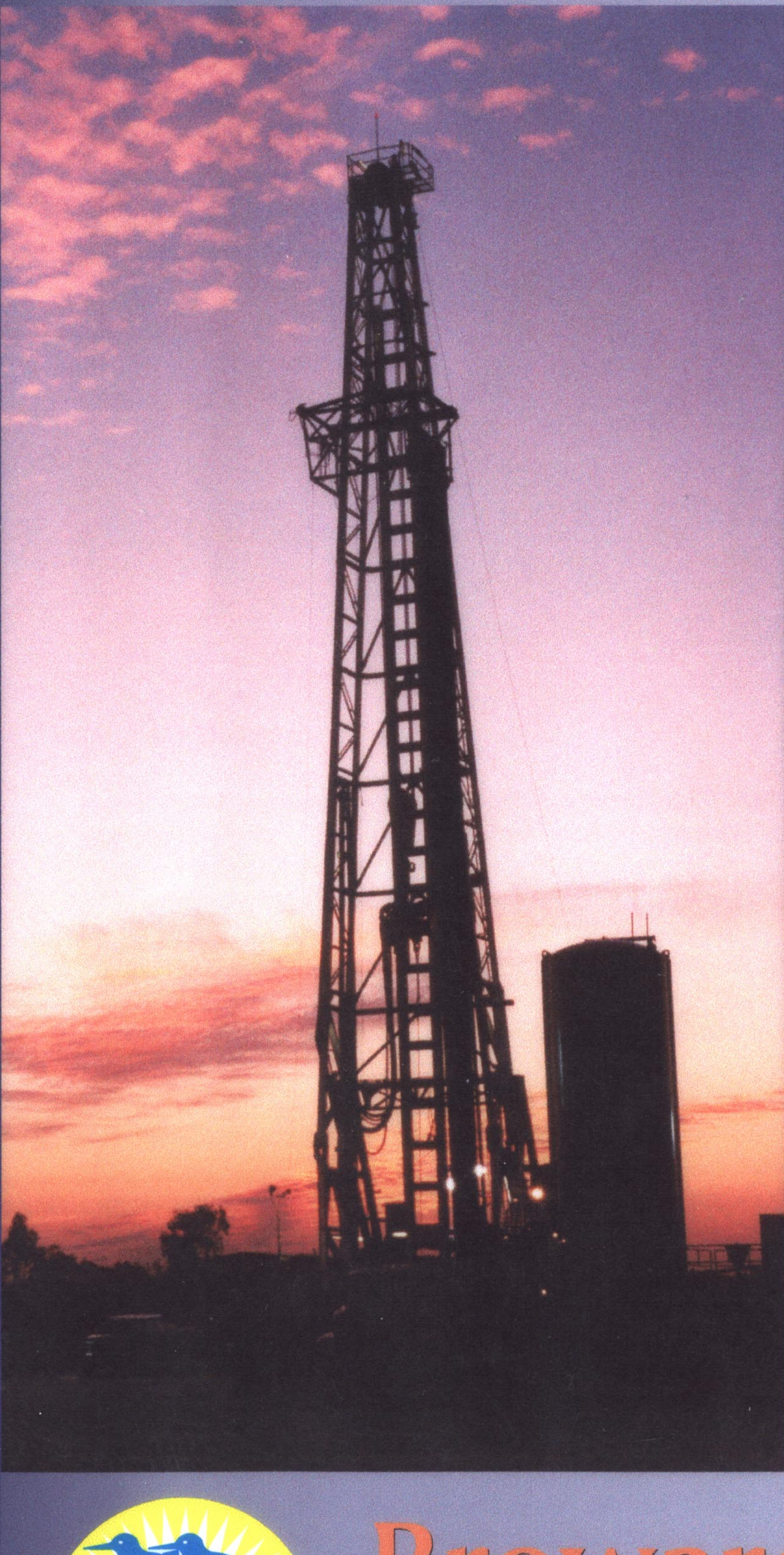
Well Completion Report



Injection Wells 5 and 6 Construction Completion Report North Regional Wastewater Treatment Plant

July 2000

HAZEN AND SAWYER
Environmental Engineers & Scientists

BROWARD COUNTY
FLORIDA

Broward County
Office of Environmental Services

K/cover/4598c-02

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August 2, 2000

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400 North Congress Avenue
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Injection Wells 5 and 6 Completion Report
Broward County North Regional WWTP
BCOES Project No. 8624 BP-A
DEP Permit No. 0051336-005-UC (IW5)
DEP Permit No. 0051336-006-UC (IW6)

Dear Mr. Calas:

In fulfillment of the above-referenced permits and Florida Administrative Code Rule 62-528, Hazen and Sawyer, P.C. (H&S) and Water Technology Associates are pleased to submit the attached Injection Wells 5 and 6 Construction Completion Report on behalf of the Broward County Office of Environmental Services. The wells are located at the North Regional Wastewater Treatment Plant (NRWWTP). The report presents the results of the construction and testing performed during the drilling of Injection Well 5 (IW5) and Injection Well 6 (IW6) and Monitor Well 3 (MW3). The construction of these wells is a continuation of the injection well program which also included the construction and testing of Monitor Well 4 (MW4).

The drilling and testing program of IW5, IW6, MW3 and MW4 provides reasonable assurance of the presence of confinement between 1650 and 2000 feet below pad level (bpl), and a suitable lower monitoring zone above the confinement. The presence of favorable geologic conditions enables the use of injection wells for disposal of treated effluent at the NRWWTP in accordance with existing State and Federal Underground Injection Control regulations.

The well construction and testing have been completed, however, the surface equipment installation is still under construction. Surface equipment is being constructed by another contractor and it is anticipated to be completed within a few weeks. Surface equipment as-built drawings and the operation and maintenance manual will be submitted at that time along with a request to begin operational testing of the wells.

We request that the Department begin review of this completion report to expedite approval of operational testing which will enable the County to use the wells. If there are any questions, please contact either Michael Wengrenovich at (954) 987-0066 or Jim Wheatley at (561) 845-9499.

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In accordance with Rule 62-528.340(4) FAC, we certify under penalty of law that this document and all attachments were prepared under our direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on our inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of our knowledge and belief, true, accurate, and complete. We are aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Very truly yours,

HAZEN AND SAWYER, P.C.

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BROWARD COUNTY
OFFICE OF ENVIRONMENTAL SERVICES

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Injection Wells 5 and 6
Construction Completion Report
North Regional Wastewater Treatment Plant

Broward County
Office of Environmental Services

July 2000

HAZEN AND SAWYER
Environmental Engineers & Scientists

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1.0 Injection Well Program

1.1 Introduction

On February 3, 1999, Broward County was issued Permit Nos. 0051336-005-UC and 0051336-006-UC by the Florida Department of Environmental Protection (FDEP) for the construction of two 24-inch diameter Class I injection wells (IW5 and IW6) and associated dual-zone deep monitor well (MW3). The IW6 permit also includes provisions for monitor well MW4. The wells are located at the North Regional Wastewater Treatment Plant (NRWWTP). Four injection wells IW1, IW2, IW3 and IW4 and two monitor wells were previously constructed at this site. A location map of the project site is presented in Figure 1. A site plan is presented in Figure 2.

The wells were constructed in accordance with Contract Documents prepared by Hazen and Sawyer (H&S) entitled "Broward County North Regional Wastewater Treatment Plant Updating, Construction Package A, Injection Wells 5 and 6", dated March 1997. These plans and specifications for drilling two injection wells and two dual zone monitor wells, and for modifying two existing monitor wells formed the basis of a contract between the Broward County Office of Environmental Services (BCOES) and Youngquist Brothers, Inc. (referred to hereinafter as "the Contractor"). The wells were constructed in several phases as highlighted below. The Contractor was issued a Notice to Proceed for the construction of MW4 on July 14, 1997. Previous reports submitted to FDEP in conjunction with the MW1, MW2 and MW4 work are noted below. Information presented these reports is consistent with the findings and conclusions of this report.

1. Partial drilling and testing of MW4 to identify confinement was presented in "Monitor Well 4 Interim Construction Report", by H&S, dated October 1997,

2. Additional confinement analysis was presented in "Confinement Analysis, Injection Well System, Broward County North Regional Wastewater Treatment Plant, Pompano Beach, Florida" by Missimer International, Inc., dated March 1998,

3. The relocation of MW1 and MW2 lower monitor zones was presented the "MW1 and MW2 Perforation Completion Report", by H&S, dated January 1998,

4. Completion of the MW4 well was documented in "Monitor Well 4 Construction Completion Report", by H&S, dated August 1999.

Above items 1, 2 and 3 were completed and submitted to FDEP for approval. The submittal of items 1, 2 and 3 fully resolved issues associated with the freshening trend of the original lower monitoring zones of MW1 and MW2. Upon review of the submitted information, FDEP issued the permits for the construction of IW5, IW6, MW3.

The MW4 program identified satisfactory confinement between the base of the USDW and 2000 feet bpl. Accordingly, the drilling program of IW5 and IW6 focused on the collection of additional data within that horizon. A copy of the IW5 and IW6 construction permits are included in Appendix A.

For reference, a copy of the construction permit for MW4 (FDEP number UC 06-292757) is also included in Appendix A.

H&S was retained by Broward County to provide construction management services for the project. H&S utilized the services of Water Technologies Associates, Inc. (WTA), to provide partial field observation and certain hydrogeologic services. The H&S and WTA team is hereinafter referred to as "the Engineer". The Engineer provided on-site supervision during all testing, geophysical logging, casing installation and cementing operations. Construction phase responsibilities of the Engineer included obtaining approval from the FDEP on key elements of the project and reporting project progress weekly to the Technical Advisory Committee (TAC) which included members from the FDEP, the Broward County Department of Planning and Environmental Protection (BCDPEP), the South Florida Water Management District (SFWMD) and the United States Geological Society (USGS). The United States Environmental Projection Agency (EPA) is copied on TAC correspondence, but is not a member of the TAC.

On February 8, 1999, the Contractor remobilized manpower and equipment to the site to complete the project including the construction of IW5 and IW6. The final testing was completed on the wells on June 23, 2000. Final results were received by the Engineer a week later.

1.2 Purpose

The purpose of this report is to summarize the information obtained during the construction and testing of IW5, IW6 and MW3, describe the methods used to analyze the data, document the approved casing setting depths and monitoring zones for MW3, demonstrate mechanical integrity of the injection wells, identify confinement above the injection zone and verify that the wells are suitable for their designed pumping rates to allow long term operational testing of the injection wells. Pertinent information about the construction and testing of MW4 is also included in this report.

1.3 Elements of the Injection Well Contract

The project specifications contained provisions for the construction and testing of the two injection wells and the associated monitor wells. The two 24-inch diameter injection wells were to be constructed to a depth of 3500 feet bpl and two dual-zone deep monitor wells to a depth of approximately 1650 feet bpl. Provisions of the contract included:

- Conducting geologic logs, to confirm lithologic boundaries and gross lithologic properties;
- Conducting the following geophysical logs: X-Y caliper, gamma ray, fluid conductivity, dual induction, borehole compensated sonic/VDL, fluid resistivity, temperature, flowmeter and borehole televiewer;
- Conducting an open hole television survey;

- Conducting straddle packer and single packer tests in discrete zones of the pilot holes of each injection well in order to determine the hydrologic properties of lithologic units;
- Collecting and analyzing conventional cores to complement the straddle packer test data and geophysical logs;
- Collecting and analyzing of water samples in various zones to determine water quality variations with depth;
- Collecting and analyzing background water samples from the monitoring zones and the injection zones;
- Conducting casing hydrostatic pressure tests and cement bond logs on final casing strings;
- Conducting television (video) surveys and radioactive tracer surveys; and
- Conducting injection tests in both completed injection wells to demonstrate the ability of the injection well system to accept effluent at the design flow rate.

2.0 Well Drilling and Construction

2.1 Well Construction

As part of this project, MW4 was constructed first, approximately 1200 feet north of MW1. IW6 was constructed approximately 70 feet south of MW4. The drill rig was moved to IW5, located between IW6 and MW1. MW3 was constructed approximately 70 feet north of IW5. The location of these wells are presented in Figure 2. During the drilling of the wells, geophysical logging and testing was performed. Well measurements are recorded in depth below pad level (bpl).

The drilling of injection wells IW5 and IW6 proceeded generally as identified in the project specifications. Drilling activities are summarized in the following outline which identifies nominal depths. Actual depths of casings are identified in the profiles of the completed wells IW5 and IW6 presented in Figures 3 and 4, respectively.

- Drill a nominal 58-inch diameter borehole to approximately 170 feet bpl using rotary mud method.
- Set and cement in place 50-inch diameter steel casing at 160 feet bpl.
- Drill a nominal 50-inch diameter borehole to approximately 1010 feet bpl using rotary mud method.
- Set and cement in place 42-inch diameter steel casing at 1000 feet bpl.
- Drill a nominal 12-inch diameter pilot hole to 1900 feet bpl using reverse air method.
- Backplug pilot hole with cement.
- Drill a nominal 42-inch diameter borehole to 1900 feet bpl using reverse air method.
- Set and cement in place 34-inch diameter steel casing at 1890 feet bpl.
- Drill a nominal 12-inch diameter pilot hole to approximately 3000 feet bpl using reverse air method.
- Backplug pilot hole with cement.
- Drill a nominal 34-inch diameter borehole to approximately 3000 feet bpl using reverse air method.
- Set and cement in place 24-inch diameter steel casing at 2990 feet bpl.

- Drill a nominal 24-inch diameter hole to approximately 3500 feet bpl using reverse air method.

The drilling of MW3 proceeded generally as identified in the project specifications. Drilling activities are summarized in the following outline. The depth of the monitor zones was based on the data collected during the drilling and testing of IW5, IW6 and MW4 and confirmed by the data from the drilling and testing of MW3. The selection of the monitor zone depths is discussed later in the report.

- Drill a nominal 32-inch diameter borehole to approximately 170 feet bpl using rotary mud method.
- Set and cement in place 24-inch diameter steel casing at 160 feet bpl.
- Drill a nominal 24-inch diameter borehole to 1385 feet bpl using rotary mud method.
- Set and cement in place 16-inch diameter steel casing at 1380 feet bpl.
- Drill a nominal 16-inch diameter borehole to 1683 feet bpl using reverse air method.
- Set and cement in place 6⅝-inch diameter steel casing at 1633 feet bpl using cement baskets, filling the annulus space of the final casing with cement from 1633 to 1426 feet bpl.
- Drill out cement plug.

The upper monitor zone (UMZ) was established between 1380 and 1426 feet bpl and the lower monitor zone (LMZ) between 1633 and 1683 feet bpl. The upper outside 1,430 feet of the 6⅝-inch diameter casing was coated with a corrosion resistant epoxy-phenolic compound. A profile of the completed MW3 is presented in Figure 5. For reference, a copy of the completed MW4 and modified MW1 and MW2 profiles are presented in Figures 6, 7 and 8, respectively.

2.2 Data Collection

Data was collected during the construction of the wells using various methods and procedures as described in this Section. Independent testing and laboratory analyses performed by subcontractors of Youngquist Brothers, Inc. included the following: geophysical logging was performed by Florida Geophysical Logging, Inc., water quality analyses were performed by Sanders Laboratories, and testing of rock cores was performed by Ardaman & Associates, Inc. Additional water quality analyses were performed by BCOES Analytical Laboratory.

Except as noted, measurements of footage in the wells are referenced to the pad level. The mean sea level pad elevation (NGVD) at wells IW5, IW6, MW3 and MW4 is 13.20, 13.70, 13.20 and 13.70 feet, respectively.

Daily progress and activities were monitored and recorded. The Engineer prepared daily progress reports during well construction. Independent daily reports were prepared by the Contractor. In addition to recording daily drilling progress, the reports included other pertinent drilling information such as drilling speed, weight on the drill bit, penetration rates, and relative hardness of the formations. Any problems encountered during drilling were observed and noted. All activities related to the installation of well casings, cementing or other materials, as well as their quantities, were included in these reports. Detailed descriptions of test procedures and data collection, including results of inclination surveys to verify hole straightness, were recorded. The length and configuration of tools introduced into the borehole were noted. Copies of the daily and weekly progress reports were transmitted to the TAC members on a weekly basis.

An inclination survey was conducted every 90 feet in all pilot and reamed holes to confirm straight hole requirements for the wells. The results from the inclination surveys are presented in Appendix C.

Drilling fluid samples were collected every 30 feet below 1000 feet bpl to determine the potential presence of effluent and sent to BCOES Analytical Laboratory for analysis. The sample results are presented in Appendix D.

2.3 Geologic Samples

Samples of drilled cuttings were collected and analyzed from the drilling of the injection well and monitor well pilot holes. Circulation time (the time required for drilled cuttings to reach the surface) was calculated regularly to ensure that accurate sample depths were recorded. After initial examination, the samples were described by the Engineer's on-site personnel. A geologic description of each sample was entered into a log. The cuttings from the confining interval were classified in accordance with the scheme of Dunham (1962). These logs are presented in Appendix E. Two sets of drill cuttings were bagged in 10-foot intervals. After the wells were completed, the Contractor sent one set of these samples to the Florida Bureau of Geology in Tallahassee, Florida.

2.4 Cores

During the drilling of the injection well pilot holes, conventional core samples were collected and analyzed. The results of the analyses are used to demonstrate confinement. Core depths were selected primarily on the basis of reviewing and interpreting information from the existing wells on site - geophysical logs, lithology, packer tests and other cores. The Contractor used a 20-foot long, 4-inch inside diameter core barrel for this project. Each core was approximately ten feet long. Locations of the cores were selected by the Engineer. Cores from IW5, IW6 and MW4 were taken at the depths identified in Table 1.

Samples from each core were selected and sent to an independent laboratory for analysis. These samples were tested for several parameters including permeability, porosity and specific gravity. Core laboratory analysis results and geologic core descriptions are presented in Appendix F. A summary of the hydraulic conductivity from the laboratory analyses of the cores is presented in Table 2. The calculated hydraulic conductivities from the MW4 cores are also presented in Table 2. The laboratory analysis of the MW4 cores is also included in Appendix F.

2.5 Geophysical Logs

At the completion of each stage of hole drilling, geophysical logs were conducted. The purpose of these logs was to assist in casing seat selection, identify confining sequences and to help identify the location of monitoring zones. The geophysical logs performed, including a brief description of the information provided by the logs, are as follows:

- X-Y Caliper - Identification of hole diameter and hole geometry.
- Gamma-Ray - Measurement of the natural gamma ray radiation of the formation, used as a tie-in between logs.
- Dual Induction Log - A resistivity log. Identifies differentiation between limestone and dolomite beds, and, along with the gamma ray log, is useful in the correlation of lithologic units.
- Borehole Compensated Sonic Variable Density Log (VDL) - Identification of the confining sequences, as well as identification of zones which could cause problems during cementing.
- Flowmeter Surveys - Determination of where fluid may be entering or exiting the borehole.
- Temperature - Provides a profile of static and dynamic temperature of the borehole, may be useful in determining changes in fluid movement.
- Borehole Televiewer (BHTV) - Determination of where structural features (bedding planes, fractures, vugs and voids) are located.
- Cement Top Temperature - Verification of the annular space fill-up after each cementing stage.
- Cement Bond Log - Used to assess the quality of the bond between the inner casing and the cement grout around the casing. The resulting curve of the log is a function of casing size and thickness, cement strength and thickness, degree of cement bonding and tool centering.

Geophysical logs were transmitted to TAC members on a weekly basis during construction. Geophysical logs are presented in Appendix G and are boxed separately. Box 1 contains logs from IW5, Box 2 contains logs from IW6 and Box 3 contains logs from MW3. For convenience, many of the same type of logs were merged together (e.g. the dual induction log for IW5 presented in Box 1 is continuous from 1000 to 3500 feet bpl). Also in Appendix G is an index of the logs performed and a tabulation of the logs included in each box.

During the geophysical logging and testing of the well, the Engineer was on site to witness the logging and verify quality control procedures. The quality control maintained during the testing program was, to a large extent, provided by Florida Geophysical Logging, Inc. Industry standard quality control measures were observed and are documented on the logs. Detailed information of the tool calibration program utilized by Florida Geophysical Logging is attached in Appendix H.

2.6 Television Surveys

Television surveys were conducted and recorded in VHS format in the injection well pilot holes to 3000 feet bpl and in the injection casing from land surface to 2990 feet bpl. Color video surveys were made with the camera lens in two positions - downhole with a radial view and uphole with a horizontal rotating position. Air development was used to displace suspended solids from the well prior to performing the television survey. The open hole survey allowed the reviewer to visually inspect the formations encountered in the borehole, as well as to observe potential fractures and water-producing zones. Acceptable picture clarity was obtained in the surveys. A log describing the formation and structural features observed in the pilot hole of each injection well to 3000 feet bpl is presented in Appendix I. A video tape copy of the television surveys is also included in Appendix I, however, it is boxed separately with the geophysical logs. IW5 tapes are included in Boxes 1 and 3 and IW6 tapes are in Box 2.

2.7 Packer Tests

Both single packer and straddle packer tests were performed on the borehole during construction of each injection well. Single packer tests were performed during the drilling of the pilot holes. A single inflatable packer is set in the borehole and water is pumped from the open hole below the packer. Straddle packer tests were performed after the completion of the pilot holes. For the straddle packer tests, two inflatable packers are set in the borehole and water is pumped from between the packers. Packer tests were conducted at intervals to either support demonstration of confinement, to determine water quality so as to define the base of the Underground Source of Drinking Water (USDW), or to identify potential monitoring zones. The packers were used to isolate zones to perform drawdown and recovery tests. The single packer and straddle packer intervals were selected based on reviewing and interpreting information from the existing wells on site - geophysical logs, lithology, cores and other packer tests. Seven intervals were selected for IW5, and six intervals were selected for IW6.

The packers were lowered into the pilot hole to the selected interval on the 7⅝-inch (outside) diameter drill pipe, inflated and seated against the formation. A 4-inch diameter submersible pump was lowered into the drill pipe approximately 200 feet to introduce stress on the isolated interval. Prior to starting the tests, each zone was developed free of any drilling fluids by means of air lifting and pumping until the specific conductance stabilized. Development time is identified in Table 3. The isolated zone was then allowed to recover from development before beginning the pumping test.

During drawdown and recovery, water level measurements were obtained using a data logger attached to a pressure transducer (a Hermit 1000-C data logger). In addition to the hermit data logger, a battery-operated downhole pressure recorder was used for backup and quality control. The pressure transducer was lowered to a known depth. The method of analysis used on the data collected and recorded during the packer tests was the Modified Non-Equilibrium Formula derived by Cooper and Jacob (1946). The equation of the Cooper-Jacob method is on the following page.

$$T = \frac{264Q}{\Delta s}$$

where:
T = coefficient of transmissivity (gpd/ft)
Q = pumping rate (gpm)
Δs = change in drawdown over one log cycle (ft)

The calculated hydraulic conductivities from IW5, IW6 and MW4 packer tests are presented in Table 4. The raw packer test data and data plots are presented in Appendix J. Based on the stabilization of the fluid specific conductance prior to starting the packer tests and the drawdown characteristics of the data shown in Appendix J, all of the hydraulic conductivity values presented from the packer tests are considered valid.

2.8 Packer Test Water Quality Samples

Water samples obtained during the packer tests were analyzed in the field for temperature and conductivity. These water samples were collected during the drawdown phase of the packer test and sent to an independent laboratory for additional analysis. The samples were analyzed and the results are presented in Appendix K. A compilation of the packer test water quality data is presented in Table 5, including results from MW4 testing. Log derived water graphs were prepared to compare to the packer test water quality test. These graphs show good correlation, and are presented in Appendix L

2.9 Casing

Casing heat numbers stamped on the casing were verified with the mill certificates prior to running casing in the hole. Certified welders assembled random length casing into approximate 120 foot lengths in the on-site staging area. Copies of the casing mill certificates are presented in Appendix M. Cementing plans for each casing string were proposed by the Contractor and reviewed by the Engineer prior to cementing. After accepting the proposed plan, casing was set and cemented. A copy of the cement certification for each casing run is presented in Appendix N.

Final casing installations were pressure tested. The MW3 16 and 6⅝-inch casings were pressure tested as identified below. The 24-inch injection well casing pressure test are described in Section 4, "Final Testing".

On January 28, 2000, the MW3 16-inch injection well casing was internally pressurized to 69 psi. A pressure increase of 2.5 psi was observed over the 60 minute test period. This increase represents a 3.6 percent change in the original pressure, which is within the 5.0 percent maximum allowable change. A copy of the test gauge certification records and certified results of the hydrostatic pressure test are contained in Appendix O.

On February 15, 2000, the MW3 6⅝-inch injection well casing was internally pressurized to 75 psi. A pressure increase of 3.0 psi was observed over the 60 minute test period. This increase represents a 4.0 percent change in the original pressure, which is within 5.0 percent maximum allowable change. A copy of the test gauge certification records and certified results of the hydrostatic pressure test are contained in Appendix O.

2.10 Cement Bond Logs

Cement bond logs are used to assess the quality of the bond between the casing and the cement grout. The resulting curve of the log is a function of casing size and thickness, cement strength and thickness, degree of cement bonding and tool centering.

The travel time curve (left log track) is run to determine if the tool is properly centered. The critical travel time is the time recorded when the tool is absolutely centralized in high signal areas, areas with no cement (free pipe). Factors affecting the travel time curve are cycle skipping that can be caused by fast formation arrivals and formations that are so dense they actually have a faster transit time than the casing. The basic transit time of steel is slower than some dolomites and limestones.

On the amplitude curves (center log track), a time gate is set at the time corresponding to the expected arrival of the casing signal, and the amplitude of the signal in that gate is recorded. A high amplitude indicates a larger casing signal, and therefore a poorer cement bond; a low amplitude indicates a good bond.

The variable density display (left log track) displays the entire wave signal. If there is no bond, an arrival is seen at the time corresponding to the casing velocity. A the cement becomes thicker and stronger (compressive strength), the casing signal becomes weaker.

On November 3, 1999, a cement bond log was performed in the IW5 24-inch final casing. From the travel time log it can be seen that good tool centralization was maintained for the entire log. The amplitude curve over the entire casing shows no readings above 10 millivolts indicating an excellent bond. The variable density display shows no strong casing signal on any section of the 24-inch casing. The interval from the surface to 320 feet bpl had no cement in place at the time the log was conducted to provide casing signal base line data. A strong casing signal can be seen on the variable density display. The cement bond log conducted in IW5 demonstrated that there is a good cement seal around the 24-inch diameter casing and that there are no channels or conduits that would allow fluid movement adjacent to the casing. A copy of the log is included in Appendix G.

On June 22, 1999, a cement bond log was performed in the IW6 24-inch final casing. From the travel time log it can be seen that good tool centralization was maintained for the entire log. The amplitude curve over the entire casing shows no readings above 5 millivolts, indicating an excellent bond. The variable density display shows no strong casing signal on any section of the 24-inch casing. The interval from the surface to 315 feet bpl had no cement in place at the time the log was conducted to provide casing signal base line data. A strong casing signal can be seen on the variable density display. The cement bond log conducted in IW6 demonstrated that there is a good cement seal around the 24-inch diameter casing and that there are no channels or conduits that would allow fluid movement adjacent to the casing. A copy of the log is included in Appendix G.

