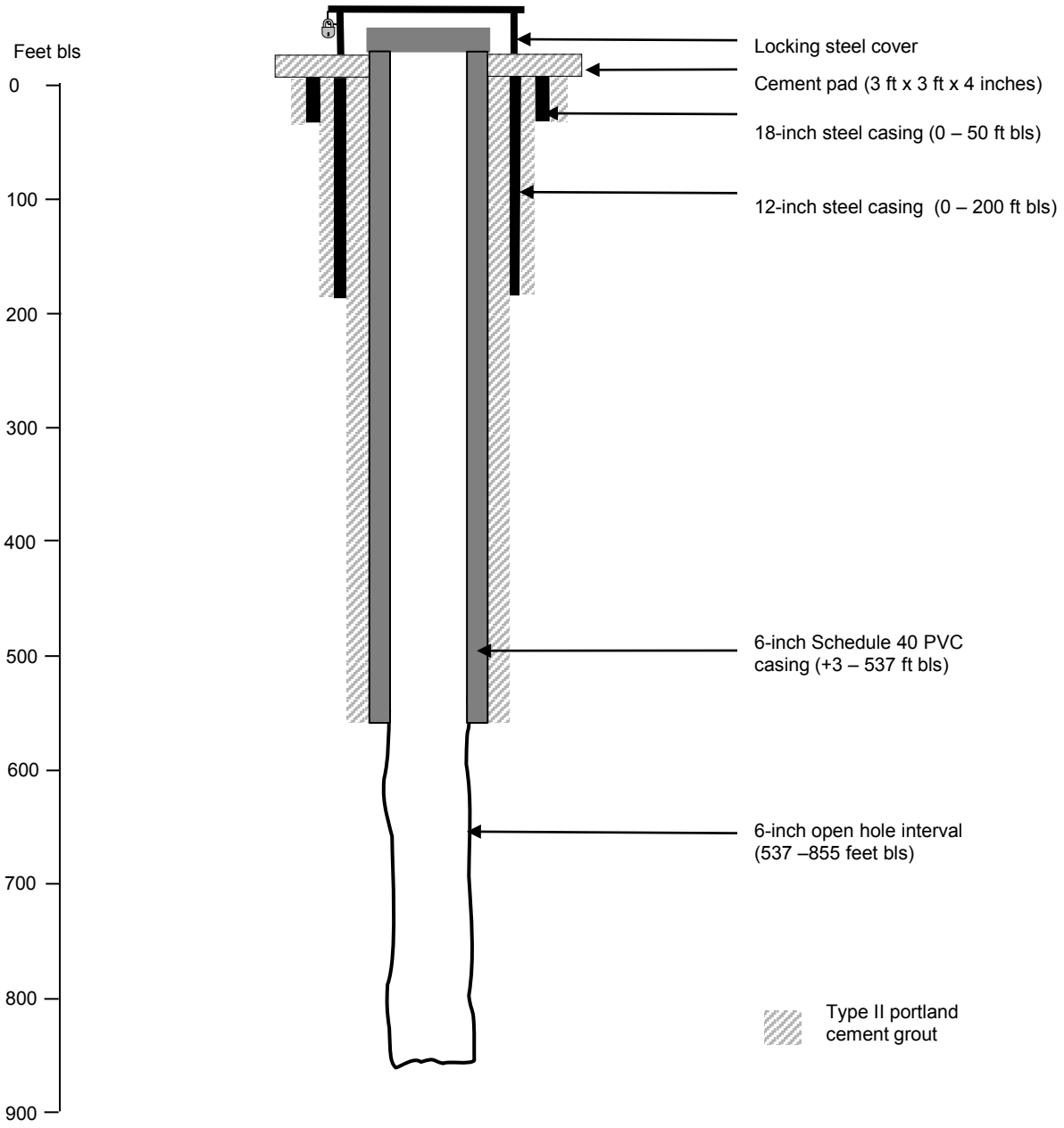
Appendix B: Well Construction Diagrams



Well Name	U FLDN AQ (AVPK) MONITOR
WCP #	809065
SID #	770770
S/T/R	S18 T29 R22
Latitude	27 58 00.21
Longitude	82 08 53.49
Specific capacity (gpm/ft)	ND

[AVPK, Avon Park; bls, below land surface; ; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit; U FLDN, Upper Floridan]

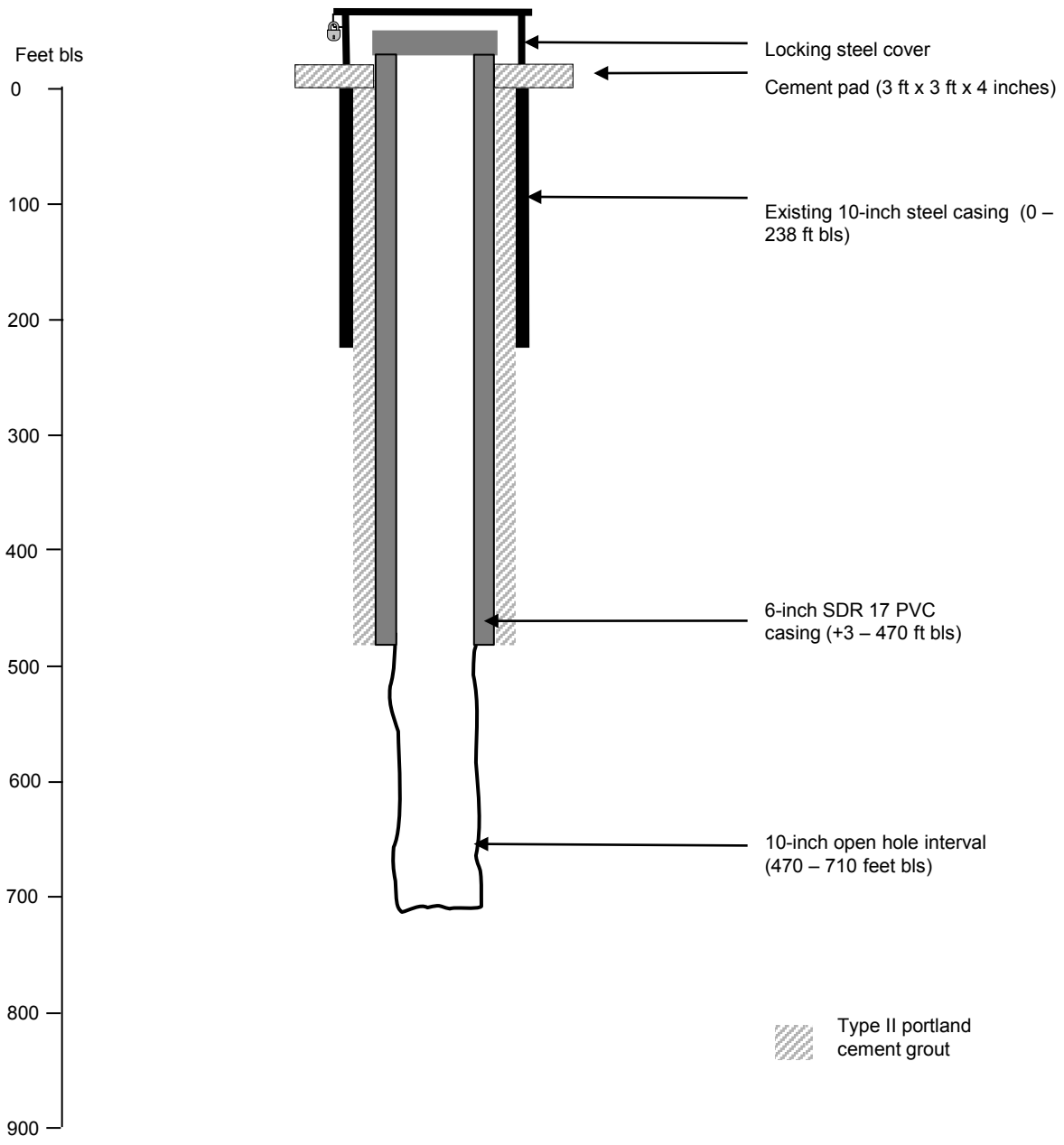
Appendix B, Figure B-1. As-built diagram for permanent Upper Floridan aquifer (Avon Park) monitor well constructed at the Dover 2 well site in Hillsborough County, Florida.



Well Name	AVPK MONITOR
WCP #	807839
SID #	768554
S/T/R	S8 T28 R22
Latitude	28 04 07.65
Longitude	82 08 07.98
Specific capacity (gpm/ft)	ND

[AVPK, Avon Park; bls, below land surface; ; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit; U FLDN, Upper Floridan]

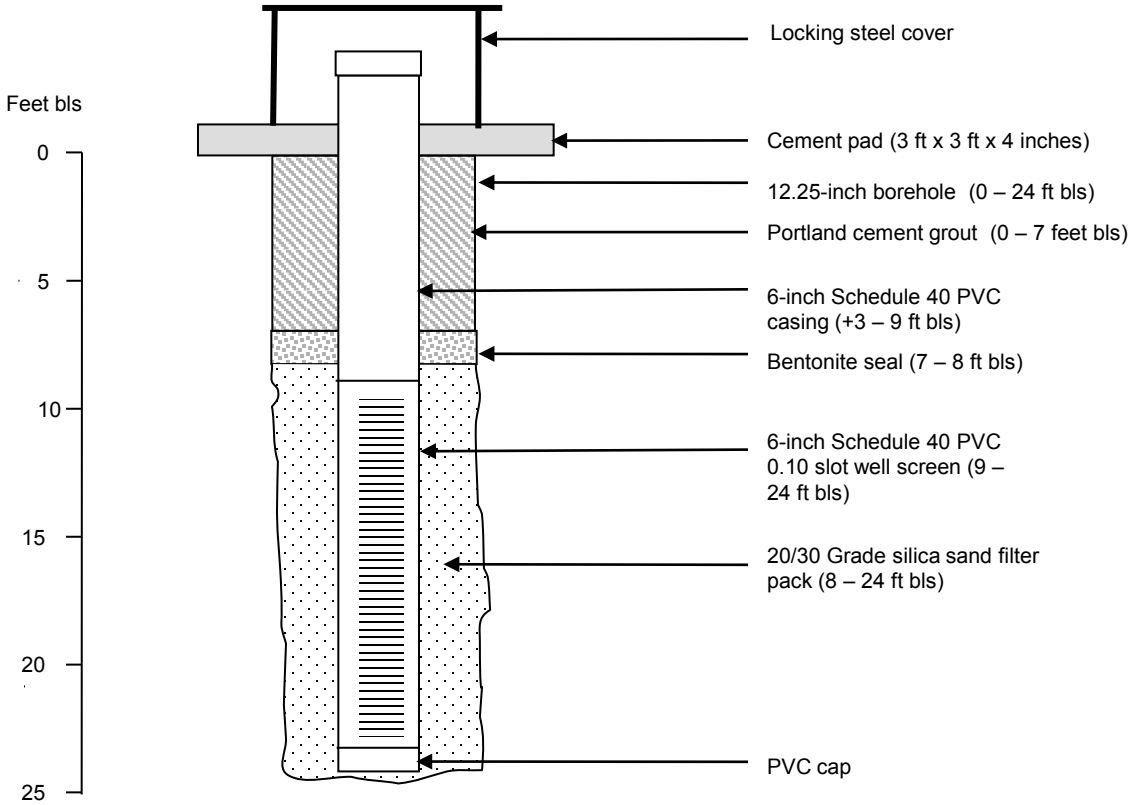
Appendix B, Figure B-2. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the McIntosh well site in Hillsborough County, Florida.



Well Name	AVPK MONITOR
WCP #	811817
SID #	777757
S/T/R	S11 T30 R23
Latitude	27 53 27.27
Longitude	81 58 56.71
Specific capacity (gpm/ft)	ND

[AVPK, Avon Park; bls, below land surface; ; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit; U FLDN, Upper Floridan]

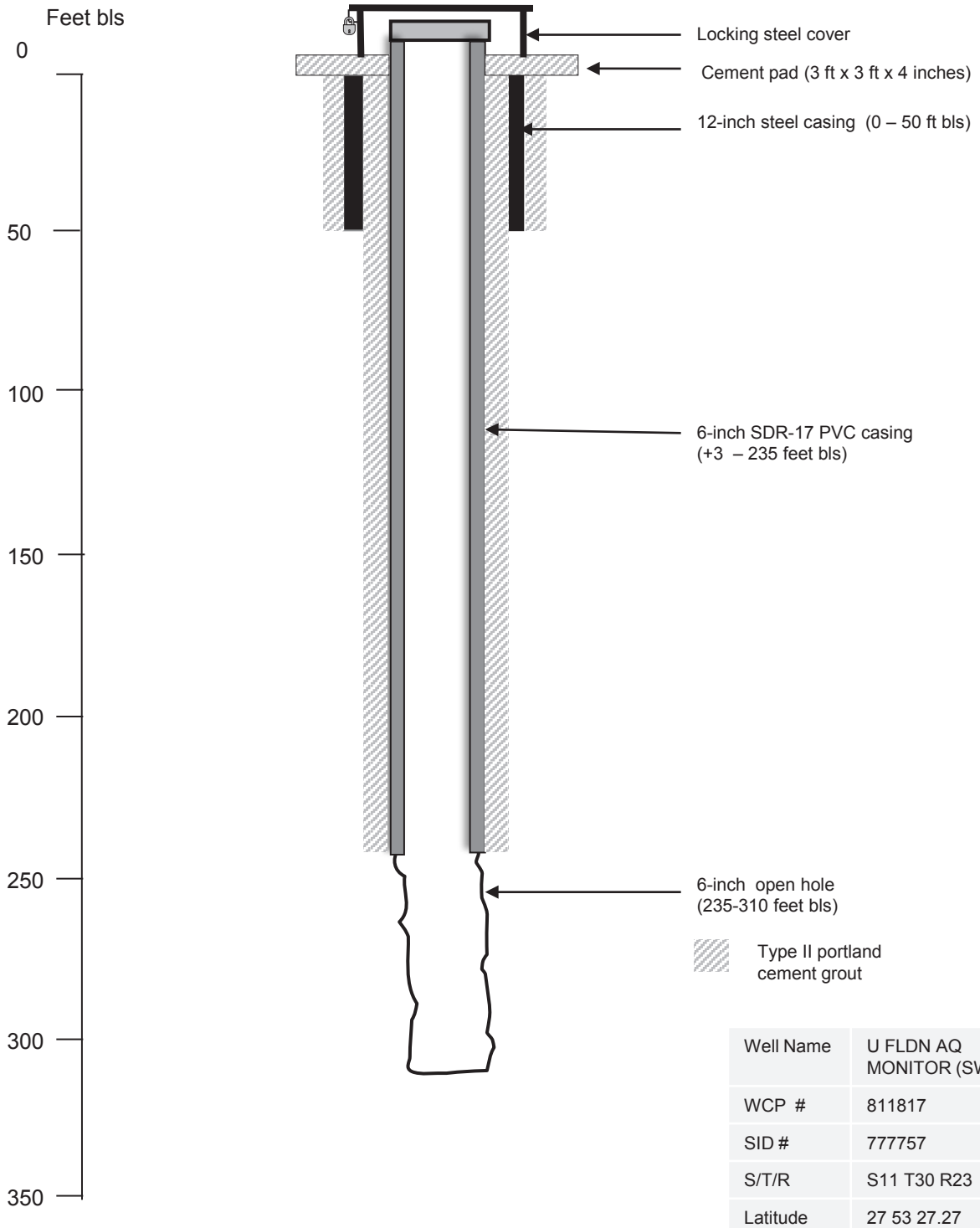
Appendix B, Figure B-3. As-built diagram for the permanent Upper Floridan aquifer (Avon Park) monitor well constructed at the ROMP 60 well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	807699
SID #	768709
S/T/R	S11 T30 R23
Latitude	27 53 27.20
Longitude	81 58 56.60
Specific capacity (gpm/ft)	ND

[bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; S/T/R, section/township/rage; WCP, well construction permit]

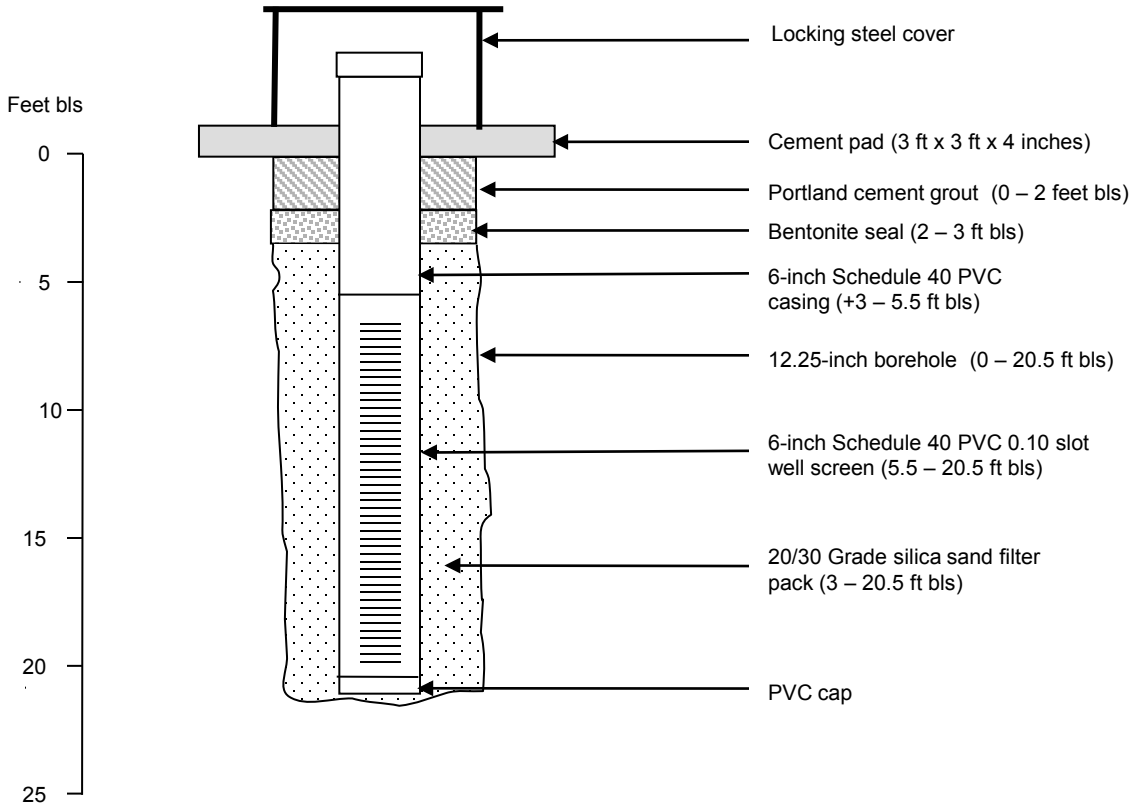
Appendix B, Figure B-4. As-built diagram for the permanent surficial aquifer monitor well constructed at the ROMP 60 - Mulberry well site in Hillsborough County, Florida.



