SSU - Southern States Utilities

MARCO ISLAND INJECTION WELL NO. 1
Well Completion Report
VOLUME 1

Marco Island Photo Produced by Viewfinders

M&A

MISSIMER & ASSOCIATES, INC.

Environmental and Groundwater Services

SOUTHERN STATES UTILITIES
MARCO ISLAND INJECTION WELL NO. 1
FINAL WELL COMPLETION REPORT
VOLUME 1

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Marco Island Injection Well
Well Completion Report
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1.0 Introduction

1.1 Background

This report describes the construction and testing of one Class I injection well and one dual-zone deep monitoring well at the Southern States Utilities (SSU) Marco Island Wastewater Treatment Plant.

The completed system consists of the injection well and dual zone monitor well. The final depth of the injection well is 3,340 feet below pad level (bpl), with a final 24-inch injection string set at 2,640 feet, and a 20-inch injection tubing set at 2,573 feet. The injection zone occurs between 2,640 and 3,340 feet, and consists of fractured, recrystallized dolomite of the boulder zone. For the purpose of this report, all depths are referenced to the level of the concrete construction pad on which the wells are located.

Some of the formations overlying the injection zone contain water having a TDS (Total Dissolved Solids) concentration less than 10,000 mg/l; these are classified as drinking water sources. These zones are separated from the injection zone by over 1,000 feet of very low permeability material from 1,600 to 2,640 feet bpl. As further protection, the dual zone monitor well, located 70 feet from IW-1, provides a method of detecting any vertical migration of the injected fluid above the injection zone. The upper zone monitors the formation from 1,000 to 1,089 feet bpl, and the lower zone monitors from 1,490 to 1,600 feet bpl.

1.2 Scope

Missimer & Associates, Inc., (M&A) was authorized in November, 1989 by Southern States Utilities (SSU) to provide services for the design, permitting and construction of a Class I

Injection Well at their Marco Island Utilities (MIU) Water and Wastewater Treatment Plant, located on Marco Island, Florida (Figure 1 and 2).

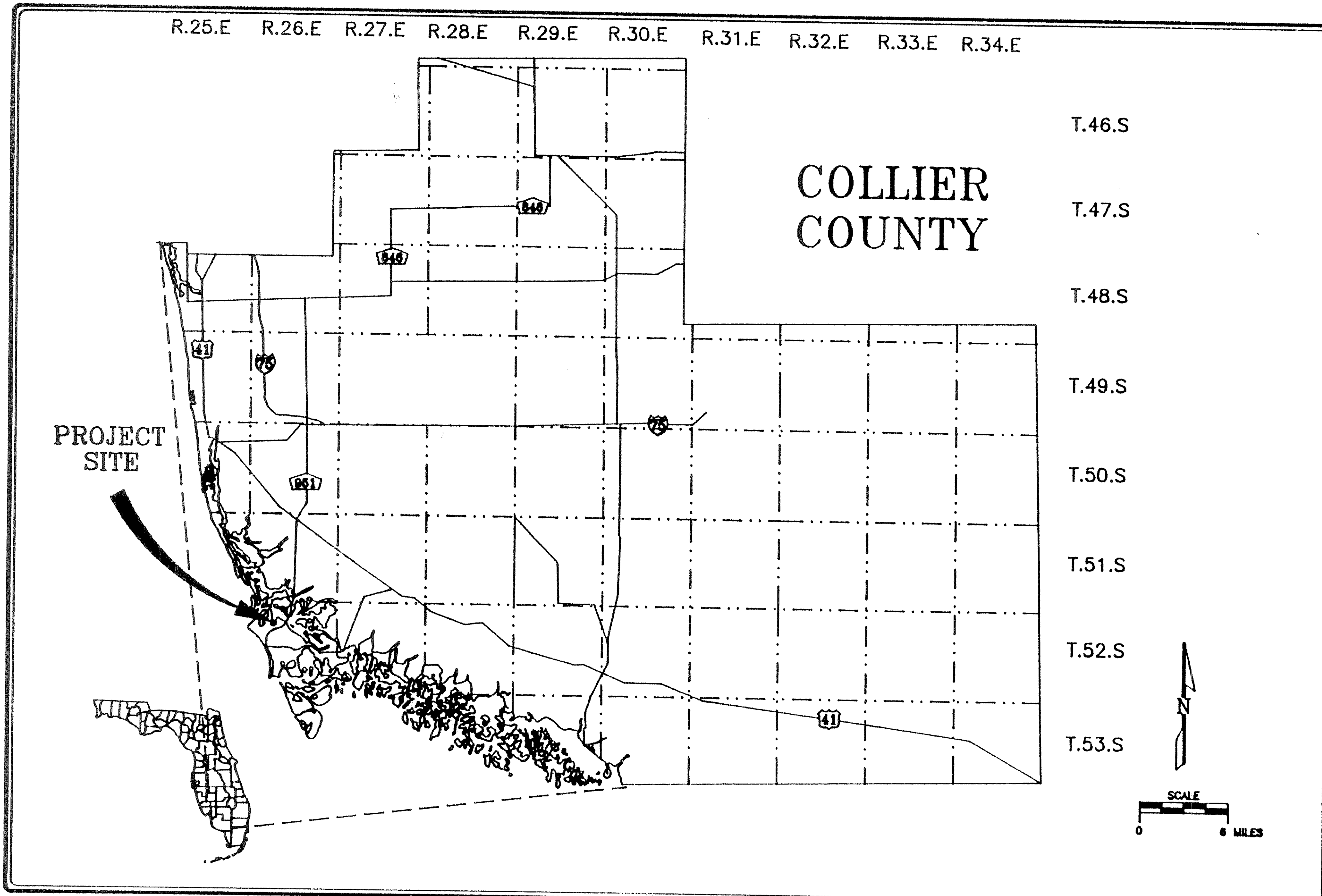
M&A's responsibilities included preliminary and final well design, preparing technical specifications, preparing the FDER construction permit application, evaluating contractor bids, performing on-site hydrogeologic supervision, and providing project management and direction throughout the duration of the project.

The well was designed to dispose of a combined stream of treated domestic effluent and concentrated brine from SSU's recently completed Reverse-Osmosis Water Treatment Plant also located on Marco Island. The design flow to the well was expected to be 8 mgd, maximum. The Class I well was to be accompanied by a dual-zone monitor well.

1.3 Project Description

The MIU Water and Wastewater Treatment Plants are located at 100 Windward Drive, Marco Island, Florida. The plant is situated on the eastern side of the island, north of State Road 951, off of El Cam Circle. On December 5, 1990, the Florida Department of Environmental Regulation (FDER) issued construction permit # UC11-179323 for the construction and testing of one Class I injection well and a dual-zone monitor well at the MIU Treatment Plant site. A copy of this permit is included in Appendix A.

Construction of IW-1 began in April of 1991. Alsay, Incorporated of Fort Pierce (low bidder) was contracted to perform the drilling and testing services for the project. Under this contract, they were to complete one construction pad, one Class I Injection Well, and one dual zone monitor well. The injection well system was completed on April 4, 1992.



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ENVIRONMENTAL AND GROUNDWATER SERVICES

DRN. BY: CAM DWG NO. A-9314GEN-1 DATE: 8/19/92

PROJECT NAME: MARCO ISLAND UTILITIES PROJECT NUMBER: H89-314

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FIGURE 1. MAP SHOWING LOCATION OF MARCO ISLAND UTILITIES INJECTION WELL NO. 1.

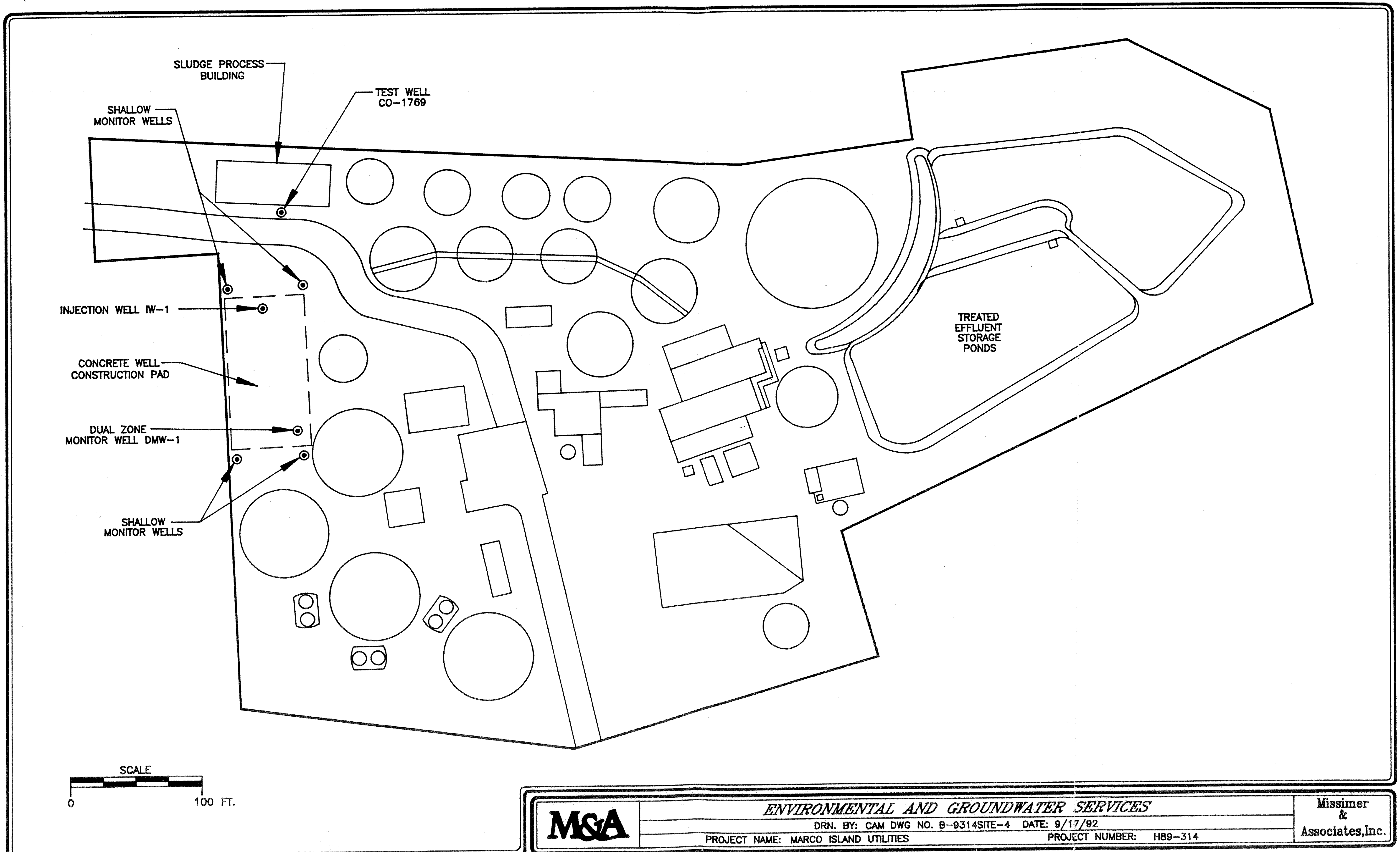


FIGURE 2. SITE PLAN OF MARCO ISLAND UTILITIES WATER AND WASTEWATER TREATMENT PLANT SHOWING LOCATIONS OF IW-1 AND DMW-1.

