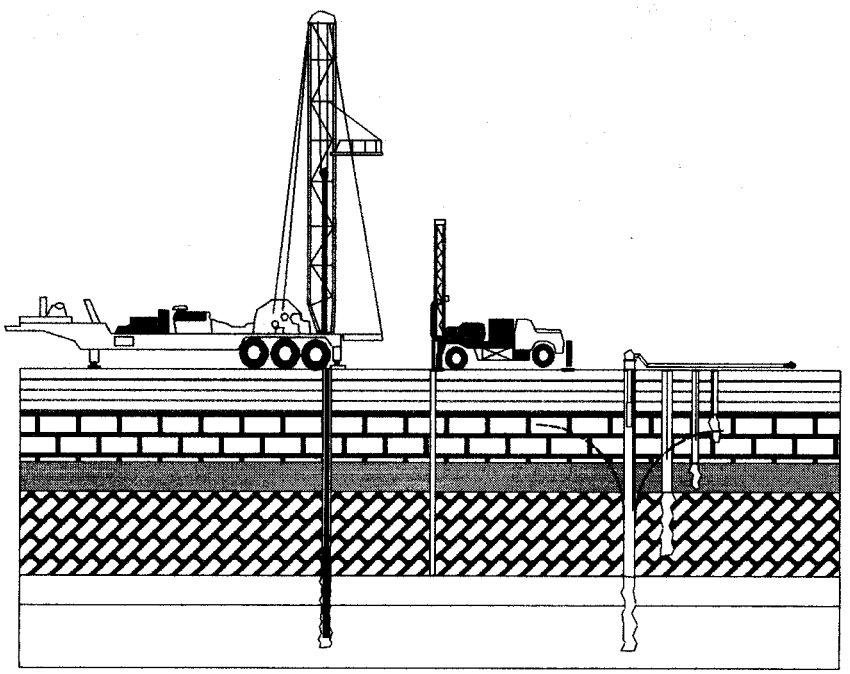
ROMP 25 LILY
MONITOR WELL SITE
HARDEE COUNTY, FLORIDA

PHASE THREE

AQUIFER PERFORMANCE TESTING



Geohydrologic Data Section
Resource Data Department
Southwest Florida Water Management District
June 2000

THE AMERICANS WITH DISABILITIES ACT INFORMATION

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ROMP 25 LILY
MONITOR WELL SITE
HARDEE COUNTY, FLORIDA

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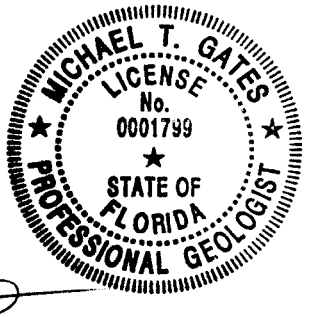
AQUIFER PERFORMANCE TESTING

June 2000

The geological evaluations and interpretations contained in the *ROMP 25 Aquifer Performance Testing Report* have been prepared by or approved by a licensed Professional Geologist in the State of Florida, in accordance with Chapter 492 Florida Statutes.



M. T. Gates

Michael T. Gates
Professional Geologist
License No. PG 1799

Date: 6-8-2000

ROMP 25 LILY
MONITOR WELL SITE
HARDEE COUNTY, FLORIDA

PHASE THREE

AQUIFER PERFORMANCE TESTING

By M. T. Gates, P. G.

Southwest Florida Water Management District

Resource Data Department
Timothy De Foe, Director

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June 2000

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1.0 INTRODUCTION

The ROMP 25 (WRAP S-6) Lily well site is one of six Regional Observation and Monitor-Well Program (ROMP) well sites constructed for the southern Water Resource Assessment Project (WRAP). The WRAP is a long-term study of the ground-water systems in all of DeSoto, Hardee, Manatee, and Sarasota Counties and portions of Charlotte, Highlands, Hillsborough, and Polk Counties (Figure 1).

The ROMP 25 Well Site was obtained by the Southwest Florida Water Management District (SWFWMD) in February 1994 for construction of a multiple well monitor site. Drilling, testing, and monitor well construction at ROMP 25 was planned in three phases. The first phase involved core drilling from land surface to 1,048 feet below land surface (bls) to define the stratigraphy and hydrology of the site. This phase began December 1995 and was completed in May 1996. The results are presented in *ROMP 25 -Phase One - Core Drilling and Testing* (Gates, 1998). The second phase, exploratory drilling and monitor well construction, began in August 1996 and continued on an intermittent basis until March 1998. The exploratory results are presented in *ROMP 25 - Phase Two - Exploratory Drilling and Monitor Well Construction* (Gates, 1999). The third and final phase of the work, aquifer performance testing, was completed in May of 1999. This report presents the aquifer performance test results.

2.0 SITE LOCATION

The ROMP 25 (WRAP S-6) Lily well site is located in Hardee County, southwest of Zolfo Springs, Florida (Figure 2). The well site is located on the south side of Roberts Road in the northeast quarter of the northeast quarter of Section 9, Township 36 South, Range 23 East at latitude 27° 21' 59" , longitude 82° 00' 25.5" (Figure 3). Land surface elevation at the well site is approximately 85 feet above the National Geodetic Vertical Datum of 1929 (NGVD). Figure 4 presents the well site layout and monitor well locations.

3.0 AQUIFER PERFORMANCE TESTING

Aquifer performance tests (APT) were conducted to determine the hydraulic properties of the permeable and confining units at ROMP 25. A diagram of the conceptual hydrogeology at ROMP 25, illustrating the permeable and confining zones, is presented in Figure 5. Aquifer performance tests were conducted on the surficial and intermediate aquifers and on the Suwannee Limestone and Avon Park permeable zones of the Upper Floridan aquifer. Short-duration single well pumping tests were performed on the surficial and intermediate aquifers. The Suwannee Limestone and Avon Park aquifer tests were longer duration and utilized observation wells for the analyses. Figures 6 - 12 present the well construction diagrams for all ROMP 25 wells. Table 1 presents the well construction details.

An In-Situ® data logger and pressure transducers were used to measure and record the water level changes in the wells during the aquifer tests. The data collected was analyzed using the AquiferTest® for Windows version 2.57 software (Waterloo Hydrogeologic, Inc. 1997). The analytical methods used in the software are based on equations and mathematical models developed by Cooper and Jacob (1946), Hantush & Jacob (1955), and Theis (1935). A description of each method used in the AquiferTest® software is presented in Appendix A, B, and C, respectively.

3.1 SURFICIAL AQUIFER SYSTEM APT

A short term, single-well, aquifer performance test was performed on the 4-inch surficial monitor well on May 22, 1996. The water level at the start of pumping was 8.13 feet below top of casing (TOC) or 80.77 feet above the National Geodectic Vertical Datum of 1929 (NGVD). The well was pumped with a gasoline powered centrifugal pump at 37 gallons per minute (gpm) for 260 minutes. Maximum drawdown during the test was 15 feet. The pump was stopped and the recovery of the water level in the pumped well was recorded. Figure 13 presents a graph of the recovery data from the 4-inch surficial well.

The recovery data was analyzed with the AquiferTest® Theis and Jacob recovery method. Figure 14 presents the curve match data for the Theis and Jacob recovery method. The results are presented below and in Table 2.

Theis and Jacob Recovery Method

Transmissivity (ft^2/day):	**2.73×10^{2}**
Horizontal hydraulic conductivity (ft/day) :	**9.10×10^{0}**

3.2 INTERMEDIATE AQUIFER SYSTEM APT

The intermediate aquifer system (IAS) at the ROMP 25 well site is comprised of one poorly transmissive semi-permeable zone located entirely within the Arcadia Formation. The Arcadia/IAS APT was performed on February 9, 1999. The water level in the permanent 8-inch Arcadia well was 22.25 feet below TOC or 65.05 feet NGVD. A 4-inch submersible pump was set at 60 feet below the static water level. The well was pumped at 45 gpm for 7 minutes before the water level drew down to the top of the pump. The pump was stopped and the recovery of the water level in the pumped well was recorded. The water level in the pumped well recovered to within 1.5 feet of the pre-pumping water level after 8.8 days (12,660 minutes). Figure 15 presents a graph of the recovery data from the pumped well.

The data from the drawdown phase of the test was not analyzed since the water level drew down to the top of pump and did not achieve steady state conditions. The recovery data from the 8-inch pumped well was analyzed using the AquiferTest® Theis and Jacob recovery method. Figure 16 presents the curve match data for the Theis and Jacob recovery method. The results are presented below and in Table 2.

Theis and Jacob Recovery Method

Transmissivity (ft^2/day):	**5.47×10^{-1}**
Horizontal hydraulic conductivity (ft/day) :	**1.36×10^{-2}**

3.3 SUWANNEE LIMESTONE APT

The Suwannee Limestone aquifer performance test was conducted in December 1998. Prior to the drawdown phase, water level changes were recorded in all permanent monitor wells from December 7, 1998 to December 9, 1998. The District-owned line-shaft turbine pump was installed into the 12-inch Suwannee permanent well and a step test was performed on December 9, 1998. Background water level changes were recorded again from December 10 to December 14, 1998. Figure 17 presents a hydrograph of the UFA for December 1998. The drawdown phase was conducted from December 14, 1998 to December 16, 1998 (Figure 18). The recovery phase was recorded from December 16, 1998 to December 29, 1998 (Figure 19).

3.3.1 Test Methods

The 12-inch Suwannee Limestone/UFA permanent well was pumped with a 30 horse-power (HP) diesel powered line-shaft turbine pump at 500 gpm for 33 hours. The discharge water was pumped through a 6-inch flexible hose 150 feet to a creek southeast of the wellsite. The discharge rate was measured with an in-line flow-meter and a manometer tube. During the APT, water level changes in the 4-inch surficial, 8-inch Arcadia/IAS, 12-inch Suwannee pumped well, 2-inch Suwannee OB well, and 18-inch Avon Park well were recorded on a data logger.

3.3.2 Test Results

The water level in 12-inch Suwannee Limestone/UFA prior to pumping was 62.42 feet below TOC or 25.2 feet above NGVD. Maximum drawdown in the 12-inch Suwannee pumped well during pumping was 20 feet. Maximum drawdown in the 2-inch Suwannee OB well was 6.5 feet. A slight drawdown (0.15 feet) occurred in the 8-inch Arcadia/IAS monitor well during pumping. Slight increases (0.15 feet - 0.20 feet) occurred in the water levels of the 4-inch surficial monitor well and the 18-inch Avon Park monitor well during pumping. The water level changes in the monitor wells during the drawdown phase are shown in Figure 18.

The regional water level trend for the UFA was increasing prior to the drawdown phase of the Suwannee Limestone APT. A regression analysis was performed on the water level data collected just prior to the start of the drawdown phase. The results of the analysis indicate the regional water level was rising at 0.0005 feet/minute. The water level data used in the AquiferTest® drawdown analyses has been corrected to account for this trend.

The recovery phase of the test was recorded for 13 days (December 16, 1998 to December 29,1998) after the pump was turned off. A slight delay occurred in recording the water levels after turning off the pump, as a result, approximately the first minute of recovery data was not recorded. The water level in the 2-inch Suwannee OB well began to recover immediately after the pump was turned off and was fully recovered after 500 minutes. Figure 19 shows the water level trends of the ROMP 25 wells for the 13 days after the pump was turned off. The sharp drawdown and recovery water level fluctuations shown in the Suwannee wells are due to pumping of nearby wells for citrus irrigation.

The drawdown data collected from the 2-inch Suwannee/UFA OB well was analyzed using the *Cooper & Jacob Time Drawdown Method* and the *Hantush Method (leaky, no aquitard storage)*. The recovery data collected from the 2-inch Suwannee/UFA OB well was analyzed using the *Theis & Jacob Recovery Test Method (confined)*. Figures 20, 21, and 22 present the curve matches for each method. The data results for each method are presented below and in Table 2.

Cooper and Jacob Time Drawdown Method

Transmissivity (ft^2/day):	**8.44×10^3**
Horizontal hydraulic conductivity (ft/day) :	**2.25×10^1**
Storativity :	**7.36×10^{-5}**

Hantush Method (leaky, no aquitard storage)

Transmissivity (ft^2/day):	**6.82×10^3**
Horizontal hydraulic conductivity (ft/day) :	**1.82×10^1**
Storativity :	**1.31×10^{-4}**

Hydraulic Resistance (days):	**1.50×10^{3}**	(See Appendix B)
Leakance ($days^{-1}$):	**6.67×10^{-4}**	(See Appendix B)

Theis & Jacob Recovery Test Method (confined)

Transmissivity (ft^2/day):	**8.16×10^{3}**
Horizontal hydraulic conductivity (ft/day) :	**2.17×10^{1}**

3.4 AVON PARK FORMATION APT

The Avon Park Formation aquifer performance test was conducted in May 1999. Prior to the drawdown phase the water level changes in all permanent wells were recorded from April 7, 1999 to May 3, 1999. Figure 23 presents a composite hydrograph of the UFA for April and May 1999. The drawdown phase was conducted from May 4, 1999 to May 7, 1999 (Figure 24). The recovery phase was conducted from May 7, 1999 to May 20, 1999 (Figure 25).

3.4.1 Test Methods

The 18-inch Avon Park Formation/UFA well was pumped with a 400 HP diesel powered line-shaft turbine pump at 4,700 gpm for 72 hours. The discharge water was pumped through 12-inch diameter poly-vinyl chloride (PVC) pipe 150 feet to a creek southeast of the site. The discharge rate was measured with an in-line flow-meter and an orifice plate and manometer tube. The supply, installation, operation and removal of the pump and discharge system was contracted to a private company (Diversified Drilling Corporation).

During the drawdown and recovery phases of the test, water level changes in the 18-inch Avon Park pumped well, 2-inch Avon Park OB well, 12-inch Suwannee Limestone well, 6-inch Evaporite/confining unit well, and 4-inch surficial well were recorded on a data logger. It should be noted that the 2-inch Avon Park OB well is a partially penetrating well (Figure12). The casing depth is equal to the pumped well (970 feet bls) but the total depth of the well is 1,556 feet bls compared to 1,785 feet of the pumped well (Figure 9).

3.4.2 Test Results

The water level in the 18-inch Avon Park Formation well prior to pumping was 87.40 feet below TOC or 0.60 feet below NGVD. During pumping the water level in the 18-inch Avon Park pumped well stabilized at 45 feet of drawdown. The water level in the 2-inch Avon Park OB well (located 500 feet west of the pumped well) had decreased nearly 4 feet after 4200 minutes. Pumping from offsite wells was responsible for the marked decline in the 2-inch Avon Park OB well after 1000 minutes (Figure 24). Only the data from the 0 to 200 minutes portion of the test was used in the drawdown analysis. The transducer installed in the 12-inch Suwannee permanent well failed at the beginning of the drawdown phase. A replacement transducer was installed in the well approximately 600 minutes after the start of the drawdown phase (Figure 24).

The regional water level trend for the UFA was increasing during the Avon Park APT. A regression analysis was performed on the water level data collected just prior to the start of the drawdown phase. The results of the analysis indicate the regional water level was rising at 0.0006 feet/minute. The water level data used in the AquiferTest® drawdown analyses has been corrected to account for this trend.

The recovery phase of the test was conducted for 13 days from May 7, 1999 to May 20, 1999. The water level recovery in the 2-inch Avon Park OB well began to recover slowly for 2000 minutes after turning off the pump. The water level in the 2-inch Avon Park well appeared to be influenced by offsite pumping after 2000 minutes. Figure 25 shows the water level trends in the ROMP 25 monitor wells during the recovery phase.

The drawdown data collected from the Avon Park OB well was analyzed using the *Cooper & Jacob Time Drawdown Method* and the *Hantush Method (leaky, no aquitard storage)*. The recovery data collected from the Avon Park OB well was analyzed using the *Theis & Jacob Recovery Test Method (confined)*. Figures 26, 27, and 28 present the curve match data for each method, respectively. The data results for each method are presented below and in Table 2.

Cooper and Jacob Time Drawdown Method

Transmissivity (ft^2/day): **2.80×10^5**

Horizontal hydraulic conductivity (ft/day) :	**3.34×10^{2}**	
Storativity :	**3.31×10^{-4}**	

Hantush Method (leaky, no aquitard storage)

Transmissivity (ft^2/day):	**2.86×10^{5}**	
Horizontal hydraulic conductivity (ft/day) :	**3.41×10^{2}**	
Storativity :	**2.57×10^{-4}**	
Hydraulic Resistance (days):	**8.72×10^{3}**	(See Appendix B)
Leakance ($days^{-1}$):	**1.15×10^{-4}**	(See Appendix B)

Theis & Jacob Recovery Test Method (confined)

Transmissivity (ft^2/day):	**3.83×10^{5}**
Horizontal hydraulic conductivity (ft/day) :	**4.56×10^{2}**

4.0 SUMMARY

A hydrogeologic investigation was completed in three phases at the ROMP 25 monitor wellsite in Hardee County, Florida. During phase one lithologic coring and testing of the site was performed to define the stratigraphy and hydrology of the site. Based on the results of phase one, monitor wells were designed and aquifer performance tests were planned.

Phase two of the project involved deep exploratory drilling and construction of the permanent and temporary monitor wells. Deep exploratory drilling was performed to characterize the permeable and confining units of Upper Floridan aquifer and locate the top of the mid-Floridan confining unit. The monitor wells were constructed for the aquifer performance tests and for collection of long-term water level and water quality data.

The third and final phase of the ROMP 25 investigation, aquifer performance testing, was conducted to determine the hydraulic properties of the aquifers and confining units at the wellsite. The hydraulic data collected from the ROMP 25 APT's will be incorporated into the southern district ground water model being developed by the Hydrologic Evaluation Section of the Resource Conservation and Development Department.

Following the completion of the aquifer testing activities all temporary observation wells were plugged and the 12-inch permanent Suwannee monitor well and the 18-inch permanent Avon Park monitor well were lined with 6-inch PVC casing.