Well Name	U FLDN AQ MONITOR (SWNN)
WCP #	811817
SID #	777757
S/T/R	S11 T30 R23
Latitude	27 53 27.27
Longitude	81 58 56.71
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit; U FLDN, Upper Floridan]

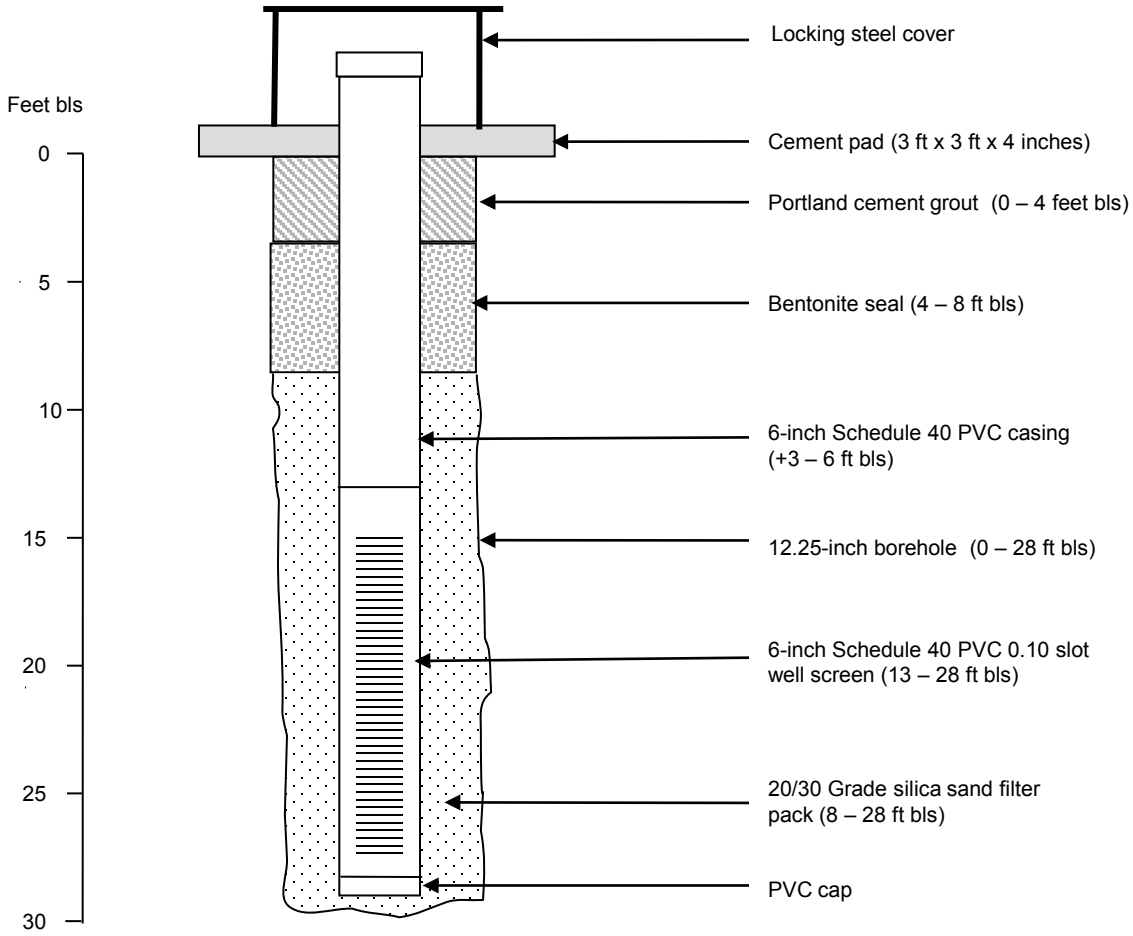
Appendix B, Figure B-5. As-built diagram for the permanent Upper Floridan aquifer (Suwannee), monitor well at the ROMP 60 – Mulberry well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	806746
SID #	763305
S/T/R	S36 T29 R21
Latitude	27 54 30.80
Longitude	82 09 40.68
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

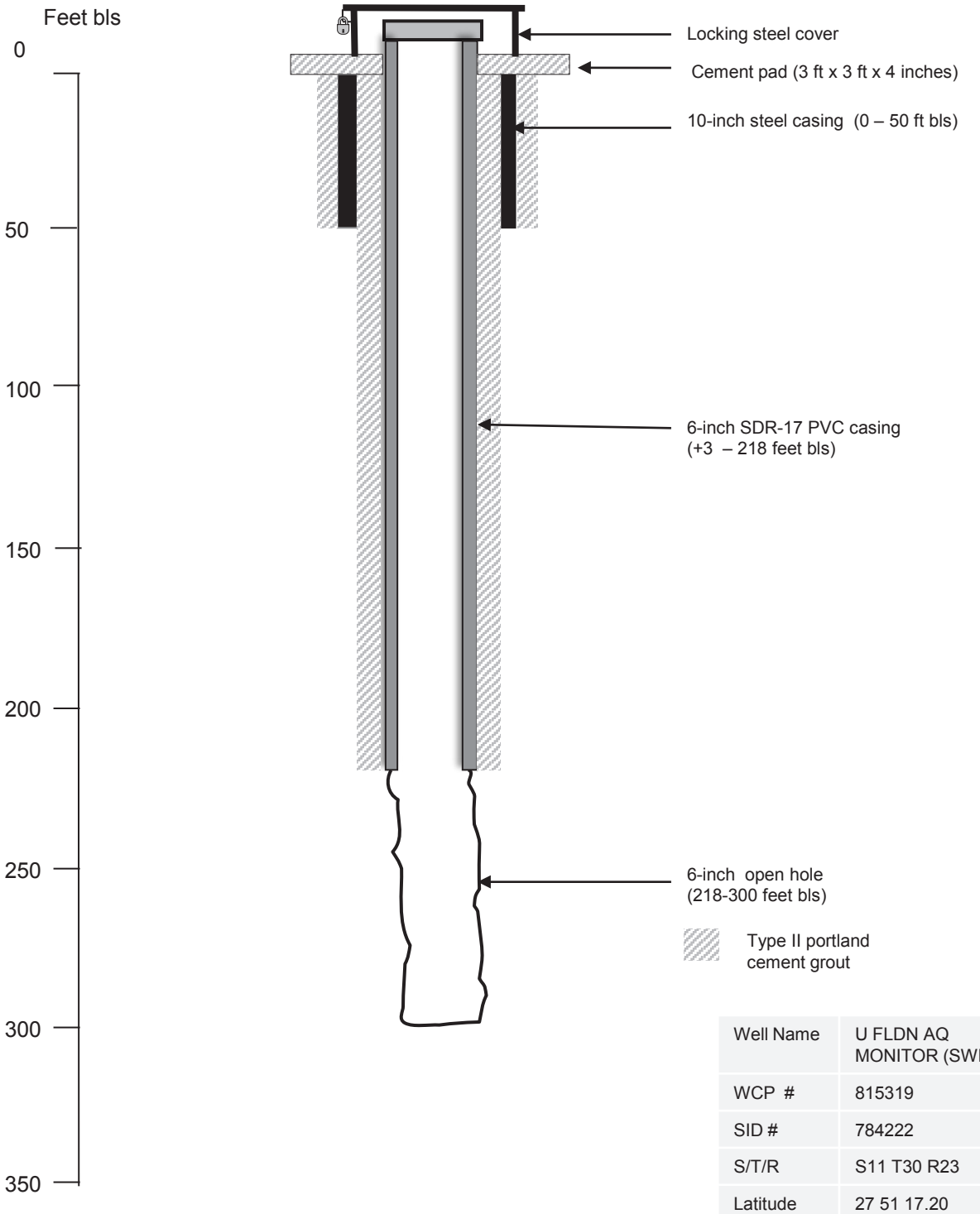
Appendix B, Figure B-6. As-built diagram for the permanent surficial aquifer monitor well constructed at the Medard Reservoir well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	815630
SID #	784219
S/T/R	S36 T29 R21
Latitude	28 05 01.26
Longitude	82 14 34.45
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

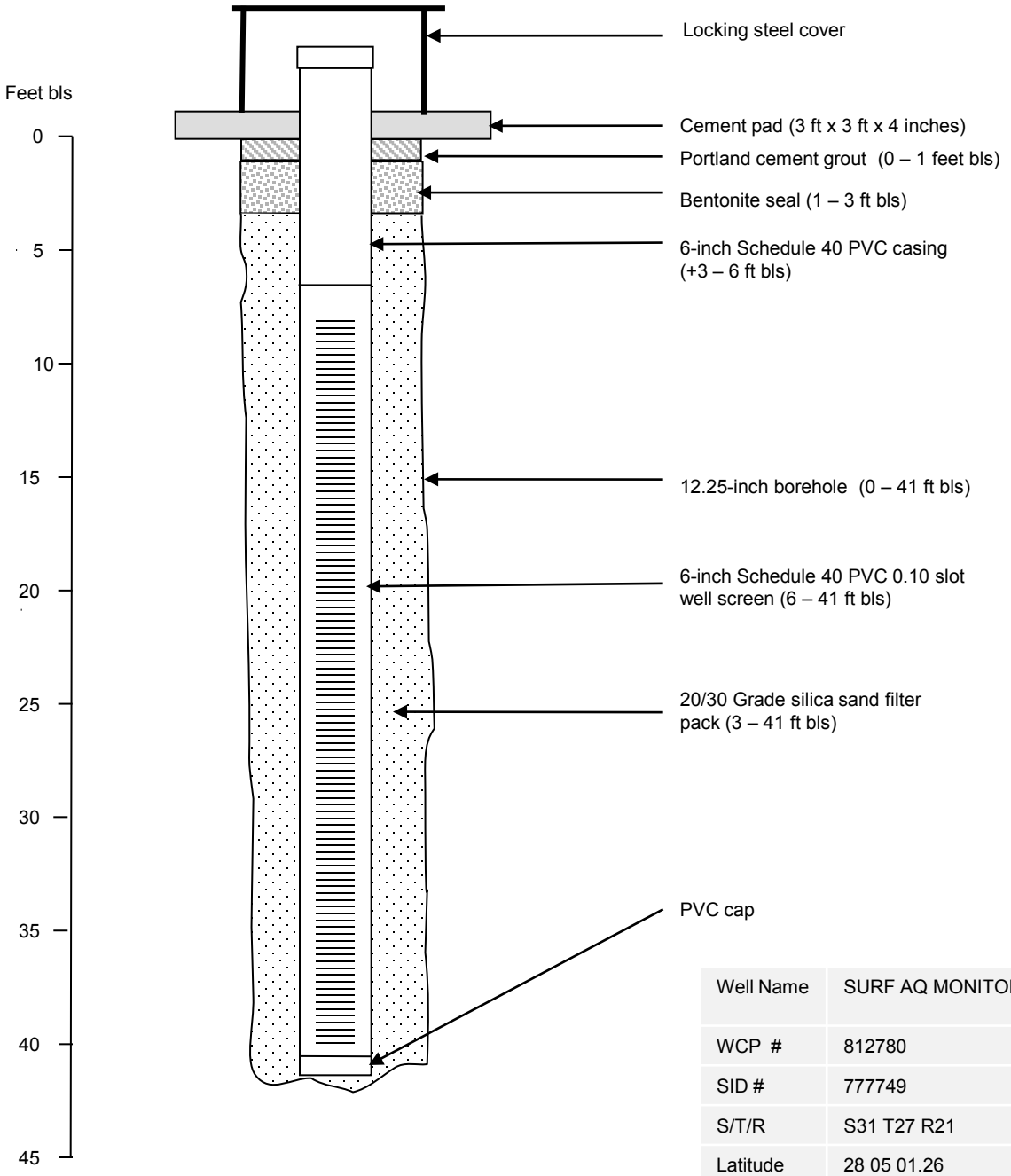
Appendix B, Figure B-7. As-built diagram for the permanent surficial aquifer monitor well constructed at the ROMP 62 – Christina well site in Hillsborough County, Florida.



Well Name	U FLDN AQ MONITOR (SWNN)
WCP #	815319
SID #	784222
S/T/R	S11 T30 R23
Latitude	27 51 17.20
Longitude	82 18 39.30
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit; U FLDN, Upper Floridan]

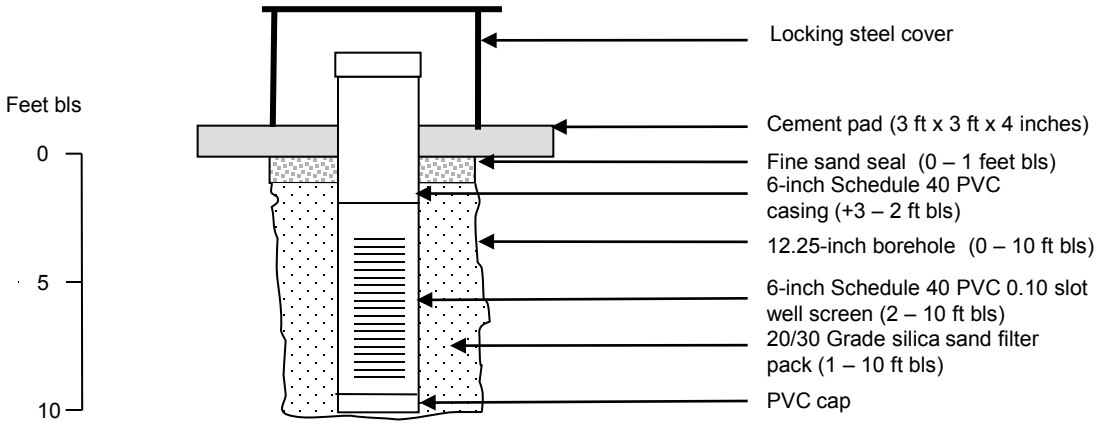
Appendix B, Figure B-8. As-built diagram for the permanent Upper Floridan aquifer (Suwannee) monitor well at the ROMP 62 – Christina well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	812780
SID #	777749
S/T/R	S31 T27 R21
Latitude	28 05 01.26
Longitude	82 14 34.45
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

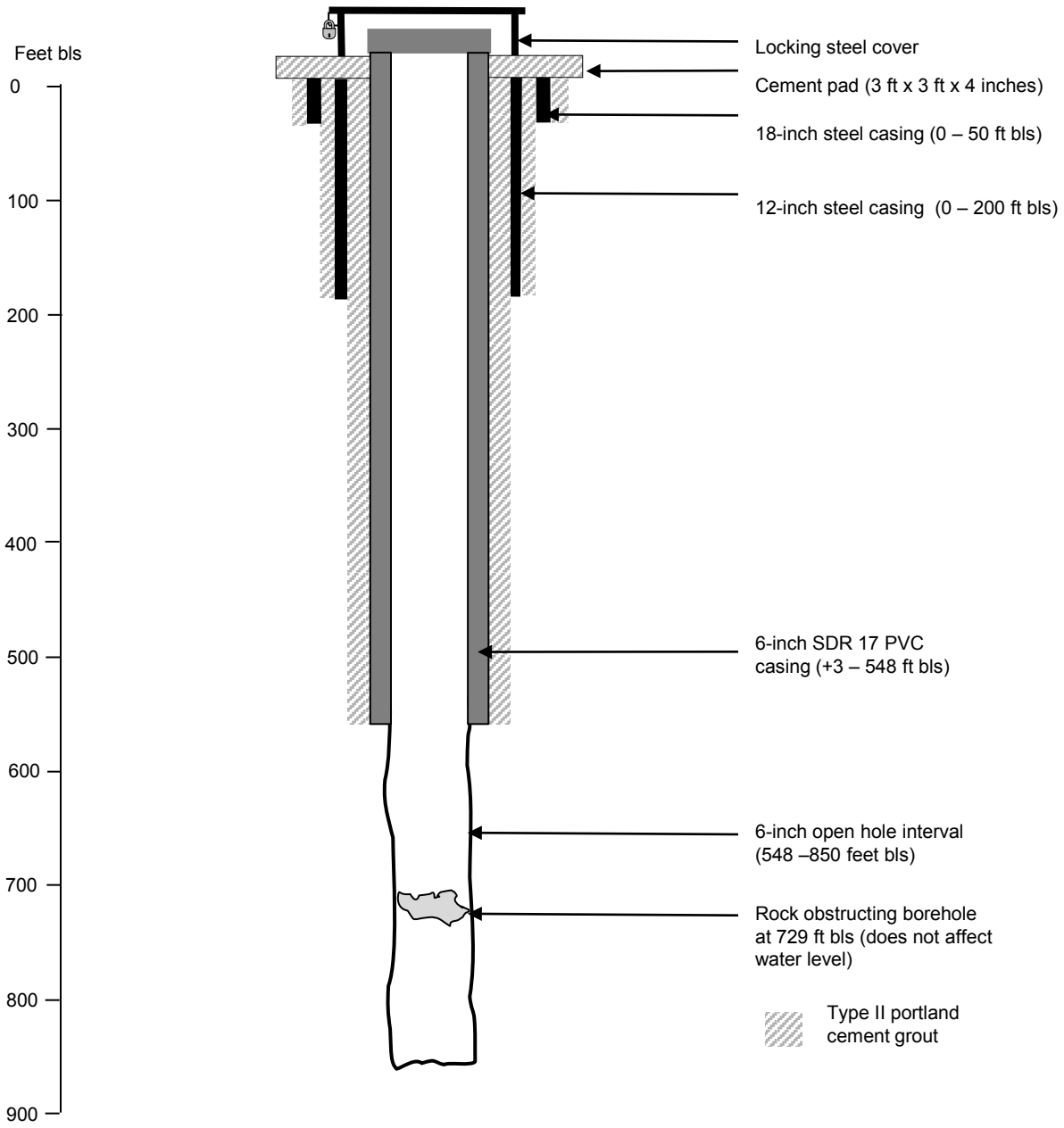
Appendix B, Figure B-9. As-built diagram for the permanent surficial aquifer monitor well constructed at the ROMP 68 – Anitoch Park well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	811365
SID #	777750
S/T/R	S19 T29 R21
Latitude	27 56 26.92
Longitude	82 15 08.70
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

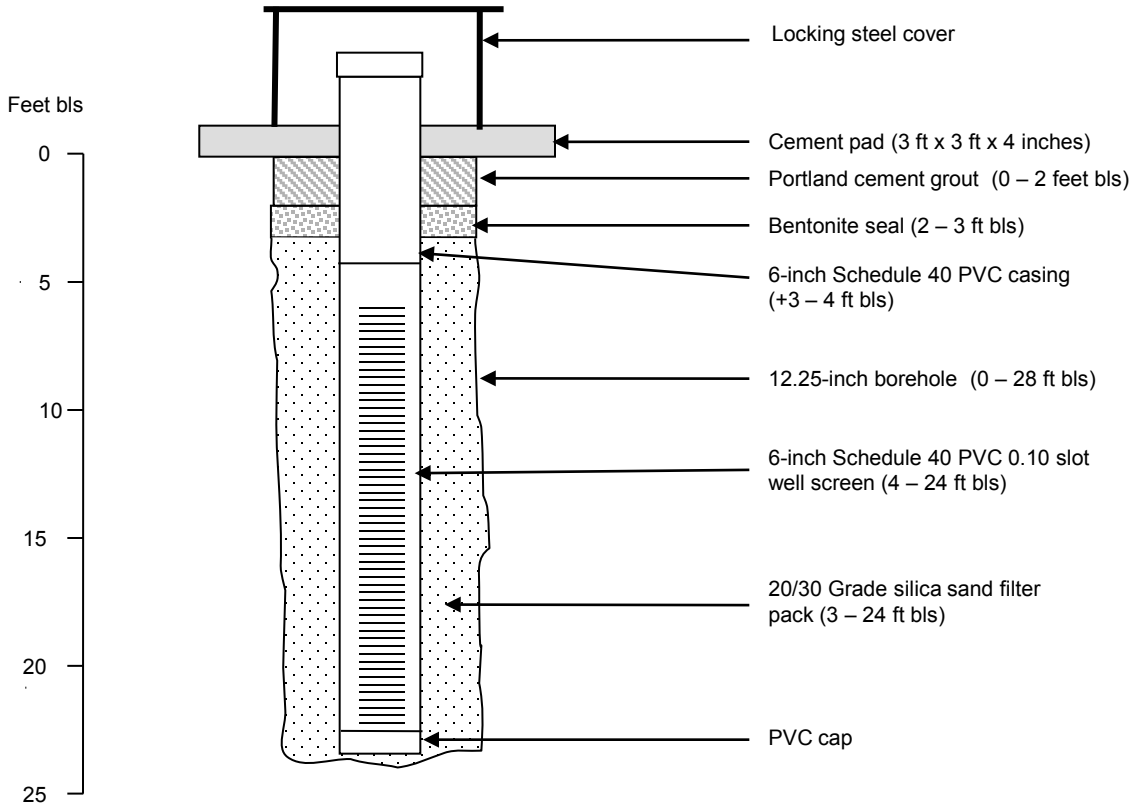
Appendix B, Figure B-10. As-built diagram for the permanent surficial aquifer monitor well constructed at the Turner well site in Hillsborough County, Florida.



