

APPENDIX 10.8

UNDERGROUND INJECTION CONTROL

Geraghty & Miller, Inc.

BOARD OF COUNTY COMMISSIONERS
PALM BEACH COUNTY
SOLID WASTE AUTHORITY
SITE 7
INJECTION WELL CONSTRUCTION
AND TESTING PROGRAM

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SOLID WASTE AUTHORITY
SITE 7
INJECTION WELL CONSTRUCTION
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INTRODUCTION

Palm Beach County intends to construct a Class I Test/Injection Well System at the Site 7 Resource Recovery Facility. The injection well system will consist of two 8-inch-diameter, Class I wells each having a disposal capacity of 1 mgd. The injection well system will have 100% redundancy. The total disposal capacity required for the system is 1 mgd. Background geologic information, design of the injection well and details of the proposed hydrogeological testing program are presented in this report. The firm of Geraghty & Miller, Inc., will be responsible under a subcontract with the Joint Venture of Barker, Osha & Anderson, Inc., and Hayden-Wegman, Inc., for all aspects of the well design, construction, and testing. The Joint Venture of Barker, Osha & Anderson, Inc., and Hayden-Wegman, Inc., will be responsible for the design of the effluent pumping station, pipeline to the wells, instrumentation, surge protection and effluent reuse aspects of the project. A description of the surge protection features designed into the system will be provided by the Joint Venture. The information in this report is submitted in support of an application for a Class I Test/Injection Well Construction Permit as required by Section 17-28.33 (FAC).

Area of Review and Geologic Setting

In compliance with the requirements of Chapter 17-28, Section 17-28.33, F.A.C., an "area of review" was established for the well site. Information used in the area of review was obtained from public records, available literature, and geologic data contained in Geraghty & Miller, Inc., files. The results of this investigation revealed that: (1) there are no known faults within the area of review; and (2) there are no

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wells or boreholes of any kind known to penetrate the potential confining beds or the injection zone within the area of review.

Wells Within Area of Review

There are 24 wells within a 1 mile radius from the well site (see Figure 1). Of these wells, three are used to produce water from the surficial aquifer for public supply. These wells are owned by the Consolidated Utilities Company. The Consolidated Utilities Company owns a fourth well; however, this well is abandoned. One well is privately owned and is used for domestic purposes. The remaining wells were installed by the Palm Beach County Solid Waste Authority and the United States Geological Survey. These wells are used for research and observation of the surficial aquifer and sediments. A summary of the available data on these wells is included in Appendix A.

HYDROGEOLOGIC SETTING

The geologic formations expected to be encountered beneath the site consist of a thick sequence of carbonate rocks of Eocene age overlain by sediments consisting of sand, shell, clay, and limestone ranging from Recent to Miocene age. Available information indicates that an injection zone exists approximately 3000 feet below land surface in fractured, cavernous dolomitic zones of the lower Eocene. Overlying these permeable dolomitic zones are middle Eocene zones of chalky limestone. These will serve as a confining sequence between the injection zone and the base of waters containing less than 10,000 mg/l of total dissolved solids. A generalized geologic column indicating the various formations underlying the area is presented in Figure 2. A brief description of the underlying strata follows. The Tamiami formation has been included with the Hawthorn formation as they both serve as a confining unit and are very similar lithologically. The Tampa and Suwannee formations have been included with the Ocala Group as they all comprise the upper Floridan aquifer and are also very similar lithologically.

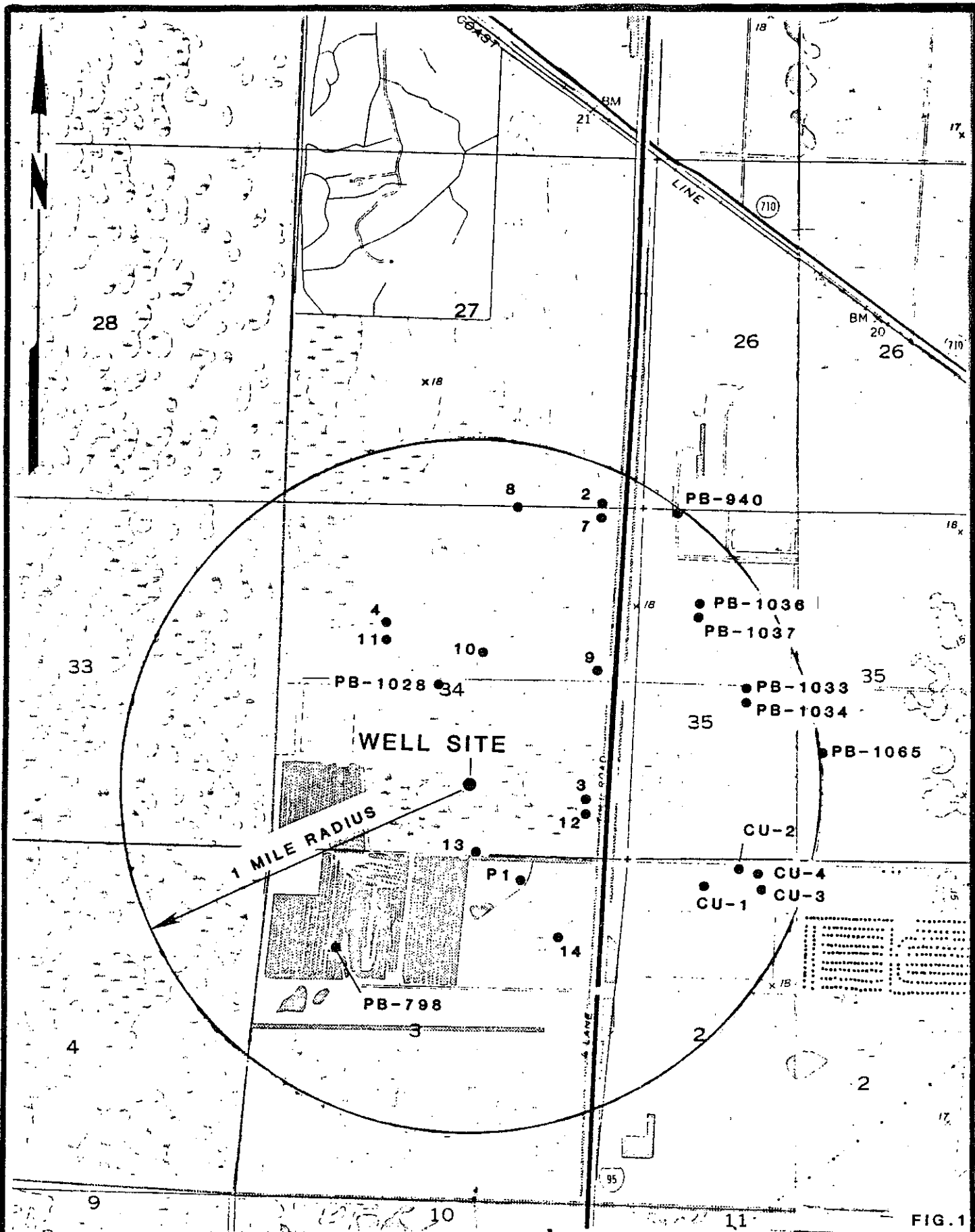


FIG. 1

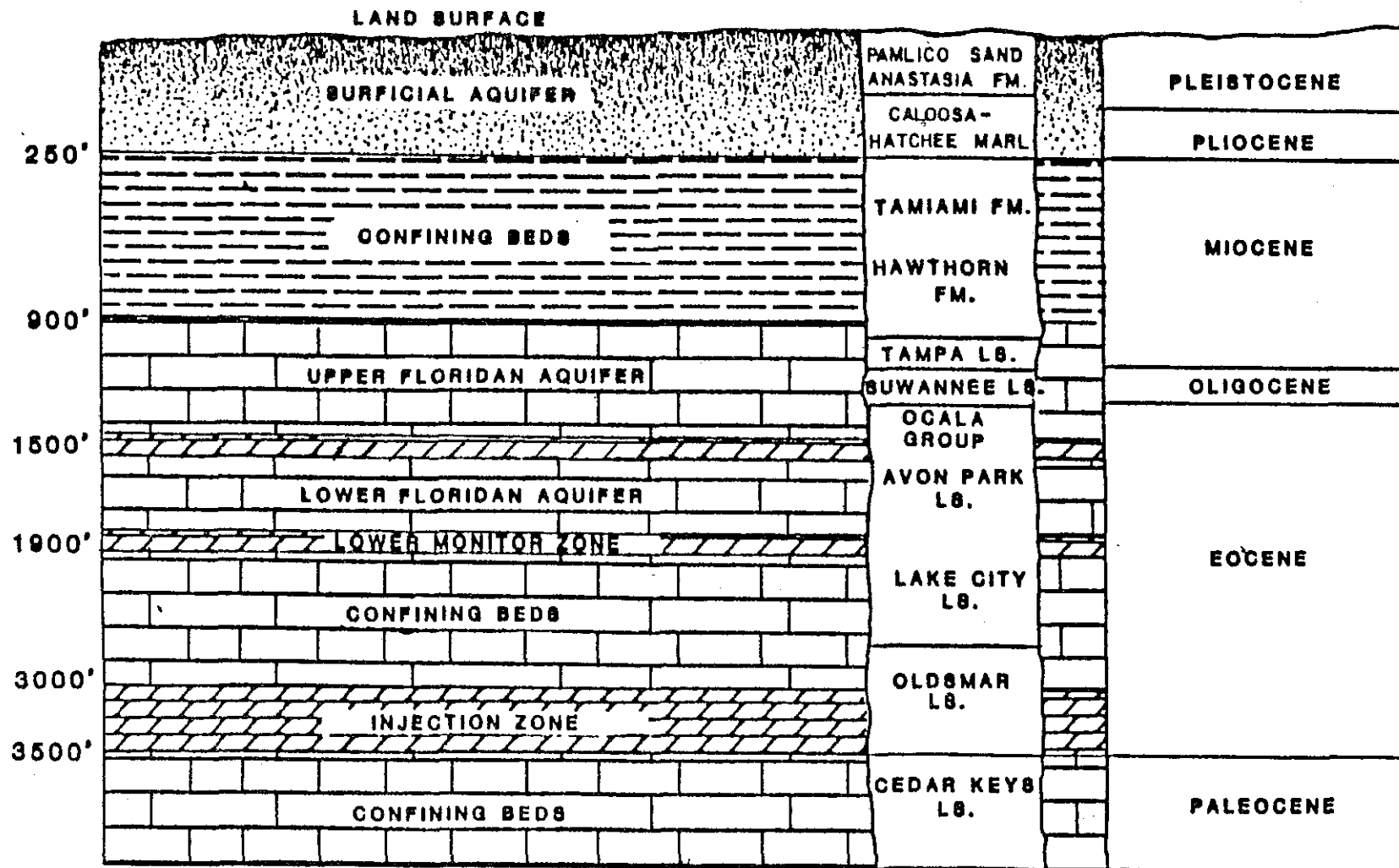
PALM BEACH COUNTY
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RESOURCE RECOVERY FACILITY



TEST INJECTION WELL PROGRAM
SITE LOCATION
AND AREA OF REVIEW
PALM BEACH COUNTY SITE 7



APPROXIMATE DEPTH BELOW LAND SURFACE



LEGEND

- | | | | |
|--|-------------------|--|-----------|
| | SAND, SHELL, SILT | | DOLOMITE |
| | CLAY, SANDY CLAY | | LIMESTONE |

NOT TO SCALE

FIG. 2

Surficial Sediments

The surficial deposits in the Site 7 area consist of unconsolidated to semiconsolidated beds of quartz sand, shells, calcareous clay and limestone. The surficial sediments extend to approximately 250 feet below land surface and range in age from Recent to Pliocene.

