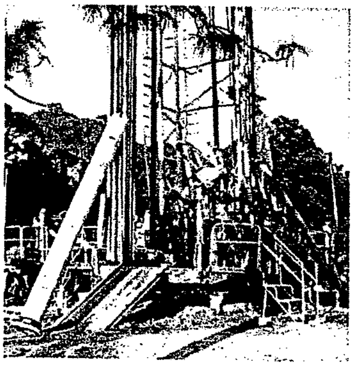
ENGLEWOOD WATER DISTRICT



Reclaimed Water ASR Well Construction and Testing Summary at the South Regional WWTP

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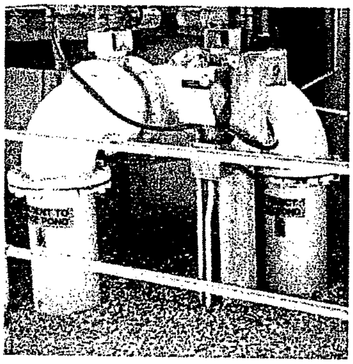
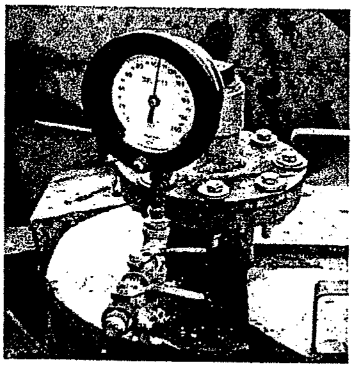


Englewood ASR

Prepared for

Englewood Water District

Southwest Florida Water Management District



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July 2000

PROFESSIONAL GEOLOGIST

The geological evaluation and interpretations contained in the *Englewood Water District Reclaimed Water ASR Well Construction and Testing Summary at the South Regional Wastewater Treatment Plant* prepared for the Englewood Water District, July 2000, were prepared by, or reviewed by, a Licensed Professional Geologist in the State of Florida.

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List of Acronyms

µmhos/cm	Micromhos per centimeter
µg/L	Micrograms per Liter
µs/cm	Microsiemen per centimeter
ASR	Aquifer storage recovery
BCS	Borehole compensated sonic
bls	Below land surface
BOP	Blowout preventer
cu ft	Cubic foot
DIL	Dual-induction lateralog
EPA	United States Environmental Protection Agency
EWD	Englewood Water District
FDEP	Florida Department of Environmental Protection
ft bls	Feet below land surface
gpd	Gallons per day
gpm	Gallons per minute
IAS	Intermediate Aquifer System
IMW	Intermediate zone monitor well
MCL	Maximum contaminant level
mg/L	Milligrams per Liter
mgd	Million gallons per day
NGVD	National Geodetic Vertical Datum
pH	Hydrogen (ion) concentration
psi	Pounds per square inch
SAS	Surficial Aquifer System
SMW	Shallow zone monitor well
SP	Spontaneous potential
SRWWTP	South Regional Wastewater Treatment Plant
SWFWMD	Southwest Florida Water Management District
SX	Sacks
SZMW	Storage zone monitor well
TAC	Technical Advisory Committee
TDS	Total dissolved solids
TON	Threshold Odor Number
TPW	Test-production well
UFAS	Upper Floridan Aquifer System
USDW	Underground source of drinking water
WT	Water table
WWS	Well Water Systems, Inc.

SECTION 1

Introduction

1.1 Project Background

Many reclaimed water systems encounter dry season irrigation demands that equal or exceed dry season reclaimed water supplies. The reverse occurs during wet seasons when reclaimed water supplies are usually more than wet-season irrigation demands. This valuable excess reclaimed water often must be disposed of through surface water discharge or deep well injection. The loss of this resource can be minimized using reclaimed water aquifer storage recovery (ASR).

The concept of reclaimed water ASR involves storing highly treated reclaimed water, which meets all primary and secondary drinking water standards and other stringent requirements, in a suitable aquifer zone using specially constructed ASR wells. The reclaimed water is normally stored during periods when the supply of the reclaimed water exceeds the demands of the system's users. These periods usually occur when rainfall is plentiful and the use of reclaimed water for irrigation is not necessary. The water is later withdrawn when the user's demands exceed the system's supply, usually during dry periods. Using this technology, the valuable water resource is preserved and the system's wet weather storage facilities can be minimized. Since the water is stored in aquifer zones, typical ASR storage volumes are usually magnitudes greater than conventional above ground storage methods at a fraction of the cost.

The South Regional Wastewater Treatment Plant (SRWWTP) is owned and operated by the Englewood Water District (EWD) and consists of twin, advanced secondary, treatment units, which provides a firm capacity of 1.2 million gallons per day (mgd). Reclaimed water from the treatment plant flows by gravity to an onsite reuse pond where it is temporarily stored before being pumped to the system's reuse customers. Presently, the plant is operating near its design limit of 1.2 mgd. Plans are currently being developed to expand the firm capacity of the plant by adding another 1.2 mgd treatment unit. This unit is scheduled to be on line by 2001.

The EWD reclaimed water system currently delivers high quality reclaimed water through a network of dedicated transmission mains to three golf courses within the EWD boundaries (Lemon Bay Golf Course, Oyster Creek Golf and Country Club and Myakka Pines Golf Club). At the reuse sites the water is stored in ponds until it is used for irrigation. Figure 1-1 shows the location of the SRWWTP and the reuse distribution system.

1.2 ASR Test System Permitting

EWD applied for and received Permit No. 43770-011-UC from the Florida Department of Environmental Protection (FDEP) to construct a reclaimed water ASR test system at the

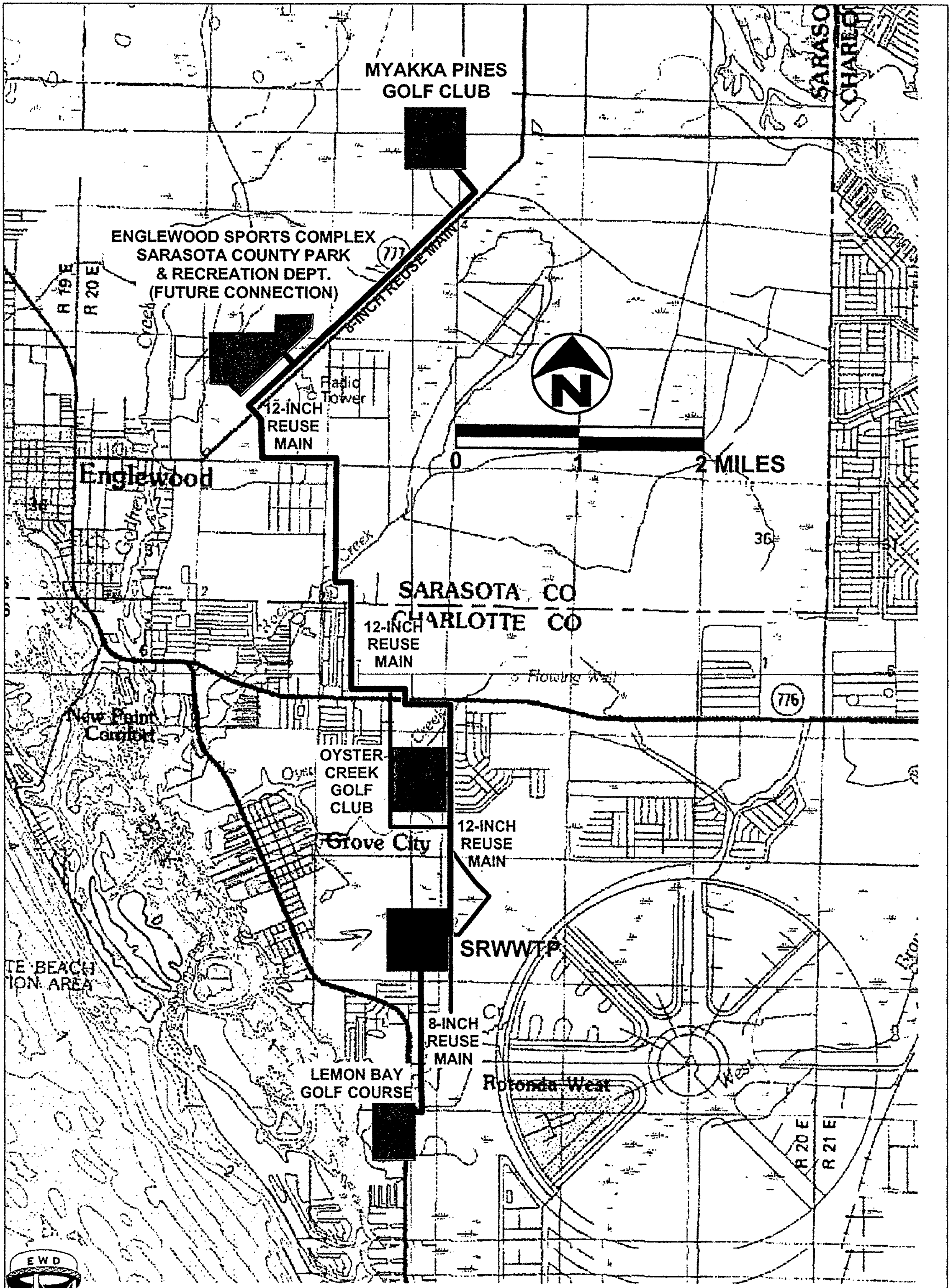

FIGURE 1-1
Location of the SRWWTP and the Reuse System

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SRWWTP. The permit issued by FDEP was for a Class V, Group 3 injection well system. Class V injection wells typically inject into a formation containing an underground source of drinking water (USDW). Group 3 wells include those wells associated with the temporary storage of reclaimed water. The 5-year permit was issued to EWD on June 3, 1999, and is presented in Appendix A, along with other pertinent regulatory correspondence.

The system for which the permit was granted consisted of:

- One 16-inch-diameter ASR test-production well (TPW-1)
- One 6-inch-diameter storage zone monitor well (SZMW-1)
- One 4-inch-diameter intermediate zone monitor well (IMW-1)
- One 6-inch-diameter shallow zone monitor well (SMW-1)

In addition to these wells, the permit required that, adjacent to the deepest wells (TPW-1 and SZMW-1), shallow water table monitor wells were to be constructed to monitor the water table aquifer during their construction to demonstrate that the water table aquifer was not affected by the drilling operation.

The ASR system will also include the pumps, piping and wellhead appurtenances necessary to convey the plant's reclaimed water from its discharge point, located at the chlorine contact chamber, to the wells and to convey the recovered water from the ASR well to the plant's reuse system. An FDEP WWTP minor permit modification has been requested (Application No. FLA014126-008-DW1P) and should be issued shortly.

EWD retained the services of CH2M HILL and PBS&J to design the ASR system, obtain a qualified well drilling contractor, and provide oversight during the construction and testing of the system. Following the operational (cycle) testing of the system, EWD intends to apply for a Class V operating permit to place the system into service.

Well Water Systems, Inc. (WWS) of Ft. Myers, Florida was the drilling contractor selected to construct the wells. Following CH2M HILL's notice to proceed, WWS began mobilization of their equipment to the site on January 11, 2000. The Southwest Florida Water Management District (SWFWMD) issued well construction permits for all of the wells on January 13, 2000. Copies of all permits and pertinent regulatory correspondence are contained in Appendix A. Drilling of the ASR system began on January 24, 2000, was completed on April 17, 2000, and the drilling equipment was removed from the site on April 26, 2000.

1.3 Site Description

The SRWWTP is located approximately 1.5 miles east of the community of Grove City, Florida and approximately 4 miles southeast of Englewood (see Figure 1-1). The plant is an advanced secondary wastewater treatment plant placed into service in 1996, and has been operating continuously since that time. The plant consists of twin circular 1.2 mgd treatment units, twin filters, and twin chlorine contact chambers. The treatment units provide the redundancy necessary to give the plant a firm (largest unit out) capacity of 1.2 mgd.

The effluent from the plant is stored in a 5 million gallon unlined reuse pond located south of the plant. Effluent is pumped from the holding pond to a 12-inch reuse main serving reuse users to the north of the plant and to an 8-inch reuse line serving Lemon Bay Golf Course to the south. In addition, the plant also has a 1M-lined reject pond, which temporarily stores substandard effluent prior to re-treatment. The plant is permitted by FDEP WWTP permit No. FLA014126-001-DW1P (including permit revision no. FLA014126-005-DW1) to treat 1.2 million gallons of wastewater per day. Figure 1-2 presents a diagram of the SRWWTP.

Figure 1-3 shows the location of the ASR system wells, TPW-1, SZMW-1, and SMW-1, at the plant. TPW-1 is the test ASR storage well. SZMW-1, located approximately 400 feet to the west of TPW-1, is intended to monitor the potentiometric pressure in the ASR storage zone and to detect water quality changes that occur in the zone as the result of the storage of reclaimed water. The shallow monitoring well, SMW-1, located approximately 150 feet to the east of TPW-1, is designed to monitor the potentiometric changes in the shallow intermediate aquifer system and to detect changes in this aquifer zone as the result of the storage of reclaimed water in the ASR storage zone. Figure 1-4 shows the location of the intermediate zone monitor well (IMW-1) in relationship to the plant. This well is located approximately 2,200 feet to the west of TPW-1. It is designed to detect potentiometric changes in the lowest production zone within the intermediate aquifer system. It is also designed to detect water quality changes in this zone. Its location at the western boundary of EWD's property will allow the well to determine potential offsite effects of the ASR system operation.

The topography of the plant site is flat, with an average land surface elevation of approximately 6 feet above the National Geodetic Vertical Datum (NGVD). The vegetation in the area consists of pine trees, shrubs and palmettos. The area is home to numerous birds and other wildlife, including American eagles, osprey, wild hogs and smaller animals. Few residences have been constructed in the immediate vicinity of the plant.

1.4 Purpose and Scope

The purpose of this report is to document the construction and testing of the EWD Reclaimed Water ASR System. A summary of the findings and appropriate recommendations are presented at the end of the report. The report is prepared in compliance with FDEP requirements contained in Chapter 62-528 of the Florida Administrative Code and a permit stipulation in the FDEP Class V, Group 3 permit issued for the ASR system.

Well construction information provided in this report includes a description of the drilling equipment and procedures, the type and quantity of the material used in the construction and a chronology of the major construction and testing events. Included also is a discussion of significant decisions made during the construction and testing of the ASR test well. Unless otherwise stated all depths given in this report refer to land surface.

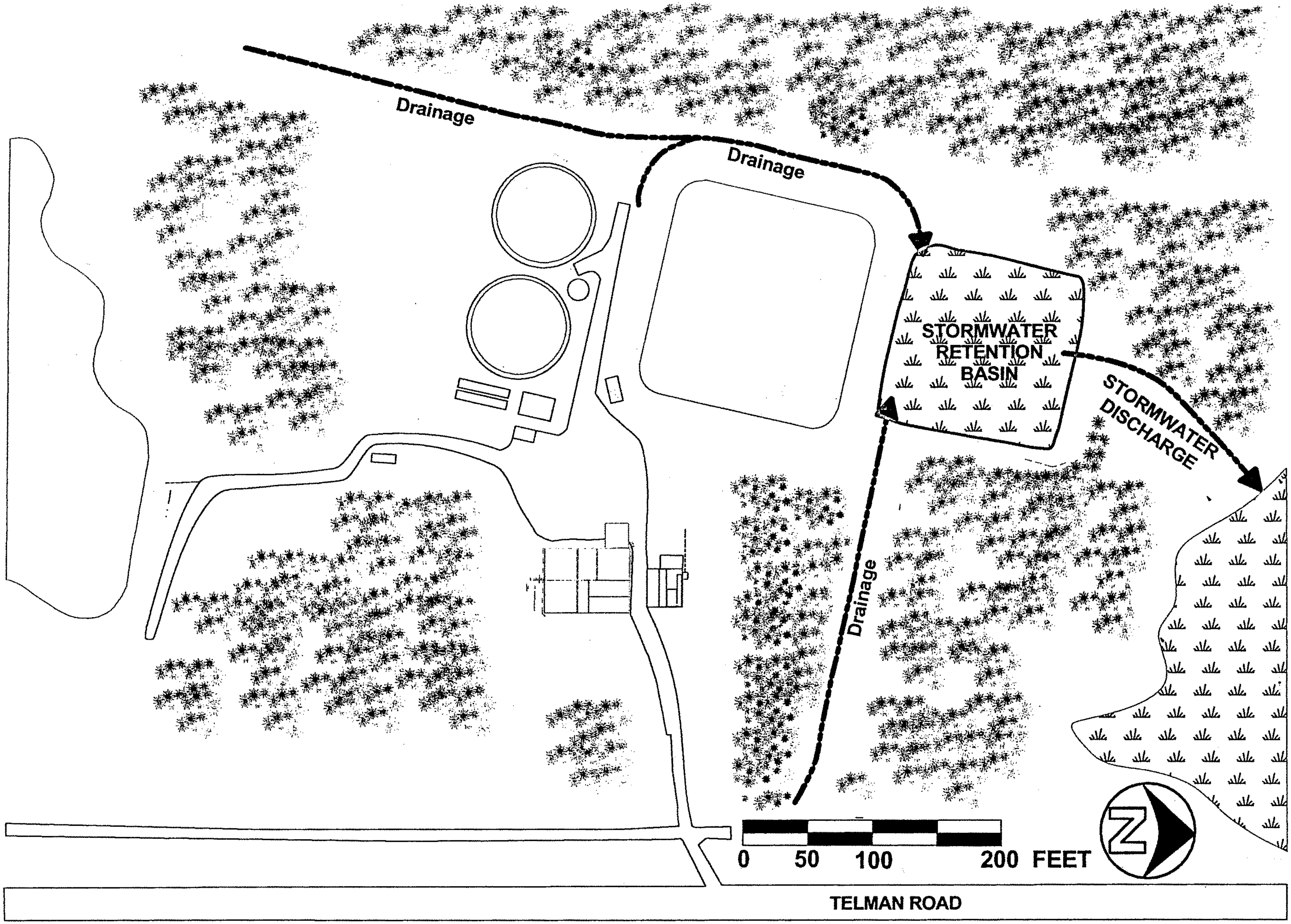

FIGURE 1-2
Diagram of the South Regional WWTP

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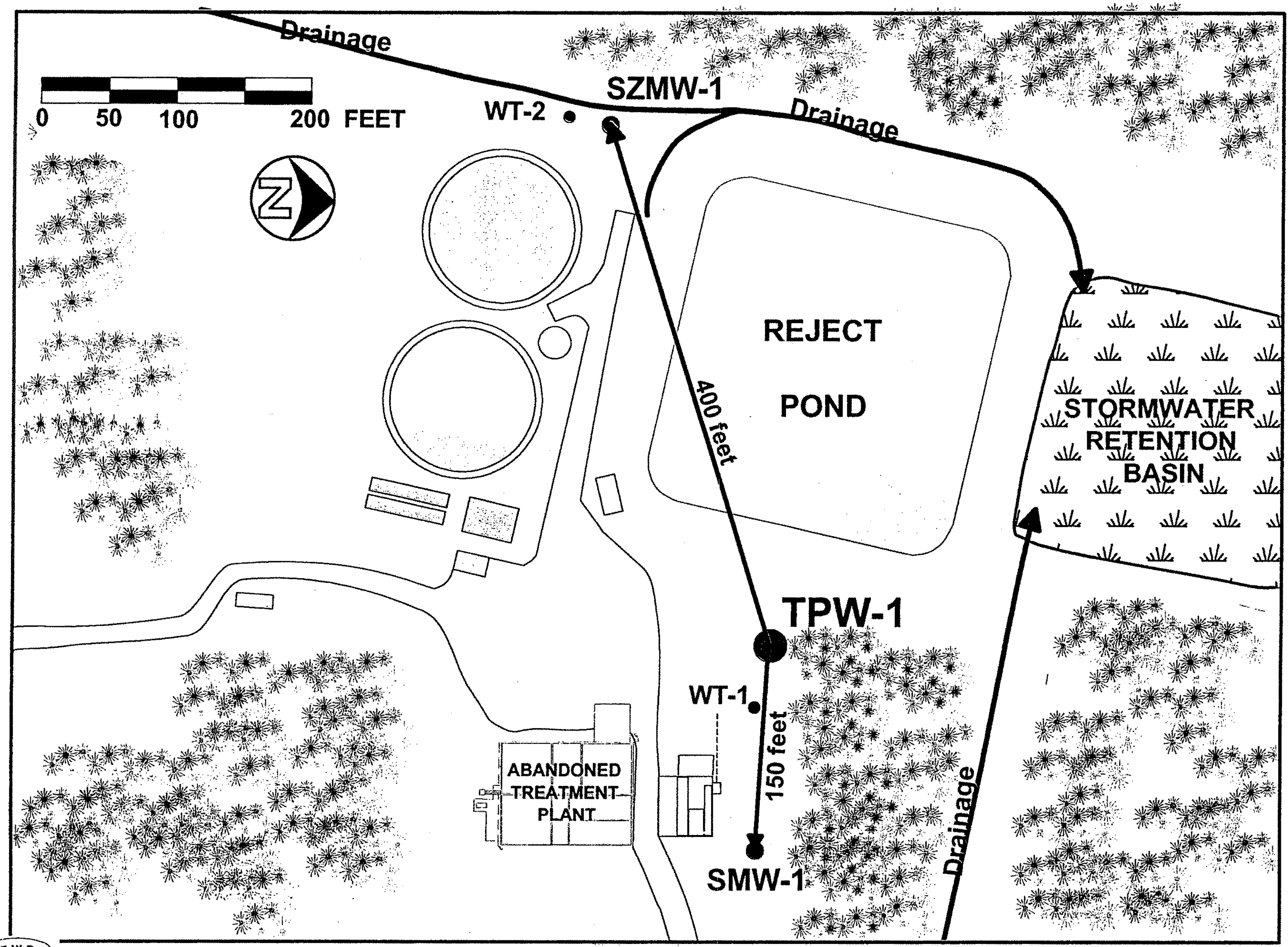

FIGURE 1-3
Location of ASR Wells at the Treatment Plant

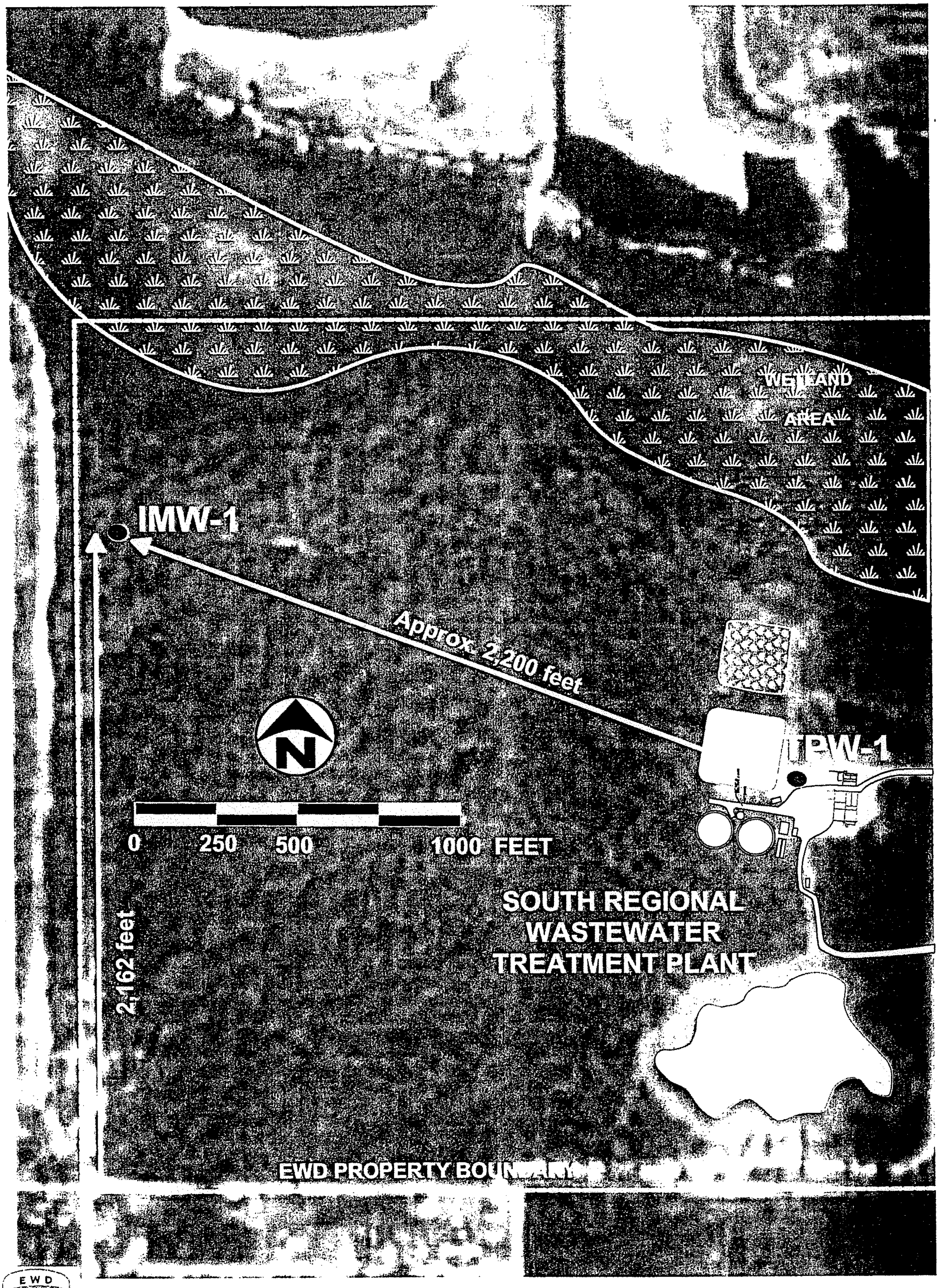

FIGURE 1-4
Location of Offsite Well IMW-1

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A complete discussion is also included on all hydrogeologic data collected during the construction period. These data include water quality testing, formation sampling, geophysical logging, and hydraulic testing.