The entire drilling and construction program was overseen by an FDER Technical Advisory Committee (TAC), comprised of representatives from the FDER, the South Florida Water Management District (SFWMD), the U.S. Environmental Protection Agency (USEPA), and the United States Geological Survey (USGS). The TAC members met periodically to review construction progress and to approve specific casing seat depths and testing programs. Daily construction logs and weekly construction summaries were submitted to the TAC.

Construction and testing of the injection well and its associated monitor well was performed in accordance with Florida Administrative Code (FAC) Chapter 17-28 Underground Injection Control (UIC), the conditions of the FDER construction permit, and following the technical specifications prepared by Missimer & Associates.

2.0 Hydrogeology

The geology/hydrogeology at the Marco Island site, with respect to formation contacts and aquifer descriptions were interpreted using various data available. Regional/vicinity data included geophysical and lithologic logs from nearby deep wells, and site-specific data included geophysical logs, lithologic samples, core analyses and television surveys.

The hydrogeology in the vicinity of the Marco Island Injection Well is characterized by three principal aquifer systems: the Surficial Aquifer System, the Intermediate Aquifer System, and the Floridan Aquifer System, which combined, extend from land surface to a depth of approximately 3,350 feet. Figure 3 shows the hydrostratigraphy at the Marco Island site with respect to construction details.

The Surficial Aquifer System extends to a depth of 100-150 feet from near land surface, and is characterized by sand, shell, limestone, and marl. This unit is generally referred to geologically as the Undifferentiated Deposits of Pleiocene/Plesitocene age. At the injection well site, this unit extends from near land surface to 100 feet.

Below the Surficial Aquifer System lies the Intermediate Aquifer System, extending 100 to 850 feet below land surface, consisting of sediments of the Hawthorne Group of Miocene Age. Missimer & Associates, Inc. identifies several producing zones within this aquifer that are described locally as the Sandstone Aquifer, and Hawthorn Zones II and III. This classification is based on various hydrogeologic investigations in the vicinity of Marco Island (Missimer, 1991). The Hawthorne Group is in turn made up of two formations: the Peace River Formation and the Arcadia Formation. The Peace River extends from 100 to 350 feet at the Marco site, and the Arcadia is found from 350 to 850 feet. At this site, the Hawthorne Group is comprised of sandy, phosphatic limestone, clay, sandstone, and dolomite in the Peace River Formation, and limestone and dolomite in the Arcadia Formation. The dolomite of the Peace River occurs in

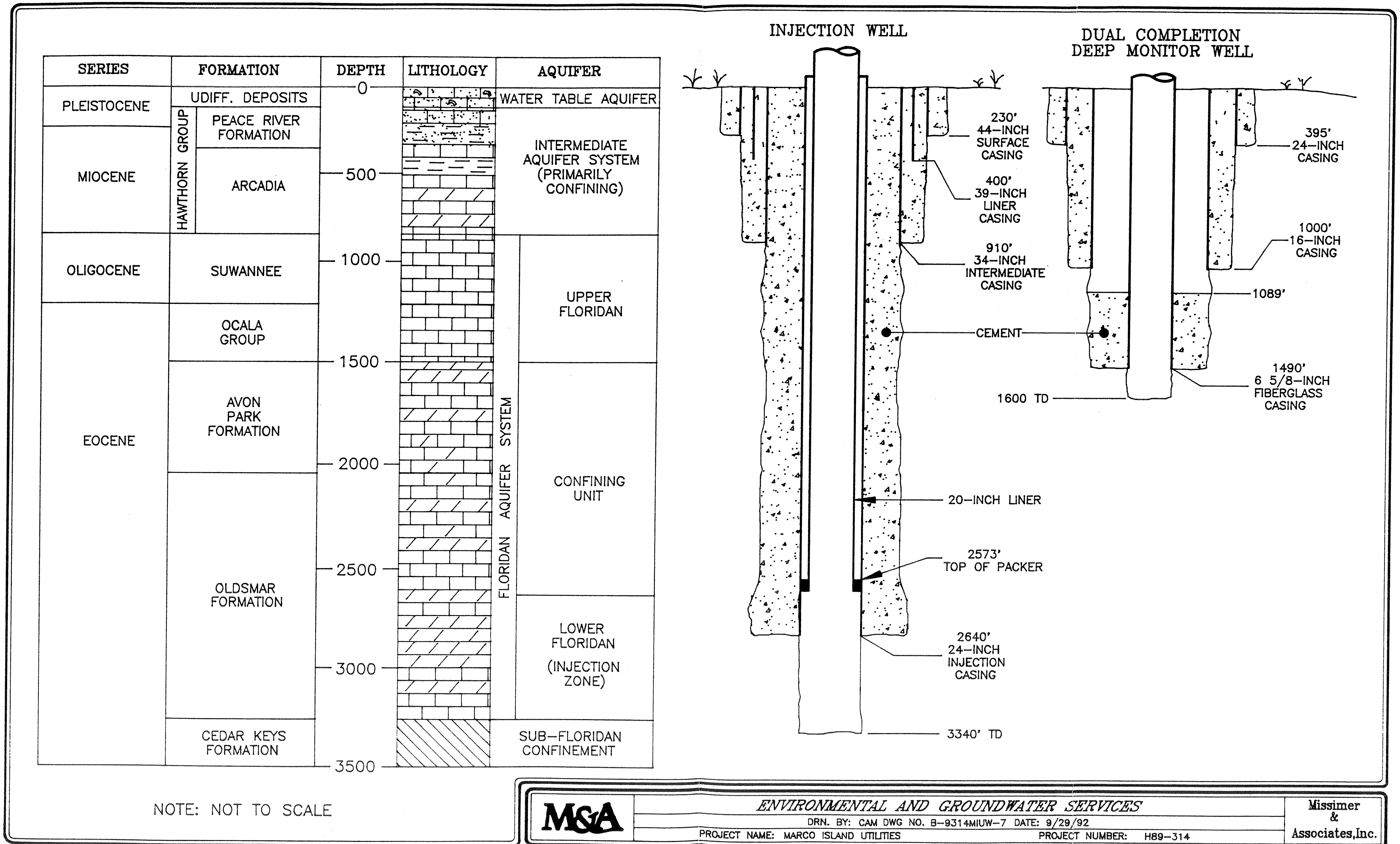


FIGURE 3. CONSTRUCTION DETAILS AND HYDROSTATIGRAPHY OF THE MARCO ISLAND UTILITIES INJECTION AND MONITOR WELLS.

the form of a fine dolosilt, which acts as a confinement between the Sandstone Aquifer above, and the Hawthorne Zone II, which occurs in the moderately permeable limestone of the Upper Arcadia, from approximately 350-550 feet. Confinement occurs again from approximately 550 to 590 feet, consisting of soft dense limestone, lime mud and some clay. Below 590 feet to approximately 640 feet is the zone classified as the Hawthorne Aquifer System Zone III. Zone III is comprised of moderate permeability limestone, grading into more confining material from 640 to 690 feet, where the lithology changes from limestone to low permeability lime mud. The Lower Arcadia consists of limestone and dolomite extending to a depth of approximately 860 feet.

Below the Hawthorne Group/Intermediate Aquifer lies the Floridan Aquifer System, an extensive aquifer system consisting of permeable carbonate rocks of Oligocene to Eocene Ages. The rocks that make up this system vary greatly in permeability vertically, so that layers of high permeability are bounded above and below by layers of low permeability.

The uppermost unit of this aquifer system is the Suwannee Formation of Oligocene Age, which generally consists of carbonates ranging from unlithified lime muds to hard dolomites, to calcarenitic limestones. At IW-1, the Suwannee consists of moderately hard to friable pale orange limestone, occurring as a biomocrite to biosparite, and is found from approximately 860-1300 feet below land surface.

Underlying the Suwannee Formation lies the Ocala Group of Eocenc Age, occurring from 1,300 to 1,500 feet at the Marco Island site. The Ocala Group consists mainly of yellowish gray micritic, fossiliferous limestone and lime mud.

Below the Ocala Group is the Avon Park Limestone of Middle Eocene Age. Extending to 2,050 feet, the Avon Park is comprised mainly of interbedded limestones and dolomites. The upper 20 feet is made up of finely crystalline dense dolomite, overlying more than 500 feet of limestone. Generally, the Avon Park varies in permeability due to variation in depositional textures and degree of secondary dissolutioning (Missimer, 1991). At the Marco Island site, the Avon Park is characterized by relatively low permeability, soft limestone. The unit is confining in nature, as evidenced by the coring and packer tests conducted within this zone.

Below 2,050 feet, to a depth of 3,330 feet lies the Lower Eocene Oldsmar Formation. This unit consists of dense, softer, cavity-riddled, fractured limestone and dolomites, and is commonly called the "Boulder Zone" where these fractures and cavities occur. The Oldsmar is identified at the Marco Island site by increased resistance on the electric log, and by a significant change on the dual induction electric log. At the Marco Island site, cavaties do not occur until a depth of approximately 2,650 feet and below. The occurence of cavities is evidenced by the BHC Sonic Log, which indicates the highly transmissive zones. For this reason, the final injection string was set at 2,640 feet, and the borehole from this point down serves as the injection zone. The base of the Oldsmar occurs at 3,333 feet, where the first anhydrite of the Cedar Keys Formation was encountered. The Cedar Keys Formation consists of dense gypsum and anhydrite, and acts as the lower confining unit below the Floridan Aquifer System.