5.0 REFERENCES

Batu, Vedat, 1998. Aquifer Hydraulics- a comprehensive guide to hydrogeologic data analysis. John Wiley & Sons, Inc.

Cooper, H. H., Jr., and Jacob, C. E., 1946. A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History. *Transactions, American Geophysical Union*, Vol. 27, No. 4.

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Hantush, M. S. and Jacob, C. E., 1955. Non-steady Radial Flow in an Infinite Leaky Aquifer and Non-steady Green's Function for an Infinite Strip of Leaky Aquifer. *Transactions, American Geophysical Union*, Vol. 37, No. 6.

Theis, C. V., 1935. The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage. *Transactions, American Geophysical Union*, Washington D.C., pp. 518-524.

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Tables

Table 1. Well Construction Details

Well Name	Formation Monitored	Aquifer Monitored	Casing Size and Type (as built)	Casing (notch) Elevation NGVD (feet)	Casing Interval (feet bls)	Monitored Interval (feet bls)
Permanent Wells						
Surficial	Undiff Surficial Deposits	Surficial Aquifer	4" PVC	88.898	+2 - 5	5 - 30
Arcadia/IAS	Arcadia Formation	Intermediate Aquifer	8" PVC	87.305	+2 - 105	105 - 145
Suwannee/UFA	Suwannee Limestone	Upper Floridan Aquifer	6" PVC	87.623	+2 - 300	300 - 676
Avon Park/UFA	Avon Park Formation	Upper Floridan Aquifer	6" PVC	86.804	+2 - 970	970 - 1785
Evaporite	Avon Park Formation	Mid-Floridan Confining Unit	6" PVC	88.482	+2 - 1866	1866 - 1911
Temporary Wells[1]						
Arcadia/IAS OB	Arcadia Formation	Intermediate Aquifer	2" PVC (dual zone)	88.324	+2 - 105	105 - 145
Suwannee/UFA OB	Suwannee Limestone	Upper Floridan Aquifer	2" PVC (dual zone)	88.503	+2 - 305	305 - 668
Avon Park/UFA OB	Avon Park Formation	Upper Floridan Aquifer	2" PVC	88.956	+2 - 970	970 - 1568

hydraulic.wb3

1 - Temporary wells plugged in January 2000.

Table 2. Aquifer Performace Test Results

Aquifer (feet bls)	Well Analyzed	Distance from pumped well (feet)	Method	Test Phase	Transmissivity (ft^2/day)	Horizontal hydraulic Conductivity (ft/day)	Storativity	Hydraulic Resistance (days)	Leakance[3] ($days^{-1}$)
Surficial (5 - 35)	4-inch Surficial pumped	0	Theis & Jacob	Recovery	2.73×10^{2}	9.10×10^{0}	N/A	N/A	N/A
IAS (105 -145)	8-inch IAS pumped	0	Theis & Jacob	Recovery	5.47×10^{-1}	1.36×10^{-2}	N/A	N/A	N/A
UFA (305 - 675)	2-inch Suwannee OB	160	Cooper & Jacob	Drawdown[1]	8.44×10^{3}	2.25×10^{1}	7.36×10^{-5}	N/A	N/A
UFA (305 - 675)	2-inch Suwannee OB	160	Hantush	Drawdown[1]	6.82×10^{3}	1.82×10^{1}	1.31×10^{-4}	1.50×10^{3}	6.67×10^{-4}
UFA (305 - 675)	2-inch Suwannee OB	160	Theis & Jacob	Recovery	8.16×10^{3}	2.17×10^{1}	N/A	N/A	N/A
UFA (970 - 1785)	2-inch Avon Park OB [2]	500	Cooper & Jacob	Drawdown[1]	2.80×10^{5}	3.34×10^{2}	3.31×10^{-4}	N/A	N/A
UFA (970 - 1785)	2-inch Avon Park OB	500	Hantush	Drawdown[1]	2.86×10^{5}	3.41×10^{2}	2.57×10^{-4}	8.72×10^{3}	1.15×10^{-4}
UFA (970 - 1785)	2-inch Avon Park OB	500	Theis & Jacob	Recovery	3.83×10^{5}	4.56×10^{2}	N/A	N/A	N/A

1 - Drawdown values corrected for regional water level trend.

hydraulic.wb3

2 - Two inch Avon Park OB well is partially penetrating (970 - 1568 feet bls)

3 - Leakance value derived from $b'/k' = B^{2}/T$ where b'/k' is hydraulic resistance, T is transmissivity, and B is leakance. See Appendix B. Leakance value applies only to confining unit directly above the pumped aquifer.

Figures

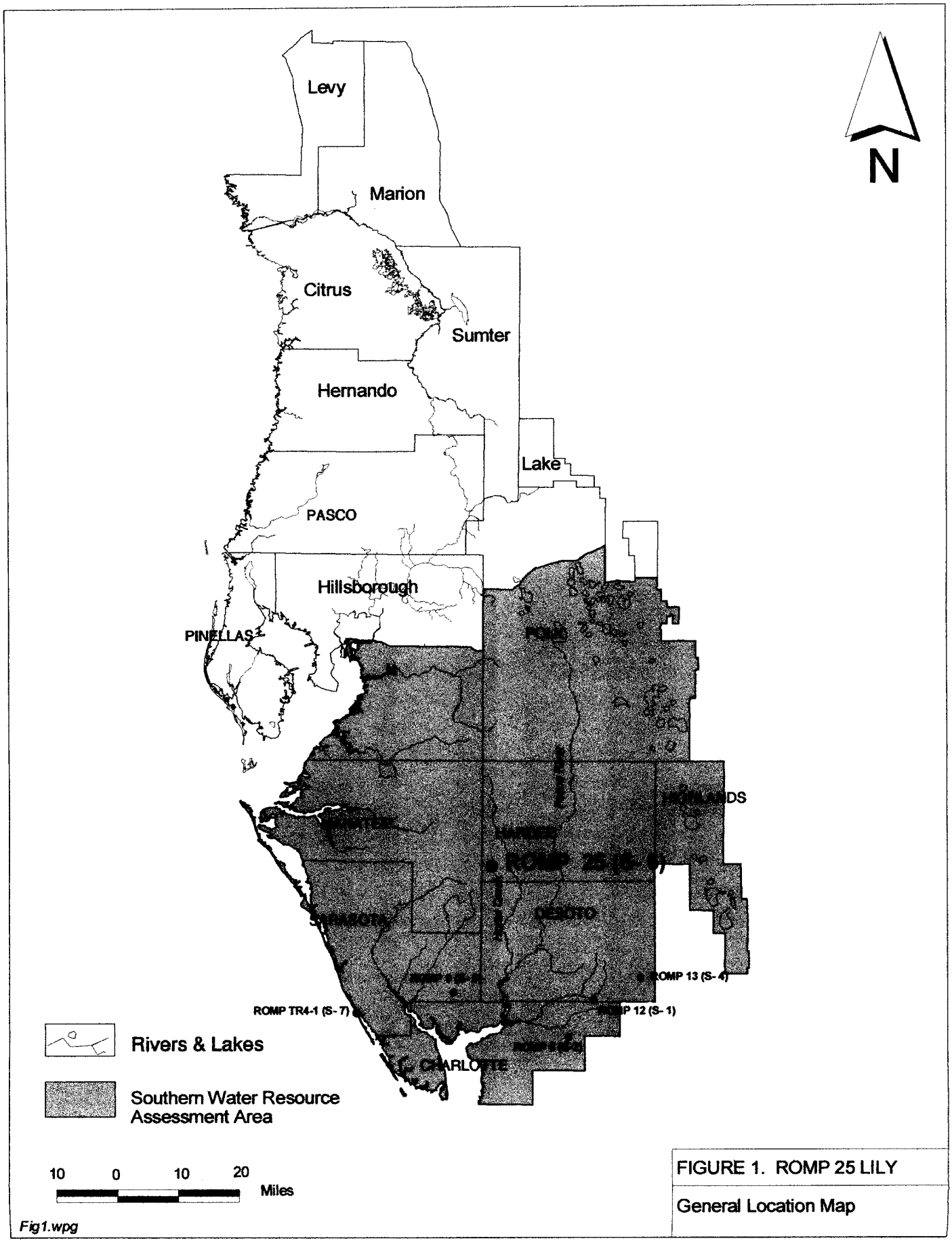


FIGURE 1. ROMP 25 LILY

General Location Map

Fig1.wpg

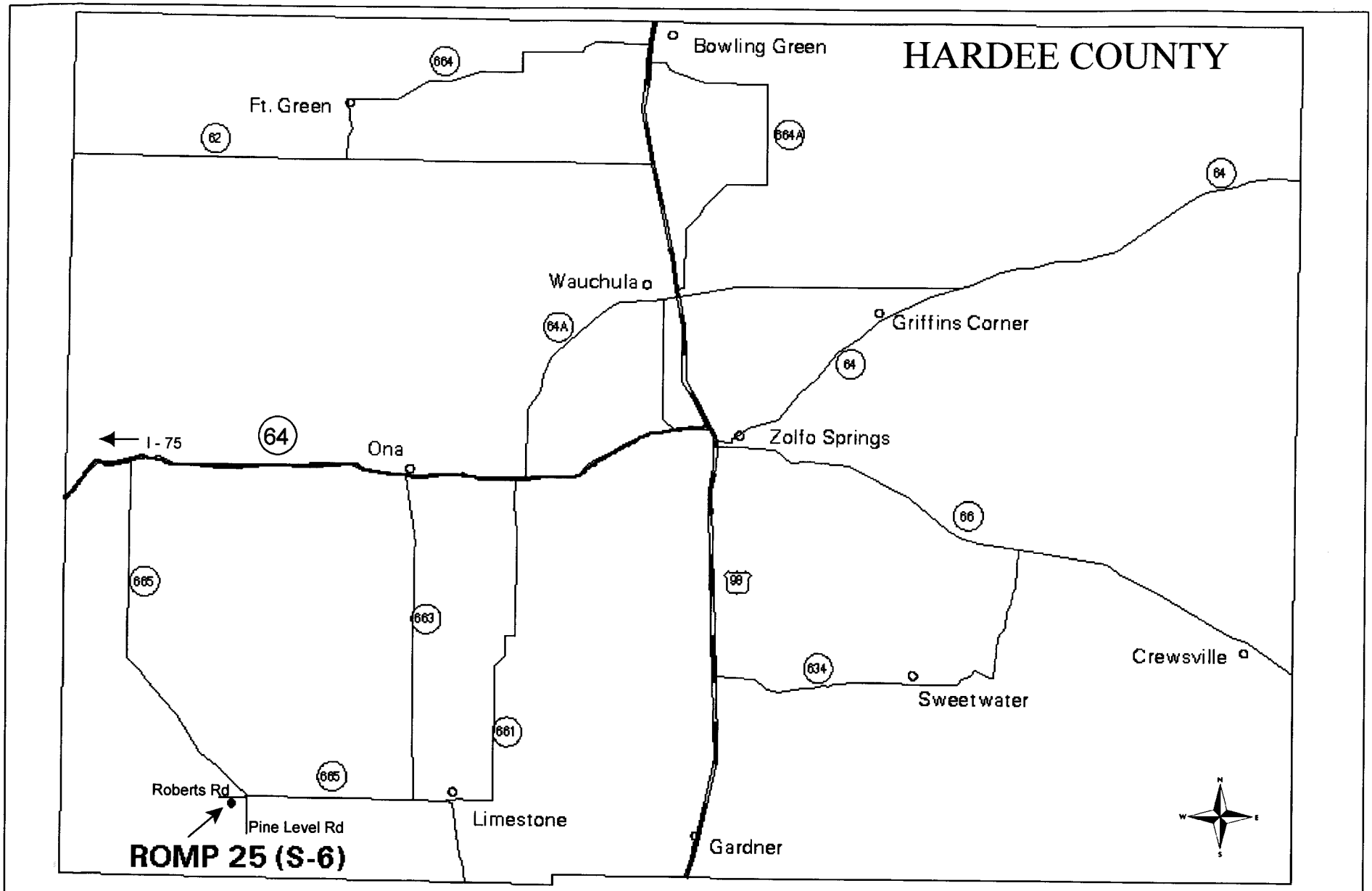
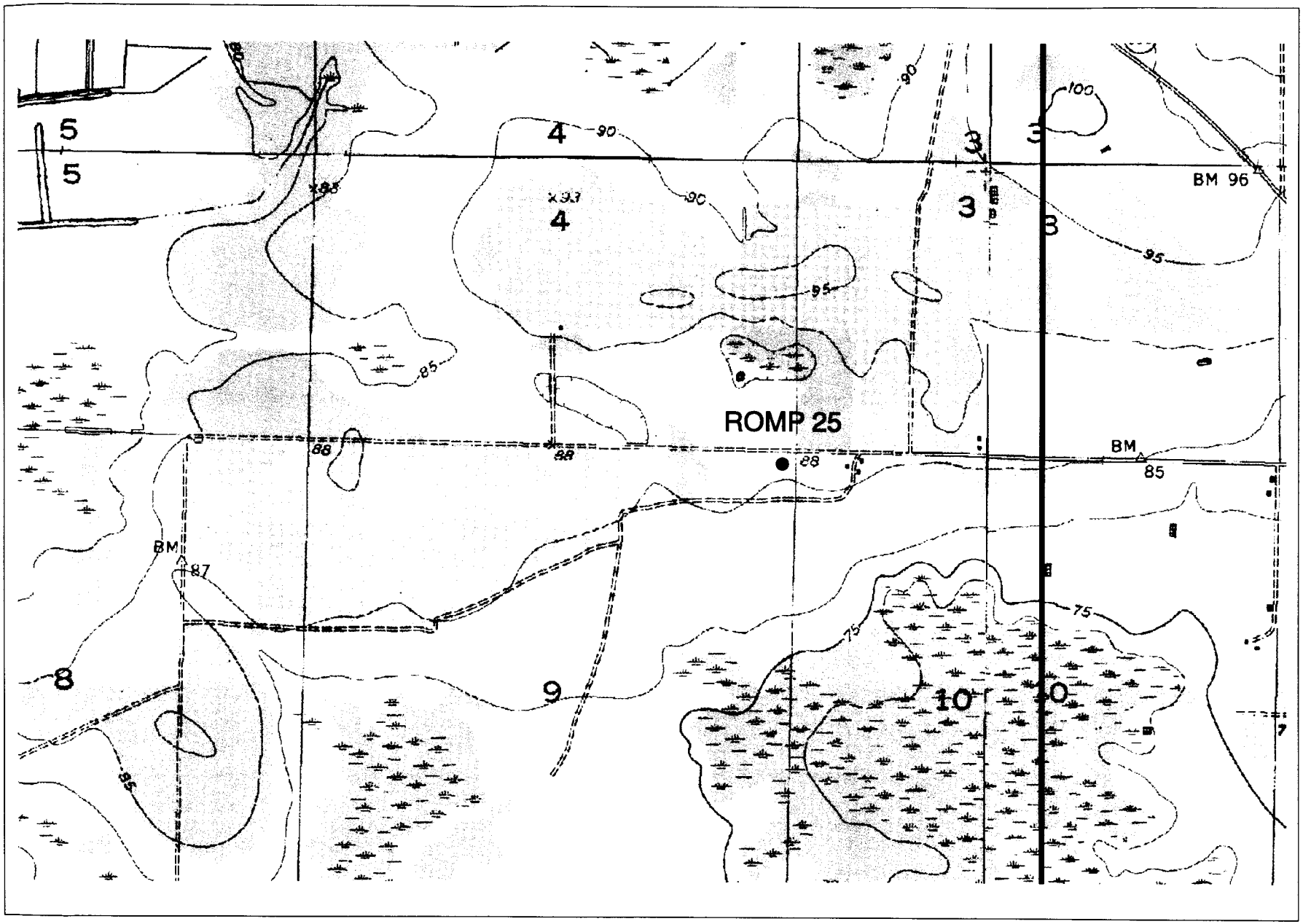