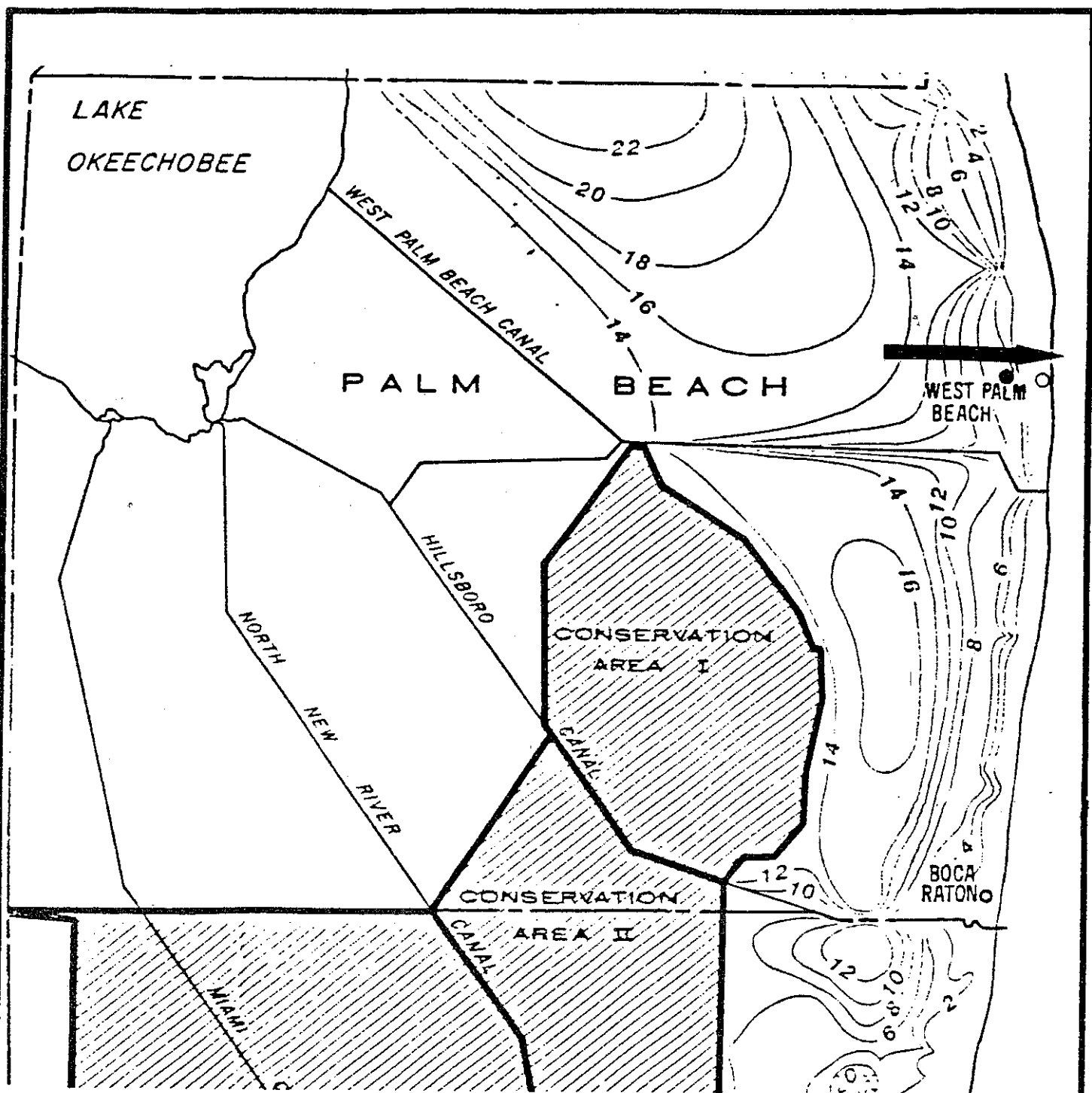
These sediments contain the surficial aquifer. This aquifer is used as a source of fresh water for public supply. The aquifer exists under water-table conditions and yields good quantities of water to wells. The aquifer is underlain by low permeability, late Miocene sediments of the Tamiami Formation. The general direction of ground-water flow in the surficial aquifer in this area is depicted on Figure 3.

Hawthorn Formation

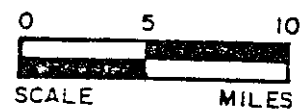
The Hawthorn Formation is of Miocene age and underlies the Tamiami Formation. The Hawthorn Formation is composed of greenish-gray, calcareous clay with varying amounts of quartz sand, phosphate, and limestone. The formation is relatively impermeable except for some limestone zones in the lower section. In general, the Tamiami and Hawthorn Formations have significantly less permeability than the underlying permeable limestone and provide good confinement for the Floridan aquifer. The lower Hawthorn and underlying Tampa Formation are considered part of the Floridan aquifer.

Ocala Group

The Ocala Group is of upper Eocene age and underlies the lower Miocene age Tampa Formation and Oligocene age Suwannee Formation. The Ocala Group consists of very permeable, fossiliferous limestone. The limestone is generally buff colored with loosely cemented fossils. The top of the limestone of the Ocala Group in this area of review occurs at approximately 1000 feet below land surface. The water present in this



SOURCE: USGS WRI OPEN-FILE
REPORT 82-255



GENERAL DIRECTION OF FLOW

● SITE LOCATION

FIG. 3

PALM BEACH COUNTY
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GENERAL DIRECTION OF GROUND-
WATER FLOW IN THE SURFICIAL
AQUIFER PALM BEACH COUNTY
SITE 7

portion of the Floridan aquifer is brackish and is not considered to be potable except with advanced treatment. The general direction of ground-water flow in the Floridan aquifer, in this area, is depicted on Figure 4.

Avon Park Limestone

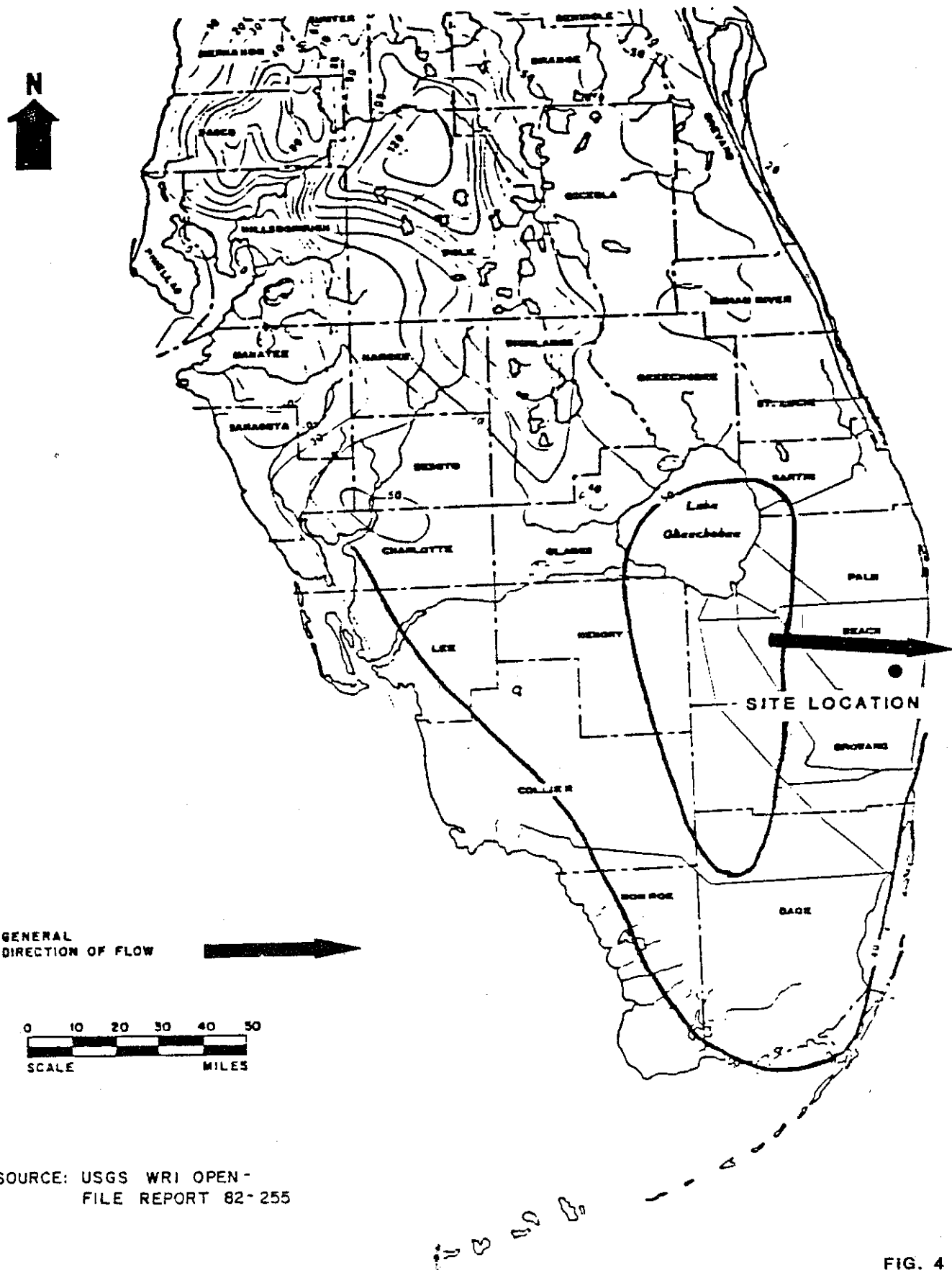
The Avon Park Limestone is of middle Eocene age and underlies the Ocala Group. The formation is expected to be found at approximately 1500 feet below land surface and is estimated to be 400 feet thick. The Avon Park is a fossiliferous limestone and dolomite. The limestone is light brown to buff colored, chalky, dense, with sections being highly fossiliferous. The dolomite is brown to dark brown, crystalline, with fossil remains and molds common. It is anticipated that the base of fresh water (total dissolved solids less than 10,000 mg/l) will be encountered within the Avon Park between 1700 feet and 1900 feet below land surface. The chalky limestones of the Avon Park will comprise part of a confining sequence overlying the injection zone.

Lake City Limestone

The Lake City Limestone is of middle Eocene age and conformably overlies the Oldsmar Limestone. The Lake City Limestone consists of chalky limestone with interbedded layers of dark brown, crystalline dolomite. The top of the Lake City Limestone should occur in this area at approximately 1900 feet and extend to approximately 2700 feet below land surface. Due to the chalky nature of the Lake City Limestone, portions will constitute an effective confining sequence for the injection zone.

Oldsmar Limestone

The Oldsmar Limestone is of lower Eocene age and the top is anticipated to be encountered at approximately 2700 feet below land surface. The Oldsmar Limestone consists of light brown to chalky white, fossiliferous limestone. Interbedded with the limestone is usually a dark brown,



SOURCE: USGS WRI OPEN-
FILE REPORT 82-255

FIG. 4

PALM BEACH COUNTY
SOLID WASTE AUTHORITY
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GENERAL DIRECTION OF GROUND-
WATER FLOW IN THE FLORIDAN
AQUIFER PALM BEACH COUNTY
SITE 7

porous, crystalline dolomite with minor amounts of gypsum and anhydrite. Throughout much of south Florida, the lower part of the Oldsmar Limestone contains cavities ranging from 5 inches to 90 feet in thickness occurring in the dolomite layers. This section is referred to as the "Boulder Zone." Many successful injection wells have been completed in this zone in south Florida and it is the anticipated injection zone for this program.

INJECTION WELL DESIGN

The Site 7 wells are each designed for a disposal capacity of 1 mgd or 694 gpm (gallons per minute). At this injection rate, the average fluid velocity inside the injection casing will be approximately 4.9 ft/sec (feet per second). The injection tubing will be 8-inch-diameter new, threaded and coupled tubing having a wall thickness of 0.352 inches. It will extend from land surface to a depth of approximately 3000 feet below land surface. The bottom of the casing will be set near the bottom of the confining sequence. A retrievable external casing packer will be set near the bottom of the tubing. The annulus outside between the 8-inch-diameter injection tubing and the 12-inch-diameter final casing string will be filled with corrosion inhibited fresh water. The annulus will be placed under pressure and monitored in order to detect leaks. The open hole portion of the well will penetrate the boulder zone over a vertical thickness of about 500 feet. The diameter of the open hole will be a nominal 12 inches.

A 12-inch-diameter final casing string will extend from land surface to about 3000 feet below land surface and will consist of new seamless steel with a 0.500-inch wall thickness. The casing will be cemented in place with ASTM Type II or API Class B sulfate-resistant cement with gel and lost-circulation material as needed.