3.0 Construction

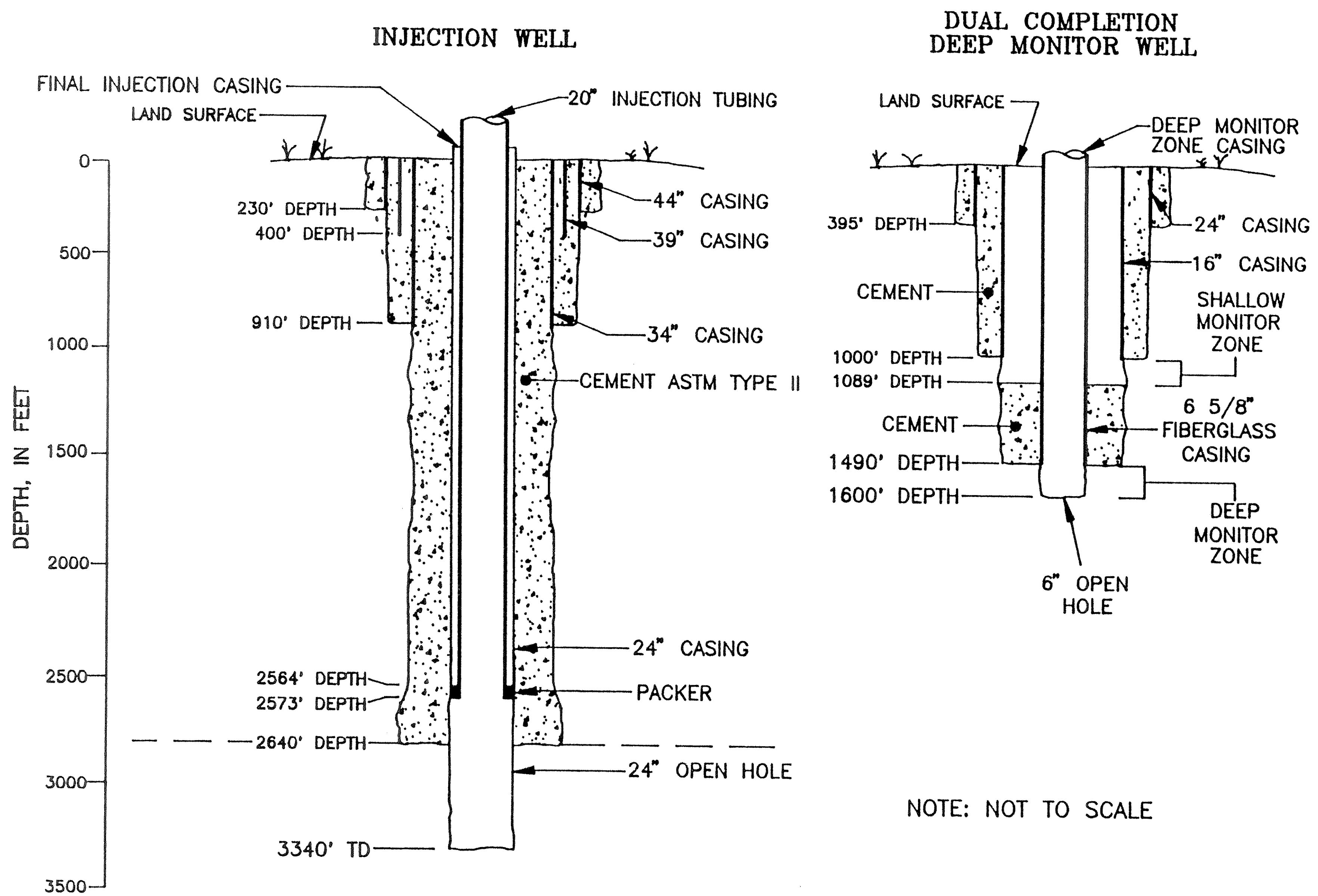
3.1 Injection Well

Notice to proceed with construction was given to Alsay, Inc., on April 8, 1991. The reinforced concrete drilling pad was completed within 9 days, and drilling began on April 17. The pad measured 60 X 100 feet, and served to stabilize the drilling site and contain fuel/chemical spills and drilling fluids. Upon completion of the pad, the injection well drilling rig, a Brewster Skytop 2000, was mobilized on site and assembled. Four (4) shallow monitor wells were drilled at each corner of the pad to provide a means of monitoring the surficial aquifer water quality throughout the construction of the well. Samples were collected each week and field analyzed for chloride concentration and conductivity, and included in the weekly construction progress reports.

During the initial stages of drilling, the mud-rotary method was used to a depth of 717 feet for the injection well, and to 440 feet bpl for the monitor well. Below these depths, the reverse-air method was used to advance the hole. During reverse-air drilling, a blow-out preventor was installed to control flowing conditions. Salt was also added as a weighting material (with regulatory agency approval and only when necessary) to suppress the hydrostatic head of the formation. Construction details of both the injection and monitor well are provided in Figure 4, and final well head construction details are shown in Figure 5.

3.1.1 Casings and Tubing

Both the injection and monitor wells were designed with multiple, concentric casings made of new, unused, seamless ASTM Grade B steel with at least a .500-inch wall thickness. All casings were set plumb and aligned, and centralized within the borehole. Each casing seat depth was selected based on data gathered during the construction and testing program, and based on



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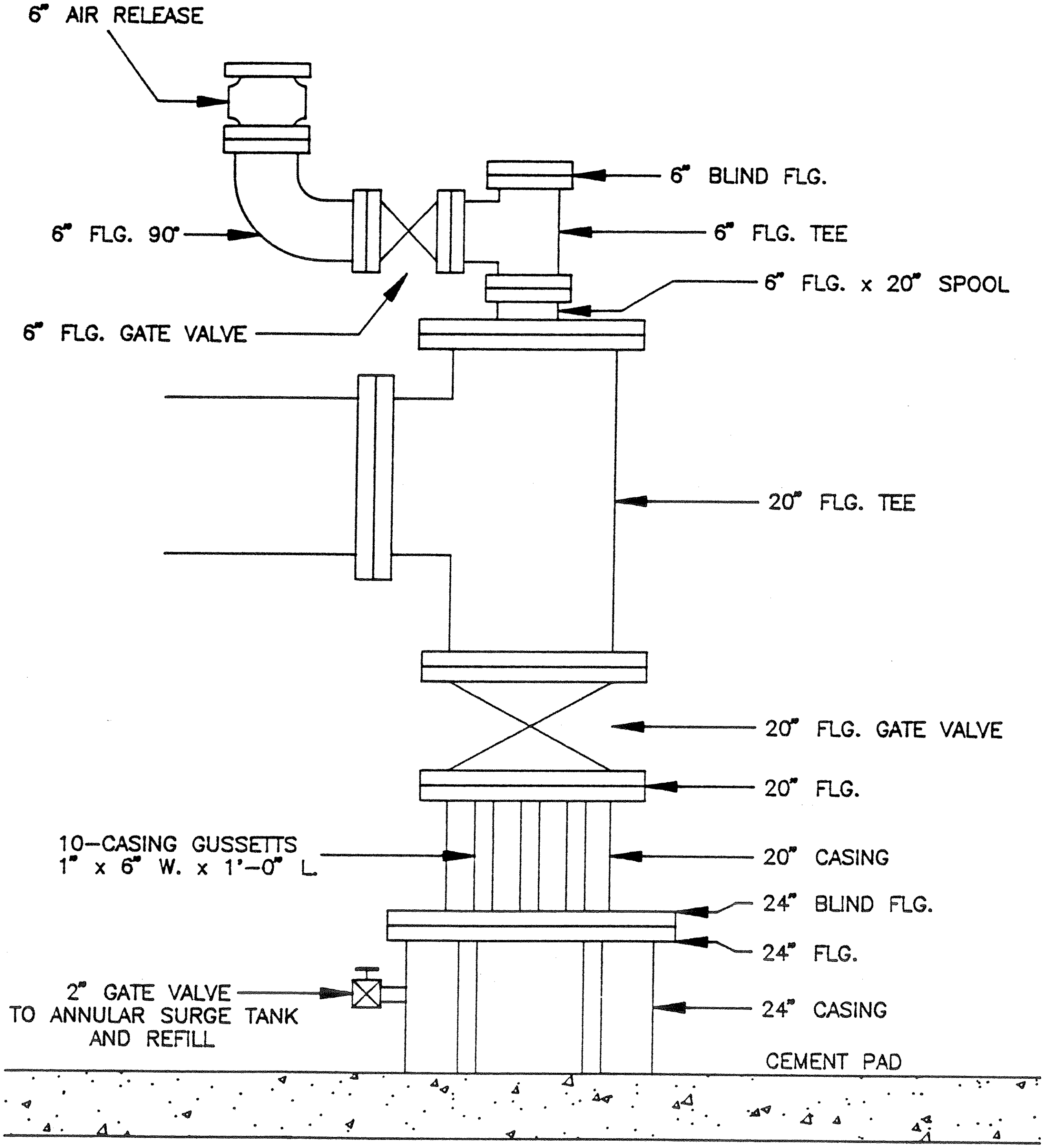
ENVIRONMENTAL AND GROUNDWATER SERVICES

DRN. BY: CAM DWG NO. A-MH9314W-1 DATE: 9/11/92

PROJECT NAME: MARCO ISLAND UTILITIES PROJECT NUMBER: H89-314

Missimer & Associates, Inc.

FIGURE 4. CONSTRUCTION SCHEMATIC OF MARCO ISLAND UTILITIES IW-1 AND DMW-1.



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	PROJECT NAME: MARCO ISLAND UTILITIES NUMBER: H89-314	

FIGURE 5. SCHEMATIC SHOWING CONSTRUCTION DETAILS OF WELL HEAD FOR INJECTION WELL NO. 1.

regulatory agency requirements. All casing ends were beveled and continuously butt welded by certified welders. A summary of the casings used on IW-1 and is provided in Table 1. Mill Certificates for each casing string are included in Appendix E.

3.1.2 Cementing Program

Casings were cemented in place from land surface to the casing seat depth by Halliburton Services, Inc., of Felda, Florida. Neat cement was used for the bottom 200 feet of each casing, and not more than 6% bentonite was used on any interval. Cementing was accomplished using both the pressure grouting and tremie methods. Only ASTM II cement was used during construction, with bentonite gel added as needed to increase yield. Calcium chloride (to reduce curing time), and Flocele (synthetic loss of circulation material) were used during certain stages of the cement program. Table 2 summarizes the cementing program for IW-1. Cementing was accomplished in stages, and a temperature log was run following each stage. The temperature logs verified the presence of cement throughout the interval, and located the top of each stage.

3.1.3 Construction Summary IW-1

Construction of the well began following completion of the drilling pad and surrounding wall. A sixty-inch pit casing was vibrated in to a depth of 60 feet for the purpose of stabilizing the surficial sediments for subsequent drilling operations. A 54-inch hole was then drilled to a depth of 230 feet bpl, and the 44-inch casing was set and cemented in place.

Drilling proceeded with a 44-inch bit to a depth of 717 feet bpl. Loss of circulation and sand bleeding into the hole slowed drilling progress and prompted the contractor to pump a cement plug into the formation. At this time, the drilling method was converted from mud rotary to reverse-air. Sand continued to flow into the borehole. After careful evaluation of the situation, the contractor set and cemented a 39-inch liner casing from land surface to 404 feet bpl.

TABLE 1

CASING SUMMARY
MARCO ISLAND IW-1

Outside Diameter (inches)	Construction Type	Wall Thickness (inches)	Total Depth (feet bpl)
60	spiral weld	0.375	60
44	spiral weld	0.375	230
39	spiral weld	0.375	400
34	spiral weld	0.395	910
24	seamless	0.500	2640
20	seamless	0.580	2573

TABLE 2

CEMENT SUMMARY
MARCO ISLAND IW-1

Date	Stage Number	Cement Mix	Cubic Feet Pumped	Actual Fillup (Lineal feet)
44-inch casing 05-23-91	1	Halliburton Light Cement (HLC)	1337	237
39-inch casing 08-01-91	1	HLC Neat Cement	359 927	172
08-02-91	2	HLC with 2% CaCL	269	2
08-03-91	3	HLC with 2% CaCL+½ lb Flocele/sack	276	83
08-04-91	4	HLC with 2% CaCL	256	133.5
34-inch casing 09-01-91	1	HLC Neat Cement	1275.12 797.58	220
09-02-91	2	HLC with 0.25 lb/sack Flocele	2171	---
09-03-91	3	HLC with 0.25 lb/sack Flocele	714	90
09-04-91	4	HLC with 1% cal. + 0.25 lb/sack Flocele	1550	291.16
09-05-91	5	HLC with 1% CaCL	671	322.84
24-inch casing 12-14-91	1	HLC with 2% CaCL + ½ lb Flocele/sack Neat cement with 2% CaCL + ½ lb Flocele/sack	759 1139	307

TABLE 2 (CONT'D)

CEMENT SUMMARY
MARCO ISLAND IW-1

Date	Stage Number	Cement Mix	Cubic Feet Pumped	Actual Fillup (Lineal feet)
24-inch casing 12-16-91	2	HLC with 2% CaCL + ½ lb Flocele/sack	2208	433
12-16-91	3	HLC with 2% CaCL + ½ lb Flocele/sack	2577	519
12-17-91	4	HLC with 2% CaCL + ½ lb Flocele/sack	1350	122
12-18-91	5	HLC with 2% CaCL + ½ lb Flocele/sack	2113	385
12-18-91	6	HLC with 2% CaCL	2265	797
12-21-91	7	HLC with 2% CaCL	303	98

Following installation of the 39-inch liner, a 34-inch casing was installed to a depth of 910 feet bpl. This casing depth was selected in order to protect the Underground Source of Drinking Water (USDW) the base of which was determined to be at approximately 820 feet bpl.
A 12¼-inch pilot hole was then drilled from 910 to 3,354 feet bpl, which was chosen as the total depth of the well. During pilot hole drilling, five geologic cores were recovered for laboratory analysis. Upon completion of the pilot hole, a complete set of geophysical logs were run in the borehole to determine the nature of the underlying formations.