FIGURE 2. ROMP 25 LILY

Project Location Map



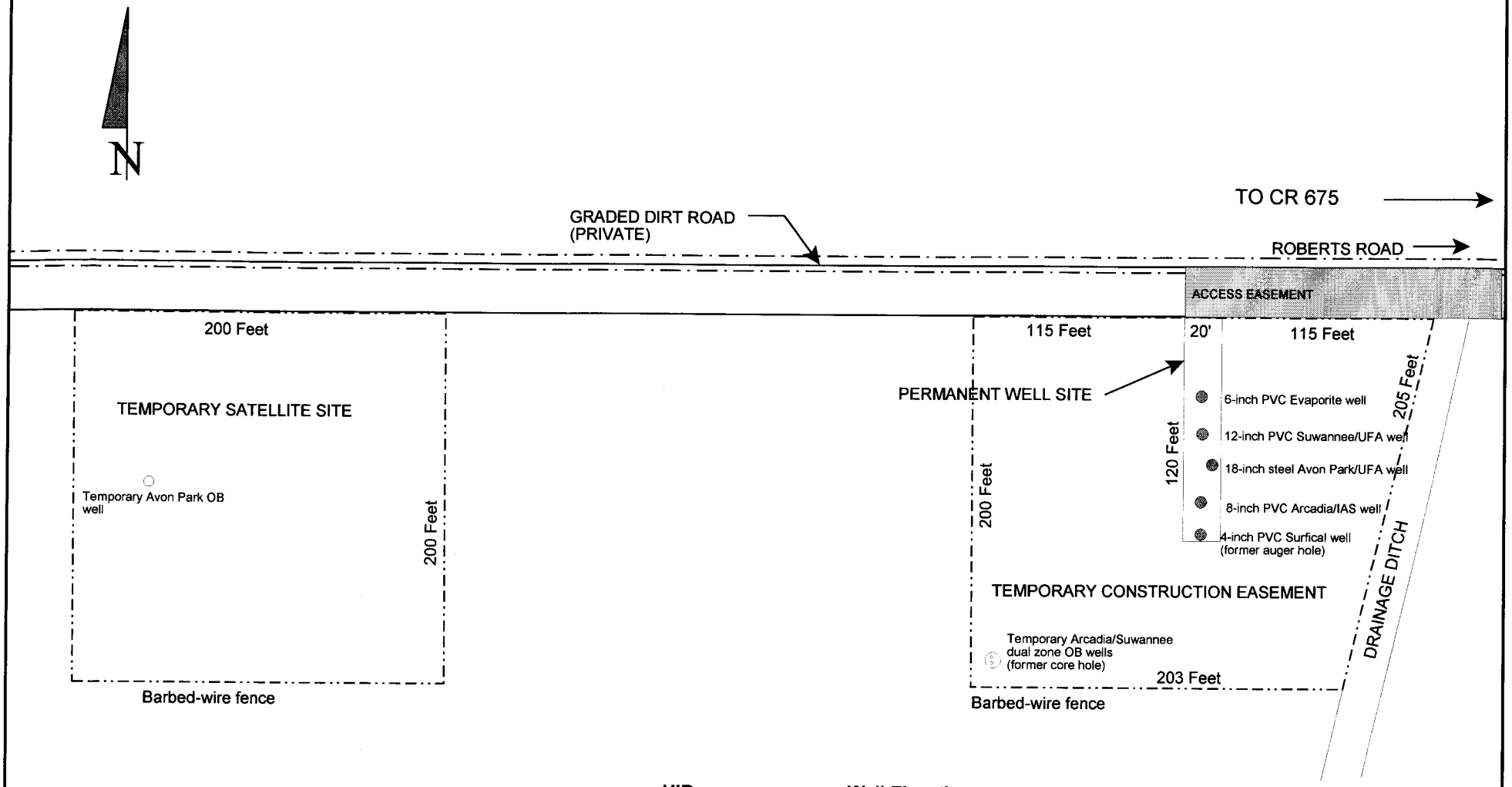
0.2 0 0.2 Miles

Hardee County
Edgeville Quadrangle
S9 T36S R23E
Lattitude: 27* 21' 59" N
Longitude: 82* 00' 25.5" W
Elevation: ~85' NGVD

FIGURE 3. ROMP 25 LILY

Well Site Location Map

r25fig3_map.apr



UID	Well Elevations:
WEL 2188 16870	6" Evaporite (Notch =88.482')
WEL 2188 17312	12" Suwannee (Notch =87.623')
WEL 2188 17258	18" Avon Park (Notch=86.804')
WEL 2188 17313	8" Arcadia (Notch=87.305')
WEL 2188 16710	4" Surficial (Notch=88.898')

District Parcel No. 20-20-065

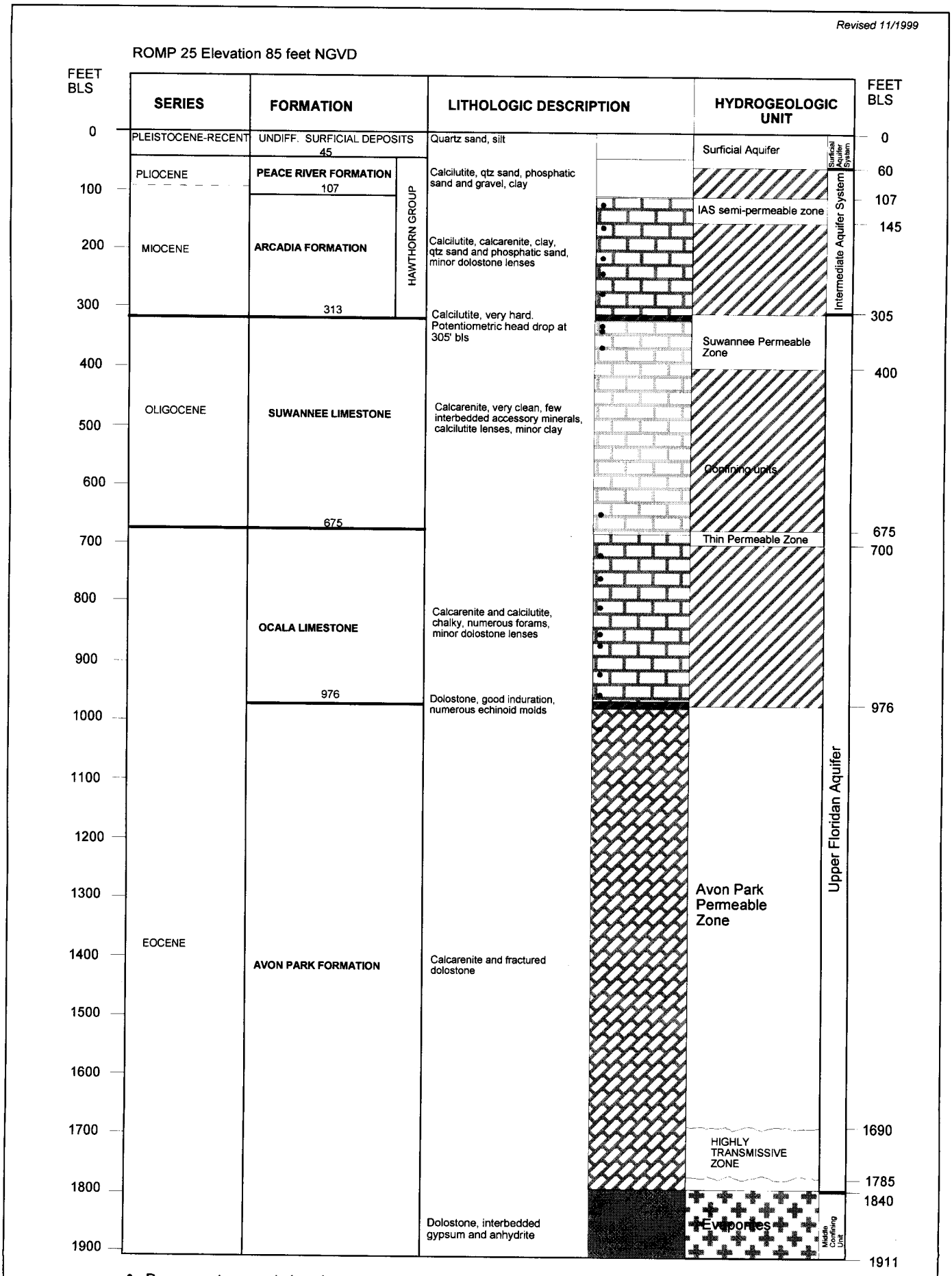
40 20 0 40
SCALE IN FEET

Wellsite.wpg

FIGURE 4. ROMP 25 LILY

Monitor Well Site Diagram

Revised 11/1999



• Permeameter sample locations (collected during coring phase)

FIGURE 5. ROMP 25 LILY

ROMP 25 Conceptual Hydrogeology

R25hyd.wpg

Latitude: 27 21' 58.95989"
Longitude: 82 00' 25.42978"
Elevation: 88.898 (notched black mark)

UID # WEL 2188 16710
WCP # 573462.01

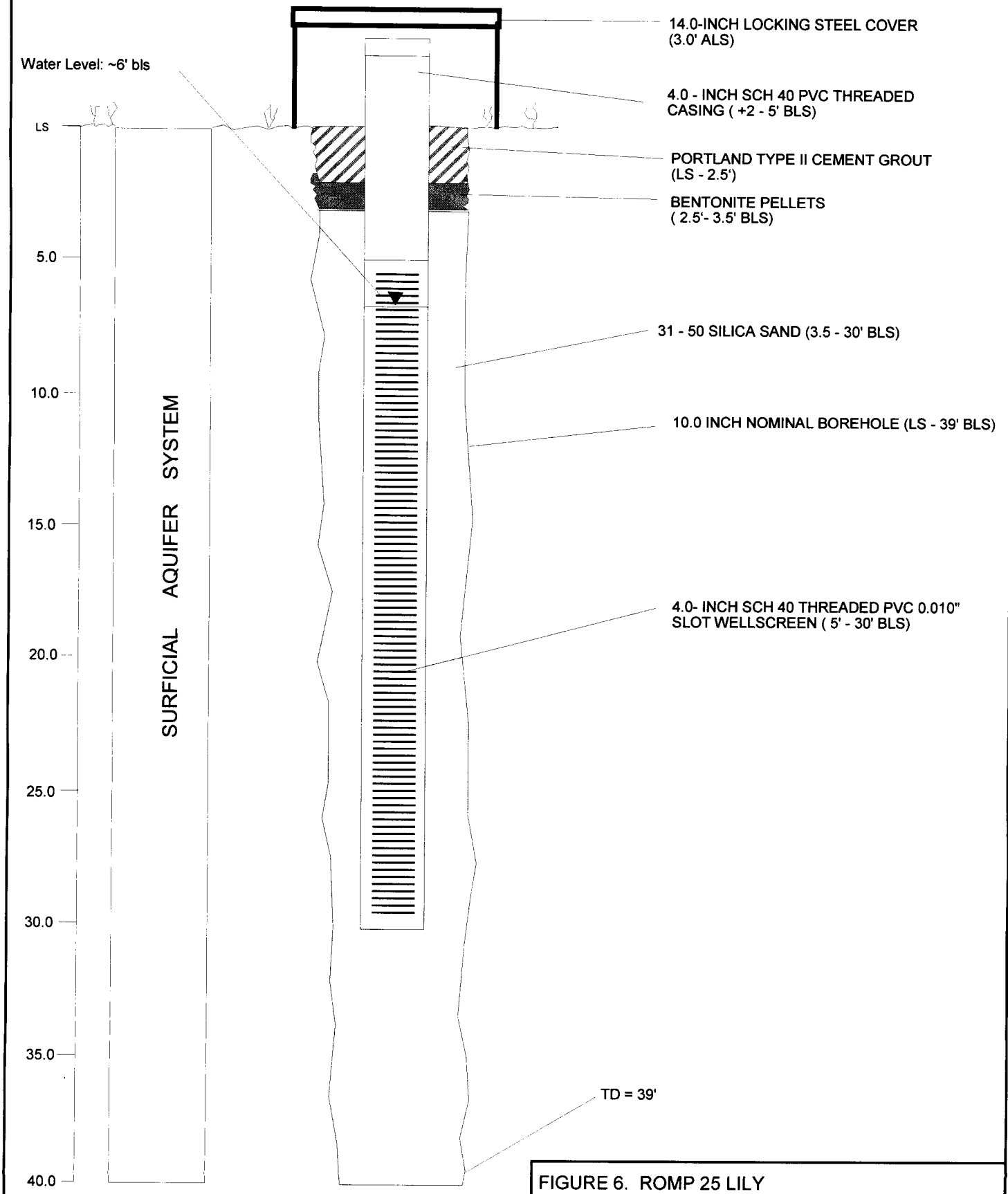


FIGURE 6. ROMP 25 LILY

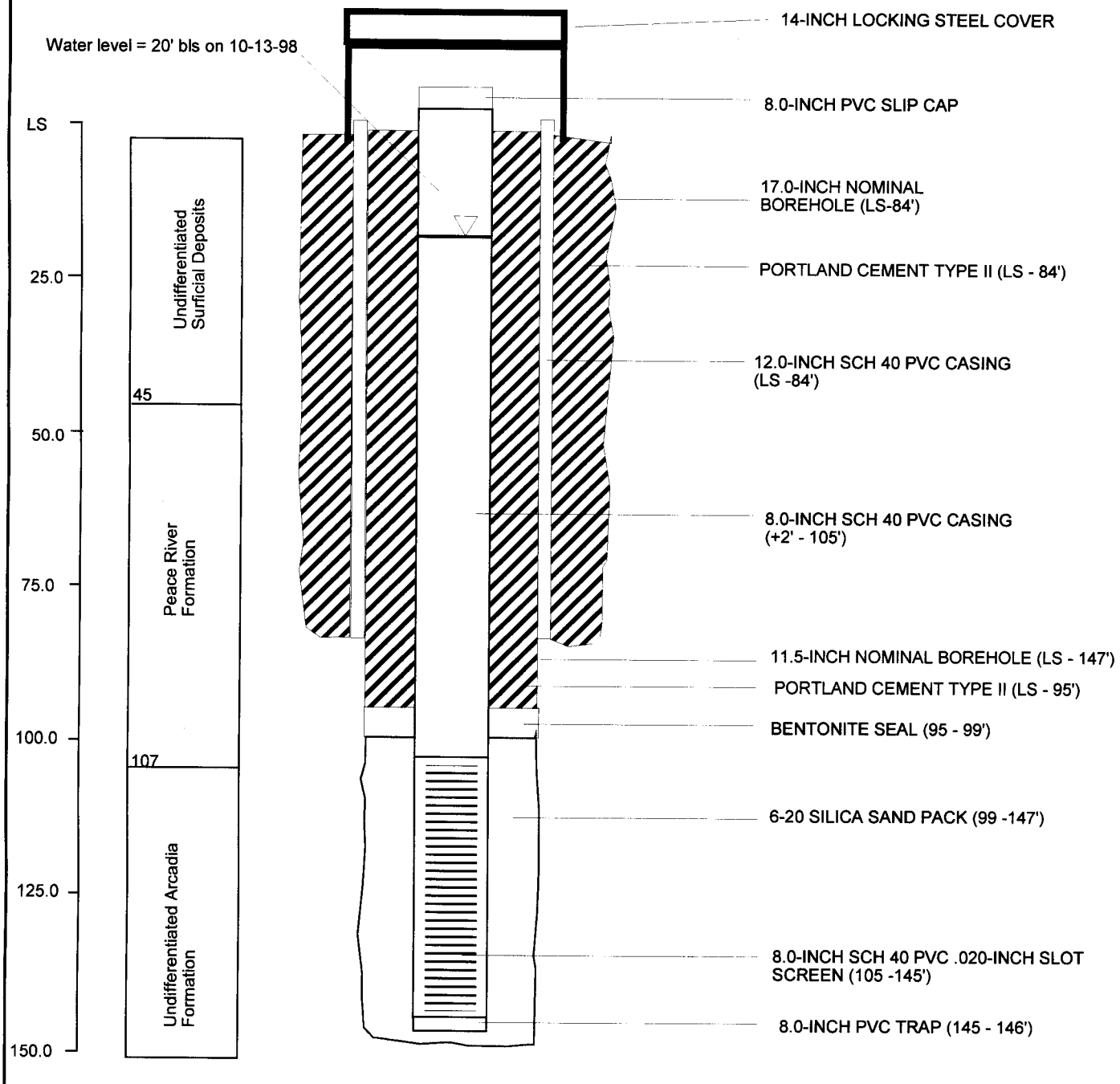
Permanent Surficial Aquifer Monitor Well
As-Built Diagram

R25SURF.WPG 7-8-98

Latitude: 27° 21' 59.10846"
Longitude: 82° 00' 25.38807"
Elevation: 87.305' (notched black mark)

NOTE: Well has low specific capacity, makes less that 5 gpm.

UID # WEL 2188 17313
WCP # 601920.01



Start: 2-5-98
Completed: 2-11-98

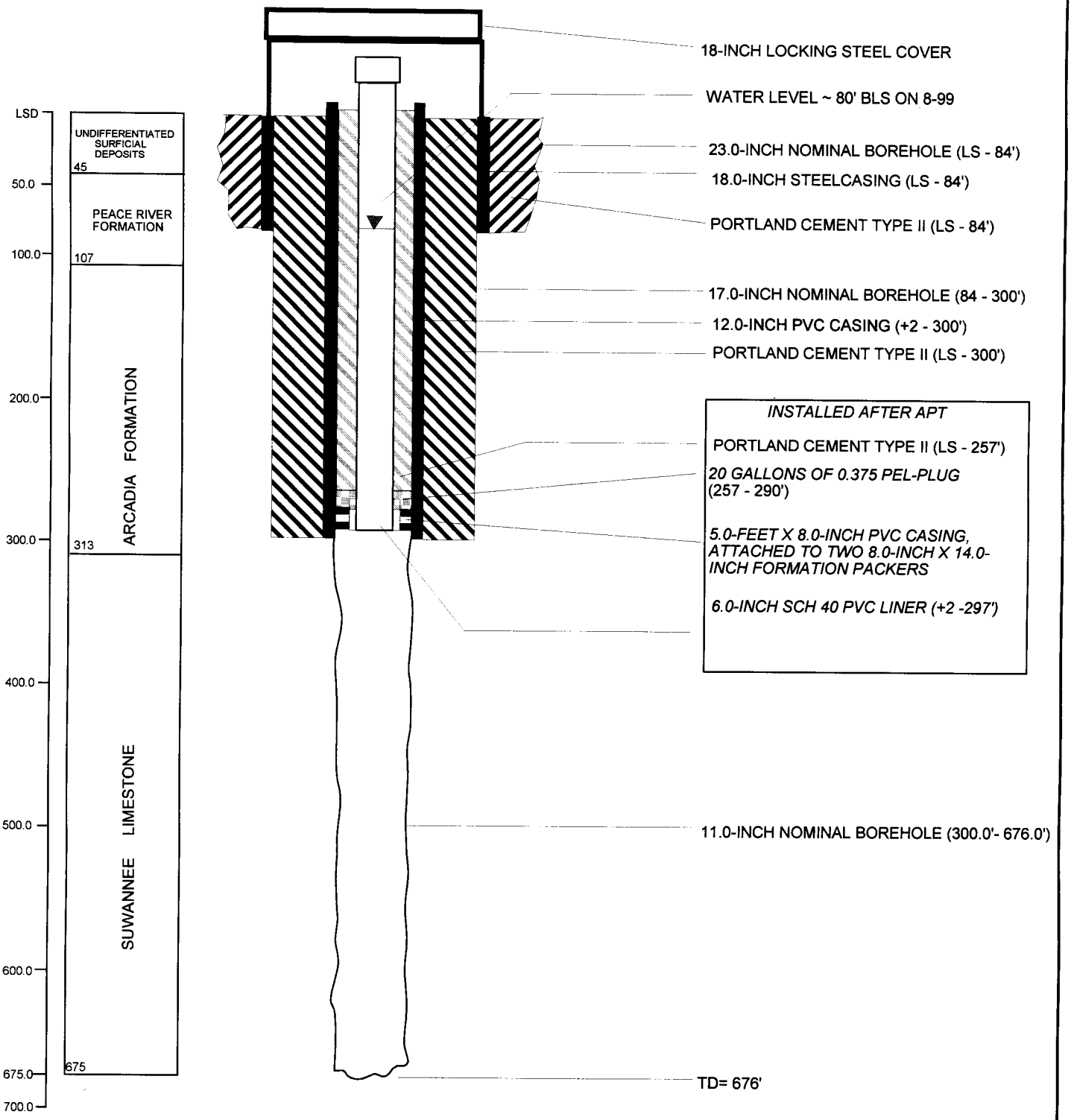
FIGURE 7. ROMP 25 LILY

Permanent Arcadia/IAS Monitor Well As-Built Diagram

Arcasb.wpg 5-18-99

Latitude: 27 21' 59.45680"
Longitude: 82 00' 25.42163"
Elevation: 87.623' (Notched black mark)