On January 27, 2000, a cement bond log was performed in the MW3 16-inch casing. From the travel time log, it can be seen that good tool centralization was maintained for the entire log. The amplitude curve from the casing seat to 400 feet bpl shows most readings not over 10 millivolts, indicating an excellent bond. The variable density display shows no strong casing signal on any section of the 16-inch casing. The cement bond log conducted in the MW3 16-inch casing demonstrate that there is a good cement seal around the 16-inch diameter casing and that there are no channels or conduits that would allow fluid movement adjacent to the casing. A copy of the log is included in Appendix G.

On February 14, 2000, a cement bond log was performed in the MW3 6⅝-inch casing. From the travel time log it can be seen that good tool centralization was maintained for the entire log. The amplitude curve from 1633 to 1604 feet bpl and from 1463 to1432 feet bpl shows no readings over 10 millivolts indicating an excellent bond. The variable density display shows no strong casing signal on any of the cemented section of the 6⅝-inch casing. The cement bond log conducted on MW3 6⅝-inch casing demonstrate that there is a good cement seal around the 6⅝-inch diameter casing and that there are no channels or conduits that would allow fluid movement adjacent to the cemented section of the casing. A copy of the log is included in Appendix G.

2.11 Monitor Zone Depths

The selection of monitor zones for MW3 was originally established based on information available from the drilling and testing of MW4 and the modifications to MW1 and MW2. During construction of MW3, the location of the upper zone was requested to be slightly adjusted. FDEP approved the requested change. The upper monitor zone was established between 1380 and 1426 feet bpl and the lower monitor zone between 1633 and 1683 feet bpl. As-built profiles of MW3, MW4, MW1 and MW2 are presented in Figures 5, 6, 7 and 8, respectively.

3.0 Subsurface Conditions

3.1 Background

This section presents the site specific geologic and hydrogeologic information obtained during this project and the results of various tests made during construction of IW5, IW6, MW3 and MW4. Extensive information is available from the drilling and testing of the other six on-site wells - IW1, IW2, IW3, IW4, MW1 and MW2.

3.2 Generalized Geologic Setting

A well defined, extensive sequence of carbonate sediments is present at the Broward County NRWWTP site. This is consistent with information obtained from other projects in the area, including the six on-site previously drilled wells. The geologic units found during construction of the monitoring well satisfy the requirements of FAC Rule 62-528. The presence of a suitable confining sequence and suitable monitor zones were confirmed by geophysical logging and testing. A brief description of the various geologic units follows.

From land surface to approximately 350 feet bpl, the sediments are comprised of limestone, sandy limestone, limey sandstone, sandy clay and varying amounts of unconsolidated shell and sand. The limestone and sandy limestone are a light gray to grayish olive packstone and grainstone. The limey sandstone is generally light gray to grayish yellow and olive, fine to medium-grained and slightly phosphatic. The sandy clay is grayish olive, soft, plastic and slightly calcareous with very fine to fine-grained quartz sand. Various amounts of shell and quartz sand are also present in these sediments. The dissolution features and generally poor cementation apparent in the upper 350 feet of sediments give this unit the high permeability characteristic of the Biscayne Aquifer. These sediments are Pleistocene to Miocene in age and correspond to descriptions of the Anastasia and Plamico Sand formations.

From approximately 350 feet to 770 feet bpl, the sediment is predominantly composed of an olive gray, plastic clay. From 770 feet to about 970 feet bpl, the sediment is predominantly carbonate marl. The marl is mostly pale or light grayish olive, soft and composed of silty clay with interbedded limestone present throughout the interval. The limestone varies from grayish olive to dark gray and is micritic. The sediments in the interval between approximately 350 and 970 feet bpl are Miocene to Late Eocene in age and correspond to the Hawthorn Formation.

From about 970 feet to 1965 feet bpl, the sequence is composed almost entirely of limestone interbedded with dolomite, typically a pale orange to grayish orange, fine to medium grained packstone. Below 1740 feet, thin beds and stringers of dolomite are present. The limestone in this sequence is Middle to Late Eocene age and is delineated as part of the Avon Park Limestone.

Between 1965 feet and 2130 feet bpl, the sequence is composed almost entirely of dolomite.

In the interval from 2130 feet to 3000 feet bpl, limestone is interbedded with dolomite, light to moderate yellowish-brown and fine to medium grained cryptocrystalline. These dolomite units comprise about 20 percent of the sequence. The limestone in this interval is generally very pale orange, pellodial or micritic, fine to medium grained and soft. The section is comprised of sediments of Early to Middle Eocene Age of the Avon Park Limestone.

Below 3000 feet the sequence is composed almost entirely of dolomite. The dolomite in the upper interval is predominantly pale yellowish or moderate brown, massive, fine grained or micritic and dense with some dissolution features. The interbedded limestone in the upper interval consists of pale orange to tan, fine to medium grained, soft and biosparite. This section contains sediments of Early Eocene Age corresponding to the Lower Avon Park Limestone Formation.

The "boulder zone" extends from approximately 3000 to at least 3500 feet bpl in the Lower Oldsmar Formation. The lower limit of the injection zone was not determined since drilling was terminated at approximately 3500 feet bpl. The television surveys indicate that the dolomite in this zone exhibits extensive dissolution cavities as well as fracturing.

The various formations penetrated by IW5, IW6, MW3 and MW4 correlate closely with those encountered in the other wells at the site, demonstrating the continuity and uniformity of the beds. A hydrogeologic cross section of the wells on site is presented in Figure 9.

3.3 Hydrogeologic Setting

The upper 350 feet of rock and sediments are Pleistocene and Upper Miocene sandstone, limestone, clay and unconsolidated sand and shell. These sediments comprise the Biscayne Aquifer which is used as a source of drinking water throughout South Florida.

Underlying the Biscayne Aquifer are approximately 680 feet of Miocene clay and marl of the Hawthorn Formation which form a confining bed between the Biscayne Aquifer and the Oligocene to Eocene limestones and dolomites of the Floridan Aquifer. The clay and marl confining sequence is called the Hawthorn Formation. Water from the Floridan Aquifer in South Florida contains concentrations of dissolved solids which exceed drinking water standards. The aquifer is not currently used as a main source of drinking water in Broward County; however, some water utilities have begun to use it.

Within the Eocene limestones, a confining sequence has been identified between 1650 and 2000 feet bpl as discussed in Section 3.5. It consists of a thick sequence of dense limestone with some interbedded layers of dolomite and is discussed in greater detail later in this report.

3.4 Water Quality

Water samples were collected from the drilling fluid every 30 feet as drilling progressed below 1000 feet bpl and from isolated sections of the borehole during the single packer and straddle packer tests.

Water samples collected every 30 feet below 1000 feet bpl were utilized to investigate the potential presence of effluent. The samples were analyzed for chlorides, conductivity and ammonia. Test results are included in Appendix D. The results show that indicators of effluent were detected below 2000 feet bpl. The program therefore focused on identification of confining sequences between 2000 feet bpl and the base of the USDW.

The water samples from the packer tests were analyzed for selected parameters to establish background water quality and to identify the depth of the 10,000 mg/l total dissolved solids (TDS). The tests were conducted in intervals considered suitable as confining zones and intervals suitable as monitor zones. During the packer tests, a sample of the formation water from the tested interval was collected just prior to shutting off the pump, after significant development time. Water samples from the packer tests were analyzed for TDS, chloride, sulfate, specific conductivity, ammonia as nitrogen, nitrate as nitrogen, nitrite as nitrogen, total kjeldahl nitrogen and total organic nitrogen. Results of the laboratory analyses are presented in Appendix K. Table 5 summarizes the results of the laboratory analyses from the packer tests.

The base of the USDW is defined as water having less than 10,000 mg/l TDS. The base of the USDW was identified by performing water quality analysis on samples obtained from packer tests and geophysical log interpretation. Based on the water quality testing, the base of the USDW currently occurs between 1630 and 1650 feet bpl. Also used in determining TDS was the geophysical log derived water quality data. Based on the log derived water quality data, the base of the USDW occurs at approximately 1650 feet bpl, as presented in Appendix L.

3.5 Confinement Analysis

3.5.1 Identification of Confining Units

The presence of satisfactory confining sequences between 1650 and 1900 feet bpl was established at the NRWWTP during the drilling of MW4. Two reports previously submitted to the TAC documented the presence of this confinement on site. These reports are entitled "Confinement Analysis, Injection Well System, Broward County North Regional Wastewater Treatment Plant, Pompano Beach, Florida" dated March 1998, by Missimer International and "North Regional Wastewater Treatment Plant Monitor Well 4 Construction Completion Report" dated August 1999, by H&S. Data collected during the construction of IW1 through IW4 indicated the presence of additional confining sequences between 1900 and 2000 feet bpl. This information was presented to the TAC in the following reports: "Construction and Testing of Injection Wells #1 and #2 with Associated Deep Monitor Well #1 Broward County North District Regional Wastewater Treatment Plant" dated June 1990 and "Construction and Testing of Injection Wells #3 and #4 with Associated Deep Monitor Well #2 Broward County North District Regional Wastewater Treatment Plant Pompano Beach Florida" dated September 1991. During the construction of IW5 and IW6, the objective was to supplement previously documented confinement and to identify additional confinement between 1900 and 2000 feet bpl.

The approach to the evaluation of vertical confinement was as follows. Available borehole geophysical, geological data and open hole testing data were used to identify intervals of rock between 2000 feet bpl and the base of the USDW (+/- 1640 feet bpl) that exhibit confining properties. The vertical confinement provided by each interval was then evaluated. Particular attention was given to locating beds of limestone, dolomite, clay or marl that have low matrix vertical hydraulic conductivities and are not penetrated by fractures and/or solution cavities. Such tight beds provide the primary vertical confinement of the injected effluent.

3.5.2 Geophysical Logs

The wire line geophysical logs for IW5, IW6, MW3 and MW4 were examined in detail for the presence of units of rock that could provide vertical confinement for injected fluids. A combination of sonic, caliper and resistivity logs were used to identify well-cemented limestone and/or dolomite beds that would be expected to have low matrix porosities and hydraulic conductivities. Borehole televiewer logs were used to locate fractures and/or cavernous zones that could be conduits for vertical fluid flow. Information on the orientation and thickness of beds was also obtained from the borehole televiewer logs.

The development and conditioning of the wells prior to logging is not an issue for the sonic, caliper, gamma ray, temperature, resistivity and borehole televiewer logs as these logs were designed to, and are often, run in mudded boreholes. Fine scale features, such as bed contacts, are readily distinguishable on the borehole televiewer log, which indicates that borehole conditions did not have a significant adverse effect on log quality.

Flowmeter, temperature and fluid resistivity/conductivity logs provide information on the location of flow zones into wells and on changes in the salinity of formation waters. These logs were run under both static and dynamic conditions. The pilot holes were packed off at 1650 feet bpl so the tests would be performed across only the confining sequence. These logs did not provide useful information concerning vertical confinement in the 1650 feet bpl to 1900 feet bpl interval. Fluid resistivity/conductivity and temperature were relatively constant in all wells below the base of the USDW. Flowmeter logs under the best of circumstances can provide information on the location of beds or series of beds with high horizontal hydraulic conductivities. Flowmeter logs are of very limited value for identifying beds with low vertical hydraulic conductivities because a single zone of high hydraulic conductivity very often dominates the flow for the entire tested interval, making it difficult to evaluate other portions of the logged interval.

3.5.3 Characterization of Well Cuttings

Cuttings collected during the pilot hole drilling in all wells were examined in detail for lithology, macroporosity (visible porosity) and apparent matrix hydraulic conductivity using a stereomicroscope. A copy of the geologic log over this interval is attached. The cuttings were grab samples collected at 10 foot intervals during the construction of each well. The lithology of the limestone cuttings was characterized using the limestone classification scheme of Dunham (1962). The most common grain types were silt to fine-sand sized rounded carbonate grains that are described as either peloids (fecal pellet-shaped grains of indeterminate origin) or as bioclasts (transported fossil fragments). The mineralogy of the samples (calcite versus dolomite) was confirmed by reaction with dilute hydrochloric acid. Dolomite was classified according to crystal size as being either microcrystalline (crystals are not visible with the low-powered microscope), finely crystalline (1/64 to 1/16 mm) or medium crystalline (1/16 to 1/4 mm).

The macroporosity (visible porosity) of the samples was characterized as being either very low (< 2%), low (2-5%), moderate (5-15%), high (15-25%) or very high (>25%). The apparent matrix hydraulic conductivity was qualitatively evaluated as being very low to high based on the porosity, size of the pores and likely degree of interconnection of the pores. Geological logs for each well are contained in Appendix E.

3.5.4 Core Examination and Data Analysis

Fourteen cores were taken from IW5 and IW6 between 1630 to 1996 feet bpl. This supplements the nine cores taken from MW4 between 1520 and 1900 feet bpl. The lithology of the cores was evaluated in order to determine if there were any significant biases in the cutting samples. The well cuttings appeared to have somewhat less intergranular carbonate mud than the cores. In some limestone cuttings, the carbonate mud appeared to have been washed out of the samples during drilling. Some limestone cuttings, particularly grainstone and packstone lithologies, thus appear to be more porous than they actually are. The cores were also examined for the presence of fractures or solution features (vugs) that might be conduits for vertical fluid flow. Copies of the core descriptions are contained in Appendix F. Sections of each core were selected and submitted for laboratory analysis for hydraulic conductivity. Results from the laboratory core analysis are summarized in Table 2. The complete laboratory analysis is presented in Appendix F.

3.5.5 Packer Test Data

Single and straddle packer test data collected during the drilling of IW5, IW6 and MW4 were analyzed for information on the hydraulic conductivity of potential confining units. The straddle packer data were analyzed using the Cooper and Jacob (1946) modification of the Theis (1935) non-equilibrium equation (i.e., the straight line method). The transmissivity values calculated from both the pumping and recovery phase data for each test were very similar.

It should be noted that the transmissivity and average hydraulic conductivities values calculated from the packer test data are largely a function of horizontal hydraulic conductivities. Packer test data thus tend to over estimate vertical hydraulic conductivities. For example, a packer test performed on an interval containing one or more high hydraulic conductivity beds interbedded between very low hydraulic conductivity beds would give a high transmissivity and average hydraulic conductivity value whereas the interval would have a very low vertical hydraulic conductivity. The results from each packer pumping test are contained in Appendix J. A summarization of the results of the packer tests is shown in Table 4.

3.5.6 Stratigraphic Correlation

The geologic and geophysical logs of IW5, IW6, MW3 and MW4 indicate excellent correlation as would be expected from wells in such close proximity. An example of this excellent correlation can be seen when the dual induction logs from IW5, IW6, MW3 and MW4 are placed side by side. With the logs in this position, it can be seen that the logs are nearly identical. Examples of this can be seen with peaks at 1800 feet bpl are at the same depth and of the same magnitude. This correlation can also be seen on the VDL, gamma ray, dual induction and borehole televiewer logs.

3.5.7 Testing Quality Control Quality Assurance

For each of the testing procedures conducted, quality control and quality assurance procedures were implemented and documented. A copy of the calibration theory and practice for the geophysical logs conducted are contained in Appendix H. Quality control procedures for the packer testing and development records are contained in Appendix K.

3.5.8 Criteria for Identification of Confinement Intervals

Beds or intervals of rock that are likely to offer good vertical confinement were identified using the following criteria:

- Low sonic transit times and derived sonic porosities.
- VDL pattern consisting of either straight parallel vertical bands, where lithology is relatively uniform, or a "chevron" pattern of continuous parallel bands, where the formation consists of interbedded rock with differing densities and/or degrees of consolidation. Fractured rock typically has an irregular VDL log pattern.
- Low vertical hydraulic conductivities measured on core samples.
- Low hydraulic conductivities calculated using packer and flow test data.
- Low macroporosity (i.e., visible pore spaces) and a high degree of cementation (hardness) as observed in microscopic examination of cuttings and core samples
- Borehole diameters on caliper logs close to the bit size. Fractured dolomite and limestone are commonly manifested by an enlarged borehole.
- Relatively high resistivities, which in the middle and lower Floridan Aquifer System are often indicative of tight dolomite beds.
- Absence of evidence of fractures from the television survey and borehole televiewer log.

3.6 Confinement Intervals

The confinement properties of the strata between the base of the USDW (+/-1640 feet bpl) and 1900 feet bpl was evaluated using the above criteria and data. The studied section was divided into four intervals based on their vertical confinement properties. The four confining intervals are discussed below.

3.6.1 Interval From 1650 to 1790 Feet bpl

This interval consists predominantly of light-colored limestone. Grainstones and packstones are the most common lithologies. The grainstones and packstones are interbedded with subsidiary beds of carbonate-mud rich lithologies (fossiliferous mudstones and wackestones). The borehole televiewer log indicates that the beds are horizontal and range in thickness from approximately 0.5 to 10 feet. The bedding appears to consist of stacked sequences of carbonate sand-rich (grainstones and packstones) and carbonate mud-rich (packstones to mudstones) limestones. The mudstone and wackestone beds, which have low macroporosities and are well cemented, can provide better vertical confinement than the thicker grainstone and packstone beds.

The majority of the cuttings and core samples have low to moderate (2 to 15%) macroporosities and matrix hydraulic conductivities. Sonic porosities throughout the interval range mostly between 35 and 45%. Core plug porosities range from 33 to 42%. The relatively high sonic porosities and low macroporosities (i.e., visible pore spaces) indicate that the limestone has a high microporosity. For a given total porosity, microporous limestones tend to have much lower hydraulic conductivities than more coarsely porous limestones.

A total of three cores were collected and nineteen laboratory analyses were conducted from all wells over this interval. Core vertical hydraulic conductivities range from 2.2×10^{-6} to 1.0×10^{-3} cm/sec. Nine packer tests were performed over this interval and yielded hydraulic conductivities ranging from 8.0×10^{-5} to 1.1×10^{-4} cm/sec. No evidence of vertical fractures or solution cavities was visible on the borehole televiewer log or the television survey videos. The geological and geophysical data for this interval are characteristic of good vertical confinement.

3.6.2 Interval From 1790 to 1830 Feet bpl

This interval consists of interbedded limestones and dolomites. The borehole televiewer log indicates that the beds are horizontal and range in thickness from <0.1 feet to approximately 4 feet. The macroporosity and apparent hydraulic conductivity of the dolomite cuttings are variable (very low to high). Much of the dolomite has low to very low porosities and apparent hydraulic conductivities. The visible porosity consists of small vugs (< 2 millimeter in diameter) that do not appear to be connected. The limestones consist mostly of grainstones and packstones that have low to moderate porosities and matrix hydraulic conductivities.

Dolomite beds showing the characteristics of good confinement were identified at the following depths:

- 1788-1791 feet bpl
- 1792-1794 feet bpl
- 1798-1800, feet bpl
- 1810-1816 feet bpl
- 1820-1825 feet bpl

The above noted dolomite beds had sonic porosities locally of less than 25%. The overlying and underlying limestones had sonic porosities predominantly between 35 to 45%. A constriction of the borehole was also evident on the caliper logs at the dolomite beds. Fractured, and thus highly transmissive, dolomite beds very often show an enlarged borehole on caliper logs. The VDL log had a "chevron" pattern of parallel bands that is characteristic of intervals of interbedded rock with differing densities and degrees of consolidation. No evidence of vertical fractures or solution cavities was seen on the borehole televiewer logs or the television surveys videos. Three packer tests were performed during the pilot hole drilling and yielded hydraulic conductivities ranging from 3.0×10^{-5} to 3.2×10^{-4} cm/sec. A total of three cores were collected and 16 laboratory analyses were conducted from all wells over this interval. Core vertical hydraulic conductivities range from 4.1×10^{-9} to 1.1×10^{-4} cm/sec. The geological and geophysical data indicate that this interval will provide very good vertical confinement.

3.6.3 Interval From 1830 to 1930 Feet bpl

This consists predominantly of fossiliferous limestones. The most common lithologies are grainstones and packstones. These limestones consist of scattered, large (millimeter-sized) fossils and fossil fragments in a matrix of carbonate mud and/or silt to very fine sand-sized peloids and bioclasts. The interval appears to consist of stacked sequences of carbonate sand-rich (grainstones and packstones) and carbonate mud-rich (packstones to mudstones) limestones. The beds are horizontal and range in thickness from approximately 0.2 to 4 feet, as indicated by the borehole televiewer log.

The peloid bioclast grainstones and packstones have a low to moderate (generally <15%) macroporosity and apparent matrix hydraulic conductivity. Subsidiary mudstone and wackestone beds are present that have very low macroporosities and apparent matrix hydraulic conductivities. The limestone throughout this interval have sonic porosities in the range of 35 to 45%. Core sample porosities from range from 38 to 40%. The relatively high sonic porosities and low macroporosities (i.e., visible pore spaces) indicate that the limestone has a high microporosity.

Two cores were collected and 11 laboratory analyses were conducted from all wells over this interval. Core vertical hydraulic conductivities range from 7.4×10^{-5} to 8.2×10^{-4} cm/sec. Three packer tests were performed during the pilot hole drilling and yielded hydraulic conductivities ranging from 3.5×10^{-5} to 3.1×10^{-4} cm/sec. No evidence of vertical fractures or solution cavities was seen on the borehole televiewer log or the television survey videos over this interval. This interval has the geological and geophysical characteristics of good vertical confinement.

3.6.4 Interval From 1930 to 2000 Feet bpl

This interval consists of interbedded dolomite and limestone. The dolomite is mostly finely crystalline, has very low to low macroporosities and very low apparent matrix hydraulic conductivities. The limestone consists mostly of fossil peloid grainstones and packstones with low to moderate macroporosities and matrix hydraulic conductivities.

These dolomitic units are characterized by low sonic transit times, a constriction of the borehole, higher than background resistivities and a variable density log "chevron" pattern of continuous parallel bands. No evidence of vertical fractures or solution cavities was seen on the borehole televiewer log or the television survey videos over this interval.

Three cores were collected and eleven laboratory analyses were conducted from all wells over this interval. Core vertical hydraulic conductivities range from 1.6 x 10^{-9} to 1.4 x 10^{-3} cm/sec. Two packer tests were performed during the pilot hole drilling and yielded hydraulic conductivities ranging from 5.3 x 10^{-5} to 8.0 x 10^{-5} cm/sec. No evidence of vertical fractures or solution cavities was seen on the borehole televiewer log or the television survey videos over this interval. The geological and geophysical data indicate that this interval provides very good vertical confinement.

3.6.5 Confinement Summary

During the drilling and testing of these wells at the at the North Regional WWTP, an extensive program was implemented to identify confinement between the base of the USDW and the depth 2000 feet bpl. An unprecedented number of cores and packer tests were performed over a relatively small depth interval.

The limestones and dolomites present from 1650 to 2000 feet bpl in IW5, IW6 and MW4 have geological and geophysical characteristics indicative of good confinement. The available borehole televiewer and television surveys show no evidence of fractures or cavernous zones that could be conduits for the upward migration of injected effluent. The majority of the 1650 to 2000 feet bpl interval consists of horizontally bedded, fossiliferous limestone. The limestones have visible porosities (i.e. macroporosities) estimated to range mostly between 0 and 15%. Sonic and core sample total porosities range mostly between 33 and 45%. The majority of the porosity of the limestones is microporosity (microporosity = total porosity minus macroporosity). Microporosity rocks, where unfractured, typically have low hydraulic conductivities. The vertical hydraulic conductivity of core samples range from 1.6 x 10^{-9} to 1.0 x 10^{-3} cm/sec.

Dolomite beds located between 1790 and 1830 feet bpl and between 1930 and 2000 feet bpl provide very good confinement in addition to that provided by the limestone. Vertical core hydraulic conductivity from these zones range from 1.6 x 10^{-9} to 1.0 x 10^{-8} cm/sec. These dolomite beds show no evidence of fractures in the borehole televiewer logs and television surveys. The absence of indicators of effluent in samples above 2000 feet bpl provides strong evidence for the presence of effective confinement between 1900 and 2000 feet bpl. The low vertical hydraulic conductivity limestone and dolomites beds present between 1650 and 2000 feet bpl provide additional confinement and protection of the USDW. The combined hydrogeological, geological and geophysical data provide reasonable assurance that confinement exist below the USDW.

4.0 Final Testing

4.1 General

After the injection well construction was completed, background water samples were taken from MW3 and final testing on IW5 and IW6 began. This testing included mechanical integrity testing and a short term injection test. The mechanical integrity testing (MIT) includes a hydrostatic pressure test of the injection casing, a temperature log, a television survey and a radioactive tracer survey (RTS). The short term injection test consisted of injecting plant effluent into the wells for a twenty four hour period. During the injection test, well pressures were monitored before, after and during the injection test.

4.2 Background Water Quality

Water samples were obtained from both the upper and lower monitor zones of MW3 and the injection zone of IW5 and IW6. Prior to sampling, the wells were developed by using the reverse air procedure then allowing the well to flow naturally for a minimum of three well volumes. The samples were analyzed for a variety of constituents to establish the "natural" or background quality of the water. Background water quality laboratory analysis results from the injection zones of IW5 and IW6 and the upper and lower monitor zones of MW3 are presented in Appendix M. The results from the analyses of the MW4 background water quality testing are also included in Appendix M.

Water samples of the plant effluent that is presently being injected in the existing onsite wells are regularly analyzed. Results of the analysis are presented in Appendix M.

4.3 Mechanical Integrity Testing

In accordance with FAC Rule 62-528, the injection wells were tested for mechanical integrity. Testing consisted of a hydrostatic pressure test of the injection casing, a temperature log, a television survey and a RTS. The hydrostatic pressure test, which was conducted at a pressure at least 50% greater than the maximum allowable operating pressure, identifies internal casing integrity. The temperature log identifies temperature variations in the well. The television survey provides visual verification of internal casing integrity. The radioactive tracer survey provides data on the external mechanical seal of the casing. The following describes the testing methods, results of the testing and presents the interpretation of the data collected during the mechanical integrity tests.

4.3.1 IW5 Casing Pressure Test

On November 5, 1999, the 24-inch injection well casing was internally pressurized to 197 psi. A pressure decline of 3.0 psi was observed over the 60 minute test period. This decline represents a 1.5 percent change in the original pressure, which is within the 5.0 percent limit specified by the regulations. A copy of the test gauge certification record and certified results of the hydrostatic pressure test are contained in Appendix L. This test was witnessed by Michael W. Wengrenovich, P. E. (H&S) and Len Fishkin, P.G. (FDEP).

4.3.2 IW6 Casing Pressure Test

On June 24, 1999, the 24-inch injection well casing was internally pressurized to 232 psi. A pressure increase of 1.0 psi was observed over the 60 minute test period. This increase represents a 0.4 percent change in the original pressure, which is within the 5.0 percent limits specified by the regulations. A copy of the test gauge certification records and certified results of the hydrostatic pressure test are contained in Appendix L. This test was witnessed by Christina Garcia-Marquez, P. E. (H&S) and Mark Silverman, P.G. (FDEP).

4.3.5 IW5 Temperature Log

On March 3, 2000, a temperature log was conducted on IW5 from the surface to a total depth of 3507 feet bpl. The temperature from surface to 200 feet bpl increased from 70° F to 76° F; below this point the temperature decreased to 70° F to a depth of 1190 feet bpl. From 1190 to 2500 feet bpl, the temperature decreased to 65° F. From 2500 to 2700 feet bpl, the temperature log increases to about 70° F. At a depth of 2995 feet bpl, the base of the 24-inch-diameter casing the temperature log increased to about 74° F. From 3020 to 3070 feet bpl, the temperature decreased to 61° F. At a depth of 3320 feet bpl, the log indicated a rapid decrease in temperature to 53° F. This decrease seems to indicate that most of the injected fluid will be received by the formation above 3325 feet bpl. A copy of the temperature log is contained in Appendix G.