Following competion of geophysical logging, seven straddle packer tests were conducted at various depth intervals of the borehole. A discussion of the methodology and analysis of each packer test is presented in section 4.5.

During the first straddle packer test, the inflatable packer tool was broken off of the drill string and became lodged in the lower portion of the hole. The remainder of the straddle packer tests were completed using mechanical packers and a TV survey was conducted through the open portion of the hole to determine the exact location of the packers. The packer was seen at about 2,730' bpl. Fishing operations for the lost packer began on October 13 by reaming out the pilot hole to 17 inches in order to accommodate a fishing tool. During fishing operations, the fishing tool was also lost in the hole. Fishing operations continued until November 21, when all tools lost in the hole were recovered.

Upon completion of fishing operations, a drillable bridge plug consisting of gravel topped with cement was placed in the borehole from 3354 to 2650 feet, in preparation for setting the 24-inch final injection casing. The 24-inch casing served to isolate the Upper Floridan Aquifer from the injection zone, the top of which was identified at 2650 feet. The 24-inch casing (API 5L Grade B Seamless, .500-inch wall thickness) was set and cemented from surface to 2640 feet bpl, following which, the bridge was drilled out and the open hole cleared to 3340 feet.

A TIW (Texas Iron Works) liner hanger was then installed at a depth of 2,573 feet, and the 20-inch injection tubing was set from land surface to this depth. Technical specifications of the TIW assembly are included in Appendix E. The annular space between the 20-inch tubing and 24-inch casing was filled with Baracore A, a corrosion-inhibiting fluid. Technical specifications for this fluid are provided in Appendix F. Installation of the Baracor marked the completion of IW-1 construction. A TV survey of the 20-inch tubing was conducted from surface to the total depth of the well. A chronological summary of construction progress on the injection well is provided in Table 3, and construction details are shown in Figure 4.

3.2 Construction Dual Zone Monitor Well

The dual-zone monitor well is required to detect any upward migration of injected fluid above the confining zones into overlying aquifers. Construction of the monitor well began on June 27, 1992. The monitor well was constructed using similar methods as those used on IW-1. The mud rotary drilling method was employed to a depth of 410 feet bpl, after which reverse air was used for the remainder of the well.

3.2.1 Casing

Three strings of casing were used to construct DMW-1. The casing depths were selected based on lithologic, geophysical, hydrogeologic, and water quality data obtained during construction and testing of IW-1 and DMW-1. Setting of the final two casing strings was not permitted until testing was complete in the injection well. After completing the packer tests on the injection well, a TAC meeting was held on November 5, 1991, to review the data collected and evaluate M&A's proposed casing seat points and monitor zones. Table 4 summarizes the casings used in the construction of DMW-1.

TABLE 3

MARCO ISLAND
INJECTION WELL 1
CHRONOLOGY

START DATE	END DATE	ACTIVITY
5-17-91	5-21-91	Drilled 54" hole to 230'.
5-21-91	5-21-91	Ran caliper log of 54" hole.
5-22-91	5-22-91	Set and cemented 44" casing.
5-26-91	6-05-91	Drilled 44" hole from 230' to 717' BPL.
6-10-91	6-10-91	Pumped cement plug into 44" hole.
6-11-91	6-15-91	Switched from mud rotary to reverse air drilling.
6-15-91	6-21-91	Reamed 44" hole from 232 to 650' BPL; sand filled hole to 234' BPL.
6-23-91	6-23-91	Pumped cement plug just below 44" casing to alleviate sand flowing conditions.
6-23-91	7-28-91	Evaluated situation, ordered 39" liner casing, waited on casing.
7-29-91	8-04-91	Set and cemented 400 feet of 39" casing.
8-14-91	8-28-91	Reamed 39" hole from 400 to 910'.
8-30-91	9-05-91	Set and cemented 34" casing to 910'.
9-06-91	10-1-91	Drilled 12¼" pilot hole from 910 to 3,354'.
9-11-91	9-21-91	Cut seven cores from pilot hole.
10-3-91	10-3-91	Ran geophysical logs on pilot hole: caliper, gamma ray, dual induction, BHC Sonic/VDL, temperature.
10-3-91	10-12-91	Conducted seven straddle packer tests on pilot hole.
10-4-91	--------	Lodged straddle packer in pilot hole at 2,790 feet.
10-13-91	--------	Fished for lost straddle packer in pilot hole.

TABLE 3 (CONT'D)

MARCO ISLAND
INJECTION WELL 1
CHRONOLOGY

START DATE	END DATE	ACTIVITY
10-13-91	10-16-91	Reamed hole to 17" for fishing tool.
10-16-91	11-21-91	Fished for lost packer.
11-21-91	--------	Retrieved packer out of hole.
11-22-91	11-24-91	Place bridge plug in hole to 2,650'.
11-25-91	11-28-91	Set 24" casing to 2,640' BPL.
11-29-91	--------	Lost cement string in hole.
12-09-91	--------	Retrieved cement string from hole.
12-10-91	--------	Ran TV Survey of 24" casing.
12-14-91	12-19-91	Cemented 24" casing.
12-21-91	--------	Ran cement bond log of 24" casing.
12-31-91	--------	Conducted pressure test of 24" casing.
12-31-91	01-17-92	Drilled out cement plug below 24" casing.
01-18-92	01-20-92	Developed injection zone prior to sampling for background water quality.
01-22-92	01-25-92	Ran casing scraper in 24" casing.
01-24-92	01-25-92	Installed liner hanger and packer inside 24" casing.
01-26-92	01-30-92	Set 20" injection tubing inside 24" casing.
01-31-92	--------	Filled annulus between 24 and 20" casings with Baracore A corrosion-inhibiting fluid.
01-31-92	--------	Conducted pressure test on 20" casing.
02-04-92	02-07-92	Pumped fresh water bubble prior to conducting RTS.
02-07-92	--------	Conducted TV Survey of 20" casing and injection zone.
02-13-92	--------	Conducted RTS.
03-31-92	04-04-92	Conducted injection test.

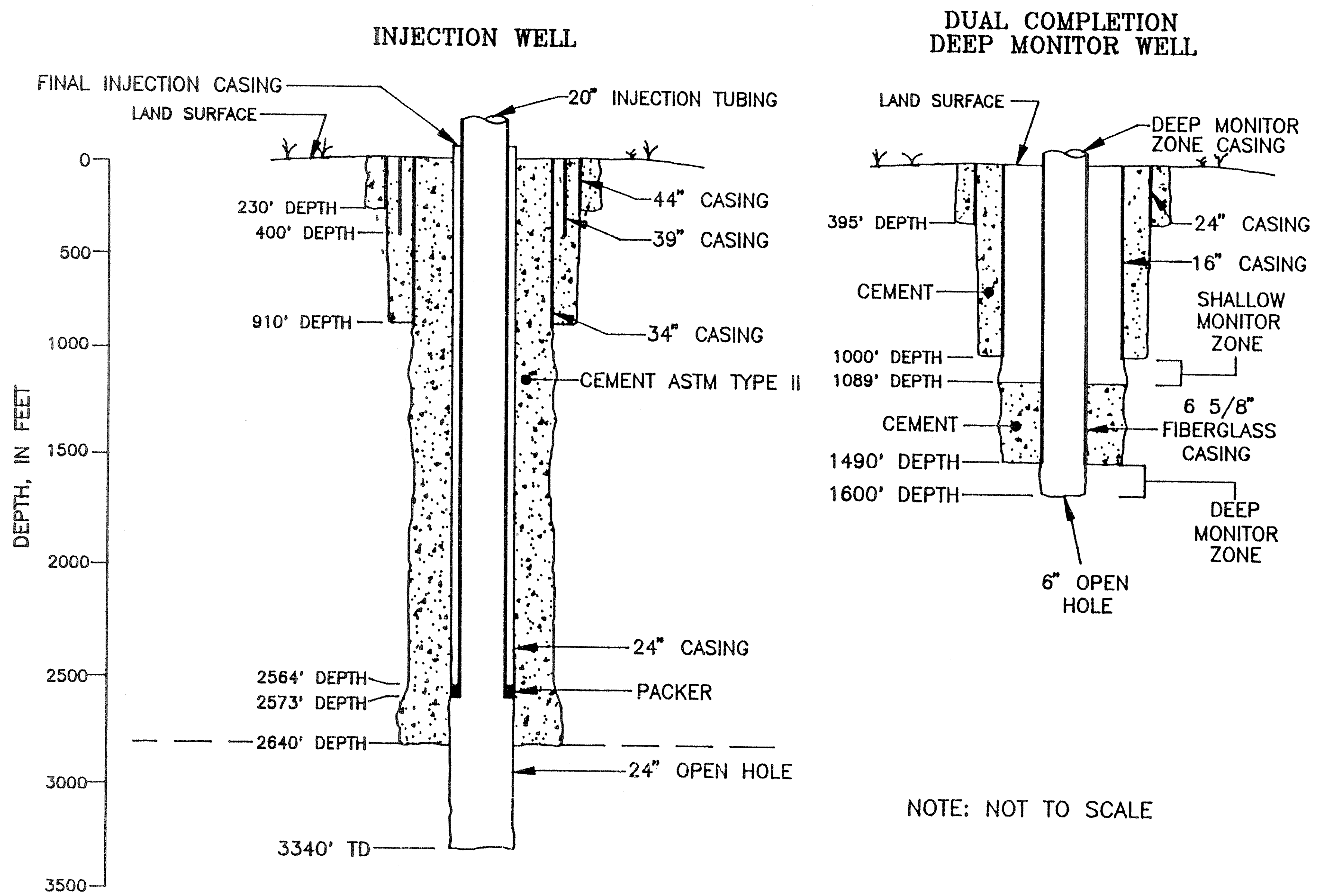

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FIGURE 4. CONSTRUCTION SCHEMATIC OF MARCO ISLAND UTILITIES IW--1 AND DMW-1.