An intermediate casing will extend from land surface to about 2000 feet below land surface. The intermediate casing will be new steel, having a 0.375-inch wall thickness, and will be 22 inches in diameter. A

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2-3/8-inch-diameter monitor tube will be cemented in the annulus outside the intermediate casing. The monitor tube will extend to approximately 1800 feet below land surface. The bottom 30 feet of the tube will be perforated and gravel packed. Both the casing and monitor tube will be cemented in place with ASTM Type II or API Class B sulfate-resistant cement with gel and lost-circulation material as needed.

A surface casing will extend from land surface to approximately 1000 feet below land surface. The surface casing will be new steel with a 0.375-inch wall thickness, and be 32 inches in diameter. The casing will be cemented in place with ASTM Type II or API Class B sulfate-resistant cement with gel and lost-circulation material as needed.

A conductor casing will extend from land surface to approximately 120 feet below land surface. The conductor casing will be new steel with a 0.375-inch wall thickness, and be 40 inches in diameter. The casing will be cemented in place with ASTM Type II or API Class B sulfate-resistant cement with gel and lost-circulation material as needed.

The monitor tubing will be new, nominal 2-3/8-inch-diameter, 0.190-inch wall thickness. The monitor tubing will be an integral joint such as Hydril A-95 manufactured by Hydril Tubular Products Division. The monitor tubings will be installed in the annulus of the intermediate casings with the bottom 30 feet perforated or slotted. The monitor zones will be approximately 1800 feet below land surface. The monitor zones will be gravel packed with washed silica gravel. The final depths and lengths for the perforated sections will be based on data obtained during drilling and testing of the pilot holes.

The injection well design and details of the coring and testing program are shown in Figure 5.

DRILLING PROGRAM

Site Preparation

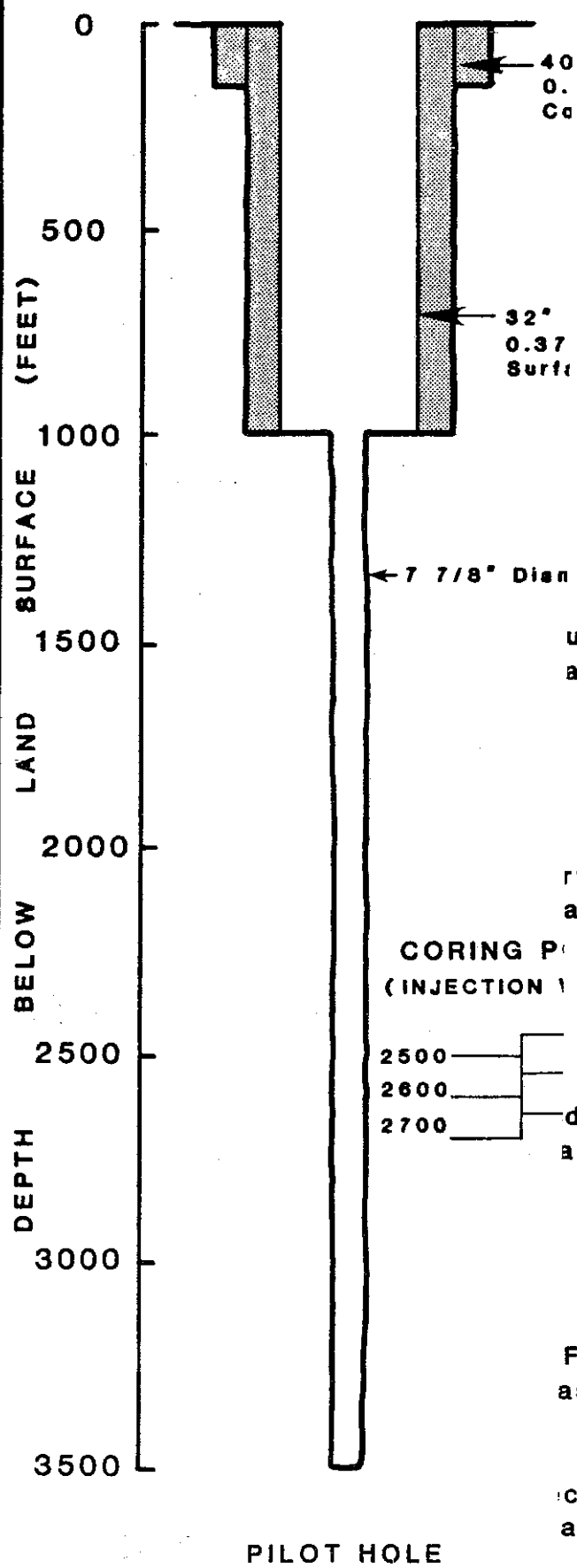
Before drilling begins, site preparation will be completed by the Contractor. Items such as temporary access roads, water lines, and electrical power will be necessary before actual construction can begin. Included as part of the site preparation will be the installation of a pit casing and the construction of a drilling pad. The intent of the pit casing is to prevent the collapse of unconsolidated sediments during the initial drilling operations. The pit casing will be a section of pipe with an inside diameter sufficient to accommodate a 46-inch-diameter drilling bit. The material, length, and method of installation will be at the Contractor's option subject to approval by the Consultant.

Following the installation of the pit casing, a concrete drilling pad will be constructed. The pad site will be cleared, filled, graded, and compacted. Coarse material such as rocks and sticks will be removed. A reinforced concrete pad with curbing will be constructed. The Contractor will be required to maintain the pad in satisfactory condition during construction of the well.

Water-Table Monitoring Wells

Four monitoring wells will be installed around the drilling pad in order to monitor the water quality of the shallow aquifer for increases in chlorides and/or other constituents due to any spills of salty or brackish water during drilling operations. These wells will be two inches in diameter, approximately 10 feet deep, with three feet of well screen. Construction details of the water-table monitoring wells can be found on Figure 6 and their typical locations are shown on Figure 7.

Water samples will be collected from each monitoring well on a weekly basis and analyzed for chloride concentrations. Samples will be

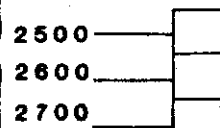


← 7 7/8" Dia Casing Schedule

uctor 40-Inch Diameter,
 asing: 0.375 Inch Wall Pipe
 May Be Spiral Wound,
 ERW, Or DSAW Pipe,
 Welded Joints

CORING P
 (INJECTION)

rface 32- Inch Diameter,
 asing: 0.375 Inch Wall Pipe
 May Be Spiral Wound,
 ERW, Or DSAW Pipe,
 Welded Joints



diate 22- Inch Diameter,
 asing: 0.375 Inch Wall Pipe
 May Be Spiral Wound,
 ERW, Or DSAW Pipe,
 Welded Joints

Final 12- Inch Diameter,
 asing: 0.500 Inch Wall,
 ERW, Welded Joints

ction 8- Inch Diameter,
 asing: 0.352 Inch Wall,
 Threaded And Coupled

INJECTION WELL DESIGN
 AND DETAILS OF THE CORING
 AND TESTING PROGRAM



PALM BEACH COUNTY
 SOLID WASTE AUTHORITY
 RESOURCE RECOVERY FACILITY

FIGURE 5

collected prior to drilling to establish background values. These analyses will be performed by a Geraghty & Miller staff geologist using a field analysis kit. If, during the construction and testing of the test-injection wells, an increase in chloride concentration is observed in a monitoring well that can be attributed to a spill of drilling fluids or saline water, the Contractor will be required to restore the water quality to natural background conditions. This clean-up may be accomplished by pumping out the monitoring wells and properly disposing of the water. Additional wells may be necessary to facilitate an adequate clean-up and will be installed if needed.

Drilling Methods

The conventional mud-rotary drilling method will be employed for the first stage of drilling through the Surficial aquifer and confining unit to the underlying Floridan aquifer. For the remaining drilling, the reverse-circulation rotary drilling method will be employed with drilling mud and/or salt being used as the weight material. In all of the drilling phases, inclination or directional surveys will be performed at approximately 60-foot intervals.

During drilling, all fluids and cuttings will be contained in a closed-circulation system in which the cuttings are removed and the fluid returned to the borehole. The closed-circulation system will consist of leak-proof steel tanks with a minimum capacity for storing 2000 cubic feet (15,000 gallons) of fluid and cuttings. The circulation system also will contain suitable devices such as screens, shale shakers, and settling tanks, for the removal of cuttings from the drilling fluids.

During reverse circulation drilling, the borehole will be open to the Floridan aquifer and will tend to flow. The Contractor will be required to prevent the well from flowing at all times. A blow-out preventer will be kept on site at all times and will be placed on the well when no work is being performed below the Hawthorn Formation.