4.3.6 IW6 Temperature Log

On March 7, 2000, a temperature log was conducted on IW6 from the surface to a total depth of 3510 feet bpl. The temperature was a constant 70° F from surface to 500 feet bpl; below this point the temperature decreased to 62° F to a depth of 2830 feet bpl. From 2830 to 2995 feet bpl, the approximate base of the 24-inch-diameter casing the temperature increased to about 68° F. From 2995 to 3150 feet bpl, the temperature decreased to 51° F. This decrease seems to indicate that most of the injected fluid will be received by the formation above 3150 feet bpl. The temperature in the open hole from 3150 feet bpl to the bottom of the logged interval remained generally constant at 51° F. A copy of the temperature log is contained in Appendix G.

4.3.7 IW5 Television Survey

A television (video) survey of IW5 was performed on November 4, 1999. The survey was performed from pad level to a depth of 3506 feet bpl. Water clarity was good, enabling the camera to capture clear images of the casing interior, casing seat and open-hole section. The survey revealed that the casing was in excellent condition. A video copy of the television survey is included in Appendix I.

4.3.8 IW6 Television Survey

A television survey of IW6 was performed on November 9, 1999. The survey was performed from pad level to a depth of 3510 feet bpl. Water clarity was good, enabling the camera to capture clear images of the casing interior, casing seat and open-hole section. The survey revealed that the casing was in excellent condition. A video copy of the television survey is included in Appendix I.

4.3.9 IW5 Radioactive Tracer Survey

On March 6, 2000, a RTS was conducted on IW5. A schematic of the logging tool is shown in Figure 9. The RTS was witnessed by James A. Wheatley, P. G. of WTA and Mark Silverman, P.G. of FDEP. A copy of the radioactive tracer survey of the injection well is contained in Appendix G.

The test began by conducting a background gamma ray log (GRL) and a casing collar locator (CCL). The background GRL was "memorized" and subsequently reprinted on each out-of-position logging run to serve as a means of comparison. Each logging run is identified by its name presented at the top of the log. After the completion of the background GRL, the logging tool ejector was calibrated to a 0.5 millicurie (mCi) per second discharge, and the reservoir was loaded with 10 mCi of radioactive Iodine 131.

The first test conducted was a static test. For this test, the ejector port was positioned one foot below the bottom of the 24-inch injection casing, and a two mCi slug of tracer material was released under static conditions (no injection occurring). Time drive monitoring was conducted for 60 minutes after release. At about the 2 ½ minute mark, the middle detector showed evidence of the slug dispersing downward from the ejector. At about the 5 minute mark, the top detector showed evidence of the slug dispersing upward from the ejector. At this time, the logging tool was moved up hole 20 feet, and the monitoring period resumed. At about the 20 minute mark, the top detector showed evidence of the slug dispersing upward from the ejector. At this time, the logging tool was moved up hole 20 feet, and the monitoring period resumed. From the 20 minute mark to the end of the monitoring period, no tracer was detected. After the 60 minutes of time drive logging, the tools were moved up hole and logged out-of-position. After the log out-of-position, the well was flushed with approximately 24,000 gallons of potable water. After flushing, an additional log out-of-position was conducted. This log showed that all tracer material had been flushed out of the casing since all gamma ray levels returned to background. The results of this test indicated that the tracer material had dispersed to points approximately 20 feet from the point of ejection.

A dynamic test was performed next. An injection rate of 100 gpm was established using potable water. The tracer ejector was positioned five feet above the bottom of the casing. The recorder was placed in the time drive mode, and a two mCi slug of tracer material was ejected. The readings from the middle gamma ray detector began to increase from background within one minute of ejection. The readings from the bottom detector increased from background approximately three minutes after ejection. No detection of the tracer material was observed at the upper gamma ray detector any time during 60 minutes of time drive monitoring. The tools were then logged out-of-position to a depth of 2750 feet bpl. The results of the log out-of-position showed no indication of tracer material movement up hole. The injection casing was then flushed with approximately 21,000 gallons of potable water. Following the flushing, an out-of-position log was conducted from below the casing to 2750 feet bpl. This log showed that all tracer material had been flushed out of the casing because the gamma ray levels on the top detector returned to background levels. The levels recorded on the middle and bottom detectors indicated that tool staining had occurred. These results demonstrate casing integrity and that there are no channels behind the casing.

The final tracer test was a second dynamic test. The injection rate into the well was adjusted to 100 gpm using potable water. The logging tools were positioned so that the ejector was five feet above the bottom of the casing. The recorder was placed in time drive mode, and two mCi slug of tracer material was ejected. The readings from the middle gamma ray detector began to increase from background within one minute of ejection. The readings from the bottom detector increased from background approximately three minutes after ejection. No detection of the tracer material was observed at the upper gamma ray detector any time during 60 minutes of time drive monitoring. The tools were then logged out-of-position to a depth of 2750 feet bpl. The results of the log out-of-position showed no indication of tracer material movement up hole. The injection casing was then flushed with approximately 10,000 gallons of potable water. Following the flushing, an out-of-position log was conducted from below the casing to 2750 feet bpl; this log showed that all tracer material had been flushed out of the casing because the gamma ray levels on the top detector returned to background levels. The levels recorded on the middle and bottom detectors indicated that tool staining had occurred. These results demonstrate casing integrity and that there are no channels behind the casing.

Upon the completion of all the above mentioned tests, a final background log was conducted on the total depth of the well. The logs were recorded over traces of the initial background log and showed excellent repeatability on all detectors.

4.3.10 IW6 Radioactive Tracer Survey

On March 8, 2000, a RTS was conducted on IW6. A schematic of the logging tool is shown in Figure 9. The RTS was witnessed by James A. Wheatley, P. G. of WTA and Mark Silverman, P.G. of FDEP. A copy of the radioactive tracer survey of the injection well is contained in Appendix G.

The test began by conducting a background GRL and a CCL. The background GRL was "memorized" and subsequently reprinted on each out-of-position logging run to serve as a means of comparison. Each logging run is identified by its name presented at the top of the log. After the completion of the background GRL, the logging tool ejector was calibrated to a 0.5 mCi per second discharge, and the reservoir was loaded with 10 mCi of radioactive Iodine 131.

The first test conducted was a static test. For this test, the ejector port was positioned one foot below the bottom of the 24-inch injection casing, and a two mCi slug of tracer material was released under static conditions (no injection occurring). Time drive monitoring was conducted for 60 minutes after release. At about the 15 minute mark, the top detector showed evidence of the slug dispersing upward from the ejector. At this time, the logging tool was moved up hole 20 feet and the monitoring period resumed. At about the 50 minute mark, the top detector showed evidence of the slug dispersing upward from the ejector. At this time, the logging tool was moved up hole 20 feet and the monitoring period resumed. After the 60 minutes of time drive logging, the tools were moved up hole and logged out-of-position. After the log out-of-position, the well was flushed with approximately 6,000 gallons of potable water. After flushing, an additional log out-of-position was conducted. This log showed that all tracer material had been flushed out of the casing since all gamma ray levels returned to background. The results of this test indicated that the tracer material had dispersed to points approximately 20 feet from the point of ejection.

A dynamic test was performed next. An injection rate of 100 gpm was established using potable water. The tracer ejector was positioned five feet above the bottom of the casing. The recorder was placed in the time drive mode, and a two mCi slug of tracer material was ejected. No detection of the tracer material was observed on any gamma ray detector any time during 60 minutes of time drive monitoring. The tools were then logged out-of-position to a depth of 2750 feet bpl. The results of the log out-of-position showed no indication of tracer material movement up hole. The injection casing was then flushed with approximately 6,000 gallons of potable water. Following the flushing, an out-of-position log was conducted from below the casing to 2750 feet bpl. This log showed that all tracer material had been flushed out of the casing because the gamma ray levels on the top detector returned to background levels. The levels recorded on the middle and bottom detectors indicated that tool staining had occurred. These results demonstrate casing integrity and that there are no channels behind the casing.

The final tracer test was a second dynamic test. The injection rate into the well was adjusted to 100 gpm using potable water. The logging tools were positioned so that the ejector was five feet above the bottom of the casing. The recorder was placed in time drive mode, and a two mCi slug of tracer material was ejected. No detection of the tracer material was observed on any gamma ray detector any time during 60 minutes of time drive monitoring. The tools were then logged out-of-position to a depth of 2750 feet bpl. The results of the log out-of-position showed no indication of tracer material movement up hole. The injection casing was then flushed with approximately 6,000 gallons of potable water. Following the flushing, an out-of-position log was conducted from below the casing to 2750 feet bpl. This log showed that all tracer material had been flushed out of the casing because the gamma ray levels on the top detector returned to background levels. The levels recorded on the middle and bottom detectors indicated that tool staining had occurred. These results demonstrate casing integrity and that there are no channels behind the casing.

Upon the completion of all the above mentioned tests, a final background log was conducted on the total depth of the well. The logs were recorded over traces of the initial background log and showed excellent repeatability on all detectors.

4.3.11 MIT Conclusions

Based on the results of the temperature logs, hydrostatic pressure tests, television surveys and radioactive tracer surveys, IW5 and IW6 have been demonstrated to have mechanical integrity.

4.4 Injection Tests

4.4.1 IW5 Injection Test

On June 22, 2000, a controlled injection test was conducted on IW5 utilizing plant effluent as the source water for testing. The test consisted of a 24-hour background period, during which transducers were placed at a depth of 2990 feet bpl in IW5 and IW6 to monitor bottomhole pressure changes. Transducers were also placed such that wellhead pressure changes of IW5, IW6 and both zones MW3 and MW4 could be monitored. During the test, pressures at IW1, IW2, IW3, IW4 and both zones of MW1 and MW2 were monitored by the existing plant control system. After performing background monitoring, the 24-hour injection test was started. The injection rate was 16,400 gpm. This injection rate equates to a velocity of approximately 12.7 ft/sec. The maximum wellhead pressure during the tests was approximately 65 psi. The wellhead shut-in pressure before and after the testing was approximately 30 psi. During the testing period, the bottom hole pressure showed an increase of approximately five psi. This pressure is not sufficient to induce fractures in the injection zone or confining sequences. During the test, no measurable pressure changes attributable to injection were detected in any of the monitor zones. A copy of the data obtained during the injection test is presented in Appendix Q.

4.4.2 IW6 Injection Test

On June 7, 2000, a controlled injection test was conducted on IW6 utilizing plant effluent as the source water for testing. The test consisted of a 24-hour background period, during which transducers were placed at a depth of 2990 feet bpl in IW6 and IW5 to monitor bottomhole pressure changes. Transducers were also placed such that wellhead pressure changes of IW6, IW5 and both zones MW3 and MW4 could be monitored. During the test, pressures at IW1, IW2, IW3, IW4 and both zones of MW1 and MW2 were monitored by the existing plant control system. After performing background monitoring, the 24-hour injection test was started. The injection rate was 16,400 gpm. This injection rate equates to a velocity of approximately 12.7 ft/sec. The maximum wellhead pressure during the tests was approximately 61 psi. The wellhead shut-in pressure before and after the testing was approximately 30 psi. During the testing period, the bottom hole pressure showed an increase of approximately four psi. This pressure is not sufficient to induce fractures in the injection zone or confining sequences. During the test, no measurable pressure changes attributable to injection were detected in any of the monitor zones. A copy of the data obtained during the injection test is presented in Appendix Q.

5.0 Findings and Recommendations

5.1 Findings

The following list summarizes the findings identified during the construction of the injection and monitor wells.

- The base of the USDW, the point where the water contains 10,000 mg/l TDS, occurs approximately between 1630 to 1650 feet bpl.
- The confining sequences generally occurs between 1650 feet and 2000 feet bpl.
- Vertical hydraulic conductivity determined from core testing within the confining sequences ranged from 1.6×10^{-9} to 1.4×10^{-3} cm/sec.
- Hydraulic conductivity determined from packer testing within the confining sequences ranged from 3.0×10^{-5} to 6.6×10^{-4} cm/sec.
- Indicators of plant effluent were detected below 2000 feet bpl during the drilling of IW5 and IW6. This indicates that the top of the injection zone may extend up to this level.
- The data demonstrates the existence of an extremely transmissive injection zone below 3000 feet bpl saturated with saline water (containing more than 10,000 mg/l TDS) similar to that which exists at other on-site operating injection wells.
- The injection zone is capable of accepting the maximum design flowrate equivalent to a velocity of 12 feet per second in the wells at a reasonable injection pressure that will not promote fractures in the injection zone or confining sequences.
- IW5 and IW6 were successfully pressure tested at 197 and 232 psi, respectively.
- The testing program has demonstrated that IW5 and IW6 have mechanical integrity.
- Two dual zone monitor wells were drilled. The constructed upper lower monitor zone for MW3 is from 1380 to 1426 feet bpl and the lower zone is from 1633 to 1683 feet bpl. The constructed upper lower monitor zone for MW4 is from 1385 to1 435 feet bpl and the lower zone is from 1580 to 1630 feet bpl.

5.2 Conclusions

The presence of favorable geologic conditions, a highly transmissive injection zone filled with water having greater than 10,000 mg/l TDS, suitable confining sequence, and suitable monitor zones will permit the use of injection wells for disposal of treated effluent at the Broward County NRWWTP in accordance with existing state and federal underground injection control regulations.

Based on the results of the geophysical logging and testing performed at the Broward County NRWWTP, injection wells IW5 and IW6 have mechanical integrity and are ready to begin operational testing.

5.3 Recommendations

Operation of the monitor wells is to begin within one month after the construction of the surface facilities is complete. Injection well operation may begin operating under the construction permit after operational testing approval is issued by FDEP.

The following recommendations are in accordance with requirements of FAC Rule 62-528 for the safe operation of an injection well system. These procedures should be carried out conscientiously to ensure compliance with the injection well construction permits (refer to Appendix A) and all regulatory requirements and to ensure successful operation of the well. Additional information on monitoring and reporting data is discussed in Section 5.4.

- Dual zone monitor well pressure is to be continuously monitored.
- Injection wellhead pressure is to be continuously monitored.
- Flow to injection wells is to be continuously monitored.
- Dual zone monitor well water quality is to be monitored weekly.
- Waste stream (plant effluent) water quality is to be monitored monthly.
- Injection well injectivity tests are to be performed quarterly.
- A complete analysis of the waste stream is to be performed yearly.
- Injection well mechanical integrity tests are to be performed every five years.
- The eight shallow pad wells are to be maintained for future use.

5.4 Well Operation, Maintenance and Future Testing

When each injection well is operational, a variety of data will be collected to satisfy statutory/permit requirements and to assist in managing the system. This section discusses the basic requirements for data collection to maintain permit compliance during both the initial testing and long-term operation of the injection well system. Initially, the injection wells will be operating under the construction permits. Six months of operation are required before the County can apply for an operating permit. The construction permits for IW5 and IW6 expire February 2, 2004. It is essential that the performance data collection begin upon operational startup in order to establish baseline information which both satisfies regulatory requirements and serves for future data comparison and performance analyses. These records should be permanently maintained.

5.4.1 Monitor Well Data Collection

The purpose of monitor zone data collection is to detect changes in water quality attributable to the injection of treated effluent into the nearby injection wells. In order to collect the water quality samples, the deep monitor well zones have been equipped with two sampling pumps, one for each zone. Interconnection of piping from the different zones and wells is not permitted by FDEP. Prior to collecting water samples for analysis, at least three well volumes have to be pumped from the monitor zones. Well water is pumped to the sample sinks in the injection well pump station. Excess well water is discharged into the injection well pump station wetwell and is pumped down the injection wells.

Dual zone monitor well water quality is to be monitored through weekly samples from the two dual zone monitor well zones which are to be collected and analyzed weekly for TDS, chlorides, ammonia, TKN, nitrate, nitrite, pH, specific conductance, fecal coliform, total phosphorous, sulfate and temperature. The results of these analyses are to be sent to the FDEP monthly.

The pressure in both zones of the dual zone monitor wells is to be continuously monitored and recorded. Average, maximum and minimum pressure are to be reported to FDEP monthly.

5.4.2 Injection Well Data Collection

Beginning with the start of the use of injection wells, injection records should be maintained to evaluate injection well performance.

The pressure at the injection wellheads is to be continuously monitored and recorded. Average, maximum and minimum pressure are to be reported to FDEP monthly.

The flowrate into the injection wells is to be continuously monitored and recorded. Average, maximum, and minimum flow rates, as well as the total volume of effluent pumped into the well are to be reported to the FDEP on a monthly basis.

5.4.3 Injectivity Testing

Periodic determination of the injectivity of a well is used as a measure of the efficiency of a well and is a permit requirement as a management tool for the injection well system. The injectivity test involves injecting effluent into a well at three (or more) injection rates and recording the injection pressure for each rate. The shut-in pressure of the injection well is to be measured before each different injection rate. The injectivity is calculated by dividing the injection rate by the required injection pressure (wellhead injection pressure minus shut-in wellhead pressure). The result is expressed as gallons per minute per pounds per square inch (mgd/psi).

Factors effecting the injection wellhead pressure are a function of:

- The density differential between treated effluent and the formation water in the injection zone;
- The friction loss in the casing; and
- The bottom hole pressure (injection zone transmissivity).

The latter is fairly constant as long as the temperature and density of the injection and formation fluids remain constant. Friction loss in the casing and bottom hole pressure can vary as a result of changes in the flowrate, physical condition of the injection zone and physical condition of the pipe. In general, pressure builds slowly with time (for a given pumping rate) as the casing "ages". Similarly, plugging of an injection zone can cause a gradual pressure build-up over time. Testing is required to be conducted quarterly for the life of the well. The testing rates for injectivity testing should be established as soon as the well is placed in operation. The test procedure should be easily repeatable.

A specific injectivity test is required to be performed quarterly. The pumping rates should be established after the well is in operation. Flow to the wells and wellhead pressures are to be recorded during this period. Test results are to be reported to the FDEP upon completion of the testing.

5.4.4 Mechanical Integrity

An injection well has mechanical integrity when there is no leak in the casing and no fluid movement into the underground source of drinking water through channels adjacent to the well bore. Mechanical integrity testing includes a pressure test, a radioactive tracer survey, a high resolution temperature log and a television survey. This testing will be used, along with the monitoring data of the upper and lower monitor zones, to demonstrate the absence of fluid movement above the injection zone.

Each injection well is to be tested for mechanical integrity every five years in accordance with FAC Rule 62-528. Based on the dates of testing during construction, the next MIT to be performed on IW5 and IW6 is November 5, 2004 and June 24, 2004, respectively. The proposed MIT plan must be approved by FDEP prior to performing mechanical integrity testing. Request for approval should be made approximately six months prior to the required completion date.

5.4.5 Waste Stream Analysis

Samples from the waste stream are to be collected and analyzed monthly for TDS, ammonia, TKN, nitrate, specific conductance, total phosphorous and pH. The results of these analyses are to be sent to the FDEP monthly.

5.5 Plugging and Abandonment Plan

In the event that an injection well has to be abandoned, the well must be effectively sealed (or plugged) to prevent upward migration of the injection zone fluid or the interchange of formation water through the borehole or along the casing. The plugging program will require the services of a qualified drilling contractor with equipment capable of installing drill pipe to a depth of 3,000 feet and pumping neat cement.

The following procedures would be followed to abandon an injection well:

- Obtain a permit from the FDEP.
- Suppress the wellhead pressure with drilling mud.
- Remove the wellhead assembly.
- Fill the open hole with crushed limestone.
- Place a sand cap on the crushed limestone to the bottom of the 24-inch casing.
- Fill the 24-inch casing with neat cement.

The following procedures would be followed to abandon a dual zone monitor well:

- Obtain a permit from the FDEP.
- Suppress the wellhead pressure with drilling mud.
- Remove the wellhead assembly.
- Fill the deep zone and the 6⅝-inch diameter casing with neat cement grout.
- Fill the shallow zone and the 16-inch diameter casing with neat cement grout

A cost estimate for plugging and abandoning the wells is presented in Table 6.

TABLES

Table 1
Core Depths

IW5 Core Depth (feet bpl)	IW6 Core Depth (feet bpl)	MW4 Core Depth (feet bpl)
1680 - 1690	1786 - 1796	1520 - 1530
1745 - 1755	1796 - 1805	1546 - 1556
1800 - 1810	1805 - 1815	1576 - 1586
1850 - 1860	1815 - 1836	1587 - 1597
1950 - 1960	1965 - 1975	1630 - 1640
	1982 - 1996	1650 - 1661
		1708 - 1720
		1758 - 1788
		1886 - 1896

Table 2 (continued)
Hydraulic Conductivity Derived from MW4 Cores

Interval (feet bpl)	Well	Horizontal Hydraulic Conductivity (cm/sec)	Vertical Hydraulic Conductivity (cm/sec)
1889.75 – 1890.25	MW4	3.6×10^{-4}	5.3×10^{-4}
1889.75 – 1890.25	MW4	4.7×10^{-4}	3.4×10^{-4}
1890.25 – 1890.85	MW4	1.2×10^{-4}	1.4×10^{-4}
1891.00 – 1891.50	MW4	3.6×10^{-4}	2.0×10^{-4}
1894.75 – 1895.40	MW4	3.1×10^{-5}	7.4×10^{-5}
1951.4 – 1952.05	IW5	1.5×10^{-3}	1.6×10^{-9}
1953.95 – 1954.55	IW5	1.5×10^{-5}	1.4×10^{-5}
1955.25 – 1955.9	IW5	1.5×10^{-5}	1.4×10^{-5}
1966.0 – 1966.4	IW6	3.9×10^{-6}	2.2×10^{-6}
1966.5 – 1967.7 [t]	IW6	1.5×10^{-6}	2.0×10^{-6}
1966.5 – 1967.7 [b]	IW6	2.6×10^{-8}	3.8×10^{-8}
1968.0 – 1968.5	IW6	4.2×10^{-6}	3.1×10^{-6}
1988.0 – 1989.4	IW6	2.0×10^{-8}	3.1×10^{-9}
1989.3 – 1991.0	IW6	3.9×10^{-7}	1.9×10^{-7}
1993.5 – 1994.0	IW6	1.9×10^{-3}	1.4×10^{-3}
1995.3 – 1996.0	IW6	2.7×10^{-8}	9.6×10^{-5}

t = Top of sample consisted of limestone.
b = Bottom of sample consisted of dolomite.

Table 3
Packer Test Development

Depth (feet bpl)	Well	Air Development Time (min)	Air Development Rate (gpm)	Pump Development Time (min)	Pump Development Rate (gpm)
1380 – 1430 [d]	IW5	480	350	364	70
1520 – 1530 [s]	MW4	110	80	405	50
1546 – 1556 [s]	MW4	75	60	415	58
1587 – 1597 [s]	MW4	90	62	709	50
1626 – 1645 [d]	IW6	NA	NA	305	55
1633 – 1647 [d]	IW5	585	60 – 70	311	40
1633 – 1683 [d]	IW5	287	80	367	63
1634 – 1648 [d]	MW4	233	55	123	50
1650 – 1661 [s]	MW4	284	20	180	16 – 17
1664 – 1683 [d]	MW4	225	35	112	31
1684 – 1698 [d]	MW4	290	30	67	24
1708 – 1720 [s]	MW4	414	10	175	12 – 13
1737 – 1751 [d]	IW5	195	30	275	20
1756 – 1768 [s]	MW4	188	60	105	50
1765 – 1779 [d]	MW4	208	50	82	40
1776 – 1790 [d]	IW6	310	25	289	19
1791 – 1805 [d]	IW6	815	10	145	8
1793 – 1807 [d]	IW5	375	15	266	20
1816 – 1830 [d]	IW6	256	60	288	46
1834 – 1843 [d]	MW4	150	50	207	50
1863 – 1877 [d]	IW5	285	60	300	52
1864 – 1883 [d]	MW4	124	140	48	45
1882 – 1900 [s]	IW6	340	8	185	10
1884 – 1896 [s]	MW4	520	10 – 11	630	4 – 5
1920 – 1960 [s]	IW6	1665	70	455	43
1950 – 1960 [s]	IW5	560	7	385	5

d = Straddle packer.
s = Single packer.