TABLE 4

CASING SUMMARY MARCO ISLAND DMW-1			
Outside Diameter (inches)	**Construction Type**	**Wall Thickness (inches)**	**Total Depth (feet bpl)**
24	spiral weld steel	.375	397
16	spiral weld steel	.375	1000
6⅝	fiberglass	.30	1490

3.2.2 Cementing Program

The cementing program for the deep monitor well was similar to that used for the injection well. Cementing was accomplished in stages, with temperature logs run on each stage. Table 5 presents a summary of the monitor well cement program.

3.2.3 Construction Summary

Initially, a 30-inch steel casing was set to 50 feet for construction stability. In order to isolate the potable water of the surficial aquifer, and to isolate swelling clays and provide stability for deeper drilling, a 24-inch steel casing was set to a depth of 397 feet below pad level and cemented to surface.

A 16-inch casing was then set to 1,000 feet in order to protect the waters above the 10,000 mg/l TDS interface. This casing was also cemented from total depth to land surface.

A 15-inch hole was then drilled to 1,977 feet, and construction was halted while waiting for results from the hydrogeologic testing of IW-1. After conducting hydrogeologic testing on IW-1, the lower monitor zone was selected as the depth between 1,490 and 1,600 feet bpl. This was determined to be the first transmissive zone above the confining units. Consequently, the open hole from 1,600 to 1,977 feet was back-filled with cement.

Originally, a string of 6.5-inch I.D. Burgess brand fiberglass casing was installed to a depth of approximately 1,490 feet. However, during installation, a tremie pipe was cemented into the well and ultimately the casing was damaged during attempts to drill out the tubing and cement. This casing was removed from the well and replaced with 6⅝-inch Fibercast brand (RB-2530) casing, installed to a depth of 1,490 feet. The new casing was cemented from 1,490 feet to 1,089 feet bpl which provided 89 feet (1,000 to 1,089) of open formation to serve as the upper

TABLE 5

CEMENT SUMMARY
MARCO ISLAND DMW-1

Date	Stage Number	Cement Mix	Cubic Feet Pumped	Actual Fillup (Lineal feet)
24-inch casing 07-07-91	1	Haliburton Light Cement (HLC) Neat Cement	1271 460	255 140
16-inch casing 08-07-91	1	HLC with 2% CaCL + ¼ lb Flocele/sack Neat Cement	1170.88 640.32	
08-08-91	2	HLC with 2% CaCL + ¼ lb Flocele/sack	837.20	
08-09-91	3	HLC with 2% CaCL + ¼ lb Flocele/sack	600.00	
08-10-91	4	HLC with 2% CaCL + ¼ lb Flocele/sack	662.40	
08-11-91	5	HLC with 2% CaCL + ¼ lb Flocele/sack	73.6	
6⅝-inch casing 03-22-92	1	HLC with 2% CaCL + ¼ lb Flocele/sack	471	
03-23-92	2	HLC	552	
03-24-92	3	HLC	250	
03-24-92	4	HLC	81	

monitor zone. This zone was selected based on hydrogeologic test results which indicated that this was the first transmissive zone below the USDW.

Each zone of the monitor well was completed with separate access ports to allow collection of representative water samples. Table 6 provides a chronological summary of the construction of DMW-1.

TABLE 6

MARCO ISLAND DMW-1
CHRONOLOGY

START DATE	END DATE	ACTIVITY
6/27/91	7/05/91	Drilled 33" hole from 0 to 395'.
7/06/91	7/08/91	Set and cemented 24" casing to 395'.
7/15/91	--------	Switched from mud to rotary to reverse air drilling method.
7/17/91	8/04/91	Drilled 22" hole from 395 to 1000'.
8/06/91	8/12/91	Set and cemented 16" casing.
8/16/91	--------	Ran cement bond log on 16" casing.
9/13/91	--------	Conducted pressure test of 16-inch casing.
9/16/91	9/25/92	Drilled nominal 15-inch hole from 1,000' to 1,977' BPL.
11/20/91	--------	Conducted TV Survey of 16-inch casing and open hole portion of well.
12/19/91	--------	Cemented hole from 1,977' to 1,600' BPL.
12/21/91	--------	Filled hole with gravel from 1,600' to 1,490' BPL.
1/07/92	1/08/92	Set 6⅝" fiberglass casing from 0 to 1,490' BPL.
1/09/92	--------	Attempted to cement fiberglass casing, seals on joints failed, cement pipe lodged in hole.
1/16/92	1/17/92	Tripped out fiberglass casing.
1/21/92	2/04/92	Milled out cement pipe and a partial joint of fiberglass casing; cleaned hole.
3/21/92	3/25/92	Set and cemented new string of fiberglass casing (Fibercast brand) to 1,490' BPL.
3/26/92	--------	Conducted pressure test on 6⅝" fiberglass casing.
3/27/92	3/28/92	Reamed plug from 1,490 to 1,600'.
3/28/92	3/30/92	Developed both monitor zones, sampled and disinfected.

4.0 Hydrogeological Testing/Data Collection

Throughout construction of both the injection and monitor wells, specific information was collected to determine the hydraulic characteristics and geologic nature of the underlying formations. The data was used for the determination of confining intervals, monitoring zones, and casing seat depths, and to verify the alignment of the boreholes.

4.1 Inclination Surveys

Inclination refers to the degree of deviation of the borehole from vertical. Inclination surveys as described in FAC 17-28 220(3)(a) and as specified in the FDER construction permit, were conducted at 60 foot intervals throughout the construction progress of each well in order to monitor the amount of deviation of the hole while drilling. The maximum allowable inclination is one degree (60 minutes), and the maximum allowable between any two successive surveys is one half of a degree (30 minutes). If a survey indicated the deviation was approaching the allowable limits, measures were taken to remediate the condition.

Each survey was conducted by sending a "sure-shot" deviation survey tool on a wire line inside the drill pipe to a specified depth above the bit. The surveys were recorded on a paper disk which indicates the degree of deviation from vertical. A record of each inclination survey is presented in Table 7.

4.2 Formation Sampling

Formation samples were collected at a minimum of 10 foot intervals, or at formation changes. Five sets of samples were collected, and upon completion of drilling were distributed to Southern States Utilities, Collier County, The Florida Bureau of Geology, the University of Florida and

TABLE 7

MARCO ISLAND IW-1

INCLINATION SURVEY RECORD

DATE	DEPTH BELOW PAD (FEET)	INCLINATION (DEGREES)
5/18/91	120	.66
5/20	180	.11
5/25	141	.166
5/26	260	.33
5/27	318	.50
5/28	379	.25
5/29	440	.50
5/31	480	.50
6/2	625	.33
6/4	686	.78
8/22	743	.15
8/27	837	0
9/7	947	.18
9/7	1005	.08
9/7	1068	0
9/8	1129	0
9/8	1190	0
9/8	1313	.08
9/8	1375	.08
9/9	1436	.16
9/9	1497	.08

TABLE 7 (CONT'D)

MARCO ISLAND IW-1

INCLINATION SURVEYS

DATE	DEPTH BELOW PAD (FEET)	INCLINATION (DEGREES)
9/9/91	1558	.07
9/9	1610	.17
9/9	1655	.16
9/9	1714	.08
9/10	1774	.08
9/10	1864	.20
9/10	1925	.23
9/10	1980	.15
9/10	2040	.15
9/11	2100	.15
9/14	2160	.18
9/15	2220	.18
9/16	2322	.08
9/17	2380	.08
9/18	2446	.08
9/18	2508	.03
9/20	2569	.16
9/22	2660	.16
9/23	2700	.30
9/23	2760	.30
9/24	2820	.10

TABLE 7 (CONT'D)

MARCO ISLAND IW-1

INCLINATION SURVEYS

DATE	DEPTH BELOW PAD (FEET)	INCLINATION (DEGREES)
9/25	2910	.07
9/26	3000	.20
9/27	3090	.35
9/29	3180	.25
10/2	3270	.30

Missimer & Associates. Samples were examined and described in a lithologic log, which is included in Appendix B.

4.3 Formation Fluid Sampling

Formation water samples were collected every 30 feet at each drill rod change during reverse-air drilling. Samples were field analyzed for chloride, conductivity and temperature; results are provided in Appendix D. The results of the field analysis were used to determine the base of the Underground Source of Drinking Water (USDW).

4.4 Coring Program

During drilling of the injection well pilot hole, five geologic cores were recovered at specific depths in anticipation of identifying potential confinement. Coring was accomplished using a 4-inch diameter 10-foot long carbide-tipped core barrel. Cores were taken in order to aid in identifying transmissive and confining zones. Core samples were sent to Core Laboratories of Carollton, Texas for analyses of horizontal and vertical permeability, porosity and comprehensive strength. Vertical permeabilities derived from laboratory analysis ranged from 2×10^{-7} to 1.43×10^{-4} cm/sec. Table 8 presents a summary of the coring program and analyses results. The complete laboratory report is included in Appendix B.

4.5 Geophysical Logs

Throughout the construction of both the injection and monitor wells, geophysical logging was conducted to provide information for construction decisions. Caliper logs were run on each borehole prior to cementing to aid in developing each cement program and identify any areas that may present problems during casing runs. Temperature logs were performed following each stage of cementing to verify the linear fill up of cement and to evaluate the curing temperatures

TABLE 8

CORING PROGRAM SUMMARY
MARCO ISLAND IW-1

Core #	Interval Cored (feet/bpl)	Feet Recovered	Percent Recovered
1	2140-2150	0.00	0
2	2151-2161	1.25	12.5
3	2202-2212	9.50	95.0
4	2294-2304	6.80	68.0
5	2391-2401	3.30	33.0
6	2507-2517	10.00	100
7	2602-2612	8.50	85.0

of the cement. Cement bond logs were run as part of the mechanical integrity testing of each well. A detailed explanation of these logs is given in Section 5.0.

Following completion of the pilot hole drilling and coring, a full set of geophysical logs were conducted in the borehole by Shchumberger, Inc. The geophysical logs were performed to aid in characterizing the hydraulic and geologic properties of the various formations encountered, from land surface to total depth. These logs included: Caliper, Gamma Ray, Temperature, Borehole Compensated (BHC) Sonic, and Dual Induction Electric logs. A summary of all logs conducted on each well is provided in Table 9.

4.6 Straddle Packer Tests

Seven straddles packer tests were performed on the pilot hole between the depths of 1,488 and 2,810 feet bpl. Tests were conducted in order to characterize the hydrogeology and water quality of the formations. This information was used to select monitoring zones for the monitor well, and to evaluate the location and degree of confinement available above the injection zone. A summary of the packer test program, including calculated hydraulic coefficients, is provided in Table 10.

The following is a summary of the procedures used for conducting straddle packer tests:

1. Intervals to be tested were selected based on geologic logs, geophysical logs, and the caliper log.
2. A Baker straddle packer tool was connected to the drill pipe.
3. The tool was lowered to the selected depth interval, and the rubber packers were set, thereby isolating the portion of the formation between the packers from those above and below.