1.5 Acknowledgements

The successful completion of the ASR system was the result of close cooperation by numerous individuals and agencies. The FDEP Technical Advisory Committee (TAC) provided valuable agency support and technical assistance throughout the project. Key District 7 FDEP TAC members include:

- Mr. Jack Myers, P.G. FDEP, Chairman
- Mr. Joe Haberfeld, P.G., FDEP, Tallahassee
- Mr. Eric Eshom, SWFWMD, Brooksville
- Ms. Nancy Marsh, EPA, Region IV, Atlanta

The Englewood Water District personnel also provided valuable support and assistance during the development and execution of the project. Key personnel included:

- Englewood Water District Board of Supervisors:
    - Mr. Paul J. Phillips, Chairman
    - Mr. Toddington S. Tracy, Vice Chairman
    - Mr. Ken Burda, Supervisor
    - Ms. Sydney Crampton, Supervisor
    - Ms. Kerry E. Mack, Supervisor
- Mr. James Elder, P.E., EWD Administrator
- Wayne R. Roddey, Assistant Administrator
- Mr. Philip E. Wagoner, SRWWTP Plant Superintendent

The EWD is also very appreciative of the support of the Southwest Florida Water Management District. The District is co-funding 50 percent of this project and its overall support of the reclaimed water ASR technology has been instrumental in advancing this key water resources management concept in west-central Florida.

SECTION 2

Well Construction

Prior to the start of well construction, WWS submitted specific data on all materials that they intended to use in the construction of the wells. This data was reviewed and approved by CH2M HILL. Submittals of mill certifications for each well casing are contained in Appendix B.

During the construction period, onsite observation was provided by a PBS&J, Inc. onsite geologist. These observations were summarized in a weekly summary report that was submitted to all members of the TAC. Copies of the weekly TAC summary reports are contained in Appendix C.

2.1 Water Table Monitor Wells

Water table (WT) monitor wells were installed to determine the effect of the drilling operations on the water table aquifer in the vicinity of the ASR test production well TPW-1 and the storage zone monitor well SZMW-1, both of which penetrate brackish aquifer zones which are under flowing artesian conditions. Each water table well was sampled on a weekly basis for selected parameters which are presented and discussed in later sections of this report.

2.1.1 Location

WT-1 is located approximately 40 feet southeast of the ASR well, TPW-1, while WT-2 is located approximately 47 feet south of the storage zone monitor well, SZMW-1 (see Figure 1-4). These locations are designed to monitor the effect of any major release of brackish or saline water that may have occurred during the drilling operations

2.1.2 Construction

Both wells were constructed to a total depth of 20 feet. They were constructed using a hollow-stem auger type-drilling rig. Each well has 5 feet of 10-slot, PVC screen and approximately 15 feet of Schedule 40 PVC casing. The annular space outside of the screen was filled with coarse (6/20) sand, with the remainder of the annulus filled with neat cement grout. Both wells were constructed on January 21, 2000. Appendix D contains the well completion reports for these wells. Figure 2-1 presents a typical completion diagram for the wells.

2.2 Test-Production Well TPW-1

TPW-1 was constructed first since the majority of the data collection program would be implemented during its construction. The construction details of the other wells in the ASR system were refined based on the data collected during this program.

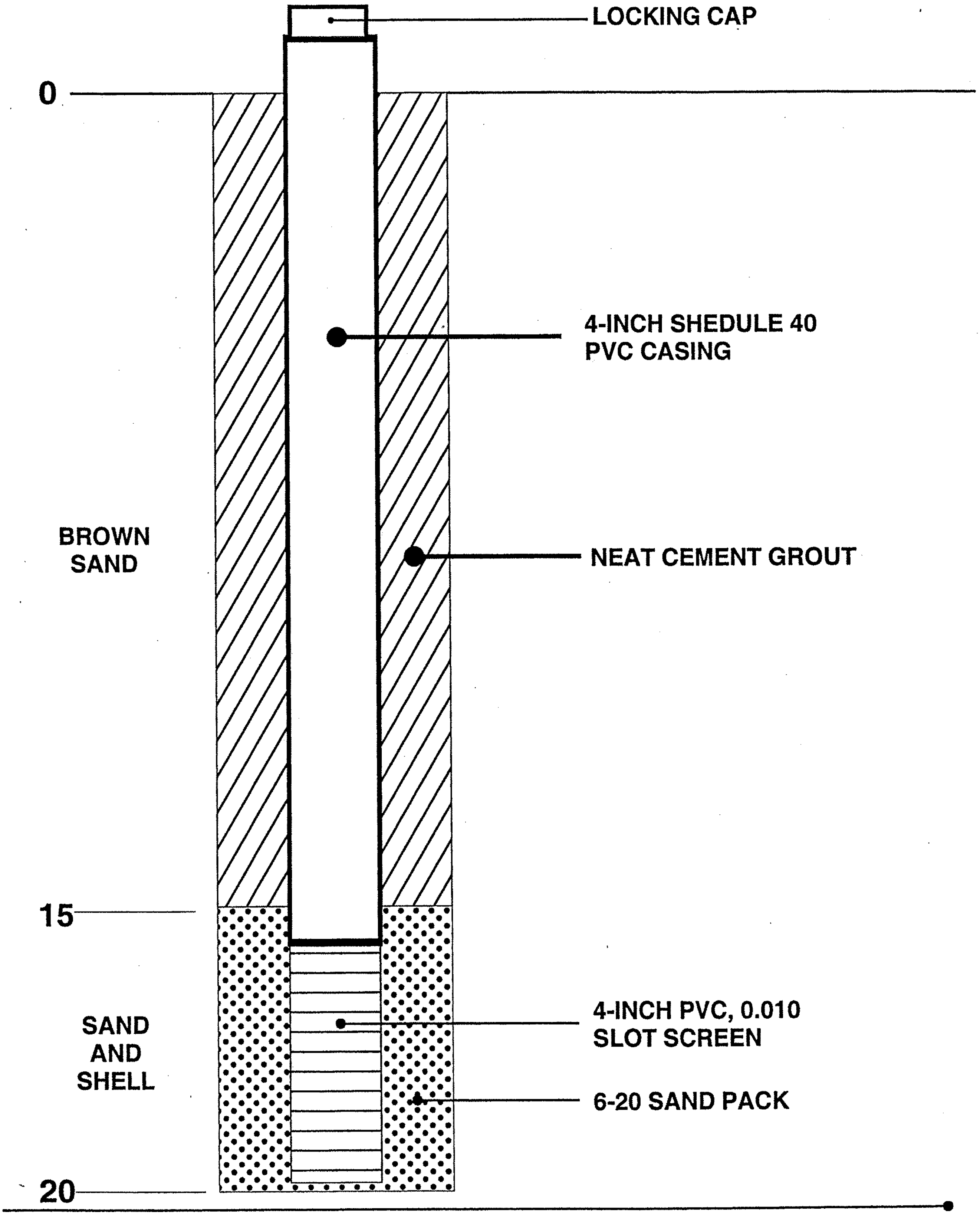

FIGURE 2-1
Water Table Monitor Well (Typical)

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Table 2-1 presents the chronology of the construction of TPW-1. Figure 2-2 presents a construction diagram of TPW-1.

TABLE 2-1
TPW-1 Construction Chronology

Date	Event
1/21/00	Well Water System obtained SWFWMD well construction permit.
1/24/00	Mobilization complete. Drilling started.
1/24/00	30-inch surface casing installed and cemented.
1/28/00	7-7/8-inch pilot hole to 330 feet completed.
1/31/00	Geophysical logs on pilot hole to 330 feet completed.
2/4/00	Drilling 28-1/2-inch reamed hole to 298 feet completed.
2/7/00	24-inch casing installed to 295 feet.
2/8/00	24-inch casing cemented to surface
2/14/00	Started drilling 7-7/8-inch pilot hole using reverse-air.
2/15/00	Stopped using reverse-air.
2/18/00	Attempted drilling 7-7/8-inch pilot hole using mud. Start plugging back pilot hole with cement/sand.
2/23/00	Resumed attempt to drill with mud.
2/24/00	Started drilling with reverse-air under mud cap.
2/25/00	Drilling stopped at 583 feet to run packer test.
2/28/00	Packer test of 563 to 583 foot interval completed.
2/29/00	7-7/8-inch pilot hole drilled to 808 feet.
3/1/00	Geophysical logging performed on pilot hole to 807 feet.
3/2/00	Borehole video survey performed on pilot hole.
3/7/00	Packer test of 630 to 807 foot interval performed.
3/9/00	Pilot hole cemented back to 700 feet.
3/13/00	Pilot hole backfilled to 477 feet with sand topped with cement.
3/16/00	Pilot hole reamed to 23 inches to 512 feet.
3/20/00	16-inch casing installed to 507 feet.
3/22/00	16-inch casing cemented to surface.
3/24/00	Pressure test completed on 16-inch casing.
3/29/00	Open hole drilled to 700 feet.
3/30/00	Air development completed.
3/31/00	Geophysical logging and step-test performed on completed well. Final water quality sample taken.
4/6/00	Rig demobilized from TPW-1.

Figures 2-3 and 2-4 illustrate the TPW-1 drilling site, the rig used in the construction of that well, and the equipment used to mix and condition drilling mud. The drilling mud equipment includes a dual cone desander, which removes sand suspended in the mud and the shale shaker that has a vibrating screen to remove larger drill cuttings. The use of such equipment maintains the drilling mud in good condition and ensures that the samples obtained from the well are representative of the strata being drilled.

2.2.1 Location

Well TPW-1 was located during the design and permitting approximately 60 feet east of the southeast corner of the plant reject storage pond. This location, however, proved unworkable due to the presence of underground utilities at that location and insufficient room for pipe handling during construction. After receiving approval from FDEP the location of the well was moved an additional 50 feet east and 50 feet north of the planned location.

2.2.2 Surface Casing

The surface casing on this well is primarily a construction casing installed at the option of the contractor. It was installed to stabilize the unconsolidated surficial sands during subsequent drilling. The exact depth of the casing depended on the material encountered during drilling. The setting depth was largely at the option of the Contractor.

The borehole for the surface casing was drilled on January 24, 2000 to a depth of 37 feet using a nominal 39-inch bit and mud rotary drilling methods. The hole penetrated sand to a depth of approximately 31 feet. A layer of relatively hard rock and shell was encountered from 31 to 34 feet. Below that depth, soft clay and sand was encountered from 34 to 37 feet. The Contractor was confident that the rock layer encountered was sufficient to protect the surface around the well and elected to stop drilling and set casing to this depth.

A 30-inch, 0.375-inch wall thickness, spiral welded, steel casing was then installed to a total depth of 35 feet. The casing was cemented into place using 125 sacks of ASTM Type II Portland neat cement. The cement top in the annulus was tagged the following day at 3 feet below land surface. The top of the cement inside the casing was later encountered at a depth of 30 feet (7-foot cement plug). The theoretical cement volume, required to fill the annular space, was 126 sacks (assuming a slurry yield of 1.18 cubic feet per sack). Table 2-2 presents the theoretical vs. actual cement quantities for TPW-1 and other wells constructed onsite.

2.2.3 Intermediate Casing

The pilot hole for the intermediate casing was started January 26, 2000 and was completed to a total depth of 330 feet on January 28, 2000. The hole was drilled using mud rotary techniques using a 7-7/8-inch rock bit.

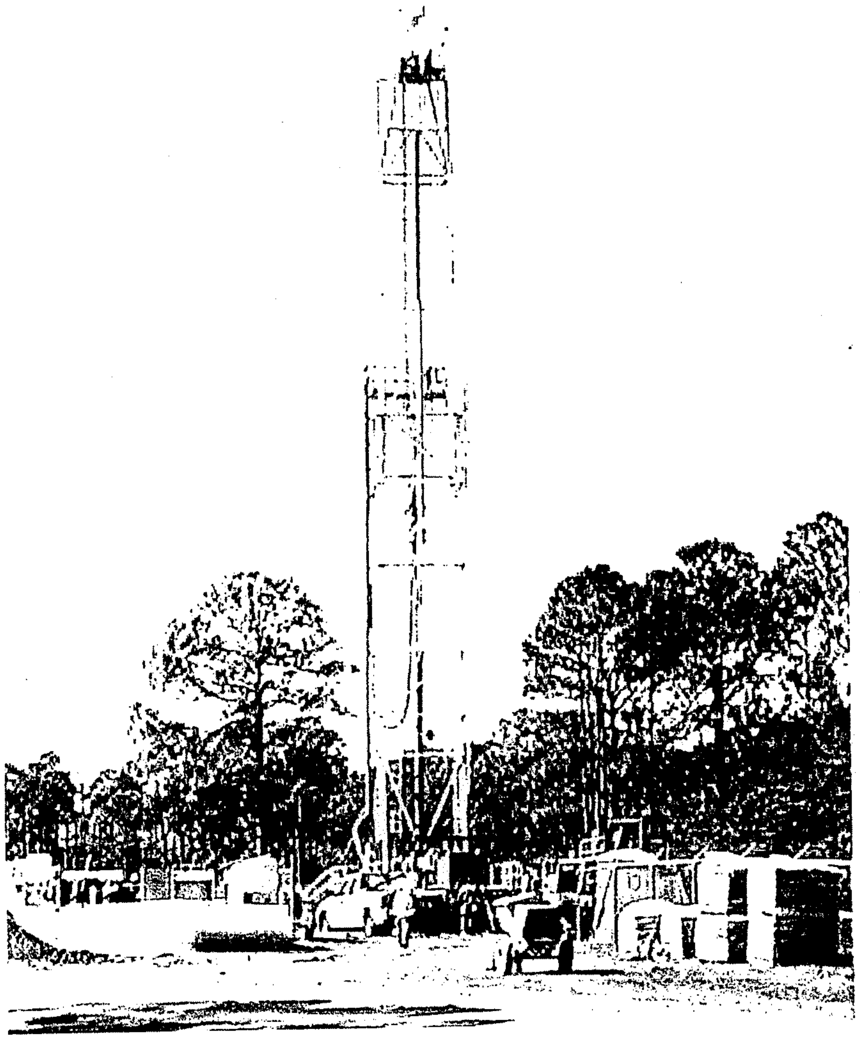
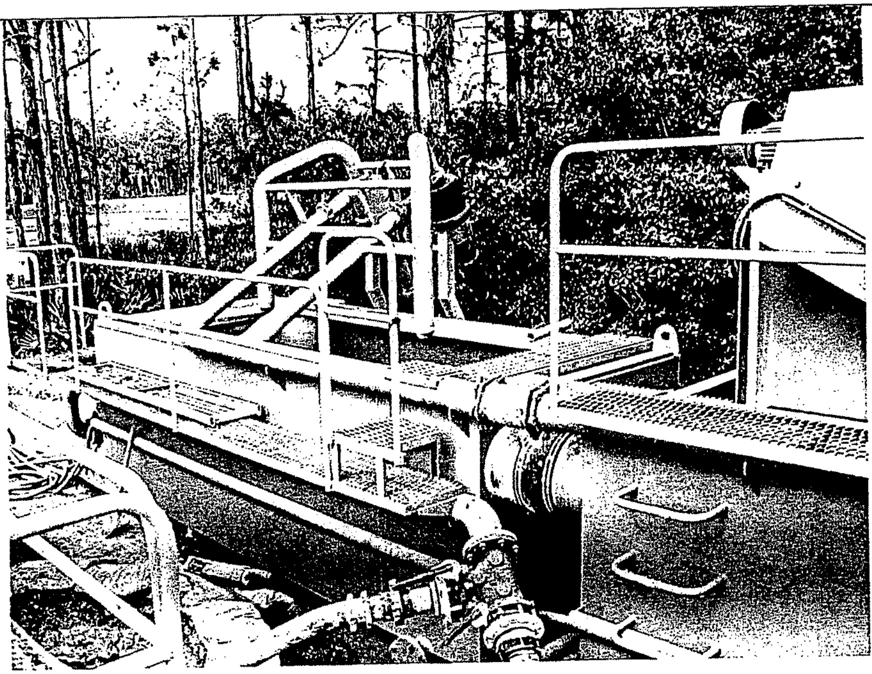


FIGURE 2-3
Well Drilling Rig



Drilling
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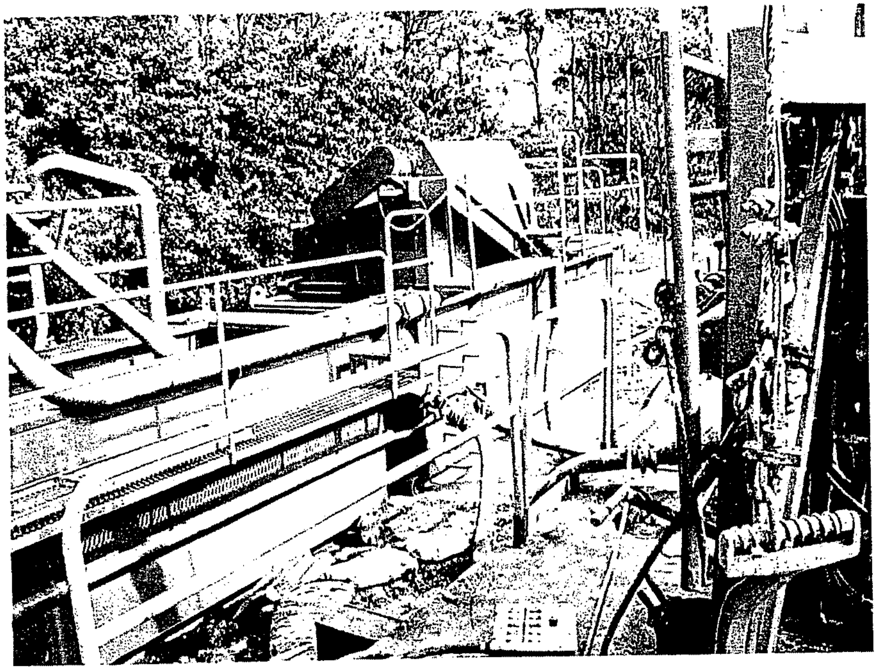

Shale
Shaker

FIGURE 2-4
Drilling Mud Processing Equipment

TABLE 2-2
Cement Volume Calculations

			Annular Segment				Grouting Program		
Well	**Casing**	**Stage**	**From**	**To**	**Length (ft)**	**Volume (cu ft)**	**Additives**	**Quantity (cu ft)**	**Placement Method**
TPW-1	24-inch	1	295	30	265	359	Total	363	Pressure
		tail					Neat	71	
		lead					4% Gel	292	
		2	30	0	30	46	Neat	73	Tremmie
	16-inch	1	507	349	158	229	Total	393	Pressure
		tail					Neat	237	
		lead					6% Gel	156	
		2	349	310	39	53	12% Gel	218	Tremmie
		3	310	0	310	422	Neat	254	Tremmie
SZMW-1	14-inch	1	290	0	290	261	4% Gel	279	Pressure
	6-inch	1	510	250	260	151	Neat	111	Pressure
		2	250	0	250	179	Neat	122	Tremmie
IMW-1	4-inch	1	280	80	200	46	Neat	38	Tremmie
		2	80	0	80	18	Neat	29	Tremmie
SMW-1	6-inch	1	170	0	170	98	Neat	90	Pressure

Contractor personnel collected formation samples at 5-foot intervals. These samples were carefully washed of drilling mud, described, and re-bagged by the project's onsite geologist. The descriptive lithologic logs from this drilling and others in the project are contained in Appendix E. A more in-depth discussion of the lithology encountered will be discussed in a later section of this report.

During this portion of the pilot hole drilling, detailed records were taken on the drilling rate so that competent rock layers could be identified, particularly the top of the lower Hawthorn aquifer (PZ-3). The drilling rate and other data indicated that the top of PZ-3 was encountered at 310 feet. The rock immediately above this depth was very friable but was nevertheless consolidated and contained little sand. At a depth of approximately 316 feet, a void was encountered. Geophysical logging performed on the pilot hole confirmed that the top of PZ-3 was at approximately 310 feet. The log from this and other logging efforts for the project are contained in Appendix F. A more in-depth discussion of this logging and other logging performed during the project is contained in a later section of this report. Based upon the data collected, CH2M HILL determined that the intermediate casing could be set at 300 feet, as planned.

approximately 11,000 milligrams per liter (mg/L) total dissolved solids (TDS), which was significantly greater than was expected for this depth. The elevated concentration would severely limit the amount of drilling water that could be diverted to the reject pond without adversely impacting the treatment process. Finally, the unexpectedly high permeability of the rock below the intermediate casing at approximately 316 feet, combined with a significant artesian head, produced substantial flow quantities when a drilling rod change was attempted. Because of these factors, the drilling operation was suspended while alternative drilling and testing options could be evaluated.

It was decided that the best course of action was to return to mud-drilling techniques. The pilot hole was mud drilled to a total depth of 338 feet without resulting in any mud return circulation. In an attempt to plug off the lost-circulation zone, 40 sacks of 6 percent gel cement was pumped into the bottom of the hole and allowed to set until Monday, February 21, 2000. The cement top was tagged at 325 feet (13 feet of fill). An additional stage of 40 sacks of 6 percent gel cement was then pumped into the bottom of the hole. The top of the cement was tagged later that day; however, the tag indicated only a few inches of fill. A third stage of 40 sacks of 6 percent gel cement was again pumped into the bottom of the hole. A subsequent tag indicated no cement fill. Stage four consisted of 6 sacks of 6-20 sand followed by 40 sacks of 6 percent gel cement were then pumped into the hole. Later that day, a tag of the cement top again showed no measurable fill. Ten additional sacks of sand were then slurried into the bottom of the hole followed by a 40-sack batch of cement mixed with 5 sacks of sand (stage 5). During this operation, returns were observed at the surface, indicating that the lost circulation zone had, at least partially, been plugged off. The cement top was tagged the morning of Wednesday, February 23, 2000 at 266 feet. This depth was well up into the intermediate casing. Drilling with mud resumed later that morning. The pilot hole was advanced to a depth of 368 feet where circulation was again lost and the drilling operation halted to evaluate drilling options.

An alternative drilling program was developed by the contractor and the CH2M HILL/PBS&J Team. This program included maintaining a plug of heavy mud in the intermediate casing and drilling below the mud wafer using the reverse-air method. The water produced by the drilling would be pumped to the tanks of the abandoned treatment plant nearby the well site, allowed to settle, and then returned to the well at the end of the daily drilling operation. Drilling using this alternate program began Thursday, February 24, 2000, and was used successfully throughout the remainder of the construction of ASR well TPW-1.