Well Name	AVPK PZ MONITOR
WCP #	812279
SID #	780106
S/T/R	S8 T28 R22
Latitude	28 01 47.26
Longitude	82 13 23.18
Specific capacity (gpm/ft)	ND

[AVPK, Avon Park; bls, below land surface; ; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit; U FLDN, Upper Floridan]

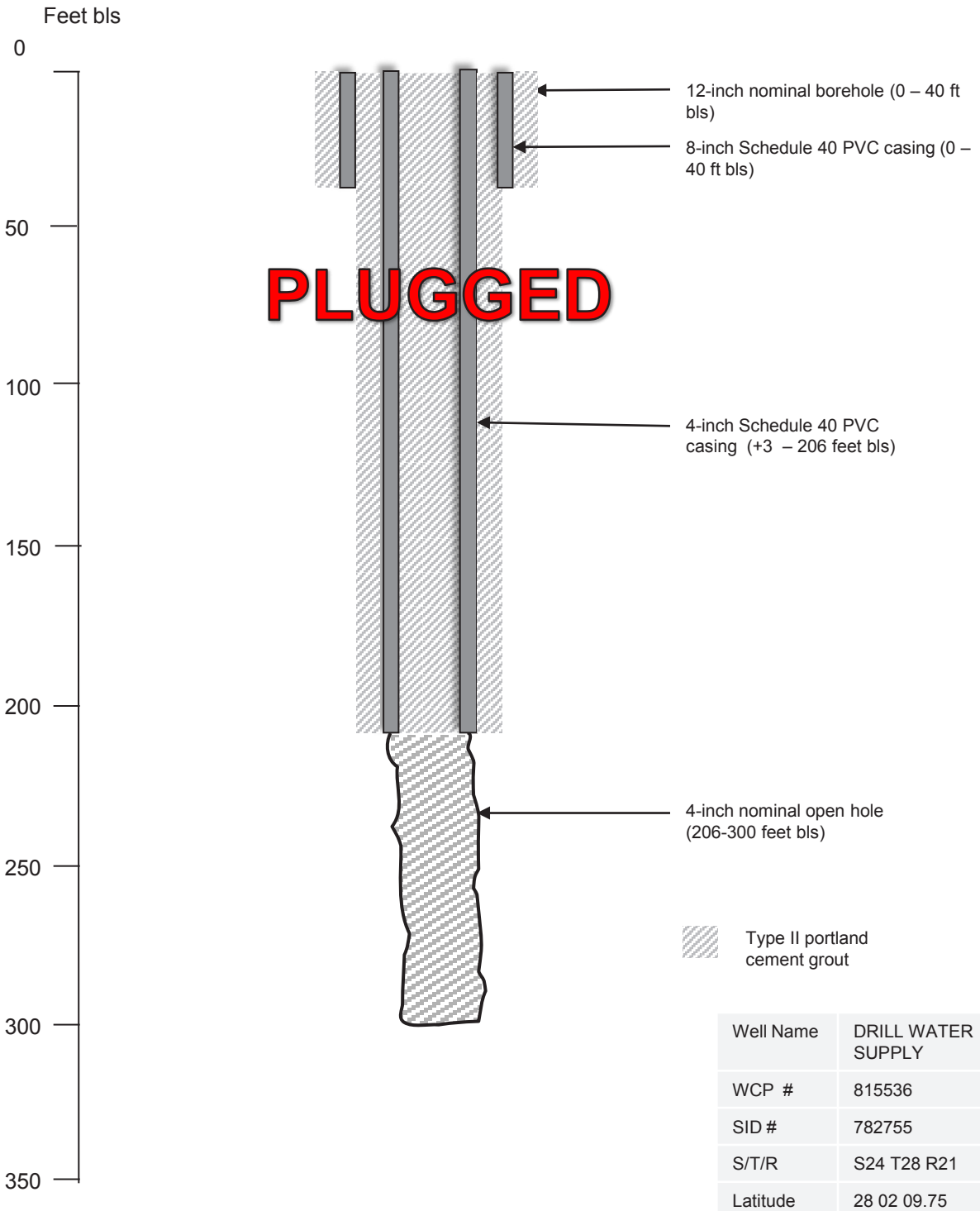
Appendix B, Figure B-11. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the Tampa 15 well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	813344
SID #	780114
S/T/R	S20 T28 R21
Latitude	28 01 47.24
Longitude	82 13 23.09
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

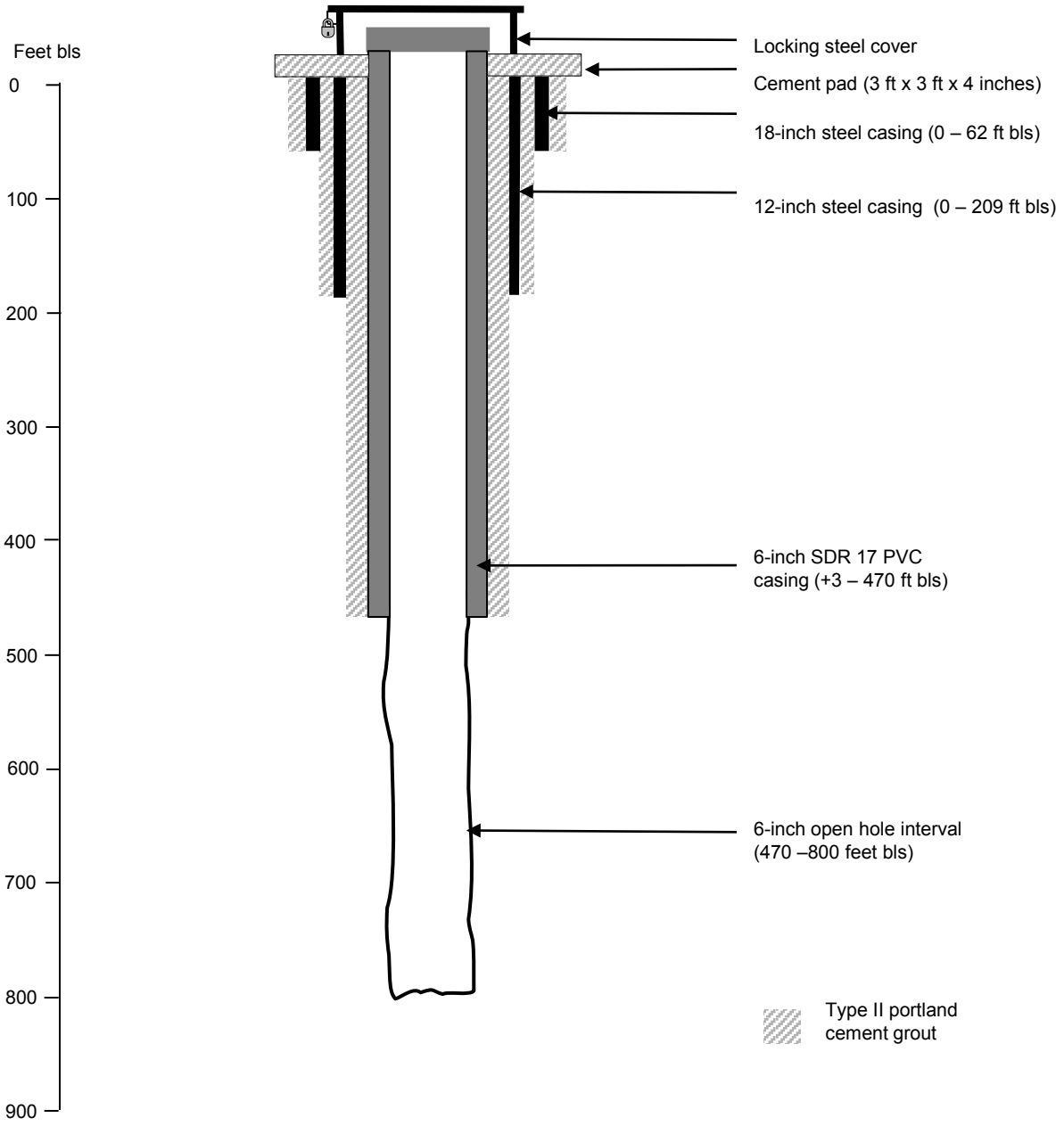
Appendix B, Figure B-12. As-built diagram for the permanent surficial aquifer monitor well constructed at the Tampa 15 well site in Hillsborough County, Florida.



Well Name	DRILL WATER SUPPLY
WCP #	815536
SID #	782755
S/T/R	S24 T28 R21
Latitude	28 02 09.75
Longitude	82 09 33.62
Specific capacity (gpm/ft)	ND

[bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit]

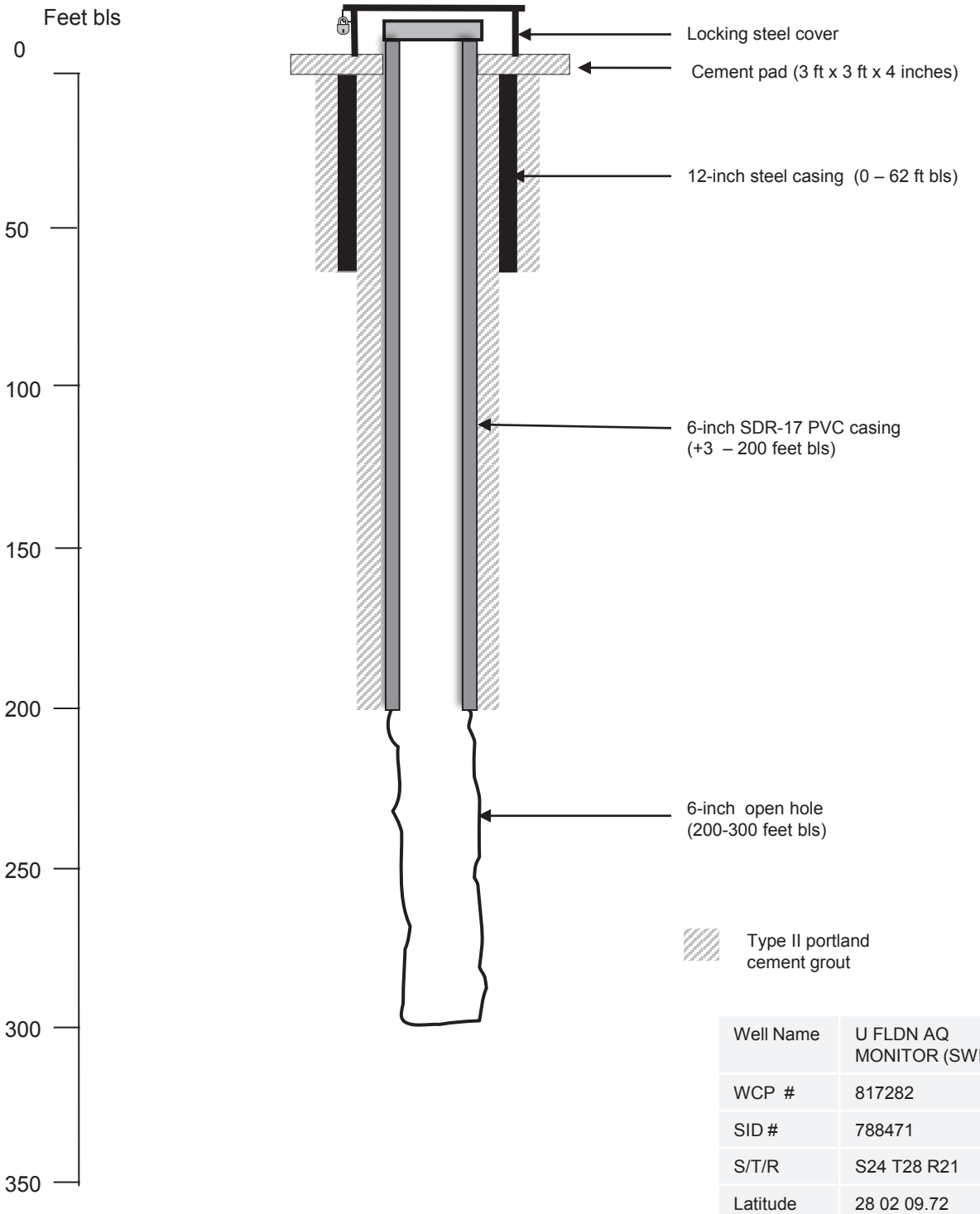
Appendix B, Figure B-13. As-built diagram for the temporary drilling water supply well at the Dover North – Cork Prairie well site in Hillsborough County, Florida.



Well Name	AVPK PZ MONITOR
WCP #	815920
SID #	788472
S/T/R	S24 T28 R21
Latitude	28 02 09.38
Longitude	82 09 33.89
Specific capacity (gpm/ft)	170

[AVPK, Avon Park; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit]

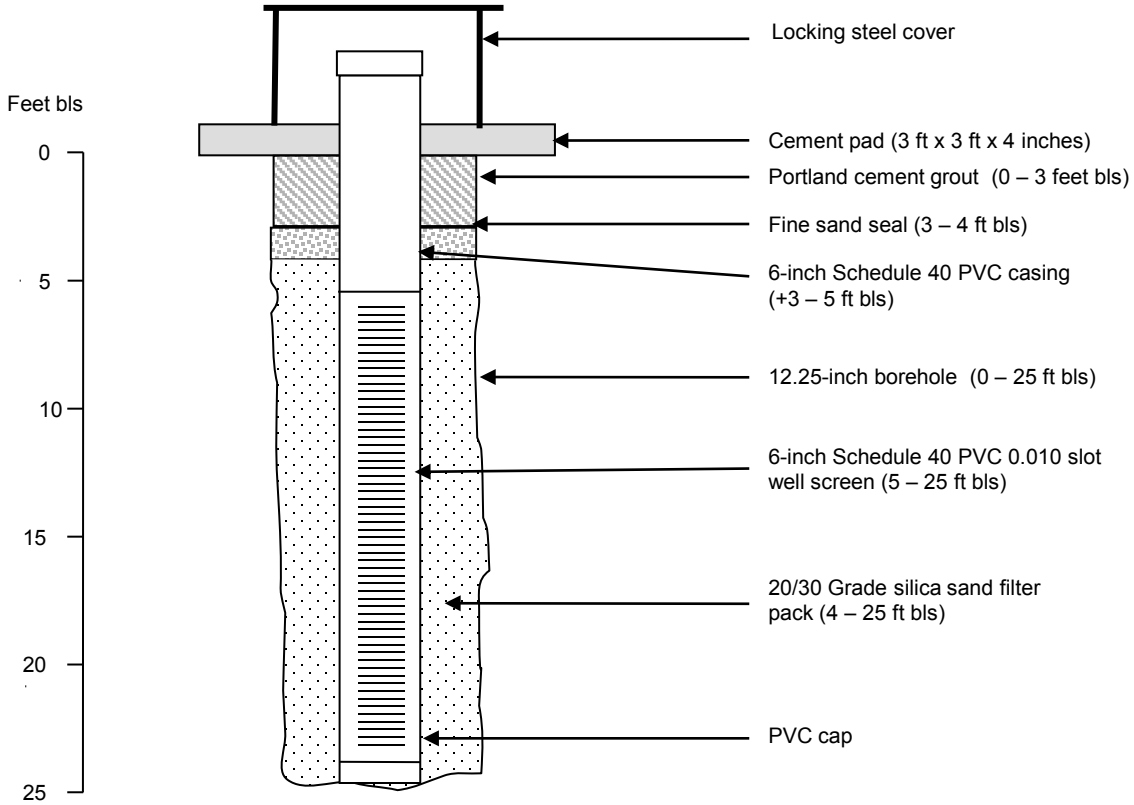
Appendix B, Figure B-14. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the Dover North – Prairie Creek well site in Hillsborough County, Florida.



Well Name	U FLDN AQ MONITOR (SWNN)
WCP #	817282
SID #	788471
S/T/R	S24 T28 R21
Latitude	28 02 09.72
Longitude	82 09 34.08
Specific capacity (gpm/ft)	7

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit; U FLDN, Upper Floridan]

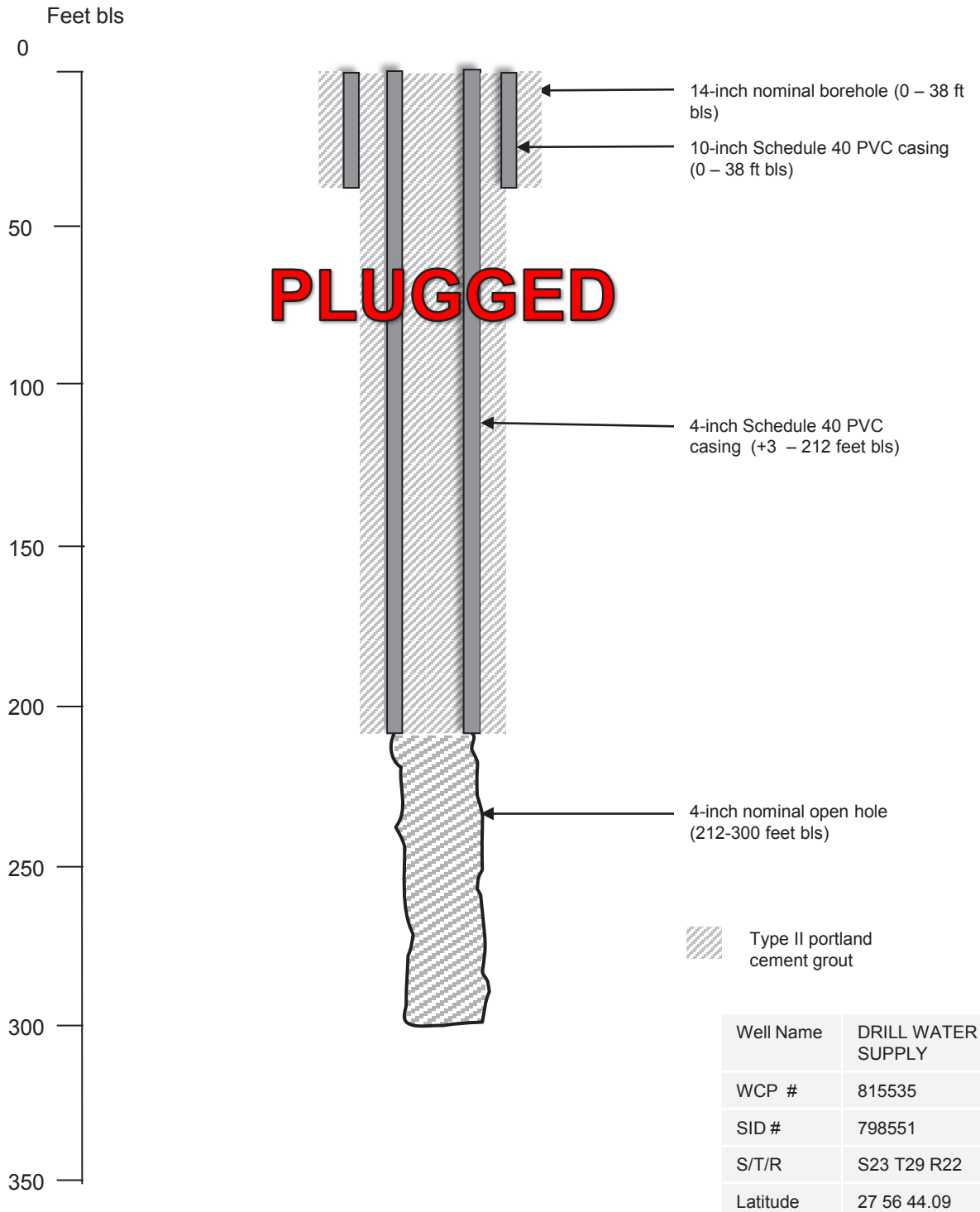
Appendix B, Figure B-15. As-built diagram for the permanent Upper Floridan aquifer (Suwannee) monitor well at the Dover North – Prairie Creek well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	818255
SID #	790045
S/T/R	S24 T28 R21
Latitude	28 02 09.57
Longitude	82 09 33.87
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; GPM, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

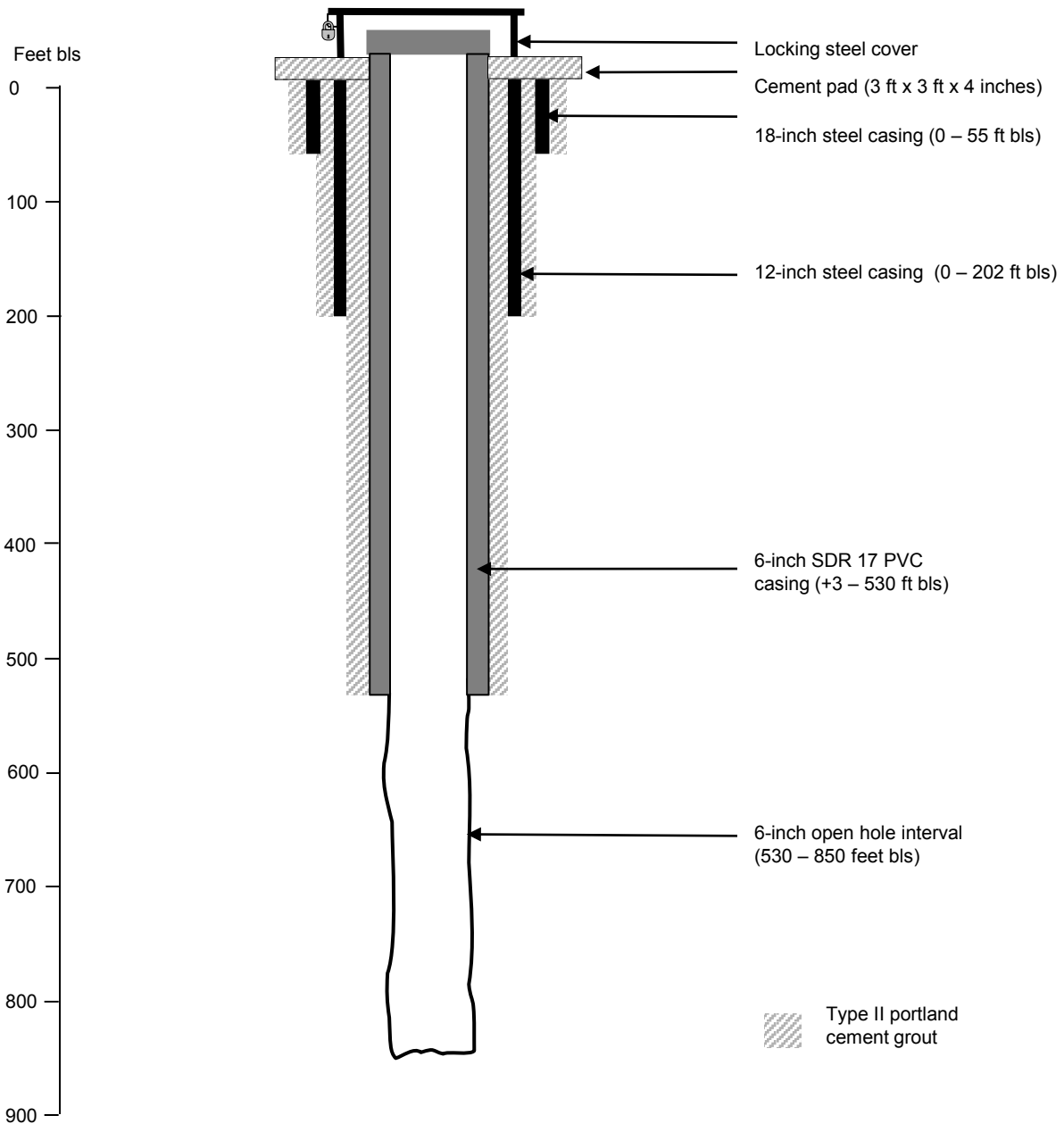
Appendix B, Figure B-16. As-built diagram for the permanent surficial aquifer monitor well constructed at the Dover North – Cork Prairie well site in Hillsborough County, Florida.