SWFWMD UID # 2188 17312
SWFWMD WCP # 601705.01



Start: **1-22-98**
Completed: **3-9-98**
6-inch liner: **8-99**

FIGURE 8. ROMP 25 LILY

Permanent Suwannee/UFA Monitor Well As-Built Diagram

suwasb.wpg 9-17-99

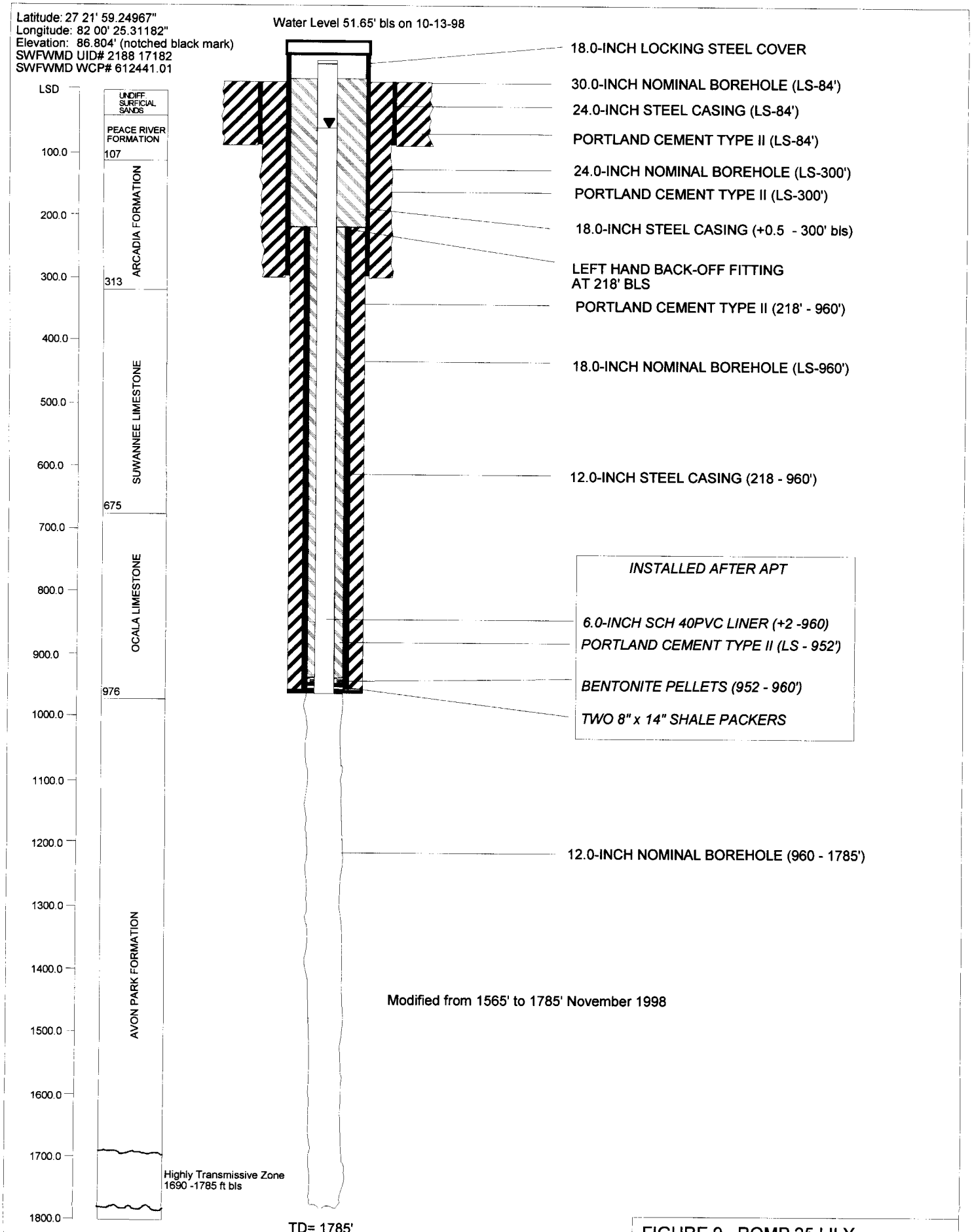
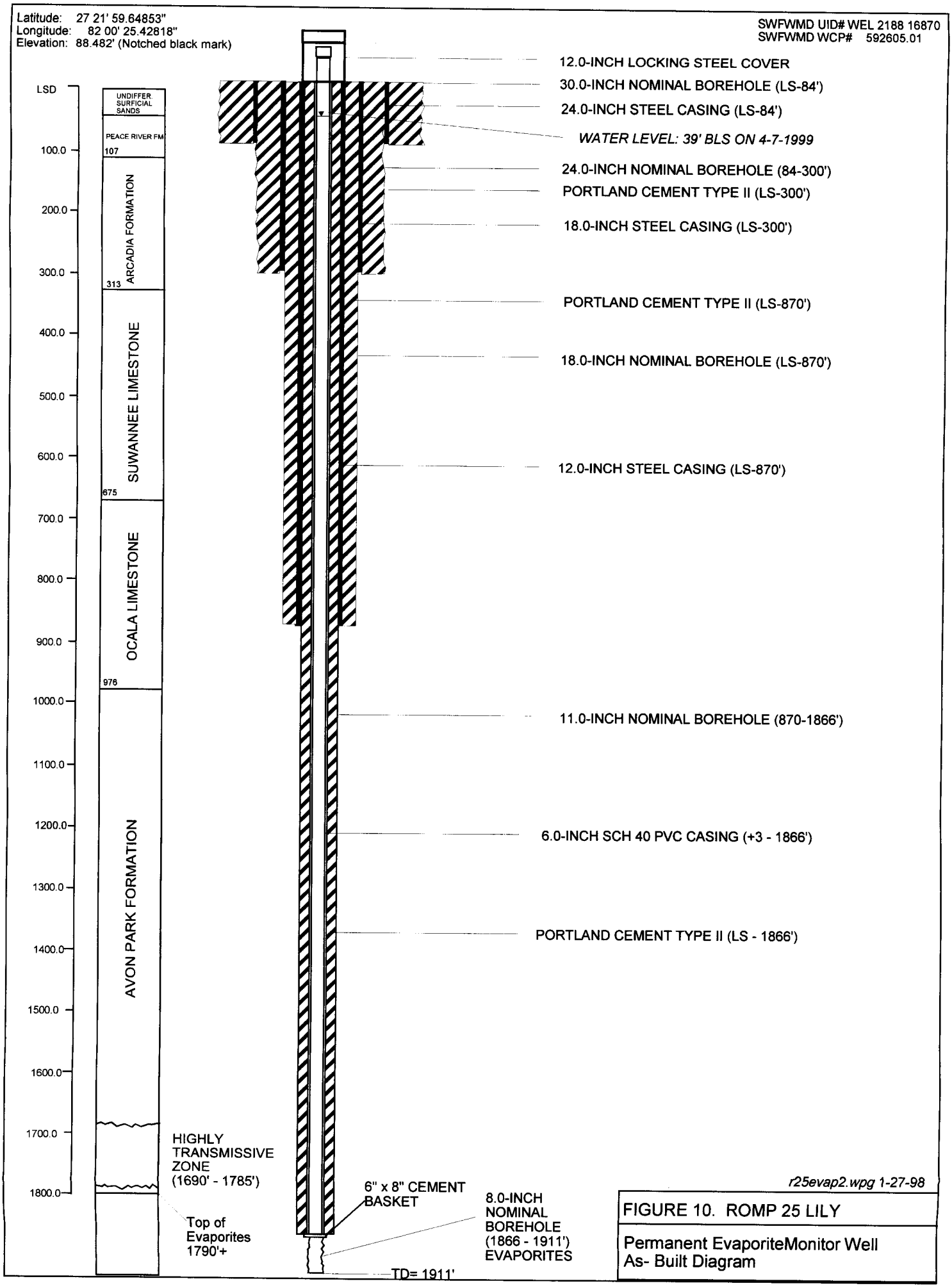
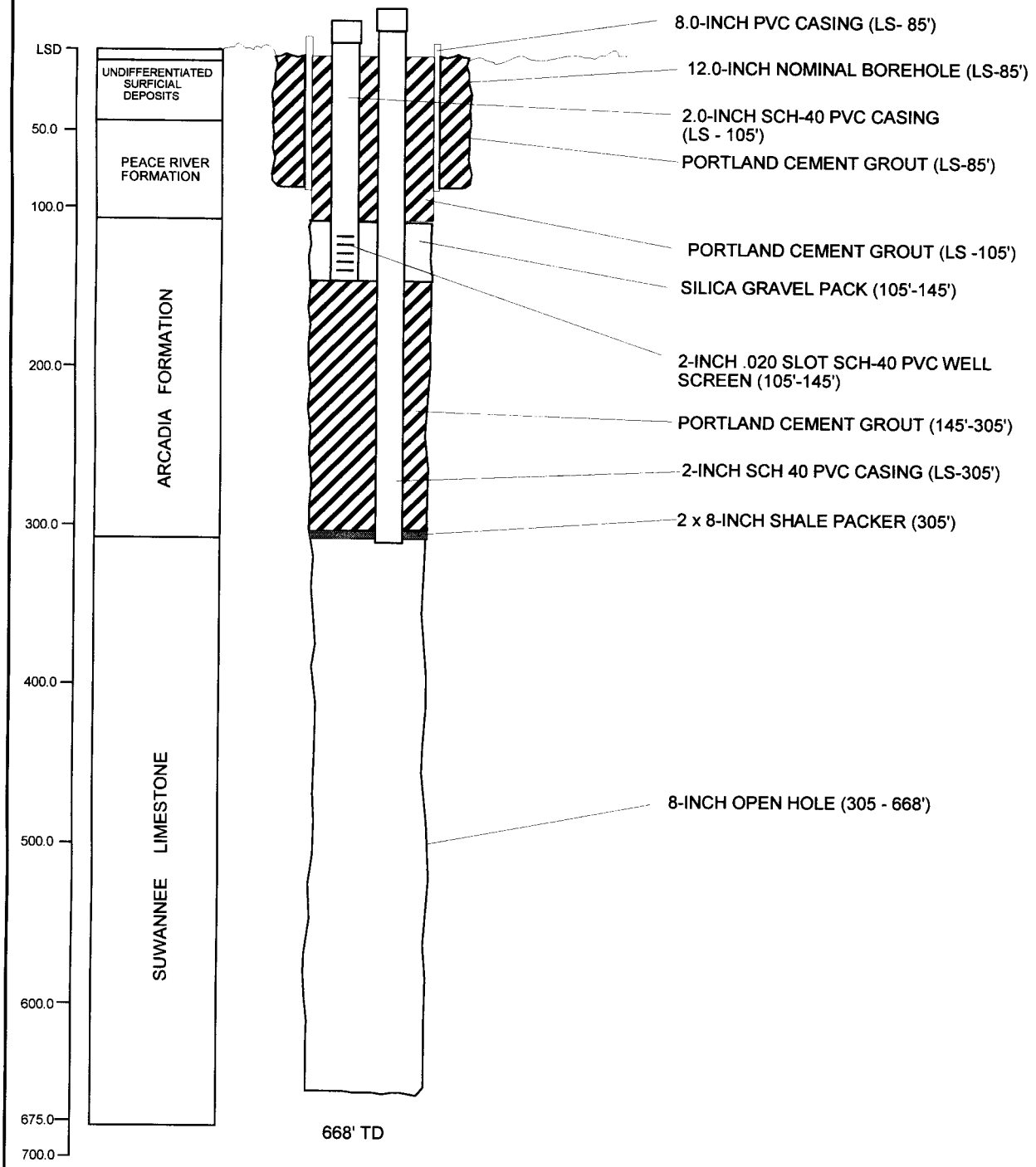


FIGURE 9. ROMP 25 LILY

Permanent Avon Park/Upper Floridan Monitor Well As-Built Diagram

r25avonasb.wpg 12-3-98


Latitude: 27 21' 59.64853"
Longitude: 82 00' 25.42818"
Elevation: 88.482' (Notched black mark)
SWFWMD UID# WEL 2188 16870
SWFWMD WCP# 592605.01
LSD
UNDIFFER. SURFICIAL SANDS
PEACE RIVER FM
107
ARCADIA FORMATION
313
SUWANNEE LIMESTONE
675
OCALA LIMESTONE
976
AVON PARK FORMATION
100.0
200.0
300.0
400.0
500.0
600.0
700.0
800.0
900.0
1000.0
1100.0
1200.0
1300.0
1400.0
1500.0
1600.0
1700.0
1800.0
12.0-INCH LOCKING STEEL COVER
30.0-INCH NOMINAL BOREHOLE (LS-84')
24.0-INCH STEEL CASING (LS-84')
WATER LEVEL: 39' BLS ON 4-7-1999
24.0-INCH NOMINAL BOREHOLE (84-300')
PORTLAND CEMENT TYPE II (LS-300')
18.0-INCH STEEL CASING (LS-300')
PORTLAND CEMENT TYPE II (LS-870')
18.0-INCH NOMINAL BOREHOLE (LS-870')
12.0-INCH STEEL CASING (LS-870')
11.0-INCH NOMINAL BOREHOLE (870-1866')
6.0-INCH SCH 40 PVC CASING (+3 - 1866')
PORTLAND CEMENT TYPE II (LS - 1866')
HIGHLY TRANSMISSIVE ZONE (1690' - 1785')
Top of Evaporites 1790'+
6" x 8" CEMENT BASKET
8.0-INCH NOMINAL BOREHOLE (1866 - 1911') EVAPORITES
TD= 1911'
r25evap2.wpg 1-27-98
FIGURE 10. ROMP 25 LILY
Permanent EvaporiteMonitor Well
As- Built Diagram



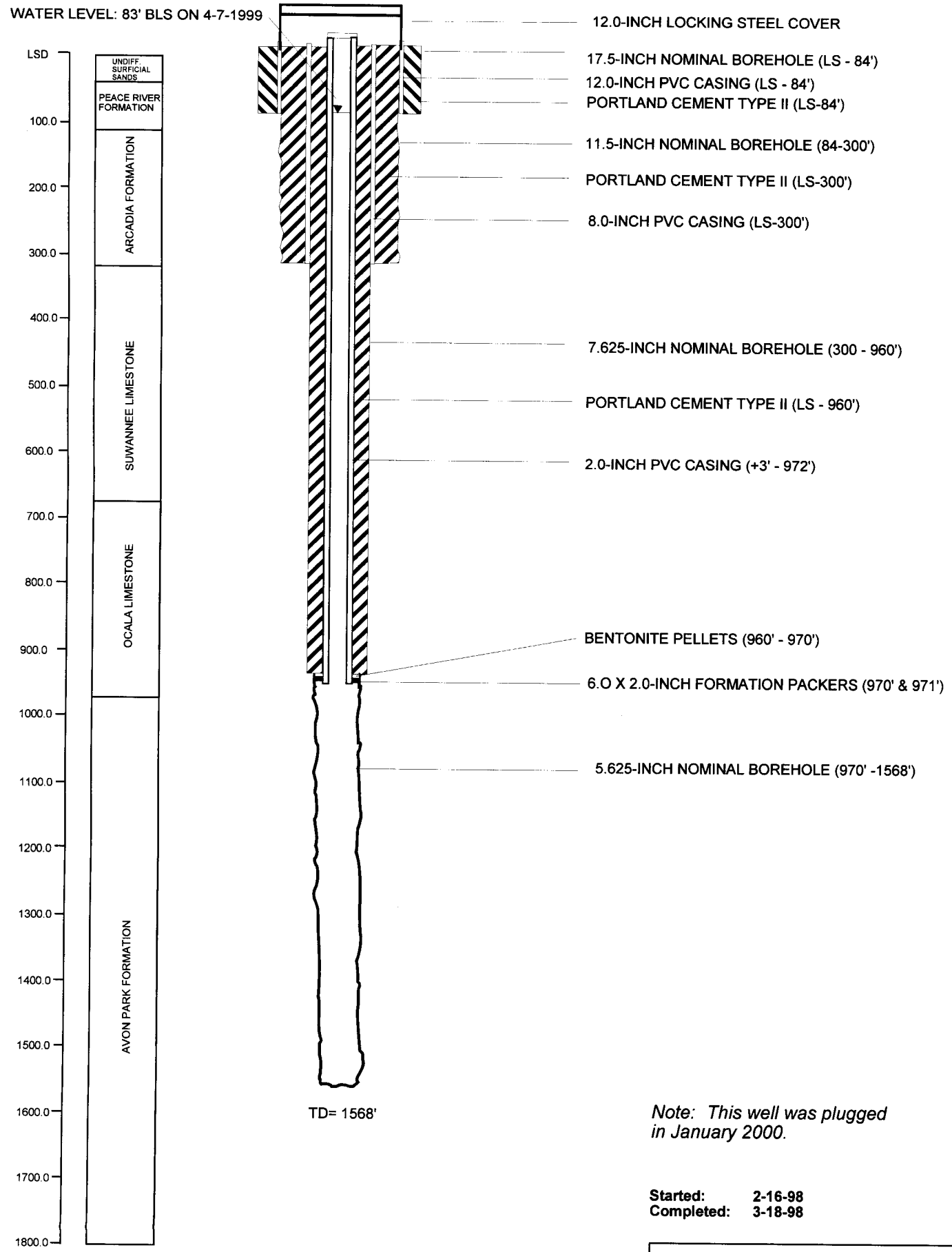
Note: These wells were plugged in January 2000.