Table 4
Hydraulic Conductivity Derived from Packer Tests

Depth Interval (feet bpl)	Well	Pumping Rate (gpm)	Maximum Drawdown (feet)	Drawdown Hydraulic Conductivity (cm/sec)	Drawdown Transmissivity (gpd/ft)	Recovery Hydraulic Conductivity (cm/sec)	Recovery Transmissivity (gpd/ft)
1380 – 1430	IW5	70	45	1.7×10^{-3}	1848	7.3×10^{-4}	782
1520 – 1530	MW4	50	51	6.7×10^{-3}	1419	1.4×10^{-3}	303
1546 – 1556*	MW4	—	—	—	—	—	—
1587 – 1597*	MW4	—	—	—	—	—	—
1626 – 1645	IW6	57	191	3.7×10^{-3}	111	3.8×10^{-4}	114
1633 – 1647	IW5	41	234	2.2×10^{-4}	68	2.2×10^{-4}	68
1633 – 1683	IW5	62	128	2.3×10^{-3}	165	1.2×10^{-3}	165
1634 – 1648	MW4	42	180	3.4×10^{-4}	102	3.9×10^{-4}	117
1650 – 1661	MW4	12.9	171	1.5×10^{-4}	37	1.0×10^{-4}	25
1664 – 1683	MW4	39	197	2.1×10^{-4}	85	1.5×10^{-4}	62
1684 – 1698	MW4	25	188	1.7×10^{-4}	52	1.4×10^{-4}	43
1708 – 1720	MW4	12	177	8.0×10^{-5}	20	8.0×10^{-5}	20
1737 – 1751	IW5	20	155	1.1×10^{-4}	36	1.2×10^{-4}	37
1756 – 1768	MW4	50	130	6.6×10^{-4}	167	5.4×10^{-4}	138
1765 – 1779	MW4	40	134	4.9×10^{-4}	146	2.9×10^{-4}	89
1776 – 1790	IW6	18	177	1.0×10^{-4}	31	1.0×10^{-4}	31
1791 – 1805	IW6	8	243	4.0×10^{-5}	12	3.0×10^{-5}	9
1793 – 1807	IW5	15	180	8.9×10^{-5}	27	8.0×10^{-5}	25
1816 – 1830	IW6	48	181	3.1×10^{-4}	93	3.2×10^{-4}	97
1863 – 1877	IW5	53	200	3.1×10^{-4}	93	2.4×10^{-4}	74
1882 – 1900	IW6	9	217	4.5×10^{-5}	17	3.1×10^{-5}	11
1884 – 1896	MW4	4.8	170	5.5×10^{-5}	14	3.5×10^{-5}	9.1
1920 – 1960	IW6	41	201	8.0×10^{-5}	68	8.0×10^{-5}	68
1950 – 1960	IW5	4	132	5.9×10^{-5}	12	5.3×10^{-5}	11

**Test results for water quality only.*

Table 5
Water Quality Analysis from Packer Tests

Depth Interval (feet)	Well	Ammonia (mg/l)	Chloride (mg/l)	Conductivity (umhos/cm)	Nitrite (mg/l)	Nitrate (mg/l)	Total Nitrogen (mg/l)	Organic Nitrogen (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Sulfate (mg/l)	TDS (mg/l)
1380 – 1430	IW5	0.38	2,512	7,300	< 0.01	< 0.01	2.2	1.8	2.2	609	4,700
1520 – 1530	MW4	1.11	3,549	9,030	< 0.01	< 0.05	1.18	< 0.20	1.18	637	6,020
1546 – 1556	MW4	1.02	3,299	8,670	< 0.01	0.03	1.11	< 0.20	1.08	575	5,840
1587 – 1597	MW4	0.99	3,349	9,030	< 0.01	0.03	1.14	< 0.20	1.11	575	5,900
1626 – 1645	IW6	0.46	4,650	12,310	< 0.01	< 0.01	2.0	1.54	2.0	542	8,830
1633 – 1683	IW5	0.43	6,848	20,400	< 0.01	0.05	0.95	0.52	0.95	667	13,735
1633 – 1647	IW5	0.48	6,200	14,700	< 0.01	< 0.01	0.21	< 0.2	0.54	630	9,090
1634 – 1648	MW4	0.55	6,998	13,000	< 0.01	< 0.01	1.09	0.54	1.09	594	8,620
1650 – 1661.5	MW4	0.62	7,998	15,720	< 0.01	< 0.01	1.39	0.77	1.39	845	10,375
1664 – 1683	MW4	0.48	8,997	16,380	< 0.01	0.05	1.05	0.52	1.00	703	15,400
1684 – 1698	MW4	0.51	9,497	18,980	< 0.01	< 0.01	1.07	0.56	1.07	797	14,900
1708 – 1720	MW4	0.40	14,496	22,000	< 0.01	< 0.01	1.28	0.87	1.27	1,150	17,680
1737 – 1751	IW5	0.33	14,000	32,200	< 0.01	< 0.01	0.25	< 0.2	0.25	33	28,300
1756 – 1768	MW4	0.36	16,495	24,300	< 0.01	< 0.01	0.91	0.55	0.91	1,450	20,010
1765 – 1779	MW4	0.18	13,496	24,300	< 0.01	< 0.01	0.78	0.60	0.78	1,333	21,680
1776 – 1790	IW6	0.42	13,000	38,500	N/A	< 0.01	< 0.2	< 0.2	< 0.2	1,250	24,400
1791 – 1805	IW6	0.41	11,600	26,750	< 0.01	< 0.01	1.2	0.8	1.2	898	20,000
1793 – 1807	IW5	0.30	11,997	20,500	< 0.01	< 0.01	0.3	< 0.1	0.30	3,418	16,625
1816 – 1830	IW6	0.43	12,600	29,800	N/A	< 0.01	< 0.2	< 0.2	< 0.2	1,250	23,250
1863 – 1877	IW5	0.30	15,300	33,800	< 0.01	< 0.01	1.2	0.9	1.2	1,891	22,750
1882 – 1900	IW6	0.21	17,095	46,700	< 0.01	< 0.01	0.21	1.9	2.1	2,120	36,950
1884 – 1896	MW4	0.09	17,944	29,200	< 0.01	0.05	0.64	0.50	0.59	2,355	18,130
1920 – 1960	IW6	0.94	16,500	33,900	< 0.01	< 0.05	1.5	0.6	1.5	1,423	32,348
1950 – 1960	IW5	0.69	16,495	35,100	< 0.01	< 0.01	1.29	0.60	1.29	4,708	28,625

Note: Data from Sanders Laboratories

Table 6
Plugging and Abandonment Cost Estimates

Task	Unit Cost	Plan Estimate
Injection Well		
Mobilization	$20,000	$20,000
MIT	$20,000	$20,000
Crushed Limestone	$10/cu ft	$40,000
4,000 cu ft	$10/cu ft	$40,000
Neat Cement	$10/cu ft	$100,000
10,000 cu ft	$10/cu ft	$100,000
20% Contingency		$36,000
TOTAL		$216,000
Dual Zone Monitor Well		
Mobilization	$10,000	$10,000
Neat Cement	$10/cu ft	$30,000
3000 cu ft	$10/cu ft	$30,000
20% Contingency		$8,000
TOTAL		$48,000

FIGURES

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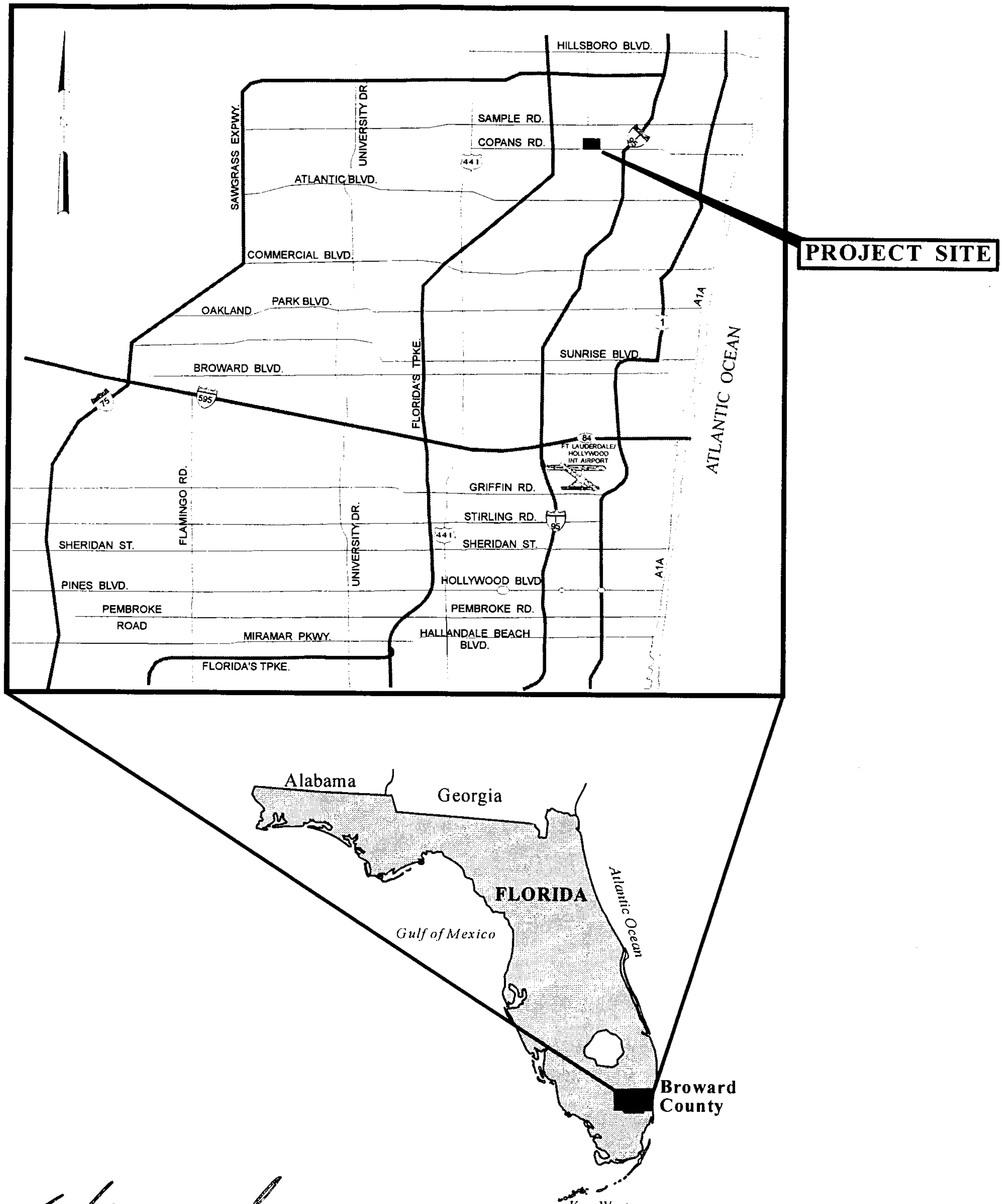


MICHAEL W. WENGRENOVICH, P.E.
Registration No. 34939 6/2/02

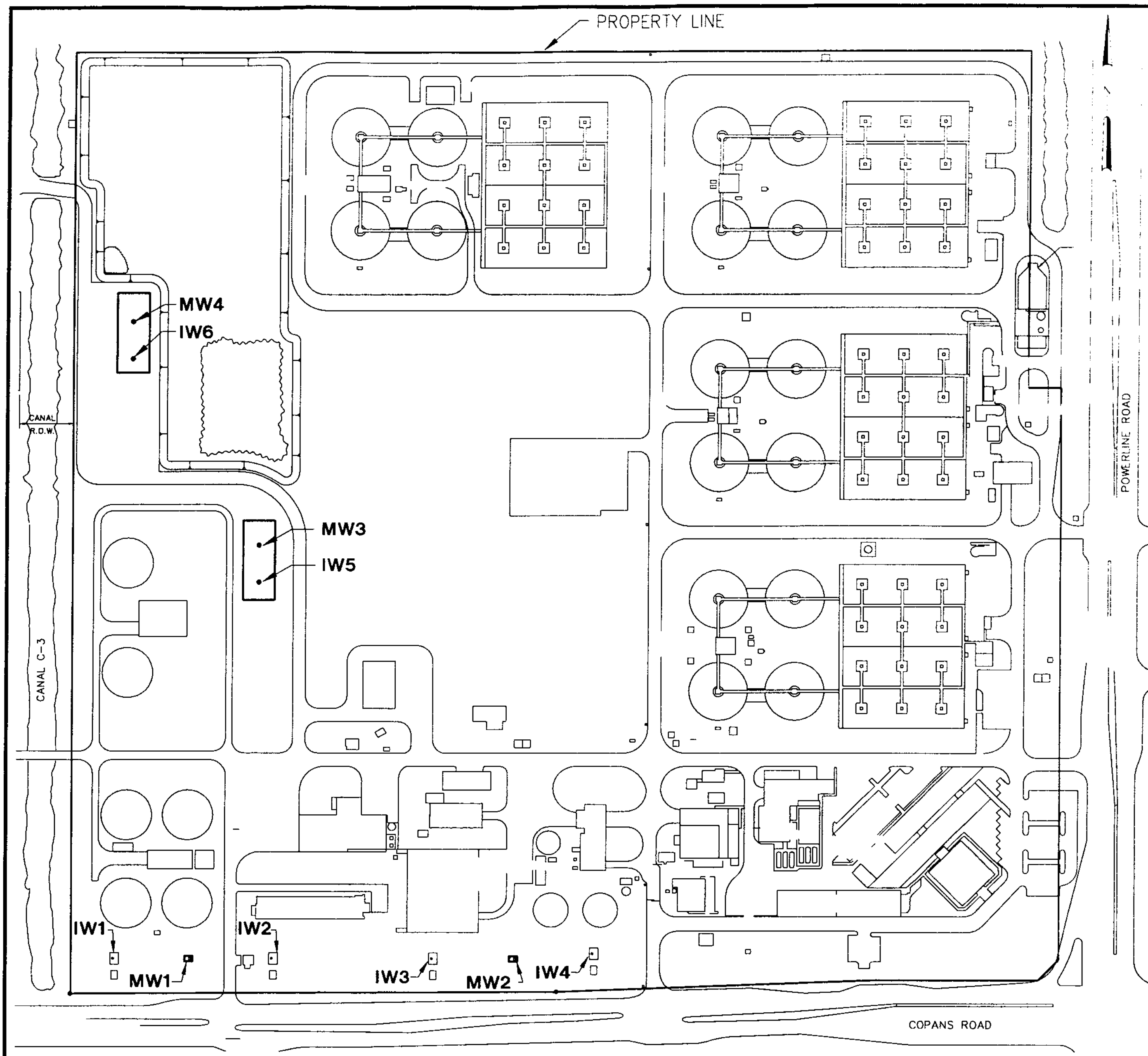
HAZEN AND SAWYER
Environmental Engineers & Scientists
4000 Hollywood Boulevard, Suite 750N
Hollywood, Florida 33021
(954) 987-0066

BROWARD COUNTY FLORIDA

INJECTIONS WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

LOCATION MAP

FIGURE 1



BROWARD COUNTY NORTH REGIONAL WWTP

WELL LOCATION

WELL	LATITUDE	LONGITUDE
IW5	N 26° 15' 45"	W 80° 09' 24"
IW6	N 26° 15' 49"	W 80° 09' 27"
MW3	N 26° 15' 46"	W 80° 09' 24"
MW4	N 26° 15' 49"	W 80° 09' 27"

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1"=300'
300 150 0 300'

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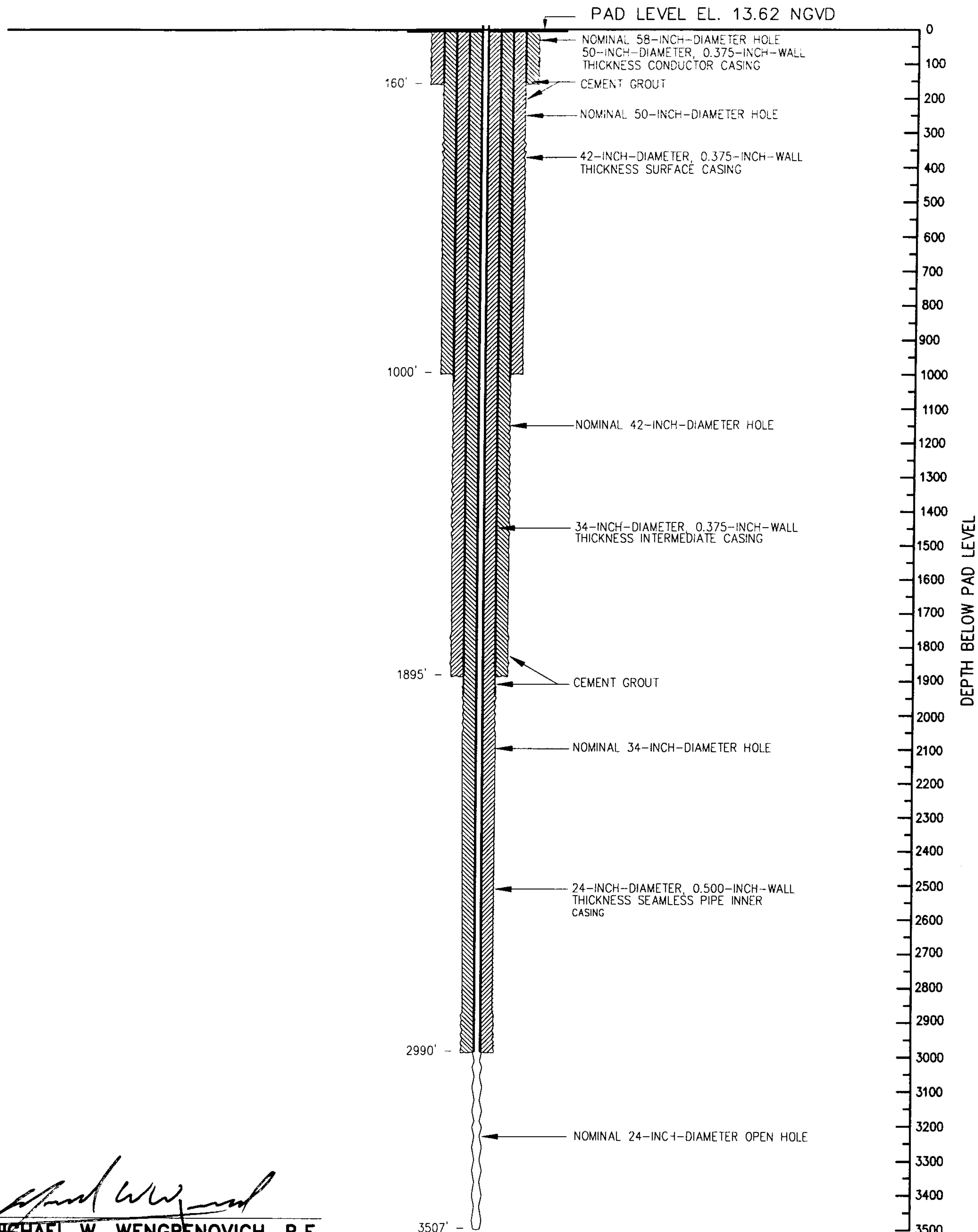
BROWARD COUNTY
FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

WELL LOCATION
AS-BUILT SITE PLAN

FIGURE
2



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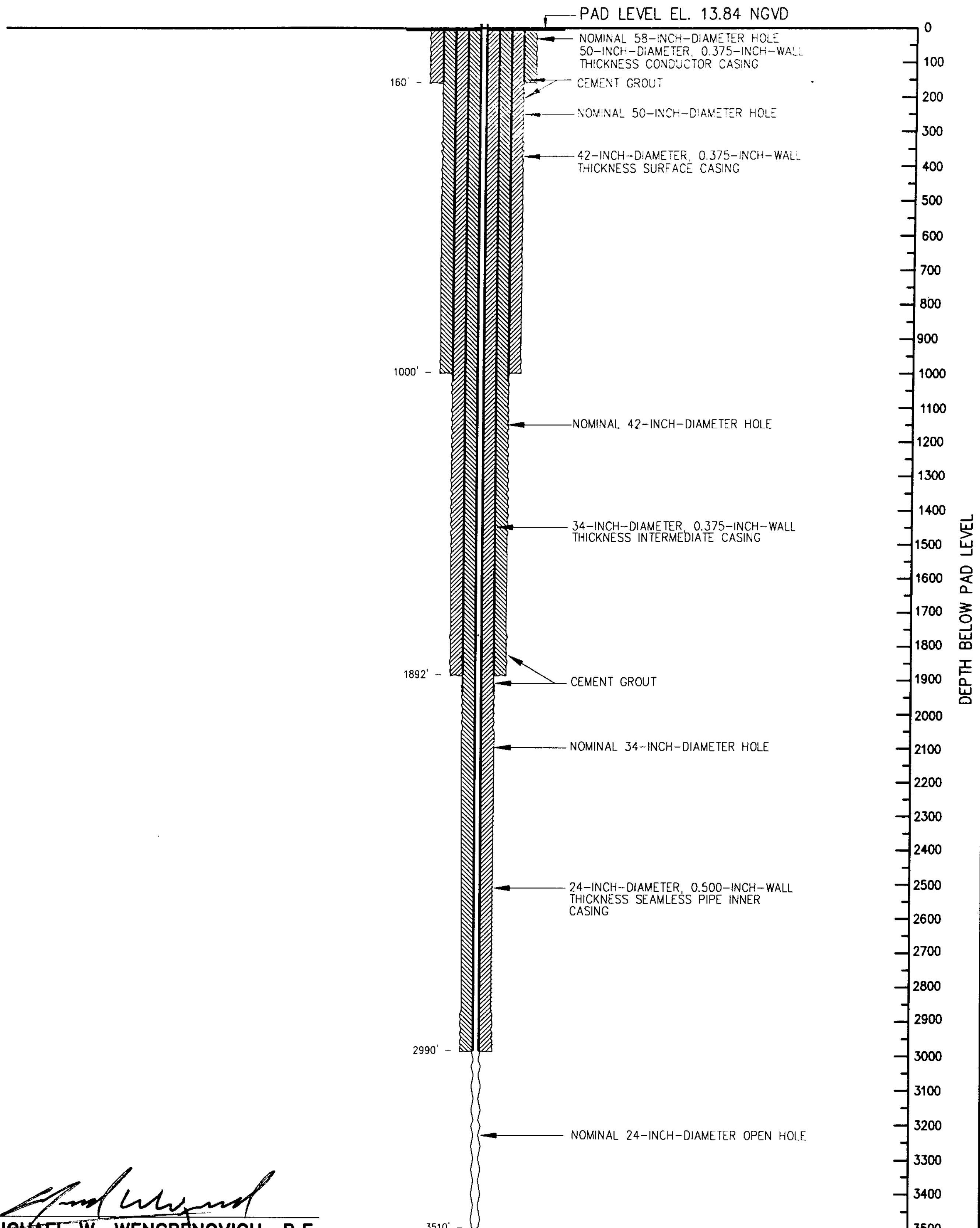
BROWARD COUNTY
FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

IW5 AS-BUILT WELL PROFILE

FIGURE
3

7/25/2000/9:44 A.M. - 07 HLWD - H:\4598\EXHIBITS\Well5-6\4598x3.dwg - XREFS: - PS 1=1



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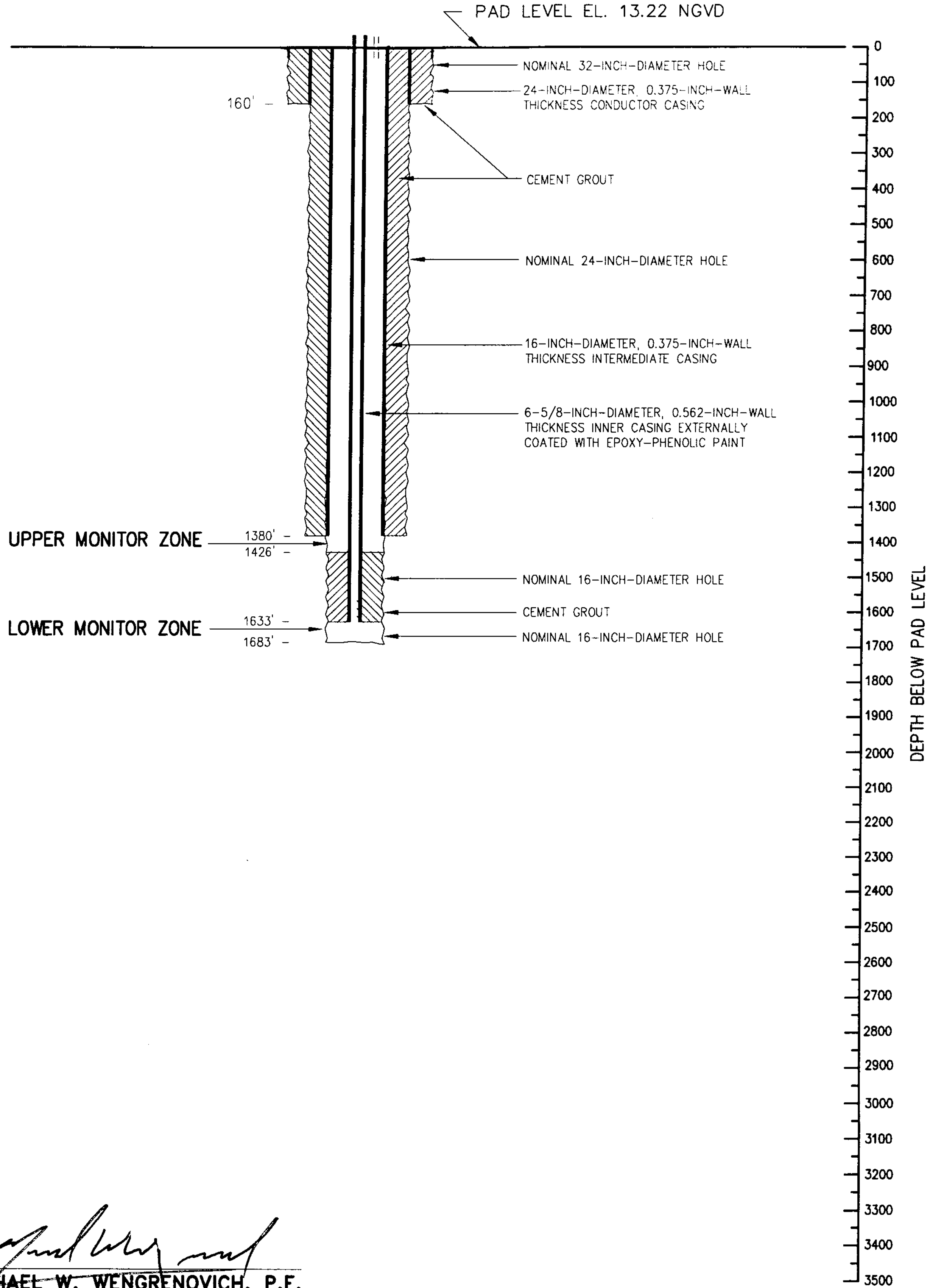
BROWARD COUNTY
FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

IW6 AS-BUILT WELL PROFILE

FIGURE
4

7/25/2000/9:50 A.M. - 07 HLWD - H:\4598\EXHIBITS\Well5-6\4598x4.dwg - XREFS: - PS 1=1



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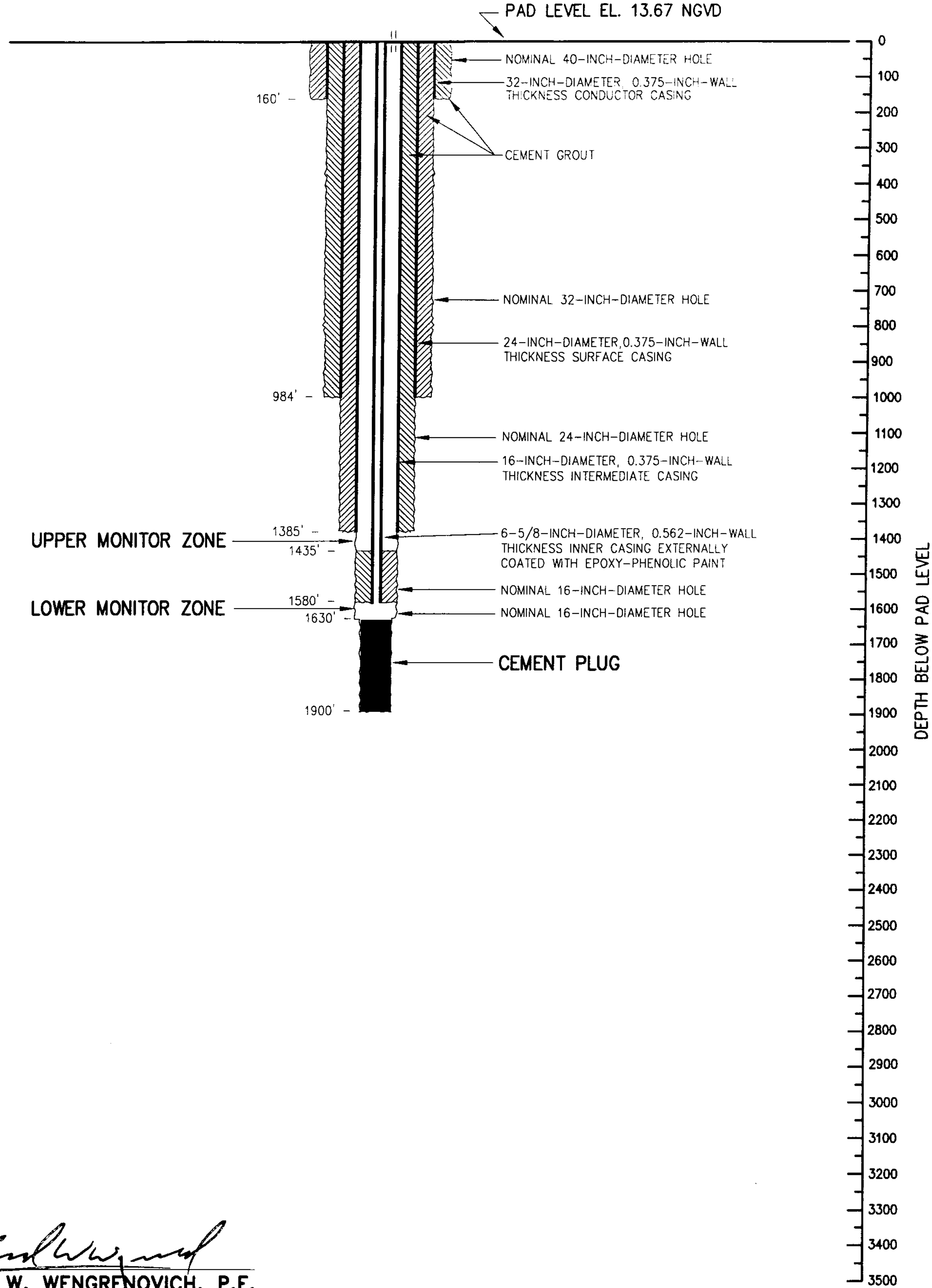
BROWARD COUNTY
FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