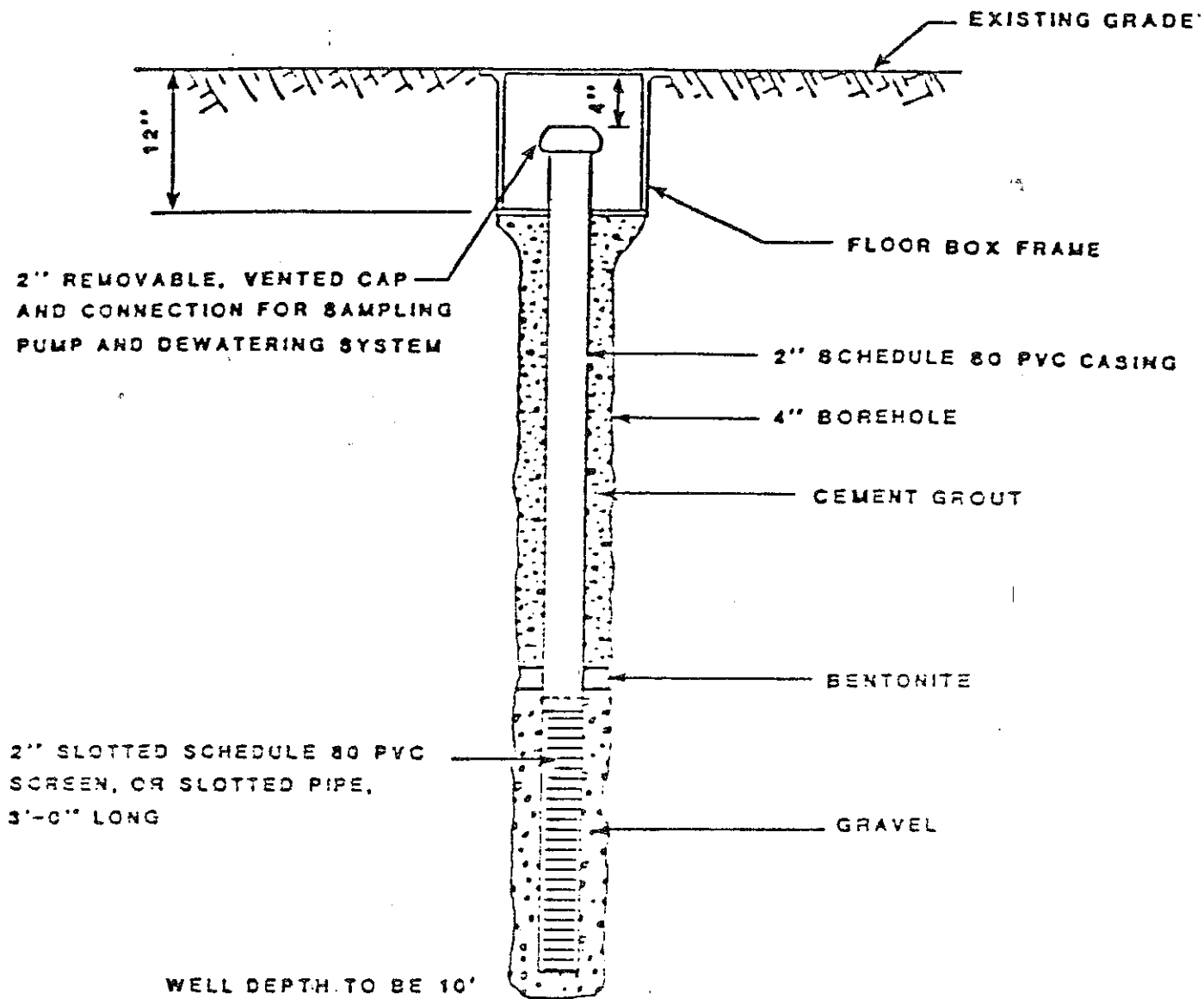


FIG. 6

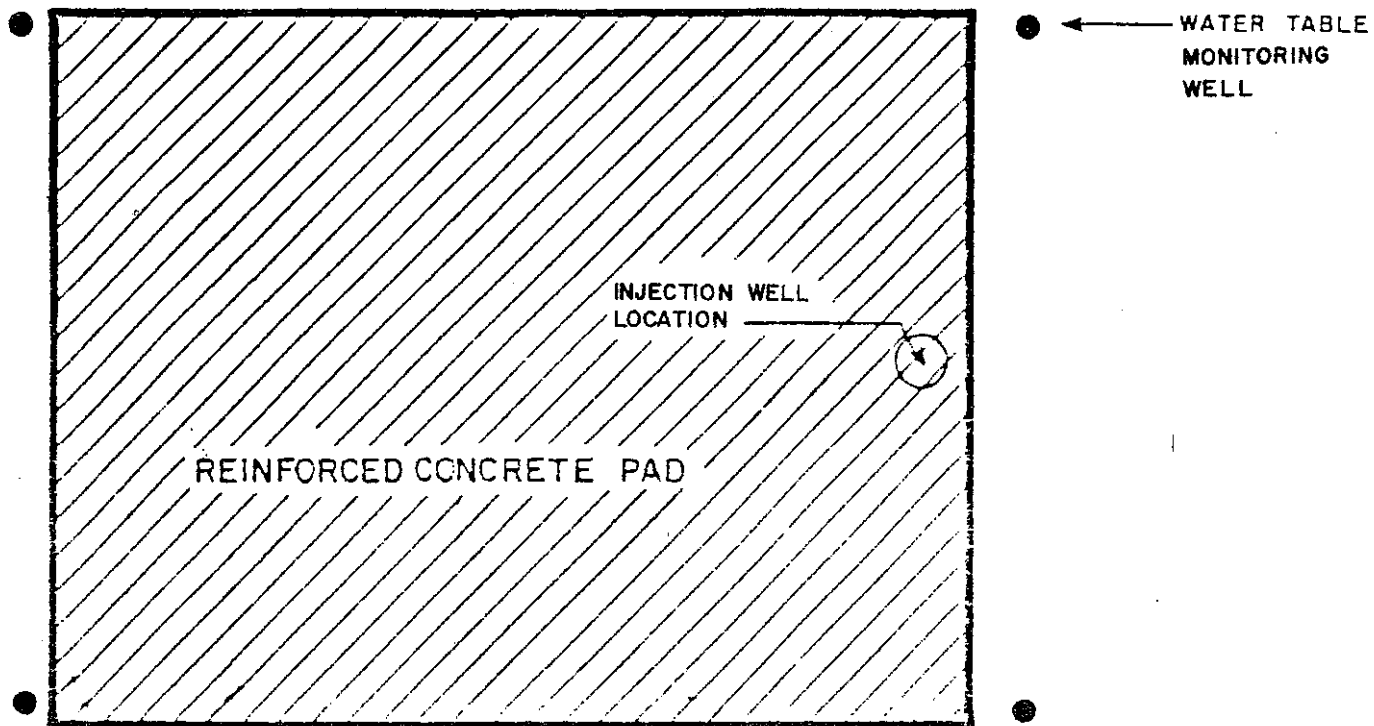


FIG.7

Drill cuttings, excess mud, and drilling fluid will be removed from the drilling site and disposed of at an approved location. The fluid displaced from the borehole during cementing operations will be considered as excess drilling fluid and will be disposed of at an approved location.

During all drilling, formation samples will be collected at ten-foot intervals and at formation changes or drilling breaks. Two complete sets of formation samples will be collected, preserved in well-marked bags, and stored on-site. Upon completion of the program, one complete set of samples will be furnished to the Florida Bureau of Geology. Additional sample sets will be collected, if requested by any interested agency or member of the TAC.

HYDROGEOLOGIC TESTING PROGRAM AND INJECTION WELL CONSTRUCTION OUTLINE

The following is a general outline of the drilling and testing programs for Injection Well 1 and Injection Well 2:

A. Site Preparation and Mobilization

1. Set pit pipe

(a) size and depth-Contractor's option

2. Pad and water-table monitoring well construction

3. Equipment set-up

B. Drilling

1. Drill 46-inch-diameter hole to approximately 120 feet below land surface. Conduct inclination surveys at 60-foot intervals
2. Set and cement in place 40-inch-diameter, 0.375-inch wall thickness steel conductor casing to approximately 120 feet below land surface
3. Drill a nominal 40-inch-diameter hole from 120 feet below land surface to approximately 1000 feet below land surface; conduct inclination surveys every 60 feet and run caliper log upon completion
4. Set and cement in place 32-inch-diameter, 0.375-inch wall thickness steel surface casing to approximately 1000 feet below land surface
5. Drill 7-7/8-inch-diameter pilot hole from bottom of 32-inch-diameter casing to 3500 feet below land surface
 - (a) Formation samples collected every 10 feet and at formation changes or drilling breaks
 - (b) Obtain 8 cores (6 in Injection Well 1 and 2 in Injection Well 2) from the confining sequence overlying the injection zones
 - (1) Proposed coring points (feet below land surface) for Injection Well 1
 - a. 2450
 - b. 2500
 - c. 2550
 - d. 2600
 - e. 2650
 - f. 2700

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(2) Coring points for Injection Well 2 will be based on results of pilot hole testing in Injection Well 1.

(3) Core diameter 4 inches

(4) Core length 10 feet

(c) Conduct inclination surveys every 60 feet

C. Testing

1. Perform geophysical logging in pilot hole

- (a) Electric
- (b) Gamma ray
- (c) Temperature
- (d) Caliper
- (e) Dual Induction
- (f) Borehole-compensated sonic

NOTE: Logs to be performed by a qualified service company as part of the drilling contract

2. Packer Testing

(a) Perform straddle-packer tests (six) in Injection Well 1

(1) Determine water-quality distribution

(2) Determine confining sequence hydraulic properties

NOTE: Depth for straddle-packer tests will be determined from field data (i.e., cores, geologic and geophysical logs).

3. Core Analyses

(a) Perform laboratory tests for:

(1) Permeability (ASTM D2435)

(2) Porosity

(3) Specific gravity (ASTM D854)

(4) Elastic modulus (ASTM D2938)

(5) Compressive strength (ASTM D2938)

(b) Fracturing

(c) Core description

D. Well Completion and Mechanical Integrity Testing

1. Conduct gyroscopic survey of pilot hole
2. Set drillable plug at top of injection zone
3. Ream nominal 32-inch-diameter hole from bottom of 32-inch-diameter casing to approximately 2000 feet below land surface. Conduct combination inclination and directional surveys every 60 feet and run caliper log upon completion
4. Set approximately 2000 feet of 32-inch-diameter, 0.375-inch wall thickness intermediate casing and cement bottom $\pm$ 200 feet

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5. Install monitor tube to approximately 1800 feet and place gravel around the perforated or slotted section
6. Cement in place the 22-inch-diameter casing and monitor tube from the top of the monitor zone gravel pack to land surface
7. Ream nominal 22-inch-diameter hole from approximately 2000 feet to 3000 feet below land surface. Conduct combination inclination and directional surveys every 60 feet and run caliper log upon completion
8. Set and cement in place approximately 3000 feet of 12-inch-diameter, 0.500-inch wall thickness, steel casing
9. Conduct pressure test on 12-inch-diameter casing
10. Conduct cement bond log on 12-inch-diameter casing
11. Drill out cement plug and ream injection zone to approximately 3500 feet below land surface to a nominal 12-inch-diameter hole
12. Install 3000 feet of 8-inch-diameter 0.352-inch wall thickness, threaded and coupled tubing with a retrievable external casing packer set near the bottom
13. Fill annulus between 8-inch-diameter tubing and 12-inch-diameter casing with corrosion inhibited fresh water and pressure test annulus to 1.5 times the expected wellhead operating pressure (The expected wellhead operating pressure is about 62 pounds per square inch)
14. Conduct controlled injection test

15. Perform color television survey of injection well from surface to total depth

Note: The Contractor should keep in mind that this is a test-injection program and that the depths are approximate and that actual depths will be determined based on site-specific data as required in Chapter 17-28 FAC. Also, the Contractor should be aware that the sequence of testing such as coring, straddle-packer tests, geophysical logging, and injection tests described in this outline may be changed in order of occurrence, or deleted, and additional testing may be added.

Borehole Testing

Following completion of the pilot-hole drilling, geophysical logs and straddle-packer tests will be conducted. A color television survey and injection test will be conducted upon completion of the wells. The data obtained from these tests, along with previously obtained data from the drill cuttings and cores, will be used to evaluate the thickness and the effectiveness of the confining sequence and injection zone.

Geophysical Logs

Geophysical well logging includes all techniques in which sensing devices are lowered into a borehole to record some physical parameter that indicates characteristics of the subsurface material or the fluids contained in the subsurface material. The purpose in running geophysical logs on the test-injection wells is to obtain data on the presence and thickness of potential injection zones and confining beds.

The following series of geophysical logs will be conducted on the test-injection wells:

- (1) Electric
- (2) Gamma ray
- (3) Temperature
- (4) Caliper
- (5) Dual-induction
- (6) Borehole-compensated sonic

Logs will be performed by a qualified service company as part of the drilling contract.

Straddle-Packer Tests

The straddle-packer tests will be performed to isolate selected sections of the borehole for testing to determine their hydraulic characteristics and collect water quality data. Inflatable packers will be run into the hole on drill pipe and casing of sufficient diameter to house a submersible pump. After the testing equipment is in place and the packers are seated, a pump-out test will be conducted and drawdown and recovery data collected. During the pump-out test, the conductivity and temperature of the discharged water will be monitored. Just prior to the end of each pump-out test and upon confirmation that conductivity and temperature measurements have stabilized, a representative water sample will be collected for analysis by a qualified laboratory. The exact depths for the tests and packer settings will be determined from previously collected data (drill cuttings, cores, geophysical logs). Provision will be made in the drilling contract for six tests in Injection Well 1 with an allowance for additional tests in the event that field conditions warrant.

Injection Test

Following the completion of the wells, 24-hour injection tests will be conducted on each well. The tests will be conducted at a rate of 700 gpm (gallons per minute). Water will be pumped from one injection well into the other during these tests. The data that will be collected during the tests will consist of injection pressure (well head), injection rate, bottom hole pressure, and temperature and annulus pressure. Water levels and temperatures in the monitor zones will also be measured and recorded.

The bottom hole pressure will be continuously monitored by a pressure gauge and recording system capable of accurately measuring and detecting pressure changes of as little as 0.01 psi such as the Lynes RES-300 system. Twenty-four hours of continuous background data will be obtained before the tests are started and 12 hours of continuous data will be collected upon completion of each test.

Television Survey

Following completion of the injection tests, a color television survey will be performed on the wells from the top of the 8-inch-diameter injection tubing to the bottom of the borehole. A tape of the television survey will be made and copies furnished to the members of the TAC.

Monitor Tubes

The monitor tubing shall be new, unused, 2-3/8-inch-diameter, 4.7 pounds per foot, 0.190-inch wall thickness, and shall conform to API-J-55 standards. The monitor tubing shall be integral joint such as Hydril A-95 as manufactured by Hydril Tubular Products Division.

The monitor tubes shall be installed to depths of approximately 1800 feet below land surface in the annulus between the 32-inch-diameter

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boreholes and the 22-inch-diameter casings. Before installing the monitor tubes, the Contractor shall have the bottom 30 feet perforated or slotted. The Contractor must submit his proposed method and plans for perforating or slotting the tubing to the Consultant for approval. The bottom of the tubes, when installed, must be plugged in a manner acceptable to the Consultant.

In order to insure that representative formation water samples can be collected, the monitor tubes will be developed by pumping until conductivity measurements of the discharged water have stabilized. At a minimum, the tubes will be pumped until 5 times the calculated tube volume have been displaced. Water-quality data from the discharged water will be compared with the water-quality data obtained during the straddle-packer tests in order to confirm that representative samples of the native formation water are being produced. If the monitor tubes are not open to the formation and capable of producing representative formation water samples, the Contractor shall employ such procedures as are necessary to open up the monitor tubes to the formation.

Abandonment

In the event that no suitable confining unit or injection zone is found to exist in Test-Injection Well 1, the well would be abandoned. Geraghty & Miller would make a recommendation as to the number and depths of cement plugs to be used based on analysis of data collected during the drilling and testing and would forward its recommendation to members of the TAC for their comment and approval before proceeding.