FIGURE 11. ROMP 25 LILY

Temporary Suwannee/Arcadia Observation Well As-Built Diagram (Former Core Hole)

R25dualIwpg 1-11-2000

WCP # 603911.01



Note: This well was plugged in January 2000.

Started: **2-16-98**
Completed: **3-18-98**

FIGURE 12. ROMP 25 LILY

Temporary Avon Park/UFA Observation Well As-Built Diagram

avobasb.wpg 1-11-2000

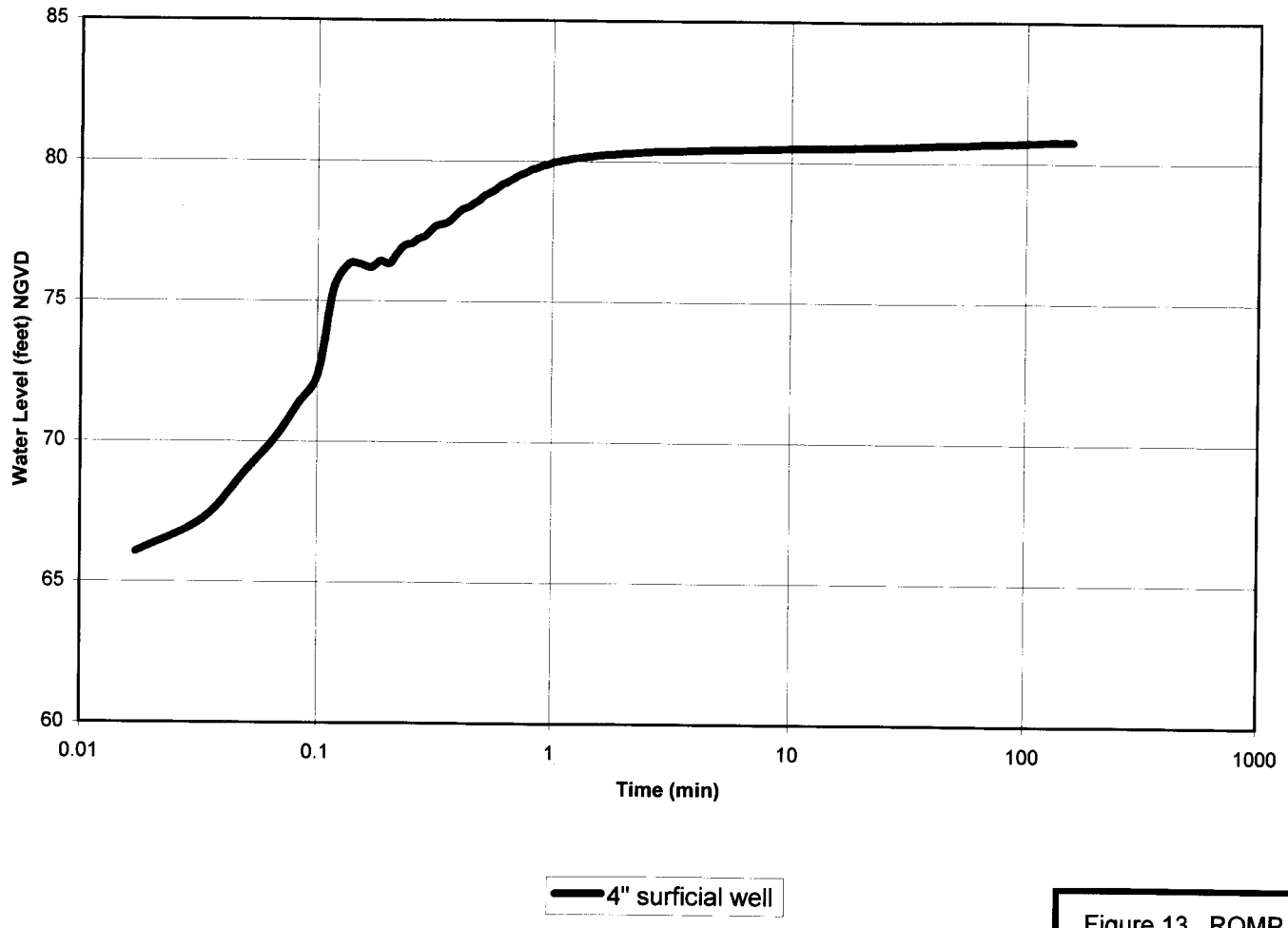
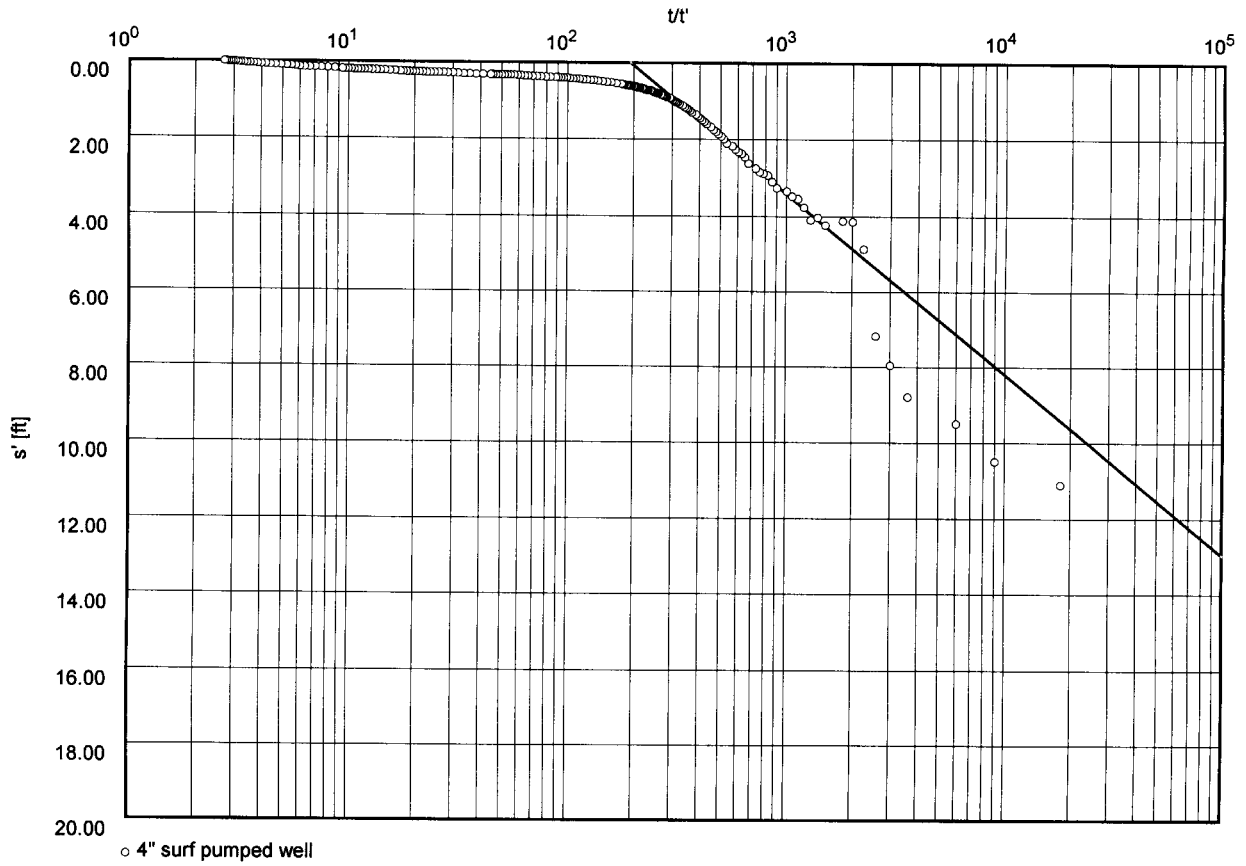


Figure 13. ROMP 25 Lily

Surficial APT - Recovery Graph

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Recovery method after THEIS & JACOB Unconfined aquifer	Date: 1-5-2000	Page 1
		Project: ROMP 25 Surfical APT	
		Evaluated by: mtg	

Pumping Test No. 1 Recovery	Test conducted on: 5-22-1996
4" Surficial well	
Discharge 37.00 U.S.gal/min	
	Pumping test duration: 0.18056 d



Transmissivity [ft²/d]: 2.73×10^2

Hydraulic conductivity [ft/d]: 9.10×10^0

Aquifer thickness [ft]: 30.00

4-inch surficial monitor well pumped with gas-powered centrifugal pump for 260 minutes at 37 gpm. Maximum drawdown 15.4 feet.

Recovery data in pumped well collected for 156 minutes.

FIGURE 14. *ROMP 25 Lily*

Theis & Jacob Curve Match for Surficial Pumped Well.

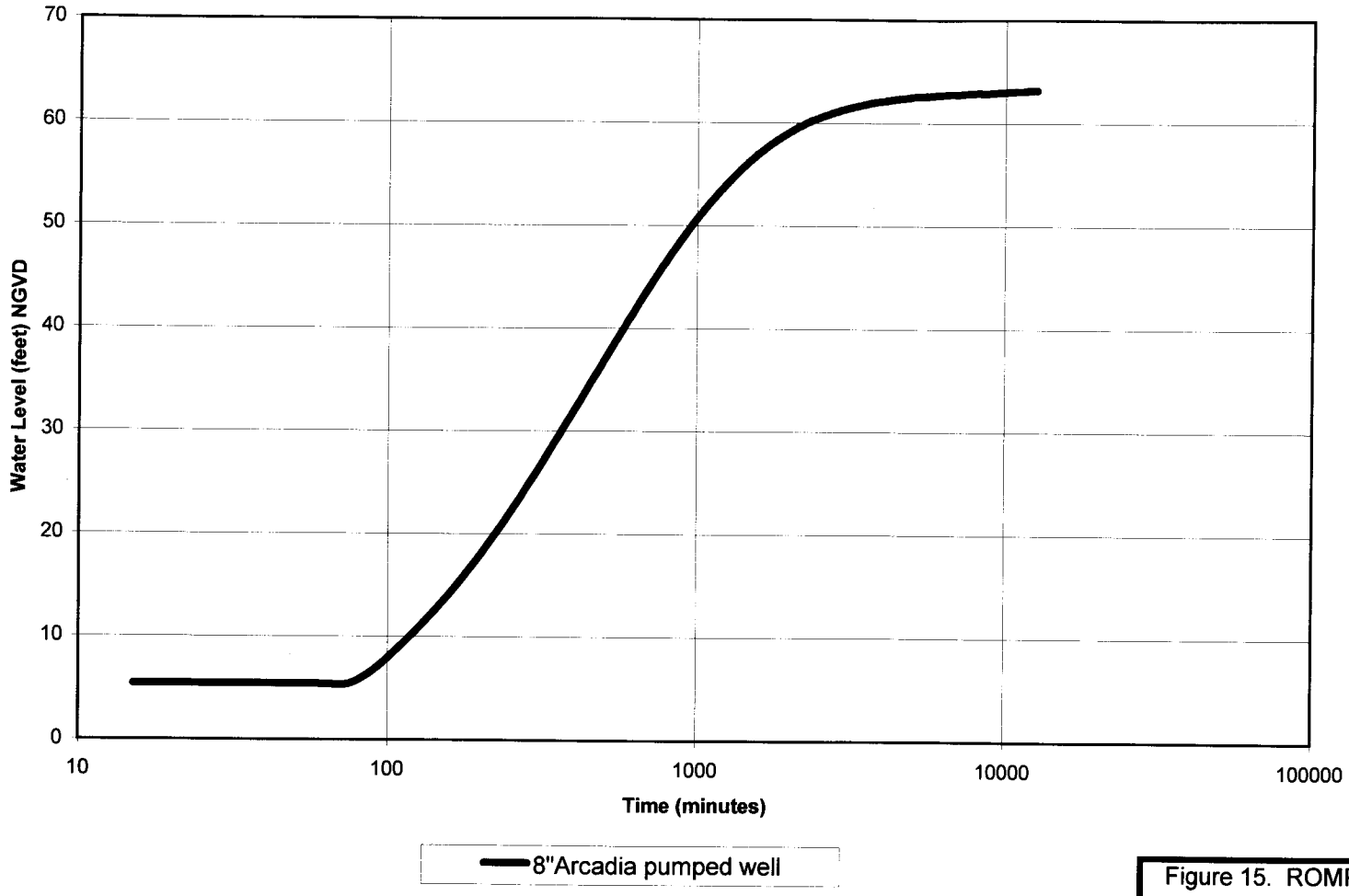


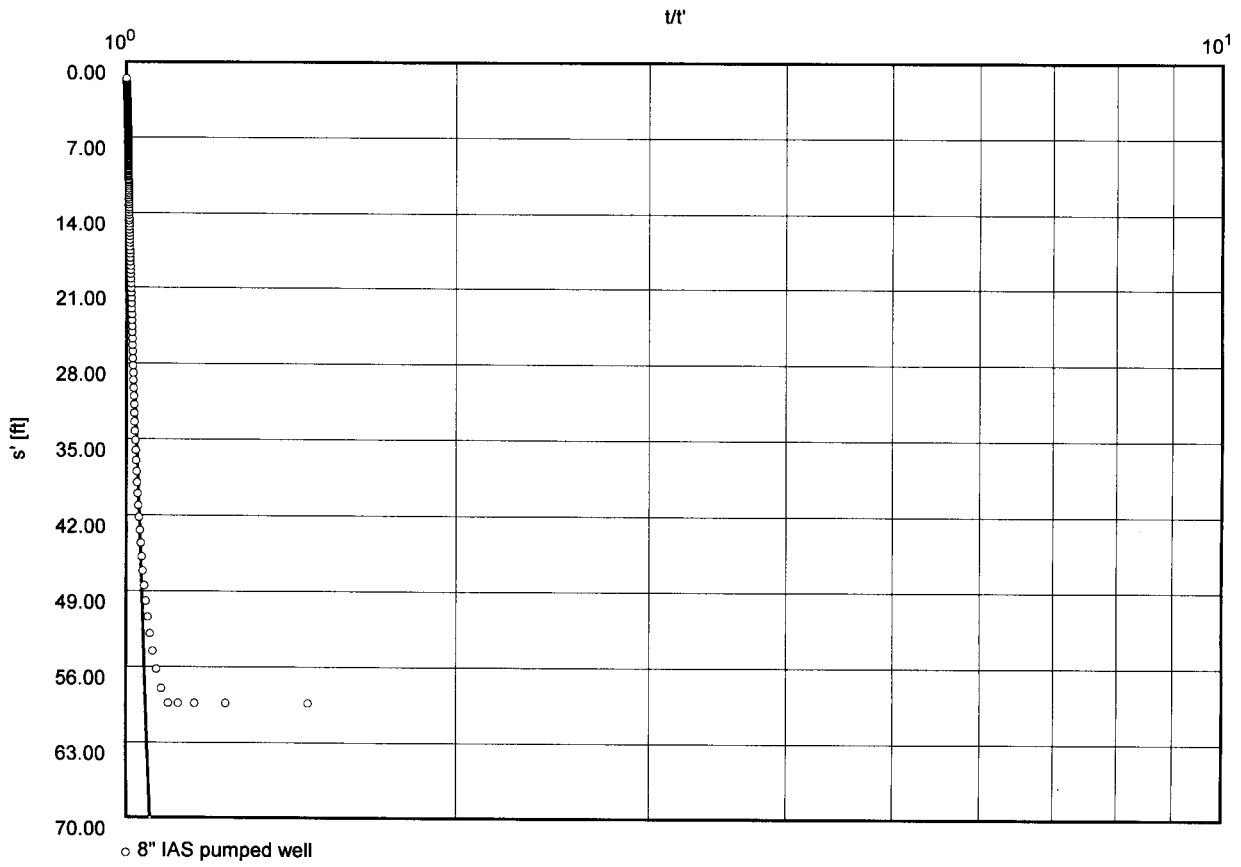
Figure 15. ROMP 25 Lily

IAS APT - Recovery Graph

iasrec.xls

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 1-5-2000	Page 1
		Project: ROMP 25 LILY	
		Evaluated by: mtg	

Pumping Test No. 1 Recovery of pumped well	Test conducted on: 2-9-1999
8-inch Arcadia/IAS (pumped well)	
Discharge 45.00 U.S.gal/min	
	Pumping test duration: 0.00486 d



Transmissivity [ft²/d]: 5.47×10^{-1}

Hydraulic conductivity [ft/d]: 1.36×10^{-2}

Aquifer thickness [ft]: 40.00

Well was pumped at approximately 45 gpm. The water level in the pumped well drew down to the top of the pump (60 feet below static water level) 7 minutes after the start of pumping.

Pumping was stopped and the recovery of the water level in the pumped well was recorded for analysis.

FIGURE 16. ROMP 25 Lily

Theis & Jacob Curve Match
for IAS Pumped Well.