The drilling operation was suspended on February 25, 2000 at a depth of 583 feet to perform a scheduled packer test on the strata overlying the target storage zone. The top of the zone was expected to be encountered at 600 feet. On February 28, 2000, an open ended, inflatable packer was set at 563 feet (approximately 20 feet off bottom). The 20-foot open borehole segment was then developed using airlift pumping to remove fines and turbidity from the zone. The development continued until the water was clear and the conductivity of the airlifted water had stabilized. A small submersible pump was then placed in the drill pipe to a depth of approximately 120 feet and an 80 minute drawdown test, followed by a 25 minute recovery test, was conducted. The pumping rate during the test was maintained at 10 gpm. Drawdown measured at the end of the

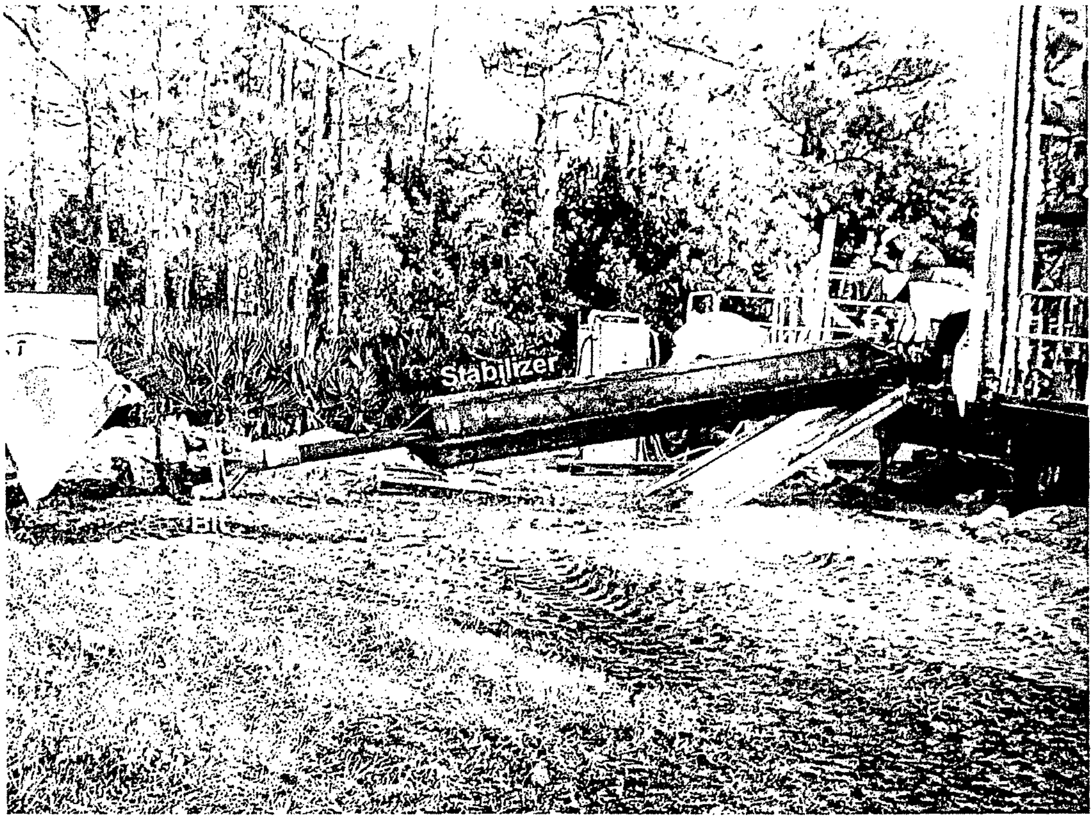

FIGURE 2-5
28 1/2-inch Reaming Bit Assembly

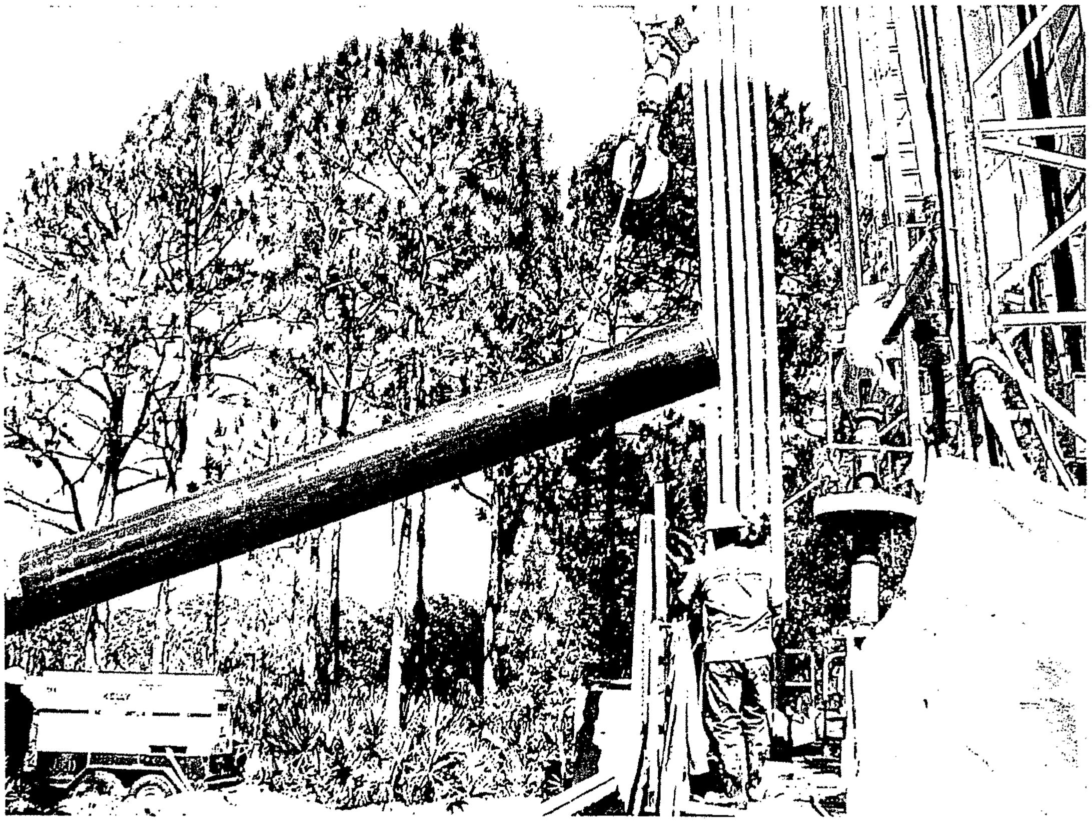

FIGURE 2-6
24-inch Casing Installation

approximately 11,000 milligrams per liter (mg/L) total dissolved solids (TDS), which was significantly greater than was expected for this depth. The elevated concentration would severely limit the amount of drilling water that could be diverted to the reject pond without adversely impacting the treatment process. Finally, the unexpectedly high permeability of the rock below the intermediate casing at approximately 316 feet, combined with a significant artesian head, produced substantial flow quantities when a drilling rod change was attempted. Because of these factors, the drilling operation was suspended while alternative drilling and testing options could be evaluated.

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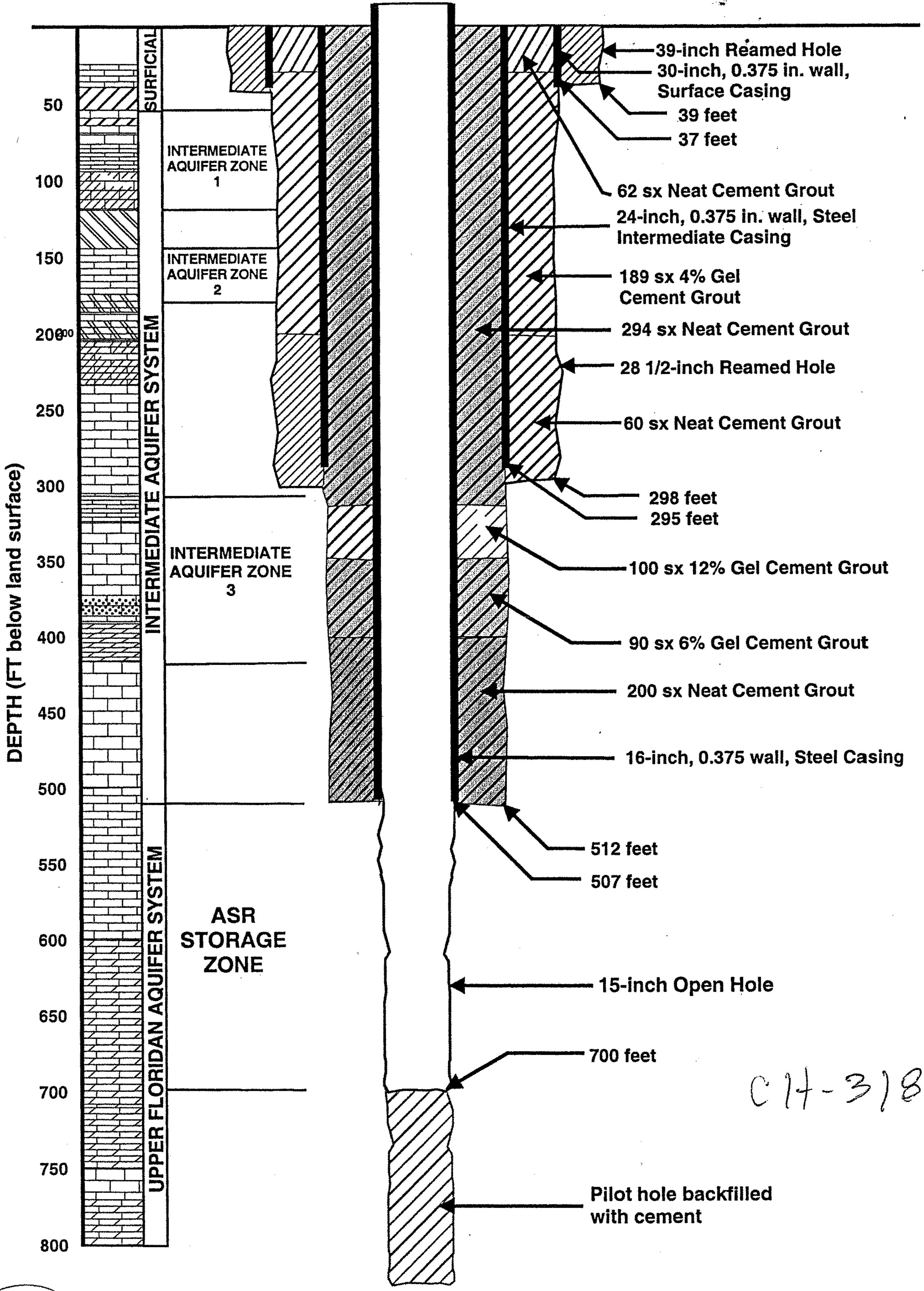

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FIGURE 2-2
TPW-1 Well Completion Diagram

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pumping period was 9.88 feet. Prior to ending the pumping test, a sample of the pumped water was collected for laboratory analysis. Further discussions of the packer tests and water quality sampling are presented in later sections of this report.

After conducting the packer test, drilling of the pilot hole was resumed on Tuesday, February 29, 2000. The borehole was then deepened to its total depth of 807 feet, using the same drilling technique. During the drilling operation, samples of the drilling water were taken at the end of each rod change. These samples were sent to the Englewood Water District water treatment plant for analysis.

A suite of geophysical logs was performed on Wednesday, March 1, 2000. This log suite consisted of caliper, gamma, electric, borehole compensated sonic, dual-induction, static and dynamic fluid resistivity and temperature; and static and dynamic flowmeter logs. The dynamic logs were performed while the well was allowed to flow at approximately 300 gpm. The water flowing from the well was pumped to the abandoned treatment plant tanks for storage where it could be settled before returning it to the well. These logs were collected and submitted to FDEP TAC for concurrence on the final casing setting depth. A detailed discussion of all logging suites is provided in later sections of this report.

On Thursday, March 2, 2000, a borehole video survey was performed while the well was again flowed at approximately 300 gpm. The primary purpose of this survey was to provide visual information on the nature of the rock and its water-producing pattern as an augmentation to the geophysical logging. This survey was only performed to a depth of 600 feet because the water below approximately 520 feet contained so much particulate matter that the borehole could no longer be seen. The presence of these particles indicates that very little flow was originating below this depth. Copies of the survey will be distributed separately to this report.

To perform geophysical and video logging described above, the heavy mud in the 24-inch casing was removed by airlifting and pumped to one of the abandoned treatment plant tanks. This mud was later pumped back into the casing after completion of the video survey. A temporary header pipe was attached to the wellhead to allow passage of the logging tools.

The geophysical logs indicated that most of the water flowing from the borehole during logging originated from the upper part of the borehole above about 330 feet. For this reason, the borehole below this depth received little hydraulic stress and it was not possible to adequately interpret the logs below this depth. A more in-depth discussion of the geophysical logs is contained in a later section of this report.

A second packer test was conducted in the open hole at 630 feet on March 6, 2000 to obtain a water quality sample of the planned storage zone from 600 to 700 feet and to provide an early indication of the injectivity of the proposed injection zone. The water used for the injection was the drilling water from the drilling of the pilot hole to be tested. It was recognized that the 3-1/2-inch ID of the drill pipe would significantly limit the injection rate due to friction losses, but these losses could be accounted for in the analysis.

The open hole was developed by airlift pumping the interval below 630 feet. A water quality sample taken at the end of development was analyzed by the EWD water plant laboratory. The total dissolved solids (TDS) of the development sample was 31,133 mg/L. Flow and water level measurements taken during this pumping indicated that the borehole below 630 feet had lower than expected capacity.

On March 8, 2000, a conference call was conducted between the CH2M HILL/PBS&J project team and representatives of FDEP (Mr. Joseph Haberfeld/TAL and Mr. Jack Myers/FMY). The project team reviewed the data collected during the pilot hole drilling and then asked for concurrence from FDEP to change the setting depth of the 16-inch final casing from the proposed 600 feet to 510 feet. This change would provide additional water production intervals available for storage. Since the geophysical data indicated that the zones below 700 feet contained very poor quality water, CH2M HILL also requested that the borehole be plugged back to 700 feet. Verbal permission was granted during this conference call and a formal written request was submitted to FDEP later that day. The letter from FDEP approving the casing setting depth is contained in Appendix A.

In preparation for final reaming to install the 16-inch casing, the borehole was cemented back to a depth of 698 feet. The pilot hole was backfilled to 516 feet with 6-20 silica sand. This sand was topped with 20 sacks of neat cement. The cement top was later tagged at 477 feet. Reaming the pilot hole to 22-1/2 inches started on Monday, March 13, 2000 and was completed at the end of the day on Thursday, March 16, 2000. The total depth of the reamed hole was 512.5 feet. The reaming operation was conducted using reverse-air drilling methods. A weighted mud cap was maintained in the 24-inch casing to offset the artesian pressure. Flow from the well was controlled at all times.

The 16-inch Final Casing on TPW-1 was installed on Monday, March 20, 2000 to a total depth of 507 feet below land surface. The casing was installed immediately after a caliper log was run on the reamed hole to verify the borehole configuration prior to casing installation. After the casing was lowered into place, it could be rotated by hand, indicating that there was no binding of the casing in the hole. The casing installed was ASTM A53, 0.375 wall thickness. Mill certifications for the casing was received prior to installation and the heat numbers checked by the PBS&J onsite geologist prior to installation. Copies of all mill certifications are contained in Appendix B.

The first pressure grouting stage was pumped immediately following the casing installation. Stage I consisted of 90 sacks of 6 percent gel cement followed by 200 sacks of neat cement. The quantity of neat cement was designed to provide neat cement in the bottom 100 feet of the casing. The cement top was tagged the following day at 349 feet. A temperature log, run on the well to verify cement coverage, indicated that the cement top was at about 340 feet. Figure 2-8 illustrates the wellhead assembly used for pressure grouting the 24-inch casing. A similar assembly was used to pressure grout the 16-inch casing.

FIGURE 2-7
Welding Sections of 24-inch Casing

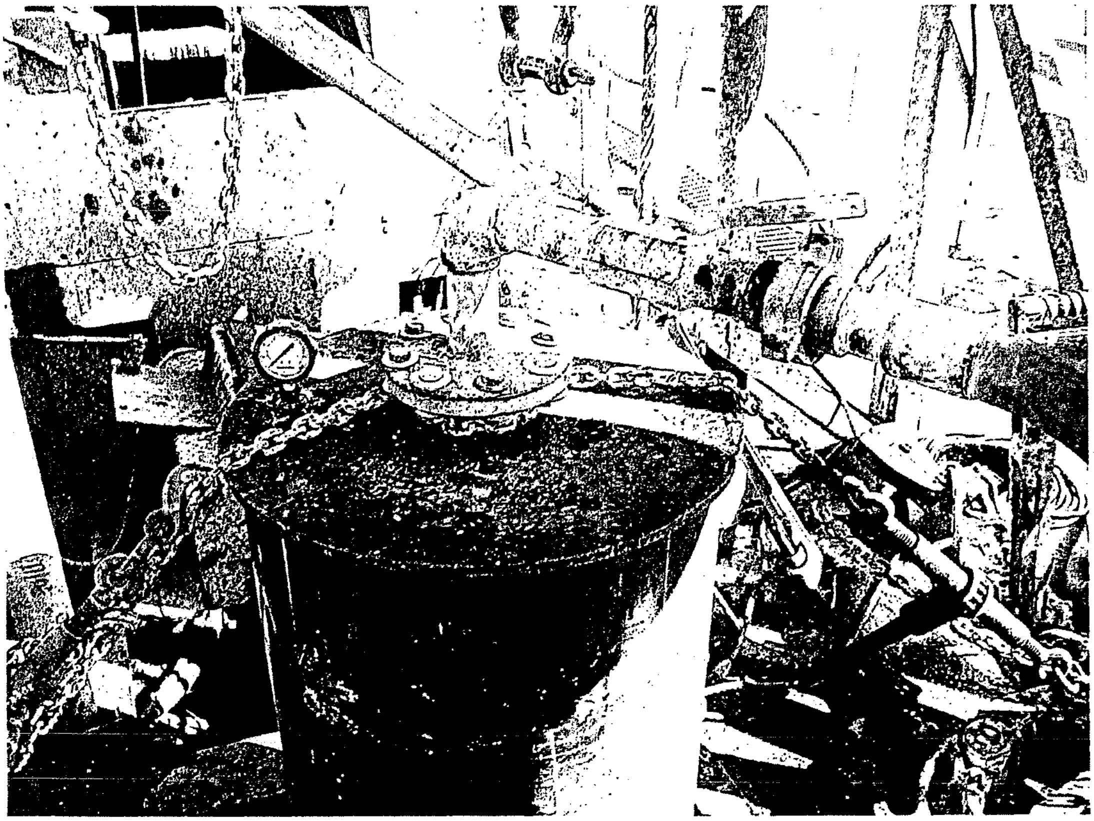

FIGURE 2-8
WellheadAssembly for Cementing of 24-inch Casing

The second stage of grouting was accomplished on Tuesday, March 21, 2000. Stage II consisted of pumping 100 sacks of 12 percent gel cement using tremmie pipe. Stage II was designed to bring the cement level to above the lost circulation zone that was observed at about 316 feet. The cement top was tagged later that day at 313 feet. A temperature log run the following morning verified that the cement top was at 310 feet.

The third and final grout stage (Stage III) on the 16-inch casing was tremmied on Wednesday, March 22, 2000, and consisted of pumping 294 sacks of neat cement. Steady mud returns were observed throughout the cementing operation, with clean cement returns observed at the surface at the end of the stage. The quantity of cement pump in Stage III was 82 percent of the theoretical fill amount, indicating that there may have been some settling of the heavy mud layer that had been maintained in the casing to offset the artesian head during the casing installation and cementing operation. This is most likely to have occurred within the 24-inch intermediate casing and will not affect the integrity of the well.

On Thursday, March 23, 2000, preparations were made to conduct a preliminary pressure test of the final 16-inch casing, with the final pressure test scheduled for Friday, March 24, 2000. Preliminary tests run on Thursday, March 23, 2000, indicated that the test would be successful. The pressure test of the 16-inch final casing was conducted successfully on Friday, March 24, 2000. FDEP was notified (Mr. Jack Myers) however, Mr. Myers was unable to attend. The casing was completely filled with water and the inside of the casing pressured to 104.5 psi and shut in. During the one-hour test, the pressure declined slightly to 104.2 psi and then rose again to a final pressure of 105.1 psi. These fluctuations were all within the 5 percent allowance for the test. Figure 2-9 illustrates the wellhead configuration used for the casing pressure test. Results of the final casing pressure test are presented in Appendix E.

Drilling below the 16-inch casing began on Tuesday, March 28, 2000. The cement plug in the bottom of the casing was encountered at 486 feet (21-foot plug). The nominal 15-inch-diameter hole was mud drilled to the total depth of 700 feet on Wednesday, March 29, 2000. During the drilling operation, only a nominal quantity of drilling mud was lost to the formation.

After the borehole was circulated clean, the drilling mud was removed from the hole. Airlift development was then used to clean the borehole of residual mud. Water produced by this development was transferred to the tanks of the abandoned treatment plant for settling. Airlift development was completed on Wednesday, March 29, 2000.

Additional development was continued using a high capacity submersible pump which was installed in preparation for the hydraulic testing of the well. The discharge from the pump was piped to the tanks of the abandoned treatment plant. The well was pumped at 1236 gpm for a total of 2 hours. The well experienced approximately 70 feet of drawdown during this pumping, indicating a specific capacity of about 17.7 gpm per foot of drawdown. The pumped water significantly cleared within the first one-half hour and had no noticeable turbidity at the end of development. The conductivity of a sample taken during the latter stage of development was 34,000 μS/cm.

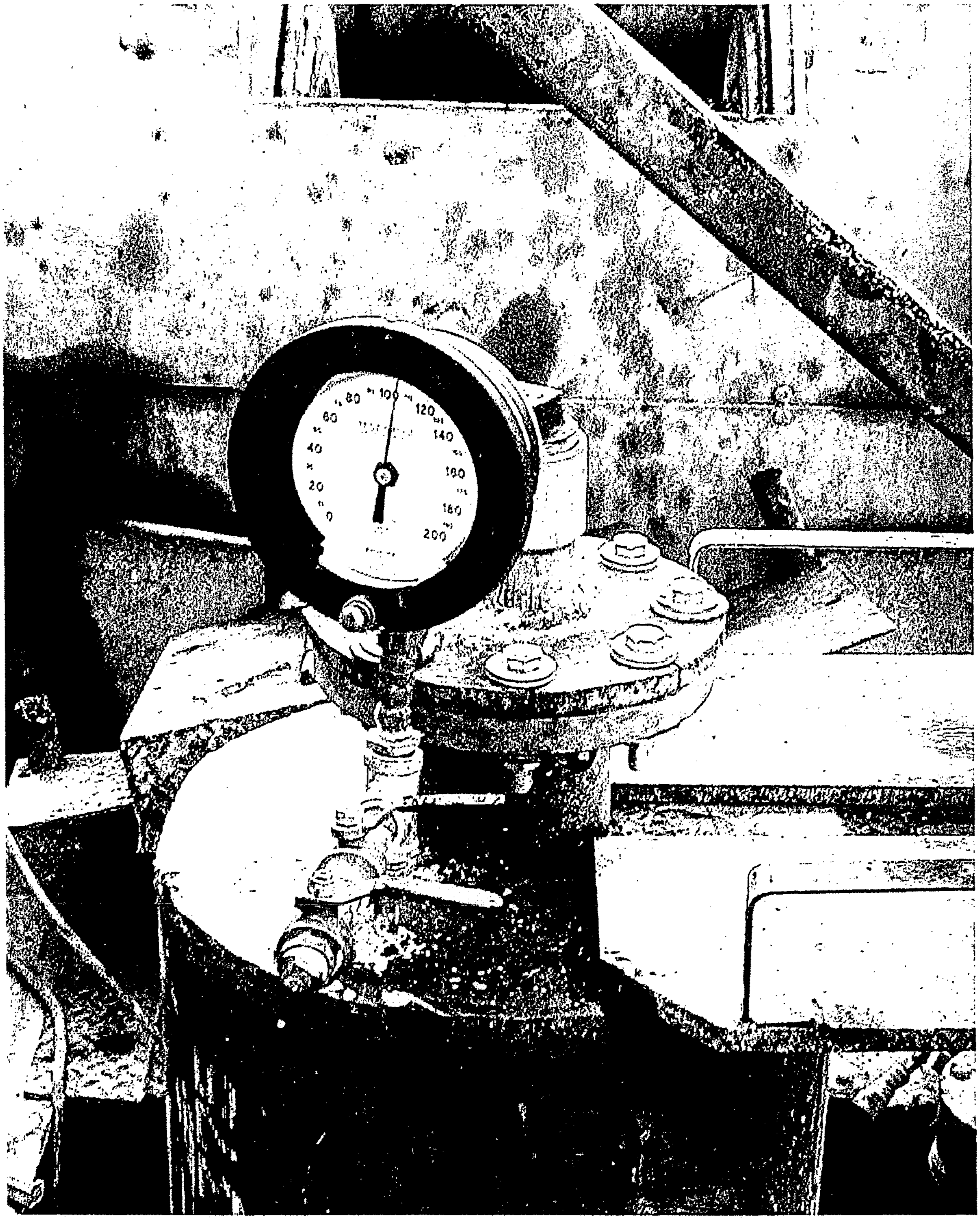

FIGURE 2-9
TPW-1 16-inch Final Casing Pressure Test Setup

A step-drawdown test of TPW-1 was conducted on Friday, March 31, 2000. The pumping rates during this test were established at 490, 681, 857, and 1050 gpm. The specific capacity measured during the test was approximately 17 gpm/ft for all of the established rates. A complete discussion of this testing is contained in a later section of this report.

Static and dynamic geophysical logs were run prior to and after the step testing. This logging effort is discussed in detail in later sections of this report.

The drilling rig was taken off the hole on Wednesday April 5, 2000, to allow for site cleanup.

2.3 Storage Zone Monitor Well

Drilling on the Storage Zone Monitor Well (SZMW-1) began Monday, April 3, 2000, with the installation of 42 feet of 20-inch surface casing. Construction continued with the drilling of a 19-inch hole to 292 feet using mud-drilling methods. Very hard limestone was encountered at approximately 290 feet which is slightly higher than the hard limestone encountered at 310 feet at TPW-1. Based on the highly transmissive zones encountered at TPW-1, the decision was made to stop drilling at this depth rather than taking the chance of encountering severe lost circulation. This drilling ended on Thursday, April 6, 2000, and preparation for casing installation was initiated. Table 2-3 presents a chronology of the construction of SZMW-1, while Figure 2-10 presents a well completion diagram of SZMW-1.