MW3 AS-BUILT WELL PROFILE

FIGURE **5**

7/25/2000/9:53 A.M. - 07 HLWD - H:\4598\EXHIBITS\Well5-6\4598x5.dwg - XREFS: - PS 1=1



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Registration No. 34939
8/2/00

7/25/2000/9:56 A.M. - 07 HLWD - H:\4598\EXHIBITS\Well5-6\4598x6.dwg - XREFS: - PS 1=1

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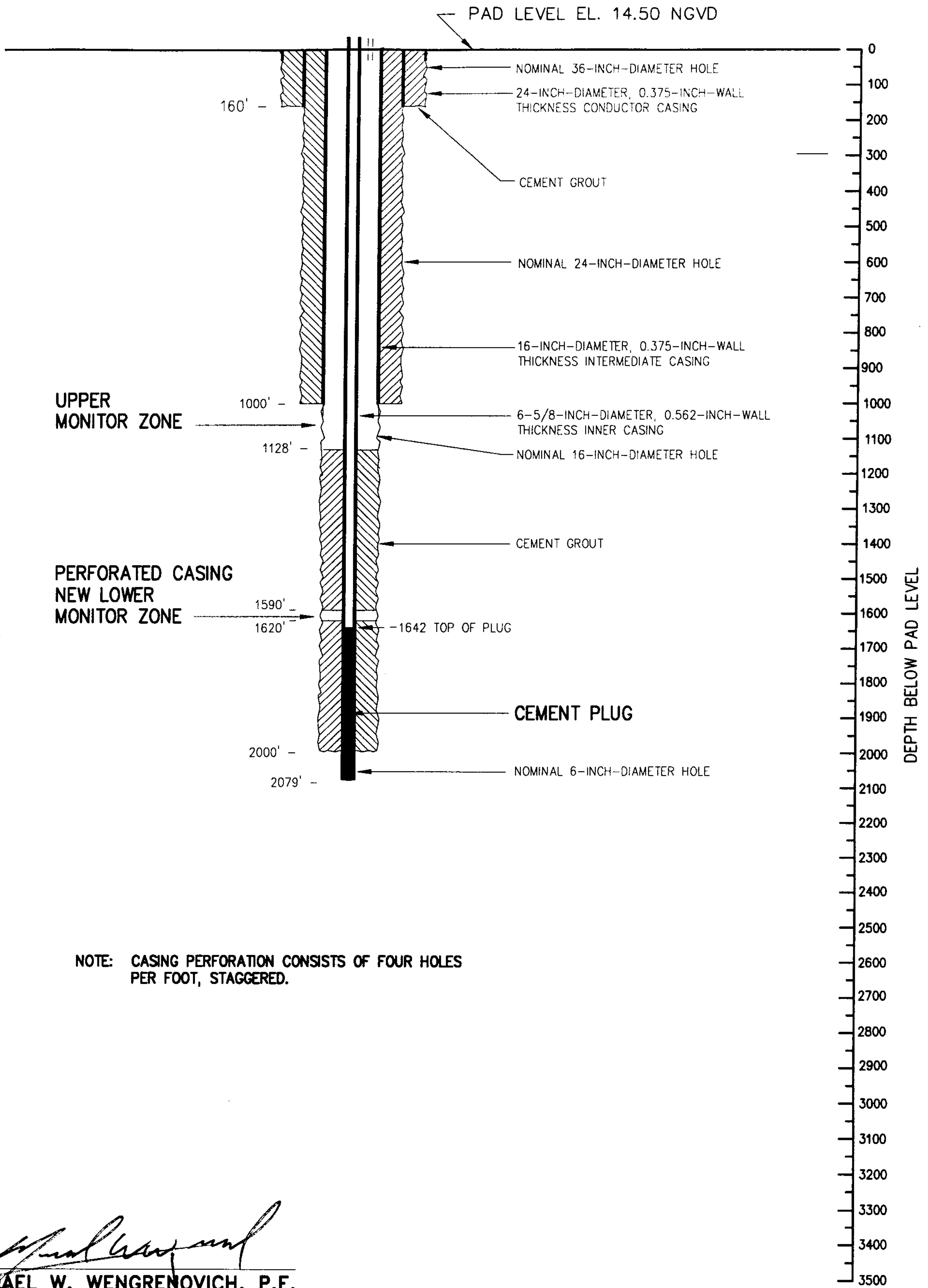
BROWARD COUNTY FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

MW4 AS-BUILT WELL PROFILE

FIGURE 6



NOTE: CASING PERFORATION CONSISTS OF FOUR HOLES PER FOOT, STAGGERED.

MICHAEL W. WENGRENOVICH, P.E.
Registration No. 34939
8/2/00

7/19/2000/10:34 A.M. - 07 HLWD - H:\4598\EXHIBITS\Well5-6\4598x7.dwg - XREFS: - PS 1=1

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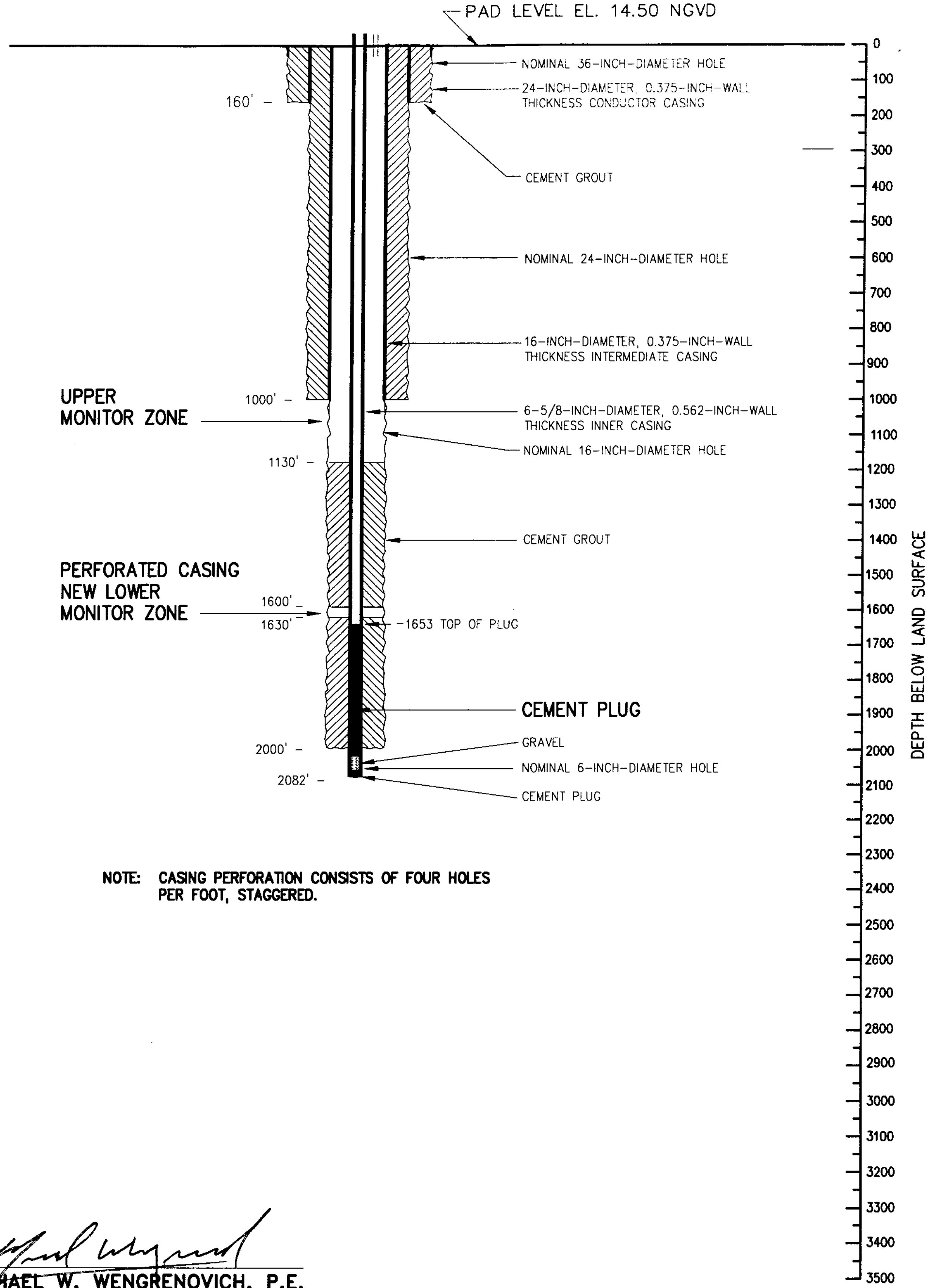
BROWARD COUNTY FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

MW1 AS-BUILT WELL PROFILE

FIGURE 7



NOTE: CASING PERFORATION CONSISTS OF FOUR HOLES PER FOOT, STAGGERED.

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Registration No. 34939
8/2/00

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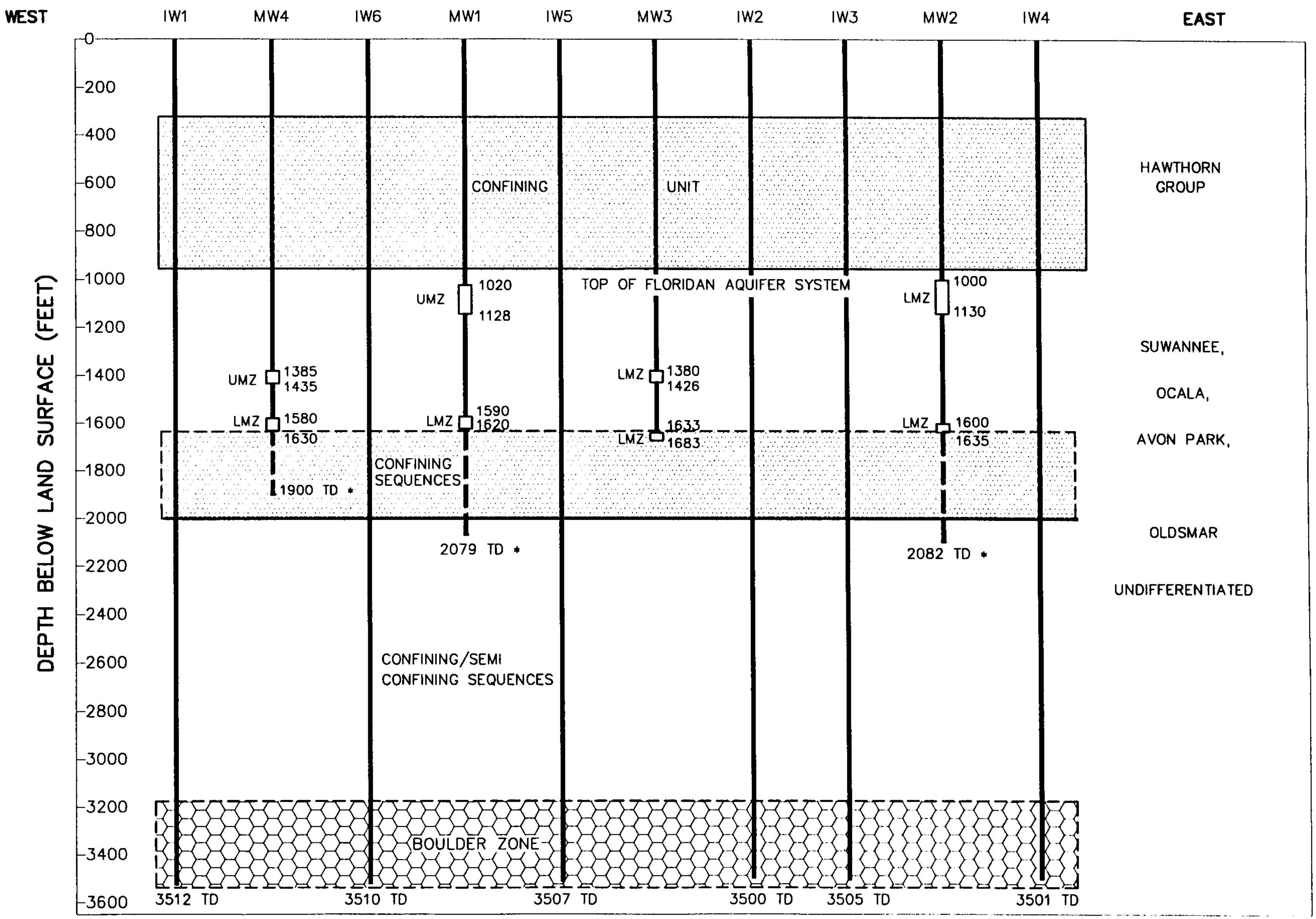
BROWARD COUNTY FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

MW2 AS-BUILT WELL PROFILE

FIGURE 8

7/19/2000/11:40 A.M. – 07 HLWD – H:\4598\EXHIBITS\Well5-6\4598x8.dwg – XREFS: – PS 1=1



* BACK PLUGGED TO BOTTOM OF LMZ

ALL INJECTION WELL CASINGS TERMINATE AT 2990

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BROWARD COUNTY FLORIDA

INJECTION WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

EAST-WEST SITE
HYDROGEOLOGIC CROSS SECTION

FIGURE
9

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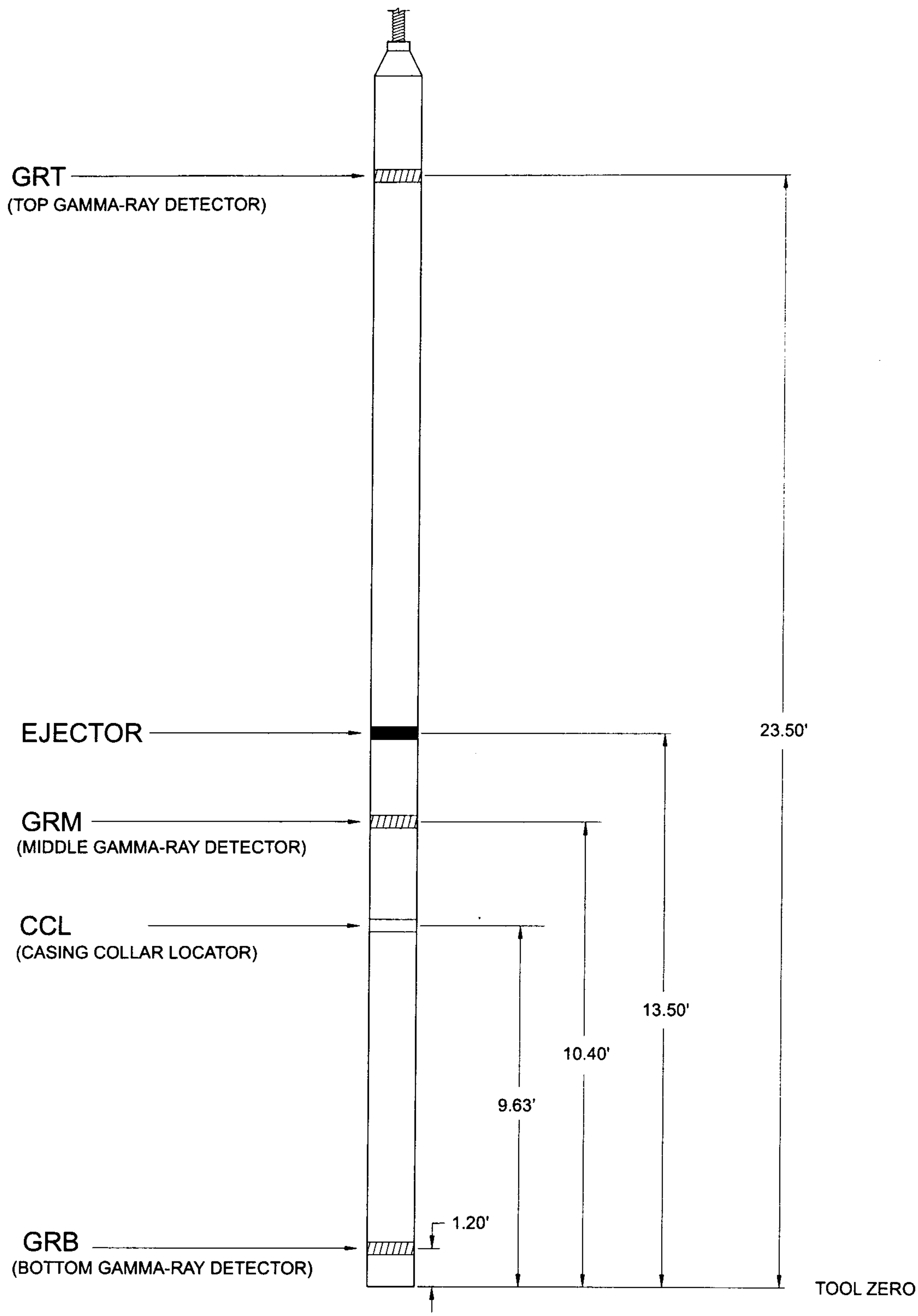

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BROWARD COUNTY
FLORIDA

INJECTIONS WELLS IW5 AND IW6 COMPLETION
BROWARD COUNTY NORTH REGIONAL WWTP

RADIO ACTIVE TRACER SURVEY TOOL

FIGURE 10

APPENDICES

APPENDIX A

FDEP CONSTRUCTION PERMITS

IW5 Construction Permit

Department of Environmental Protection

Lawton Chiles
Governor

Southeast District
P.O. Box 15425
West Palm Beach, Florida 33416

Virginia B. Wetherell
Secretary

FEB - 3 1999

NOTICE OF PERMIT

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

BROWARD COUNTY
UIC - Broward County N. Regional WWTP
FILE: 0051336-005-UC (IW-5, MW-3)

Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services
2555 West Copans Road
Pompano Beach, FL 33069

Dear Mr. Scottie:

Enclosed is Permit Number 0051336-005-UC, to construct a 24-inch outside diameter (O.D.) Class I municipal injection well, IW-5, and to operationally test IW-5 with non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional WWTP, issued pursuant to Section(s) 403.087, Florida Statutes and Florida Administrative Codes 62-4, 62-520, 62-522, 62-528, and 62-550, 62-600 and 62-601. The system is located at the Broward County North Regional WWTP.

Any party to this Order (permit) has the right to seek judicial review of the permit pursuant to Section 120.68, Florida Statutes, by the filing of a Notice of Appeal pursuant to Rule 9.110, Florida Rules of Appellate Procedure, with the Clerk of the Department in the Office of General Counsel, Mail Stop 35, 3900 Commonwealth Blvd., Tallahassee, Florida 32399-3000; and by filing a copy of the Notice of Appeal accompanied by the applicable filing fees with the appropriate District Court of Appeal. The Notice of Appeal must be filed within 30 days from the date this Notice is filed with the Clerk of the Department.

Should you have any questions, please contact Jose L. Calas, P.E., or Mark A. Silverman, P.G., of this office, at telephone (561) 681-6691 or (561) 681-6695, respectively.

Executed in West Palm Beach, Florida.

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

for [signature] 02/03/99

Carlos Rivero-deAguilar
Director of District Management
Southeast District

Date

CRA:AM:JLC:mas

Copies furnished to:

Gary Fox, BCOES
Patrick Davis, H&S
James Wheatley, WTA
Tom Missimer, MI
Steve Anderson, SFWMD/WPB

Richard Deuerling, FDEP/TLH
Brad Russell, FDEP/WPB
Cynthia Christen, OGC
Francine Ffolkes, OGC
Kathelyn Jacques, OGC

Nancy Marsh, USEPA/ATL
Scott Hoskins, USEPA/ATL
Ron Reese, USGS/MIA
Garth Hinckle, BCDNRP

CERTIFICATE OF SERVICE

This is to certify that this NOTICE OF PERMIT and all copies were mailed before the close of business on FEB - 3 1999 to the listed persons.

Clerk Stamp

FILING AND ACKNOWLEDGMENT FILED, on this date, pursuant to the §120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

[signature] FEB - 3 1999

Clerk Date

Department of Environmental Protection

Southeast District
P.O. Box 15425
West Palm Beach, Florida 33416

Lawton Chiles
Governor

Virginia B. Wetherell
Secretary

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services
2555 West Copans Road
Pompano Beach, FL 33069

GMS I. D. NUMBER: 5006C10220
PERMIT/CERTIFICATION NUMBER: 0051336-005-UC
DATE OF ISSUE: FEB - 3 1999
EXPIRATION DATE: FEB - 2 2004
COUNTY: Broward
LATITUDE/LONGITUDE: 26°15'44"N/80°09'25"W
PROJECT: Construction Permit for Class I Municipal Injection Well IW-5 at the Broward County North Regional WWTP

PROJECT: Permit to construct Injection Well IW-5, and to operationally test IW-5 with non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional Wastewater Treatment Plant (WWTP).

This permit is issued under the provisions of Chapter 403.087, Florida Statutes, and Florida Administrative Code (F.A.C.) Rules 62-4, 62-520, 62-522, 62-528, and 62-550, 62-600 and 62-601. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows:

TO CONSTRUCT AND OPERATIONALLY TEST: One twenty-four (24) inch (O.D.) Class I municipal injection well, IW-5, and a deep dual zone monitor well, MW-3. Injection Well IW-5 will be used to inject up to a flow rate of 10.0 feet per second or 18.7 million gallons per day (MGD) (peak hour flow) of non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional WWTP. The injection well will be cased to approximately 3,000 feet below land surface (bls), with an open borehole extending to the total depth of the well at approximately 3,500 feet bls. The confinement of the injection zone from overlying underground source of drinking water (USDW) aquifers and fluid movement adjacent to the wellbore of the injection well will be monitored by two monitoring zones in Monitor Well MW-3. The lower interval shall be positioned in a transmissive interval below the USDW at an appropriate point above the injection interval and major confining units to monitor for reasonable assurance of vertical confinement of injected fluids and external mechanical integrity of the injection wells. The upper interval shall be positioned in a transmissive interval immediately above the base of the USDW. If a sufficiently transmissive zone is not present below the base of the USDW and above the top of the injection horizon, as defined by testing during drilling, a sufficiently transmissive zone above the base of the USDW may be utilized as the lower monitor zone upon approval by the Department. If the lower monitor zone is established within the USDW, the upper monitor zone shall be established in the next shallower adequately transmissive interval within the USDW. Final depths will be determined during construction and field testing.

IN ACCORDANCE WITH: Application to Construct a Class I Injection Well System received September 19, 1997; Request for Information (RFI) dated December 16, 1997; meeting at the Southeast District office with the County and Hazen & Sawyer, the County's consultant, held December 17, 1997; Response to RFI received January 20, 1998; RFI dated February 17, 1998; meeting at the Southeast District office with the County and Hazen & Sawyer, held February 20, 1998; correspondence from the Department to the County dated February 27, 1998; Responses to RFI received March 19, 1998 and March 31, 1998; RFI dated April 17, 1998; Response to RFI received May 5, 1998; RFI dated June 2, 1998; Response to RFI received June 10, 1998; supplementary correspondence received July 15, 1998; comments from the Underground Injection Control - Technical Advisory Committee (UIC-TAC); publication of the Notice of Draft Permit 0051336-005-UC in the Sun-Sentinel newspaper on September 3, 1998; consideration of receipt of public comment received as a result of a public meeting held on October 6, 1998; and publication of the Intent to Issue Permit 0051336-005-UC in the Sun-Sentinel newspaper on November 18, 1998.

LOCATED AT: Broward County North Regional Wastewater Treatment Plant (WWTP), 2401 North Powerline Road, Pompano Beach, Broward County, Florida 33069.

TO SERVE: The Broward County North Regional WWTP Service Area.

SUBJECT TO: General Conditions 1-17 and Specific Conditions 1-11.

GENERAL CONDITIONS:

The following General Conditions are referenced in Florida Administrative Code Rule 62-4.160.

1. The terms, conditions, requirements, limitations and restrictions set forth in this permit, are "permit conditions" and are binding and enforceable pursuant to Sections 403.141, 403.727, or 403.859 through 403.861, FS. The permittee is placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of these conditions.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in subsections 403.087(6) and 403.722(5), FS, the issuance of this permit does not convey any vested rights or any exclusive privileges. Neither does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state, or local laws or regulations. This permit is not a waiver of, or approval of, any other Department permit that may be required for other aspects of the total project which are not addressed in this permit.

4. This permit conveys no title to land or water, does not constitute State recognition or acknowledgment of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the State. Only the Trustees of the Internal Improvement Trust Fund may express State opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, or plant life, or property caused by the construction or operation of this permitted source, or from penalties therefore; nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

6. The permittee shall properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed and used by the permittee to achieve compliance with the conditions of this permit, are required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law and at reasonable times, access to the premises where the permitted activity is located or conducted to:

   a. Have access to and copy any records that must be kept under conditions of the permit;
   b. Inspect facility, equipment, practices, or operations regulated or required under this permit;
   c. Sample or monitor any substances or parameters at any location reasonable necessary to assure compliance with this permit or Department rules. Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, permittee does not comply with or will be unable to comply with any condition or limitation specified in the permit, permittee shall immediately provide the Department with the following:

   a. A description of and cause of noncompliance; and
   b. The period of noncompliance, including dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance. The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or for revocation of this permit.

GENERAL CONDITIONS:

9. In accepting this permit, permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source, which are submitted to the Department, may be used by the Department as evidence in any enforcement case involving the permitted source arising under the Florida Statutes or Department rules, except where such use is prescribed by Section 403.111 and 403.73, FS. Such evidence shall only be used to the extent it is consistent with the Florida Rules of Civil Procedure and appropriate evidentiary rules.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance; provided, however, the permittee does not waive any other rights granted by Florida Statutes or Department rules. A reasonable time for compliance with a new or amended surface water quality standard, other than those standards addressed in Rule 62-302.500, shall include a reasonable time to obtain or be denied a mixing zone for the new or amended standard.

11. This permit is transferable only upon Department approval in accordance with Rule 62-4.120 and 62-730.300 FAC, as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit or a copy thereof shall be kept at the work site of the permitted activity.

13. This permit also constitutes:

    a. Determination of Best Available Control Technology (BACT)
    b. Determination of Prevention of Significant Deterioration (PSD)
    c. Certification of compliance with state Water Quality Standards (Section 401, PL 92-500)
    d. Compliance with New Source Performance Standards

14. The permittee shall comply with the following:

    a. Upon request, the permittee shall furnish all records and plans required under Department rules. During enforcement actions, the retention period for all records will be extended automatically unless otherwise stipulated by the Department.
    b. The permittee shall hold at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation) required by the permit, copies of all reports required by this permit, and records of all data used to complete the application for this permit. These materials shall be retained at least three years from the date of the sample, measurement, report, or application unless otherwise specified by Department rule.
    c. Records of monitoring information shall include:

        1) the date, exact place, and time of sampling or measurements
        2) the person responsible for performing the sampling or measurements
        3) the dates analyses were performed
        4) the person responsible for performing the analyses
        5) the analytical techniques or methods
        6) the results of such analyses

15. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware the relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be corrected promptly.