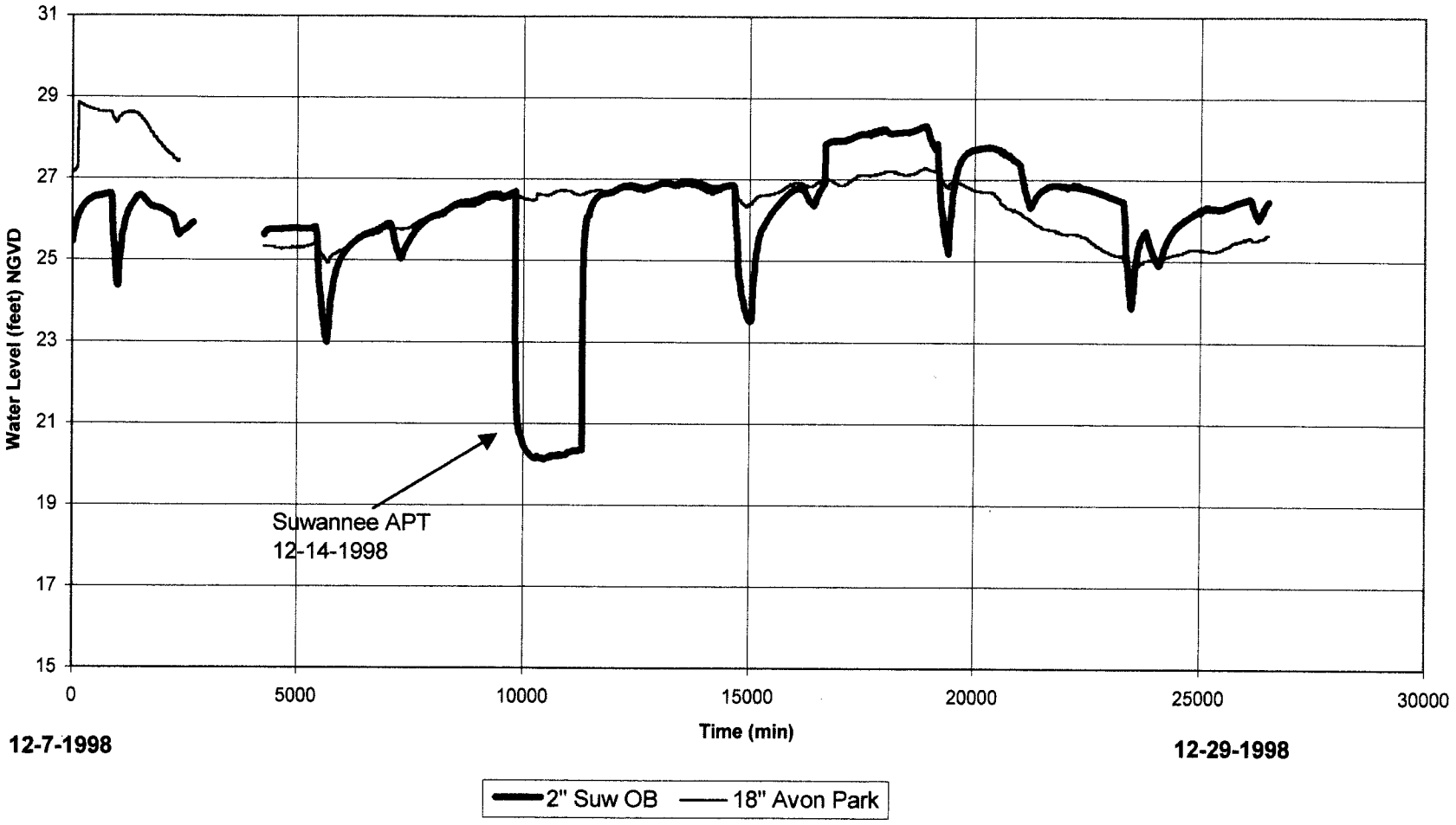


Figure 17. ROMP 25 Lily

UFA Hydrograph for December

composite.xls

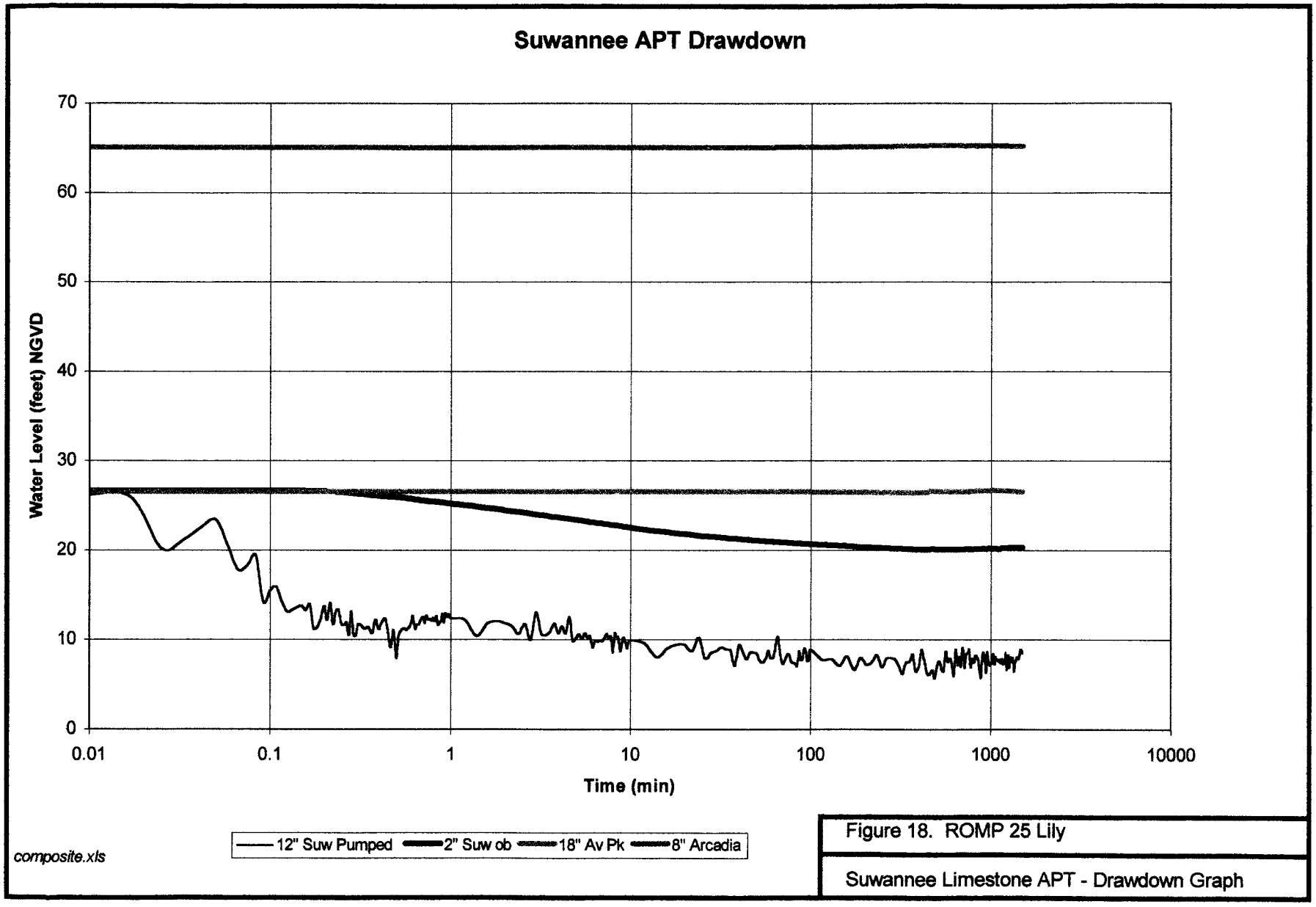
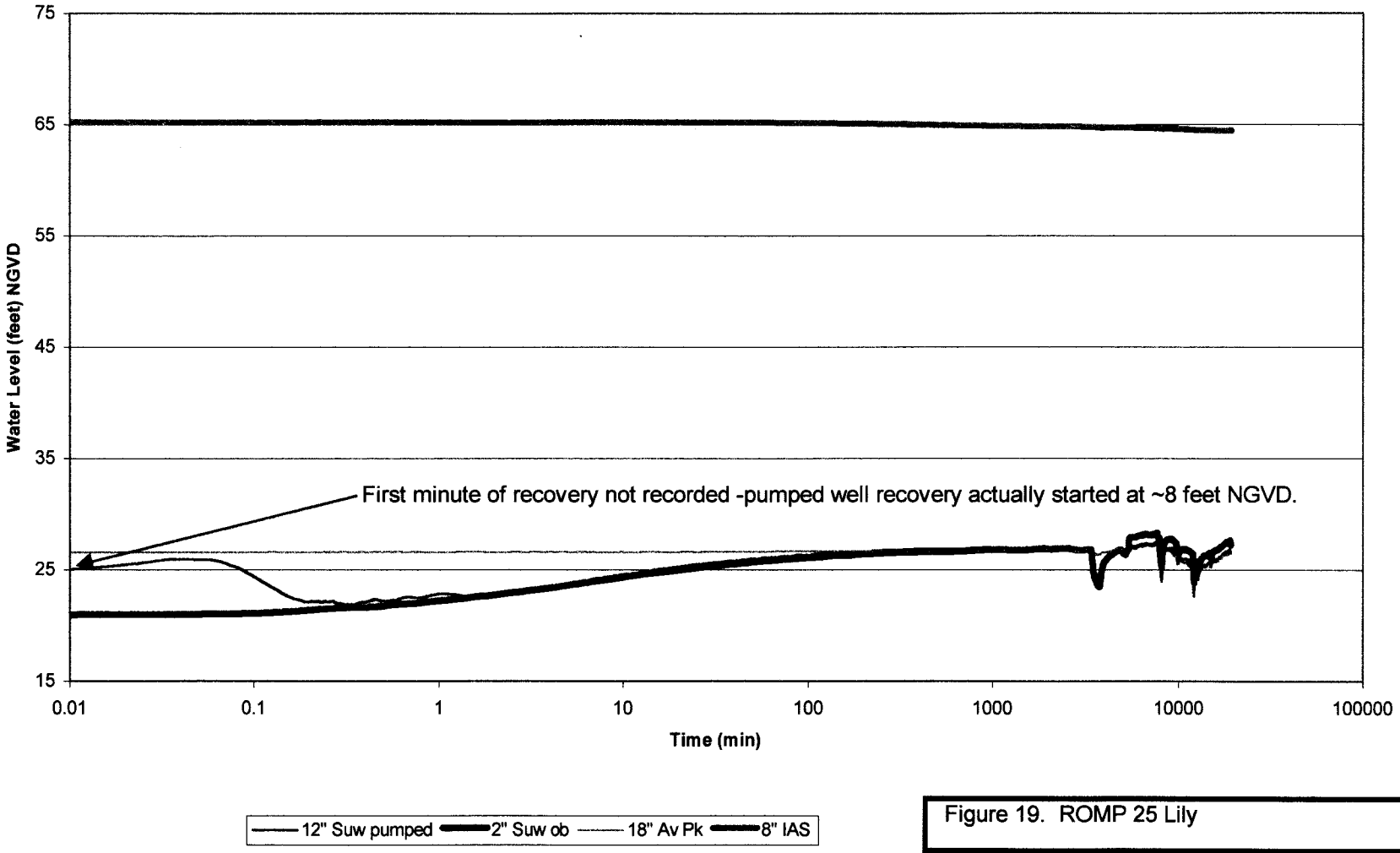


Figure 18. ROMP 25 Lily

Suwannee Limestone APT - Drawdown Graph



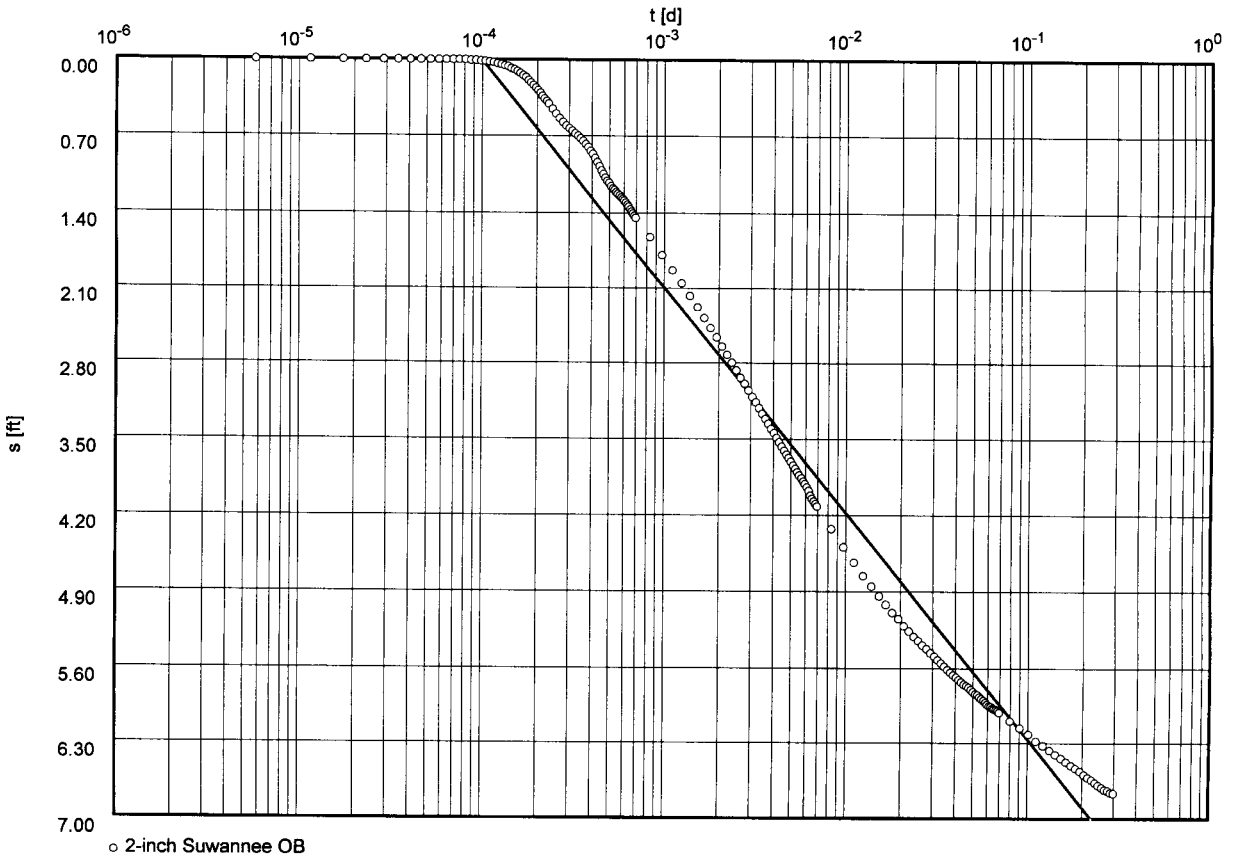
composite.xls

Figure 19. ROMP 25 Lily

Suwannee Limestone APT - Recovery Phase

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 1-4-2000	Page 1
		Project: ROMP 25 Suwannee APT	
		Evaluated by: mtg	

Pumping Test No. 1 Drawdown Phase	Test conducted on: 12-14-1998
2-inch Suwannee OB	
Discharge 500.00 U.S.gal/min	



o 2-inch Suwannee OB

Transmissivity [ft²/d]: 8.44×10^{3}

Hydraulic conductivity [ft/d]: 2.25×10^{1}

Aquifer thickness [ft]: 375.00

Storativity: 7.36×10^{-5}

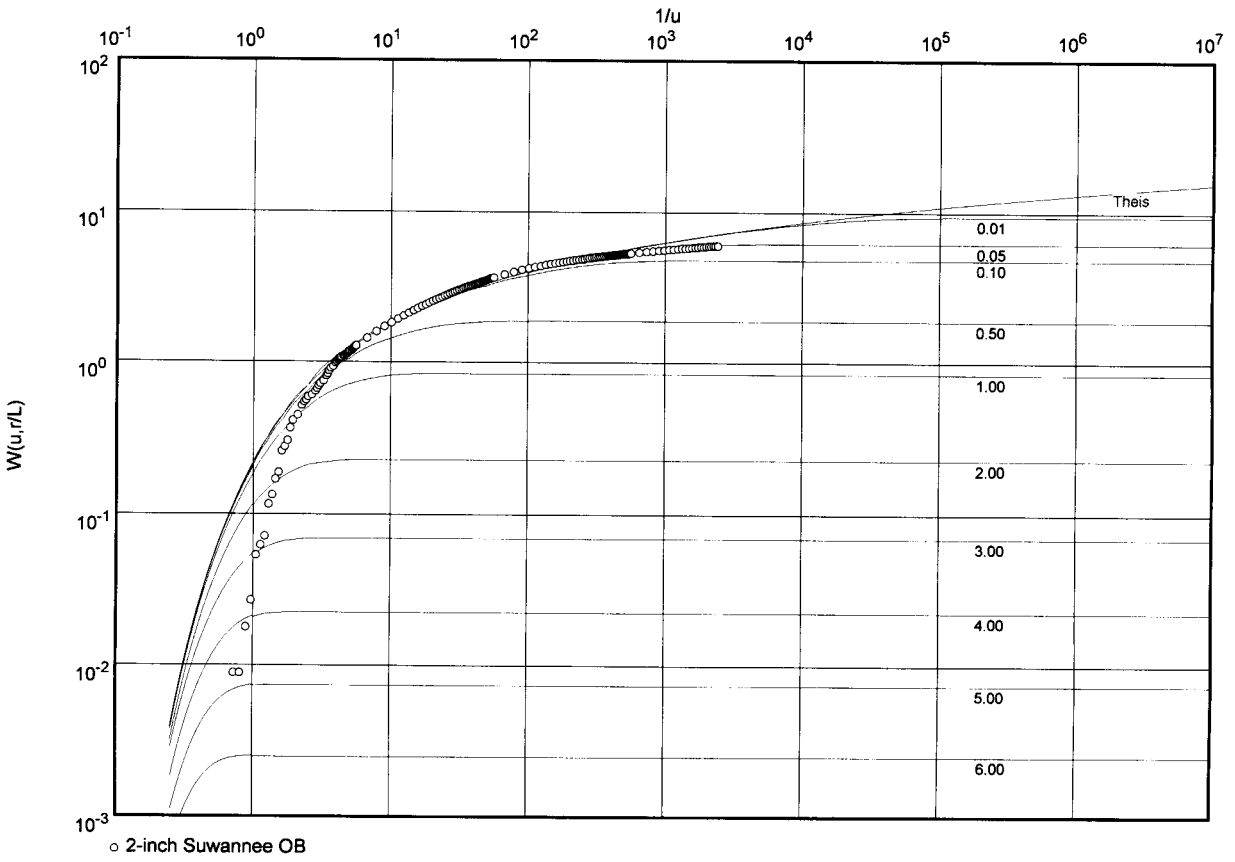
Drawdown corrected for regional water level trend.
2-inch Suwannee OB well located 160 feet from pumped well.