Well Name	DRILL WATER SUPPLY
WCP #	815535
SID #	798551
S/T/R	S23 T29 R22
Latitude	27 56 44.09
Longitude	82 04 26.83
Specific capacity (gpm/ft)	ND

[bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; S/T/R, section/township/rage; WCP, well construction permit]

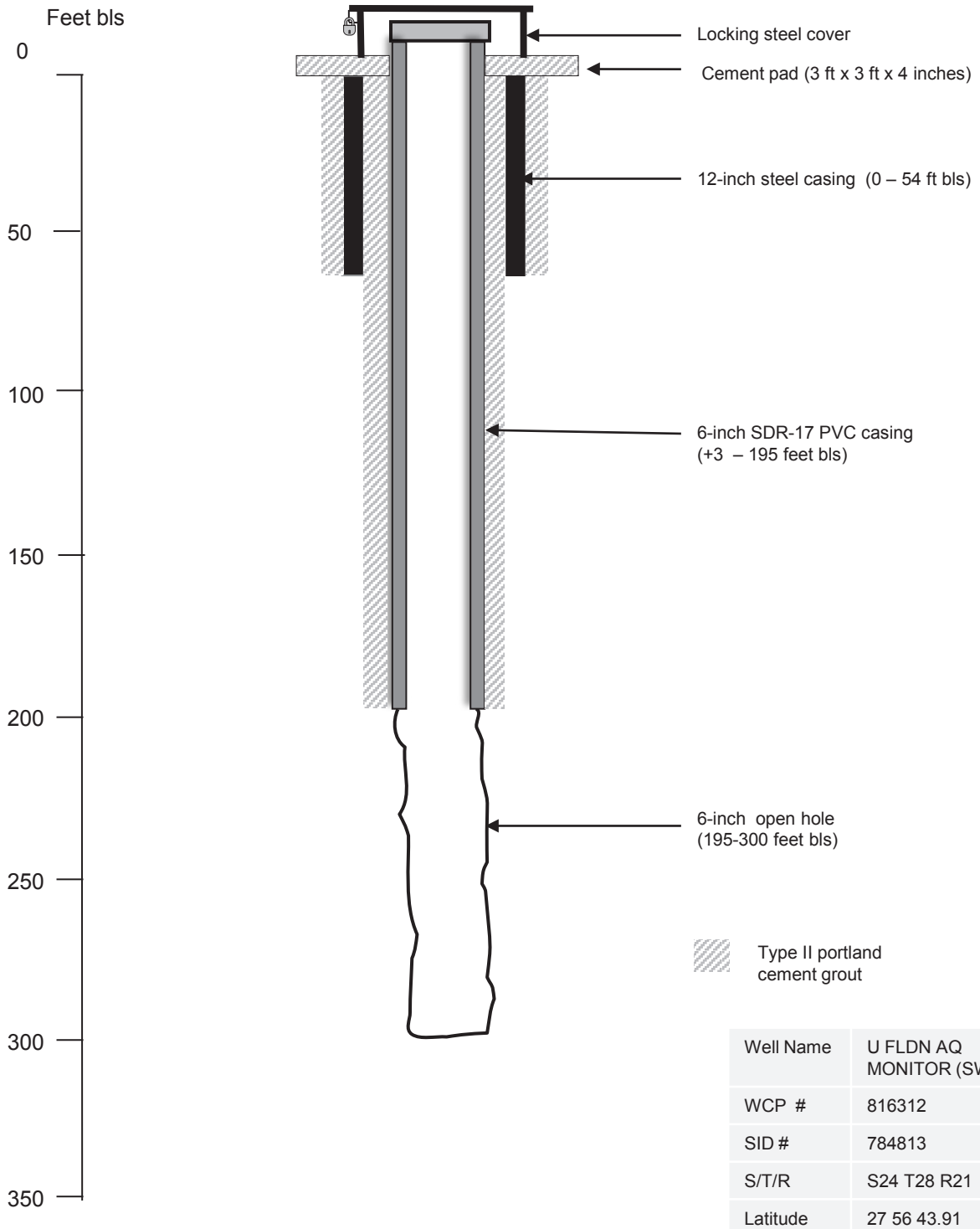
Appendix B, Figure B-17. As-built diagram for the temporary drilling water supply well at the Dover East – Bealsville well site in Hillsborough County, Florida.



Well Name	AVPK PZ MONITOR
WCP #	816307
SID #	798549
S/T/R	S23 T29 R22
Latitude	27 56 44.19
Longitude	82 04 26.79
Specific capacity (gpm/ft)	143

[AVPK, Avon Park; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit]

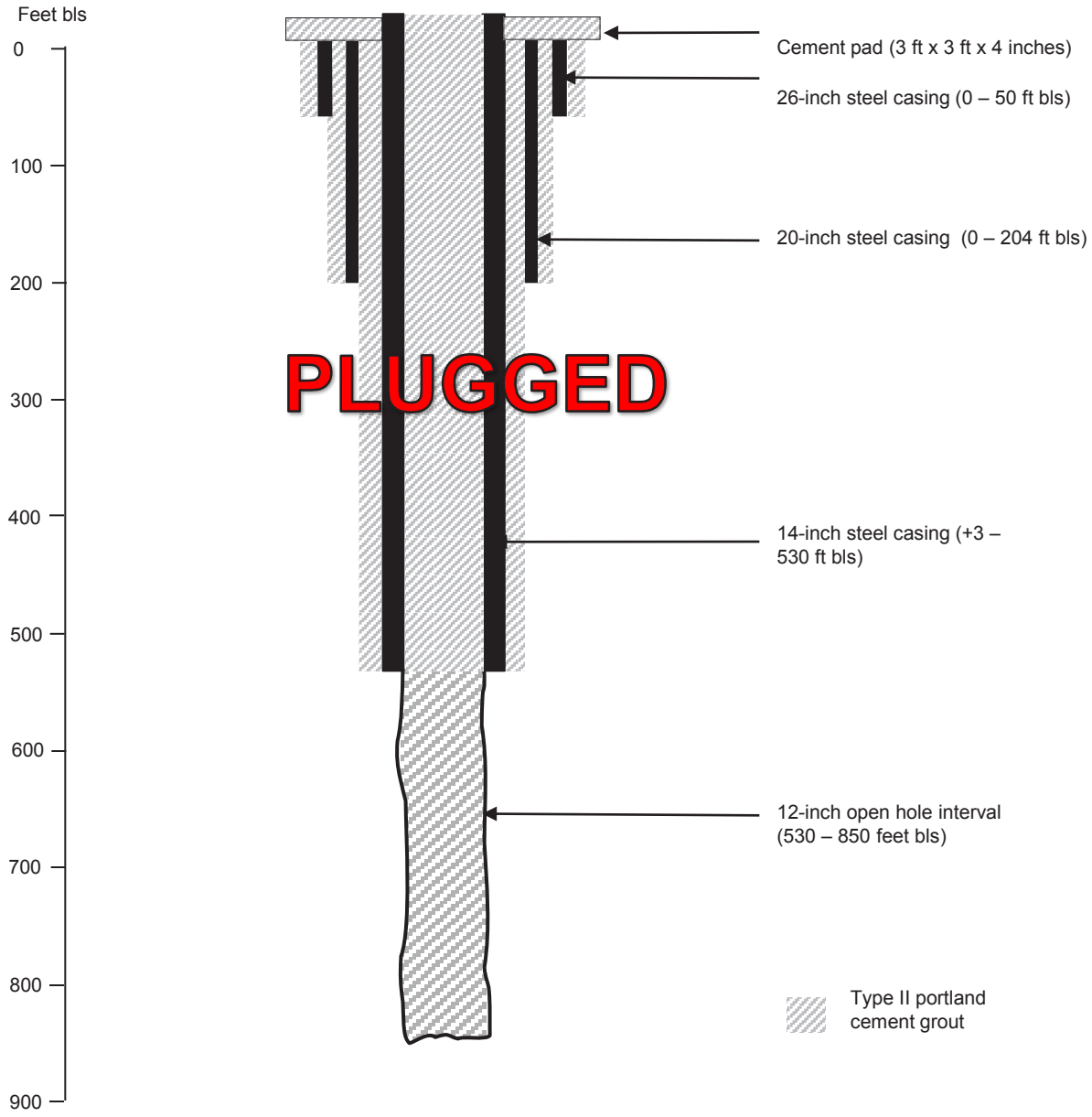
Appendix B, Figure B-18. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the Dover East – Bealsville well site in Hillsborough County, Florida.



Well Name	U FLDN AQ MONITOR (SWNN)
WCP #	816312
SID #	784813
S/T/R	S24 T28 R21
Latitude	27 56 43.91
Longitude	82 04 26.87
Specific capacity (gpm/ft)	14

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit; U FLDN, Upper Floridan]

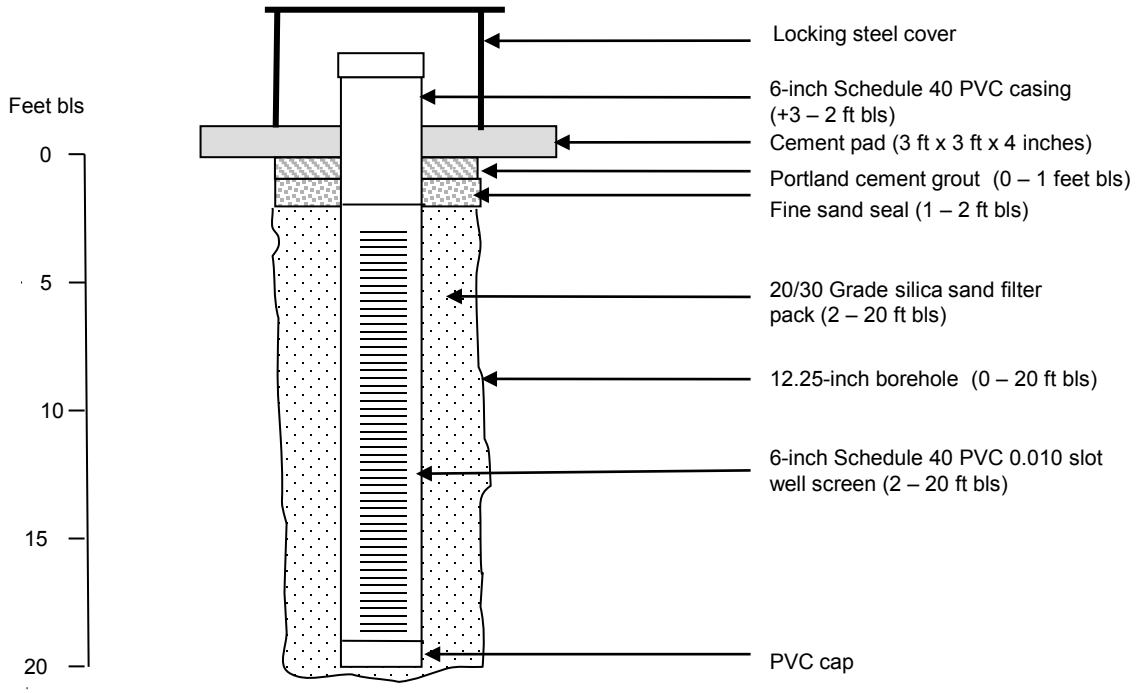
Appendix B, Figure B-19. As-built diagram for the permanent Upper Floridan aquifer (Suwannee) monitor well at the Dover East – Bealsville well site in Hillsborough County, Florida.



Well Name	AVPK PZ PRODUCTION TEMP
WCP #	816316
SID #	784815
S/T/R	S23 T29 R22
Latitude	27 56 45.98
Longitude	82 04 27.03
Specific capacity (gpm/ft)	175

[AVPK, Avon Park; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; S/T/R, section/township/rage; WCP, well construction permit]

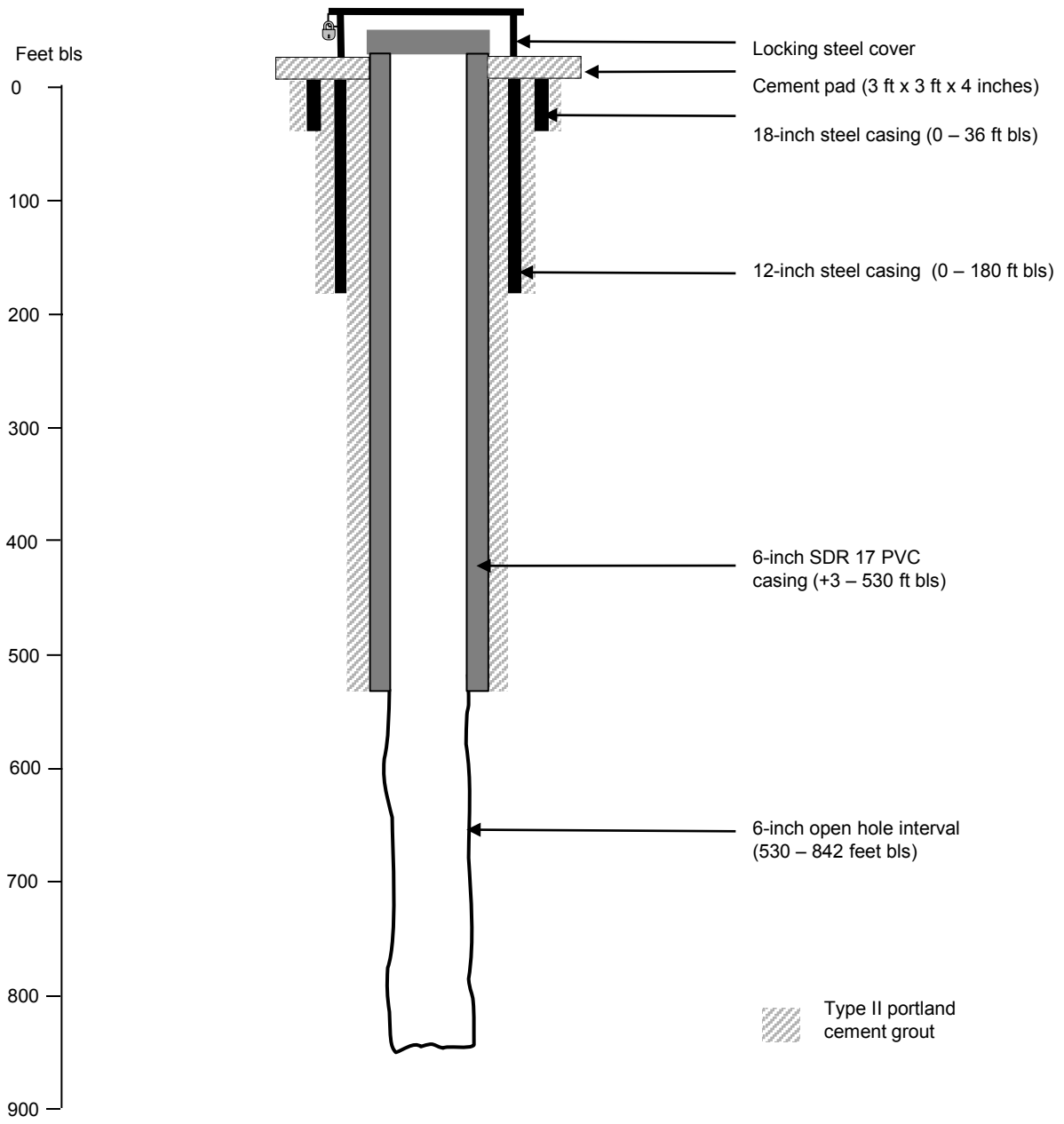
Appendix B, Figure B-20. As-built diagram for the temporary Upper Floridan aquifer (Avon Park) production well constructed at the Dover East – Bealsville well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	819338
SID #	798550
S/T/R	S23 T29 R22
Latitude	27 56 43.95
Longitude	82 04 26.91
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

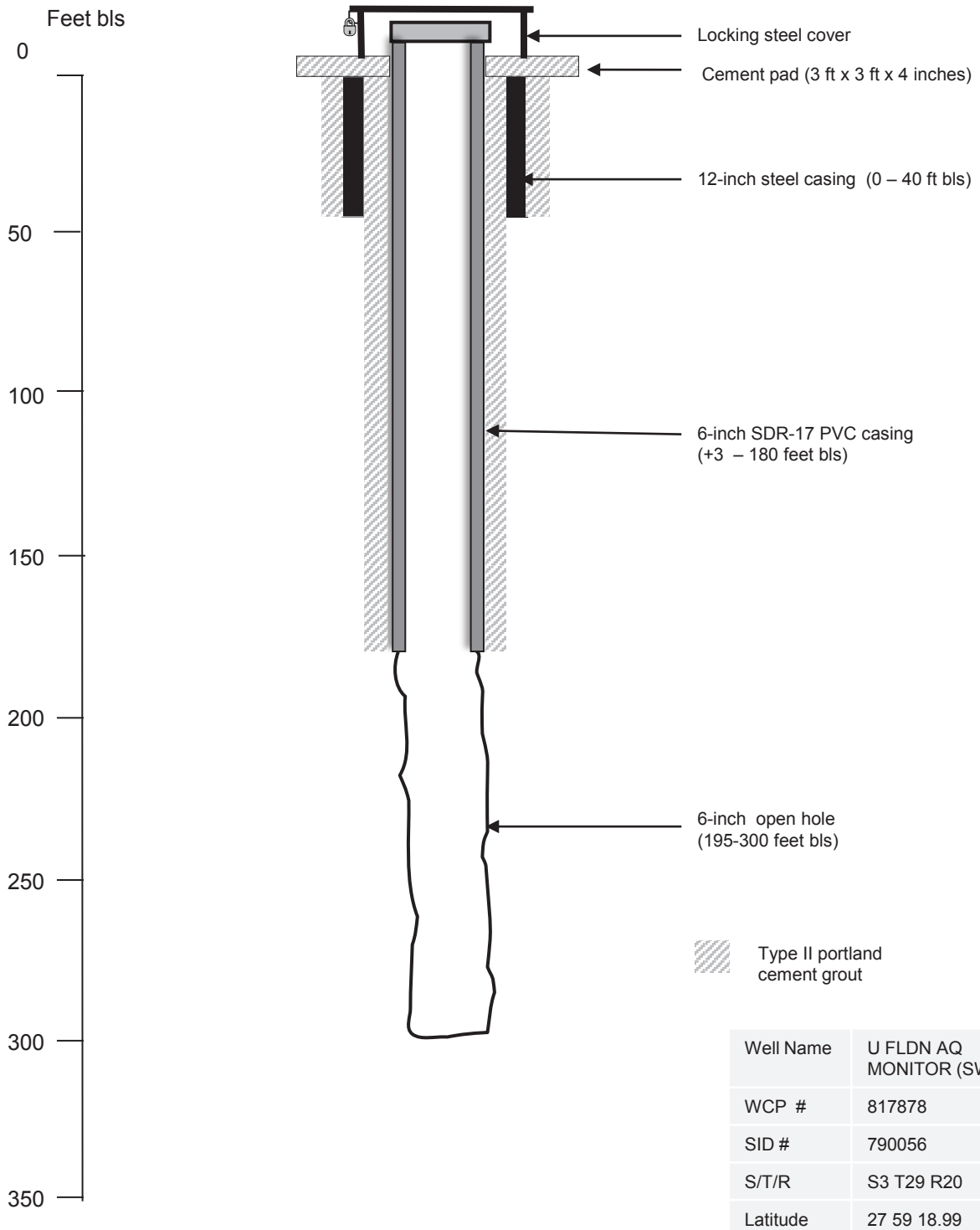
Appendix B, Figure B-21. As-built diagram for the permanent surficial aquifer monitor well constructed at the Dover East – Bealsville well site in Hillsborough County, Florida.



Well Name	AVPK PZ MONITOR
WCP #	817014
SID #	789584
S/T/R	S3 T29 R20
Latitude	27 56 44.19
Longitude	82 17 54.60
Specific capacity (gpm/ft)	158

[AVPK, Avon Park; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit]

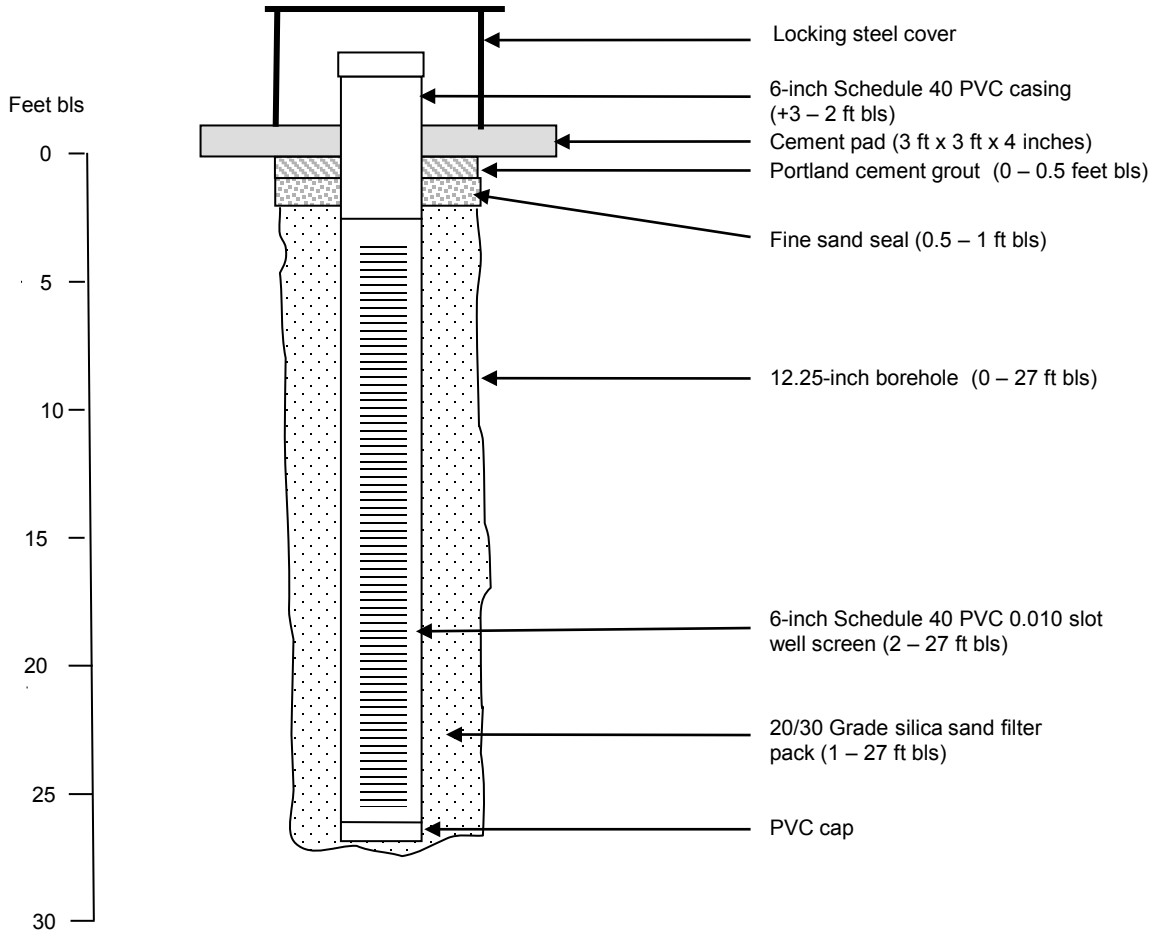
Appendix B, Figure B-22. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the Dover West – Mango well site in Hillsborough County, Florida.