GENERAL CONDITIONS:

16. In the case of an underground injection control permit, the following permit conditions also shall apply:

    a. All reports or information required by the Department shall be certified as being true, accurate and complete.
    b. Reports of compliance or noncompliance with, or any progress reports on, requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.
    c. Notification of any noncompliance, which may endanger health or the environment, shall be reported verbally to the Department within 24 hours and again within 72 hours, and a final written report provided within two weeks.

        1) The verbal reports shall contain any monitoring or other information which indicate that any contaminant may endanger an underground source of drinking water and any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between underground sources of drinking water.
        2) The written submission shall contain a description of and a discussion of the cause of the noncompliance and, if it has not been corrected, the anticipated time the noncompliance is expected to continue, the steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance and all information required by Rule 62-528.230(4)(b), FAC.

    d. The Department shall be notified at least 180 days before conversion or abandonment of an injection well, unless abandonment within a lesser period of time is necessary to protect waters of the state.

17. The following conditions also shall apply to a hazardous waste facility permit.

    a. The following reports shall be submitted to the Department:

        1) Manifest discrepancy report. If a significant discrepancy in a manifest is discovered, the permittee shall attempt to rectify the discrepancy. If not resolved within 15 days after the waste is received, the permittee shall immediately submit a letter report, including a copy of the manifest, to the Department.
        2) Unmanifested waste report. Permittee shall submit an unmanifested waste report to the Department within 15 days of receipt of unmanifested waste.
        3) Biennial report. A biennial report covering facility activities during previous calendar year shall be submitted by March 1 of each even numbered year pursuant to Chapter 62-730, FAC

    b. Notification of any noncompliance which may endanger health or the environment, including the release of any hazardous waste that may endanger public drinking water supplies or the occurrence of a fire or explosion from the facility which could threaten the environment or human health outside the facility, shall be reported verbally to the Department within 24 hours, and a written report shall be provided within 5 days. The verbal report shall include the name, address, ID number, and telephone number of the facility, its owner or operator, the name and quantity of materials involved, the extent of any injuries, an assessment of actual or potential hazards, and the estimated quantity and disposition of recovered material. The written submission shall contain:

        1) A description and cause of the noncompliance.
        2) If not corrected, the expected time of correction, and the steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance.

    c. Reports of compliance or noncompliance with, or any progress reports on, requirements in any compliance schedule shall be submitted no later than 14 days after each schedule date.

    d. All reports or information required by the Department by a hazardous waste permittee shall be signed by a person authorized to sign a permit application.

SPECIFIC CONDITIONS:

1. General Requirements

a. This permit is to construct and operationally test the Broward County North Regional WWTP Class I municipal injection well, IW-5, and an associated dual zone monitor well, MW-3. This permit does not authorize the construction or operational testing of any other well or wells associated with the Broward County North Regional WWTP Injection Well System.

b. Four permanent surficial aquifer monitor wells, identified as Pad Monitor Wells (PMWs), shall be located at the corners of the injection well drilling pad and identified by location number and pad location, i.e. NW, NE, SW, and SE. The four PMWs shall be sampled and analyzed prior to the onset of drilling. Initial analyses shall be submitted to the Department prior to the initiation of work. [See Specific Condition (S.C.) (4.e)vi).] The samples shall be analyzed for chlorides (mg/L), specific conductance (umho/cm), total dissolved solids (TDS, mg/L) and water level (relative to NGVD). These monitor wells are to be retained in service, sampled weekly for the above parameters during the construction phase of the project, monthly during the operational testing phase and quarterly once an operation permit is granted. In addition, these monitor wells shall be sampled 48 hours prior to any maintenance, testing (including mechanical integrity testing) or repairs to the system which represent an increased potential for accidental discharge to the surficial aquifer. The results of these analyses shall be submitted to the Department within thirty (30) days of the completion of the activity. A summary sheet from the FDEP Southeast District is attached for your use when reporting the above information. If located in a traffic area the well head(s) must be protected by a traffic bearing enclosure and cover. The cover(s) must lock and be specifically marked to identify the well and its purpose.

c. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

d. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

e. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this permit.

f. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures.

g. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation or reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

h. When requested by the Department, the permittee shall furnish, within the time specified, any information needed to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit.

i. The permittee shall retain all records concerning the nature and composition of injected fluid under Rule 62-528.435, F.A.C. The permittee shall deliver the records to the Department office that issued the permit at the conclusion of the retention period unless the permittee elects to continue retention of the records.

j. The permittee shall notify the Department and obtain approval prior to any physical alterations or additions to the injection or monitor well, including removal of the well head.

k. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or injection activity which may result in noncompliance with permit requirements.

SPECIFIC CONDITIONS:

2. Construction and Testing Requirements

   a. The measurement points for drilling and logging operations shall be surveyed and referenced to the National Geodetic Vertical Datum (NGVD) of 1929 prior to the onset of drilling activities for the injection well and associated dual zone monitor well.

   b. Blow-out preventers shall be installed on the wells prior to penetration of the Floridan aquifer system.

   c. No drilling operations shall begin without an approved disposal site for drilling fluids, cuttings, or waste. It shall be the permittee's responsibility to obtain the necessary approval(s) for disposal prior to the start of construction.

   d. The Department shall be notified within 48 hours after work has commenced.

   e. Hurricane Preparedness - Upon the issuance of a "Hurricane Watch" by the National Weather Service, the preparations to be made include but are not necessarily limited to the following:

      1) Secure all on-site salt and stockpiled additive materials to prevent surface and/or groundwater contamination.

      2) Properly secure drilling equipment and rig(s) to prevent damage to well(s) and on-site treatment process equipment.

   f. Waters spilled during construction or testing of the injection well system shall be contained and properly disposed.

   g. UIC-TAC and United States Environmental Protection Agency (USEPA) review and Department approval are required prior to the following stages of construction and testing:

      1) Contract documents and spud date
      2) Intermediate (34-inch) injection well casing seat
      3) Final injection well casing seat
      4) Final monitor well casing seat
      5) Monitor zone selection
      6) Proposed cementing procedures (including cement volumes, number of stages) for the intermediate and final casing must be submitted for UIC-TAC and USEPA review and Department approval.
      7) Mechanical integrity testing
      8) Operational testing

   h. The geophysical logging program shall at a minimum include:

      1) Prior to setting the surface casing in Injection Well IW-5, the following geophysical logs shall be run on the borehole, to identify the base of the Hawthorn Group at approximately 1000 feet bls, and to establish a mechanically secure casing setting depth:
         - Caliper
         - Gamma ray

SPECIFIC CONDITIONS:

2) To determine the intermediate casing depth in Injection Well IW-5, the logs indicated below shall be run on the pilot hole. These logs shall be interpreted for stratigraphic correlation, identification of potential monitoring zones, identification of confining units, identification of producing intervals, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey with rotating lens
   - Logs to be run under pumping and static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

   Pumping capability shall be supplied during the pumping flowmeter log runs to adequately stress proposed confining units and allow the log interpreter, in conjunction with other pertinent testing and logging, to identify the confining beds.

3) To determine the final casing depth in Injection Well IW-5, the logs indicated below shall be run on the pilot hole. These logs shall be interpreted for stratigraphic correlation, identification of potential monitoring zones, identification of confining units, identification of producing intervals, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey
   - Logs to be run under static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

4) In the injection zone below the final casing of Injection Well IW-5, the following logs shall be run:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey
   - Logs to be run under pumping and static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

5) In Monitor Well MW-3, the logs indicated below shall be run to the setting depth of the intermediate casing. These logs shall be interpreted for stratigraphic correlation and identification of monitoring zones, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer

6) In Monitor Well MW-3, the logs indicated below shall be run from the intermediate casing depth to the total depth of the well. These logs shall be interpreted for stratigraphic correlation and identification of monitoring zones, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer

SPECIFIC CONDITIONS:

7) Caliper logs shall be run on all reamed holes.

8) Temperature logs shall be run after each stage of cementing on all casings to identify the top of the cement.

9) In the injection well, a cement bond log shall be run after the cementing of the 24-inch casing.

10) In the monitor well, either a sector bond log, ultra sonic imager, cement bond log, or equivalent log shall be run after the cementing of the 16-inch and 6-5/8-inch casings.

i. Straddle packer testing shall at a minimum include the following:

1) A combined total of at least seven straddle packer tests shall be conducted during the drilling of Injection Well IW-5 and Monitor Well MW-3.
2) At least one (1) straddle packer test conducted in each prospective monitor zone.
3) At least four (4) straddle packer tests conducted from the lowermost zone of the USDW to the top of the proposed injection horizon. These packer tests will be used for the demonstration of confinement at the IW-5 location, and will be performed in the anticipated confining zones. At least one straddle packer test supporting the demonstration of confinement will be obtained from each interval under consideration, based on the data collected to date, to be a confining unit at the IW-5 location. [See S.C. 2.m)]. To the extent feasible, these packer tests shall be performed so as to exclude intervals of high hydraulic conductivity.
4) At least one (1) straddle packer test conducted to determine the base of the USDW at the IW-5 location. This test shall be performed within the interval where the base of the USDW has been estimated. Per the Confinement Analysis report received March 31, 1998, the base of the USDW is expected to be located between approximately 1,630 and 1,660 feet bls. The straddle packer test conducted to determine the base of the USDW at the IW-5 location shall yield a TDS value of at least 9,000 mg/L to be accepted by the Department as determining the base of the USDW.
5) Water samples shall be collected from each straddle packer test, and analyzed for total dissolved solids (TDS, mg/L), chlorides (mg/L), specific conductance (umho/cm), sulfate (mg/L), ammonia (mg/L), and Total Kjeldahl Nitrogen (TKN, mg/L), at a minimum.
6) A five (5) gallon water sample, obtained from intervals where sufficient water is available, shall be collected at the end of each straddle packer test. These samples shall be shipped to the Underground Injection Control (UIC) Section of the Department of Environmental Protection, in Tallahassee (FDEP, UIC Program, MS 3530, Twin Towers Building, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400).

j. The depth of the USDW and the background water quality of the monitor zones shall be determined during drilling and testing. Determination of the depth of the USDW shall be accomplished, interpreted, and analyzed using the following information:

1) Water samples and pumping test data from packer tests with analysis and interpretation.
2) Geophysical logging upon reaching the total depth of the appropriate pilot hole interval using the following logs: caliper, gamma, dual induction, borehole compensated sonic, pumping flowmeter, temperature, and fluid resistivity.
3) Plots of sonic porosity and apparent formation fluid resistivity (Rwa). Interpretation will include calculation of sonic porosity and Rwa. The input parameters used to make this calculation shall be provided.

SPECIFIC CONDITIONS:

k. The confinement of the injection zone in the injection well system from overlying aquifers shall be monitored using the dual zone monitor well and a regular monitoring program. The lower interval shall be positioned in a transmissive interval below the USDW (i.e., where groundwater contains a TDS concentration of greater than 10,000 mg/L) at an appropriate point above the injection interval and major confining units to monitor for reasonable assurance of vertical confinement of injected fluids and external mechanical integrity of the injection wells. The upper interval shall be positioned in a transmissive interval immediately above the base of the USDW (i.e., where groundwater contains a TDS concentration of less than 10,000 mg/L). If a sufficiently transmissive zone is not present below the 10,000 mg/l TDS interface and above the top of the injection interval and major confining units, as defined by testing during drilling, a sufficiently transmissive zone above the base of the USDW may be utilized as the lower monitor zone upon approval by the Department. If the lower monitor zone is established within the USDW, the upper monitor zone shall be established in the next shallower adequately transmissive interval within the USDW. The data and analysis supporting the selection of the monitoring intervals shall be submitted to the Department, the UIC-TAC and the USEPA, Region IV, Atlanta after the collection, interpretation and analysis of all pertinent cores, geophysical logs and analysis of fluid samples. The hydrogeologic evaluation of the proposed monitoring zone will be submitted only after the collection, interpretation and analysis of all pertinent cores, packer tests, geophysical logs and analysis of fluid samples. The final selection of the specific upper and lower monitoring intervals shall be approved by the Department.

l. To identify the upper and lower monitoring zones, the following information from the injection well and all available on-site sources of data shall be analyzed, interpreted and submitted for UIC-TAC and USEPA review and Department approval:

1) borehole televiewer
2) the permeability of the transition zone in the vicinity of the USDW
3) packer test data including water quality (total dissolved solids, chloride, ammonia, Total Kjeldahl Nitrogen, and specific conductance)
4) the hydraulic conductivity of the upper and lower monitor zones
5) the identification of the base of the USDW

m. Confinement for the Injection Well IW-5 location shall be demonstrated using, at a minimum, lithologic properties, geophysical evidence, tests performed while pumping the formation, and water quality analyses, as described in Items i) through vi) below:

1) Tests performed while pumping the formation shall include flowmeter, temperature and fluid resistivity logs (run from the base of the USDW to the planned intermediate casing depth in Injection Well IW-5), and straddle-packer tests. From the straddle-packer tests, the results of water quality sampling and the analysis of drawdown curves (measured during the packer tests) shall be reported to the Department, the UIC-TAC and the USEPA, Region IV, Atlanta, including interpretations with respect to the degree of confinement.
2) If geophysical logging and other test results (from the proposed testing program) are not adequate to demonstrate confinement then additional geophysical logging and testing may be required.
3) Prior to running flowmeter logs and downhole radial color television surveys, information shall be recorded pertaining to the development and conditioning of the borehole, detailing all measures taken (including but not limited to the number of wiper runs with bit; a description of the extent of well development methods used, etc.) and the lengths of time applied. In addition, the pumping flowmeter logging results shall include a record of the pumping rate(s) and drawdown(s) regularly recorded throughout the test to account for possible variations in the pumping rate.
4) Geophysical logs described under S.C. 2.h), and such other geophysical surveys and tests as are needed after taking into account the need for additional information that may arise as the construction of the well progresses (per Rule 62-528.410(6)(a)2., F.A.C.), shall be used to deduce and/or correlate formation properties measured from pumping tests and lithologic sample analysis.
5) Lithologic properties measured in laboratory analyses of core samples shall include: hydraulic conductivity (vertical and horizontal) and Young's modulus/elastic modulus Formation factor. No less than five (5) core samples shall be taken and analyzed from Injection Well IW-5.
6) To the extent feasible, core descriptions shall be used to address bedding characteristics, and lithologic descriptions from cores and cuttings shall include characterizations that pertain to the degree of confinement, including, but not limited to, texture, grain composition, grain shape (including the degree of flatness) pore geometry (including sorting and interlocking of grains), cement composition and degree of crystalization, rock matrix characteristics, and sedimentary depositional and diagenetic environment.

SPECIFIC CONDITIONS:

To the extent feasible, the descriptions and interpretations derived from the lines of testing referenced above should address the degree of confinement at the IW-5 injection well location. In addition, the geophysical logs shall be used to the extent feasible to extend the applicability of measurements of hydraulic characteristics obtained from the testing of discrete intervals, such as cores and straddle packer tests, to an entire bed or series of beds (in both the horizontal and vertical directions). The testing, analysis and interpretation of results shall be thorough enough to evaluate the extent of confinement between the top of the redefined injection zone and the base of the USDW.

n. Test results pertaining to confinement shall include and/or specifically reference the following informational and quality control items:

  1) Quality control measures taken, including:
     - Information which documents the calibration of tools, including field checks prior to testing.
     - The conditioning/development of the borehole prior to logging, including the techniques used and the time periods in which applied, and
     - Pertaining to straddle packer/pump testing - recording the pumping rate regularly throughout the test to account for possible variations in the pumping rate, and providing information regarding the detection of packer leaks, if any, during testing.
  2) Formulas, calculations, assumptions and constants used in the determination of porosity and formation fluid quality.

o. Representative samples of circulation fluid shall be collected a minimum of every thirty (30) feet in drilling, from a depth of approximately 1,000 feet to the top of the "Boulder Zone" at approximately 3,000 feet bls, for the IW-5 pilot hole, and to the total depth of the well, for MW-3. The representative samples shall be analyzed for chlorides (mg/L), specific conductance (umho/cm), and ammonia (mg/L), at a minimum.

p. If effluent is encountered or suspected during pilot hole drilling and testing, the Department shall be notified immediately by telephone and in writing and immediate appropriate precautionary measures shall be taken to prevent any upward fluid movement.

q. Mechanical integrity of the injection well shall be determined pursuant to Rules 62-528.300(6)(b)2. and 62-528.300(6)(c), F.A.C.

  1) The pressure test for the final casing shall be accepted if tested with a liquid filled casing at 1.5 times the operating pressure at which the well is to be permitted with a test tolerance of not greater than + or - five (5) percent over a one-hour test period.
  2) Verification of pressure gauge calibration must be provided to the Department representative at the time of the test and in the certified test report.

r. The Department shall be notified at least seventy-two (72) hours prior to all testing for mechanical integrity.

s. All testing for mechanical integrity must be initiated during normal business hours, Monday through Friday.

t. UIC-TAC meetings are scheduled on the 2nd and 4th Tuesday of each month subject to a five (5) working day prior notice and timely receipt of critical data by all UIC-TAC members and the USEPA, Region IV, Atlanta. Emergency meetings may be arranged when justified to avoid undue construction delays.

u. The dual zone monitor well (MW-3) shall not be drilled below the base of the Hawthorn Group, located at approximately 1,000 feet, until testing to determine the lower limit of the USDW in the pilot hole of Injection Well IW-5 is completed and approved by the Department.

SPECIFIC CONDITIONS:

3. Quality Assurance/Quality Control Requirements

   a. Pursuant to Rule 62-528.440(5)(b), F.A.C., the Professional Engineer(s) of Record shall certify all documents related to the completion of the Class I injection well system (including the associated Floridan aquifer monitor well) as a disposal facility. The Department shall be notified immediately of any change of the Engineer(s) of Record.

   b. In accordance with Section 492, Florida Statutes, all documents prepared for the geological/hydrogeological evaluation of the injection well system shall be signed and sealed by a Florida Licensed Professional Geologist or qualified Florida Licensed Professional Engineer.

   c. Continuous on-site supervision by qualified personnel (engineer or geologist) is required during all testing, geophysical logging, casing installation and cementing operations.

4. Reporting Requirements

   a. All reports and surveys required by this permit shall be submitted concurrently to all members of the UIC-TAC. The UIC-TAC shall consist of representatives of the following agencies:

      - Department of Environmental Protection, West Palm Beach and Tallahassee
      - United States Geological Survey (USGS), Miami
      - South Florida Water Management District (SFWMD), West Palm Beach
      - Broward County Department of Natural Resource Protection (BCDNRP), Ft. Lauderdale

      In addition, all reports and surveys required by this permit shall be submitted concurrently to the USEPA, Region IV, Atlanta. A UIC-TAC and USEPA distribution list is attached.

   b. A drilling and construction schedule shall be submitted to the Department, all members of the UIC-TAC and the EPA, prior to site preparation for the injection well system.

   c. The Department and other applicable agencies must be notified of any unusual or abnormal events occurring during construction, and in the event the Permittee is temporarily unable to comply with the provisions of the permit (e.g., on-site spills, artesian flows, large volume circulation losses, equipment damage due to: fire, wind and drilling difficulties, etc.). Any information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five (5) days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

   d. The permittee shall report any noncompliance which may endanger health or the environment, including:

      1) Any monitoring or other information which indicates that any contaminant may cause an endangerment to a USDW; or

      2) Any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between USDWs.

      Any information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five (5) days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

SPECIFIC CONDITIONS:

e. Weekly progress reports shall be submitted throughout the construction period for IW-5 and MW-3. These reports shall be submitted no later than the seventh (7th) day immediately following the period of record, and shall include at a minimum the following information:

1) A cover letter summary of the daily engineer report, driller's log and a projection for activities in the next reporting period.
2) Daily engineers report and driller's/work log with detailed descriptions of all drilling progress, cementing, testing, logging, and casing installation activities.
3) Lithologic and geophysical logs and water quality test results.
4) Interpretations shall be included with all test results and logs submitted under Items ii. and iii. above.
5) Detailed description of any unusual construction-related events that occur during the reporting period.
6) Weekly water quality analysis and water levels for the four pad monitor wells. [See S.C. 1.b).]
7) A certified evaluation of all logging and test results must be submitted with test data. [See S.C. 3.b).]
8) Description of the formations and lithology encountered.
9) Details of cementing operations including the following information, for each stage of cementing: cement slurry composition, specific gravity, pumping rate, volume of cement pumped, theoretical fill depth, and actual tag depth. From both the physical tag and the geophysical logs, a percent fill shall be calculated. An explanation of any deviation between actual versus theoretical fill shall be provided. For each casing, laboratory analysis of dry cement composition of a sample taken during the neat cement stage emplaced at the base of each casing.

f. Per Rules 62-528.410(4)(c), 62-528.420(4)(c) and 62-528.605(2), F.A.C., the final selection of specific injection and monitoring intervals must be approved by the Department. In order to obtain an approval, the permittee shall submit a request to the Department. The request shall be submitted concurrently to all members of the UIC-TAC and the USEPA, Region IV, Atlanta. All casing seat requests submitted in accordance with S.C. 2.g) for the injection well and the Floridan aquifer monitor well shall be accompanied by technical justification. To the extent possible, each casing seat request should address the following items:

1) Lithologic and geophysical logs with interpretations, as the interpretations relate to the casing seat.
2) Water quality data.
3) Identification of confining units, including hydrogeologic data and interpretations.
4) Identification of monitoring zones.
5) Casing depth evaluation (mechanically secure formation, potential for grout seal).
6) Lithologic drilling rate and weight on bit data, with interpretations (related to the casing seat).
7) Identification of the base of the USDW using water quality, Rwa plots, and geophysical log interpretations.

g. Monitor zone requests shall contain the following:

1) Identification of the base of the USDW.
2) Identification of confining units.
3) Water quality of proposed monitor zone.
4) Transmissivity or specific capacity of proposed monitor zone.
5) Packer test drawdown curves and interpretation.

h. An interpretation of all test results and geophysical logs must be submitted with all submittals.

i. The injection test request shall contain the following justifications:

1) Cement bond logs and interpretation.
2) Final downhole television survey with interpretation.
3) Radioactive tracer test results (if the test is to be run using effluent)
4) Demonstration of mechanical integrity, which shall include Items i) through iii) above, and the pressure testing and temperature logging results (if the test is to be run using effluent)
5) Reasonable assurance that adequate confinement exists.
6) Water quality analysis of injection fluid from every source.

SPECIFIC CONDITIONS:

j. Upon completion of analysis of cores and sample cuttings, the permittee shall contact the UIC Section of the Department of Environmental Protection in Tallahassee to arrange their transfer to the Florida State Geologic Survey.

k. A final report of the construction and testing of the injection well and dual zone monitor well, shall be submitted with the application for an operation permit for IW-5, pursuant to Rule 62-528.430(1)(e), F.A.C. This report shall include, at a minimum, delineation of the injection interval, all relevant confining units, the depth of the base of the USDW and all monitor zones, including all relevant data and interpretations, collected during construction and operational testing of the injection well system.

5. Operational Testing Requirements

a. The operational testing of the Class I injection well system under this permit shall not commence without written authorization from the Department.

b. Prior to operational testing, the permittee shall comply with the operational testing requirements of Rule 62-528.450(3)(a) through (c), F.A.C.

c. Prior to operational testing approval, the following items must be submitted (with the request for operational testing approval) for UIC-TAC and USEPA review and Department approval:

1) Lithologic and geophysical logs with interpretations.

2) A copy of the borehole television survey of the injection well with interpretation.

3) Certification of mechanical integrity and interpreted test data.

4) Results of the short term injection test with interpretation of the data. Each well shall first be tested for integrity of construction, and shall be followed by a short term injection test of such duration to allow for the prediction of operating pressure. The test results shall include a calculation or determination of fracture pressure of the injection formation [per Rule 62-528.410(6)(b)3., F.A.C.]. The injection test shall be conducted for a minimum of twenty-four (24) hours at a rate no less than the maximum rate at which the well is to be permitted. Pressure/water level data from the injection zone and both monitor zones shall be recorded continuously for at least twenty-four (24) hours before the test and at least twelve (12) hours following the test. The following data shall be recorded, analyzed, and reported for the duration of the injection test, i.e., all data should encompass the entire background, injection and recovery periods:

- injection flow rate (Injection Well IW-5, in MGD)
- injection pressure (Injection Well IW-5, in psig)
- pressure (psig) in Injection Wells (IW-1, IW-2, IW-3, IW-4; and IW-6, if constructed)
- injection zone pressure with no flow (shut-in pressure in psig)
- monitor well pressure (upper and lower zones of MW-1, MW-2, MW-3, and MW-4, if totally constructed)
- barometric pressure

5) A description of the actual injection procedure including the anticipated maximum pressure and flow rate at which the well will be operated under normal and emergency conditions.

6) Specification of the initial planned monthly injectivity test rates. [See S.C. 6.a)xxii).]

7) Information concerning the compatibility of the injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone.

8) Certification of completion of well construction.

9) Surface equipment (including pumping station, piping, pressure gauges and flow meters, and all appurtenances) completion certified by the Engineer of Record.

SPECIFIC CONDITIONS:

10) Draft operation and maintenance manual, including a description of water hammer control and emergency discharge management plan procedures. The emergency discharge system must be fully constructed and operational (ready to operate) prior to approval of operational testing.

11) Calibration certificates for pressure gauges and flow meters.

12) Signed and sealed record "as-built" engineering drawings of the injection well system including all well construction, the pump station, subsurface and surface piping and equipment, and appurtenances.

13) The well construction drawings shall include a geologic stratigraphic cross-section depicting the corresponding formations, the base of the USDW, and the boundaries of the confining and injection zone intervals.

14) The demonstration of confinement for the Injection Well IW-5 location, prepared providing confirmation of confinement and defining the injection and confining sequences utilizing data collected during the drilling, logging and testing of the injection well and dual zone monitor well. The report shall include the results of hydraulic testing (permeability, porosity, etc.) on the cores, and shall be reviewed and updated as appropriate after the completion of any additional injection/monitor well pairs in the future from the confining interval. This submittal shall be prepared, signed, and sealed by a Florida Registered Professional Geologist or appropriately qualified Professional Engineer.

15) The confinement report referenced above shall include local cross-sections which include information pertaining to confinement. The cross-sections shall be constructed from all of the hydrogeologic data (geophysical logs, lithologic descriptions, packer tests, core analyses, water quality data, etc.) collected during the previous construction of all of the injection wells and monitor wells completed to date at the Broward County North Regional WWTP, and shall be updated with the data collected during the drilling of Injection Well IW-5 and Monitor Well MW-3. The cross-sections shall show the hydrogeologic correlation between all the wells (IW-1, IW-2, IW-3, IW-4, MW-1, MW-2, MW-3 and MW-4) at the Broward County North Regional WWTP.

16) Wastestream analysis, sampled within six (6) months of the request for operational testing, for primary and secondary drinking water standards (62-550, F.A.C.) and minimum criteria parameters (62-520, F.A.C.) as attached.