TABLE 2-3
SZMW-1 Construction Chronology

Date	Event
1/13/00	SWFWMD well construction permit obtained by Well Water System.
4/3/00	Rig mobilized. Drilling started.
4/3/00	20-inch surface casing installed and cemented.
4/6/00	Completed drilling 19-1/2-inch hole to 292 feet.
4/7/00	Set and cemented 14-inch intermediate casing to 290 feet.
4/12/00	Completed drilling 12-1/4-inch hole to 510 feet.
4/13/00	Set and cemented 6-inch PVC CertaLock casing to 507 feet
4/17/00	Drilled 5-1/2-inch open hole to 700 feet. Developed well 1.5 hours.
4/18/00	Performed geophysical logging on completed well.
4/20/00	Completed step-drawdown test.
4/20/00	Pulled final water quality samples for primary and secondary analysis.

On Friday, April 7, 2000, 290 feet of 14-inch steel casing was set at SZMW-1. The casing was pressure grouted into place with 180 sacks of 4 percent gel cement grout, with good cement returns observed at the end of the cementing operation.

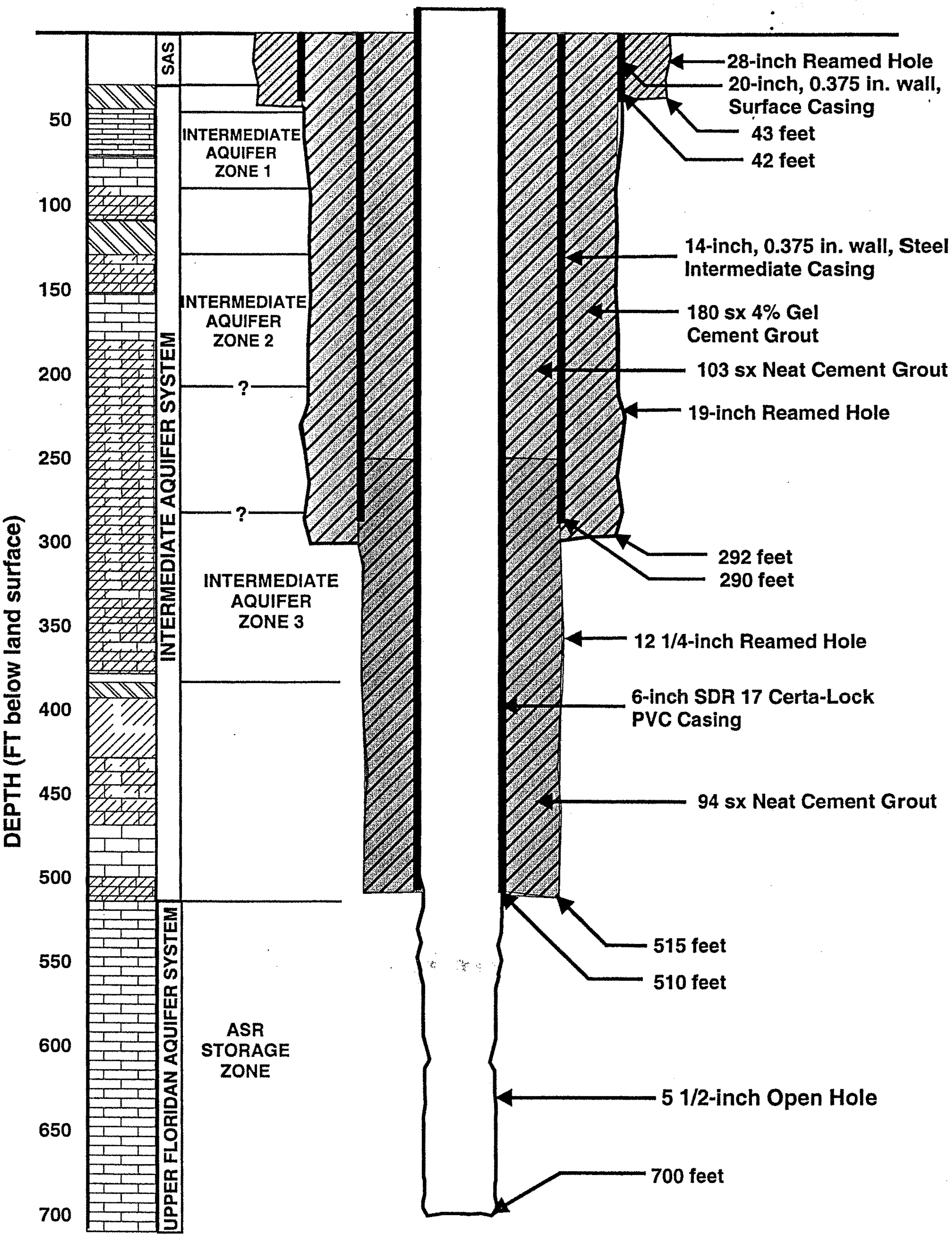

FIGURE 2-10
SZMW-1 Well Completion Diagram

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Drilling at SZMW-1 resumed on Monday, April 10, 2000. A 12-1/4-inch borehole was drilled to a depth of 515 feet using mud-drilling methods. No significant lost-circulation zones were encountered during the drilling operation. A suite of geophysical logs consisting of caliper, natural gamma, and electric were run on the completed borehole on Wednesday, April 12, 2000. The logs showed that the depths of the formations encountered were essentially the same as that found in TPW-1. Copies of these logs were transmitted to the Ft. Myers and Tallahassee FDEP TAC members to obtain concurrence on the setting depth of the 6-inch final casing for SZMW-1 at approximately 500 feet. Further explanation of the geophysical logs are presented in later sections of this report.

On Wednesday, April 12, 2000, 510 feet of 6-inch-diameter Certa-Lok PVC casing was installed and pressure grouted in place with 94 sacks of neat cement grout. The cement level in the annulus was tagged the following morning at 252 feet. The final cementing operation was completed on Thursday, April 13, 2000, with 103 sacks of neat cement grout. Good cement returns were observed at the surface at the end of the cementing operation.

On April 17, 2000, the open borehole section for SZMW-1 was drilled with a nominal 6-inch bit to the target depth of 700 feet using mud-drilling methods. After the borehole was cleaned of drill cuttings, the mud in the borehole was removed and the well developed by airlifting.

On April 18, 2000, a final suite of geophysical logs was run in SZMW-1. These logs included caliper, gamma, electric, static temperature, static fluid resistivity, static flowmeter, dynamic temperature, dynamic fluid resistivity, and dynamic flowmeter. The general appearance of these logs is similar to the logs run on TPW-1 at the same depths as detailed in Section 3.

2.4 Intermediate Zone Monitor Well

Construction of the intermediate zone monitor well (IMW-1) began on March 27, 2000, and was completed on April 6, 2000. Table 2-4 presents the construction chronology for this well, and Figure 2-11 presents a well completion diagram of IMW-1.

TABLE 2-4
IMW-1 Construction Chronology

Date	Event
1/13/00	SWFWMD well construction permit obtained by Well Water System.
3/27/00	Rig mobilized. Drilling started.
3/27/00	Set and cemented 14-inch surface casing to 40 feet.
3/30/00	Drilled 8-inch hole to 290 feet.
4/3/00	Drilled 4-inch hole to 320 feet. Set and cemented 280 feet of 4-inch Schedule 40 PVC casing.
4/6/00	Developed well with air.
4/6/00	Rig demobilized.
4/18/00	Step drawdown test performed.
4/20/00	Samples taken for primary and secondary parameters.

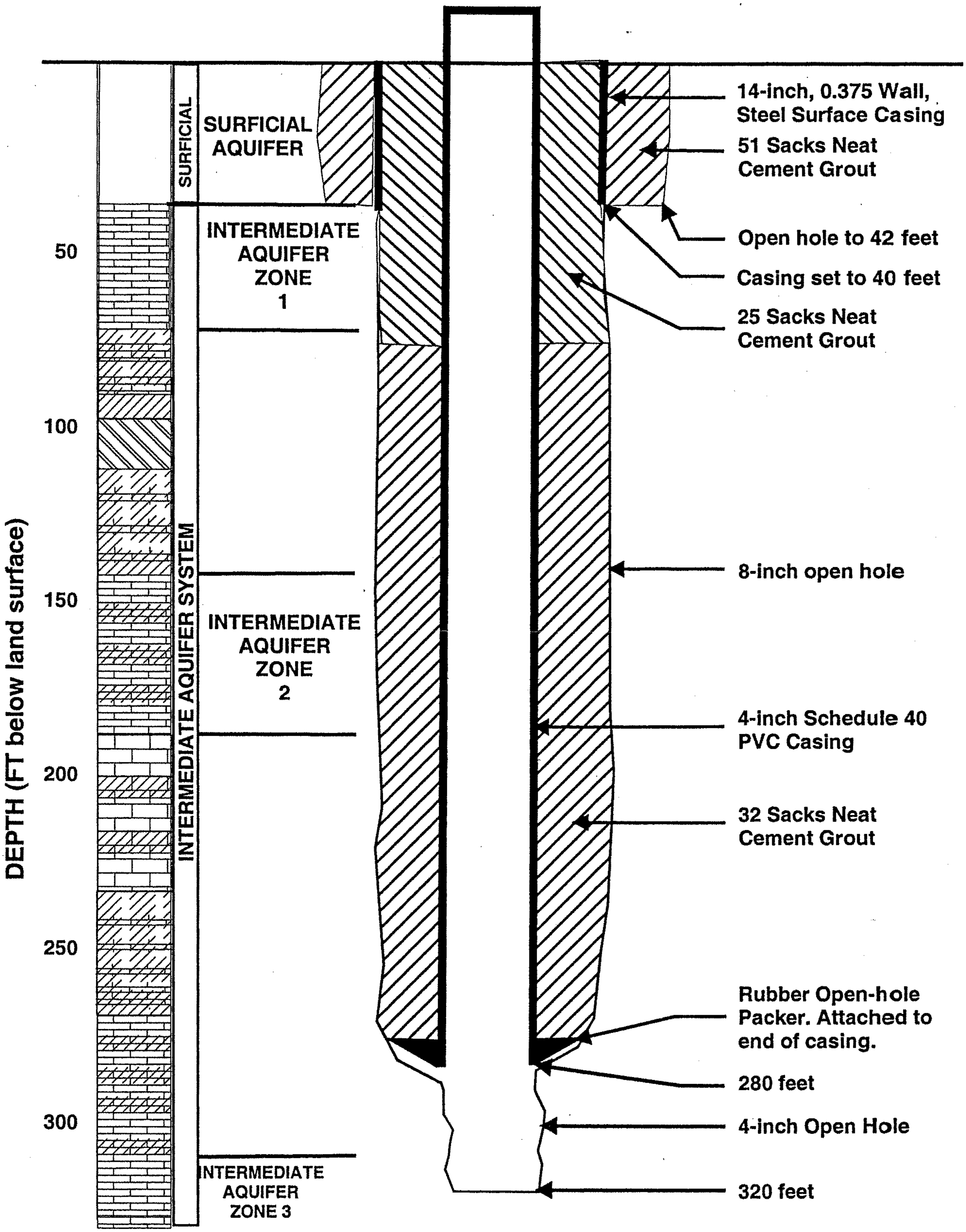

FIGURE 2-11
IMW-1 Well Completion Diagram

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The construction of IMW-1 began with drilling a nominal 19-inch-diameter hole to a depth of approximately 42 feet using mud drilling methods. Forty feet of 14-inch steel surface casing was installed in the drilled hole and cemented with 51 sacks of neat cement grout. During the cementing operation, grout was circulated to the surface.

An 8-1-4-inch hole was drilled to a depth of 280 feet using mud drilling. Drill cuttings were collected for examination during this drilling at 5-foot intervals. The bit size was then changed to 5-1/2-inch and the borehole which would become the open hole interval of the well was drilled to a depth of 320 feet. This interval was also drilled using mud drilling. Geophysical logs were run on the completed hole on March 31, 2000. These logs included electric, gamma ray and caliper. Additional logs could not be run since the borehole was drilled using mud.

On Friday, March 31, 2000, the 4-inch-diameter Schedule 40 PVC final casing was installed in IMW-1 to a depth of 280 feet. This casing had an 8-inch diameter neoprene packer attached to the bottom of the casing prior to installation. The purpose of this packer was to seal the base of the annular space outside the casing and prevent cement from entering the 5-1/2-inch-diameter open hole that was pre-drilled below the casing setting depth. The first stage cementing consisted of pumping 32 sacks of neat cement grout, using tremmie pipe installed to the base of the annular space. The cement top was later tagged at 80 feet. The annulus was then filled to land surface with 25 sacks of neat cement grout. The well was then developed for 1 hour on Thursday, April 06, 2000, after which the rig was removed from the well site.

On April 18, 2000, a variable rate step-drawdown test was performed on IMW-1 to determine the specific capacity of the well. The results of this testing will be used in the formulation of the sampling procedures that will be used for the well during ASR cycle testing and operation. A discussion of the step test and results are presented in Section 3.

2.5 Shallow Monitor Well

Drilling on the shallow monitor well (SMW-1) began on Monday, March 20, 2000, and completed on March 24, 2000. Table 2-5 presents the chronology of the well construction. Figure 2-12 presents a construction diagram of SMW-1.

Construction of SMW-1 began with the installation of 40 feet of 14-inch-diameter surface casing. The casing was installed in a nominal 19-inch-diameter hole drilled to a depth of 42 feet and cemented into place with 60 sacks of neat cement grout. At the end of the cementing grout returns were observed at the surface. Drilling continued on Tuesday, March 21, 2000, by drilling of a 12-1/4-inch hole to a depth of 174 feet. Electric, gamma, and caliper logs were run on the well on Wednesday, March 22, 2000, after which 170 feet of 6-inch Schedule 40 PVC casing was installed in the hole and cemented in place with 77 sacks of neat cement grout. Good cement returns were observed at the surface at the end of the cementing operation. The well was completed Thursday, March 23, 2000 by drilling an open hole to 205 feet using a 5-3/4-inch drill bit. After drilling the open hole interval, the well was developed by airlifting, and the rig was demobilized from the well.

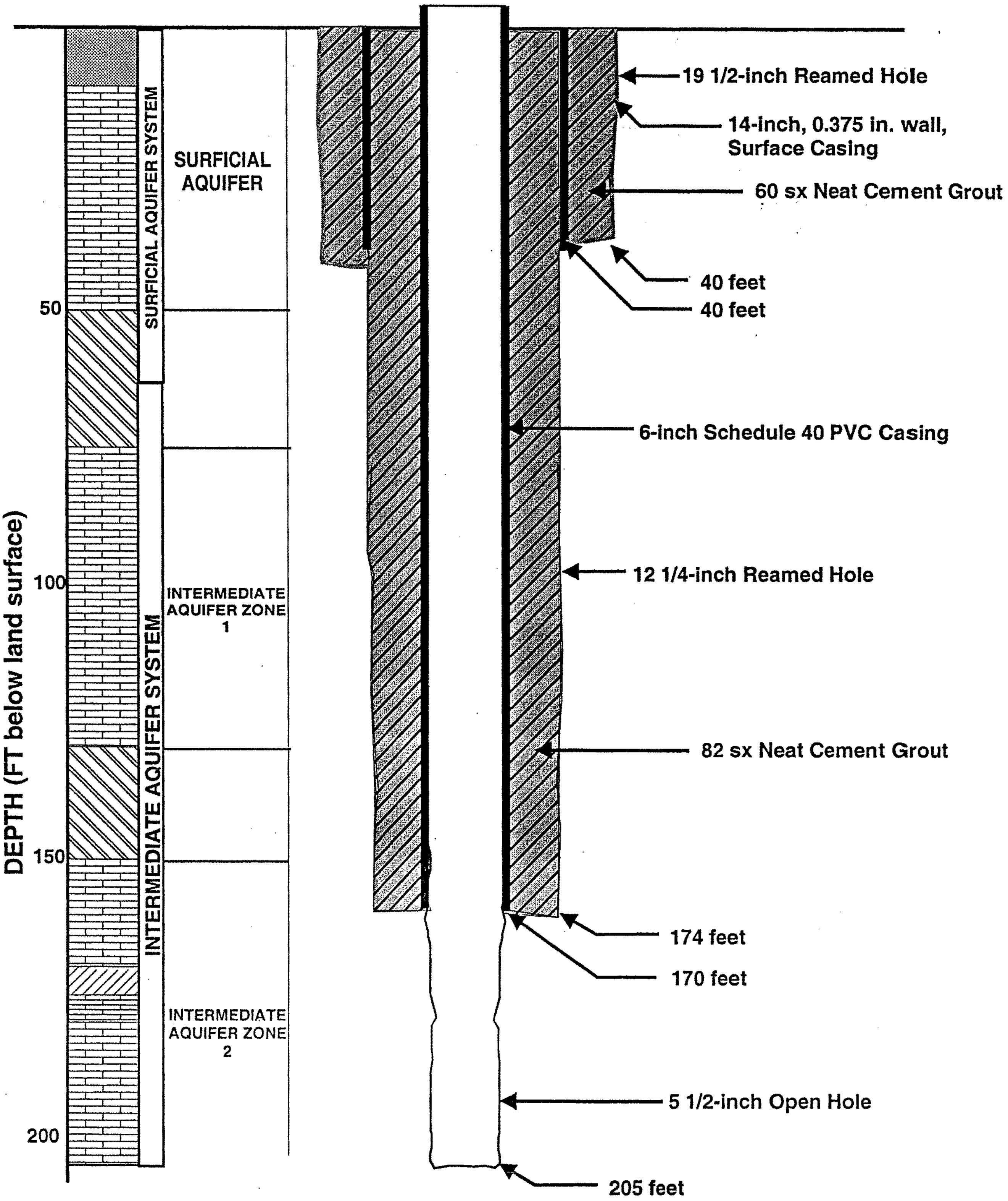

FIGURE 2-12
SMW-1 Well Completion Diagram

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TABLE 2-5
SMW Construction Chronology

Date	Event
1/13/00	SWFWMD well construction permit obtained by Well Water System.
3/20/00	Rig mobilized. Drilling started.
3/20/00	14-inch surface casing installed and cemented.
3/21/00	12-1/4-inch hole drilled to 174 feet.
3/22/00	Geophysical logging performed on hole to 174 feet.
3/22/00	6-inch Schedule 40 casing set and cemented to 170 feet.
3/23/00	5-1/2-inch hole drilled to 205 feet.
3/23/00	Rig demobilized.
3/24/00	Well developed with air.
3/30/00	Final geophysical logs run on completed well.
4/18/00	Step-drawdown test performed.
4/20/00	Well sampled for primary and secondary parameters.

SECTION 3

Hydrogeologic Data Collection And Analysis

Regional Hydrogeology

In Sarasota and Charlotte Counties, the hydrogeologic system consists of three aquifer systems: the Surficial Aquifer System (SAS), the Intermediate Aquifer System (IAS), and the Upper Floridan Aquifer System (UFAS). These aquifers are defined by strata that are permeable enough to yield usable water to wells and are separated by confining strata that is significantly less permeable. The aquifers and confining strata vary in thickness and extent and, in some locations, are difficult to differentiate. Figure 3-1 presents a north-south cross section from Manatee County to northwestern Charlotte County. Figure 3-2 presents an east-west cross-section through western Charlotte County.

The SAS is composed of unconsolidated sand, clay and shell material. The thickness of these sediments varies across the project area from a few feet to tens of feet. The water-yielding property of the sediment varies depending on the composition of the sediments and their hydraulic characteristics. The surficial aquifer's use as a water supply is limited by its thickness and transmissivity.

The IAS is composed of multiple permeable strata within the Miocene age Hawthorn group. The permeable zones are generally composed of permeable limestone and dolomite, which often contain sand and shell. The confining units that separate the aquifer zones are generally low permeable limestone and clay. In the project area, three distinct hydraulic units have been identified: PZ1, PZ2, and PZ3.

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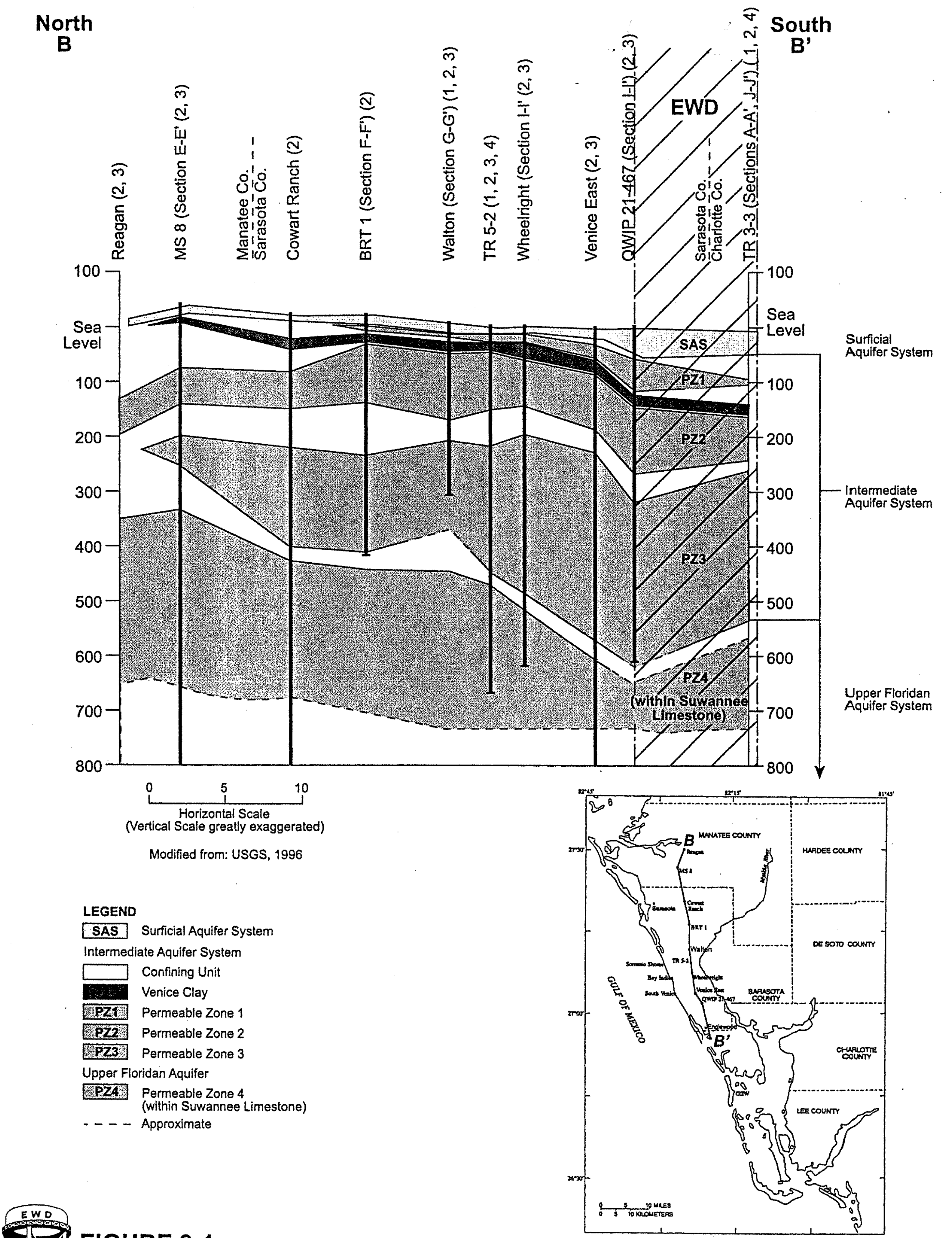
The thickness of the IAS generally increases from north to south. In the project area, the thickness of PZ1 is estimated to be about 30 feet, PZ2 is approximately 100 feet, while PZ3 is estimated to be about 300 feet. Transmissivity values for the three zones range from 1,000 to 8,000 ft^2/d for PZ1, 200 to 5,000 ft^2/d for PZ2, and 5,600 to 15,400 ft^2/d for PZ3 (CH2M HILL, 1997).

Below the IAS in the project area is the UFAS. The uppermost formation within the UFAS is the Oligocene age Suwannee Limestone. Below this formation, lies the Eocene age Ocala Limestone and the Avon Park Formation. The Suwannee Limestone generally has moderately high permeability making it useful for brackish water supply purposes and as a target ASR storage zone. The Ocala Limestone generally has lower permeability than the overlying Suwannee Limestone, while the Avon Park Formation has extremely high permeability, but in this area generally contains salt water.