Well Name	U FLDN AQ MONITOR (SWNN)
WCP #	817878
SID #	790056
S/T/R	S3 T29 R20
Latitude	27 59 18.99
Longitude	82 17 54.76
Specific capacity (gpm/ft)	5

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; SWNN, Suwannee; WCP, well construction permit; U FLDN, Upper Floridan]

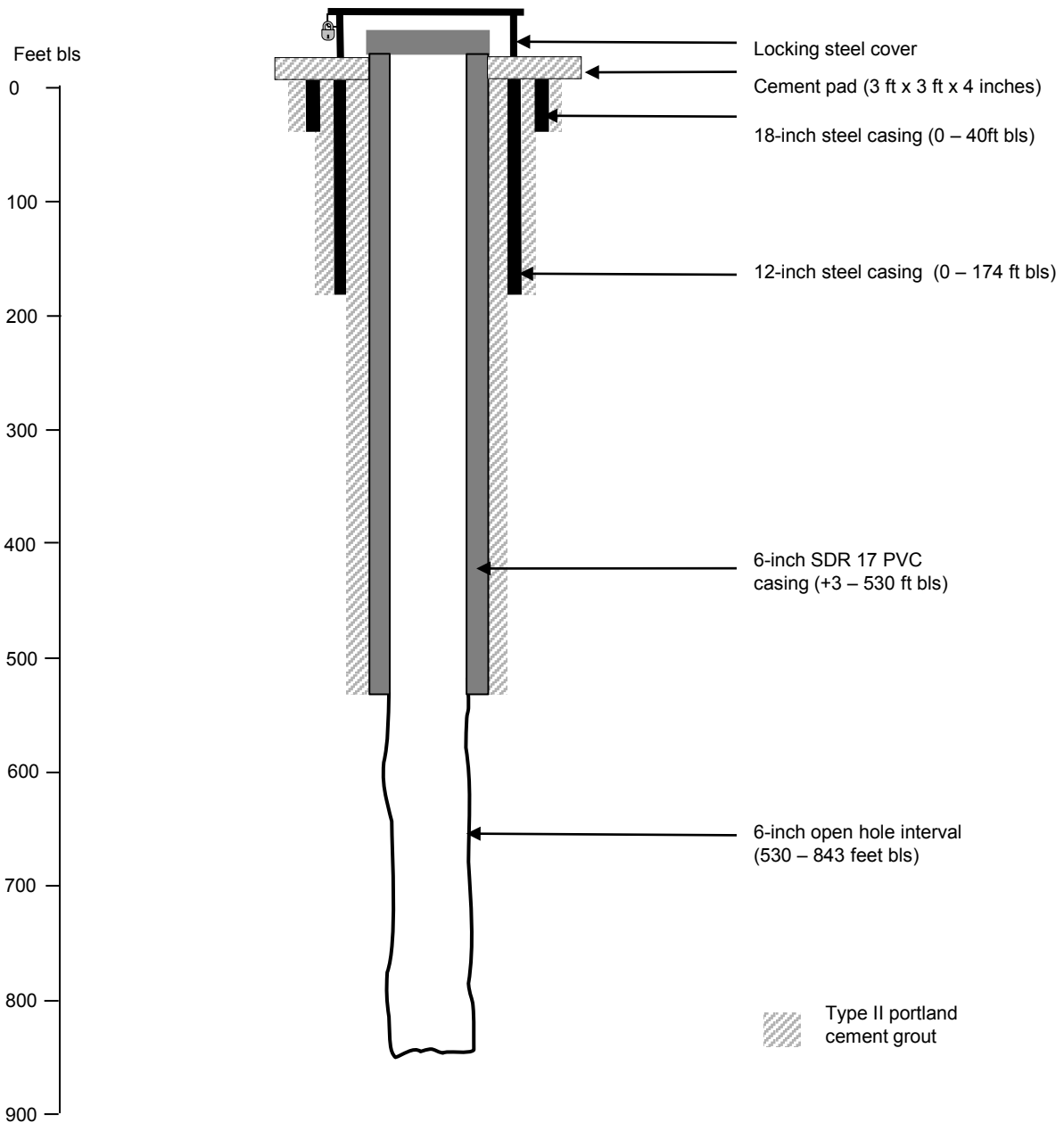
Appendix B, Figure B-23. As-built diagram for the permanent Upper Floridan aquifer (Suwannee) monitor well at the Dover West – Mango well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	818256
SID #	790057
S/T/R	S3 T29 R20
Latitude	27 59 18.95
Longitude	82 17 54.45
Specific capacity (gpm/ft)	DRY

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

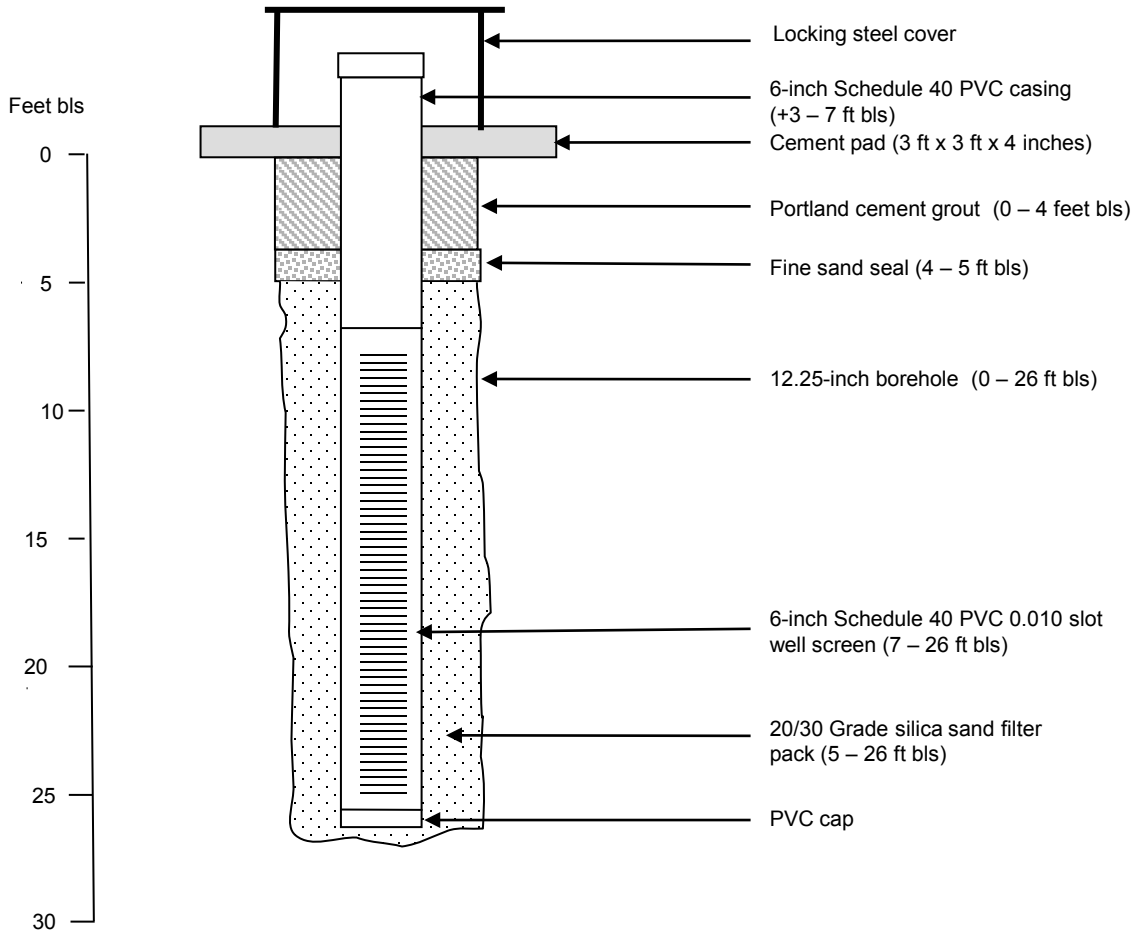
Appendix B, Figure B-24. As-built diagram for the permanent surficial aquifer monitor well constructed at the Dover West – Mango well site in Hillsborough County, Florida.



Well Name	AVPK PZ MONITOR
WCP #	818274
SID #	793066
S/T/R	S21 T29 R21
Latitude	27 56 17.69
Longitude	82 12 37.95
Specific capacity (gpm/ft)	ND

[AVPK, Avon Park; bls, below land surface; ; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SDR, standard dimension ratio; S/T/R, section/township/rage; WCP, well construction permit]

Appendix B, Figure B-25. As-built diagram for the Upper Floridan aquifer (Avon Park) monitor well constructed at the Dover South – Sydney Trails well site in Hillsborough County, Florida.



Well Name	SURF AQ MONITOR
WCP #	819339
SID #	793079
S/T/R	S21 T29 R21
Latitude	27 56 17.81
Longitude	82 12 37.94
Specific capacity (gpm/ft)	ND

[AQ, aquifer; bls, below land surface; ft, feet; gpm, gallons per minute; ND, not determined; PVC, poly vinyl-chloride; SID, site identification; S/T/R, section/township/rage; SURF, surficial; WCP, well construction permit]

Appendix B, Figure B-26. As-built diagram for the permanent surficial aquifer monitor well constructed at the Dover South – Sydney Trails well site in Hillsborough County, Florida.

Appendix C: Geophysical Logs

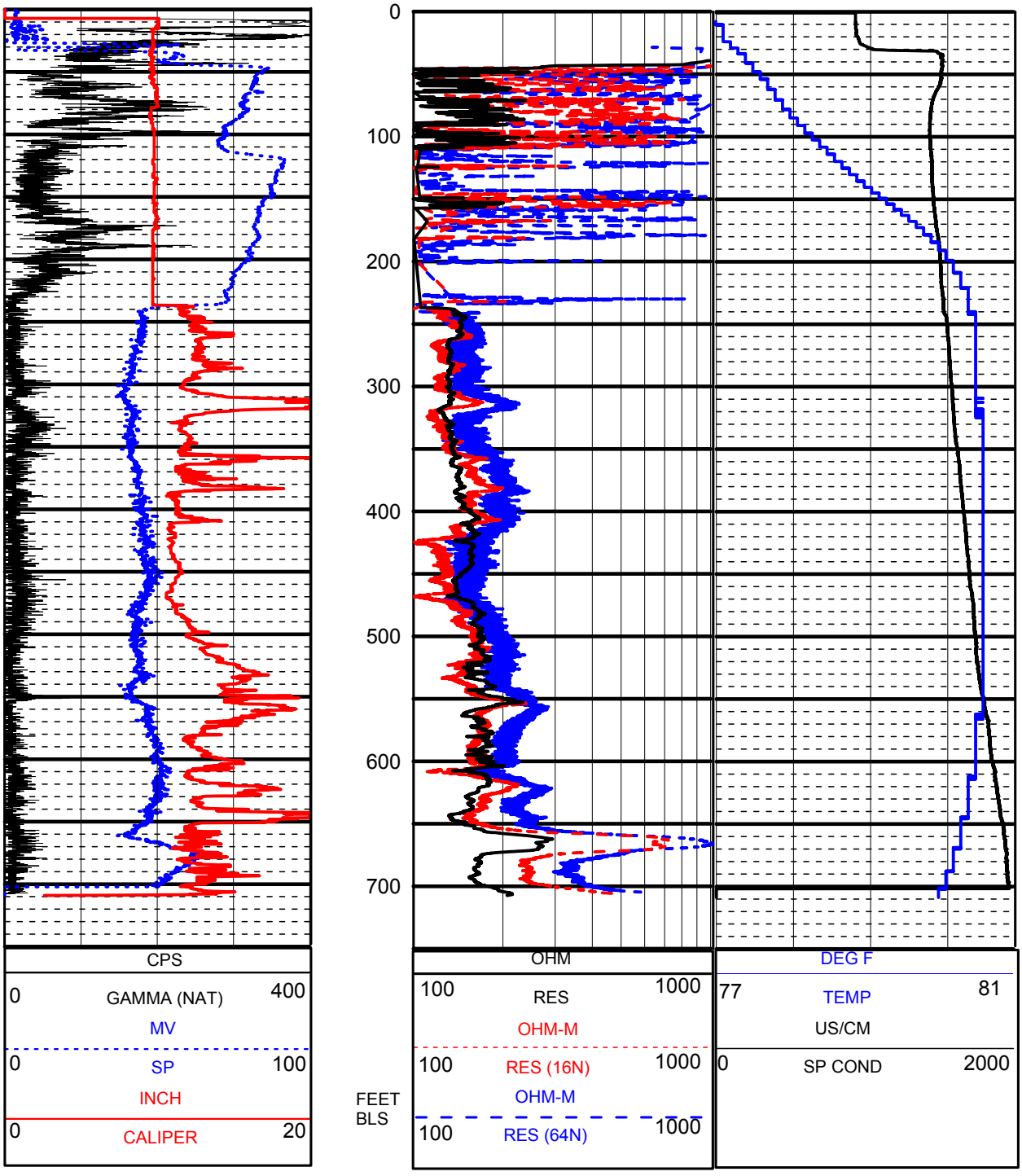


Figure C-1. ROMP 60 Geophysical suite for the U FLDN MONITOR well. Logging was performed on 11/17/2010 using the 9165 C (caliper-gamma) tool and the 8144C (multi) tool. Ten-inch diameter steel casing was installed from land surface to 237 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

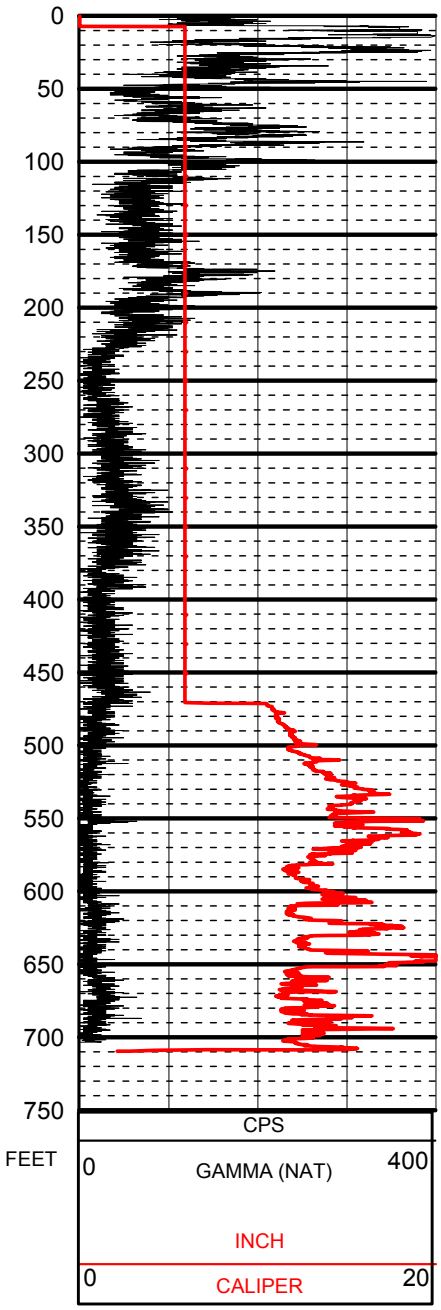


Figure C-2. ROMP 60 Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 5/19/2011 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 470 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet.

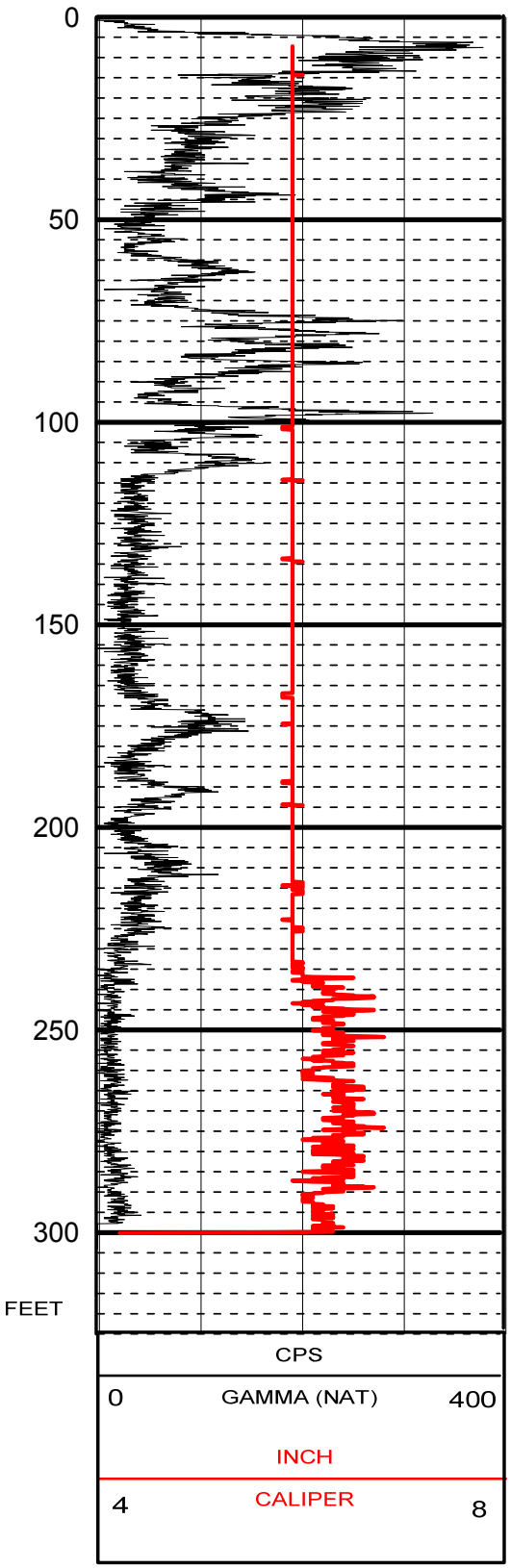


Figure C-3. ROMP 60 Geophysical suite for the SWNN PZ MONITOR well. Logging was performed on 5/19/2011 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 235 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet.