TABLE 9

GEOPHYSICAL LOG SUMMARY - MARCO ISLAND IW-1

Log Run	Date	Depth Interval of Log (ft bpl)	Purpose	Geophysical Logging Contractor
Caliper (54-inch hole)	05/21/91	0-230	To determine diameter of borehole for cement volume calculations	Schlumberger
Temperature Survey (44-inch casing)	05/23/91	0-220	To verify annular fillup of cement around casing	Schlumberger
Caliper (38-inch hole)	08/29/91	400-929	To determine diameter of borehole for cement volume calculations	Schlumberger
Temperature (34-inch casing)	09/02/91 09/06/91	0-884	To verify annular fillup of cement around casing	Southern Resource Exploration
Caliper (pilot hole)	10/02/91	910-3350	To determine diameter of borehole for cement volume calculations	Schlumberger
BHC Sonic/VDL (pilot hole)	10/02/91	910-3321	Indicated porosity and lithology of borehole	Schlumberger
Temperature (pilot hole)	10/02/91	910-3321	To determine temperature of formation fluids	Schlumberger
Dual Induction (pilot hole)	10/02/91	910-3343	Indicated conductivity of formation fluids and lithologic changes	Schlumberger

TABLE 9 (CONT'D)

GEOPHYSICAL LOG SUMMARY - MARCO ISLAND IW-1

Log Run	Date	Depth Interval of Log (ft bpl)	Purpose	Geophysical Logging Contractor
Caliper (34-inch hole)	11/22/91	910-2836	To determine diameter of borehole for cement volume calculations.	Schlumberger
Temperature (24-inch casing)	12/15/91 12/21/91	0-02582	To verify annular fillup of cement around casing	Schlumberger
Cement Bond VDL (24-inch casing)	12/21/92	0-2582	To show the quality of the cement seal around the 24-inch casing	Schlumberger
Temperature (20-inch casing)	02/12/92	0-3330	To determine temperature of the formation fluid	Schlumberger
Radioactive Tracer Survey	02/12/92	0-3330	To confirm mechanical integrity of the injection casing, liner, and cement job	Schlumberger

TABLE 9 (CONT'D)

GEOPHYSICAL LOG SUMMARY - MARCO ISLAND DMW-1

Log Run	Date	Depth Interval of Log (ft bpl)	Purpose	Geophysical Logging Contractor
Caliper (22-inch hole)	08/06/91	0-1010	To determine diameter of borehole for cement volume calculations	Southern Resource Explanation
Gamma Ray (22-inch hole)	08/06/91	0-1010	To determine natural radioactivity and lithologic characteristics	Southern Resource Explanation
Temperature (16-inch casing)	08/08/91-08/13/91	0-1000	To verify annular fillup of cement around 16-inch casing after each cementing stage	Southern Resource Explanation
Cement Bond/VDL (16-inch casing)	08/16/91	0-1000	To show the quality of the cement seal around the 16-inch casing	Schlumberger
Caliper (14¾-inch hole)	11/22/91	1000-1749	To determine diameter of the borehole for cement volume calculations	Schlumberger
Temperature (6-inch casing)	03/23/92-03/25/92	0-1478	To verify annular fillup of cement around 6-inch casing after each cementing stage	Southern Resource Exploration

TABLE 10

STRADDLE PACKER TEST SUMMARY
MARCO ISLAND IW-1

Test Number	Tested Intervals (ft)	Transmissivity gpd/ft	Pumping Time (min)	Pumping Rate (gal/min)
1	2790-2810	*	*	75
2	2551-2571	11	21.5	80
3	2500-2520	14	3.3	100
4	2296-2316	130	25	80
5	2194-2214	40	3.4	100
6	1977-1997	50	251	20
7	1488-1559	6200	201	94

* Data Invalidated

4. The seal of the packers was checked, and a standing valve removed, opening the tool to the drill string.
5. A submersible pump was installed inside the drill pipe, and a 100 psi pressure transducer was installed.
6. Static water level data was collected using a Northwest Instruments data logging instrument, and the pump was started.
7. Water level data was collected while developing the open interval, and water samples were collected and analyzed for temperature, specific conductance, and chlorida concentration. This continued until water quality had stabilized, as indicated by field analysis results.
8. The pump was then stopped, and the zone allowed to recover to static conditions.
9. The zone was then pumped while recording water levels (duration varied).
10. The pump was shut off and recovery data was collected.
11. The packers were deflated, then moved down to the next test interval.
12. Procedure 4-11 were repeated.

5.0 Mechanical Integrity Testing

Throughout the construction of both the injection and monitor wells, hydrogeologic data was collected and analyzed. This data was used as a basis for construction decisions such as casing depths and monitor zones.

Mechanical integrity of IW-1 was evaluated during construction through the following mechanical integrity tests (MIT):

1. Temperature Logs of 24-inch casing, beginning December 15, 1991
2. Cement Bond Log of the 24-inch casing, December 21, 1991
3. Pressure Test of the 24-inch casing, December 30, 1991
4. Pressure Test of annular space between the 24 and 20-inch casing, January 31, 1992
5. Television Survey of 24-inch casing and 20-inch casing and open hole, December 11, 1991, and February 12, 1992, respectively
6. Radioactive Tracer Survey (RTS), February 13, 1992
7. Injection Test, March 31 to April 4, 1992

Mechanical integrity of the dual completion deep monitor well (DMW-1) was evaluated during construction through the following MITs:

1. Temperature logs of 16-inch and 6-inch casings, on August 12, and March 23, respectively
2. Cement Bond Log of 16-inch casing, August 16, 1991
3. Pressure Test of 16-inch casing, August 31, 1991
4. Pressure Test of 6-inch casing, March 26, 1992

5.1 Injection Well No. 1 MIT

5.1.1 Temperature Logs

The first MITs conducted on the injection well were the temperature logs run on the cementing stages of the 24-inch casing, beginning on December 15, 1991. Temperature logs serve to verify presence of cement behind casing and also to verify that the appropriate temperature was reached for the type and amount of cement used. A total of 7 stages were pumped, and a total of 7 corresponding temperature logs were run by Southern Resource Exploration, Inc. Each of these logs confirmed the presence of cement and the appropriate temperature of cement behind the 24-inch casing string. A copy of each log was provided to the TAC with the weekly summary reports.

5.1.2 Cement Bond Log

The cement bond log (CBL) is a geophysical log used to evaluate the quality of the bond between casing and cement grout and between cement and formation. The CBL is an acoustic log which essentially provides a relative measure of the amount of cement behind casing, and the degree of bonding between cement and casing.

The procedure is initiated by lowering the logging tool down hole while transmitting an acoustic signal from a source (transmitter of tool) outward toward the casing walls, then recording the travel time and attenuation of the wave upon it's arrival at the tool's receivers. The sound wave is produced when the transmitter converts an electrical impulse into acoustic energy. After the signal travels through casing and cement back to the receiver, the sound wave is reconverted into electrical energy which is measured at the surface.

Since sound waves travel at different speeds and amplitudes through various materials, i.e., water, casing, cement, formation, it is possible to determine the relative amount of cement behind casing based on the attenuation of the wave. In this way the quality of the cement job can be evaluated. For example, sound waves traveling through un-cemented casing, or "free pipe", have higher amplitudes (lower attenuation) and faster arrival times than do those passing through cemented pipe. If the tool is initially calibrated to a free pipe signal (generally accomplished by leaving the upper 50-100 feet of casing un-cemented), an analysis of the log can be made based on this signal as compared to the signals received downhole. The CBL provides an evaluation of the cement bond through three measurements: travel time, casing signal amplitude, and total energy display.

Travel Time

Travel time is a measure of the time it takes for the signal to travel from the transmitter, through the casing fluid, casing, cement and formation, back to the receiver ("first arrival"). It is generally displayed on the far left of the log, and is primarily an indicator of the centralization of the tool within the casing. Tool centralization is critical to the value of the log, as an improperly centered tool will produce inaccurate responses, rendering the log useless for evaluating cement fill and bond. If the tool is properly centered, the travel time will remain constant, and should record on the log as a straight line with only minor dips at casing collar locations.

Amplitude

The casing signal amplitude is a measurement of the strength of the signal returning to the tool's receiver. As discussed earlier, as a sound wave passes through steel pipe, it loses energy (attenuation) to the pipe and to the material in contact with the pipe. The attenuation rate depends on the percent of bonded cement, the casing diameter, and the pipe thickness. If the pipe is un-cemented (free pipe) and in contact with a liquid such as formation fluid or drilling mud, the amount of energy lost will be relatively small, and the returning amplitude relatively high. If there is cement behind the casing, the cement will absorb a substantial amount of energy, resulting in a relatively low return amplitude. When using a properly centered tool, therefore, the amplitude response is directly related to the amount of cement bonded to the outer casing wall and the quality of the bond.

Total Energy Display

The third portion of the CBL is the total energy display, usually displayed as a variable density waveform log, which is used to qualitatively assess the cement to formation bond and to detect the presence of channels. The VDL also shows the location of casing joints, in the form of a W-shaped "chevron" pattern. In free pipe this pattern is clear, while in well cemented casing, it is just barely discernable, providing another measure of cement fill. The VDL log is produced from the arrivals at the lower (usually five foot) receiver.

Summary and Evaluation of 24-inch casing CBL

On December 21, a Cement Bond Log (CBL) was run by Schlumberger Well Services, Inc., from the bottom of the 24-inch casing (2640') to land surface. The log was witnessed by Vince Mele (FDER), Jim McGrath (M&A), and Suzanne Bernardini (M&A).

The cement bond log run on the 24-inch casing was run using a 25-foot CBL tool with two receivers spaced three feet and five feet from the transmitter. The tool had a minimum amplitude measurement capability of 0.7 millivolts.

As discussed earlier, of primary interest when evaluating a CBL is the transit time log, which is displayed on the far left side of the CBL, as this validates the remainder of the log. The transit times displayed on this log are consistent with values expected for this size casing, and they plot as a straight line for the majority of the log. At a depth of 1,275 feet, the transit time decreases by 20 microseconds, indicating slight tool excentering. This explanation is supported by the VDL, which shows earlier fluid wave arrivals, indicating the tool was leaning more to one side of the hole. Below this point, the log plots as a straight line with the exception of several incidences of cycle skipping at low casing signal amplitude levels. Overall, the log indicates adequate tool centralization, allowing for a valid evaluation of the amplitude curve.

The casing signal amplitude curve is presented in the middle track of the CBL, and is presented in two separate scales: 0 to 50 millivolts (mv) and 0 to 10 mv. Next to it is the variable density log, expressed in microseconds. The amplitude curve and VDL indicate a well bonded casing in most areas, with minor isolated voids or channels. The 100% annular fill amplitude value was taken from the log as 5 MV, which was supported by the logging engineers.

From the top of the cemented portion of the casing (100 feet bpl) to 615 feet, the log shows a good bond and a large annular fill percentage, based on the lack of pipe signal on the VDL, and on the relatively low amplitude values.

From 615 to 715 feet, there appears to be less than 100% annular fill, indicated by the increased amplitudes and the pipe signals on the VDL. Below 715 feet to a depth of 910 feet (with the exception of a small void from 865 to 875) the presence of cement is indicated by low amplitudes and cement signal. From 910 feet to 1,000 feet the log shows somewhat higher amplitudes and some pipe signal on the VDL.

Between 1,000 and 1,250 feet, adequate cement bond and fill is indicated, but with some faint pipe signal and isolated areas of increased amplitude.