FIGURE 20. ROMP 25 Lily

Cooper & Jacob Curve Match
for 2-inch Suwannee OB well.

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis HANTUSH's method Leaky aquifer, no aquitard storage	Date: 1-4-2000	Page 1
		Project: ROMP 25 Suwannee APT	
		Evaluated by: mtg	

Pumping Test No. 1 Drawdown Phase	Test conducted on: 12-14-1998
2-inch Suwannee OB	
Discharge 500.00 U.S.gal/min	



Transmissivity [ft²/d]: 6.82×10^3

Hydraulic conductivity [ft/d]: 1.82×10^1

Aquifer thickness [ft]: 375.00

Storativity: 1.31×10^{-4}

Hydraulic resistance (c) [d]: 1.50×10^3

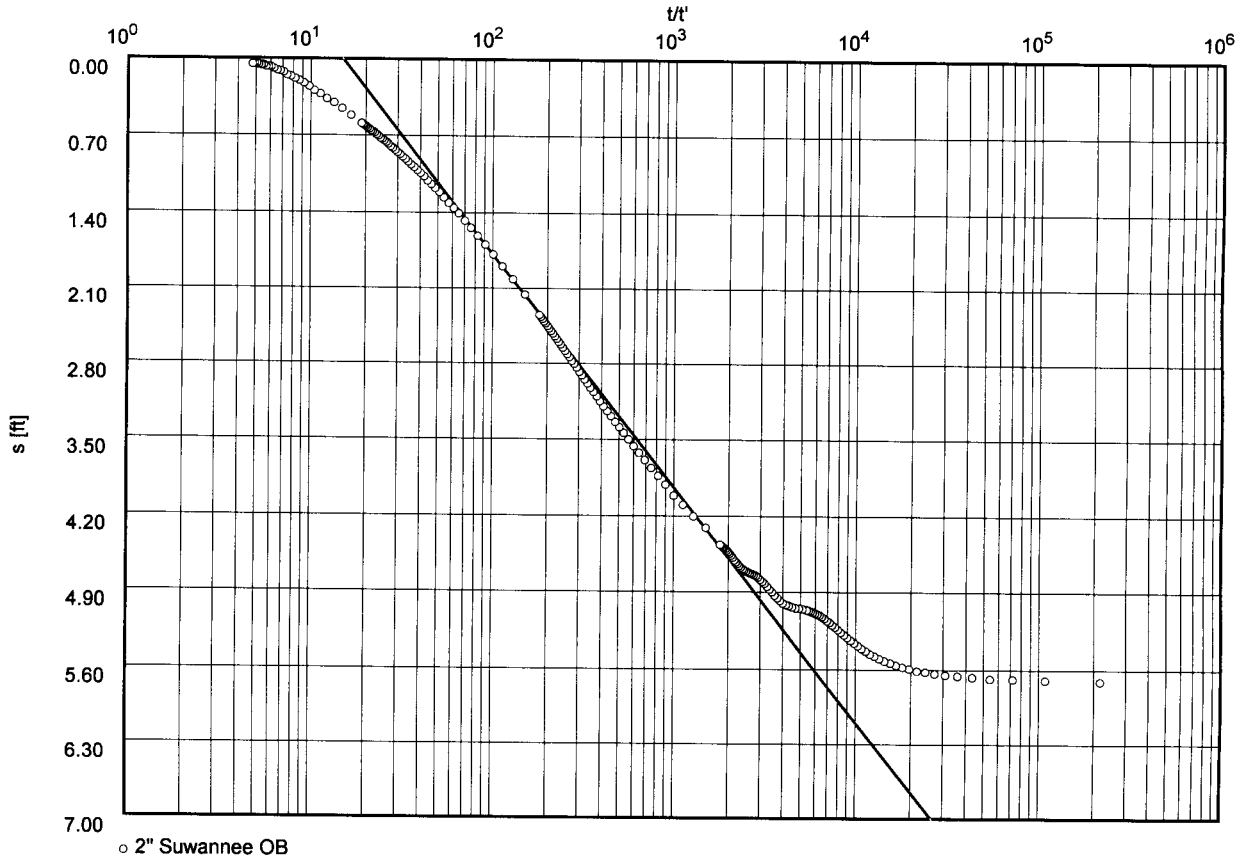
Drawdown corrected for regional water level trend.
2-inch Suwannee observation well located 160 feet from pumped well.

FIGURE 21. ROMP 25 Lily

Hantush Curve Match for
2- inch Suwannee OB well.

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 2-20-2000	Page 1
		Project: ROMP 25	
		Evaluated by: mtg	

Pumping Test No. 1 Recovery	Test conducted on: 12-16-1998 to 12-29-1998 (recovery)
Suwannee/UFA	
Discharge 500.00 U.S.gal/min	
	Pumping test duration: 1.25000 d



Transmissivity [ft²/d]: 8.16×10^3

Hydraulic conductivity [ft/d]: 2.17×10^1

Aquifer thickness [ft]: 375.00

FIGURE 22. ROMP 25 Lily

Theis & Jacob Curve Match
for 2-inch Suwannee OB well.

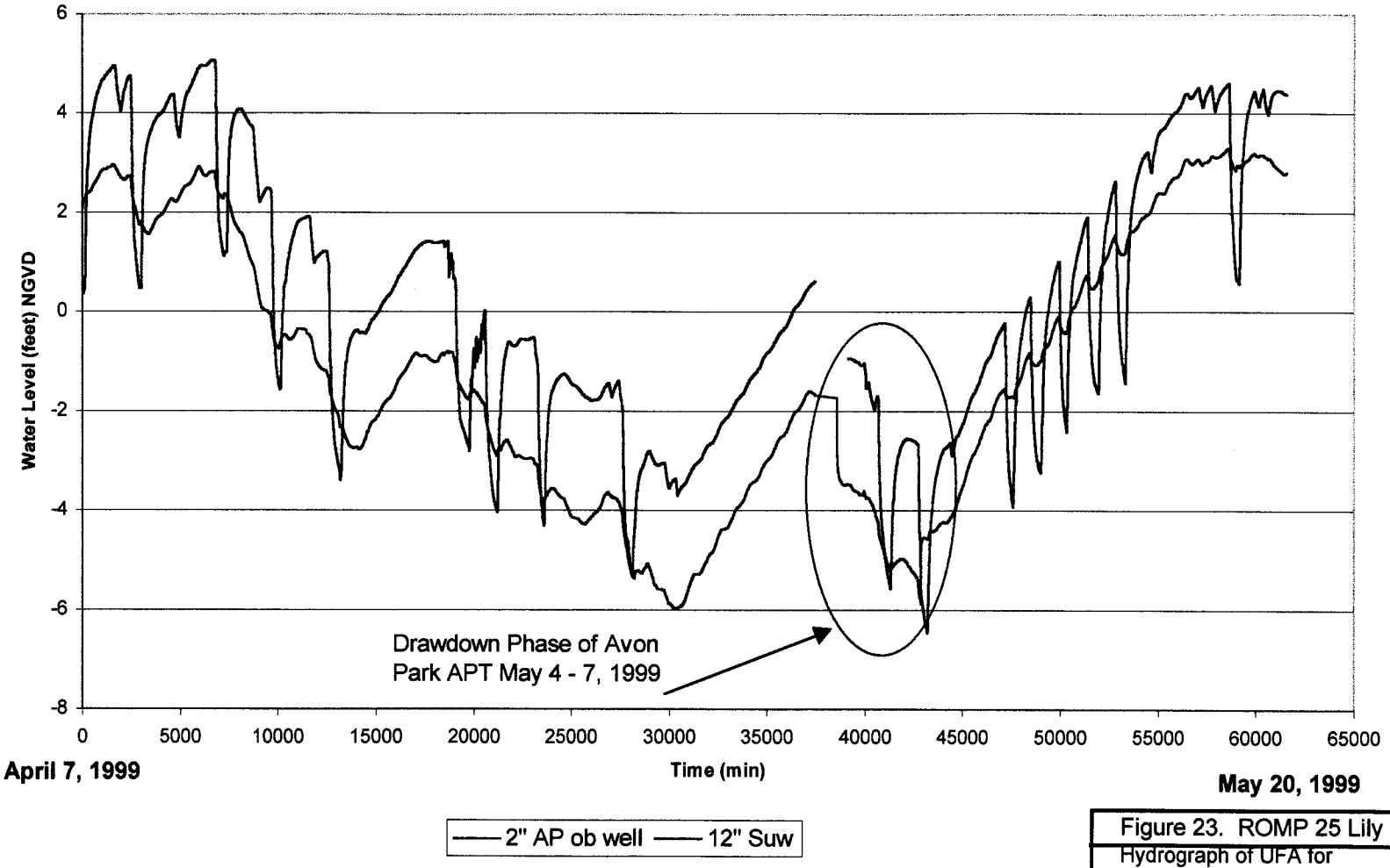
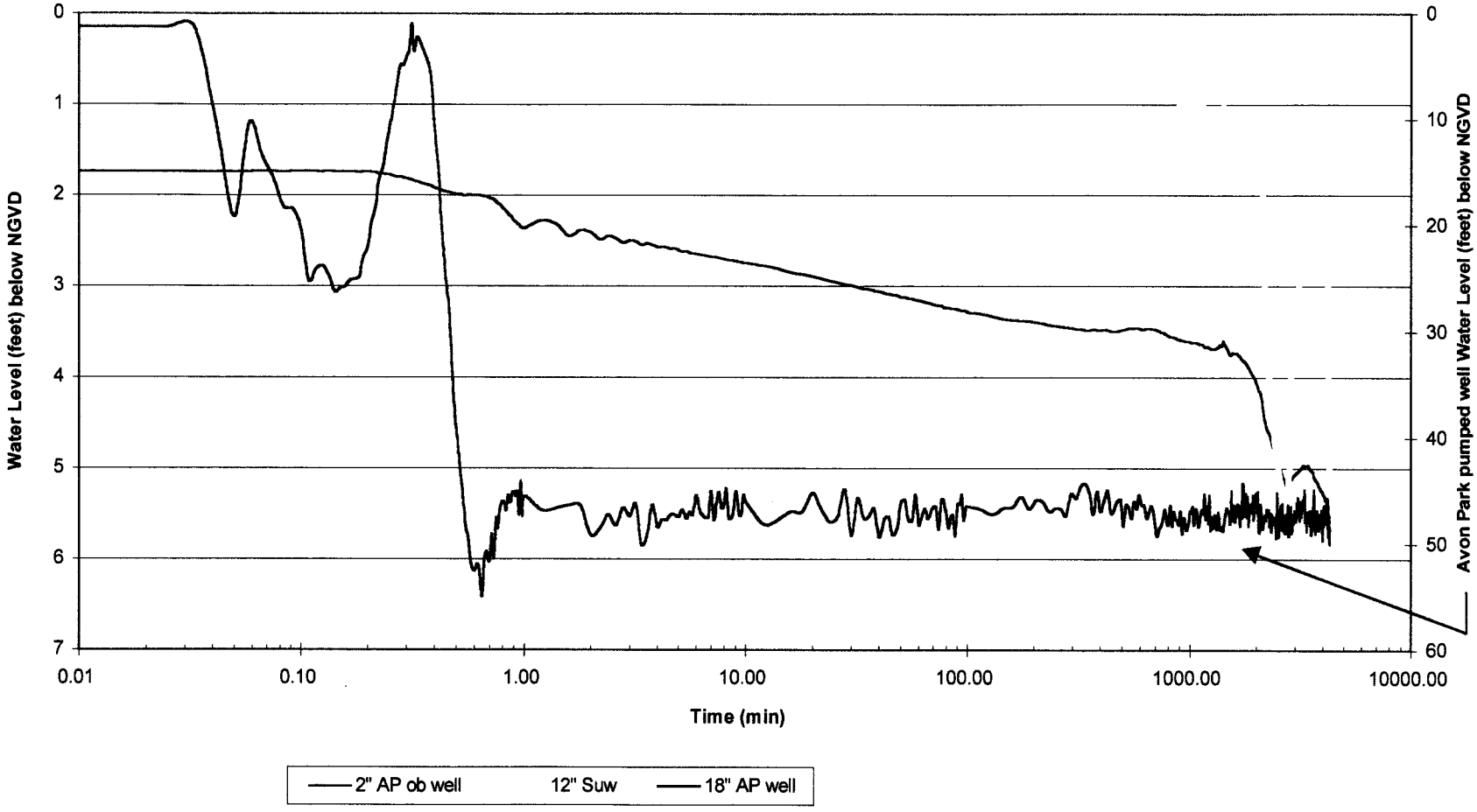


Figure 23. ROMP 25 Lily Hydrograph of UFA for April-May 1999.