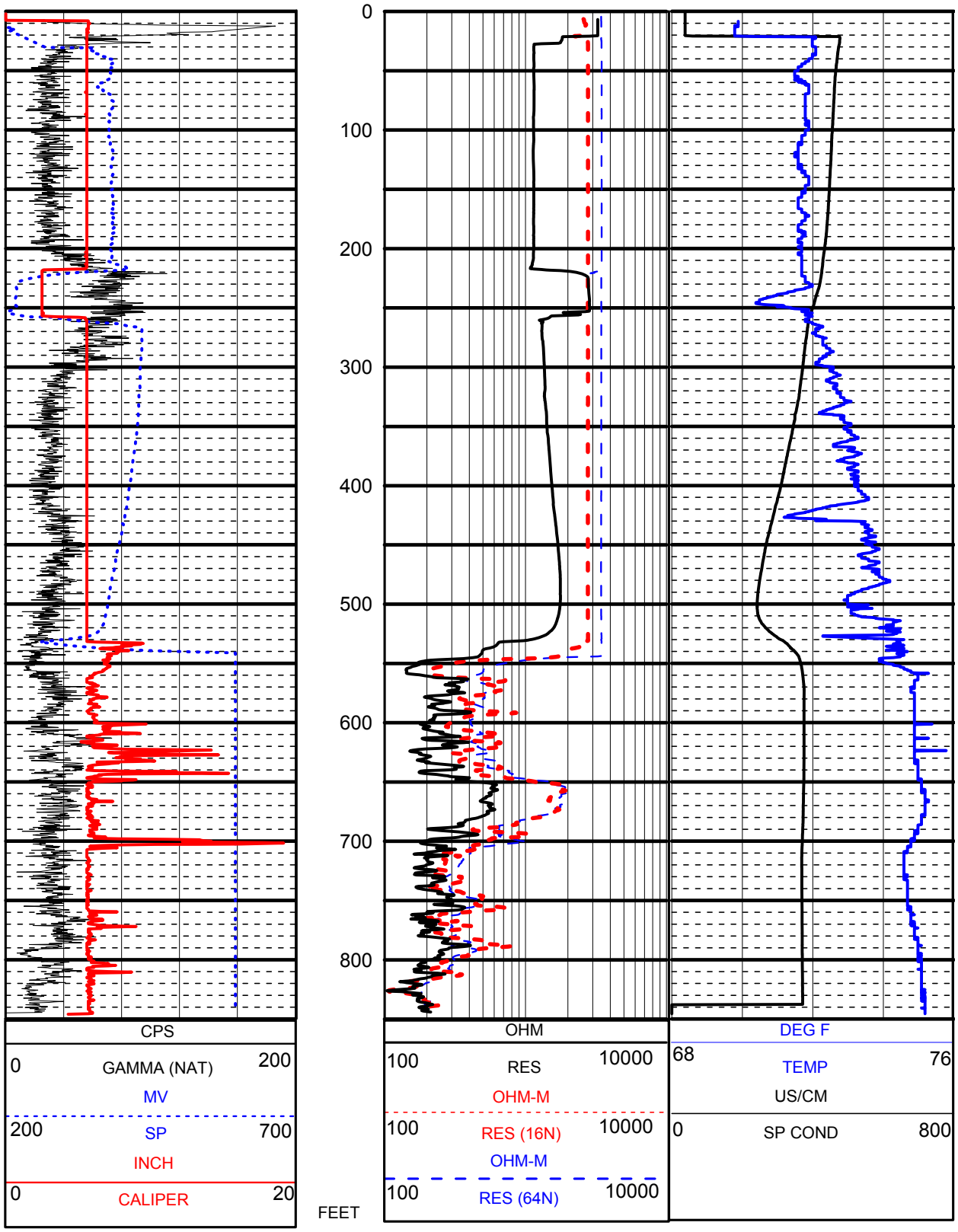


Figure C-4. McIntosh Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 1/11/2011 using the 9074 C (caliper-gamma) tool and the 8044 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 537 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

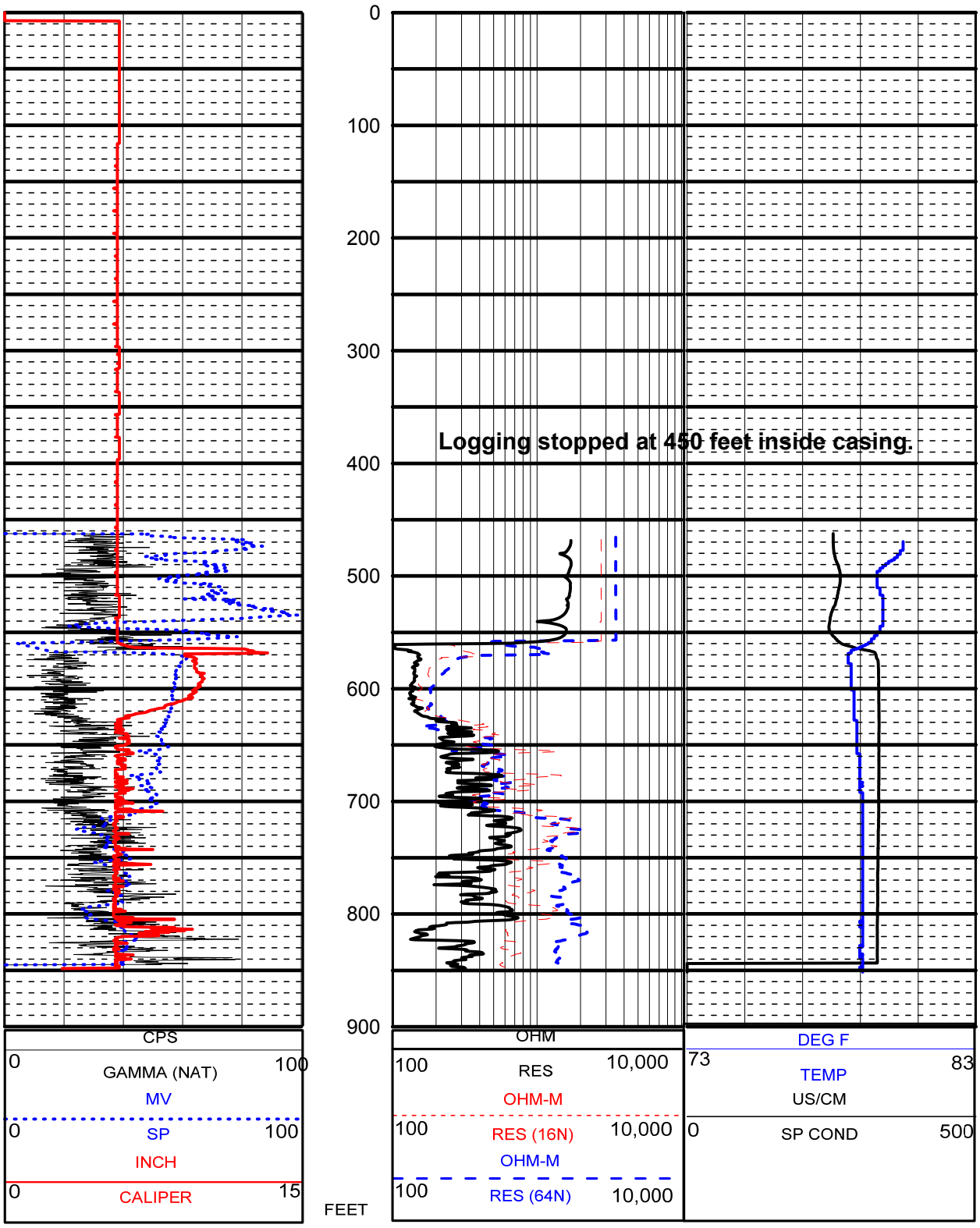


Figure C-5. DV-2 Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 1/20/2011 using the 9165 C (caliper-gamma) tool and the 8143 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 565 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

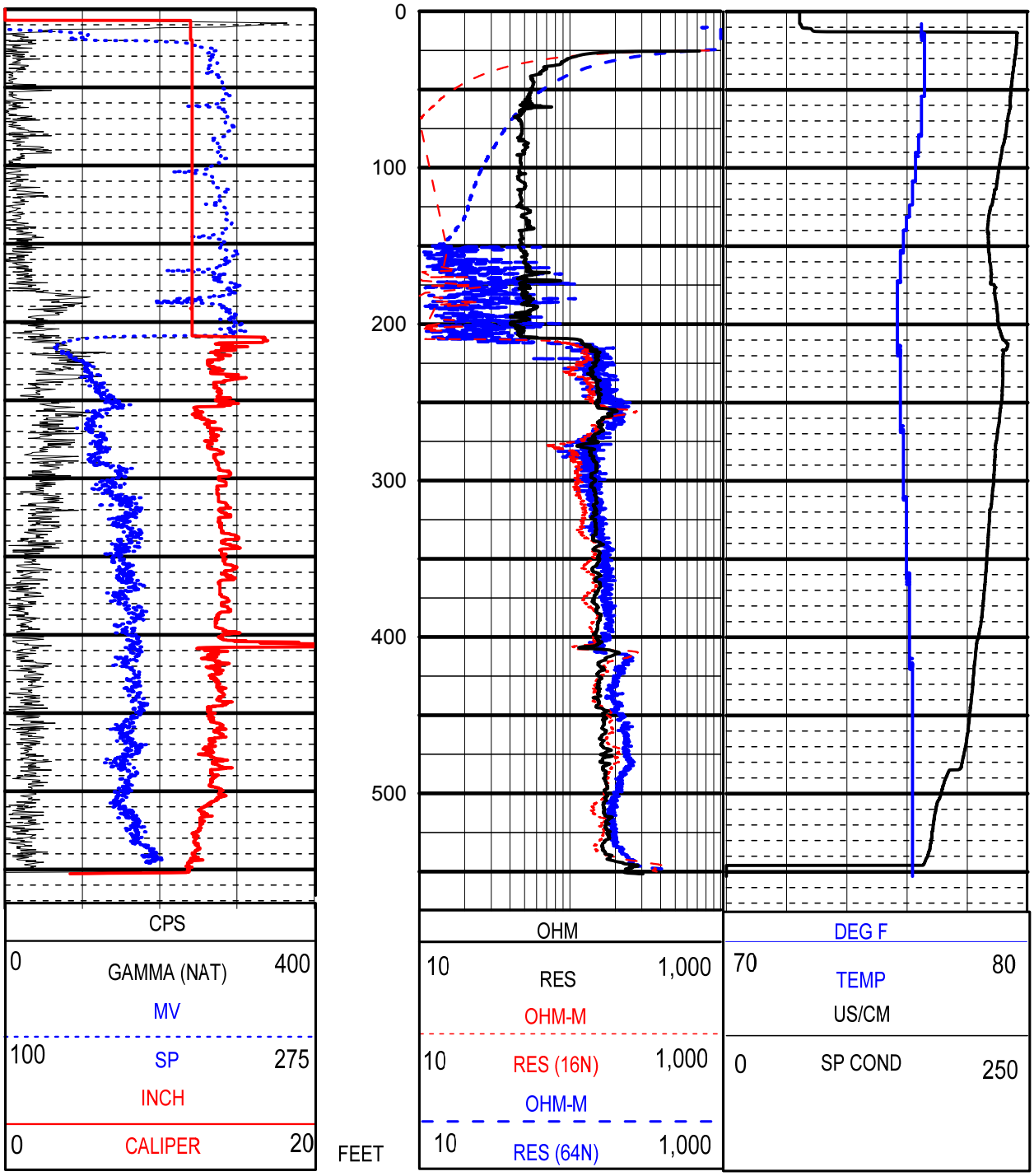


Figure C-6. TAMPA 15 Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 5/19/2011 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Twelve-inch diameter steel casing was installed from land surface to 210 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

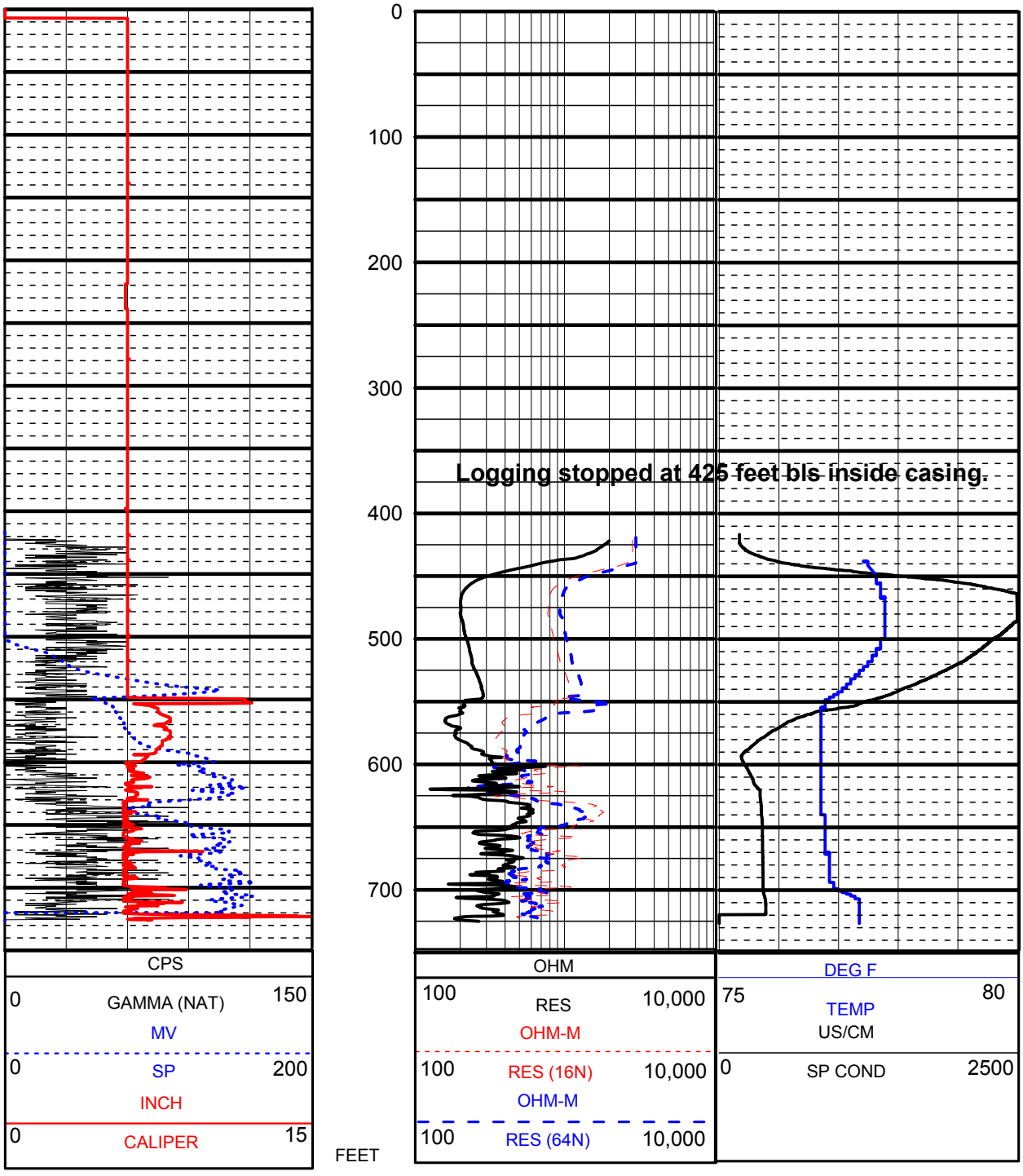


Figure C-7. TAMPA 15 Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 6/9/2011 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 548 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

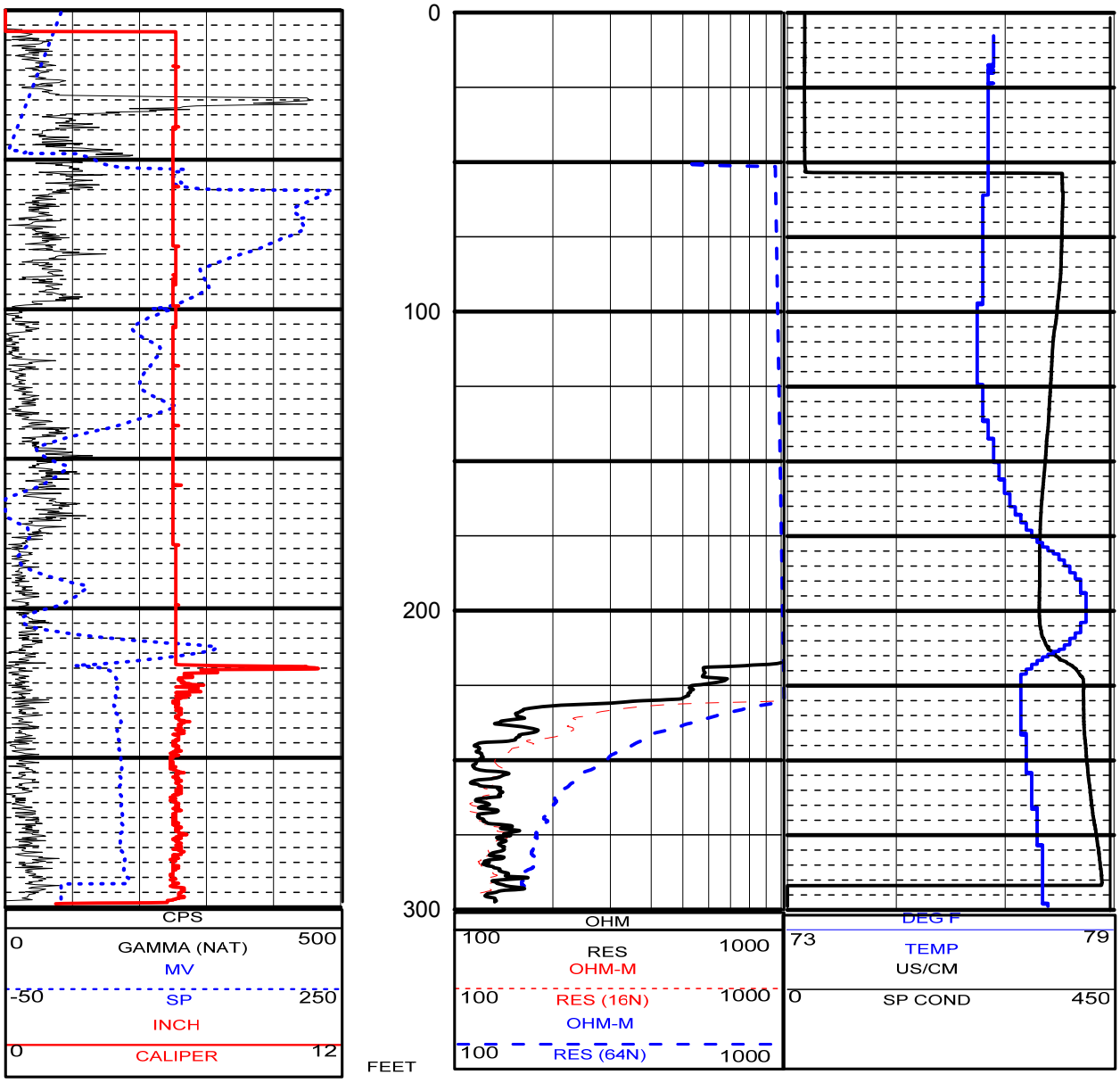


Figure C-8. ROMP 62 Geophysical suite for the SWNN MONITOR well. Logging was performed on 9/20/2011 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 218 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

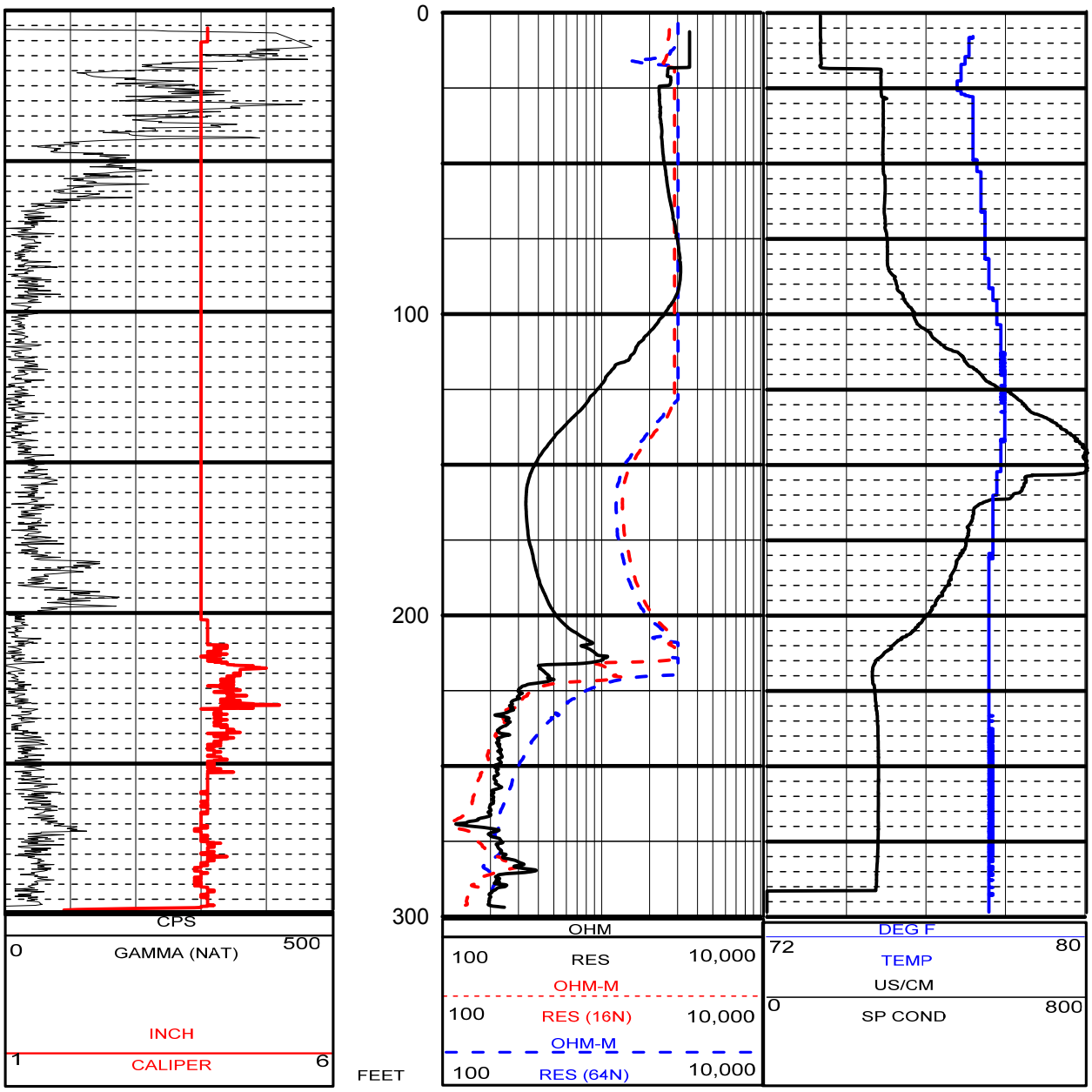


Figure C-9. Dover East (Bealsville) Geophysical suite for the DRILLING WATER SUPPLY TEMP. Logging was performed on 10/3/2011 using the 9064 A (caliper) tool and the 8144 C (multi) tool. Four-inch diameter PVC casing was installed from land surface to 212 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

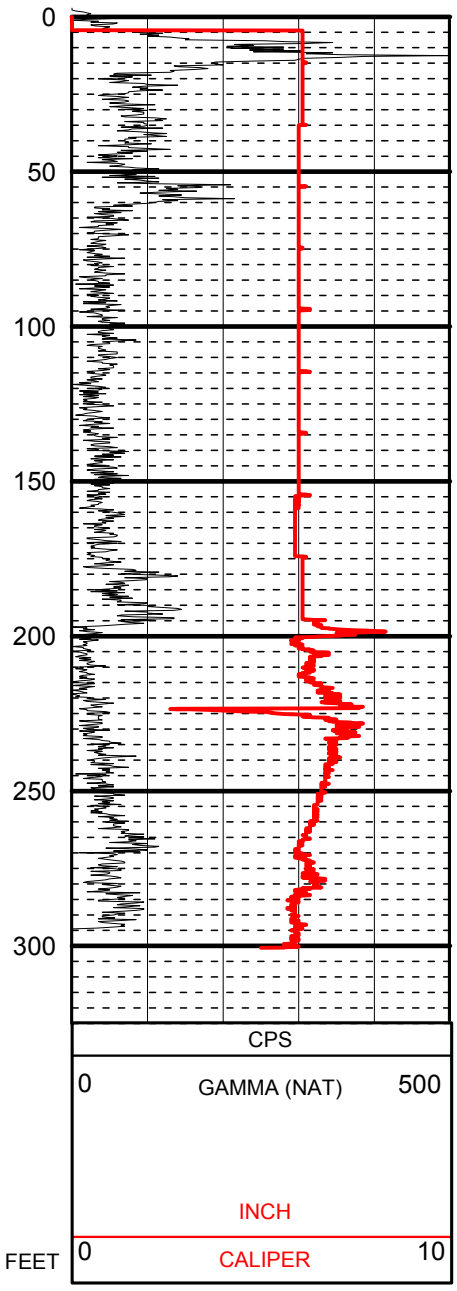


Figure C-10. Dover East (Bealsville) Geophysical suite for the SWNN MONITOR. Logging was performed on 12/15/2011 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 180 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet.