Below 1,250 feet to 1,850 feet, the log indicates a very good bond and annular fill, evidenced by low amplitudes, a lack of pipe signal, and cement signal. Within this section there are however isolated areas which appear to be voids in the cement sheath (1,560 to 1,580, 1,600 to 1,615, and 1,790 to 1,800), but these are limited in extent and are bounded above and below by well-bonded areas.

From 1,850 to 1,900 feet bpl another void is present, but below this, to 2,050 feet, the log improves, and shows a moderate annular fill and cement bond. This is interrupted by a section of very good bond and fill from 2,050 to 2,150 feet, evidenced by lack of pipe signal, very low amplitude, and cement signals showing on the VDL. Between 2,150 and 2,350 feet, the log shows moderate to low amplitude values and occasional pipe signals denoting possible isolated voids, but the definite cement signals indicate an adequate annular fill of cement. From 2,350 to 2,400 feet, the amplitudes decrease significantly, with no discernable pipe signals, implying a good bond and cement fill-up.

From 2,450 to TD at 2,460 feet, the log indicates very good bond and annular fill, particularly below 2,500 feet. The lack of pipe signal, in addition to the presence of cement signals on the VDL, demonstrates an excellent cement/pipe bond, and cement/formation bond. Additionally, the extremely low amplitudes indicate 100% annular fill.

To summarize, the cement bond log run on the 24-inch casing strongly indicates a well cemented casing that meets standards set forth in FAC 17-28.

5.1.3 Pressure Tests

Pressure tests are performed on the final casing strings of both the injection and monitor wells in order to reveal the presence of leaks in the casing or tool joint welds. The tests are conducted by filling the casing (which is plugged at the bottom) with water and sealing the well head. A pressure gauge and valve are fitted to the well head, and any air present is bled off and replaced with water. The air is removed from the casing to eliminate the effect of air compression and de-compression, which could mask any pressure drop resulting from a leak.

Summary and Evaluation of Pressure Tests

24-inch casing

A pressure test of the 24-inch injection string was successfully conducted on December 30, and witnessed by Alsay, M&A and FDER representatives. The casing was filled with water to eliminate air compression in the casing column, and a pressure gauge was fitted to the sealed well head in order to measure pressure during the one hour test. The test was conducted in accordance with specific condition #13 of the FDER construction permit, which specifies the casing to be pressure tested at 1.5 times the expected operating pressure, with a tolerance of +/- 5 percent. The casing was pressured up to 190 psi and monitored for one hour, after which time no drop in pressure had occurred. The casing was then de-pressurized in the presence of the FDER and M&A representatives.

20 and 24-inch annulus

Upon completion of installation and seating of the 20-inch injection tubing and packer, the annular space between the tubing and 24-inch casing was pressure tested, at a pressure of 193 psi. This test took place on January 31, 1992, and was witnessed by Vince Mele and Richard Orth (FDER), and Suzanne Bernardini (M&A). Prior to the test, the annular space between the 24-inch casing and 20-inch tubing was filled with fresh water mixed with a corrosion inhibiting agent (Baracore "100"), then sealed and fitted with a pressure gauge. The annulus was pressured to 193 psi, and monitored for one hour. The pressure after one hour had decreased to 190 psi, representing a decrease of 1.55%, well within the +/- 5% tolerance. Both successful pressure tests indicate that the final casings are intact, with no leaks present. Copies of the pressure test data are included in Appendix E.

5.1.4 Television Survey

On December 11, 1991, a television survey was conducted on the 24-inch casing from surface to 2,640 feet bpl, where it is set. The survey showed the 24-inch casing to be intact and free of visible defects.

On February 12, a television survey was conducted on the 20-inch tubing and open hole, from surface to the total depth of the well, at 3340 feet below bpl, in order to record the condition of the final casing and the open-hole portion of the well. On site to witness the TV survey were Vince Mele and Richard Orth (FDER), and Damon Matson (M&A). The TV survey was performed by Schlumberger, Inc., using a black and white video camera. Prior to the survey, the well was flushed with 2.5 million gallons of fresh water to ensure sufficient visibility. The TV survey showed the casing to be in good condition. The open hole portion of the well appeared relatively smooth, with occasional cavities in the dolomite. A copy of each Video Television Surveys is included with this report.

5.1.5 Radioactive Tracer Survey

Summary and Evaluation of RTS

A Radioactive Tracer Survey, or RTS, was conducted on IW-1 on February 12, 1992, by Schlumberger Well Services, and witnessed by Vince Mele and Joe Haberfeld (FDER), and Jim McGrath and Suzanne Bernardini (M&A). A copy of the RTS results is included in Appendix G. The survey was performed under both static and dynamic conditions to evaluate the integrity of the grout seal around the 24-inch casing and the packer seal below the 20-inch injection tubing. The integrity of these seals is critical in ensuring that no upward migration of injected fluid takes place. The test performed on IW-1 resulted in no upward movement of the tracer behind the casing or tubing. Prior to conducting the test, 2.5 million gallons of fresh water were pumped into the well, to provide a vertical potential for the migration the radioactive slug. The procedure for the radioactive tracer survey was as follows:

Note: The correct times corresponding to the procedures described below appear on the RTS log for each file. The "creation date" referred to on the logs is the time each file was created in the logging truck's computer. For specifics on location of detectors and ejectors, refer to the schematic diagram of the RTS tool provided on each log. Also note, the original plan to perform a static, low flow, and high flow test was altered with approval of DER in the field to include instead a static test, a low flow rate test, and then a combination static/low flow test. This substitution was made after it was agreed on that injecting water at a high rate after release of a slug would not give an indication of any tracer movement, but rather would quickly flush away any tracer that may migrate upward.

1. Perform static temperature log from land surface to TD of well and run background gamma ray log.
2. Locate bottom of casing with casing collar locator (CCL).
3. Perform Static Radioactive Tracer Survey

3a. Position tool with top ejector (UEI) one foot below bottom of 24-inch casing (2,651 feet bpl).

3b. Release first slug of tracer (2 millicuries Iodine-131), keeping tool stationary in time-drive while monitoring gamma ray detectors for 60 minutes. No gamma ray activity detected.

3c. Log out of position to 2,450 feet bpl.

3d. Flush with fresh water for 11 minutes at 1,100 gallons per minute (gpm).

3e. Lower tool to 2,710 feet bpl and run gamma ray log up to 2,300 feet bpl, compare with background log. No detection of tracer.

4. Perform Low Flow Rate Dynamic Radioactive Tracer Survey on 24-inch Casing

4a. Position tool one foot above bottom of casing so that UEI is at 2635 feet bpl. and begin injecting fresh water into well at 90 gpm.

4b. Release slug #2 (2 millicuries Iodine-131). Hold tool stationary in time drive monitoring mode for 45 minutes. Detected gamma ray at middle and bottom detectors (GRTE and GRSB). Tracer detected at GRTE within approximately 15 seconds. It is difficult to recognize this on the log due to the scale used for GRTE (0-2000 API units), and the "clipping circuit" which prevents the tool's detector from becoming saturated with exceptionally high gamma ray counts (log moves to the left as if a reduction in gamma ray activity occurred). Tracer was detected at GRSB within approximately 2 minutes.

4c. End time drive monitoring, log up to 2,450 feet, or 200 feet above bottom of casing, and compared with background log. Detected tracer at 2,620 feet (stain from slug #2).

4d. Run tool to 2,710 feet bpl, flush with fresh water for 10 minutes at 1,000 gpm. Raise tool to 20 feet below bottom of casing and log up to 2,300 feet bpl. Compare with background log. Tracer detected at 2,641 feet, attributed to stain from dynamic tracer eject at 2,635 feet.

5. Perform Combination Static/Low Flow Rate Radioactive Tracer Survey

5a. Position lower ejector (EB) at 2,571 feet, or one foot below bottom of packer, eject slug #3, 2 millicuries Iodine-131. Time drive monitor for 65 minutes. Tracer detected at GRTE less than one minute after slug ejected, also detected in GR and GRSB.

5b. Inject fresh water in well at 90 gpm, time drive monitor for 30 minutes. All detectors dropped to background levels within five minutes. Note: Blank interval on log indicates time when ejection started.

5c. Move tool out of position, log up to 2,291 feet bpl. Compare with background log. Gamma ray detected at GRSB at 2,571 feet, where slug was ejected, and showed elevated readings to 2,550 feet, due to tracer material washing off tool as it was raised. Evaluated gamma levels on GRTE to 2435 for this reason.

5d. Flush with fresh water for 5 minutes at 1,100 gpm. Run log down to 2,802 feet eject remainder of tracer (9 millicuries), begin time drive monitoring. Lower tool to TD (3,340), shut off water, log up to 1,500 feet bpl. Compared log with background gamma ray log.

To summarize, the results of the radioactive tracer survey indicate no upward migration of the tracer behind either the 24-inch casing or the 20-inch tubing. Incidences of detection of tracer were due to staining of casing after ejecting tracer material. It should be noted that the times recorded as "creation dates" on the RTS log are correct. "File dates" may not be correct in some cases because a bad film was used initially and the first half of the test had to be re-written to film ("File Date") from the computer at approximately 5:00 pm.

5.1.6 Injection Test

On April 2, 1992, a constant rate injection test was performed on IW-1 in order to evaluate the hydraulic characteristics of the well and injection zone. During an injection test, the system is tested by pumping fluid into the injection zone at a rate equal to or higher than the expected normal operating rate. Data control points are established within the system to monitor the effects of injection on the injection well, monitor well zones and surrounding formations. Typically, these control points will include well head pressure, bottom hole pressure and temperature, and monitor well pressure in both zones. Control points outside the injection system are also monitored in order to determine the nature and extent of variable influences on the system other than injection. Outside control points in for this test included water levels in the adjacent canal and barometric pressure. Data is collected from each of the points during injection and after injection to determine the rate of recovery. Data collected prior to the test establishes background conditions, against which the injection and recovery data is compared.

The Marco Island injection test consisted of 43 hours of background data collection, 24 hours of injection, and 24 hours of recovery. The injection rate for the test was 5.7 million gallons per day, or 4,000 gallons per minute (gpm). The sole water source for the test was the canal adjacent to the site, which contains brackish water with a chloride concentration of approximately 11,500 mg/l and a conductivity of 33,000 micromhos. The injection line, consisting of 24-inch steel pipe was run from the injection well to a barge set in the canal. The barge contained two V12 475 horsepower Detroit Diesel engines, and a Johnston 20 QMC vertical turbine pump. A screen attached to the underside of the barge and surrounding the intake pipe prevented large particles from entering the injection stream.

Data control points were maintained at the canal and both the injection and monitor wells with the use of pressure transducers and pressure gauges. A summary of all data collection points and methods is provided in Table 11. All pressure gauge data was recorded by hand, in addition to flow rate data, back up water level data from the canal, and barometric pressure data.

A totalizing flow meter was used to measure flow rate throughout the test. Upon stabilization (approximately 10 minutes) the flow rate remained constant throughout the remainder of the test.

During the background monitoring period, pressures remained relatively constant, fluctuating slightly at each control points due to temperature (annular pressure) and tidal changes (all other control points). The IW-1 annular pressure was stable, declining only 3.9 psi in 43 hours. Bottom hole temperature and pressure also remained relatively constant, ranging in value from 1177.72 to 1178.09 psi, and 91.8 to 92.2 degrees Fahrenheit. The upper and lower monitoring zones displayed variations in pressure correlating with tidal conditions. This phenomena continued throughout the test, and can be seen on the graph titled Figure 6.