17) Background water quality data from the monitor and injection zones, analyzed for primary and secondary drinking water standards (62-550, F.A.C.) and minimum criteria parameters (62-520, F.A.C.) as attached.

18) Other data obtained during well construction needed by the Department to evaluate whether the well will operate in compliance with Department Rules. [Rule 62-528.450(3)(a)3.i., F.A.C.]

d. Pressure gauges and flow meters shall be installed on the injection well prior to initiating injection activities at the site.

e. Prior to the authorization of operational testing by the Department, the County shall contact the UIC Section of the Department, Southeast District, to arrange a site inspection. The inspection will determine if the conditions of the permit have been met and to verify that the injection well system is operational. During the inspection, emergency procedures and reporting requirements shall be reviewed.

6. Operational Testing Conditions

a. Upon receipt of written authorization from the Department [S.C. 5.a)], the operational testing of the injection well system shall be subject to the following conditions:

1) A qualified representative of the Engineer of Record shall be present for the start-up operations.

2) The Department shall be notified in writing of the date of commencement operations.

SPECIFIC CONDITIONS:

3) Operational testing for the system shall extend for a six (6) month period and shall be reviewed by the UIC-TAC and the USEPA at three (3) months and six (6) months after operational testing has begun. Prior to the end of the six month interval, the Department shall determine whether operational testing will be authorized to continue for a specified period of up to an additional eighteen (18) months. The Department and UIC-TAC will monitor the progress of the operational testing phase of this project. UIC-TAC meetings shall be held if necessary to aid the Department in determining if it may be necessary to modify the operational testing conditions. If requested by the Department, reports evaluating the system's progress shall be submitted to the Department, each member of the UIC-TAC, and the USEPA, Region IV, Atlanta at least two (2) weeks prior to the scheduled UIC-TAC meeting. The conditions for the operational testing period may be modified by the Department at each of these UIC-TAC review intervals.

4) Flows to the injection well shall be monitored and controlled at all times to ensure the maximum injection rate does not exceed that rate at which the well was tested.

5) Injection well system monitoring devices:

   a) Pursuant to Rule 62-528.425(1)(b), F.A.C., the injection well system shall be monitored by continuous indicating, recording and totalizing devices to monitor effluent flow rate and volume, and continuous indicating and recording devices to monitor injection pressure and monitor zone pressure (or water level, as appropriate; all zones). All indicating, recording and totalizing devices shall be maintained in good operating condition and calibrated annually at a minimum.

   b) Pursuant to Rule 62-600.540(4), F.A.C., the surface equipment shall be such that manual backup capability to monitor flow and pressure shall be provided for systems utilizing automatic and continuous recording equipment.

6) Pursuant to Rule 62-600.540(4)(a), F.A.C., as a minimum, the effluent pump station shall be equipped with lightning arrestors, surge capacitors or other similar devices.

7) The flow from the monitor zones during well evacuation and sampling must not be discharged to surface waters or aquifers containing a USDW.

8) Per Rule 62-600.540(1) of the Florida Administrative Code (F.A.C.), the effluent limitations for wastewaters conveyed to the injection well must meet the secondary treatment and pH limitations specified in Rule 62-600.420(1)(d), and 62-600.445, F.A.C. The domestic effluent (injectate) conveyed to the injection well shall meet the Compliance Concentrations per Rule 62-600.740(1)(b), F.A.C.

9) The ability to disinfect the effluent shall be maintained at all times in accordance with Chapter 62-600, F.A.C.

10) The wastestream shall be non-hazardous in nature at all times, as defined in 40-CFR, Part 261 and as adopted in Chapter 62-730, F.A.C.

11) In accordance with Rule 62-528.300(43), F.A.C., the definition of a municipal injection well, only fluids that have received treatment at the Broward County North Regional WWTP and purge water from the on-site monitor wells, associated with the injection well systems at the Broward County North Regional WWTP, may be discharged into this well.

SPECIFIC CONDITIONS:

12) Mechanical Integrity

a) Injection is prohibited until the permittee demonstrates that the well has mechanical integrity. Prior to operational testing the permittee shall establish, and thereafter maintain, the mechanical integrity of the well at all times.
b) If the Department determines that the injection well lacks mechanical integrity, written notice shall be given to the permittee.
c) Unless the Department requires immediate cessation of injection, within 48 hours of receiving written notice that the well lacks mechanical integrity, the permittee shall cease injection into the well unless the Department allows continued injection pursuant to (d) below.
d) The Department may allow the permittee to continue operation of a well that lacks mechanical integrity if the permittee demonstrates that fluid movement into or between USDWs is not occurring.

13) No underground injection is allowed that causes or allows movement of fluid into an underground source of drinking water.

14) The pressure at the wellhead shall be monitored and controlled at all times to ensure the maximum pressure at the wellhead casing does not exceed 66 percent (%) of the mechanical integrity test pressure. [See S.C. 2.q).]

15) Any failure of the Class I injection well monitoring and recording equipment for a period of more than forty-eight (48) hours shall be reported within twenty-four (24) hours to the Department. A written report describing the incident shall also be given to the Department within five (5) days of the start of the event. The final report shall contain a complete description of the occurrence, a discussion of its cause(s) and the steps being taken to reduce, eliminate, and prevent recurrence of the event, and all other information deemed necessary by the Department.

16) The injection system shall be monitored in accordance with Rules 62-528.425(1)(g) and 62-528.430(2), F.A.C. The following injection well performance and monitor zone data shall be collected and reported to the Department in Monthly Operating Reports (MORs; also see S.C. 6.a)xix) and S.C. 6.a)xx)] as indicated below. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

a) Injection well performance:

(1) Physical characteristics of the injection well:

- total daily flow to injection well (MG)
- average daily flow rate to injection well (MGD)
- daily peak hour flow rate to injection well (MGD)
- daily minimum flow rate to injection well (MGD)
- monthly average of the daily flow rates to injection well (MGD)
- monthly maximum (peak hour) flow rate to injection well (MGD)
- monthly minimum flow rate to injection well (MGD)
- monthly average of the daily flow volumes to injection well (MG)
- monthly maximum of the daily flow volumes to injection well (MG)
- monthly minimum of the daily flow volumes to injection well (MG)
- daily average injection pressure at injection well (psig)
- daily maximum sustained injection pressure at injection well (psig)
- daily minimum injection pressure at injection well (psig)
- monthly average injection pressure at injection well (psig)
- monthly maximum sustained injection pressure at injection well (psig)
- monthly minimum injection pressure at injection well (psig)
- monthly wellhead pressure with no flow (shut-in pressure, psig)

SPECIFIC CONDITIONS:

(2) Chemical characteristics of the wastestream sampled from the wet well:

Monthly sampling:

- total dissolved solids (TDS, total filterable residue) (mg/L)
- ammonia, total as N (mg/L)
- total kjeldahl nitrogen (as N) (TKN, mg/L)
- nitrate (mg/L)
- specific conductance (temperature compensated, umho/cm)
- total phosphorous as P (mg/L)
- pH (standard units)

The MORs shall indicate monthly averages for all parameters sampled daily.

b) Monitor well performance:

(1) Physical characteristics - upper and lower monitor zones potentiometric surface or water table height relative to NGVD (feet of head) or pressure (psig) referenced to NGVD:

- daily maximum pressure or water level (as appropriate)
- daily minimum pressure or water level (as appropriate)
- daily average pressure or water level (as appropriate)
- monthly maximum pressure or water level (as appropriate)
- monthly minimum pressure or water level (as appropriate)
- monthly average pressure or water level (as appropriate)

(2) Chemical characteristics of the upper and lower monitor zones (to be sampled weekly):

- total dissolved solids (TDS, total filterable residue) (mg/L)
- chloride (mg/L)
- ammonia, total as N (mg/L)
- total kjeldahl nitrogen (as N) (TKN, mg/L)
- nitrate (mg/L)
- pH (standard units)
- specific conductance (temperature compensated, umho/cm)
- fecal coliform MF (# of colonies/100 ml)
- total phosphorous as P (mg/L)
- sulfate (mg/L)

The MORs shall also indicate monthly averages for all parameters sampled weekly.

c) After the upper and lower monitor zones have been sampled weekly for at least six (6) months, the permittee may submit data for UIC-TAC and USEPA review and Department approval to demonstrate that reasonable assurance of groundwater stability has been established in justification of any request to reduce the sampling frequency to monthly. The request for reduction in sampling frequency shall be accompanied by technical justification and interpretations.

17) A minimum of three (3) well volumes of fluid shall be evacuated from the monitor systems prior to sampling for the chemical parameters listed above. All samples shall be analyzed by a State-certified laboratory.

18) All samples must be collected and analyzed in accordance with the quality assurance/quality control (QA/QC) requirements of Rule 62-160, F.A.C.

19) All injection well system data submissions including MORs [see S.C. 6.a)xvi) above] shall be clearly identified on each page with facility name, I.D. Number, permit number, operator's name, license number, daytime phone number, date of sampling/recording, and type of data. Monitor zones shall be identified by well number and depth interval. The lead plant operator or higher official must sign and date each submittal. An approved summary sheet from the FDEP Southeast District UIC Section is attached.

SPECIFIC CONDITIONS:

20) The permittee shall submit monthly to the Department the results of all injection well and monitor well data required by this permit (MORs) no later than the **twenty-eighth (28th)** day of the month immediately following the month of record. The results shall be sent to the Department of Environmental Protection's Southeast District Office (FDEP, UIC Section, P.O. Box 15425, West Palm Beach, FL 33416). A copy of this report shall also be sent to the Department of Environmental Protection, Underground Injection Control Program, MS 3530, 2600 Blair Stone Road, Tallahassee, FL 32399-2400.

21) The permittee shall calibrate all pressure gauges, flowmeters, chart recorders, and other related equipment associated with the injection well system on a annual basis, at a minimum. The permittee shall maintain all monitoring equipment and shall ensure that the monitoring equipment is calibrated and in proper operating condition at all times. Laboratory equipment, methods, and quality control will follow USEPA guidelines as expressed in Standard Methods for the Examination of Water and Wastewater. The pressure gauges, flow meter, and chart records shall be calibrated using standard engineering methods.

22) A controlled specific injectivity test (rate/pressure) shall be conducted monthly during the operational testing phase of this permit in accordance with Rule 62-528.430(2)(d), F.A.C. The specific injectivity test shall be conducted using at least three specified injection flow rates. The high rate should approach maximum design flow. [See S.C. 5.c)vi).] For reporting the injectivity test results, a summary sheet and sample graph from the FDEP Southeast District UIC Section is attached. The injectivity test results shall be reported to the Department in the MORs. The following data shall be recorded and reported at each injection rate:

- injection flow rate (MGD)
- injection pressure (psig)
- wellhead pressure with no flow (shut-in pressure in psig)
- monitor zone pressures (psig)

All readings shall be taken after a minimum five minute period of stabilized flow.
Pursuant to Rule 62-528.430(2)(d), F.A.C., as part of the specific injectivity test, the well shall be shut-in for a period of time necessary to conduct a valid observation of pressure fall-off.

23) Pursuant to Rules 62-528.425(1)(a) and 62-528.450(2)(f)3., F.A.C., a wastestream analysis (24 hour composite sample) for primary and secondary drinking water standards (Chapter 62-550, F.A.C.) and minimum criteria, see attached list, shall be submitted annually (sampled in February and submitted on or before April 30).

7. Surface Equipment

a. The integrity of the monitor zone sampling systems shall be maintained at all times. Sampling lines shall be clearly and unambiguously identified by monitoring zone at the point at which samples are drawn. All reasonable and prudent precautions shall be taken to ensure that samples are properly identified by monitor zone and that samples obtained are representative of those zones. Sampling lines and equipment shall be kept free of contamination with independent discharges and no interconnections with any other lines.

b. The surface equipment for the injection well system shall maintain compliance with Chapter 62-600, F.A.C. for water hammer control, screening, access for logging and testing, and reliability and flexibility in the event of damage to the well and effluent piping. A regular program of exercising the valves integral to the well head shall be instituted. At a minimum, all valves integral to the well head shall be exercised during the regularly scheduled quarterly injectivity testing.

c. The injection well and monitor well surface equipment and piping shall be kept free of corrosion at all times.

SPECIFIC CONDITIONS:

d. Spillage onto the injection well pad shall be contained as follows:

1) During construction activities, spillage onto the injection well pad shall be contained by an impermeable wall around the edge of the pad and directed to a sump which in turn discharges to the pumping station wet well or via other approved means to the injection well system.
2) Following completion of injection well system construction activities, any waters spilled during mechanical integrity testing, other maintenance, testing or repairs to the system shall be contained by temporary containment structures. The design of the temporary containment structures shall be submitted for UIC-TAC and USEPA review and Department approval prior to a planned outage.

e. The injection well construction pad shall be maintained and retained in service for the life of the injection well. The injection and monitor well pad(s) are not, unless specific approval is obtained form the Department, to be used for storage of any material or equipment at any time.

f. The four (4) surficial aquifer monitor wells installed at the corners of the injection well pad shall be secured, maintained, and retained in service.

8. Financial Responsibility

a. The permittee shall maintain the resources necessary to close, plug and abandon the injection and associated monitor wells, at all times [Rule 62-528.435(9), F.A.C.].

b. The permittee shall review annually the plugging and abandonment cost estimates. An increase of ten (10) percent or more over the cost estimate upon which financial responsibility is based shall require the permittee to submit documentation to obtain an updated Certificate of Demonstration of Financial Responsibility.

c. In the event the mechanism used to demonstrate financial responsibility should become invalid for any reason, the Permittee shall notify the Department of Environmental Protection in writing within fourteen (14) days of such invalidation. The permittee shall then within thirty (30) days of said notification submit to the Department for approval new financial documentation in order to comply with Rule 62-528.435(9), F.A.C., and the conditions of this permit.

9. Emergency Disposal

a. All applicable federal, state, and local permits shall be in place to allow for any alternate discharges due to emergency or planned outage conditions.

b. Any proposed changes in emergency disposal methods shall be submitted for UIC-TAC and USEPA review and Department approval prior to implementation.

c. In the event of an emergency and/or discharge, or other abnormal event where the Permittee is temporarily unable to comply with any of the conditions of this permit due to breakdown of equipment, power outages, destruction by hazard or fire, wind, or by other cause, the Department shall be notified in person or by telephone within twenty-four (24) hours of the incident. A written report describing the incident shall also be submitted to the Department within five (5) days of the start of the incident. The written report shall contain a complete description of the emergency and/or discharge, a discussion of its cause(s), and if it has been corrected, the anticipated time the discharge is to continue, the steps being taken to reduce, eliminate, and prevent recurrence of the event, and all other information deemed necessary by the Department.

SPECIFIC CONDITIONS:

d. The emergency disposal method consists of the following:

1) If the emergency is limited to taking one (1) or more wells out of service, the effluent shall be diverted to the remaining permitted injection wells provided that the higher velocities are within the permitted capacities and, per Rule 62-528.415(1)(f)3., F.A.C., provided that the permittee provides the Department with reasonable assurance that the higher velocities will not compromise the integrity or operation of the wells.

2) The emergency disposal method presented in the permit application received September 18, 1997 (Attachment G) and approved by the Department as a part of this permit shall be maintained in fully operational order at all times.

3) Any emergency bypass of the injection well system shall be governed by Rule 62-620.610, F.A.C. and meet the conditions of the Wastewater Facilities Permit No. FL0031771-000-DW1P.

4) Any proposed changes in emergency disposal methods shall be submitted for UIC-TAC and USEPA review and Department approval prior to implementation.

10. Permit Extension(s), Renewal(s) and Operation Permit Application(s)

a. Pursuant to Rule 62-4.080(3), a permittee may request that a permit be extended as a modification of an existing permit. A request for an extension is the responsibility of the permittee and shall be submitted to the Department before the expiration of the permit. In accordance with Rule 62-4.070(4), F.A.C., a permit cannot be extended beyond the maximum five (5) year statutory limit.

b. If injection is to continue beyond the expiration date of this permit the permittee shall apply for, and obtain an operation permit. If necessary to complete the two-year operational testing period, the permittee shall apply for renewal of the construction permit at least sixty (60) days prior to the expiration date of this permit.

11. Signatories

a. All reports and other submittals required to comply with this permit shall be signed by a person authorized under Rules 62-528.340(1) or (2), F.A.C.

b. In accordance with Rule 62-528.340(4), F.A.C., all reports shall contain the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Issued this 03 day of FEBRUARY, 1999

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

for

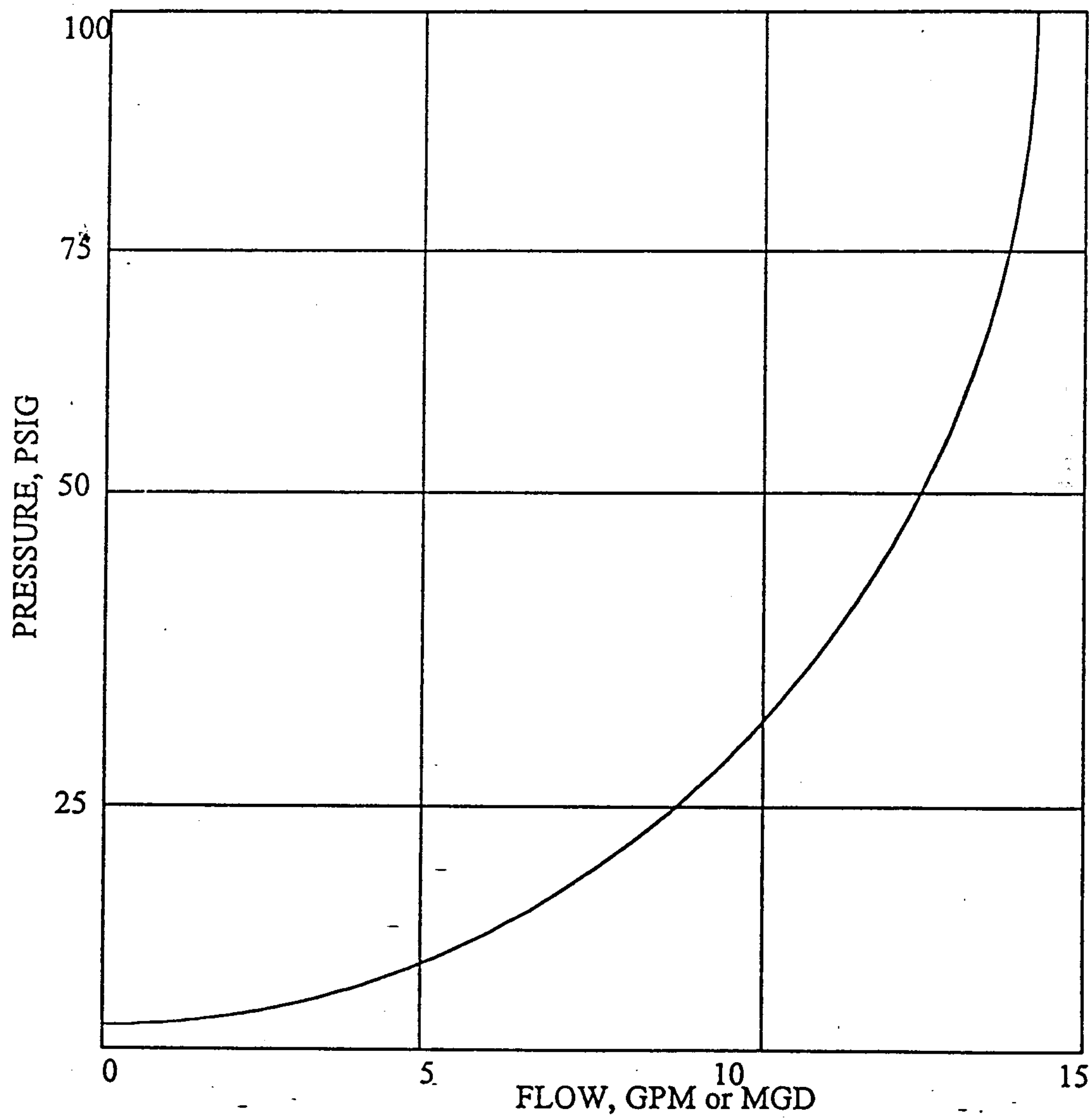
Carlos Rivero-deAguilar
Director of District Management

UNDERGROUND INJECTION CONTROL

DATE OF TEST :	FACILITY :
PERMIT NO. :	I.D. # :
WELL NO.	LEAD OPERATOR________________ SIGNATURE

INJECTIVITY TEST

SAMPLE



SOUTHEAST DISTRICT UIC SECTION

SURFICIAL AQUIFER MONITOR WELL QUARTERLY REPORT

FACILITY NAME ______________________ REPORT MO/YR.________________

OPERATOR NAME______________________ LICENSE #________________

I.D.NUMBER ______________________ PERMIT #________________

INJECTION WELL #______________________

SAMPLING DATE______________________ TIME________________

	PMW #1	PMW #2	PMW #3	PMW #4
LOCATION	NE CORNER	NW CORNER	SE CORNER	SW CORNER
ELEVATION OF TOC (NGVD)				
DEPTH TO WATER (TOC)				
WATER LEVEL (NGVD)				
CHLORIDES (MG/L.)				
CONDUCTIVITY (UMHOS)				
TEMPERATURE (F)				

ANALYZED BY:______________________ SAMPLED BY:________________

PHONE #______________________ TITLE________________

SITE PLAN OF PMW LOCATIONS

UNDERGROUND INJECTION CONTROL
INJECTIVITY TESTING SUMMARY SHEET

FACILITY________________________

Deep Injection Well System
Injectivity Testing

Injection Well No. :
DATE OF TEST:
FDER PERMIT No.:

____
Signature of Lead Operator

Were Wellhead Valves Exercised ________YES ________NO

TIME

	START	SHUT-IN PRESSURE
	MINS AFTER SHUT -IN	CALIBRATED PRESSURE GAUGE AT WELL HEAD (PSI)
	10	
	20	
	30	

COLUMN: 1	2	3	4	5	6	7	8	9	10
TIME	INJECTION WELL SHUT-IN PRESSURE AFTER 30 MINUTES (PSI)	PUMP NUMBER(S) ON-LINE	INJECTION RATE (gpm) or (mgd)	Injection Pressure after 10 minutes of pumping		PRESSURE DIFFERENTIAL (Col 5 - Col 2)	INJECTIVITY INDEX (Col 4 divide by Col 7)	UPPER MONITOR ZONE IN FEET OF HEAD ABOVE NGVD (FEET)	LOWER MONITOR ZONE IN FEET OF HEAD ABOVE NGVD (FEET)
				CALIBRATED GAUGE AT INJECTION WELLHEAD (PSI)	PRESSURE RECORDER (PSI)	FROM CALIBRATED PRESSURE GAUGE AT INJECTION WELLHEAD (PSI)	FROM CALIBRATED PRESSURE GAUGE AT INJECTION WELLHEAD (GPM / PSI)		

NOTES

1. INJECTIVITY INDEX (GPM/PSI) = INJECTION RATE (GPM) (COLUMN 4) / [(INJECTION PRESSURE (PSI) (COLUMN 5) - (SHUT-IN PRESSURE (PSI) (COLUMN 2)]

2. FOR MORE INFORMATION REGARDING EXECUTION OF THIS TEST CONSULT THE INJECTIVITY TESTING PROTOCOL IN THE O&M MANUAL

PRIMARY & SECONDARY DRINKING WATER STANDARDS & MINIMUM CRITERIA

Updated September 1998

PRIMARY DRINKING WATER STANDARDS

PARAMETER

Alachlor
Aldicarb
Aldicarb sulfoxide
Aldicarb sulfone
Aroclors (Polychlorinated Biphenyls or PCB's)
Alpha, Gross
Antimony
Arsenic
Atrazine
Barium
Benzene
Benzo(a)pyrene
Beryllium
Bis(2-ethylhexyl) adipate (Di(2-ethylhexyl) adipate)
Bis(2-ethylhexyl) phthalate (Di(2-ethylhexyl) phthalate)
Cadmium
Carbofuran
Carbon Tetrachloride (Tetrachloromethane)
Chlordane
Chlorobenzene (Monochlorobenzene)
Chloroethylene (Vinyl Chloride)
Chromium
Coliforms, Total
Cyanide
2,4-D (2,4-Dichlorophenoxyacetic acid)
Dalapon (2,2-Dichloropropionic acid)
Dibromochloropropane (DBCP)
1,2-Dibromoethane (EDB, Ethylene Dibromide)
1,2-Dichlorobenzene (o-Dichlorobenzene)
1,4-Dichlorobenzene (p-Dichlorobenzene or Para Dichlorobenzene)
1,2-Dichloroethane (Ethylene dichloride)
1,1-Dichloroethylene (Vinylidene chloride)
1,2-Dichlorethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)
cis-1,2-Dichloroethylene (1,2-Dichlorethylene)
trans-1,2-Dichloroethylene (1,2-Dichlorethylene)
Dichloromethane (Methylene chloride)
1,2-Dichloropropane
Di(2-ethylhexyl) adipate (Bis(2-ethylhexyl) adipate)
Di(2-ethylhexyl) phthalate (Bis(2-ethylhexyl) phthalate)
Dinoseb
Diquat
EDB (Ethylene dibromide, 1,2-Dibromoethane)
Endothall
Endrin
Ethylbenzene
Ethylene dichloride (1,2-Dichloroethane)
Fluoride
Glyphosate (Roundup)
Gross Alpha
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene (HCB)
gamma-Hexachlorocyclohexane (Lindane)
Hexachlorocyclopentadiene
Lead

PRIMARY DRINKING WATER STANDARDS, CONT'D

PARAMETER

Lindane (gamma-Hexachlorocyclohexane)
Mercury
Methoxychlor
Methylene chloride (Dichloromethane)
Monochlorobenzene (Chlorobenzene)
Nickel
Nitrate (as N)
Nitrite (as N)
Total Nitrate + Nitrite (as N)
Oxamyl
p-Dichlorobenzene or Para Dichlorobenzene (1,4-Dichlorobenzene)
Pentachlorophenol
Perchloroethylene (Tetrachloroethylene)
Picloram
Polychlorinated biphenyl (PCB or Aroclors)
Radium
Roundup (Glyphosate)
Selenium
Silver
Silvex (2,4,5-TP)
Simazine
Sodium
Styrene (Vinyl benzene)
Tetrachloroethylene (Perchloroethylene)
Tetrachloromethane (Carbon Tetrachloride)
Thallium
Toluene
Toxaphene
2,4,5-TP (Silvex)
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene (Trichloroethene, TCE)
Trihalomethanes, Total
Vinyl Chloride (Chloroethylene)
Xylenes (total)

SECONDARY DRINKING WATER STANDARDS

PARAMETER

Aluminum
Chloride
Color
Copper
Corrosivity
Ethylbenzene
Fluoride
Foaming Agents (MBAS)
Iron
Manganese
Odor
pH
Silver
Sulfate
Toluene
Total Dissolved Solids (TDS)
Xylenes
Zinc

MUNICIPAL WASTEWATER MINIMUM CRITERIA
GROUND WATER MONITORING PARAMETERS

INORGANICS

Ammonia
Nitrogen (organic)
Total Kjeldahl Nitrogen
Total Phosphorus (phosphate)

VOLATILE ORGANICS

Chloroethane
Chloroform
para-Dichlorobenzene (1,4 Dichlorobenzene)
1,2-Dichloroethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)

BASE/NEUTRAL ORGANICS

Anthracene
Butylbenzylphthalate
Dimethylphthalate
Naphalene
Phenanthrene

PESTICIDES AND PCBs

Aldrin
Dieldrin
Dioxin

ACID EXTRACTABLES

2-chlorophenol
Phenol
2,4,6-trichlorophenol

OTHER

Conductivity
Biological Oxygen Demand
Chemical Oxygen Demand
Temperature

IW6 / MW4 Construction Permit

Department of Environmental Protection

Lawton Chiles
Governor

Southeast District
P.O. Box 15425
West Palm Beach, Florida 33416

Virginia B. Wetherell
Secretary

FEB - 3 1999

NOTICE OF PERMIT

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

BROWARD COUNTY
UIC - Broward County N. Regional WWTP
FILE: 0051336-006-UC (IW-6, MW-4)

Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services
2555 West Copans Road
Pompano Beach, FL 33069

Dear Mr. Scottie:

Enclosed is Permit Number 0051336-006-UC, to construct a 24-inch outside diameter (O.D.) Class I municipal injection well, IW-6, and to operationally test IW-6 with non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional WWTP, issued pursuant to Section(s) 403.087, Florida Statutes and Florida Administrative Codes 62-4, 62-520, 62-522, 62-528, and 62-550, 62-600 and 62-601. The system is located at the Broward County North Regional WWTP.