3.2 Lithologic Sampling

During the drilling of the pilot holes of each of the wells, drill-cutting samples were collected by WWS personnel and delivered to the onsite geologist. During mud drilling operations, the samples were carefully washed of drilling mud and examined. Samples



Modified from: USGS, 1996

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FIGURE 3-1
Regional Hydrogeology: North-South Cross Section

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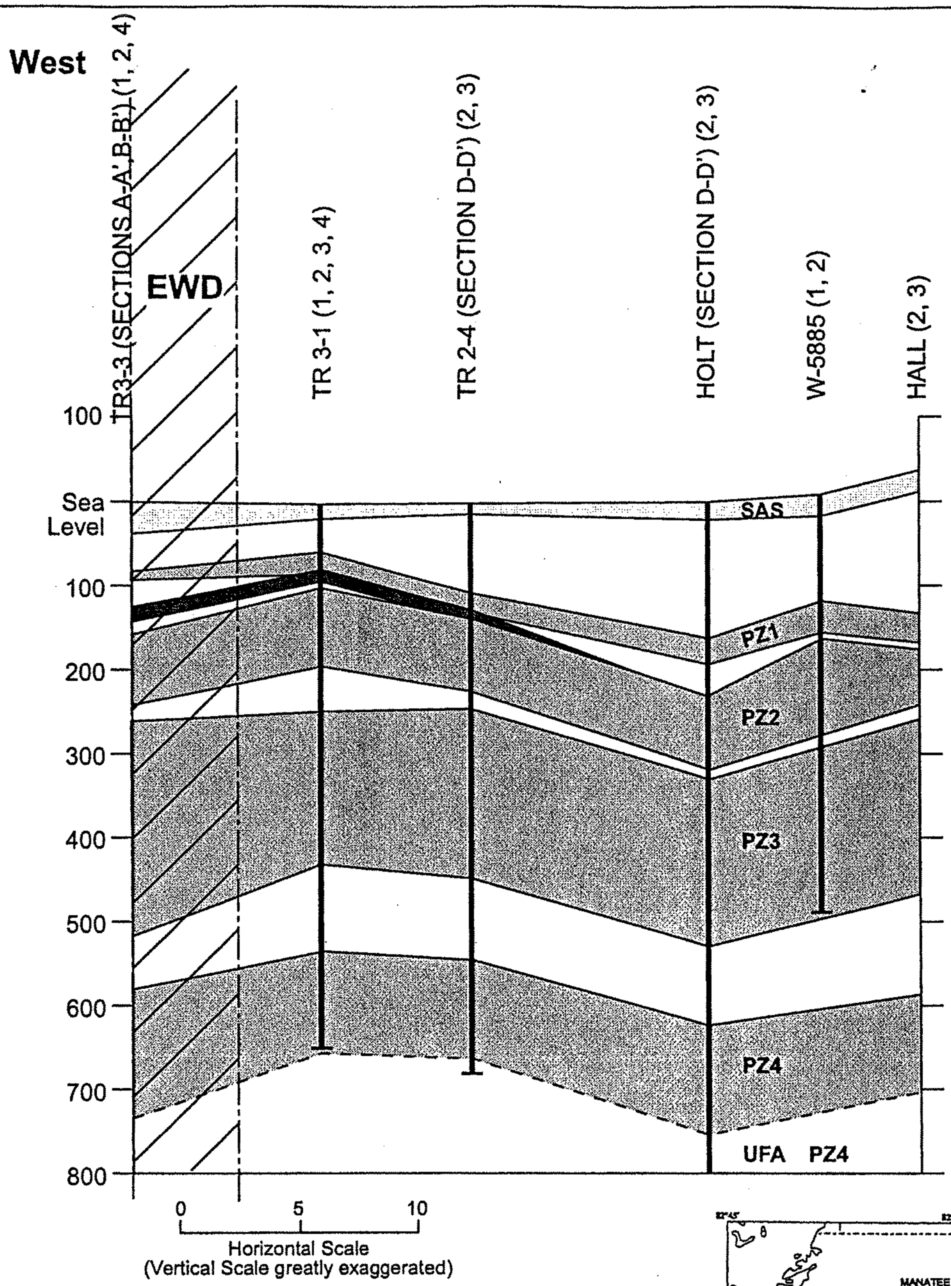


Modified from: USGS, 1996

LEGEND

- **SAS** Surficial Aquifer System
- Intermediate Aquifer System
  - ☐ Confining Unit
  - ■ Venice Clay
  - **PZ1** Permeable Zone 1
  - **PZ2** Permeable Zone 2
  - **PZ3** Permeable Zone 3
- Upper Floridan Aquifer
  - **PZ4** Permeable Zone 4 (within Suwannee Limestone)
- - - - Approximate

Data used for interpretation:
(1) Lithologic log
(2) Gamma log
(3) Electric log
(4) Head

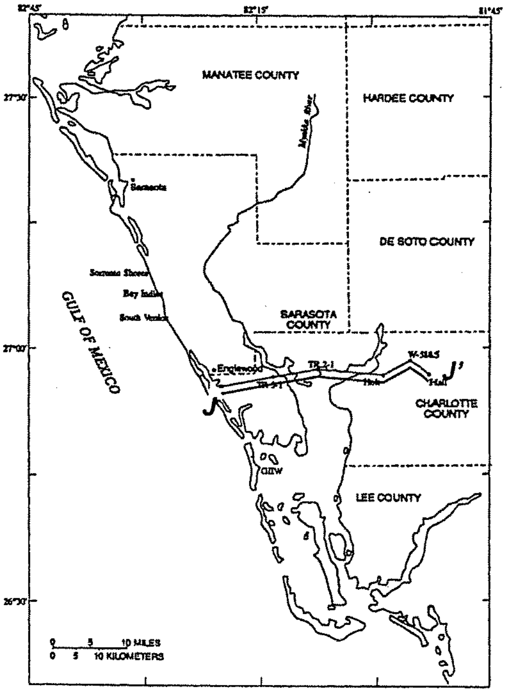


FIGURE 3-2
Regional Hydrogeology: East-West Cross Section

taken during reverse-air drilling did not require washing prior to examination. Detailed descriptions of the samples were entered on the lithologic log for each well. Lithologic logs for each of the wells are contained in Appendix F.

The quality of the information that can be obtained from drill cuttings is limited by the drilling method used, the diameter of the borehole, and the techniques used during sample collection. Cuttings from reverse-air drilling using a small diameter borehole provide the best samples. These cuttings are not mixed with drilling mud which can often be confused with natural clay. The transit time of the cutting to the surface is rapid so the depth that the cutting represent can be accurately known. On the other end of the scale, mud drilling cuttings from relatively large holes provide cuttings that contain mixed interval and poor definition of intervals where clay is present.

In the following sections, data from drill cuttings during the drilling operations will be described separately. The interpretation of the subsurface lithology must be viewed as a composite of all of the descriptions since apparent changes may be due to collection and processing rather than real subsurface variations. Drilling of the pilot holes below the intermediate casing of TPW-1 were accomplished using a small bit and reverse-air drilling and are probably the most reliable.

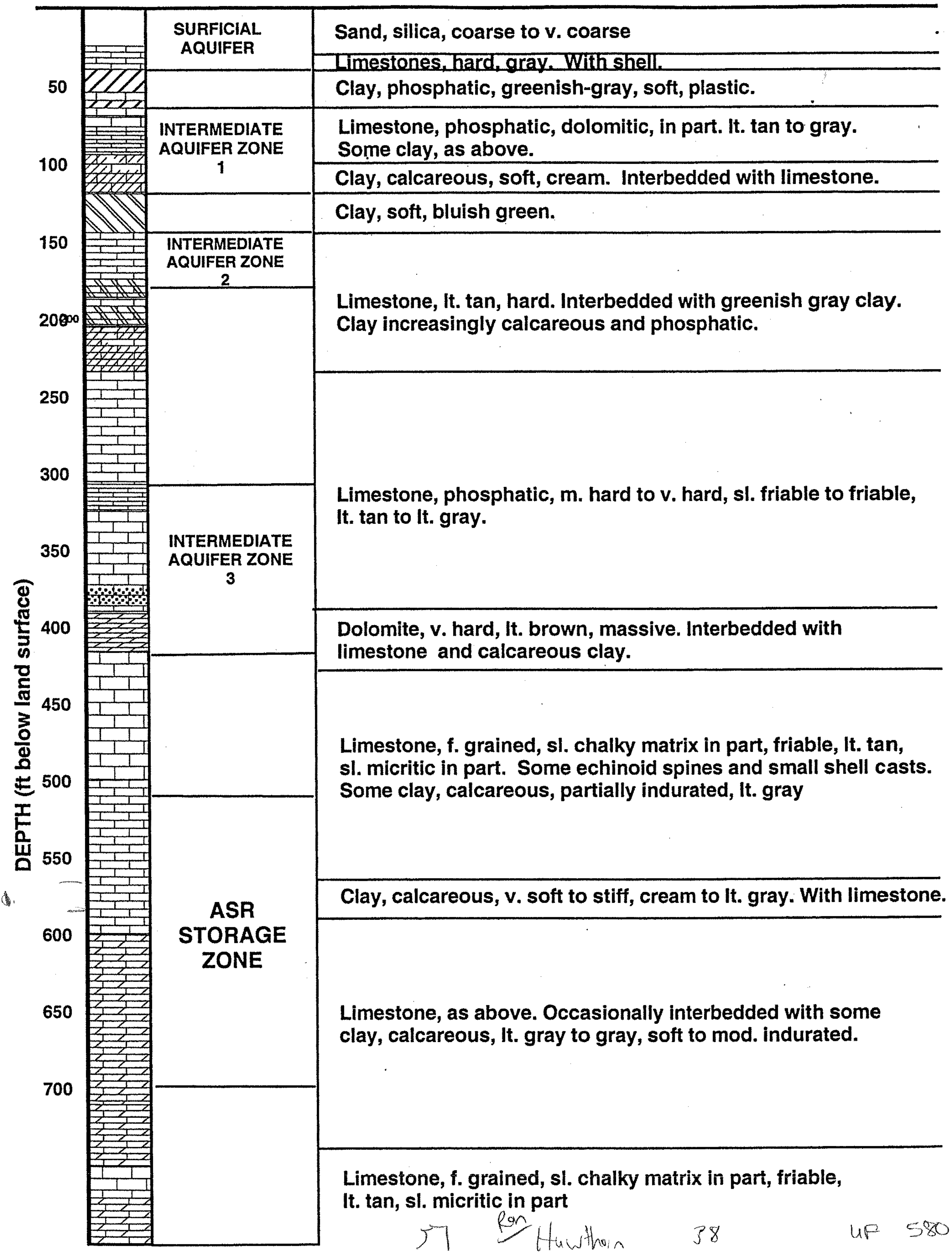
Figure 3-3 presents a summary of the drill cutting samples collected during the drilling of TPW-1. In this summary, the description of the major lithologic units have been grouped and generalized for clarity. Also presented on the figure is a graphic interpretation of the lithology. This interpretation is based on the drill cutting description, geophysical logs, and drilling characteristics of the formation encountered. Figures 3-4, 3-5, and 3-6 present similar data for SZMW-1, IMW-1, and SMW-1, respectively. A suggestion of the local definition of the surficial aquifer, the production intervals within the intermediate aquifer system, and the storage zone within the Suwannee limestone are provided on these figures.

3.3 Geophysical Logging

Geophysical logging was performed during the drilling operation after the completion of each of the pilot holes, reamed hole and after final completion of the wells. Each logging operation will be discussed individually in the following sections Table 3-1 presents a summary of the geophysical logging performed during the well construction. Copies of all geophysical logs are presented in Appendix G and are separated by individual logging suite.

3.3.1 Suite 1 TPW-1 Pilot Hole to 330 Feet

Logging Suite 1 consisted of logging the pilot hole of TPW-1 to 330 feet and included electric log (16 and 64-inch normal resistivity logs with the spontaneous potential [SP] log), natural gamma log, and caliper. Logging of this pilot hole was limited by the fact that the pilot hole to 330 feet was drilled using mud rotary methods.



Sand, silica, coarse to v. coarse

Limestones, hard, gray. With shell.

Clay, phosphatic, greenish-gray, soft, plastic.

Limestone, phosphatic, dolomitic, in part. lt. tan to gray. Some clay, as above.

Clay, calcareous, soft, cream. Interbedded with limestone.

Clay, soft, bluish green.

Limestone, lt. tan, hard. Interbedded with greenish gray clay. Clay increasingly calcareous and phosphatic.

Limestone, phosphatic, m. hard to v. hard, sl. friable to friable, lt. tan to lt. gray.

Dolomite, v. hard, lt. brown, massive. Interbedded with limestone and calcareous clay.

Limestone, f. grained, sl. chalky matrix in part, friable, lt. tan, sl. micritic in part. Some echinoid spines and small shell casts. Some clay, calcareous, partially indurated, lt. gray

Clay, calcareous, v. soft to stiff, cream to lt. gray. With limestone.

Limestone, as above. Occasionally interbedded with some clay, calcareous, lt. gray to gray, soft to mod. indurated.

Limestone, f. grained, sl. chalky matrix in part, friable, lt. tan, sl. micritic in part

57 Ron Hawthorn 38 UF 580
63 Suwannee - 430
74 Ocala - 744

FIGURE 3-3
Lithology at TPW-1

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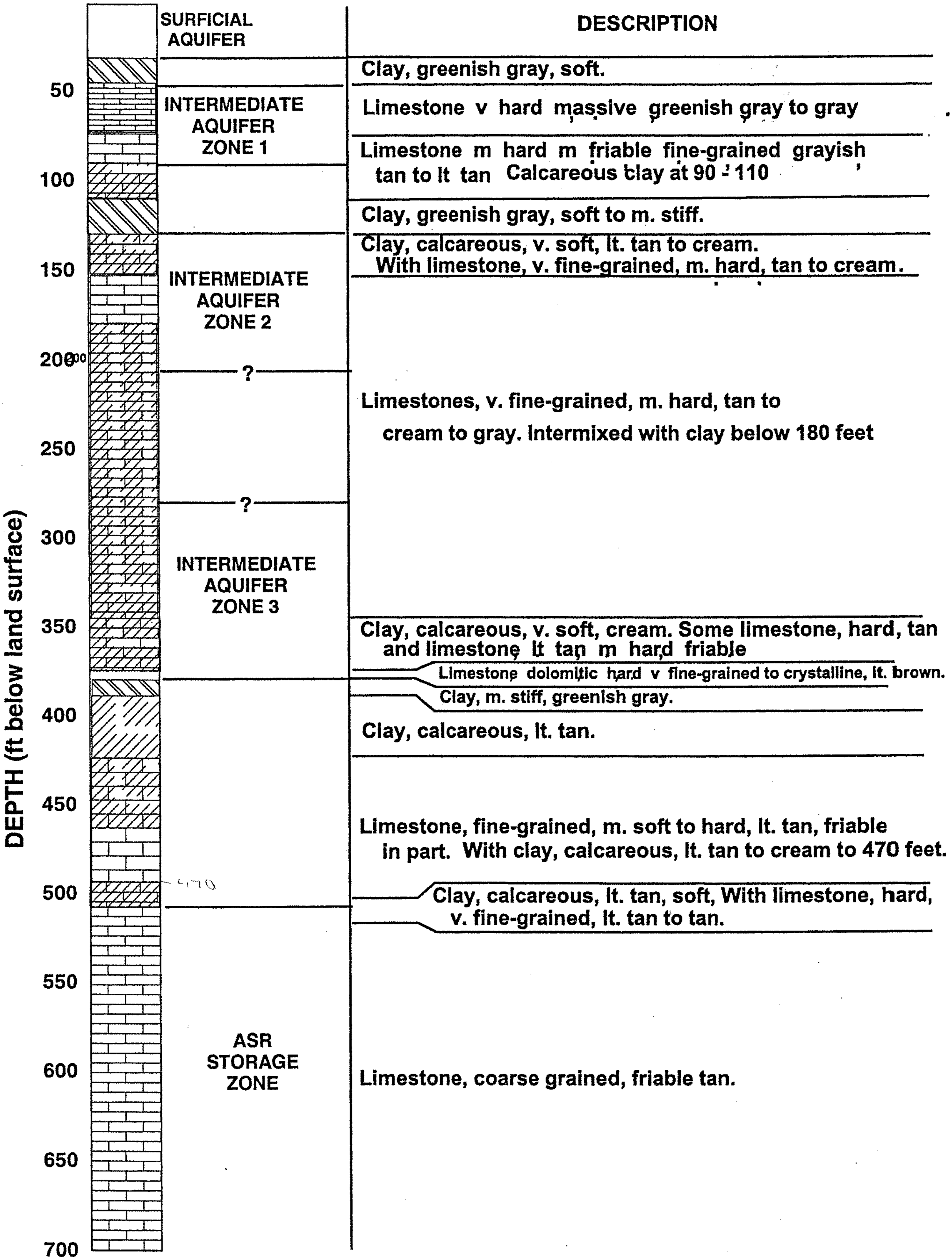

Clay, greenish gray, soft.

Limestone v hard massive greenish gray to gray

Limestone m hard m friable fine-grained grayish tan to lt tan Calcareous clay at 90 - 110

Clay, greenish gray, soft to m. stiff.

Clay, calcareous, v. soft, lt. tan to cream. With limestone, v. fine-grained, m. hard, tan to cream.

Limestones, v. fine-grained, m. hard, tan to cream to gray. Intermixed with clay below 180 feet

Clay, calcareous, v. soft, cream. Some limestone, hard, tan and limestone lt tan m hard friable

Limestone dolomitic hard v fine-grained to crystalline, lt. brown.

Clay, m. stiff, greenish gray.

Clay, calcareous, lt. tan.

Limestone, fine-grained, m. soft to hard, lt. tan, friable in part. With clay, calcareous, lt. tan to cream to 470 feet.

Clay, calcareous, lt. tan, soft, With limestone, hard, v. fine-grained, lt. tan to tan.

Limestone, coarse grained, friable tan.

FIGURE 3-4
Lithology at SZMW-1

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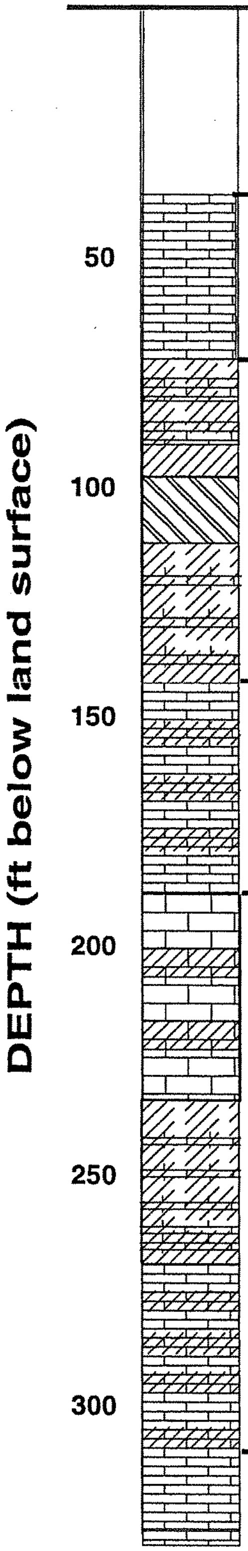

SURFICIAL AQUIFER	
INTERMEDIATE AQUIFER ZONE 1	Limestone, v. phosphatic to phosphatic, sandy in part, course to f. grained, v. hard, tan to gray. Numerous shell fragments & spines.
	Clay, calcareous, cream, v. soft. Interbedded with limestone, as above.
	Clay, soft, greenish-gray.
	Clay, calcareous, soft, tan. Interbedded with limestone, hard, f. grained.
INTERMEDIATE AQUIFER ZONE 2	Limestone, hard, v. fine-grained, tan to cream. Interbedded with clay, calcareous, tan, v. soft. Grades to v. sandy
	Limestone, phosphatic, v. fine, cream to lt. tan. Interbedded, in part, with clay, calcareous, lt. tan.
	Clay, calcareous, greenish tan to greenish gray, v. soft. Interbedded with limestone, v. fine-grained, hard.
	Limestone, phosphatic, v. hard, v. fine-grained, cream to lt. tan. Some clay, calcareous, cream.
INTERMEDIATE AQUIFER ZONE 3	Limestone, hard, coarse grained, mod friable, lt. tan.

FIGURE 3-5
Lithology at IMW-1

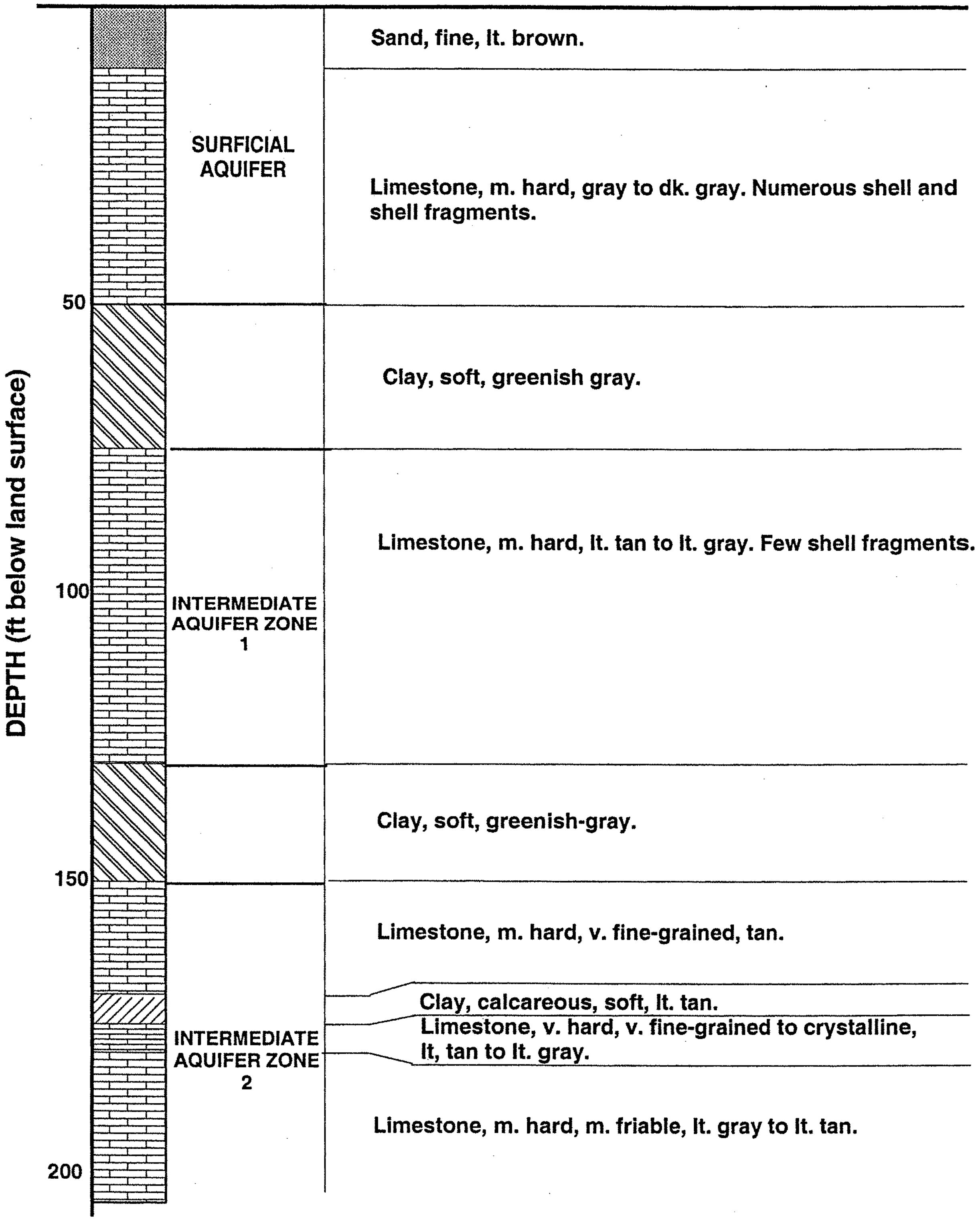

FIGURE 3-6
Lithology at SMW-1

TABLE 3-1

Geophysical Logging Summary

Suite No.	Date	Well	Construction Stage	Logged Depth	Logs
1	1/31/00	TPW-1	7-7/8-inch pilot	330 ft	Electric, Gamma, Caliper.
2	2/7/00	TPW-1	28-1/2-inch reamed hole.	298 ft	Caliper
3	3/1/00	TPW-1	7 7/8-inch pilot hole.	806 ft	Electric, Gamma, Caliper, DIL, BCS, Temp., Fl. Res., Flow.
4	3/20/00	TPW-1	22-1/2-inch reamed hole.	512 ft	Caliper
5	3/21-22/00	TPW-1	1st & 2nd stage cementing of 16-inch casing	486 ft	Temperature
6	3/31/00	TPW-1	Well completion	700 ft	Electric, Gamma, Caliper, DIL, BCS, Temp., Fl. Res., Flow.
7	3/22/00	SMW-1	12-1/4-inch reamed hole	174 ft	Electric, Gamma, Caliper.
8	3/30/00	SMW-1	Well completion	205 ft	Electric, Gamma, Caliper, Temp., Flow.
9	3/31/00	IMW-1	Reamed hole	320 ft	Caliper, Electric, Gamma
10	4/12/00	SZMW-1	12-1/4-inch reamed hole	515 ft	Electric, Gamma, Caliper.
11	4/18/00	SZMW-1	Well Completion	700 ft	Electric, Gamma, Caliper, Temperature, Flow

Note: Electric log includes 16 and 64-inch normal, S.P., and single point resistivity.

The natural gamma log indicates that the surficial aquifer extends to a depth of approximately 38 feet where the increase in gamma activity indicates the penetration of Miocene age sediments. Miocene age sediments frequently contain grains of phosphorite (calcium phosphate) which are enriched in uranium. Some strata contain phosphorite concentrations that produce very high gamma ray peaks. The gamma ray log indicates that Miocene age sediments extend at least to a depth of 330 feet.

The SP log reacts to the transition between strata with different electrical properties. In sand and clay sequences, it clearly delineates these sediments. In carbonate sediments, which are most common in the project area, the SP log is of limited value.