It is not anticipated that cement plugs would be set in the permeable zones in the Floridan aquifer. These zones would be filled with crushed limestone gravel to reduce cement losses to the formation. The cement to be used in the plugs would consist of ASTM Type II or API Class B, sulfate-resistant cement grout with gel and lost circulation material as needed.

CLOSING COMMENTS

The techniques employed in the design of the wells and the features of their construction are proven and accepted. The mechanical integrity of the injection wells will be established initially by pressure testing and television survey. During operation, the mechanical integrity of the wells will be continuously evaluated by monitoring the annulus pressure of the injection casings. Provision will be included in the wellhead design to allow for the introduction of logging tools and a television camera while the wells are under pressure. The techniques used initially to evaluate mechanical integrity can be used in the injection well in the future to evaluate their condition. The wells have been designed so that mechanical integrity may be evaluated in accordance with the requirements of 17-28.13 (6). In the event that the injection wells are shown to lack mechanical integrity, a variety of techniques are available to restore them. As an example, squeeze cementing can be used, casing patches can be applied, or sections of the injection casing replaced. These are standard techniques, accepted in the industry, whose reliability has been tested by time.

During the course of the program, Geraghty & Miller will be responsible for keeping the TAC informed of progress. Daily construction/progress reports will be submitted to the TAC on a weekly basis. Additionally, the TAC will be informed of any problems when they occur. As the program progresses, regularly scheduled meetings will be held with the TAC. These meetings will be held after the pilot hole in Test-Injection Well 1 has been completed, logged, and tested; and following the completion of the injection wells and the mechanical integrity testing of the wells. The TAC will be kept advised of the scheduling of coring, logging, testing, and construction operations (casing and cementing) in the event any or all of the committee members wish to observe.

The final report to be prepared by Geraghty & Miller will serve as the supporting document for the operating permit for the wells. It will be a descriptive report interpreting the results of the various geophysical

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logs, core and test data demonstrating the adequacy of the injection zone and confining sequence. The quality of water in the injection and monitor zones also will be included. Copies of all logs, laboratory reports, and test data will be included, along with certifications of mechanical integrity and a plugging and abandonment program. Finally, recommendations will be presented regarding injection well operating procedures.

Respectfully submitted,
GERAGHTY & MILLER, INC.

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March 1985

Geraghty & Miller, Inc.

APPENDIX A

WELL INVENTORY DATA

APPENDIX A

WELLS WITHIN AREA OF REVIEW
PALM BEACH COUNTY
SYSTEM #7

Well Number	Diameter (inches)	Borehole Depth (feet)	Pumpage (gpm)	Owner
Pl	—	—	—	6501 45th Street
2	4	120	—	Palm Beach County
3	4	130	—	Solid Waste Authority
4	4	120	—	" "
7	2	16	—	" "
8	2	16	—	" "
9	2	16	—	" "
10	2	16	—	" "
11	2	16	—	" "
12	2	16	—	" "
13	2	16	—	" "
14	2	16	—	" "
PB-798	—			" "
PB-940	—	65	—	" "
PB-1028	—		—	" "
PB-1033	—	115	—	" "
PB-1034	—	45	—	" "
PB-1036	—	42	—	" "
PB-1037	—	24	—	" "
PB-1065	—	115	—	" "
CU-1	8	120	300	Consolidated
CU-2	8	120	400	Utilities Company
CU-3	—	—	—	" "
CU-4	6	115	225	" "

Geraghty & Miller, Inc.

APPENDIX B
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Geraghty & Miller, Inc.

CLASS 1 INJECTION WELL PROGRAM
TECHNICAL SPECIFICATIONS
PALM BEACH COUNTY SOLID WASTE AUTHORITY
SITE 7

March 1985

Prepared for:
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TECHNICAL SPECIFICATIONS

PART 1 - GENERAL

1.01 SCOPE: The work described in these Specifications and accompanying plans is for the construction and testing of two injection wells for the Palm Beach County Solid Waste Authority at Site 7 west of West Palm Beach, Florida.

The wells shall be drilled into aquifers containing saline water under pressure. The shallow aquifer contains potable water at the well site; it is required that the saltier water from the deep aquifers be handled so that there shall be no spills upon the ground. Requirements will be set forth in these specifications regarding the handling of salty water, drilling fluids, and cuttings. Requirements also are set forth for controlling the flow of the wells during construction and providing a closed, steel-lined circulation system for all drilling operations. Drilling pads will be required and shall be constructed to retain spillage of water from drilling and related operations. Water-table monitor wells will be installed around each pad. Due precautions should be taken to prevent spills; any spillage of fluids shall be returned to the closed-circulation system.

At the completion of drilling, the Contractor shall remove the closed-circulation system and its appurtenances which are not part of the completed well and leave the site in good condition acceptable to the Consultant.

1.02 OUTLINE SPECIFICATIONS OF WELLS:

A. Site Preparation and Mobilization

1. Clearing, access-road construction, and grubbing
2. Set pit pipe

3. Construction of pad and water-table monitor wells (IW-1)

4. Equipment set-up

B. Drilling and Testing (IW-1)

1. Drill nominal 46-inch-diameter hole to approximately 120 feet below land surface; conduct inclination surveys every 60 feet.

2. Set and cement in place 40-inch-diameter, 0.375-inch wall thickness steel casing to approximately 120 feet below land surface.

3. Drill a nominal 40-inch-diameter hole from 120 feet below land surface to approximately 1000 feet below land surface; conduct inclination surveys every 60 feet and run caliper log upon completion.

4. Set and cement in place 32-inch-diameter, 0.375-inch wall thickness steel surface casing to approximately 1000 feet below land surface.

5. Drill 7-7/8-inch-diameter pilot hole from approximately 1000 feet to approximately 3500 feet, collecting cores as directed by the Consultant; conduct inclination surveys every 60 feet.

6. Conduct geophysical logging as directed by the Consultant.

7. Conduct straddle-packer tests as directed by the Consultant.

C. Well Completion (IW-1)

1. Set cement plug in pilot hole at the top of the injection zone approximately 3000 feet below land surface.
2. Conduct gyroscopic survey of pilot hole.
3. Drill nominal 32-inch-diameter hole from approximately 1000 feet to approximately 2000 feet below land surface; conduct directional surveys every 60 feet and run caliper log upon completion.
4. Set and cement in place 22-inch-diameter, 0.375-inch wall thickness steel casing to approximately 2000 feet below land surface with a 2-3/8-inch diameter monitor tube set in the annulus at approximately 1800 feet below land surface.
5. Drill nominal 22-inch-diameter hole from approximately 2000 feet to approximately 3000 feet below land surface; conduct directional surveys every 60 feet and run caliper log upon completion.
6. Set and cement in place 12-inch-diameter, 0.500-inch wall thickness seamless steel casing to approximately 3000 feet below land surface.
7. Conduct pressure test on 12-inch casing.
8. Conduct cement bond log on 12-inch casing.
9. Drill nominal 12-inch-diameter hole from approximately 3000 feet to approximately 3500 feet below land surface and develop the well.

10. Set approximately 3000 feet of 8-inch-diameter, 0.352-inch wall thickness, threaded and coupled injection tubing with a retrievable external casing packer.
11. Fill annulus between the 8-inch-diameter injection tubing and the 12-inch-diameter casing with corrosion inhibited fresh water.
12. Pressurize the annulus to 1.5 times the anticipated wellhead pressure during operation.

D. Pad Preparation (IW-2)

1. Set pit pipe.
2. Construction of pad and water-table monitor wells
3. Equipment set-up

E. Drilling (IW-2)

1. Drill 46-inch-diameter hole to approximately 120 feet below land surface; conduct inclination surveys every 60 feet.
2. Set and cement in place 40-inch-diameter, 0.375-inch wall thickness steel casing to approximately 120 feet below land surface.
3. Drill nominal 40-inch-diameter hole to approximately 1000 feet below land surface; conduct inclination surveys every 60 feet and run caliper log upon completion.
4. Set and cement in place 32-inch-diameter, 0.375-inch wall thickness steel casing to approximately 1000 feet below land surface.

5. Drill 7-7/8-inch diameter pilot hole from approximately 1000 feet to 3500 feet below land surface collecting cores as directed by the Consultant; conduct inclination surveys every 60 feet.
6. Conduct geophysical logging as directed by the Consultant.
7. Conduct straddle-packer tests as directed by the Consultant.
8. Set cement plug at the top of the injection zone approximately 3000 feet below land surface.
9. Conduct gyroscopic survey of the pilot hole.
10. Drill nominal 32-inch-diameter hole to approximately 2000 feet below land surface; conduct directional surveys every 60 feet and run caliper log upon completion.
11. Set and cement in place 22-inch-diameter, 0.375-inch wall thickness steel casing to approximately 2000 feet below land surface with a 2-3/8-inch diameter monitor tube set in the annulus at approximately 1800 feet below land surface.
12. Drill nominal 22-inch-diameter hole from approximately 2000 feet to 3000 feet below land surface; conduct directional surveys every 60 feet and run caliper log upon completion.
13. Set and cement in place 12-inch-diameter, 0.500-inch wall thickness seamless steel casing to approximately 3000 feet below land surface.
14. Conduct cement bond log of the 12-inch casing.
15. Conduct pressure test on the 12-inch casing.

16. Drill nominal 12-inch-diameter hole from approximately 3000 feet to 3500 feet below land surface and develop well.
17. Set approximately 3000 feet of 8-inch-diameter, 0.352-inch wall thickness threaded and coupled injection tubing with a retrievable external casing packer.
18. Fill annulus between the 8-inch-diameter injection tubing and the 12-inch-diameter casing with corrosion inhibited fresh water and pressure test to 1.5 times the anticipated operating wellhead pressure.

NOTE: The two injection wells must be completed before injection testing may be performed.

F. Injection Testing

1. Conduct controlled injection test on Injection Well 1.
2. Conduct controlled injection test on Injection Well 2.
3. Perform color television surveys on completed injection wells from total depth to surface.

NOTE: The Contractor should keep in mind that this is an injection well program and that the depths are approximate. Also, the Contractor should be aware that the sequence of testing such as coring, straddle-packer tests, geophysical logging, and injection tests described in this outline may be changed in order of occurrence, deleted, and additional testing may be added.

1.03 LOCAL GEOLOGIC CONDITIONS: It is anticipated that the boreholes will encounter beds of shells, sand, and clay to a depth of

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approximately 250 feet below land surface. Below this depth, clays, marl and limestone are present. Permeable zones contain brackish water under pressure and flowing conditions will be present. Below approximately 1400 feet, interbedded layers of limestone and dolomite should be found. Below approximately 2000 feet below land surface, cavities may be encountered.

Information regarding subsurface conditions is intended to assist the Contractor in preparing his bid. The Owner or Consultant does not guarantee its accuracy or that it is necessarily indicative of conditions to be encountered in drilling the well. The Contractor shall satisfy himself regarding all local conditions affecting his work by personal investigation and neither the information on local geology, nor that derived from maps or plans nor from the Owner or his agents or employees shall act to relieve the Contractor of any responsibility hereunder or from fulfilling any and all of the terms and requirements of the contract and Specifications.

1.04 SITE PREPARATION: Within the limits of the staging area as shown on the working drawings, the Contractor shall clear and grub trees as directed, stumps, brush, and other objects standing on or protruding from the ground. All roots shall be grubbed and removed to a minimum of 18 inches below the surface of the ground. Holes caused by grubbing operations shall be filled to the level of adjacent ground. All material and debris resulting from clearing and grubbing operations shall be burned or otherwise disposed of in a manner approved by the Consultant. It shall be the responsibility of the Contractor to obtain any permits that are required.

The cost for all site preparation shall be included in the lump sum price for Injection Well 1.

1.05 DRILLING PAD: At the site of the injection wells, the Contractor shall build suitable concrete pads as work floors for his drilling rigs. The pads shall be formed with curbing to contain spills of water and

drilling fluids and a method of returning them to the required closed-circulation system as shown on the Contract Drawings. The Contractor shall submit for approval of the Engineer his pad design. Included on the Plan shall be the overall pad dimensions, curbs, method of drainage, and the amount of steel reinforcement needed to handle the greatest weight of rig and work load anticipated.