During injection, three principal factors affect the injection pressure or well-head pressure. These principal factors are additive and include: friction loss, density differential, and formation

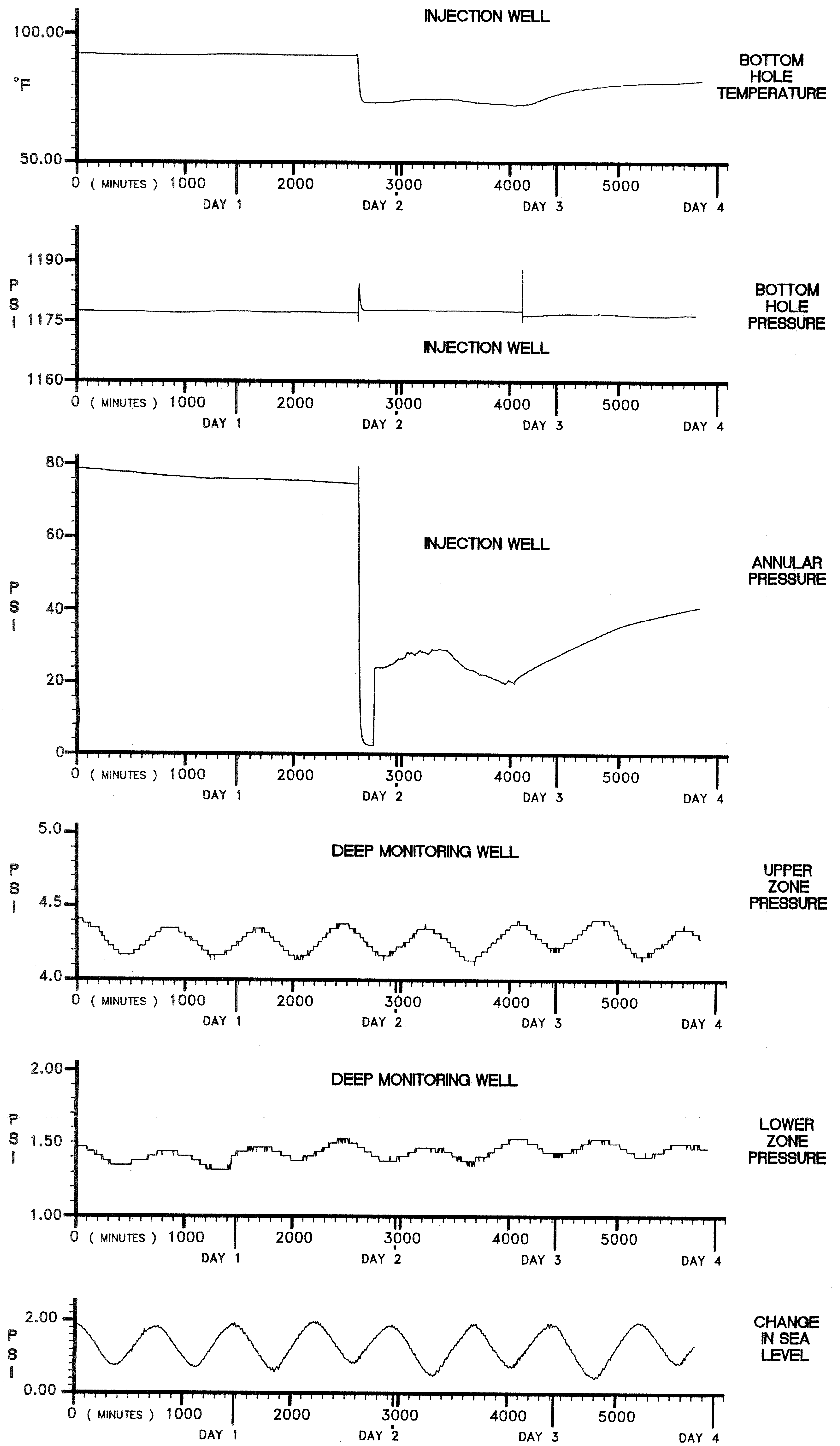
TABLE 11

INJECTION TEST DATA CONTROL POINTS
MARCO ISLAND IW-1

CONTROL POINT	IW-1 Bottom Hole Temperature	IW-1 Bottom Hole Pressure	IW-1 Annulus	MW-1 Upper Zone	MW-1 Lower Zone	Canal	Flow Meter	Barometer	IW-1 Wellhead Injection Line
COLLECTION METHOD	6000 psi Transducer/ Temp. Tool	6000 psi Transducer/	100 psi Transducer	30 psi Transducer	30 psi Transducer	5 psi Transducer	Hand	Hand	300 psi gauge
	-	-	150 psi Gauge	60 psi Gauge	60 psi Gauge	Wetted Tape	-	-	-

pressure. The resistance to flow into the injection zone which is quantified by the transmissivity of the injection zone, affects the injection pressure by increasing pressure proportional to that resistance. Bottom hole pressure was measured during this test to eliminate the other factors, friction loss and density. The bottom hole pressure measured by the transducer, reflects only the resistance to flow due to formation pressure/transmissivity. The well-head pressure readings collected by hand from the pressure gauge on the well-head, includes partial pressures from each of these factors. Since the injection test was conducted with salt water of slightly higher density than the injection zone, and the well contained fresh water prior to injection, injection pressure and well-head pressures are difficult to interpret during the first few minutes of the test while the fresh water was being displaced by the more saline canal water.

Injection of canal water began on April 2 at 0700 hours and continued for 24 hours. At the start of injection, injection pressure, recorded at the well-head, reached 39 psi, and proceeded to drop to 4 psi within 15 minutes. Pressure fluctuated between 4 and 6 psi throughout the test. Monitor zone pressure remained constant, fluctuating only relative to the tide, as explained earlier. The fluid in the annulus responded dramatically to the injection of the canal water, dropping from 75 psi to 5 psi within 50 minutes. This was determined to be due to the temperature difference between the injected fluid and the formation fluid in the injection zone. In this case, the ambient bottom hole temperature was approximately 92 degrees, and the canal water at the time of injection was approximately 73 degrees. To verify that this pressure drop was in fact due to temperature and not to any mechanical failure, the annulus was pressured up to 25 psi and monitored; it dropped only slightly below this point at any time during the remainder of the test. Immediately after the start of injection, bottom hole pressure dropped to 1175 psi, then peaked at 1188.4 psi within 11 minutes. After pressure reached a maximum, it decreased to 1178.8 within 14 minutes, or within 0.8 psi of background pressure. Bottom hole pressure continued to decrease to a low of 1178.15 psi at the end of injection. Figure 6 shows bottom hole pressure and temperature throughout the test.



PREPARED FOR: SSU / MARCO ISLAND UTILITIES

FIGURE TITLE: IW–1 INJECTION TEST DATA

JOB NUMBER: H89–314

DATE DRAWN: 08/21/92

FIGURE NUMBER: 6

The injection portion of the test was terminated on April 3 at 0700 hours, at which time recovery data collection began and continued for 24 hours. Within the first minute after the pump was stopped and the gate valve closed, the injection line pressure dropped to 0. The annular pressure gradually increased over the following 24 hours, as cool injection water was warmed by the ambient formation water. This took a considerable amount of time since a total of 5.7 million gallons had been pumped into the well which had to reach equilibrium with the natural formation water. By the end of recovery, the annular pressure had reached 41 psi, and the bottom hole temperature had reached 83.4 degrees. Immediately after the pump was shut off, the bottom hole pressure fell to 1176.2, increased to 1176.9, then gradually decreased to 1177.5 psi by the end of recovery. No difference in pressure was seen in the monitor well zones other than that caused by tidal fluctuations discussed earlier.

Summary and Evaluation of Injection Test

The results of the injection test indicate the injection zone is capable of receiving a minimum of 4,000 gpm with no appreciable increase in pressure. The minimal pressure build-up indicates that the well is most likely capable of accepting a higher injection rate, and that there will be insignificant upward hydraulic force which would induce flow through the confining units during injection. The lack of response from either monitor zone during injection indicates there is no hydraulic communication between the injection zone and the monitor zones. Records of all data collected during the test are included in Appendix C.

5.2 Mechanical Integrity Testing-Dual Zone Monitor Well

5.2.1 Temperature Logs

Mechanical integrity testing of the Dual Completion Monitor Well began on August 12, during the cementing of the 16 inch steel casing. Following each stage of cement pumped, a temperature log was run in the casing by Southern Resources Exploration, Inc. Each temperature log confirmed the presence of cement behind the casing. Temperature logs were also conducted on the cement stages of the 6-inch fiberglass casing beginning on March 23, 1992.

5.2.2 Cement Bond Logs

Following cementing of the 16-inch casing a cement bond log (CBL) was run on August 16, 1991, in order to evaluate the integrity of the grout seal around the casing. The log was performed by Schlumberger Well Services, Inc., and was witnessed by FDER representative Richard Orth, and M&A representative Damon Matson. The CBL indicated a satisfactory bond between the cement and the steel casing.

With approval by DER, a cement bond log was not conducted on the nominal 6-inch fiberglass casing, as specified in the construction permit . This decision was made after discussion with Schlumberger, Inc. engineers. The logging engineers agreed that a CBL run in a fiberglass casing is useless for the purpose of evaluating the amount of fill or quality of the cement bond. This is due to the excessive attenuation of the acoustic signal by the fiberglass material.

5.2.3 Pressure Tests

A pressure test was conducted on the 16-inch casing on September 13, 1991, at a pressure of 160 psi. The casing held pressure for one hour, with a decrease of 5 psi. This represents a drop of 3.13%, well within the +/- 5% allowable change.

A pressure test was also conducted on the 6-inch fiberglass casing on March 26,1992. The casing was filled with water and pressured to 40 psi, and then monitored for one hour. FDER representative Richard Orth witnessed the test, and Suzanne Bernardini was on site representing

M&A. After one hour, the pressure in the casing had dropped to 38.2 psi, a change in pressure of 4.5%.

5.2.4 Television Survey

A video survey was run on the well on November 20 inside the 16-inch casing and nominal 16-inch open hole to a depth of 1700 feet bpl. This survey was conducted as a substitute for the unsuccessful one attempted on the injection well on October 29th. The video survey showed the 16-inch casing to be in good condition. This survey was terminated at a depth of 1700 feet bpl due to the turbidity of the water. A copy of the video survey will be submitted under a separate cover.

5.3 MIT Summary and Conclusions

To summarize:

- All Cement Bond Logs conducted on both the injection and monitor well casings indicated a sufficient bond between casing and cement.
- All pressure tests performed on both the injection well and monitor well casings passed the FDER permit requirements of a pressure change not in excess of +/- 5%.
- The television survey of the injection well showed no abnormalities or defects in the 20-inch tubing, and showed no obstructions in the open hole portion of the well.
- The Radioactive Tracer Survey performed on the injection well indicated no upward migration of tracer behind either the 24-inch or 20-inch casing.
- The Injection Test showed the injection zone capable of accepting fluid at a rate of 4,000 gpm at 5 psi. The injection test also indicated that the annulus is free of leaks, and that no hydraulic communication exists between the injection zone and either monitor zones.