The long (64-inch) and short (16-inch) normal resistivity tool measures the bulk resistivity of the rock near the borehole, the electrode spacing gives two different radii of investigation. The short normal is most influenced by the invasion of drilling mud into the formation. The long normal investigates rock less invaded by the mud. The relative response of the long and short normal trace can often indicate permeable strata. Such responses occur in the log from 115 to 122 feet, from 177 to 194 feet and 308 to the bottom of the hole at 330 feet. These response intervals may correspond to the permeable intervals of PZ1, PZ2, and PZ3, respectively.

The caliper log is used to verify borehole dimensions, for material verification, and can often give an indication of the competency of the rock within the borehole. Soft incompetent rock tends to wash out during drilling. Harder, more competent rock tends to produce a nearly gauge hole. Hard, fractured rock tends to be gauge but with a jagged appearance on the log. These characteristics are more pronounced in air-reverse drilled holes and less pronounced in mud drilled holes.

In the pilot hole to 330 feet, the caliper log indicates soft strata from the bottom of the surface casing to 70 feet, through the interval that clay was present in the drill cuttings. A change in borehole diameter opposite the blue-green clay from about 120 to 140 is not readily apparent on the log. A soft interval from 190 to 210 feet corresponds to a layer of soft, chalky limestone. The caliper indicates that the strata from 275 to 310 feet are relatively competent, but not fractured as it is below this interval.

3.3.2 Suite 2 TPW-1 - 28-1/2-inch Reamed Hole to 300 feet

This suite consisted of a single caliper log from the base of the 30-inch surface casing to 300 feet. The purpose of the log was to demonstrate that the reamed hole was free from obstructions and suitable for the installation of the 24-inch intermediate casing. The caliper log was also used to estimate cement quantities needed for grouting operations. The log shows that the hole is somewhat less than gauge from 238 to the bottom of the borehole, which suggests a mud cake on the borehole walls. It may also be due to the borehole being somewhat oval shaped.

3.3.3 Suite 3 TPW-1 Pilot Hole to 807 Feet

Suite 3 was performed on the pilot hole after it was drilled using the reverse-air drilling method. This drilling method allowed the use of an expanded suite of logs than previous suites. The water within the borehole was saline and therefore conductive. The logs performed included electric, gamma, caliper, dual-induction lateralog (DIL), borehole compensated sonic (BCS), static and dynamic temperature/fluid resistivity, and static and dynamic flowmeter.

The borehole intersected only carbonate rock strata. In such strata, the response of the SP log is severely limited. As expected, the log trace for the SP is essentially featureless.

The lack of drilling mud in the borehole limited the differential response of the long and short normal resistivity tools. As a result both traces generally parallel each other. Both traces show that the rock is generally more resistive above 500 feet. they also show a marked increase in resistivity from 400 to 420 feet, which correlates to the dolomite strata identified by the drill cutting samples.

The caliper log indicates that the rock is relatively competent and probably fractured from the base of the casing to about 435 feet. Below this depth, the rock appears to be softer and less competent. Another hard and probably fractured, strata is encountered from 720 to 740 feet.

The natural gamma ray log shows the phosphorite peaks characteristic of the Miocene age sediments down to a depth of 420 feet. Below this depth the gamma ray activity is noticeably lower and is more characteristic of early Miocene or Oligocene age sediments. The marked reduction of gamma ray activity below 744 feet probably corresponds to the top of the Eocene Ocala Limestone. A gamma ray log of the strata deeper than 800 feet would likely confirm the identification of the top of this formation.

The dual-induction lateralog is similar to that of the normal resistivity in that it measures the bulk resistivity of the rock near the borehole. It differs from the resistivity because the resistivity is measured by induction coils rather than electrodes. The DIL is much less sensitive to the electrical properties of the borehole fluid and therefore is often more definitive in boreholes filled with saline fluid. The DIL run on this borehole produced a log very similar to the normal resistivity log. However, it shows a decrease in resistivity below 750 feet that was not apparent on the normal logs. This change reinforces the gamma ray log that there is a change in formation at this depth.

The borehole compensated sonic tool measures the sonic travel time through the rock near the tool. In general, sound travels slower in rock that is more porous, so that the log can be used as an indication of primary, or inter-granular, porosity. The exact relationship between sonic travel times and porosity is difficult to determine, particularly in the relatively young poorly consolidated limestones found in Florida. No attempt at quantification will be attempted in this report. Nevertheless, the log indicates that the apparent primary porosity of the rock is greatest between 500 and 600 feet. Below 600 feet the rock is less porous. Between 325 and 350 feet and between 420 and 440, the rock is significantly more porous than throughout the rest of the borehole. The first interval corresponds with the highly productive zones encountered at that depth. SAS 0-40
The second interval corresponds with a layer of calcareous clay identified in the drill cuttings.

Generally, the temperature of the water in aquifer zones increases with depth, as a result of the naturally occurring geothermal gradient. In most limestone aquifers water is produced at discrete intervals. The temperature of the water produced will correspond to the depth of the interval. When a well is pumped the water in the borehole at a particular depth is a blend of the producing intervals below that depth. A sensitive temperature log can clearly show water production intervals by the temperature profile in the borehole. Under static conditions, there is often inter-borehole flow between production intervals of the borehole due to natural differences in hydraulic head between the zones. The temperature log run on the pilot hole to 807 feet shows numerous production intervals. These intervals are apparent at: 316, 326, 417, 470, 487, 517, 534, 548, 560, 580, 590, 598, 606, 630, 660, 690, 710, and 725.

120
[illegible]

Below about 760 feet there is little temperature difference between water present in the borehole under static condition and under flowing conditions. This lack of difference is due to essentially no water production either because there is no permeable zone presence or because the change in head within the borehole when the well was allowed to flow was insufficient to induce flow. The pattern of the pumping temperature log indicates that only a small amount of water is being produced below about 420 feet. Again, this lack of production may be due to the small amount of head change that was induced when the well was allowed to flow. The temperature log indicates that almost all of the flow originated from about 330 feet. Because of the large fraction of flow from the 330-foot interval, it is not possible to adequately evaluate the production capabilities of any of the production intervals below 420 feet from the temperature log.

UFA at
510

The fluid resistivity log measures the electrical resistivity of the borehole fluid. Fluid resistivity is related to fluid conductivity by the relationship:

$$Conductivity = \frac{10{,}000}{resistivity}$$

The conductivity of water has a direct relationship to the total dissolved solids in the water. The proportionality constant is approximately 0.6 for most Florida ground water.

A fluid resistivity log was run in the pilot hole from 295 to 807 feet under both static and flowing conditions. The well was flowed at approximately 300 gpm, which was limited by the inability to discharge the pumped fluid. The conductivity of the water produced at about 700 feet was sufficient to cause the conductivity of the water in the borehole above that depth to become uniformly more conductive. The pattern of the conductivity profile indicates that little water was produced from about 500 to 700 feet. At 420 feet, the production is high enough to blend out the lower water and the water in the borehole closely represents the water at 420 feet. There appears to be little difference in the conductivity of the water above 420 feet since no shift in quality is apparent on the log.

The flowmeter tool used in this suite of logging has about a 4-1/2-inch-diameter impeller. This tool has the capability of detecting flow changes of 3 to 5 feet per minute. In an 8-inch-diameter borehole, this corresponds to a flow rate of 8 to 13 gpm. During the logging of this borehole, the well was allowed to flow at about 300 gpm. The detection limit of the flowmeter as a fraction of total flow was 2 to 4 percent. The static flowmeter logs that were run failed to detect any internal flow in the borehole. The pumping flowmeter failed to detect flow below 440 feet. About 10 gpm appeared to be entering the borehole between 420 and 440. The remainder of the water entered the borehole at about 325 feet. This production profile is consistent with the profile suggested by the temperature log.

3.3.4 Suite 4 TPW-1 22-1/2-inch Reamed Hole

This logging suite consisted of a single caliper log that was run to ensure that the borehole was suitable to install the 16-inch final casing and to assist in calculation of cement quantities. The log showed a relatively gauge hole down to a depth of 440 feet. At that depth the borehole increases gradually to about 30 inches, and at 490 feet, the hole diameter returns to approximately gauge. The increase in diameter indicates that the rock between 440 and 490 is softer and less competent than that above and below this interval.

3.3.5 Suite 5 TPW-1 Cementing of 16-inch Final Casing

Suite 5 consisted of two separate temperature logs. The first log was run after the first cementing stage of the 16-inch casing, which indicates that the cement top was at 330 feet. The second log was run after the second cementing stage, which indicates a cement top at 310 feet, which is into the 24-inch intermediate casing so additional temperature logs were not required.

3.3.6 Suite 6 TPW–1 Final Logging

Suite 6 was run before and after the completion of the variable rate step-test of TPW-1 and was used to establish hydraulic background conditions at the well. The static logs were run immediately before pumping started and the dynamic logs were run after the completion of the testing. The pumping logs were run while pumping the well at 1,050 gpm. The suite consisted of electric, gamma ray, caliper, static temperature/fluid resistivity, static flowmeter, dynamic temperature/fluid resistivity, and dynamic flowmeter.

The caliper log shows the base of the casing at 503 feet. An enlarged section from this depth to 512 feet is the base of the reamed hole below the end of the cemented casing. The majority of the borehole is approximately 15 inches, the gauge size of the bit. From 685 feet bls to the total depth logged, the hole is enlarged several inches.

The electric and gamma ray logs are similar to those produced for TPW-1 - Suite 3 and will not be discussed in this section. Refer to the previous section for discussion.

The static temperature log shows elevated temperature toward the bottom of the casing as the result of the recent cementing of this casing. The cooler water below the base of the casing to approximately 600 feet is due to the proximity of transmissive intervals. The temperature of the water below 600 feet is consistently 85°F to the bottom of the hole. This consistent temperature suggests that there may be some intra-borehole flow.

The dynamic temperature clearly shows major water production from 503 to 508 feet, from 537 to 555 feet, and from 575 to 588 feet. The log also indicates some production between 580 and 582 feet. Little production is indicated except for these intervals.

Because of the high TDS of the water in the borehole, the scale of the fluid resistivity log was difficult to establish accurately. The static resistivity log shows relatively consistent water quality from the base of the casing to about 590 feet. Below this depth, the resistivity of the water decreases steadily and is lowest at the bottom of the borehole.

The pumping fluid resistivity log shows that the water from about 554 to the bottom of the hole has the same resistivity as the static log measured for the bottom portion of the hole. The origin of this water is probably the small production zone from 580 to 582 feet. Above 554 feet, the shifts in resistivity coincide with the production intervals identified by the temperature log.

The static flowmeter survey was performed by lowering the tool to the bottom of the hole at a rate of 40 feet per minute and then raising the tool at the same rate. The traces from this survey form two approximately parallel lines. The offset in these lines is probably due to a slight lowering of the tool's sensitivity when it is pulled up. This decrease in sensitivity is due to the fact that the water must flow around the body of the tool before entering the impeller chamber. The survey does not indicate any flow within the borehole under static conditions.

The pumping flowmeter log indicates the approximately 40 percent of the flow into the borehole comes from the first production interval from 503 to 508 feet. Approximately 20 percent of the flow comes from the interval from 588 to 555 feet. About 10 percent of the flow enters between 575 and 588 feet. The log indicates also that between 634 and 650 feet there may be flow into the borehole that contributes as much as 20 percent of the flow. Finally, about 10 to 15 percent of the total flow enters from the lowest production zone between 680 and 682 feet.

3.3.7 Suite 7 SMW-Borehole to 174 Feet

This suite was run after completion of the 12-1/2-inch hole in SMW-1 to 174 feet, which was drilled using mud. Suite 7 consisted of electric, gamma ray and caliper. The logs were essentially identical to those run on TPW-1 and showed no substantial deviations. The electric log clearly shows the clay layer identified by the drill cuttings from 130 to 150 feet. The remainder of the electric log is indistinct. The gamma ray log shows the same peaks from phosphorite that was seen at TPW-1, indicating that the occurrence of selected lithologic units are relatively consistent across the site.

3.3.8 Suite 8 SMW-1 After Well Completion

This suite was run on the open hole section of the well from 174 feet to a total depth of 205 feet. Suite 8 consisted of electric, gamma ray, caliper, dynamic temperature, and dynamic fluid resistivity logs. The short length of the open borehole resulted in little definition of the open hole, however, showed no deviation from the same intervals logged in other wells.

3.3.9 Suite 9 IMW-1 Borehole to 320 Feet

Suite 9 was run on the borehole from the surface casing set at 40 feet to the total depth of the well at 320 feet. The suite consisted of electric, gamma ray and caliper. The electric and gamma ray logs show that the strata at this well was approximately 20 feet shallower than that identified by logs a TPW-1. These data suggested that the final casing should be set to 280 feet rather than 300 feet as originally planned. Since this suite logged the final open hole of the well, final logging was not performed.

3.3.10 Suite 10 SZMW-1 Borehole to 515 feet

Suite 10 was run on the 12-1/4-inch borehole drilled below the intermediate casing of SZMW-1. The borehole was drilled with mud so the logging was limited to electric, gamma ray, and caliper logs. These logs were similar to those run on TPW-1, and showed no major deviations from logs run on other wells.

3.3.11 Suite 11 SZMW-1 After Well Completion

Suite 11 was run after installation of the 6-inch final casing with the borehole open to the total depth of 700 feet and after development with air. The suite consisted of electric, gamma ray, static and dynamic temperature/fluid resistivity, and static and dynamic flow meter logs. The dynamic logs were run with the well being pumped at 100 gpm. The dynamic temperature log indicates production in the interval between the base of the casing at 510 to about 550 feet. Additional production is indicated at about 580, 605, and 675 feet. The dynamic flow meter log indicates that substantial flow is present at about 540 feet, 580 feet, 605 feet, and 675 feet, which is similar to producing zones identified in TPW-1.

3.3.12 Summary of Geophysical Data

The geophysical data indicate that in the project area, the surficial aquifer extends to a depth of approximately 38 feet. The first unit of the intermediate aquifer (PZ-1) is located from about 70 feet to 120 feet. The most permeable interval within PZ1 is located between 115 to 120 feet. The second unit of the intermediate aquifer (PZ2) is located between approximately 175 and 205 feet with the most permeable interval within PZ2 located between 177 and 194 feet. The third unit of the intermediate aquifer (PZ-3) is located between 310 and 420 feet. Significant permeable intervals, however, were encountered in the UFAS between about 500 and 700 feet in depth.

3.4 Water Quality Sampling

During the construction of the wells, water quality samples were taken whenever the nature of the drilling operation permitted such sampling. Samples were collected during reverse-air drilling operations, packer tests, and variable rate step tests. A discussion of the sampling and the results of their analysis are presented in the following sections.

3.4.1 Water Table Aquifer Sampling

The two water table monitor wells, WT-1 and WT-2, were developed, prior to sampling, by pumping the wells at a high rate until the pumped water was clear and free of turbidity and sand. The wells were then each sampled weekly during the construction of their companion wells. Water levels and water samples were collected after first purging a minimum of 3 casing volumes from the wells using a portable pump. The initial sample from each well was analyzed by the EWD Water Treatment Facility Laboratory (DOH Lab No. 54211). The laboratory reports for these analyses are presented in Appendix H. The weekly samples were analyzed at the onsite laboratory at the SRWWTP. Figure 3-7 shows the chloride and TDS levels for WT-1 during the construction of TPW-1. Figure 3-8 presents the chloride and TDS levels for WT-2 during the construction of SZMW-1. The first TDS value for each well is the value from the EWD Water Treatment Facility Laboratory. This value was used to establish the TDS/Conductivity ratio, which was used to calculate the subsequent TDS values based on the measured conductivity. Table 3-2 presents all of the data collected from these two water table wells.

At WT-1, the chloride concentration ranged from 55 to 160 mg/L, while at WT-2 the chlorides ranged from 25 to 50 mg/L. The maximum contaminant level (MCL) for this parameter is 250 mg/L. At WT-1 the TDS ranged from 142 to 354 mg/L, while at WT-2 the TDS ranged from 142 to 156 mg/L. The MCL for TDS is 500 mg/L. Therefore, the testing of WT-1 and WT-2 shows that the drilling operations at each location did not impact the water table aquifer near each site.

3.4.2 Drilling Water Sampling

During reverse-air drilling, water produced by the formation is drawn into the drilling bit and is airlifted, along with the drill cuttings, up the drill pipe and is discharged from the kelly hose. The quantity of water produced during drilling depends on the diameter and length of the drill pipe and the quantity of airline being used. During the drilling of TPW-1, approximately 240 feet of airline was used inside of 3.5-inch ID drill pipe. This produced approximately 200 gpm of drilling water.

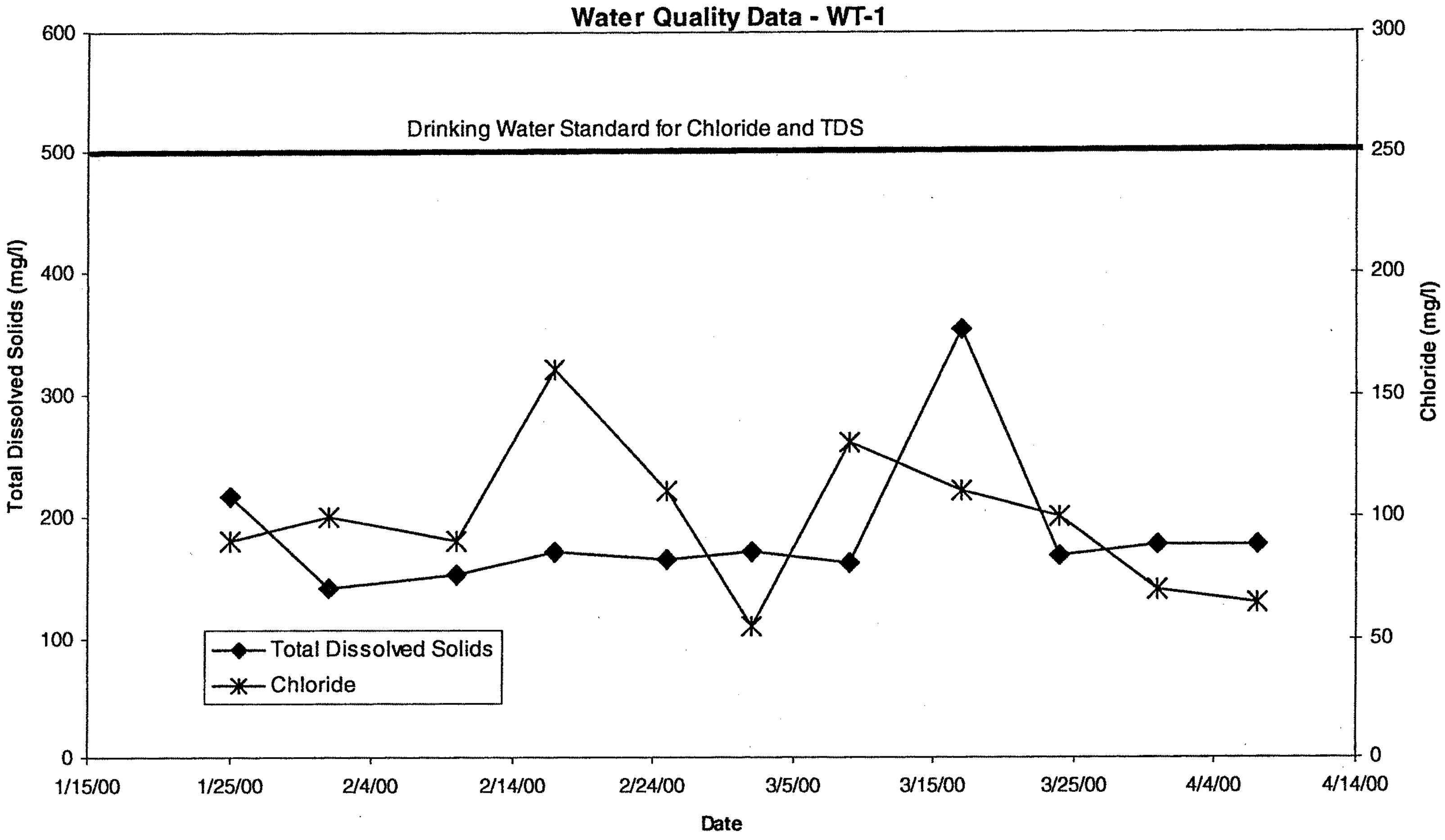

FIGURE 3-7
WT-1 Chloride and TDS

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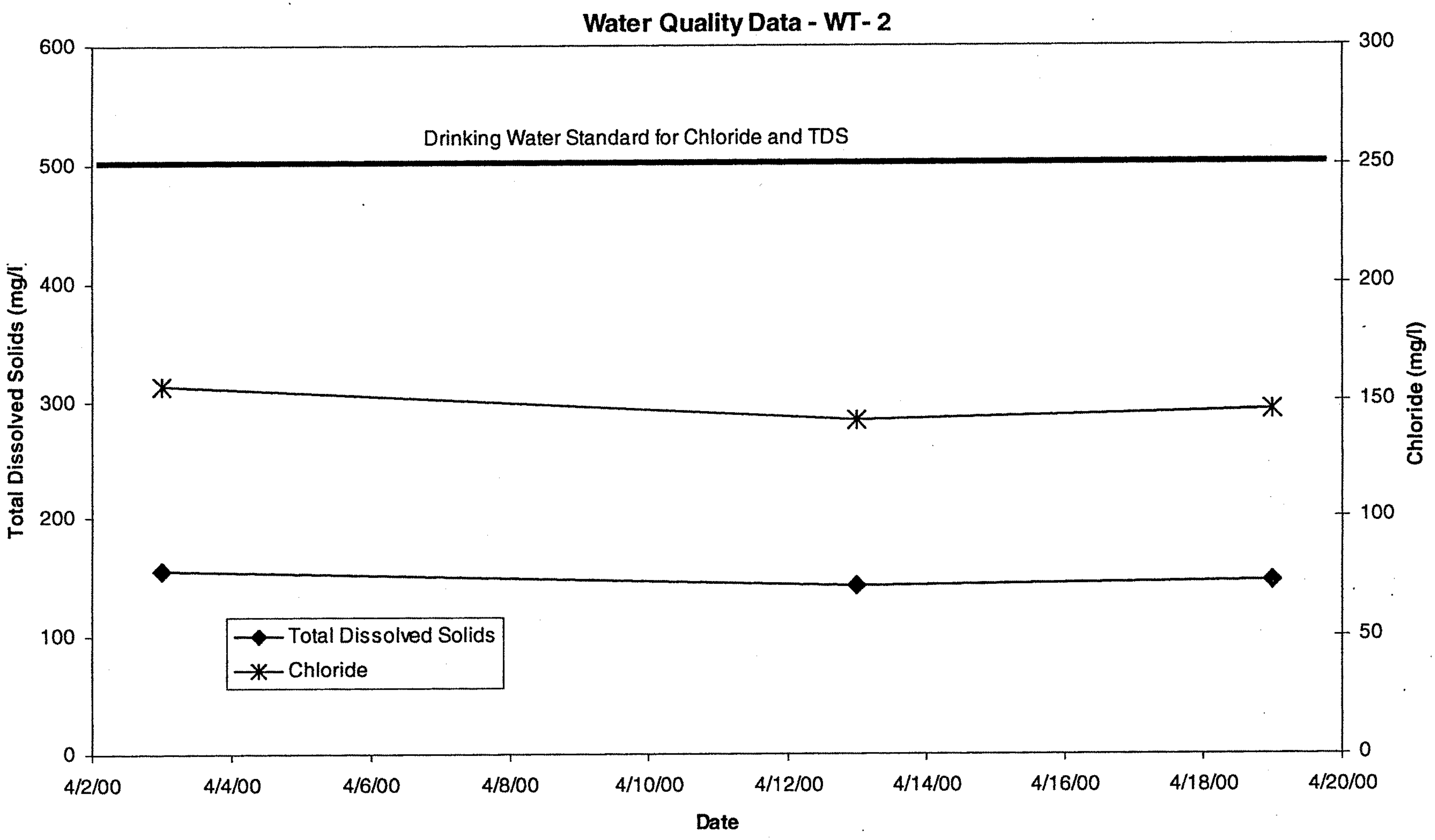

FIGURE 3-8
WT-2 Chloride and TDS

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TABLE 3-2
WT-1 and WT-2 Water Quality Data

Date	Depth to Water (ft TC)*	Analysis					
		Conductivity (mμS/cm)	TDS (mg/L) **	pH	Chloride (mg/L)	Sulfate (mg/L)	Remarks
WT-1 Data							
1/25/00	na	368	216	5.2	90	69	TDS/Cond. Ratio = 0.59
2/1/00	2.40	240	142	5.3	100	na	
2/10/00	2.75	260	153	5.3	90	na	
2/17/00	2.85	290	171	5.4	160	na	
2/25/00	2.80	280	165	na	110	na	
3/2/00	2.77	290	171	5.4	55	na	
3/9/00	3.14	275	162	5.8	130	na	
3/17/00	3.41	600	354	5.5	110	na	
3/24/00	na	285	168	5.5	100	na	
3/31/00	3.60	300	177	5.6	70	na	
4/7/00	na	300	177	5.9	65	na	
WT-2 Data							
4/3/00	na	180	156	5.6	50	13	TDS/Cond. Ratio = 0.86
4/13/00	3.95	165	142	na	65	na	
4/19/00	3.92	170	146	5.85	25	na	

* Top of casing (TC) of WT-1 is approximately 0.5 feet above the mean land surface elevation of 10 feet NGVD

* Top of casing (TC) of WT-2 is approximately 1.5 feet above the mean land surface elevation of 10 feet NGVD

** Total dissolved solids (TDS) for WT-1 is based on the TDS/Conductivity ratio determined by the 1-25-00 lab analysis

** Total dissolved solids (TDS) for WT-2 is based on the TDS/Conductivity ratio determined by the 4-3-00 lab analysis

The origin of this water depends on the productivity of the formation being drilled. If the formation being drilled produces a substantial portion of the drilling water, then the quality of the water is largely reflective of the quality of the water in the formation at the depth sampled. If the formation being drilled is not productive, the quality of the drilling water is a blend of water drawn down from productive intervals in shallower portions of the borehole.