r25\tables\bkg.xls



avonpark\composite.xls

Figure 24. ROMP 25 Lily

Avon Park Formation APT - Drawdown Graph

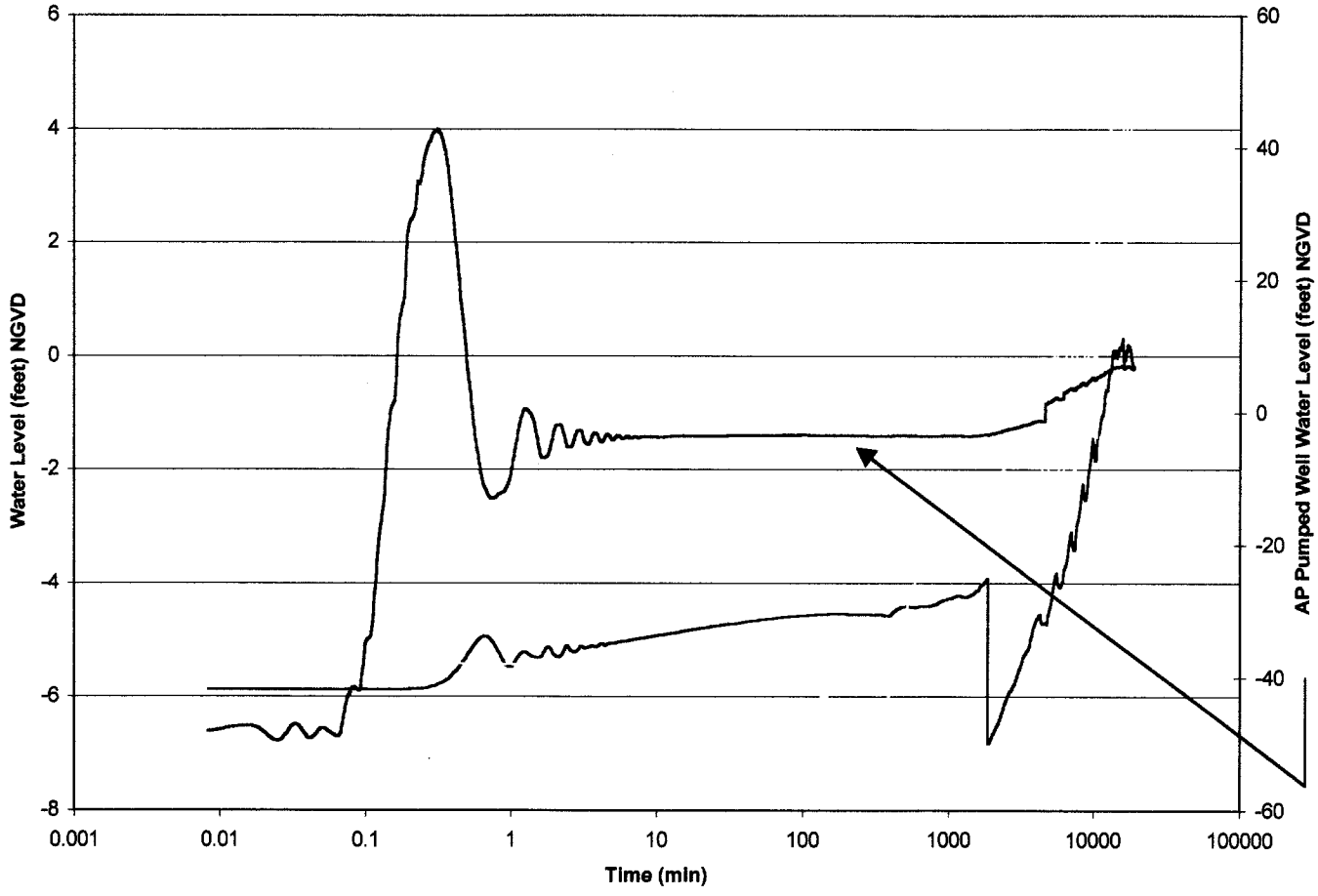


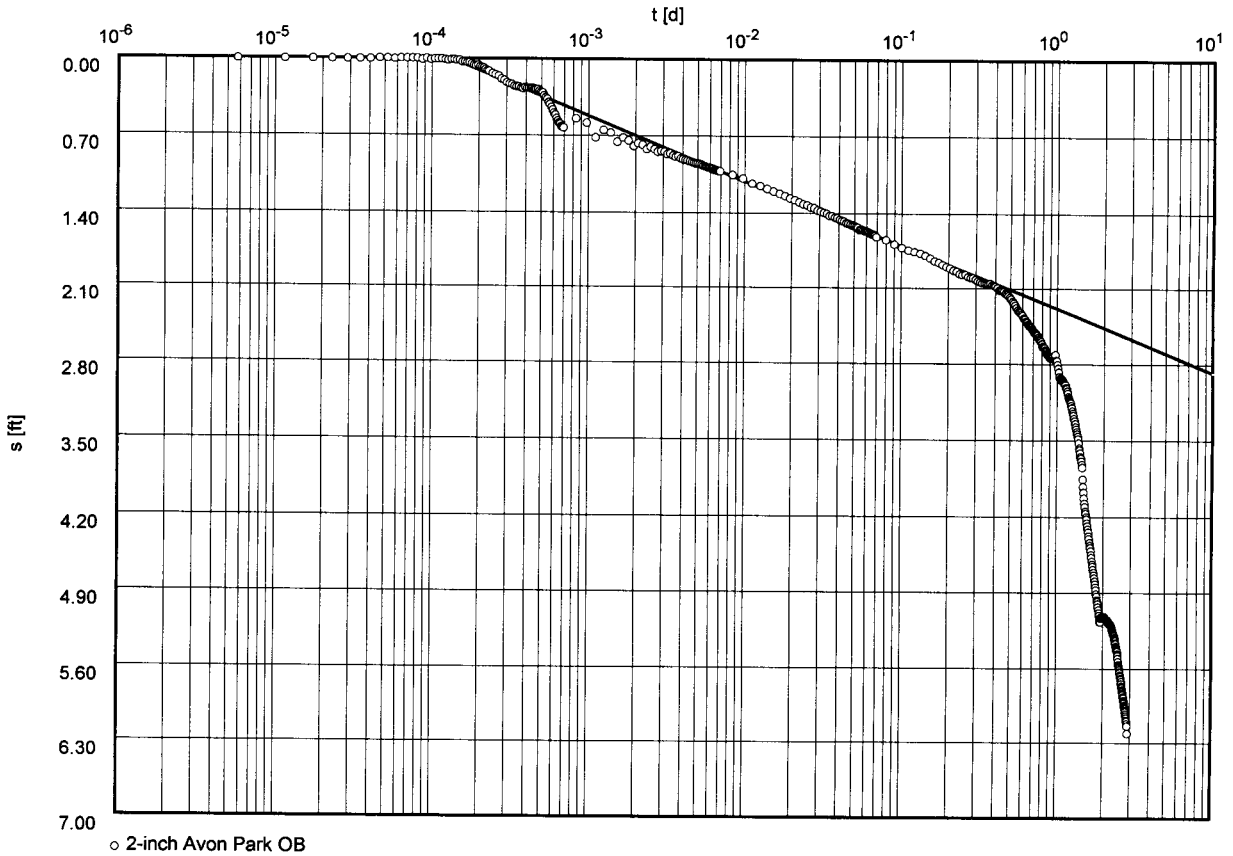
Figure 25. ROMP 25 Lily

Avon Park Formation APT - Recovery Graph

bkg.xls

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Time-Drawdown-method after COOPER & JACOB Confined aquifer	Date: 1-4-2000	Page 1
		Project: ROMP 25 Avon Park APT	
		Evaluated by: mtg	

Pumping Test No. 1 Drawdown Phase	Test conducted on: 5-4-99
2-inch Avon Park OB	
Discharge 4700.00 U.S.gal/min	



Transmissivity [ft²/d]: 2.80×10^5

Hydraulic conductivity [ft/d]: 3.34×10^2

Aquifer thickness [ft]: 840.00

Storativity: 3.31×10^{-4}

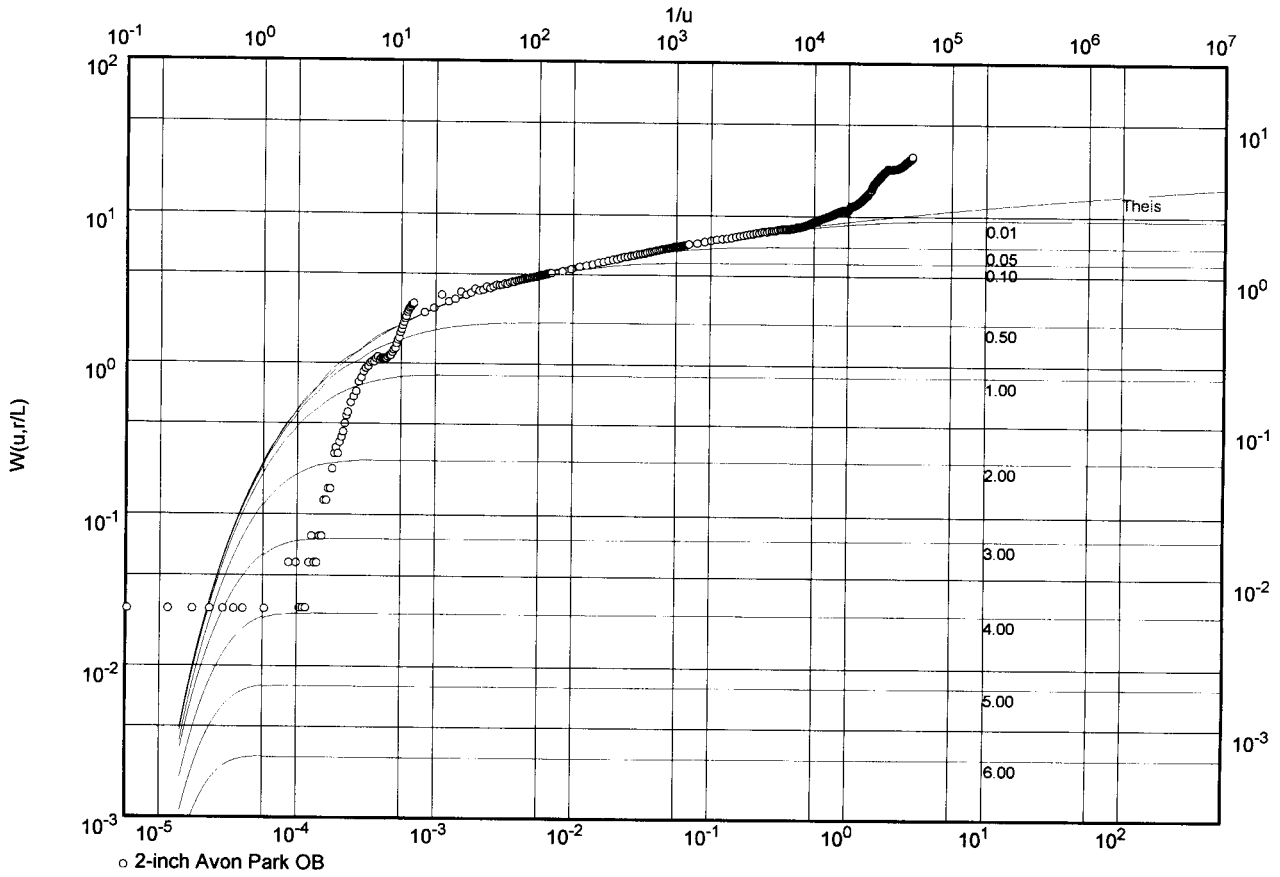
Drawdown corrected for regional water level trend.
2-inch Avon Park OB well located 500 feet from pumped well.

FIGURE 26. ROMP 25 Lily

Cooper & Jacob Curve Match
for 2-inch Avon Park OB well.

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis HANTUSH's method Leaky aquifer, no aquitard storage	Date: 1-4-2000	Page 1
		Project: ROMP 25 Avon Park APT	
		Evaluated by: mtg	

Pumping Test No. 1 Drawdown Phase	Test conducted on: 5/4 to 5/7/1999
2-inch Avon Park OB	
Discharge 4700.00 U.S.gal/min	



Transmissivity [ft²/d]: 2.86×10^5

Hydraulic conductivity [ft/d]: 3.41×10^2

Aquifer thickness [ft]: 840.00

Storativity: 2.57×10^{-4}

Hydraulic resistance (c) [d]: 8.72×10^3

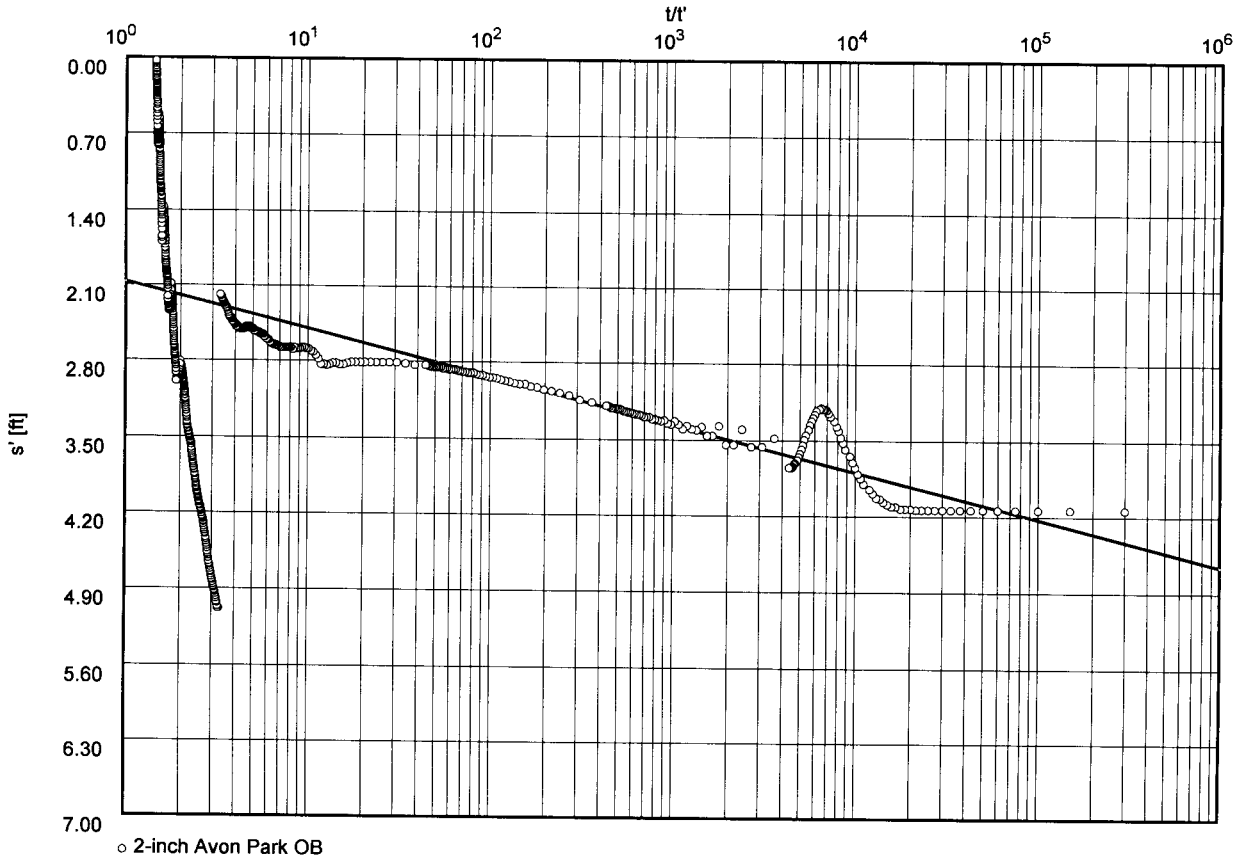
Water level data corrected for regional water level trend.
2-inch Avon Park OB well located 500 feet from pumped well.

FIGURE 27. ROMP 25 Lily

Hantush Curve Match
for 2-inch Avon Park OB well.

SWFWMD Geohydrologic Data Section Brooksville, Florida 1-800-423-1476	Pumping test analysis Recovery method after THEIS & JACOB Confined aquifer	Date: 1-3-2000	Page 1
		Project: ROMP 25 Lily Avon Park APT	
		Evaluated by: mtg	

Pumping Test No. 1 Recovery	Test conducted on: 5-7-99 to 5-24-99 (Recovery)
2-inch Avon Park OB	
Discharge 4700.00 U.S.gal/min	
	Pumping test duration: 3.00000 d



Transmissivity [ft²/d]: 3.83×10^5

Hydraulic conductivity [ft/d]: 4.56×10^2

Aquifer thickness [ft]: 840.00

FIGURE 28. ROMP 25 Lily

Theis & Jacob Curve Match
for 2-inch Avon Park OB well.

Appendix A

Cooper and Jacob Method

Cooper & Jacob Method (Confined, Small r or Large Time)

(From: AquiferTest® User's Manual)

The Cooper and Jacob (1946) method is a simplification of the Theis method. This method is valid for later time values and decreasing distance from the pumping well (small values of μ). The AquiferTest® software uses the Cooper and Jacob equation:

$$s = \left(\frac{2.3Q}{4\pi T}\right) \log_{10}\left(\frac{2.25Tt}{Sr^2}\right)$$

Where:

s = drawdown ($h-h_o$)

Q = pumping well discharge

π = 3.14159265359

T = transmissivity

t = time since pumping began

r = radius from pumping well to observation well

The Cooper and Jacob method assumes the following:

- the aquifer is confined and has an apparent infinite extent
- the aquifer is homogeneous, isotropic, and of uniform thickness over the pumped area
- the piezometric surface was horizontal prior to pumping
- the well is pumped at a constant rate
- the well is fully penetrating
- water removed from storage is discharged instantaneously with decline in head
- the well diameter is small so well storage is negligible
- the values of μ are small ($\mu < 0.01$)

Appendix B

Hantush Method (leaky, no aquitard storage)

Hantush Method

(From: AquiferTest® User's Manual)

The Hantush Method solves the flow equation for a confined aquifer with leakage described by:

$$\frac{\partial^2 h}{\partial r^2} + \frac{1}{r}\frac{\partial h}{\partial r} - \frac{hK'}{Tb'} = \frac{S}{T}\frac{\partial h}{\partial t}$$

where,

K' = vertical hydraulic conductivity of the leaky layer

b' = the thickness of the leaky layer

The Hantush and Jacob (1955) solution to the above equation is :

$$S = \frac{Q}{4\pi T}\int_{\mu}^{\infty}\frac{1}{y}\exp\left(-y - \frac{r^2}{L^2 y}\right)dy$$

where:

$$S = \frac{Q}{4\pi T}W\left(\mu, \frac{r}{L}\right)$$

where:

$$\mu = \frac{r^2 S}{4\pi T}$$

where:

s = drawdown in the observation well

Q = well discharge

T = transmissivity

r = radial distance from the pumped well

L = leakage factor

S = storativity

A log/log scale plot of the relationship W(u,r/L) along the y axis versus 1/u along the x axis is used as the type curve. The field measurements are plotted as t along the x-axis and s along the y-axis. The data analysis is done by curve matching.

The Hantush method assumes:

- the aquifer is leaky and has an apparent infinite extent
- the aquifer and the confining layer are homogeneous, isotropic, and of uniform thickness over the area influenced by pumping
- the peizometric surface was horizontal prior to pumping
- the well is pumped at a constant rate
- the well is fully penetrating
- water removed from storage is discharged instantaneously with decline in head
- the well diameter is small so well storage is negligible
- leakage through the confining layer is vertical and proportional to drawdown
- the head in the confining layer and any unpumped aquifers remain constant
- storage in the confining layer is negligible

Note: Leakance values should be used with caution. The leakance values apply only to the confining unit directly above the pumped aquifer and are for *vertical* leakance only.

The Hantush method was used to determine values for transmissivity (T), horizontal hydraulic conductivity (K_h), and storativity (S) of the aquifer, and hydraulic resistance (c) or $\left(\frac{b'}{K'}\right)$ of the leaky confining unit. The values for leakance and vertical hydraulic conductivity of the confining units were obtained from the equation $\frac{b'}{K'} = \frac{B^2}{T}$, where b' = thickness of leaky aquitard, K' = vertical hydraulic conductivity of the leaky aquitard, T= transmissivity and B = leakage factor. Matching the drawdown curve to the Hantush family of curves gives a value for $\frac{r}{B}$. The resulting value is substituted into the equation. Example: if $\frac{r}{B}$ = .05 the equation becomes $\frac{b'}{K'} = \frac{\left(\frac{r}{.05}\right)^2}{T}$ where r = the distance from the observation well to the pumped well (Batu 1998).

Appendix C

Theis & Jacob Recovery Test

Theis and Jacob Recovery Test (Confined)

From: AquiferTest® User's Manual

The recovery data from a well after the pump has been shut off can be used to estimate aquifer transmissivity. The AquiferTest® software uses equations developed by Theis and Cooper-Jacob to determine the aquifer parameters. The residual drawdown after pumping has ceased is described by Theis (1935) by:

$$s' = \frac{Q}{4\pi T} W(u) - W(u')$$

where

$$u = \frac{r^2 S}{4Tt}, \quad u' = \frac{r^2 S'}{4Tt'}$$

where,

Q = discharge

T = transmissivity

r = distance to the observation well

s' = residual drawdown

S = storativity during pumping

S' = storativity during recovery

t = elapsed time since start of pumping

t' = elapsed time since end of pumping

Using the approximation for the well function, $W(\mu)$, shown in the Cooper and Jacob (1946) method, the equation becomes:

$$s' = \frac{Q}{4\pi T}\left(\ln\frac{4Tt}{r^2 S} - \ln\frac{4Tt'}{r^2 S'}\right)$$

When S and S' are constant and equal and T is constant, the equation is reduced to:

$$s' = \frac{2.3Q}{4\pi T}\log\left(\frac{t}{t'}\right)$$

To analyze the data, s' is plotted on the logarithmic y-axis and time is plotted on the linear x-axis as the ratio of t/t' (total time since pumping began divided by time since pumping ceased).

The Theis and Jacob Recovery Method assumes:

- the aquifer is confined and has an apparent infinite extent
- the aquifer is homogeneous, isotropic, and is of uniform thickness over the area influenced during pumping
- the piezometric surface was horizontal prior to pumping
- the well is pumped at a constant rate
- the well is fully penetrating
- the water removed from storage is discharged instantaneously with decline in head
- Well storage is negligible