1.06 WATER SUPPLY: The responsibility shall be upon the Contractor to provide and maintain, at his own expense, an adequate supply of water for domestic consumption and construction at the construction site. The cost for all water supply shall be included in the lump sum price for the wells.

1.07 ELECTRICITY: All electric current required by the Contractor shall be furnished at his own expense. All temporary lines will be furnished, installed, connected, and maintained by the Contractor at his cost in a workmanlike manner satisfactory to the Owner and Consultant and shall be removed by the Contractor in like manner at his expense at the completion of the work.

1.08 WATER-TABLE MONITOR WELLS: The Contractor shall install four small-diameter monitor wells in the area around each injection well drilling pad. The purpose of these wells will be to monitor the water-table aquifer for increases in chlorides due to spills of salty water during drilling operations and (possibly) to pump out the shallow aquifer to reduce any contaminant level to normal if a spill occurs.

These wells shall be cased with 2-inch-diameter Schedule 80 PVC pipe to a depth of approximately 10 feet, or tapping the water table. The bottom three feet of PVC pipe shall be slotted as shown on contract drawings. The size of the slots shall be compatible with the gravel to be used, and shall be approved by the Consultant before installation.

PVC casings shall be lowered into a predrilled hole and cemented in place, in accordance with the detail shown on the drawings. Each well

casing shall be provided with an access box at the surface as called for on the working drawings.

After completion, each monitor well shall be pumped until the water is clear, and a one-quart sample shall be collected, properly labeled, and transmitted to the Consultant. Cost of the monitor wells for the entire job will be included in the lump sum price for each injection well.

1.09 DAILY LOG: The Contractor shall maintain a detailed daily log of his operations during the drilling of the monitor and injection wells. The log shall give a complete description of all formations encountered, footage and size of hole drilled, depth and sizes of all casings installed in the wells, fluid losses, water-level changes and the depths at which they occurred, cementing operations, and other such pertinent data as may be requested by the Consultant. The daily log shall be maintained on the site and available for inspection by the Consultant at all times.

1.10 RECORD DRAWING: Upon completion of the work, the Contractor shall supply the Consultant with a reproducible record drawing of each well. The drawings shall show hole and casing diameters and depths and other information that may be required by the Consultant and regulatory agencies.

1.11 REMEDIAL WORK: If remedial work proves to be necessary to make a well acceptable and come within the Specifications because of accident, loss of tools, defective material, or for any other cause, the Contractor shall propose a method of correcting the problem, in writing. Suggested methods shall be reviewed and approved by the Consultant before work proceeds. Such work shall be performed at no additional cost to the Owner and it shall not extend the length of the Contract. The Contractor is notified that all specifications shall be met, including hole straightness and setting of casings and monitor tubes to the points designated by the Consultant.

1.12 ABANDONMENT OF WELL BY CONTRACTOR: Any hole in which the Contractor voluntarily stops work, and/or fails to complete in a satisfactory manner, in accordance with the Specifications and approved changes, shall be considered as abandoned by him. If the Owner declares the hole abandoned by the Contractor, then no payment will be made for the abandoned hole. All abandoned holes shall be properly plugged and sealed by the Contractor at his own cost in accordance with state and local regulations. All salvageable material furnished by the Contractor may be removed and remain his property. The Contractor shall submit his plan of action for abandonment and plugging. Casings may be removed only with the permission and approval of the Consultant.

1.13 FIELD OFFICE: The Contractor shall provide a suitable, weatherproof field office for the use of the Consultant and his representatives. It shall be located in a position which in the opinion of the Consultant is adequate for supervision and inspection of the work. The Contractor shall furnish the field office with water, sanitary facilities, lighting, heating, air conditioning, telephone, and janitor service. The cost of this field office and maintenance thereof shall be included in the lump sum price of the wells.

1.14 GUARANTEE: The Contractor guarantees that the work and service to be performed under the Contract and all workmanship, materials, and equipment performed, furnished, used, or installed in the work shall be free from defects and flaws, and shall be performed and furnished in strict accordance with these Specifications and contract documents; that the strength of all parts of all manufactured equipment shall be adequate and as specified; and that performance test requirements of the Contract shall be fulfilled. The Contractor shall repair, correct, or replace all damage to the work resulting from failures covered by the guarantee. The guarantee shall remain in effect for one year from the date of completion.

1.15 STANDBY TIME: The Owner and/or Consultant may order the Contractor to stop his operations so that extra work not included in the

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Specifications such as logs can be run, tests performed, or data collected. The Consultant will advise the Contractor when he proposes to do this and will schedule his request so it causes a minimum of delay. The Contractor will be reimbursed at hourly rates which will be listed in the Bid Proposal Form. All extra work must be approved by the Consultant.

The Contractor shall include the cost of 120 hours of standby time in the lump sum price in each injection well. A credit or charge for more or less hours than the number specified will be taken into account in the unit price schedule of the Agreement.

PART 2 - OPERATING REQUIREMENTS

2.01 GENERAL: It is essential that salty or brackish water produced from any source during the drilling operations is prevented from contaminating the shallow aquifer which contains fresh water. Any water produced during the drilling shall be confined to the circulation system and drilling pad.

The drilling will be accomplished using a circulation system designed and constructed so that under no conditions shall there be an overflow. The Contractor shall be required to take all necessary steps to prevent accidental spillages from occurring. Tanks for the circulation system shall be steel and leakproof. The Contractor shall submit plans for the circulation system to the Consultant for approval. In no case will a system capable of storing less than 2000 cubic feet (15,000 gallons) of fluid and cuttings be considered. Written approval from the Consultant will be required before the Contractor is allowed to proceed.

Flowing conditions in the injection wells shall be kept under control at all times. Drilling mud and/or salt may be used as weight material to keep the drilling fluid at a density necessary to suppress the flow. No salt may be used until a well is cased to approximately 1000 feet below land surface. No naturally-occurring brines such as those produced from

oil wells can be used as drilling fluid or weight material. As flowing conditions are anticipated during the drilling of the injection wells, the Contractor shall furnish and install a suitable blow-out preventer. The type of preventer shall be approved by the Consultant and shall be used during drilling operations below the Hawthorn Formation. When no work is being done on the well, the preventer shall be put in place.

Drill cuttings and drilling fluid shall be removed from the drilling site and disposed of at an approved location. The fluid displaced from the borehole during cementing operations shall be considered excess drilling fluid and shall be properly disposed of; all costs of disposal shall be included.

When all casings are being set and cemented in place, it is the Contractor's responsibility to insure that these operations are conducted in such a manner that the casing collapse and burst strengths are not exceeded and the casings are not caused to fail.

2.02 EQUIPMENT REQUIREMENTS: Equipment in first-class working order shall be provided. The Contractor shall use his own drilling equipment having the minimum capabilities necessary to do the described work. No unnecessary delays or work stoppages will be tolerated because of equipment failure. They will not be considered as a valid reason for extending the length of the contract. The Contractor shall be held responsible and payment may be withheld for damages to the well due to any cause of negligence, faulty operation, or equipment failure.

The Contractor shall provide and operate equipment capable of handling the largest load that will be placed upon the rig during this contract. If conditions develop in the field that prove the rig that has been supplied by the Contractor is incapable of completing the well, the Contractor will be required to provide a larger rig with the necessary capacity.

The drilling rig employed in drilling the injection wells shall use a geograph capable of recording drilling time and weight of the tool string. This information shall be recorded by the Contractor and records or copies furnished to the Consultant.

2.03 DRILLING METHODS: The conventional mud-rotary method will be employed for all drilling of the injection wells through the Hawthorn Formation, approximately 1000 feet below land surface. All drilling below this point shall be done by the reverse circulation rotary method, and there shall be no discharge of drilling fluids and/or formation fluids. During all reaming operations, the Contractor must incorporate the use of a lead bit or stinger and staged drilling assembly to facilitate the tracking of the pilot hole. If, in the opinion of the Contractor, conditions are found that would warrant the use of some other drilling method, he may propose the use of an alternative. Prior to implementing the proposed method, it shall be approved by the Consultant. A closed-circulation system shall be used for the drilling fluids employing suitable devices such as screens, shale shakers, and settling tanks to remove cuttings. There are no means of handling or disposing of drilling fluids on the site.

2.04 CONDITIONS AND HAZARDS: The Contractor should be advised and be aware of difficult drilling conditions and problems he may encounter during the drilling, construction, and testing of the well. Typical examples he may have to cope with include, but are not limited to, lost circulation and cavities in the Floridan aquifer; squeezing zones in the Hawthorn Formation; fractured zones, with attendant caving problems. A priority requirement of these Specifications is the drilling of straight holes and setting all casings and monitor tubes to specified depths. Hole straightness, which will permit casings to be set at specified depths and facilitate achieving a proper cement seal, shall not be sacrificed for drilling speed. These and other pertinent factors shall be taken into consideration by the Contractor in planning and executing the work.

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The goal of the program is the successful completion of the wells described in these Specifications. In the event of any problems or difficulty which may jeopardize the successful completion of a well in accordance with the Specifications and approved changes, it is the Contractor's responsibility to perform work required to successfully remedy any problem and perform such surveys as necessary to demonstrate the problem has been solved and that the well is in compliance with the Specifications. In the event a problem occurs, the Contractor will be notified in writing by the Consultant. The Contractor will submit to the Consultant his plan of action to identify and/or solve the problem and the Consultant will review the plan of action. In the event the problem is considered serious enough to jeopardize successful completion of the well, in accordance with the drawings and Specifications, the Consultant may request technical concurrence from the regulatory and scientific agencies. The Consultant will notify the Contractor that:

- a. Plan of action is acceptable;
- b. Plan of action is acceptable with Consultant's suggested modifications;
- c. Plan of action is not acceptable.

Under (a), the Contractor shall proceed with the plan of action. The Contractor shall bear all costs of surveys associated with detecting the problem, implementing his plan of action, and tests to confirm the plan of action was carried to successful completion and to obtain approval of the Consultant.

Under (b), the Contractor shall resubmit his plan of action with necessary backup and justification of revised plan of action. The Consultant shall notify the Contractor that the revised plan of action is (a) acceptable or (c) not acceptable.

If the plan of action is not acceptable to the Consultant and the Contractor elects to pursue the unacceptable plan of action, then two options exist for the Consultant.

OPTION 1: If the unacceptable plan of action jeopardizes the well construction, completion, or operation in the Consultant's opinion, and the Contractor elects to implement the unacceptable plan of action, the Consultant may declare the well abandoned by the Contractor. A determination shall be made by the Consultant whether to abandon the well or attempt to correct the existing well. The Contractor shall bear all costs of rig time, etc., from original verbal notification and all cost of either abandoning the well or taking steps to complete a successful well.

OPTION 2: If the unacceptable plan of action does not jeopardize the well construction, completion, or operation in the Consultant's opinion, the Contractor may, at his own risk, proceed with his plan of action. The Contractor shall bear all costs associated with his plan of action including testing, remedies, surveys, and programs to solve the problem. When completed, the Contractor shall notify the Consultant that the problem has been solved. The Contractor shall bear all costs of testing, surveys, and work deemed necessary by the Consultant to confirm that the problem has been solved. If the Consultant is satisfied that the problem has been solved by the Contractor, then the Contractor shall proceed with the construction of the well, bearing all costs of the plan of action and the Consultant's program to confirm successful completion.

2.05 STRAIGHT HOLE REQUIREMENTS: Priority requirements of these Specifications is the drilling of straight holes, positive documentable proof that all pilot holes have been wiped out or covered by the reaming operations, and setting the casing to the required depths. The

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Contractor will be required to perform the schedule of surveys as specified in this section. To insure that the casing and tubing can be set to the required depths and properly cemented, all of the holes shall be drilled so that they are straight. Hole straightness, which will allow setting the casing at the required depths and provides room for proper cementing, as well as for setting the monitor tubes, and provides positive documentable assurance that the pilot hole has been wiped out by the reaming operations shall not be sacrificed for drilling speed.

During all drilling in the injection wells, the Contractor shall perform inclination or combination inclination and directional surveys at intervals of 60 feet as the drilling and reaming progresses. Directional surveys shall be performed using a monel collar of sufficient length in the drilling tool assembly to assure that valid survey data are obtained. The Contractor shall provide the Consultant with written verification from the manufacturer of the survey equipment that the instrument will work properly in the Contractor's drilling assembly. These surveys shall be performed using a wire-line instrument equipped with an inclination unit having a range of from 0 to 2 degrees of inclination from the vertical and the survey record shall be capable of being read to the nearest 0.1 degrees.