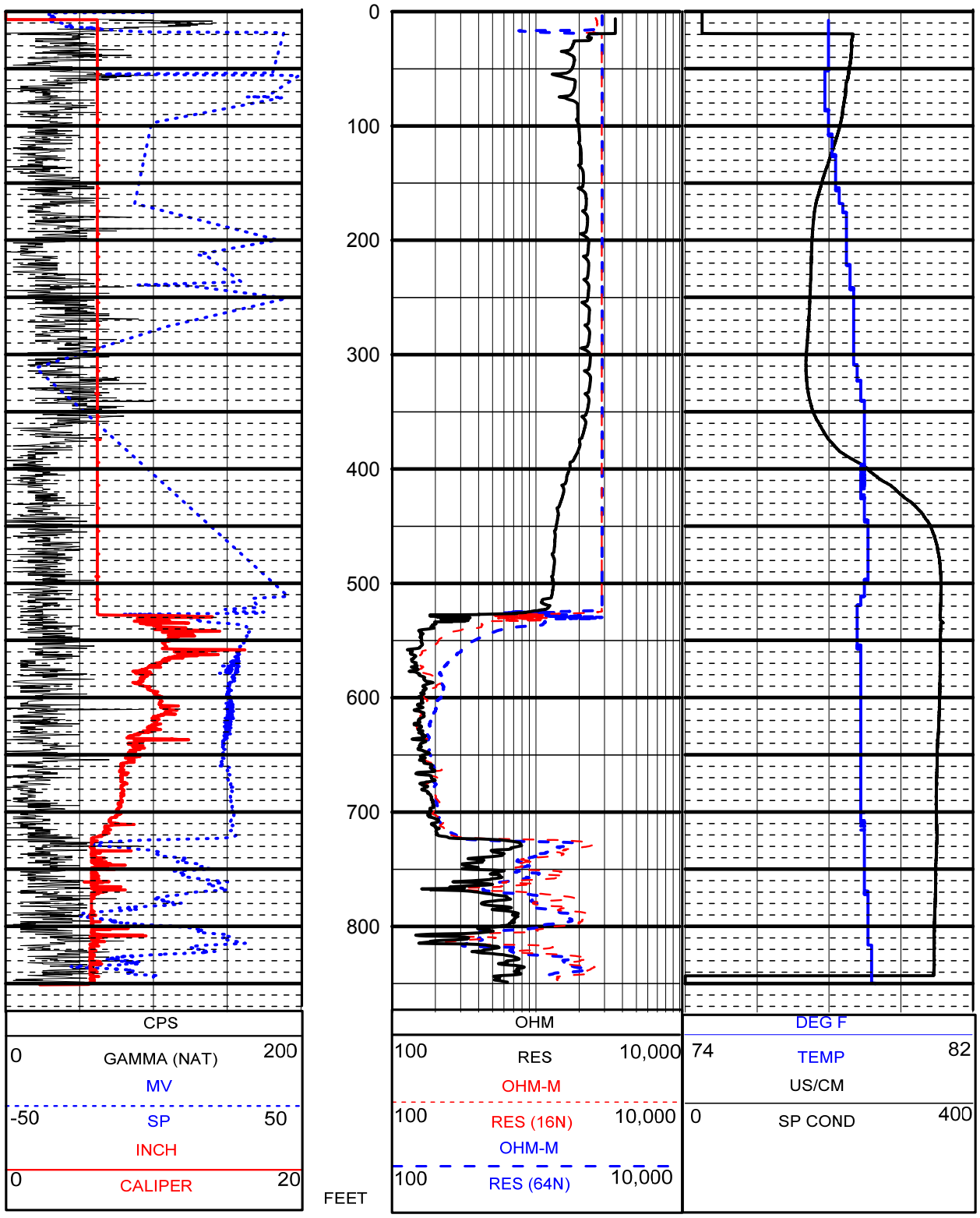


Figure C-11. Dover East (Bealsville) Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 12/2/2011 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 530 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

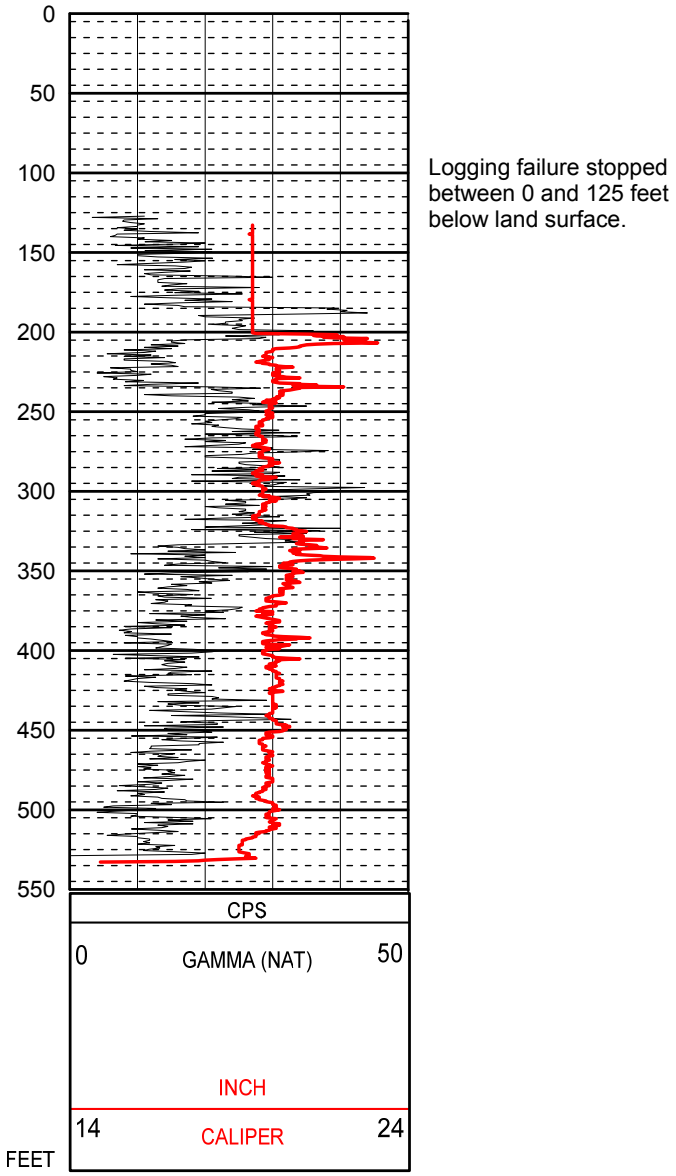


Figure C-12. Dover East (Bealsville) Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 1/17/2012 using the 9165 C (caliper-gamma) tool. Twenty-inch diameter steel casing was installed from land surface to 204 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet.

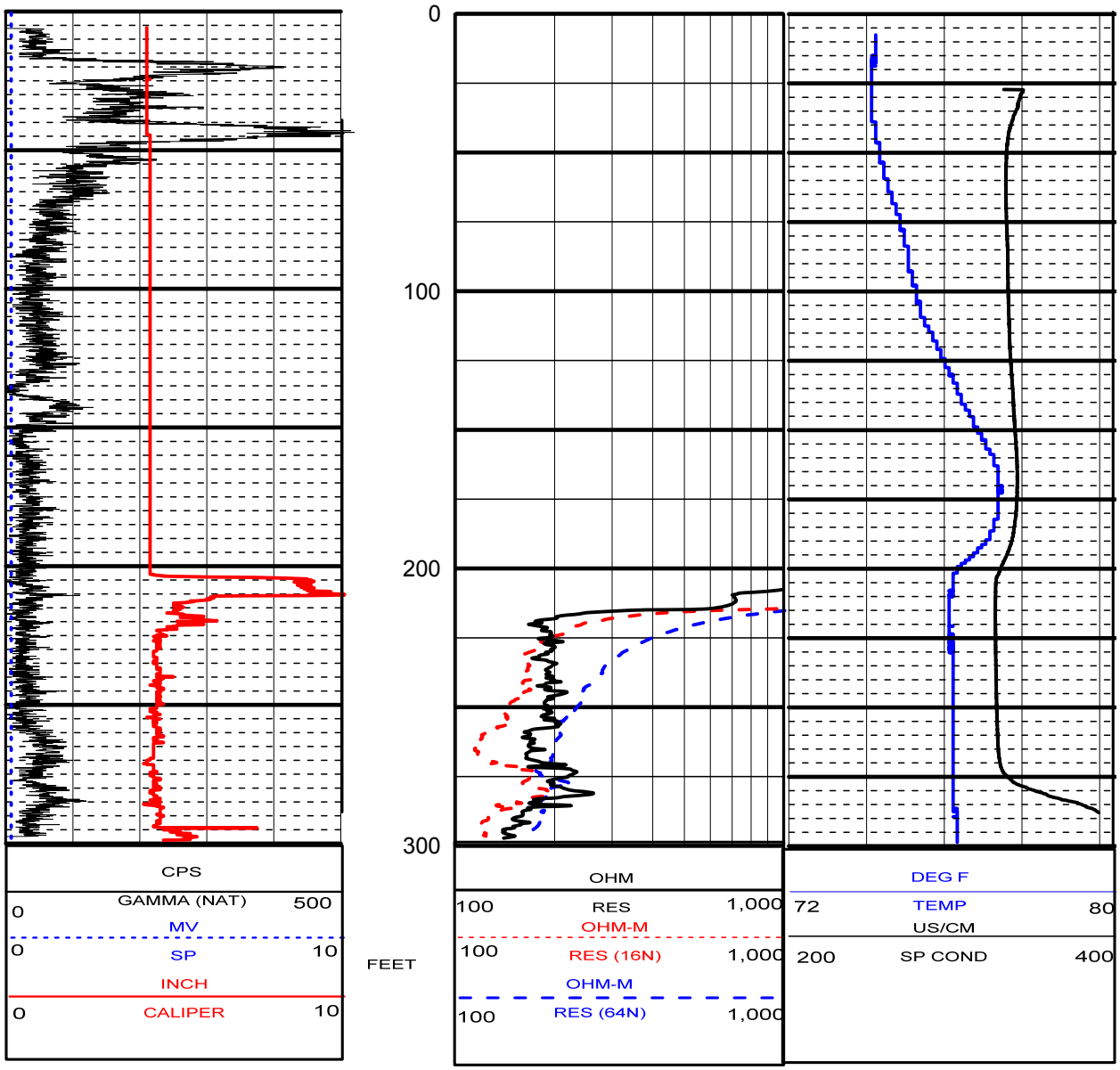


Figure C-13. Dover North (Cork Prairie) Geophysical suite for the DRILLING WATER SUPPLY TEMP. Logging was performed on 10/4/2011 using the 9064 A (caliper) tool and the 8144 C (multi) tool. Four-inch diameter PVC casing was installed from land surface to 215 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

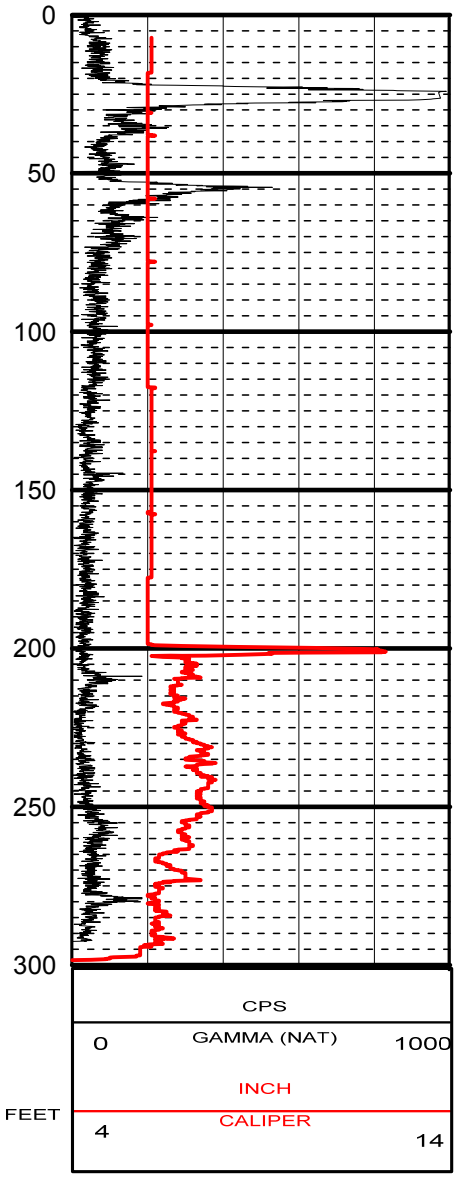


Figure C-14. Dover North (Cork Prairie) Geophysical suite for the SWNN MONITOR well. Logging was performed on 1/5/2012 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 195 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet.

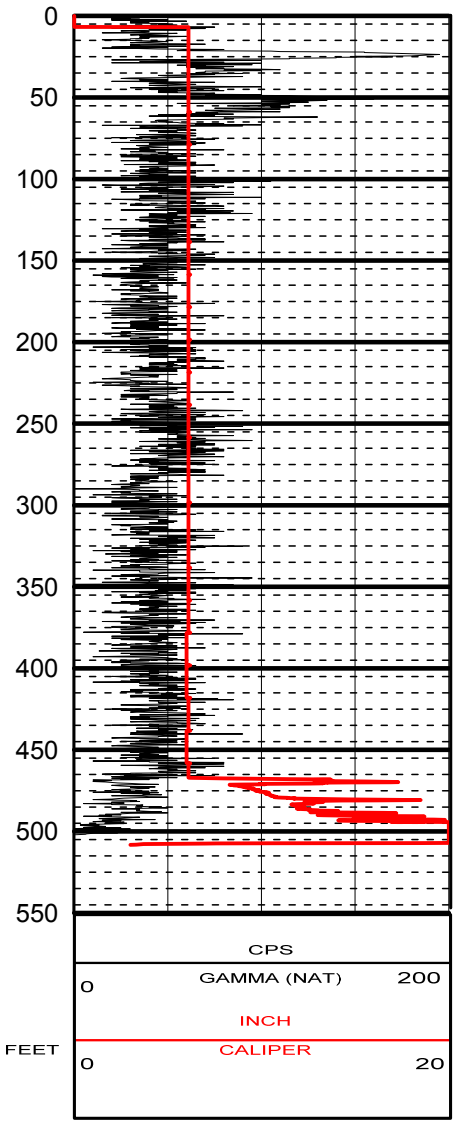


Figure C-15. Dover North (Cork Prairie) Geophysical suite for the AVPK PZ MONITOR. Logging was performed on 1/5/2012 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 470 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet.

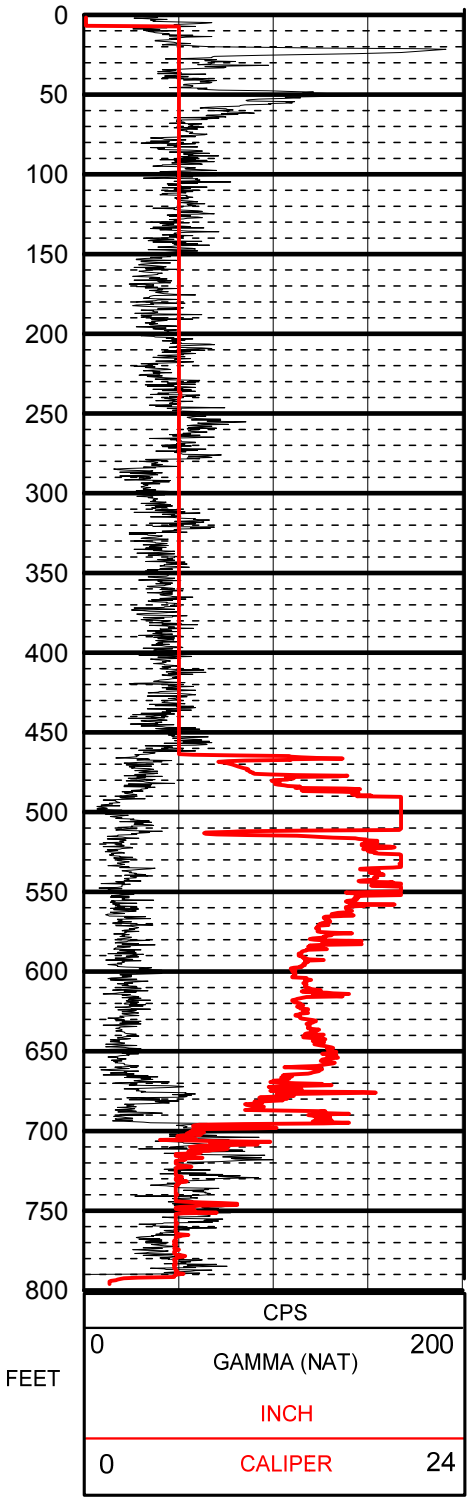


Figure C-16. Dover North (Cork Prairie) Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 1/8/2012 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 470 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet.

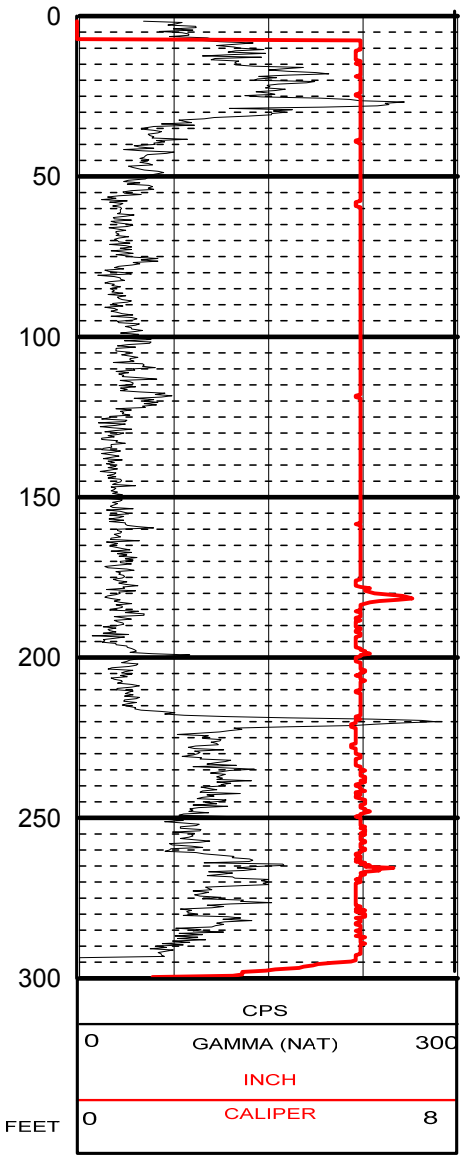


Figure C-17. Dover West (Mango) Geophysical suite for the SWNN PZ MONITOR. Logging was performed on 1/18/2012 using the 9165 C (caliper-gamma) tool. Six-inch diameter PVC casing was installed from land surface to 180 feet bls at the time of logging. The vertical scale is 1-inch per 50 feet.