During reverse-air drilling of TPW-1, samples of the drilling water were taken from the kelly discharge, at approximately 30-foot intervals. These samples were analyzed by the EWD Water Treatment Facility Laboratory. The results of these analyses are contained in Appendix H. Table 3-3 presents a tabulation of this data. Figure 3-9 presents a diagram of the total dissolved solids and chloride data for the drilling water vs. depth.

The drilling water sample taken with the total depth of the borehole at 330 feet bls had a TDS concentration of 9,700 mg/L. This sample was taken immediately after the fresh drilling mud that was in the 24-inch casing, which had been set to 295 feet, had been airlifted out. The sample was relatively clear, containing little if any residual of drilling mud.

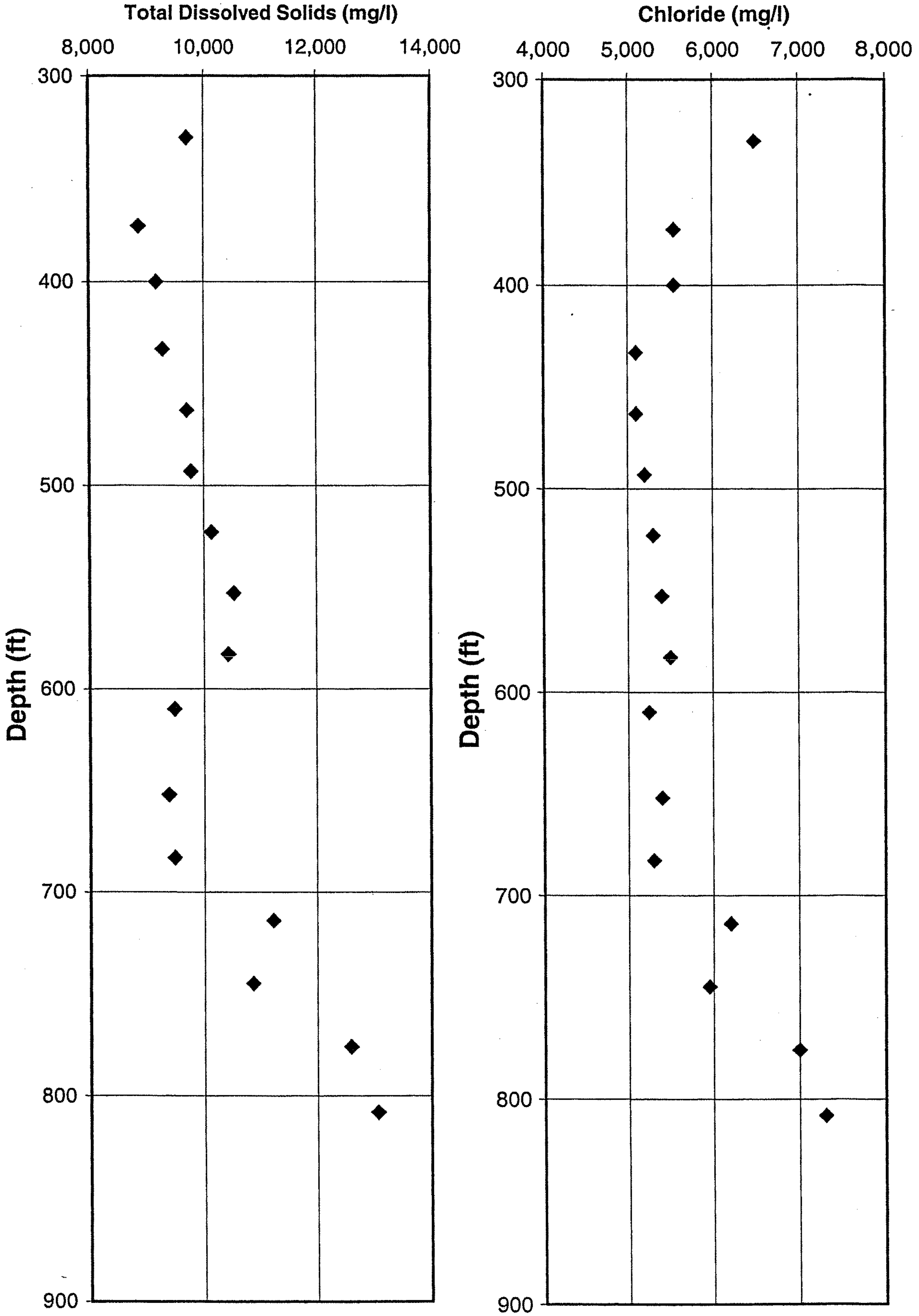

FIGURE 3-9
TPW-1 Drilling Water Chloride and TDS

TABLE 3-3
Drilling Water Quality Data

		Analysis						
Date	Depth (ft bls)	Conductivity (mµS/cm)	TDS (mg/L)	pH	Chloride (mg/L)	Sulfate (mg/L)	Chloride/ Sulfate Ratio	Remarks
2/16/00	330	15,780	9,700	7.7	6,500	635	10.2	Beginning of rev-air drilling
2/24/00	373	15,130	8,850	9.6	5,550	549	10.1	
2/24/00	400	15,760	9,150	8.2	5,550	614	9.0	
2/25/00	433	15,530	9,267	8.8	5,100	608	8.4	
2/25/00	463	15,380	9,700	10.0	5,100	494	10.3	
2/25/00	493	15,840	9,767	8.5	5,200	560	9.3	
2/25/00	523	15,980	10,133	8.5	5,300	566	9.4	
2/25/00	553	16,250	10,533	8.2	5,400	580	9.3	
2/25/00	583	16,340	10,433	8.1	5,500	606	9.1	
2/29/00	610	15,780	9,467	8.0	5,250	551	9.5	First sample after packer test
2/29/00	652	16,020	9,367	8.0	5,400	570	9.5	
2/29/00	683	15,840	9,467	8.0	5,300	587	9.0	
2/29/00	714	18,470	11,233	8.0	6,200	694	8.9	
2/29/00	745	17,630	10,867	7.8	5,950	696	8.5	
2/29/00	776	20,300	12,600	8.0	7,000	848	8.3	
2/29/00	808	20,900	13,067	8.3	7,300	848	8.6	
3/2/00	295-808	16,800	10,267	8.2	5,200	664	7.8	Sampled during logging and video survey

The sample taken with the total depth of the borehole at 373 feet had a TDS concentration of 8,850 mg/L. At this depth, the geophysical logs indicated that only a minor production interval had been intersected at 340 feet. The slight drop in TDS may indicate that this additional interval may be slightly fresher than major production interval at 330 feet. The sample taken with the borehole deepened to 400 feet bls had a TDS concentration of 9,150 mg/L. This sample should also primarily represent the quality of the formation water from 330 to 340 feet bls.

At a total depth of 523 feet, there is a noticeable increase in TDS. Geophysical logging showed that there is a production zone at about 520 feet bls. The increase indicates that the quality of the water in this zone is significantly poorer that that of the shallower zones. The logging also indicates that all of the zones deeper than 420 feet produce little water compared with the zones above that depth. Given this fact, the quality of the water at 520 feet is considerable poorer than indicated by the sample.

At 714 feet bls, there is again a noticeable increase in TDS. The relative contribution of this zone, according to the geophysical logs, again is small so that the quality of groundwater at this depth is most likely significantly poorer than the sample indicates.

Below 714 feet to the total depth of the well, the drilling water shows a steady increase in TDS. This indicates that the quality of the water continues to degrade with depth.

The data indicate that the quality of the drilling water down to 500 feet is reflective of the very productive intervals identified during geophysical logging at 316 to 326 feet. The TDS of the drilling water becomes significantly poorer after the production interval at 516 is passed, suggesting that a significant amount of water is produced at that depth. The sample taken at 610 feet bls shows a marked improvement in TDS, suggesting that the productive intervals between 598 bls and 606 bls produce water with a lower TDS than those above. The sharp increase in TDS below 700 feet indicates that the zones below this depth have significantly poorer quality water than those in the rest of the well.

3.4.3 Packer Test Sampling

Only two packer tests were run during the pilot hole drilling of TPW-1. The first test was performed to determine the hydraulic characteristics of the low permeability strata overlying the top of the target injection zone at 600 feet. The interval packer tested was from 565 to 585 feet. The second packer test was performed on the open hole below 630 feet. This test, performed between 630 and 807 feet, was designed primarily to determine the water quality of the target storage zone.

The water quality sample taken from the first packer test (565 to 585 feet) was taken at the end of the variable-rate step test. The results of the laboratory analysis of the sample is presented in Table 3-4 and shows that the water in this strata has a TDS value of 21,000 mg/L and chloride concentration of 12,000 mg/L. This concentration level is approximately twice that of the samples taken of the drilling water when this depth was penetrated. The high concentration level reinforces the conclusion that the majority of the drilling water produced during the construction of the pilot hole to 808 feet bls was from the highly permeable intervals directly below the 24-inch casing.

TABLE 3-4
Packer Test Water Quality Data

		Analysis					
Date	Depth (ft bls)	Conductivity (mμS/cm)	TDS (mg/L)	pH	Chloride (mg/L)	Sulfate (mg/L)	Chloride/ Sulfate Ratio
2/26/00	563-583	31,600	21,100	7.3	12,000	881	13.6
3/6/00	630-808	50,100	31,133	7.8	17,500	na	na

3.4.4 Well Completion Samples

Final water quality samples (background) were taken at the end of the step-drawdown test performed at each of the four artesian wells constructed during this project. The samples were collected by personnel from Sanders Laboratory of Nokomis, Florida, who also provided the sample collection kits. All of the samples were analyzed for the complete suite of primary and secondary drinking water standards, excluding asbestos

Table 3-5 presents the results of the regulated inorganic analysis of all of the final samples. Table 3-6 presents the results of the regulated secondary chemical and the radiochemical analysis of all of the final samples. Table 3-7 presents the regulated and unregulated organic analysis that were above the detection limit and other unregulated chemical analysis. The laboratory reporting forms from Sanders Laboratory are contained in Appendix I. These forms present the complete analysis results.

3.4.5 Protozoan Sample Collection

During the variable rate step-test conducted on the completed well TPW-1, a sample was collected to determine if *Cryptosporidium* and *Giardia lambila* are present in the native groundwater. Specifically, the purpose of the sampling was to determine the background concentration of these species in the ASR storage zone. The sample collection apparatus that was used for the collection had been previously used by EWD to determine the concentration of these protozoa in the plant effluent. The apparatus consisted of a cartridge-type water filter, flowmeter, and valves to control the volume and rate of sampling. The sampling protocol was provided by the Tampa Water Department who also performed the analyses. The protocol required that 100 to 1,000 liters of the sampled water be flowed through the filter at no more than 4 liters/min. During the sampling of TPW-1, 566 liters of the water being pumped from TPW-1 was flowed through the filter. Table 3-8 presents the data collection summary for the sampling of TPW-1. The filter was then removed from the apparatus, refrigerated and sent to the Tampa Water Department laboratory.

Examination by the Tampa Water Department laboratory failed to detect any concentration of either *Cryptosporidium* or *Giardia lambila*. A copy of the laboratory report from the City of Tampa Water Department is contained in Appendix I.

3.4.6 Summary of Groundwater Quality

Table 3-9 presents a summary of the major ions reported for the samples taken of the four completed wells of the ASR system. The major ions contained in normal seawater are provided for comparison. In general, the proportion of the ions is similar to that of diluted seawater except that all are enriched in calcium and bicarbonate and slightly depleted in magnesium and sulfate. The apparent enrichment in calcium and bicarbonate is due to the solubility of calcium carbonate. The depletion of magnesium indicates that a component of the water originates from deep within the aquifer system. Figure 3-10 presents a graphical representation of the major ion concentration for the four wells constructed for the ASR system.

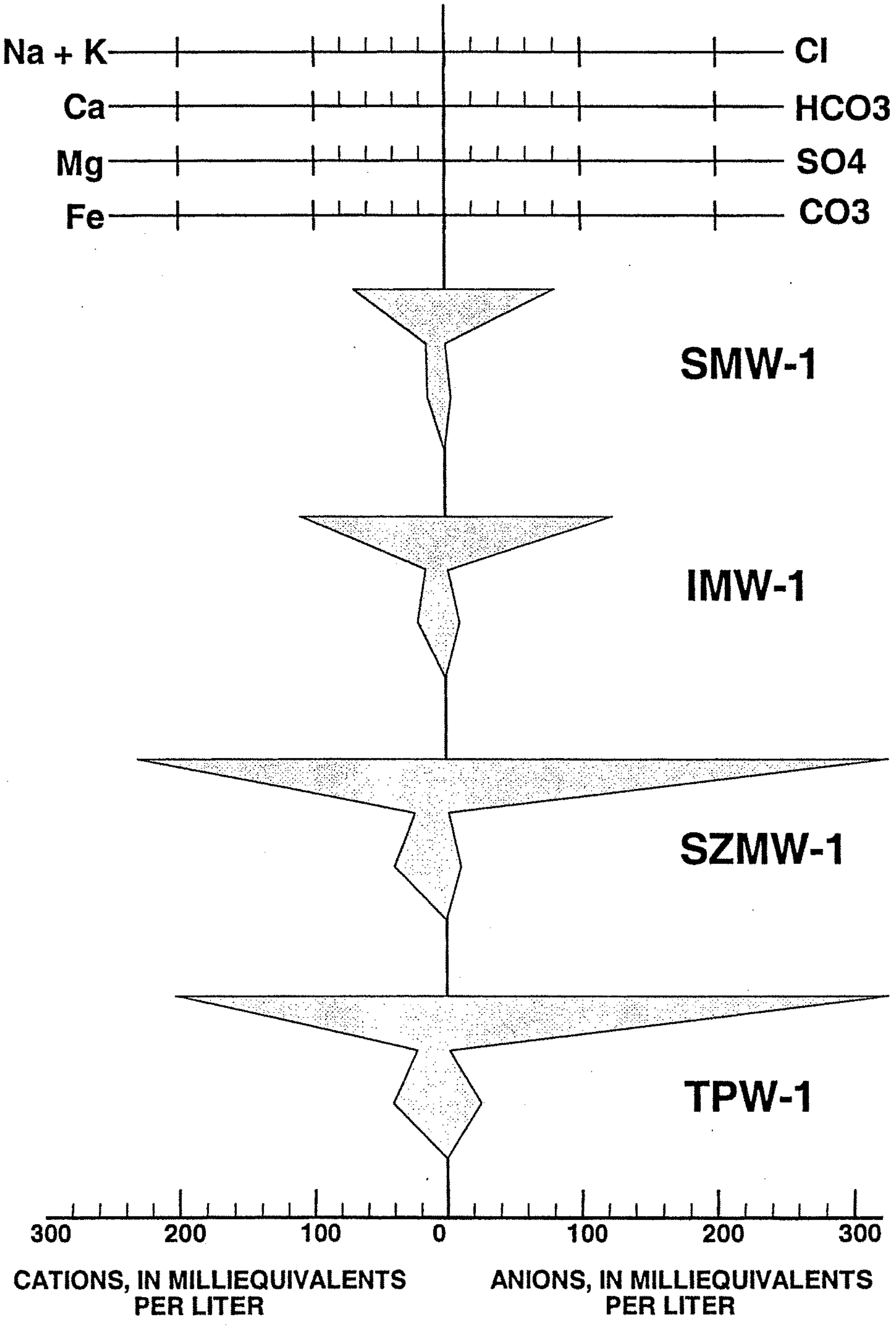

FIGURE 3-10
Summary of Ambient Groundwater Quality

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TABLE 3-5
Well Completion Water Quality – Inorganic Analysis

Inorganic Analysis
62-550.310(1)

Parameter	Detection Limit	MCL	Analysis TPW-1	SZMW-1	IMW-1	SMW-1
Arsenic	0.0028	0.05	<0.0028	<0.0028	<0.0028	<0.0028
Barium	0.0001	2	<0.0001	<0.0001	<0.0001	0.142
Cadmium	0.0002	0.005	<0.0002	<0.0002	<0.0002	<0.0002
Chromium	0.001	0.1	0.002	<0.001	<0.001	<0.001
Cyanide	0.006	0.2	0.007	<0.006	<0.006	0.007
Fluoride	0.1	4	0.9	1.0	1.0	0.6
Lead	0.001	0.015	0.002	<0.001	<0.001	<0.001
Mercury	0.001	0.002	<0.001	<0.001	<0.001	<0.001
Nickel	0.001	0.1	0.002	<0.001	<0.001	<0.001
Nitrate	0.01	10	<0.01	<0.01	<0.01	<0.01
Nitrite	0.01	1	<0.01	<0.01	<0.01	<0.01
Selenium	0.004	0.05	<0.004	<0.004	<0.004	<0.004
Sodium	0.35	160	4,501	5,145	2,476	1,572
Antimony	0.001	0.006	<0.001	<0.001	<0.001	<0.001
Beryllium	0.00008	0.004	0.0025	0.0013	0.00064	0.00046
Thallium	0.002	0.002	0.002	<0.002	<0.002	<0.002

TABLE 3-6
Well Completion Water Quality – Secondary Chemical Analysis

Secondary Chemical Analysis
62-550.320

Parameter	Detection Limit	MCL	Analysis TPW-1	SZMW-1	IMW-1	SMW-1
Aluminum	0.02	0.2	0.012	<0.02	<0.02	<0.02
Chloride	0.064	250	11,595	10,997	4,458	2,875
Copper	0.0016	1	0.0021	<0.0012	<0.0012	<0.0012
Fluoride	0.1	2	0.9	1.0	1.0	0.6
Iron	0.03	0.3	<0.030	<0.030	<0.030	<0.030
Manganese	0.0002	0.05	0.012	489	0.0029	0.0016
Silver	0.001	0.1	0.009	<0.001	<0.001	<0.001
Sulfate	0.12	250	1,279	1,106	535	204
Zinc	0.002	5	0.01	<0.002	0.002	<0.002
Color (PtCo)	1	15	16	<1	<1	<1
Odor (TON)	1	3	50	<1	<1	<1
pH	n/a	6.5-8.5	7.18	7.11	7.40	7.23
Total Dissolved Solids	7	500	19,350	22,100	8,040	6,000
Foaming Agents	0.05	1.5	<0,05	0.040	0.030	0.030

Note: Results in mg/L unless otherwise noted
Values in bold are questionable

Radiochemical Analysis
62-550.310(5)

		Analysis							
		TPW-1		SZMW-1		IMW-1		SMW-1	
Parameter	MCL	Result	D.L. +/-	Result	D.L. +/-	Result	D.L. +/-	Result	D.L. +/-
Gross Alpha	15			7.0	3.5	35.4	6.8	65.9	9.1
Ra_{226}	5			2.1	0.3	29.1	1.0	51.4	1.7
Ra_{228}	5					2.2	0.10	3.4	1.2

Note: Results in pCi/L

TABLE 3-7
Well Completion Water Quality – Other Analysis

Pesticide/PCB Analysis Above Detection Limit
62-550.310(2)(c)

		Analysis			
Parameter	Detection Limit	TPW-1	SZMW-1	IMW-1	SMW-1
Hardness, Total	1	4,375	4,400	2,325	1,525
Non-Carb. Hardness		4,232	4,263	2,188	1,388
Alkalinity	3	143	137	137	137
Conductivity	1	27,000	21,600	11,780	8,410
Water Temperature (ºC)	0.1	24.2	21.0	21.0	21.0
Calcium	0.0023	442	455	331	271
Magnesium	0.0056	487	487	255	151
Potassium	0.055	219	202	75.8	47.1
Total Organic Carbon	1	3	3	2	5
Hydrogen Sulfide, Total	0.01	0.01	0.31	1.27	1.34
Corrosivity		(-) 2.52	(-) 3.19	(-) 0.30	(-) 0.09
Density		1.015	1.015	1.018	1.005

Unregulated Group II Analysis Above Detection Limit
62-550.410

		Analysis			
Parameter		TPW-1	SZMW	IMW-1	SMW-1
Benzo(a)pyrene (µg/L)	0.040	--	0.840	--	--
Chloroform (µg/L)	0.16	0.43	--	--	--

TABLE 3-8
TPW-1 *Cryptosporidium* and *Giardia lambila* Collection Data

Time	Totalizer (gallons)	Flow Rate (gpm)	Flow Rate (lpm)	Total Volume Gallons	Total Volume Liters
10:07	814	--	--	0	0
10:17	822	0.813	3.1	8	31
10:24	828	0.86	3.2	14	53
10:28	831	0.75	2.8	17	65
10:34	836	0.83	3.2	22	84
10:41	842	0.86	3.2	28	106
10:53	852	0.83	3.2	38	144
11:19	871.8	0.76	2.9	58	219
11:31	880.8	0.75	2.8	67	253
12:02	908	0.88	3.3	94	356
13:05	963.5	0.88	3.3	150	566

TABLE 3-9
Summary of Major Ions

	Result				
Parameter	**Normal Seawater (mg/L)**	**TPW-1 (mg/L)**	**SZMW-1 (mg/L)**	**IMW-1 (mg/L)**	**SMW-1 (mg/L)**
Cations					
Potassium	380	219	202	76	47
Calcium	400	442	455	331	271
Magnesium	1350	487	487	255	151
Sodium	10500	4,501	5,146	2,476	1,572
Anions					
Sulfate	2700	1,219	1,106	535	204
Chloride	19,000	11,595	10,997	4,458	2,875
Bicarbonate (from alkalinity)	173	174	167	167	167
Sum of Major Ions	34,503	18,637	18,560	8,298	5,287
Total Dissolved Solids	34,524	19,350	22,100	8,040	6,000
Variance	(21)	(713)	(3,540)	258	(713)
Alkalinity		143	137	137	137
Chloride/Sulfate Ratio	7.0	9.5	9.9	8.3	14.1

Note: Values in bold are questionable

3.5 Hydraulic Testing

Several hydraulic tests were performed during the construction of the ASR system. The primary purpose of the tests was to measure the performance of the wells. A secondary purpose was to estimate the hydraulic conductivity of the strata penetrated by the wells. Data from the testing of TPW-1 will be used to design the pumping equipment that will be used for recovery of water from the well. Data from the monitor wells will be used to develop the sampling protocol for each of the wells.

The following sections will describe the individual hydraulic tests that were performed and the results of the data analysis. A complete listing of the data collected and the details of the analysis are contained in Appendix K and L for the packer tests and specific capacity tests, respectively.

3.5.1 Packer Tests

Packer tests were conducted using an inflatable, open-hole type, open-ended packer. The packer was lowered into place using the 3-1/2-inch inside diameter drill pipe that was also used for drilling. The packer was inflated with water to approximately 300 psi using a high-pressure pump. The inflation pressure was periodically monitored to ensure that water did not leak past the packer elements. Testing was accomplished either by installing a small diameter pump in the upper section of the drill pipe string or by injecting water through the drill pipe using a surface mounted pump. After testing, the packer elements were deflated and the packer assembly removed from the hole.

Two packer tests were performed during the well construction program. The following sections provide a discussion of each of the tests and the results obtained from the testing. Table 3-10 presents a summary of the data collected during the packer testing and the results of the analysis of that data. Data collected during this testing are contained in Appendix K.

TABLE 3-10
TPW-1 Packer Tests - Data Summary

Test Interval	563 to 583 Feet Drawdown	563 to 583 Feet Recovery	630 to 807 feet Injection
Test Time (min)	80	25	243
Pumping Rate (gpm)	10	10	131
Maximum Drawdown (ft)	10		24
Specific Capacity (gpm/ft)	1.00		4.98
Drawdown per log cycle	1.10	0.78	na
Transmissivity (gpd/ft)	2,400 *	3,400 *	10,000 **
Permeability (gpd/ft^2)	120	170	57

* Transmissivity = (264 x Pumping Rate)/Drawdown per log cycle
** Transmissivity = Specific Capacity x 2000

3.5.1.1 Packer Test at 563 to 585 Feet

This packer test was scheduled to determine the hydraulic conductivity of the strata overlying the target injection zone. The top of this zone was anticipated to be located at about 600 feet bls. Drilling was suspended at a total depth of 585 feet, and the packer installed approximately 20 feet off bottom and inflated. The 20-foot open borehole segment was developed by airlift pumping to remove fines and turbidity from the zone. The development continued until the water was clear and the conductivity of the airlifted water had stabilized. A small submersible pump was then placed in the drill pipe to a depth of approximately 120 feet and an 80-minute drawdown test, followed by a 25-minute recovery test, was conducted.