All holes for the injection wells shall be round, straight, and true to line. No dog-legs or departures from a straight line shall be permitted which will interfere or prevent casing and tubing from being set to their required depths. The maximum allowable inclination from the vertical at any portion of a hole or survey point shall be one (1) degree; the maximum allowable difference between any two successive survey points shall be 0.5 degree (30 minutes). Any deviation greater than one (1) degree or difference greater than 0.5 degree (30 minutes) between two surveys shall be corrected by the Contractor at his own expense.

Should the inclination surveys or the results of the drilling of any of the pilot and/or reamed holes indicate that conditions have been or are

being created that would prevent the casing and tubing from being set to their prescribed depths and properly cemented or prevent the well from being properly and successfully completed, the Contractor shall take steps to straighten the hole or correct the drift or deviation at his own expense so that casing and/or tubing can be installed to the prescribed depths and allow for proper cementing.

Unless he can demonstrate competence in the use of the surveying equipment, the Contractor shall utilize the services of a qualified technician employed by the survey equipment manufacturer to instruct in the performance of the survey and in the maintenance of the equipment. The technician shall remain on the job until the drilling crews are proficient in the use of the equipment, as judged by the Consultant. The equipment shall be kept on the job at all times. The costs for surveys described in this section, including those required to diagnose a problem and demonstrate the effectiveness of any remedial work, or demonstrate that no problem has occurred shall be the responsibility of the Contractor.

The following are the minimum survey requirements:

Injection Wells

1. Nominal 46-inch-diameter hole
 - A. Inclination survey every 60 feet.
2. Nominal 40-inch-diameter hole
 - A. Inclination survey every 60 feet
3. 7-7/8-inch-diameter pilot hole
 - A. Inclination survey every 60 feet

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B. Gyroscopic survey upon completion

4. Nominal 32-inch-diameter hole

A. Combination inclination and directional survey every 60 feet

Gyroscopic surveys shall be performed by a qualified service company specializing in this type of work. The survey shall be performed through the drill pipe with a bit of the same diameter as the hole. The bit shall be set as close as possible to bottom of each hole so the drill string will be centralized. Survey points shall be run over the entire length of the bore hole at intervals of 30 feet between survey points. The gyroscopic survey and combination inclination and directional survey data will be used to determine that the reamed holes are tracking and/or wiping out the pilot holes. If these data indicate that the reamed hole is not tracking and/or wiping out the pilot hole, it shall be the Contractor's responsibility to provide at his own cost positive documentable proof acceptable to the Owner, Consultant and regulatory authorities.

Directional surveys shall be performed during the reaming operations, every 60 feet, using conventional directional survey equipment capable of measuring a range of from 0 to 2 degrees of inclination from the vertical. A monel drill collar (non-magnetic) of suitable length and diameter shall be used.

During the drilling operation, the Contractor shall submit the film record of each inclination survey to the Consultant on the site. The Consultant shall analyze the data and shall attempt to notify the Contractor of the survey results within three hours. Normally, survey results should be available in thirty (30) minutes. In the event other duties delay the Consultant from interpreting the data, the Contractor should have a qualified crew member proficient in the interpretation of the raw data. The Contractor may continue drilling during this

three-hour period. In the event the survey data indicate hole drift or departure in excess of the specified limits, the Contractor shall take the following steps:

1. Run additional surveys to demonstrate that the hole is within the specified limits.
2. If instrument is indicating that the hole is not meeting the specified limits, then the Contractor shall re-ream the hole and repeat the directional survey. This process will be repeated or other actions taken by the Contractor to meet the specified limits.
3. If the Contractor feels that the instrument is in error, it will be his responsibility to obtain a new instrument to confirm the directional survey data. If a new instrument requires more than 24 hours to be shipped to the site, the Contractor may, with the Consultant's approval, continue the drilling operation. However, this does not relieve the Contractor of his responsibility of maintaining the hole within the specified limits. The Contractor shall bear all of the costs of repeated directional surveys, re-reaming the hole, or other steps required to meet hole alignment.

The Contractor shall provide ten copies of all the records of the gyroscopic directional surveys to the Consultant including the printout showing the various depths and inclination data and coordinate position of the hole at each survey point. This information shall be furnished to the Consultant for review prior to permission being granted to set casing in each hole.

The directional surveys shall be performed with equipment supplied by Sperry-Sun, Eastman Whipstock, or approved equal. The Contractor shall furnish copies of the film record of each survey to the Consultant.

2.06 FORMATION SAMPLES: Cutting samples shall be collected at intervals of 10 feet and at every formation change, and shall be preserved in receptacles to be furnished by the Contractor. The sample containers shall be plainly marked with the well identification and shall show the depth below the ground surface from which they were taken.

Upon completion of drilling and upon authorization by the Consultant, the Contractor shall forward the formation samples to the Florida Bureau of Geology in Tallahassee. If sample storage becomes a problem on the site, samples may be forwarded to the Florida Bureau of Geology as work progresses following accepted procedures and with the approval of the Consultant.

2.07 CEMENTING PROCEDURES: Cementing will be completed by an approved company expert in well cementing such as Halliburton Services unless the Contractor can demonstrate that he has the equipment and expertise to perform these operations. Cementing will be accomplished in stages by means of a collarless tremie pipe. After each stage of cementing and before the next stage, the Contractor shall tag the top of the cement with a collarless tremie pipe. The method of cementing applies to all cementing procedures in all casing.

Cementing procedures shall be continuous for each stage after cementing begins. If loss of circulation or no return of cement is encountered, and the problem is not corrected in a reasonable period of time, the Consultant shall be notified immediately of what remedial measures are underway to re-establish the circulation and complete the cementing program according to well design and specifications.

If good bonding between casing, cement, and formation is not obtained, remedial work shall be done to the satisfaction of the Consultant. In addition, the Consultant may require temperature or cement bond logs to substantiate the effectiveness of any remedial grout work done. These operations shall be performed at the Contractor's expense.

When the casings and tubings are being set and cemented in place, it is the Contractor's responsibility to insure that these operations are conducted in such a manner that the casing collapse and burst strengths are not exceeded and the casings are not caused to fail. Cement shall be pumped or placed so that excessive pressures will not result and affect the bond.

2.08 GRAVEL-PACKING PROCEDURES: Gravel shall be emplaced by pumping with a tremie pipe. A sufficient amount to fill the prescribed volumes will be used. The Contractor shall insure that the proper fill-up has been achieved by "tagging" the top of the gravel by a method acceptable to the Consultant.

After the pack has been emplaced, a cap of fine-grained sand, ten (10) feet thick, shall be put on top of the gravel. Its purpose shall be to prevent cement from invading the gravel pack and plugging it.

PART 3 - GEOPHYSICAL LOGGING AND TESTING

3.01 GEOPHYSICAL LOGGING: The Contractor shall employ the services of an approved company to obtain geophysical logs of the injection wells. The Contractor shall prepare and condition each hole to insure it is open and can be logged with a minimum of delay. The following logs shall be run at the stages listed and their cost shall be included. No payment will be made for logs which are unuseable or inaccurate due to poor performance of the logging equipment.

Following the completion of the 7-7/8-inch-diameter pilot hole below the 32-inch casing to approximately 3500 feet below land surface:

- Dual-induction
- Borehole-compensated sonic
- Long and short normal caliper
- Gamma ray
- Temperature

Following the completion of cementing the 12-inch-diameter casings in place:

Cement bond

The Contractor shall furnish 15 field copies of the various logs to the Consultant and shall provide a field evaluation of their quality as well. Twenty copies of the finished logs shall be provided to the Consultant as soon as possible after the logging along with copies of the original films or mylars of the logs.

The Contractor will also perform caliper logs on the reamed holes before the installation of the 22-inch-diameter and 12-inch-diameter casings.

3.02 CORES: Cores shall be taken during the drilling of the 7-7/8-inch-diameter pilot hole in the injection wells. Four-inch-diameter cores, 10 feet long, shall be taken at points designated by the Consultant. A diamond core head and 10-foot barrel are to be as manufactured by the Christensen Diamond Products Company or approved equal. The taking of cores will be observed by technicians from the manufacturer of the coring tool unless the Contractor can demonstrate previous experience.

The cost of six cores is to be included in Injection Well 1 and the cost of two cores is to be included in Injection Well 2. A credit or charge for more or less than the specified number of cores will be taken into account in the unit price schedule of the Agreement.

Coring points are to be determined from information derived during drilling operations and as directed by the Consultant. All cores will be stored in wooden boxes marked with the depth from which they are taken. Tops and bottoms of the cores are to be marked. After collection, boxing, and labeling, each core will be furnished to the Consultant. The Consultant will then select a portion of each core on

which the Contractor will have laboratory analyses conducted to determine the coefficients of permeability and porosity. The Contractor shall submit the name of the laboratory for approval to the Consultant before analyses. The cost of the six cores and six analyses is to be included in the lump sum price for Injection Well 1. The cost of two cores and two analyses is to be included in Injection Well 2.

3.03 TELEVISION SURVEY: Following completion of the final injection tests on the injection wells, the Contractor shall have a color television survey performed on the entire wells from the top of the 8-inch-diameter tubing to the bottom of the hole by a qualified service company using equipment capable of surveying and recording to the required depth. The Contractor may use his own equipment providing it is capable of surveying as required and the Contractor shall furnish proof of the capability of the equipment. The television camera shall be centralized within the borehole. Nine copies of the complete survey shall be provided by the Contractor for distribution.

To insure that the borehole fluid is of sufficient clarity to allow a color television survey to be conducted, the Contractor shall pump into the injection wells a quantity of water not less than two volumes of the entire borehole. It is the Contractor's responsibility to make all arrangements and scheduling for the television surveys.

While pumping in the water and during the television survey, the well may be under artesian pressure and may flow. The Contractor shall be required to provide and use a stripper head assembly and any other equipment necessary to keep any flow under control at all times.

Costs for pumping clear water into the borehole to achieve the desired level of clarity; for the television surveys and tapes (including time spent waiting for the television equipment); and for rig and crew labor for all activities associated with preparing for, performing, and dismantling equipment related to the television surveys shall be included in the lump sum price for each well.

3.04 STRADDLE PACKER TESTS: Upon the completion of the geophysical logs in the 7-7/8-inch-diameter pilot hole to approximately 3500 feet in Injection Well 1, the Contractor shall perform six straddle-packer tests as directed by the Consultant. To perform the straddle-packer tests, the Contractor shall employ the services of an approved company recognized as expert in this form of testing, such as, but not limited to, Lynes or TAM International. The open-hole straddle-packer test shall be conducted such that the hydrologic properties of the formation can be determined and a water sample collected for analysis. The Consultant will select the depth intervals to be tested in conjunction with the service company representative based on evaluation of the geophysical logs and other available data.

The tests shall be performed using two inflatable packers with a section of perforated pipe between them installed in the borehole on drill pipe with the upper 250 feet consisting of casing or drill pipe with a six-inch inside diameter to facilitate the installation of a four-inch-diameter submersible pump which shall be set at an elevation of approximately 250 feet below land surface. The internal surfaces of drill pipe, casings, and other fittings used for the packer tests shall be free of rust, scale, and other material that could be dislodged and interfere with a test. Should a test fail because of the presence of any of these materials in the tools or pipe, the Contractor will not be reimbursed for the test and he will be required to clean the pipe, re-set it and the packer, and re-run the test successfully as part of the contract requirements.

After successfully inflating and setting the packers and before the Contractor conducts a four-hour pumping test and a two-hour recovery test for each straddle-packer test, he shall develop each zone so that it is free of any drilling mud to the satisfaction of the Consultant. It is anticipated that rates of between 20 and 50 gpm will be obtained during the pumping test. The water produced during the pumping test shall be confined to the closed-circulation system. The Contractor will

be responsible for providing all necessary pumps, prime movers, pipelines, meters, and gauges necessary for testing and will provide access for water-level measurements using an M-scope or tape. Just prior to the completion of each pumping test, the Contractor shall collect a water sample from the discharge and have the following analyses performed by a state-certified laboratory approved by the Consultant.