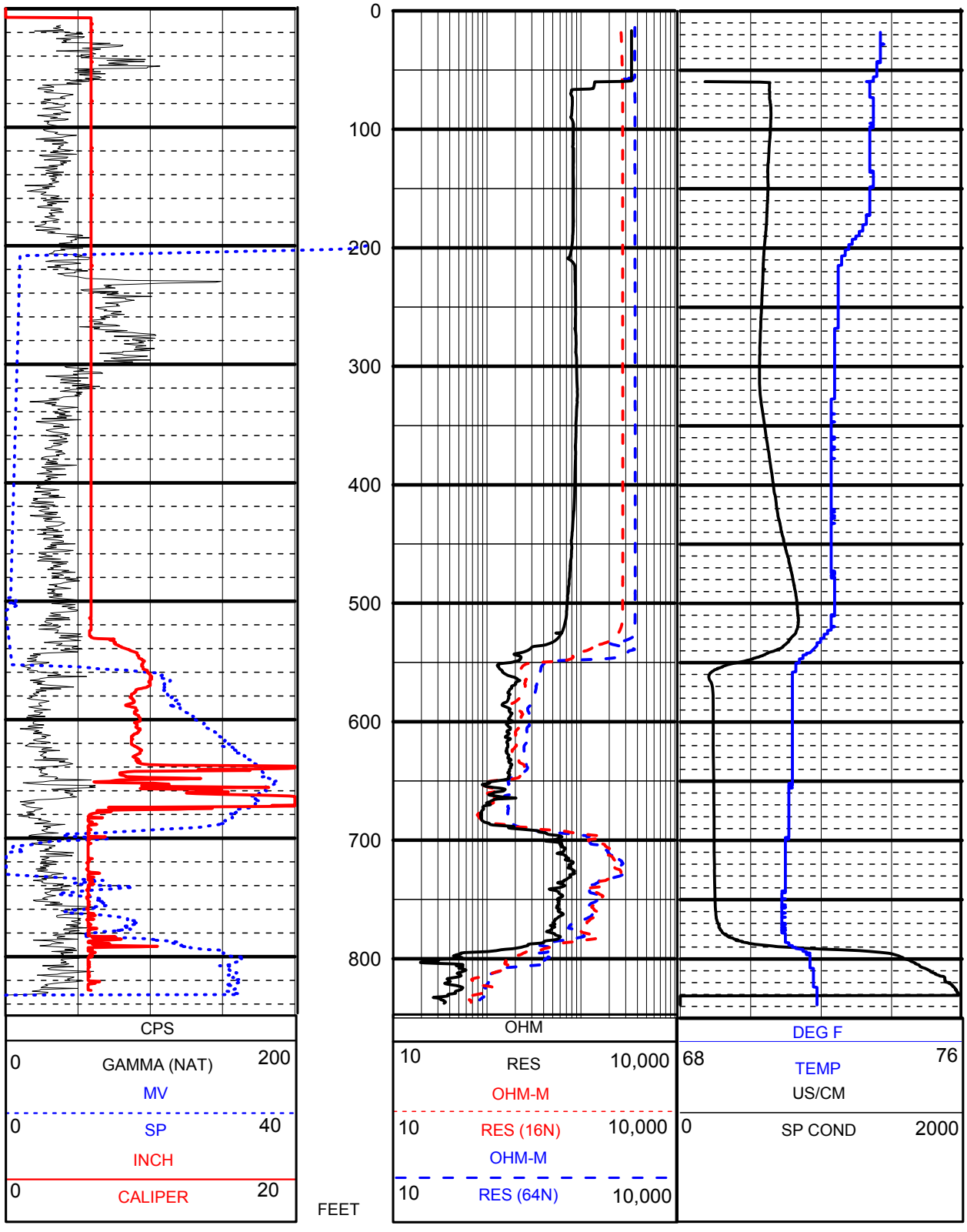


Figure C-18. Dover West (Mango) Geophysical suite for the AVPK PZ MONITOR well. Logging was performed on 1/18/2012 using the 9165 C (caliper-gamma) tool and the 8143 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 530 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

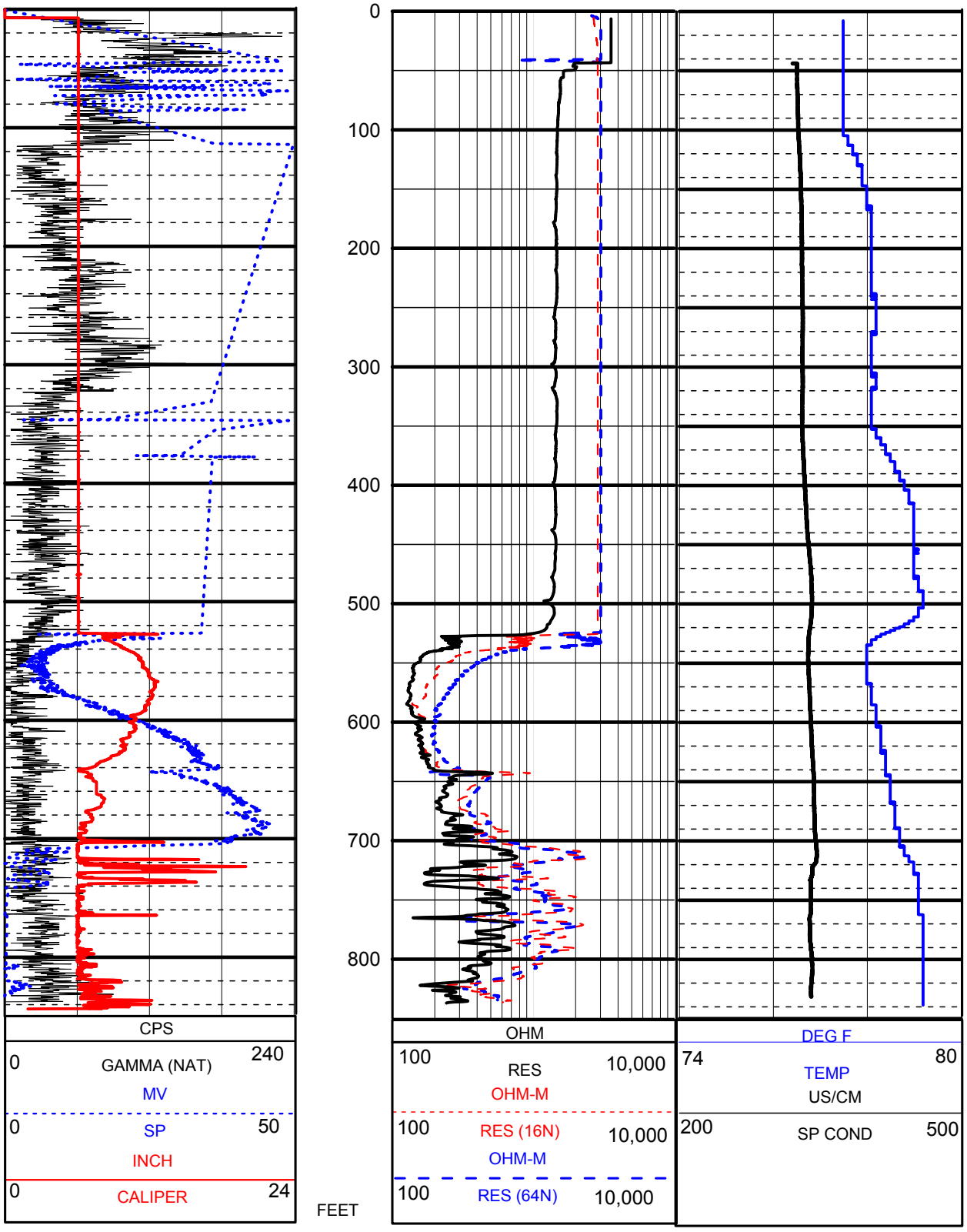
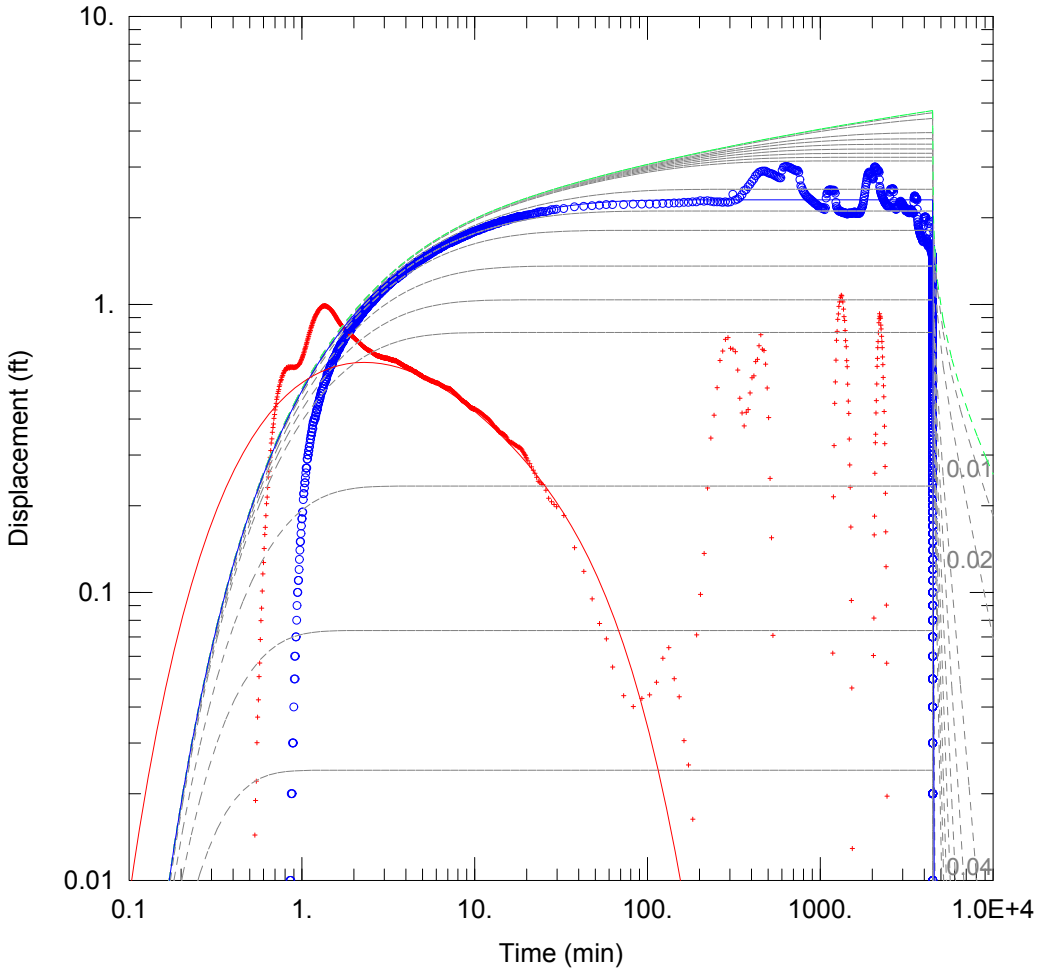


Figure C-19. Dover South Geophysical suite for the AVPK PZ MONITOR. Logging was performed on 3/8/2012 using the 9165 C (caliper-gamma) tool and the 8144 C (multi) tool. Six-inch diameter PVC casing was installed from land surface to 530 feet bls at the time of logging. The vertical scale is 1-inch per 100 feet. Tracks 1 and 3 are linear scale and track 2 is logarithmic scale.

Appendix D: Aquifer Performance Test Curve Matches



WELL TEST ANALYSIS

Data Set: D:\...\SWNN_DD_and_REC_CORR_Hantush_DD.aqt
Date: 06/10/13 Time: 10:19:10

PROJECT INFORMATION

Client: SWFWMD
Project: DOVER
Location: Bealsville
Test Well: 6-inch SWNN
Test Date: 5/14/2012

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
6-inch SWNN	0	0

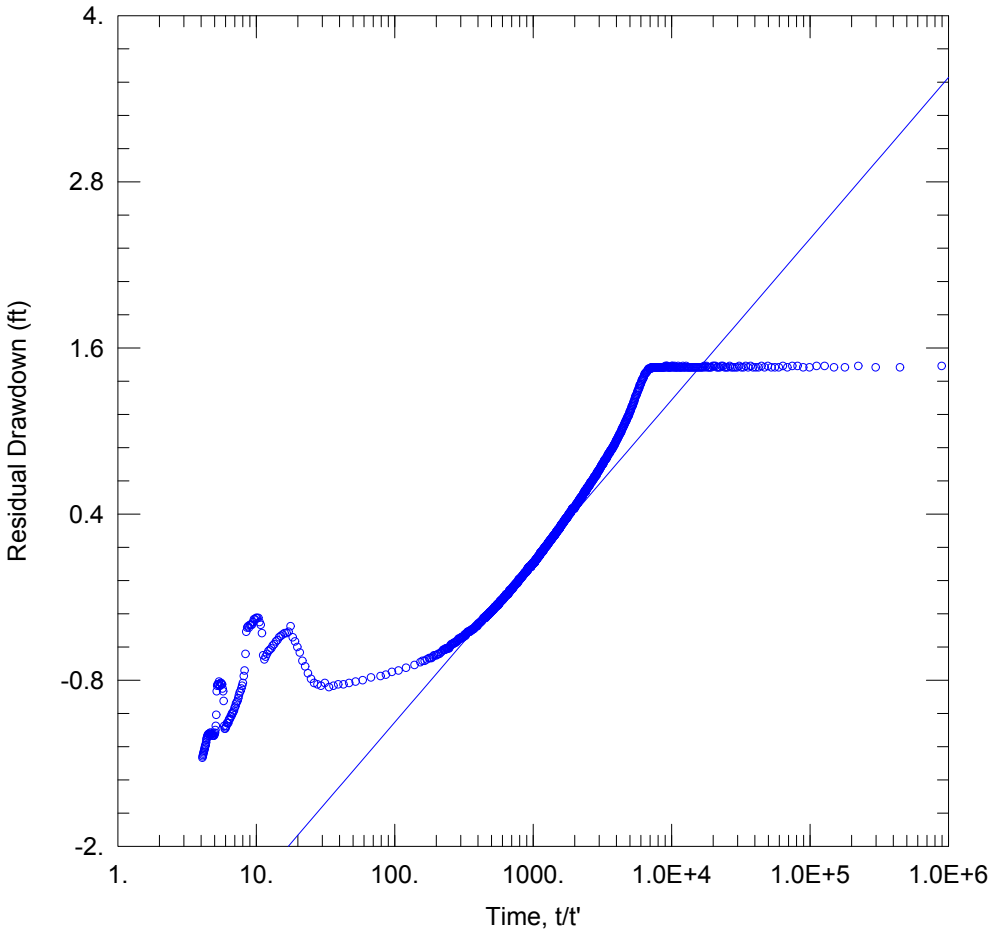
Observation Wells

Well Name	X (ft)	Y (ft)
○ 4" SWNN OB	80	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 3739.1 ft^2/day
S = 0.0009127
r/B = 0.2468
Kz/Kr = 0.1
b = 290. ft



WELL TEST ANALYSIS

Data Set: D:\...\SWNN_DD_and_REC_Theis_Rec.aqt
Date: 06/10/13 Time: 10:12:56

PROJECT INFORMATION

Client: SWFWMD
Project: DOVER
Location: Bealsville
Test Well: 6-inch SWNN
Test Date: 5/14/2012

AQUIFER DATA

Saturated Thickness: 290. ft Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
6-inch SWNN	0	0

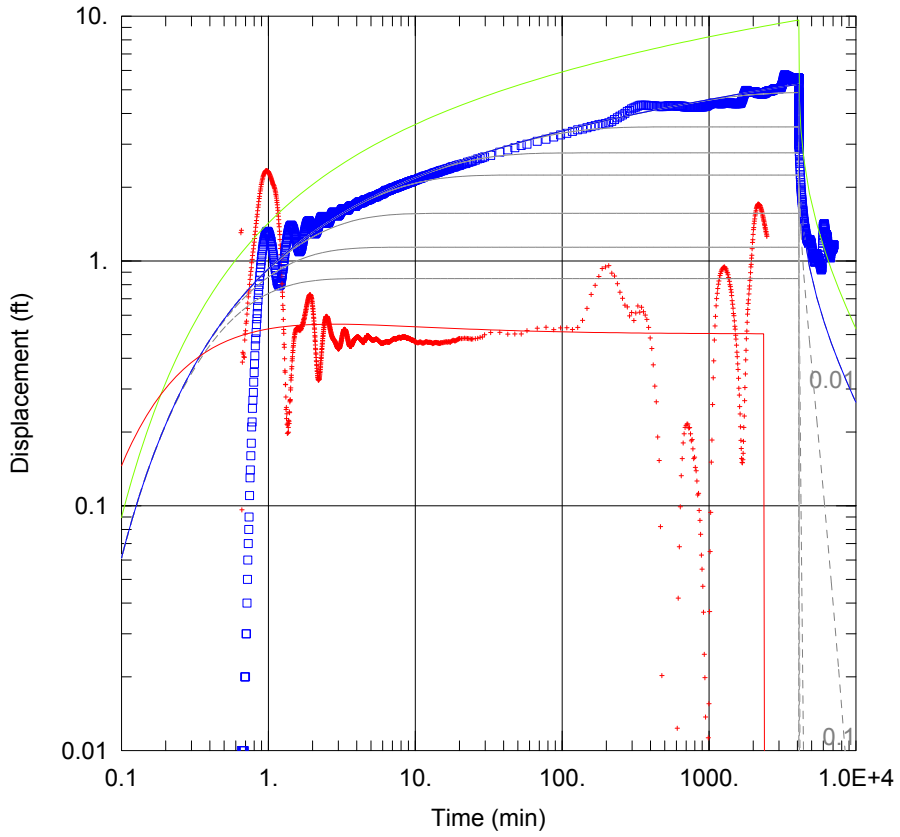
Observation Wells

Well Name	X (ft)	Y (ft)
○ 4" SWNN OB	80	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 3210.9 ft^2/day S/S' = 889.1



WELL TEST ANALYSIS

Data Set: D:\...\AVPK_DD_REC_CORR_DD_Hantush.aqt
Date: 07/22/13 Time: 15:50:52

PROJECT INFORMATION

Client: SWFWMD
Project: DOVER
Location: Bealsville
Test Well: 14-inch AV PK
Test Date: 5/29/2012

AQUIFER DATA

Saturated Thickness: 490. ft
Aquitard Thickness (b'): 150. ft
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 300. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
14-inch AV PK	0	0

Observation Wells

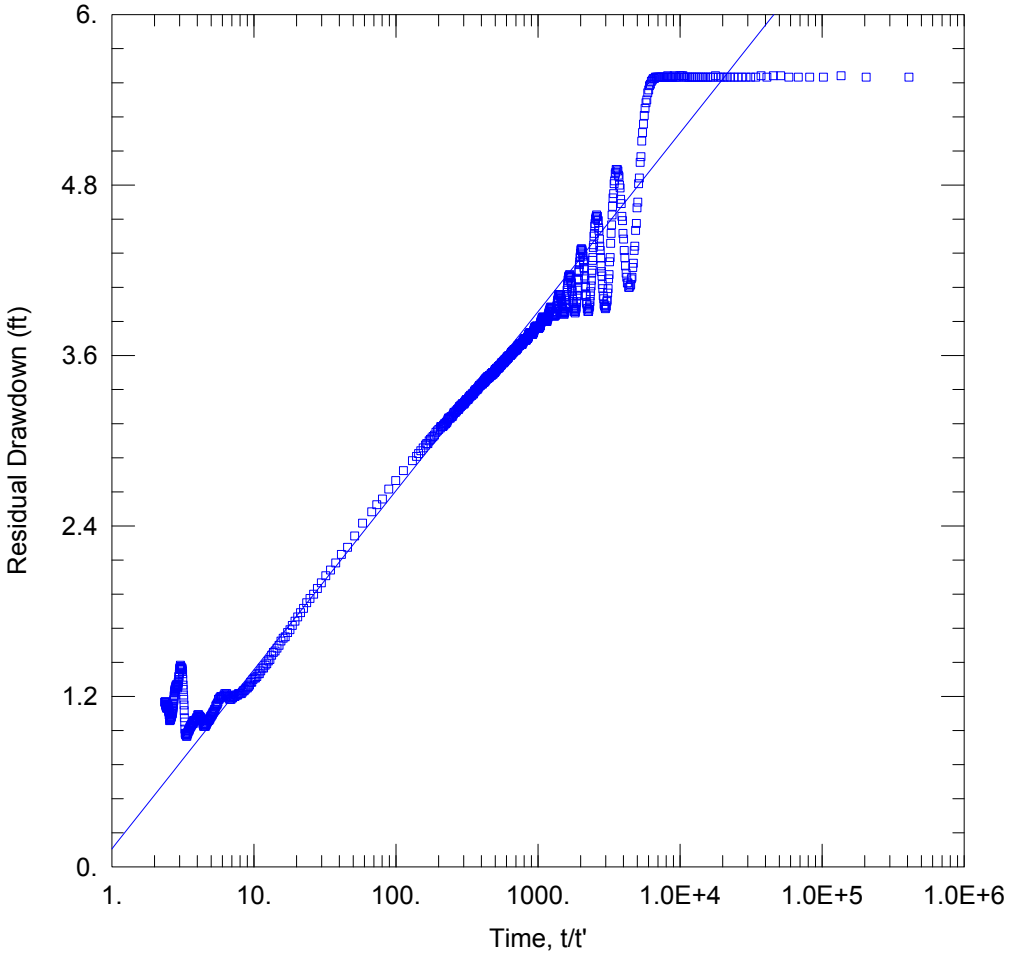
Well Name	X (ft)	Y (ft)
▫ 6-inch Av Pk OB	140	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 3.661E+4 ft^2/day
r/B' = 0.01
r/B" = 0.

S = 0.0008198
ß' = 0.1794
ß" = 0.



WELL TEST ANALYSIS

Data Set: D:\...\AVPK_DD_REC_CORR_Theis_REC.aqt
Date: 07/22/13 Time: 15:42:28

PROJECT INFORMATION

Client: SWFWMD
Project: DOVER
Location: Bealsville
Test Well: 14-inch AV PK
Test Date: 5/29/2012

AQUIFER DATA

Saturated Thickness: 490. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
14-inch AV PK	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
6-inch Av Pk OB	140	0

SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 6.732E+4 ft^2/day S/S' = 0.7943