The pumping rate during the test was maintained at 10 gpm, which was the maximum rate for the small pump. Drawdown measured at the end of the pumping period was 9.88 feet. The average drawdown toward the end of the test was approximately 10 feet. Prior to ending the pumping test, a sample of the pumped water was collected for laboratory analysis.

To analyze the data drawdown measurements were plotted vs. pumping time. The slope of the early straight line portion of the data plot was 1.10 feet per log cycle. The transmissivity calculated from the slope and pumping rate was 2,400 gpd/ft. Assuming an open hole interval of 20 feet, the hydraulic conductivity, or permeability of the interval was 120 gpd/ft^2.

Recovery measurements were taken for a total of 25 minutes. The slope of the early (straight line) portion of the data was 0.78 feet per log cycle. The transmissivity calculated from the slope and the pumping rate from the drawdown test was 3,400 gpd/ft. Again assuming an open hole interval of approximately 20 feet, the hydraulic conductivity of the interval was calculated at 170 gpd/ft^2.

The transmissivity values from the two parts of the test were similar. Generally, calculations made on recovery data give the most reliable estimates of transmissivity.

3.5.1.2 Packer Test at 600 to 807 feet

The geophysical logging performed on the pilot hole of TPW-1 to 807 feet provided little data for evaluating the hydraulic characteristics and water quality of the target storage zone (600 to 700 feet). The highly transmissive interval between 310 and 420 feet prevented the lower intervals from being subjected to significant hydraulic stress. Subsequently, an additional packer test was conducted to provide additional data on this lower interval. The primary purpose of this test was to obtain a water quality sample from the target zone and attempt to estimate the injectivity of the zone.

The preferred method of testing the interval would be to develop the open hole interval and pump the interval at as high a rate as possible. Unfortunately, such a test would produce a large quantity of saline water that would interfere with the drilling program, because of disposal limitations.

The alternate testing program developed for the packer test included developing the zone by airlifting, obtain a water quality sample, settling the development water, and then returning the water back into the zone following completion of the test. During this return pumping, flow measurements and wellhead pressure measurements would be taken. These data would permit the estimation of the injectivity of the targeted ASR zone.

Pipe friction loss of the drill pipe used for the packer assembly would account for a substantial part of the injection head measured while the water is pumped back into the well. To account for this friction loss, the measured wellhead pressure would be corrected for the friction loss during the data analysis. To perform this calculation, the effective inside diameter and the roughness coefficient needs to be accurately known. Unfortunately, an accurate determination of these values was not possible, however, analysis of the data was based upon estimated values.

The 4-inch drill pipe used for the test was standard API pipe with a listed inside diameter of 3.476 inches. The pipe was not new so a roughness coefficient of 100 would be assumed in the calculation. The open-ended packer was set to 630 feet on the end of the drill pipe and the packer inflated to 250 psi. The zone was developed by airlifting the drill pipe at approximately 200 gpm for approximately 4-1/2 hours. After the development, the packer was kept inflated overnight while the discharged water was allowed to settle, prior to re-pumping (returning) the water to the well.

Re-pumping of the water to the well began on Tuesday, March 7, 2000, and lasted a total of 336 minutes. The initial pumping rate was 220 gpm while decreasing to about 90 gpm by the end of the test. The pumping rate was limited primarily by the centrifugal pump that was used to transfer the water from the settling tanks to the well. Wellhead pressures ranged from 8 psi to 45 psi.

Analysis of the data showed that at the beginning of the test, about 20 percent of the wellhead pressure was due to the buoyancy of the fluid injected compared to the formation water and about 80 percent was due to pipe friction losses. At the end of the test, 22 percent of the wellhead pressure was due to buoyancy and 15 percent was due to pipe friction losses. Table 3-10 presents the injectivity data for this packer test. The change in injectivity with time was similar to what would be expected for injection into an aquifer (see Appendix K). However, after about 280 minutes of injection, the injectivity started to decline significantly, due to plugging of the receiving zone. If the decline is actually due to plugging, it is likely that the zones below 630 feet are relatively diffuse. Tabular and graphical presentations of all packer tests are presented in Appendix K.

3.5.2 Variable Rate Step-drawdown Tests

Step drawdown tests were conducted on each artesian well after completion and development. The purpose of these tests was to measure the hydraulic performance of each well to assist in the formulation of the testing plan for the system in addition to acquiring hydraulic data to properly design the injection system and to size the pump that will be used for recovery. Measuring the performance of the monitor well was necessary in order to determine the purge time required to obtain samples from the wells.

In addition to well performance, the step tests provided an estimate of the hydraulic conductivity or permeability of the aquifer zones penetrated by the wells. Values of hydraulic conductivity obtained from step testing, however, should be taken as only "order-of-magnitude" estimates. The aquifer test that is planned for the completed ASR system will provide more accurate estimates of the hydraulic conductivity of the ASR storage zone. In addition, the test will provide estimates of the storativity of the zone and the leakance through the semi-confining layers above and below the zone. Figure 3-11 shows the submersible pumping apparatus used for the variable rate step test. Tabular and graphical presentations of all variable-rate step tests performed during construction are presented in Appendix L.

3.5.2.1 Variable Rate Step Drawdown Test of TPW-1

The step-drawdown test of TPW-1 was conducted after the well was drilled to its total depth of 700 feet and developed. The well was pumped at four distinct rates ranging from 490 gpm to 1,050 gpm. The drawdown measured at the well ranged from 28.80 feet to 61.65 feet. The calculated specific capacity of the well remained relatively constant at about 17 gpm/ft throughout the test.

The transmissivity of the open hole interval was estimated at approximately 35,000 gpd/ft, based upon the assumption that the transmissivity is approximately 2,000 times the specific capacity of the aquifer zone. The calculated hydraulic conductivity of the aquifer zone at TPW-1 was 175 gpd/ft^2. Table 3-11 presents a summary of the step test data and analysis for TPW-1.

3.5.2.2 Variable Rate Step Drawdown Test of SZMW-1

SZMW-1 was constructed with its final casing set to 510 feet with open hole to 700 feet. The step test of SZMW-1 was conducted at three distinct pumping rates. These rates ranged from 31 gpm to 101 gpm. Drawdown observed in the well ranged from 2.19 feet to 7.05 feet. The specific capacity remained relatively constant during the testing at approximately 14 gpm/ft. The consistency of the specific capacity values is probably due to the low rate that the well was pumped and the efficiency of the open hole interval. Table 3-12 presents a tabulation of the test data and analysis.

3.5.2.3 Variable Rate Step Drawdown Test of IMW-1

IMW-1 was constructed with its final casing set to 280 feet with open hole to 320 feet. The step test of IMW-1 was also conducted at three distinct pumping rates. These rates ranged from 28 gpm to 60 gpm. Drawdown during the testing ranged from 5.16 feet to 15.01 feet. The specific capacity varied during the testing from approximately 4 to approximately 5.5 gpm/ft. Correcting for well losses the aquifer specific capacity was approximately 8.2 gpm/ft. The estimated hydraulic conductivity was 425 gpd/ft^2. This value is about 2.5 times that measured at TPW-1. Table 3-13 presents a tabulation of the test data and analysis. The complete data set is contained in Appendix L.

3.5.2.4 Variable Rate Step Drawdown Test of SMW-1

SMW-1 was constructed with its final casing set to 170 feet with open hole to 205 feet. The step test of SMW-1 was conducted at three distinct pumping rates. These rates ranged from 9.3 gpm to 18 gpm. Drawdown during the testing ranged from 12.8 feet to 17.7 feet. The specific capacity remained relatively constant during the testing at approximately 1.0 gpm/ft. The consistency of the specific capacity values is probably due to the low rate that the well was pumped. The estimated hydraulic conductivity was 65 gpd/ft^2. This value is about 0.4 times that measured at TPW-1. Table 3-14 presents a tabulation of the test data and analysis. The complete data set is contained in Appendix L.

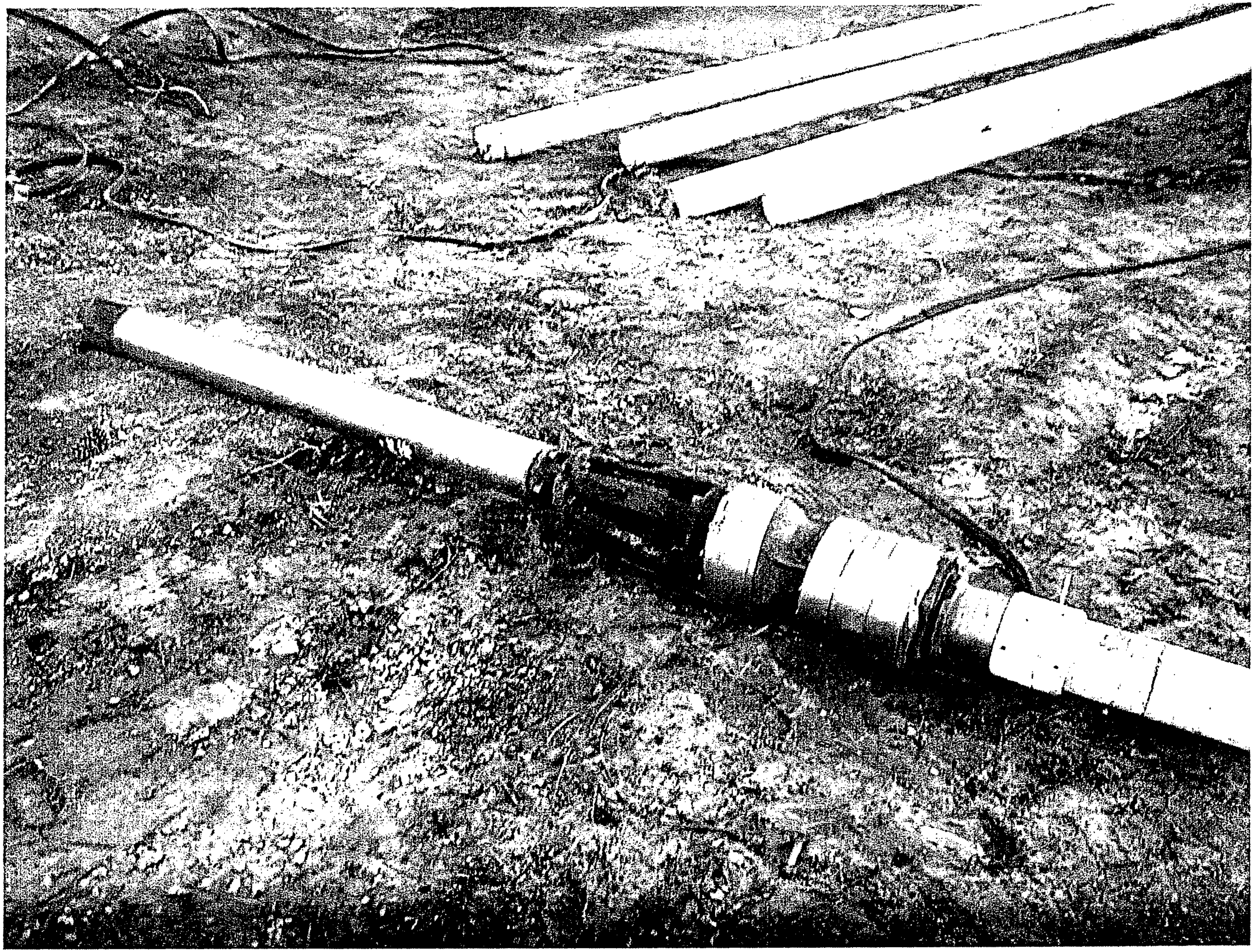

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FIGURE 3-11
Test Pump for Step Test of TPW-1

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TABLE 3-11
Step Drawdown Test of TPW-1

Step	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Drawdown (ft/gpm)	Well Loss Coefficient	Well Losses	Aquifer Drawdown (ft)
1	490	28.80	17.01	0.059	*	0	17.01
2	681	38.80	17.55	0.057	*	0	17.55
3	857	48.15	17.80	0.056	*	0	17.80
4	1050	61.35	17.11	0.058	*	0	17.11

Average specific capacity (gpm/ft): 17.34
Open hole length (ft): 200
Estimated transmissivity (gpd/ft): 35,000
Estimated permeability (gpd/ft^2): 175

* Well loss coefficient too small to be determined during testing
Note: Static water level was 5.12 ft above L.S.

TABLE 3-12
Step Drawdown Test of SZMW-1

Step	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Drawdown (ft/gpm)	Well Loss Coefficient	Well Losses	Aquifer Drawdown (ft)
1	31	2.19	14.07	0.071	*	0	2.19
2	65	4.93	13.27	0.075	*	0	4.93
3	101	7.05	14.28	0.070	*	0	7.05

Average Specific Capacity: 13.87
Open hole length (ft): 200
Estimated Transmissivity (gpd/ft): 28,000
Estimated Permeability (gpd/ft^2): 140

* Well loss coefficient too small to be determined during testing

TABLE 3-13
Step-Drawdown Test of IMW-1

Step	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Drawdown (ft/gpm)	Well Loss Coefficient	Well Losses	Aquifer Drawdown (ft)
1	28.34738	5.16	5.49	0.18	0.00229	1.84	3.32
2	45.51843	10.98	4.15	0.24	0.00229	4.74	6.23
3	59.52967	15.01	3.97	0.25	0.00229	8.12	6.89

Avg. Aquifer Specific Capacity (gpd/ft): 8.16
Open hole length (ft): 20
Est. Transmissivity (gpd/ft): 17,000
Estimated permeability (gpd/ft^2): 425

TABLE 3-14
Step Drawdown Test of SMW-1

Step	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft)	Specific Drawdown (ft/gpm)	Well Loss Coefficient	Well Losses	Aquifer Drawdown (ft)
1	9.3	12.8	0.72	1.38	*	0.00	12.79
2	11.9	11.9	1.00	1.00	*	0.00	11.88
3	17.7	17.7	1.00	1.00	*	0.00	17.70

Average Aquifer Specific Capacity (gpm/ft): 1.00
Open hole length (ft): 31
Estimated Transmissivity (gpd/ft): 2,000
Estimated Permeability (gpd/ft^2): 65

* Well loss coefficient too small to be determined during testing

* Graphical analysis for well loss coefficient was indeterminate. Losses were apparently too small at the pumping rates performed to produce losses. A zero coefficient will therefore be used.

Department of
Environmental Protection

Jeb Bush
Governor

South District
P.O. Box 2549
Fort Myers, Florida 33902-2549

David B. Struhs
Secretary

PERMIT

PERMITTEE:
Englewood Water District
201 Selma Ave.
Englewood, Florida 34233

Permit/Certification
Number: 43770-011-UC
Date of Issue: June 3, 1999
Expiration Date: June 2, 2004
County: Charlotte
Latitude: 26 54' 15" N
Longitude: 82 16' 04" W
Section/Town/Range: 16/41S/20E
Project: Englewood Reclaimed Water
Class V ASR Injection Well

This permit is issued under the provisions of Chapter 403 of the Florida Statutes (F.S.) and rules 62-4, 62-520, 62-550, 62-528, 62-600, 62-601, and 62-610 of the Florida Administrative Code. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents, attached hereto or on file with the Department and made a part hereof and specifically described as follows:

Construct one (1) Class V Group Three Aquifer Storage and Recovery (ASR) injection well with one (1) storage zone monitoring well, one (1) intermediate monitor well, and one (1) shallow monitor well. The purpose is to store, in the Suwanee Limestone, reclaimed water treated to meet reuse standards to meet the seasonal demands of a regional irrigation system. The basic well design will consist of a 16-inch diameter injection well to a proposed total depth of approximately 800 feet and cased to approximately 600 feet below land surface (bls). There will be one 6-inch storage zone monitoring well, one 6-inch shallow zone monitor well, and one 6-inch intermediate zone monitor well. This ASR well is designed to inject a maximum of one (1) million gallons per day. This project is depicted on the Englewood Water District application and associated documents submitted in support of this project. The location for this project is at the EWD South Regional Wastewater Treatment Facility, Charlotte County, Florida.

Subject to General Conditions 1-16 and Specific Conditions 1-18.

"Protect, Conserve and Manage Florida's Environment and Natural Resources"

PBSJ

LITHOLOGIC LOG

EWD RECLAIMED WATER ASR SYSTEM **FDEP Permit No. 43770-011-UC** **PBS&J Project No. 100051.00** **CH2M Hill Project No. 155487**	**WELL:** **TEST-PRODUCTION (TPW-1)**

DEPTH INTERVAL		DESCRIPTION	BY
FROM	TO		
0	5	Organic topsoil	SFR
5	10	Sand, silica, coarse to v. coarse	SFR
10	15	Missing sample	SFR
15	20	Sand, silica, coarse to v. coarse	SFR
20	25	Sand, silica, coarse to v. coarse. Some shell	SFR
25	30	Missing sample	SFR
30	35	Limestones, hard, gray. With shell.	SFR
35	40	Limestone/ Shell, as above	SFR
40	45	Clay, greenish-gray, soft, plastic. With numerous shell fragments.	SFR
45	50	Clay/Shell, as above.	SFR
50	55	Limestone, phosphatic, f. grained, lt. tan to tan. Numerous shell fragments, incl. etch. spines.	SFR
55	60	Clay, phosphatic, greenish gray. Numerous mod. large phos. nodules.	SFR
60	65	Missed sample.	SFR
65	70	Limestone, phosphatic, lt. tan to gray. Numerous fine shell fragments. Some clay, as above.	SFR
70	75	Limestone, as above. lt. greenish gray to greenish gray.	SFR
75	80	Limestone, as above.	SFR
80	85	Limestone, phosphatic, lt. tan to tan.	SFR
85	90	Limestone, phosphatic, lt tan to tan. Dolomitic, in part.	SFR
90	95	Limestone, as above.	SFR
95	100	Limestone, as above.	SFR
100	105	Clay, calcareous, soft, cream. Some phosphorite nodules.	SFR
105	110	Limestone, v. soft, cream to lt. tan. Some clay, as above.	SFR
110	115	Limestone, m. hard, f. grained, lt. tan.	SFR
115	120	Limestone, phosphatic, m. hard, cream to tan.	SFR
120	125	Clay, soft, bluish green.	SFR

EWD RECLAIMED WATER ASR SYSTEM **FDEP Permit No. 43770-011-UC** **PBS&J Project No. 100051.00** **CH2M Hill Project No. 155487**	**WELL:** **TEST-PRODUCTION (TPW-1)**

DEPTH INTERVAL		**DESCRIPTION**	**BY**
FROM	**TO**		
275	280	Limestone, granular, v. friable, lt. tan to lt. gray.	
280	285	Limestone, as above.	SFR
285	290	Limestone, as above.	SFR
290	295	Limestone, as above.	SFR
295	300	Limestone, as above.	SFR
300	310	Limestone, as above.	SFR
		Top of PZ3	
310	315	Limestone, v. hard, fine-grained, tan to gray	SFR
315	320	Limestone, v, hard, fine-grained, gray. Shell fragments.	SFR
320	325	Limestone, m. hard, friable, lt. tan. Some limestone, as above.	SFR
325	330	Limestone, as above.	SFR
330	335	Limestone, m. fine-grained, cream to lt. gray, friable in part. Numerous fossil cast and shell fragments.	SFR
335	340	Limestone, as above.	SFR
340	345	Limestone, as above.	SFR
345	350	Limestone, as above.	SFR
350	355	Limestone, as above.	SFR
355	360	Limestone, as above.	SFR
360	365	Limestone, as above.	SFR
365	370	Limestone, as above.	SFR
370	375	Limestone, as above.	SFR
375	380	Limestone, as above.	SFR
380	385	Limestone, as above.	SFR
385	390	Limestone, as above, v. soft. Some calcareous clay.	SFR
390	395	Dolomite, massive, v. hard, lt. brown and dk. greenish gray. Limestone, as above.	SFR
395	400	Dolomite and limestone, as above.	SFR
400	405	Dolomite, massive, v. hard, grayish tan.	SFR
405	410	Dolomite, v. hard, lt. brown, some casts and molds, vuggy, fine crystallization	SFR
410	415	Dolomite, v hard, gray to lt brown.	SFR
		Bottom of PZ-3	
415	420	Dolomite, v. hard, lt. brown, massive. With limestone, soft to mod. hard, fine-grained. Some inclusions of clay, calcareous, v. soft, cream.	SFR
420	425	Dolomite/limestone/clay, as above.	SFR

EWD RECLAIMED WATER ASR SYSTEM **FDEP Permit No. 43770-011-UC** **PBS&J Project No. 100051.00** **CH2M Hill Project No. 155487**	**WELL:** **TEST-PRODUCTION (TPW-1)**

DEPTH INTERVAL			
FROM	**TO**	**DESCRIPTION**	**BY**
425	430	Clay, calcareous, cream, soft. With limestone, as above.	SFR
430	435	Limestone, as above. Some clay, as above.	SFR
430	440	Limestone, f. grained, sl. chalky matrix in part, friable, lt. tan, sl. micritic in part. Some echinoid spines and small shell casts.	SFR
440	445	Limestone, as above.	SFR
445	450	Limestone, as above.	SFR
450	455	Limestone, as above.	SFR
455	460	Limestone, as above.	SFR
460	465	Limestone, as above.	SFR
465	470	Limestone, as above.	SFR
470	475	Limestone, as above.	SFR
475	480	Limestone, as above.	SFR
480	485	Limestone, as above.	SFR
485	490	Limestone, as above.	SFR
490	495	Limestone, as above.	SFR
495	500	Limestone, as above.	SFR
500	505	Limestone, as above.	SFR
505	510	Limestone, as above.	SFR
		Top of Storage Zone	
510	515	Limestone, as above.	SFR
515	520	Limestone, as above.	SFR
520	525	Limestone, as above.	SFR
525	530	Limestone, as above.	SFR
530	535	Limestone, as above.	SFR
535	540	Limestone, as above.	SFR
540	545	Limestone, as above.	SFR
545	550	Limestone, as above.	SFR
550	555	Limestone, as above. Some clay, calcareous, partially indurated, lt. gray.	SFR
555	560	Clay, calcareous, part indurated, tan to cream. With Limestone, as above.	SFR
560	565	Limestone, as above.	SFR
565	570	Clay, calcareous, v. soft to stiff, cream to lt. gray. With limestone, as above.	SFR
570	575	Limestone, as above. Some calcareous clay as above.	SFR
575	580	Limestone, as above.	
580	585	Limestone, as above.	SFR

EWD RECLAIMED WATER ASR SYSTEM
FDEP Permit No. 43770-011-UC
PBS&J Project No. 100051.00
CH2M Hill Project No. 155487

WELL:

TEST-PRODUCTION (TPW-1)

DEPTH INTERVAL		DESCRIPTION	BY
FROM	TO		
585	590	Limestone, as above.	SFR
590	595	Limestone, as above. With some clay, calcareous, lt. gray to gray, soft to mod. indurated.	SFR
595	600	Limestone, as above. Greater amount of clay, as above.	SFR
600	605	Limestone, as above.	SFR
605	610	Limestone, as above.	SFR
610	615	Limestone, as above. Some minor amount of clay, as above.	SFR
615	620	Limestone, as above.	SFR
620	625	Limestone, as above.	SFR
625	630	Limestone, as above. Some clay, as above	SFR
630	635	Limestone, as above.	SFR
635	640	Limestone, as above.	SFR
640	645	Limestone, as above.	SFR
645	650	Clay, as above. With limestone, as above.	SFR
650	655	Limestone, as above.	SFR
655	660	Limestone, as above.	SFR
660	665	Limestone/clay, as above.	SFR
665	670	Limestone/clay, as above.	SFR
670	675	Limestone, as above.	SFR
675	680	Limestone, as above.	SFR
680	685	Limestone, as above.	SFR
685	690	Limestone, as above.	SFR
690	695	Limestone, as above.	SFR
695	700	Limestone, as above.	SFR
		Bottom of Storage Zone	
700	705	Limestone, as above.	SFR
705	710	Limestone, as above.	SFR
710	715	Limestone, as above.	SFR
715	720	Limestone, as above.	SFR
720	725	Limestone, as above.	SFR
725	730	Limestone, as above.	SFR
730	735	Clay, calcareous, tan, soft. With limestone, as above	SFR
735	740	Clay, calcareous, tan, soft. With limestone, as above	SFR
740	745	Limestone, as above.	SFR
745	750	Limestone, as above.	SFR
750	755	Limestone, as above.	SFR
755	760	Limestone, as above.	SFR

EWD RECLAIMED WATER ASR SYSTEM **FDEP Permit No. 43770-011-UC** **PBS&J Project No. 100051.00** **CH2M Hill Project No. 155487**		**WELL:** **TEST-PRODUCTION (TPW-1)**	
DEPTH INTERVAL			
FROM	**TO**	**DESCRIPTION**	**BY**
760	765	Limestone, as above.	SFR
765	770	Limestone, as above.	SFR
770	775	Limestone, as above.	SFR
775	780	Limestone, as above.	SFR
780	785	Limestone, as above.	SFR
785	790	Limestone, as above.	SFR
790	795	Limestone, as above.	SFR
795	800	Limestone, as above.	SFR
800	808	Limestone, as above.	SFR