Total Dissolved Solids

Chloride

Conductivity

Sulfate

The service company representative shall provide a preliminary field evaluation of the data as soon as practical after the completion of each test. In addition, he shall prepare a formation evaluation report and submit five copies to the Consultant within seven days after the completion of each test. The report shall contain the basic data from the test and their interpretation. The Contractor shall include the cost for six straddle-packer tests and six sets of water-quality analyses in the lump sum price for Injection Well 1. If more or less tests are performed, a credit or charge will be provided for in the Agreement.

3.05 INJECTION TESTS: After the completion of both injection wells, injection tests shall be run for a 24-hour period on each injection well. Just prior to the completion of the first injection test, the Contractor shall have a water sample collected from the discharge of the pumped well and the following analyses performed by a state-certified laboratory approved by the Consultant.

Water Temperature	Total Phosphorus
pH	Total Nitrogen
Turbidity	Nitrate
Color	Nitrite
Sulfate	Organic Nitrogen
Iron	Ammonia
Total Dissolved Solids	Conductivity
Total Hardness	Calcium
Hydroxide	Magnesium
Hydrogen Sulfide	Carbon Dioxide
Non-carbonate Hardness	Carbonate
Bicarbonate	Potassium
Sodium	Chloride

The Contractor shall be responsible for providing all necessary pumps, prime movers, pipelines, meters and gauges necessary for the testing and should include these in his base price. Each injection test will be performed at a rate of 700 gpm. A pump, capable of discharging the required volumes for the specified durations, will be placed in one well and water pumped into the other well via a pipeline. This test will be repeated by pumping water from the well that was injection tested into the well that was pumped. The Contractor shall provide a layout drawing of his piping for approval by the Consultant.

The test pump and prime mover shall be capable of not less than 24 hours of continuous pumping. If accidental shutdown occurs prior to 24 hours and invalidates the test data in the opinion of the Consultant, the Contractor shall make any necessary repairs and restart the test. No payment will be made for pumping time prior to any accidental shutdown if the test results are invalid.

The Contractor shall furnish and install in the pipeline a flow meter capable of recording instantaneous flow rates and of totalizing flow. The flow meter shall have an accuracy of five percent at the tested rate. The flow meter shall be sufficiently removed from obstructions in

the pipeline, valves, elbows, reductions, to allow the meter to perform within specifications.

To the extent possible, the speed of the pump and motor shall remain constant throughout the tests. The pumping rate shall be controlled and adjustable by means of a valve in the pipeline. The pumping rate shall not be adjusted by changing the speed of the motor or pump, except when absolutely necessary.

During the injection test, bottom-hole pressures and temperatures shall be monitored and recorded. The Contractor shall employ the services of a company specializing in furnishing and operating the equipment used in collecting this information. An approved pressure gauge and recording system capable of accurately measuring and detecting pressure changes of as little as 0.01 psi (pounds per square inch) such as the Lynes RES-300 or Geophysical Research Corp. EPG-520 system will be used. The Contractor shall provide the Consultant with technical data on the pressure-measuring and recording system before the injection tests. The system will be installed in the injection wells at the top of the injection zone at a depth determined by the Consultant.

The pressure-recording system will be operated for a period of 24 hours prior to the start of the injection test (to collect information on natural bottom-hole pressure fluctuations), during the injection test, and for a 12-hour period after the injection test. The Consultant shall be furnished a copy of all of the basic data recorded as part of the injection tests.

The costs for these services shall be included in the lump sum price of each well. For time spent more or less, the Contractor shall be paid or given credit on the basis of an hourly charge to be listed in the Agreement.

3.06 MONITOR TUBES WATER-QUALITY ANALYSIS: After the monitor tubes have been demonstrated to be functioning, they shall be pumped to remove

any fluid that may have been introduced into the monitor zones during construction. Upon concurrence of the Consultant that representative water is being produced from the monitor tubes, the Contractor shall collect a sample from each tube and have the following analyses performed by a State-certified laboratory approved by the Consultant.

Water Temperature	Total Phosphorus
pH	Total Nitrogen
Turbidity	Nitrate
Color	Nitrite
Sulfate	Organic Nitrogen
Iron	Ammonia
Total Dissolved Solids	Conductivity
Total Hardness	Calcium
Hydroxide	Magnesium
Hydrogen Sulfide	Carbon Dioxide
Non-carbonate Hardness	Carbonate
Bicarbonate	Potassium
Sodium	Chloride

The Contractor shall include the cost for the collection and chemical analyses for one sample in the lump sum price of the monitor tube for each well.

3.07 ADDITIONAL TESTING BY OUTSIDE AGENCIES OR SERVICES: The Consultant and/or the Owner may issue written authorization for additional testing and for logging to be performed by outside agencies, the Consultant's staff, or competent testing firms. The Contractor shall be given due notification of the test program and the firm or agency performing the test. The Contractor shall be compensated for standby time during any such well testing or logging.

In the event a tool owned by the outside firm or agency is lost in the well and cannot be retrieved, the Contractor shall be compensated for correcting the situation (if necessary). The Contractor shall be

reimbursed for all costs incurred for rental of extra tools and equipment needed for these measures. The Contractor shall furnish the Owner copies of invoices for all extra tools and equipment used during these operations.

The Contractor shall be responsible for and shall receive no additional compensation for cleaning the well of debris or loose wall material which is dislodged during the test. The condition of the well is the Contractor's responsibility and no compensation shall be made for maintaining a clean hole.

3.08 PRESSURE TESTING: Prior to conducting the cement bond logs, the 12-inch-diameter casing shall be pressure tested. The casing shall be filled with water and placed under approximately 85 pounds per square inch of pressure. No pressure decline is allowed in sixty minutes. If a slight (1- to 2-psi) pressure decline occurs which can be attributed to temperature or density variations, the test shall be repeated under controlled conditions to the satisfaction of the Consultant and the regulatory agencies. If the pressure declines or if there is some other indication of leakage, the Contractor shall take steps to locate the leak and make repairs using methods acceptable to the Consultant. Pressure testing shall be witnessed and certified in writing by the Consultant.

Following the installation of the 8-inch-diameter tubings and packer, the annulus shall be pressure tested following the same procedures as for the 12-inch-diameter casings.

The cost of pressure tests shall be included in the lump sum price of each injection well.

PART 4 - MATERIALS SPECIFICATIONS

4.01 CASING: All well casing and tubing shall be new. The Contractor may propose to the Consultant the use of well casing of a higher grade.

The casing shall have minimum standards in the following specifications. Before casings are installed in the wells, the Contractor shall supply the Consultant with mill certificates.

4.02 CASING AND TUBINGS

4.021 PIT CASING: The Contractor shall install a pit casing with an inside diameter sufficient to accommodate a 46-inch-diameter drilling bit. The material, length, and method of installation shall be at the Contractor's option subject to approval by the Consultant. The cost of the pit casing shall be included in the lump sum price of each well.

4.022 CONDUCTOR CASING: The conductor casing shall be new, unused, steel, random length, 40-inch-diameter, 0.375-inch wall thickness, and shall conform to API 5L Grade B, ASTM A53 Grade B or Spiral Weld A139 Grade B standards. The casing shall be plain end and beveled for welding and shall be joined together by certified welders. The Contractor must provide the Consultant proof of welders' certifications before any welding may be started. The Contractor shall include the cost for 120 feet of conductor casing in each injection well.

4.023 SURFACE CASING: The surface casing shall be new, unused steel, random length, 32-inch-diameter, 0.375-inch wall thickness, and shall conform to either API 5L Grade B, ASTM A53 Grade B or Spiral Weld A139 Grade B standards. The casing shall be plain end and beveled for welding and shall be joined together by certified welders. The Contractor shall include the cost of 1000 feet of surface casing in each injection well.

4.024 INTERMEDIATE CASING: The intermediate casing shall be new, unused steel, random length, 22-inch-diameter, 0.375-inch wall thickness, and shall conform to either API 5L Grade B, ASTM A53 Grade B or Spiral Weld A139 Grade B standards. The casing shall be plain end and beveled for welding and shall be joined together by certified welders. The Contractor shall include the cost of 2000 feet of intermediate casing in each injection well.

4.025 FINAL CASING: The final casing shall be new, unused seamless steel, random length, 12-inch-diameter, 0.500-inch wall thickness, and shall conform to either API 5L Grade B or ASTM A53 Grade B standards. The casing shall be plain end and beveled for welding and shall be joined together by certified welders. The Contractor shall include the cost of 3000 feet of final casing in each injection well.

4.026 INJECTION TUBING: The injection casing shall be new, unused, seamless, random length, 8-inch-diameter, 0.352-inch wall thickness, threaded and coupled and shall conform to either API 5L Grade B or ASTM A53 Grade B standards. The Contractor shall include the cost of 3000 feet of injection casing in the price of each injection well.

4.027 MONITOR TUBING: The monitor tubing shall be new, unused 2-3/8-inch outside diameter. The monitor tubing shall have an integral joint such as Hydril A-95 as manufactured by Hydril Tubular Products Division approved or equal. Before installing the monitor tubings, the Contractor shall have the bottom 30 feet perforated or slotted. The Contractor shall submit his proposed method and plans for perforating or slotting the tubing to the Consultant for approval. The bottom of the tubing, when installed, must be plugged in a manner acceptable to the Consultant.

Following the monitor tube completion and development, a test satisfactory to the Consultant shall be run to see that the monitor tubes are open and the perforated sections are in contact with adjacent formation materials. If the monitor tubes are not open to the

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formation, the Contractor shall employ such procedures as are necessary to open up the monitor tubes. These procedures shall be conducted at no additional cost to the Owner.

The Contractor shall include the cost of 1800 feet of monitor tubing, bottom plug, and 30 feet of perforations or slotting in his lump sum price for each injection well.

The cost of all coatings for the tubing shall be included in the lump sum price of the monitor well.

4.03 CENTRALIZERS: All casing of the injection wells shall be fitted with Halliburton-type centralizers with steel straps at 0, 90, 180, and 270 degrees around the casing at each position. The centralizers shall be located as follows:

1. One at 20 feet above the bottom end of the casing
2. Two at 40-foot intervals above the bottom centralizer
3. One at 20 feet below land surface

All other casings and tubings:

1. One at 20 feet above the bottom end of the casing
2. Three at 40-foot intervals above the bottom centralizer and at approximate intervals of 200 feet thereafter
3. The topmost centralizer to be at a depth of 20 feet below land surface

All centralizers shall be in a precise vertical alignment, one above the other, to allow for the placement of monitor tubes and tremie pipes in the annuli. The cost of all centralizers shall be included in the lump sum price of each well.

4.04 CEMENT: Sulfate-resistant cement shall be used for all cementing of casings and hole plugging. Either ASTM Type II, API Class B, or Florida Class H can be used with additives and lost-circulation materials (Flocele and/or gilsonite) as necessary and approved by the Consultant. Gel may be used in concentrations up to a maximum of 12 percent. Cement emplaced at the bottom 200 feet of the surface and injection casings in the injection wells shall be neat; however, lost-circulation material such as Flocele and gilsonite may be used as needed. At the Contractor's option, the entire conductor casing may be cemented with neat cement. All cement mixtures shall be approved by the Consultant. Mixed cement shall include cement and all additives approved by the Consultant. The Contractor shall include the cost of 22,200 cubic feet of mixed cement in the lump sum price of each injection well.

4.05 PACKER: The 8-inch-diameter injection tubing shall have a retrievable external casing packer mounted as close as possible to the bottom of the casing. The packer shall be capable of sealing the annular space between the 8-inch and 12-inch-diameter injection tubings. The Contractor shall submit specifications for the packer to the Consultant for approval prior to installation. The Contractor shall include the cost of this item in his lump sum price for each injection well.

4.06 GRAVEL-PACKING MATERIALS: The material to be used for gravel packing the annular space around the perforated or slotted section of the monitor tubing shall be clean, washed, and well rounded. The gravel shall have a size gradation of 1/4 to 3/8 inch, and shall be free of sand. The sand placed on top of the gravel shall be finely-crushed limestone. The Contractor shall furnish the Consultant a five-pound

sample of the gravel and the sand materials for examination and approval before installation. The Contractor shall include the cost of 132 cubic feet of gravel and the cost of 44 cubic feet of sand in his lump sum price of the monitor well.

4.07 WELL HEAD COMPLETION: The Contractor shall finish the well heads with flanges, valves, and caps as shown in the working drawings. The Contractor shall include the cost of this item in his lump sum price for each well.