Any party to this Order (permit) has the right to seek judicial review of the permit pursuant to Section 120.68, Florida Statutes, by the filing of a Notice of Appeal pursuant to Rule 9.110, Florida Rules of Appellate Procedure, with the Clerk of the Department in the Office of General Counsel, Mail Stop 35, 3900 Commonwealth Blvd., Tallahassee, Florida 32399-3000; and by filing a copy of the Notice of Appeal accompanied by the applicable filing fees with the appropriate District Court of Appeal. The Notice of Appeal must be filed within 30 days from the date this Notice is filed with the Clerk of the Department.

Should you have any questions, please contact Jose L. Calas, P.E., or Mark A. Silverman, P.G., of this office, at telephone (561) 681-6691 or (561) 681-6695, respectively.

Executed in West Palm Beach, Florida.

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

for [signature] 02/03/99

Carlos Rivero-deAguilar
Director of District Management
Southeast District

Date

CRA:AM:JLC:mas

Copies furnished to:

Gary Fox, BCOES
Patrick Davis, H&S
James Wheatley, WTA
Tom Missimer, MI
Steve Anderson, SFWMD/WPB

Richard Deuerling, FDEP/TLH
Brad Russell, FDEP/WPB
Cynthia Christen, OGC
Francine Ffolkes, OGC
Kathelyn Jacques, OGC

Nancy Marsh, USEPA/ATL
Scott Hoskins, USEPA/ATL
Ron Reese, USGS/MIA
Garth Hinckle, BCDNRP

CERTIFICATE OF SERVICE

This is to certify that this NOTICE OF PERMIT and all copies were mailed before the close of business on FEB - 3 1999 to the listed persons.

Clerk Stamp

FILING AND ACKNOWLEDGMENT FILED, on this date, pursuant to the §120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

Linda Schappa [signature]
Clerk

FEB - 3 1999
Date

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

Printed on recycled paper.

Department of
Environmental Protection

Lawton Chiles
Governor

Southeast District
P.O. Box 15425
West Palm Beach, Florida 33416

Virginia B. Wetherell
Secretary

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services
2555 West Copans Road
Pompano Beach, FL 33069

GMS I. D. NUMBER: 5006C10220
PERMIT/CERTIFICATION NUMBER: 0051336-006-UC
DATE OF ISSUE: FEB - 3 1999
EXPIRATION DATE: FEB - 2 2004
COUNTY: Broward
LATITUDE/LONGITUDE: 26°15'48"N/80°09'28"W
PROJECT: Construction Permit for Class I Municipal Injection Well IW-6 at the Broward County North Regional WWTP

PROJECT: Permit to construct Injection Well IW-6, and to operationally test IW-6 with an associated dual zone monitor well, MW-4, with non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional Wastewater Treatment Plant (WWTP).

This permit is issued under the provisions of Chapter 403.087, Florida Statutes, and Florida Administrative Code (F.A.C.) Rules 62-4, 62-520, 62-522, 62-528, and 62-550, 62-600 and 62-601. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows:

TO CONSTRUCT: One twenty-four (24) inch (O.D.) Class I municipal injection well, IW-6, and
TO OPERATIONALLY TEST: IW-6 with a deep dual zone monitor well, MW-4. Injection Well IW-6 will be used to inject up to a flow rate of 10.0 feet per second or 18.7 million gallons per day (MGD) (peak hour flow) of non-hazardous secondary treated domestic wastewater (effluent) from the Broward County North Regional WWTP. The injection well will be cased to approximately 3,000 feet below land surface (bls), with an open borehole extending to the total depth of the well at approximately 3,500 feet bls. The confinement of the injection zone from overlying underground source of drinking water (USDW) aquifers and fluid movement adjacent to the wellbore of the injection well will be monitored by two monitoring zones in Monitor Well MW-4. The lower interval may be positioned in a transmissive interval above the base of the USDW at an appropriate point above the injection interval and major confining units to monitor for reasonable assurance of vertical confinement of injected fluids and external mechanical integrity of the injection wells. The upper interval may be positioned in the next shallower adequately transmissive interval within the USDW.

IN ACCORDANCE WITH: Application to Construct a Class I Injection Well System received September 19, 1997; Request for Information (RFI) dated December 16, 1997; meeting at the Southeast District office with the County and Hazen & Sawyer, the County's consultant, held December 17, 1997; Response to RFI received January 20, 1998; RFI dated February 17, 1998; meeting at the Southeast District office with the County and Hazen & Sawyer, held February 20, 1998; correspondence from the Department to the County dated February 27, 1998; Responses to RFI received March 19, 1998 and March 31, 1998; RFI dated April 17, 1998; Response to RFI received May 5, 1998; RFI dated June 2, 1998; Response to RFI received June 10, 1998; supplementary correspondence received July 15, 1998; comments from the Underground Injection Control - Technical Advisory Committee (UIC-TAC); publication of the Notice of Draft Permit 0051336-006-UC in the Sun-Sentinel newspaper on September 3, 1998; consideration of receipt of public comment received as a result of a public meeting held on October 6, 1998; and publication of the Intent to Issue Permit 0051336-005-UC in the Sun-Sentinel newspaper on November 18, 1998.

LOCATED AT: Broward County North Regional Wastewater Treatment Plant (WWTP), 2401 North Powerline Road, Pompano Beach, Broward County, Florida 33069.

TO SERVE: The Broward County North Regional WWTP Service Area.

SUBJECT TO: General Conditions 1-17 and Specific Conditions 1-11.

GENERAL CONDITIONS:

The following General Conditions are referenced in Florida Administrative Code Rule 62-4.160.

1. The terms, conditions, requirements, limitations and restrictions set forth in this permit, are "permit conditions" and are binding and enforceable pursuant to Sections 403.141, 403.727, or 403.859 through 403.861, FS. The permittee is placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of these conditions.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in subsections 403.087(6) and 403.722(5), FS, the issuance of this permit does not convey any vested rights or any exclusive privileges. Neither does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state, or local laws or regulations. This permit is not a waiver of, or approval of, any other Department permit that may be required for other aspects of the total project which are not addressed in this permit.

4. This permit conveys no title to land or water, does not constitute State recognition or acknowledgment of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the State. Only the Trustees of the Internal Improvement Trust Fund may express State opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, or plant life, or property caused by the construction or operation of this permitted source, or from penalties therefore; nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

6. The permittee shall properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed and used by the permittee to achieve compliance with the conditions of this permit, are required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law and at reasonable times, access to the premises where the permitted activity is located or conducted to:

   a. Have access to and copy any records that must be kept under conditions of the permit;
   b. Inspect facility, equipment, practices, or operations regulated or required under this permit;
   c. Sample or monitor any substances or parameters at any location reasonable necessary to assure compliance with this permit or Department rules. Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, permittee does not comply with or will be unable to comply with any condition or limitation specified in the permit, permittee shall immediately provide the Department with the following:

   a. A description of and cause of noncompliance; and
   b. The period of noncompliance, including dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance. The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or for revocation of this permit.

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services

GMS I. D. NUMBER: 5006C10220
PERMIT/CERTIFICATION NUMBER: 0051336-006-UC
DATE OF ISSUE: FEB - 3 1999
EXPIRATION DATE: FEB - 2 2004

GENERAL CONDITIONS:

9. In accepting this permit, permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source, which are submitted to the Department, may be used by the Department as evidence in any enforcement case involving the permitted source arising under the Florida Statutes or Department rules, except where such use is prescribed by Section 403.111 and 403.73, FS. Such evidence shall only be used to the extent it is consistent with the Florida Rules of Civil Procedure and appropriate evidentiary rules.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance; provided, however, the permittee does not waive any other rights granted by Florida Statutes or Department rules. A reasonable time for compliance with a new or amended surface water quality standard, other than those standards addressed in Rule 62-302.500, shall include a reasonable time to obtain or be denied a mixing zone for the new or amended standard.

11. This permit is transferable only upon Department approval in accordance with Rule 62-4.120 and 62-730.300 FAC, as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit or a copy thereof shall be kept at the work site of the permitted activity.

13. This permit also constitutes:

    a. Determination of Best Available Control Technology (BACT)
    b. Determination of Prevention of Significant Deterioration (PSD)
    c. Certification of compliance with state Water Quality Standards (Section 401, PL 92-500)
    d. Compliance with New Source Performance Standards

14. The permittee shall comply with the following:

    a. Upon request, the permittee shall furnish all records and plans required under Department rules. During enforcement actions, the retention period for all records will be extended automatically unless otherwise stipulated by the Department.
    b. The permittee shall hold at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation) required by the permit, copies of all reports required by this permit, and records of all data used to complete the application for this permit. These materials shall be retained at least three years from the date of the sample, measurement, report, or application unless otherwise specified by Department rule.
    c. Records of monitoring information shall include:

        1) the date, exact place, and time of sampling or measurements
        2) the person responsible for performing the sampling or measurements
        3) the dates analyses were performed
        4) the person responsible for performing the analyses
        5) the analytical techniques or methods
        6) the results of such analyses

15. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware the relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be corrected promptly.

PERMITTEE:
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GENERAL CONDITIONS:

16. In the case of an underground injection control permit, the following permit conditions also shall apply:

    a. All reports or information required by the Department shall be certified as being true, accurate and complete.
    b. Reports of compliance or noncompliance with, or any progress reports on, requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.
    c. Notification of any noncompliance, which may endanger health or the environment, shall be reported verbally to the Department within 24 hours and again within 72 hours, and a final written report provided within two weeks.

        1) The verbal reports shall contain any monitoring or other information which indicate that any contaminant may endanger an underground source of drinking water and any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between underground sources of drinking water.
        2) The written submission shall contain a description of and a discussion of the cause of the noncompliance and, if it has not been corrected, the anticipated time the noncompliance is expected to continue, the steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance and all information required by Rule 62-528.230(4)(b), FAC.

    d. The Department shall be notified at least 180 days before conversion or abandonment of an injection well, unless abandonment within a lesser period of time is necessary to protect waters of the state.

17. The following conditions also shall apply to a hazardous waste facility permit.

    a. The following reports shall be submitted to the Department:

        1) Manifest discrepancy report. If a significant discrepancy in a manifest is discovered, the permittee shall attempt to rectify the discrepancy. If not resolved within 15 days after the waste is received, the permittee shall immediately submit a letter report, including a copy of the manifest, to the Department.
        2) Unmanifested waste report. Permittee shall submit an unmanifested waste report to the Department within 15 days of receipt of unmanifested waste.
        3) Biennial report. A biennial report covering facility activities during previous calendar year shall be submitted by March 1 of each even numbered year pursuant to Chapter 62-730, FAC

    b. Notification of any noncompliance which may endanger health or the environment, including the release of any hazardous waste that may endanger public drinking water supplies or the occurrence of a fire or explosion from the facility which could threaten the environment or human health outside the facility, shall be reported verbally to the Department within 24 hours, and a written report shall be provided within 5 days. The verbal report shall include the name, address, ID number, and telephone number of the facility, its owner or operator, the name and quantity of materials involved, the extent of any injuries, an assessment of actual or potential hazards, and the estimated quantity and disposition of recovered material. The written submission shall contain:

        1) A description and cause of the noncompliance.
        2) If not corrected, the expected time of correction, and the steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance.

    c. Reports of compliance or noncompliance with, or any progress reports on, requirements in any compliance schedule shall be submitted no later than 14 days after each schedule date.

    d. All reports or information required by the Department by a hazardous waste permittee shall be signed by a person authorized to sign a permit application.

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services

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EXPIRATION DATE: FEB - 2 2004

SPECIFIC CONDITIONS:

1. General Requirements

a. This permit (FDEP Permit 0051336-006-UC) is to construct the Broward County North Regional WWTP Class I municipal injection well, IW-6, and to operationally test IW-6 with an associated dual zone monitor well, MW-4. This permit does not authorize the construction or operational testing of any other well or wells associated with the Broward County North Regional WWTP Injection Well System. This permit does not supersede FDEP Permit UC-06-292757 requirements which pertain to the construction of Monitor Well MW-4 at the Broward County North Regional WWTP. All conditions of FDEP Construction Permit UC-06-292757 remain in effect, with the exception of monitoring requirements for Monitor Well MW-4 previously addressed in FDEP Permit UC-06-292757 Specific Condition [S.C.] 5. The monitoring of Monitor Well MW-4 shall be conducted in accordance with the requirements of FDEP Permit 0051336-006-UC.

b. Four permanent surficial aquifer monitor wells, identified as Pad Monitor Wells (PMWs), shall be located at the corners of the injection well drilling pad and identified by location number and pad location, i.e. NW, NE, SW, and SE. The four PMWs shall be sampled and analyzed prior to the onset of drilling. Initial analyses shall be submitted to the Department prior to the initiation of work. [See Specific Condition (S.C.) (4.e)vi).] The samples shall be analyzed for chlorides (mg/L), specific conductance (umho/cm), total dissolved solids (TDS, mg/L) and water level (relative to NGVD). These monitor wells are to be retained in service, sampled weekly for the above parameters during the construction phase of the project, monthly during the operational testing phase and quarterly once an operation permit is granted. In addition, these monitor wells shall be sampled 48 hours prior to any maintenance, testing (including mechanical integrity testing) or repairs to the system which represent an increased potential for accidental discharge to the surficial aquifer. The results of these analyses shall be submitted to the Department within thirty (30) days of the completion of the activity. A summary sheet from the FDEP Southeast District is attached for your use when reporting the above information. If located in a traffic area the well head(s) must be protected by a traffic bearing enclosure and cover. The cover(s) must lock and be specifically marked to identify the well and its purpose.

c. Any permit noncompliance constitutes a violation of the Safe Drinking Water Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

d. It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

e. The permittee shall take all reasonable steps to minimize or correct any adverse impact on the environment resulting from noncompliance with this permit.

f. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures.

g. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation or reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

h. When requested by the Department, the permittee shall furnish, within the time specified, any information needed to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with this permit.

i. The permittee shall retain all records concerning the nature and composition of injected fluid under Rule 62-528.435, F.A.C. The permittee shall deliver the records to the Department office that issued the permit at the conclusion of the retention period unless the permittee elects to continue retention of the records.

j. The permittee shall notify the Department and obtain approval prior to any physical alterations or additions to the injection or monitor well, including removal of the well head.

k. The permittee shall give advance notice to the Department of any planned changes in the permitted facility or injection activity which may result in noncompliance with permit requirements.

SPECIFIC CONDITIONS:

2. Construction and Testing Requirements

a. The measurement points for drilling and logging operations shall be surveyed and referenced to the National Geodetic Vertical Datum (NGVD) of 1929 prior to the onset of drilling activities for the injection well and associated dual zone monitor well.

b. Blow-out preventers shall be installed on the wells prior to penetration of the Floridan aquifer system.

c. No drilling operations shall begin without an approved disposal site for drilling fluids, cuttings, or waste. It shall be the permittee's responsibility to obtain the necessary approval(s) for disposal prior to the start of construction.

d. The Department shall be notified within 48 hours after work has commenced.

e. Hurricane Preparedness - Upon the issuance of a "Hurricane Watch" by the National Weather Service, the preparations to be made include but are not necessarily limited to the following:

1) Secure all on-site salt and stockpiled additive materials to prevent surface and/or groundwater contamination.

2) Properly secure drilling equipment and rig(s) to prevent damage to well(s) and on-site treatment process equipment.

f. Waters spilled during construction or testing of the injection well system shall be contained and properly disposed.

g. UIC-TAC and United States Environmental Protection Agency (USEPA) review and Department approval are required prior to the following stages of construction and testing:

1) Contract documents and spud date
2) Intermediate (34-inch) injection well casing seat
3) Final injection well casing seat
4) Proposed cementing procedures (including cement volumes, number of stages) for the intermediate and final casing must be submitted for UIC-TAC and USEPA review and Department approval.
5) Mechanical integrity testing
6) Operational testing

h. The geophysical logging program shall at a minimum include:

1) Prior to setting the surface casing in Injection Well IW-5, the following geophysical logs shall be run on the borehole, to identify the base of the Hawthorn Group at approximately 1000 feet bls, and to establish a mechanically secure casing setting depth:
   - Caliper
   - Gamma ray

2) To determine the intermediate casing depth in Injection Well IW-6, the logs indicated below shall be run on the pilot hole. These logs shall be interpreted for stratigraphic correlation, identification of potential monitoring zones, identification of confining units, identification of producing intervals, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey with rotating lens
   - Logs to be run under pumping and static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

   Pumping capability shall be supplied during the pumping flowmeter log runs to adequately stress proposed confining units and allow the log interpreter, in conjunction with other pertinent testing and logging, to identify the confining beds.

SPECIFIC CONDITIONS:

3) To determine the final casing depth in Injection Well IW-6, the logs indicated below shall be run on the pilot hole. These logs shall be interpreted for stratigraphic correlation, identification of potential monitoring zones, identification of confining units, identification of producing intervals, and to aid in the casing seat determination:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey
   - Logs to be run under static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

4) In the injection zone below the final casing of Injection Well IW-6, the following logs shall be run:
   - Caliper
   - Gamma ray
   - Dual induction
   - Borehole compensated sonic with VDL display
   - Borehole televiewer
   - Downhole radial color television survey
   - Logs to be run under pumping and static conditions:
     - Flowmeter
     - Temperature
     - Fluid resistivity

5) Caliper logs shall be run on all reamed holes.

6) Temperature logs shall be run after each stage of cementing on all casings to identify the top of the cement.

7) In the injection well, a cement bond log shall be run after the cementing of the 24-inch casing.

i. Straddle packer testing shall at a minimum include the following:

1) A total of at least five straddle packer tests shall be conducted during the drilling of Injection Well IW-6, as proposed in the Technical Specifications included in the County's permit application received on September 19, 1997.
2) At least four (4) straddle packer tests conducted from the lowermost zone of the USDW to the top of the proposed injection horizon. These packer tests will be used for the demonstration of confinement at the IW-6 location, and will be performed in the anticipated confining zones. At least one straddle packer test supporting the demonstration of confinement will be obtained from each interval under consideration, based on the data collected to date, to be a confining unit at the IW-6 location. [See S.C. 2.j)]. To the extent feasible, these packer tests shall be performed so as to exclude intervals of high hydraulic conductivity.
3) Water samples shall be collected from each straddle packer test, and analyzed for total dissolved solids (TDS, mg/L), chlorides (mg/L), specific conductance (umho/cm), sulfate (mg/L), ammonia (mg/L), and Total Kjeldahl Nitrogen (TKN, mg/L), at a minimum.
4) A five (5) gallon water sample, obtained from intervals where sufficient water is available, shall be collected at the end of each straddle packer test. These samples shall be shipped to the Underground Injection Control (UIC) Section of the Department of Environmental Protection, in Tallahassee (FDEP, UIC Program, MS 3530, Twin Towers Building, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400).

SPECIFIC CONDITIONS:

j. Confinement for the Injection Well IW-6 location shall be demonstrated using, at a minimum, lithologic properties, geophysical evidence, tests performed while pumping the formation, and water quality analyses, as described in Items i) through vi) below

1) Tests performed while pumping the formation shall include flowmeter, temperature and fluid resistivity logs (run from the base of the USDW to the planned intermediate casing depth in Injection Well IW-6), and straddle-packer tests. From the straddle-packer tests, the results of water quality sampling and the analysis of drawdown curves (measured during the packer tests) shall be reported to the Department, the UIC-TAC and the USEPA, Region IV, Atlanta, including interpretations with respect to the degree of confinement.
2) If geophysical logging and other test results (from the proposed testing program) are not adequate to demonstrate confinement then additional geophysical logging and testing may be required.
3) Prior to running flowmeter logs and downhole radial color television surveys, information shall be recorded pertaining to the development and conditioning of the borehole, detailing all measures taken (including but not limited to the number of wiper runs with bit; a description of the extent of well development methods used, etc.) and the lengths of time applied. In addition, the pumping flowmeter logging results shall include a record of the pumping rate(s) and drawdown(s) regularly recorded throughout the test to account for possible variations in the pumping rate.
4) Geophysical logs described under S.C. 2.h), and such other geophysical surveys and tests as are needed after taking into account the need for additional information that may arise as the construction of the well progresses (per Rule 62-528.410(6)(a)2., F.A.C.), shall be used to deduce and/or correlate formation properties measured in pumping tests and lithologic sample analysis.
5) Lithologic properties measured in laboratory analyses of core samples shall include: hydraulic conductivity (vertical and horizontal) and Young's modulus/elastic modulus Formation factor. No less than five (5) core samples shall be taken and analyzed from Injection Well IW-6.
6) To the extent feasible, core descriptions shall be used to address bedding characteristics, and lithologic descriptions from cores and cuttings shall include characterizations that pertain to the degree of confinement, including, but not limited to, texture, grain composition, grain shape (including the degree of flatness) pore geometry (including sorting and interlocking of grains), cement composition and degree of crystalization, rock matrix characteristics, and sedimentary depositional and diagenetic environment.

To the extent feasible, the descriptions and interpretations derived from the lines of testing referenced above should address the degree of confinement at the IW-6 injection well location. In addition, the geophysical logs shall be used to the extent feasible to extend the applicability of measurements of hydraulic characteristics obtained from the testing of discrete intervals, such as cores and straddle packer tests, to an entire bed or series of beds (in both the horizontal and vertical directions). The testing, analysis and interpretation of results shall be thorough enough to evaluate the extent of confinement between the top of the redefined injection zone and the base of the USDW.

k. Test results pertaining to confinement shall include and/or specifically reference the following informational and quality control items:

1) Quality control measures taken, including:
   - Information which documents the calibration of tools, including field checks prior to testing.
   - The conditioning/development of the borehole prior to logging, including the techniques used and the time periods in which applied, and
   - Pertaining to straddle packer/pump testing - recording the pumping rate regularly throughout the test to account for possible variations in the pumping rate, and providing information regarding the detection of packer leaks, if any, during testing.
2) Formulas, calculations, assumptions and constants used in the determination of porosity and formation fluid quality.

l. Representative samples of circulation fluid shall be collected a minimum of every thirty (30) feet in drilling, from a depth of approximately 1,000 feet to the top of the "Boulder Zone" at approximately 3,000 feet bls, for the IW-6 pilot hole. The representative samples shall be analyzed for chlorides (mg/L), specific conductance (umho/cm), and ammonia (mg/L), at a minimum.

m. If effluent is encountered or suspected during pilot hole drilling and testing, the Department shall be notified immediately by telephone and in writing and immediate appropriate precautionary measures shall be taken to prevent any upward fluid movement.

SPECIFIC CONDITIONS:

n. Mechanical integrity of the injection well shall be determined pursuant to Rules 62-528.300(6)(b)2. and 62-528.300(6)(c), F.A.C.

1) The pressure test for the final casing shall be accepted if tested with a liquid filled casing at 1.5 times the operating pressure at which the well is to be permitted with a test tolerance of not greater than + or - five (5) percent over a one-hour test period.
2) Verification of pressure gauge calibration must be provided to the Department representative at the time of the test and in the certified test report.

o. The Department shall be notified at least seventy-two (72) hours prior to all testing for mechanical integrity.

p. All testing for mechanical integrity must be initiated during normal business hours, Monday through Friday.

q. UIC-TAC meetings are scheduled on the 2nd and 4th Tuesday of each month subject to a five (5) working day prior notice and timely receipt of critical data by all UIC-TAC members and the USEPA, Region IV, Atlanta. Emergency meetings may be arranged when justified to avoid undue construction delays.

r. The pilot hole of Injection Well IW-6 shall not be drilled below the depth of the 34-inch casing (of IW-6) until the subsurface construction of Monitor Well MW-4 is completed.

s. Monthly sampling of Monitor Well MW-4 (upper and lower zones, to be conducted prior to operational testing) shall commence within thirty (30) days of the combined completion of Monitor Well MW-4 and Injection Well IW-6. The monthly sampling program shall include all monitoring parameters indicated in S.C. 6.a)xvi)b)(2) (of FDEP Permit 0051336-006-UC), and shall be conducted in accordance with the following specific conditions of FDEP Permit 0051336-006-UC: S.C. 6.a)vii), S.C. 6.a)xvii), S.C. 6.a)xviii), S.C. 6.a)xix), and S.C. 6.a)xx).

3. Quality Assurance/Quality Control Requirements

a. Pursuant to Rule 62-528.440(5)(b), F.A.C., the Professional Engineer(s) of Record shall certify all documents related to the completion of the Class I injection well system (including the associated Floridan aquifer monitor well) as a disposal facility. The Department shall be notified immediately of any change of the Engineer(s) of Record.

b. In accordance with Section 492, Florida Statutes, all documents prepared for the geological/hydrogeological evaluation of the injection well system shall be signed and sealed by a Florida Licensed Professional Geologist or qualified Florida Licensed Professional Engineer.

c. Continuous on-site supervision by qualified personnel (engineer or geologist) is required during all testing, geophysical logging, casing installation and cementing operations.

4. Reporting Requirements

a. All reports and surveys required by this permit shall be submitted concurrently to all members of the UIC-TAC. The UIC-TAC shall consist of representatives of the following agencies:

- Department of Environmental Protection, West Palm Beach and Tallahassee
- United States Geological Survey (USGS), Miami
- South Florida Water Management District (SFWMD), West Palm Beach
- Broward County Department of Natural Resource Protection (BCDNRP), Ft. Lauderdale

In addition, all reports and surveys required by this permit shall be submitted concurrently to the USEPA, Region IV, Atlanta. A UIC-TAC and USEPA distribution list is attached.

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services

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SPECIFIC CONDITIONS:

b. A drilling and construction schedule shall be submitted to the Department, all members of the UIC-TAC and the EPA, prior to site preparation for the injection well system.

c. The Department and other applicable agencies must be notified of any unusual or abnormal events occurring during construction, and in the event the Permittee is temporarily unable to comply with the provisions of the permit (e.g., on-site spills, artesian flows, large volume circulation losses, equipment damage due to: fire, wind and drilling difficulties, etc.). Any information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five (5) days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

d. The permittee shall report any noncompliance which may endanger health or the environment, including:

1) Any monitoring or other information which indicates that any contaminant may cause an endangerment to a USDW; or

2) Any noncompliance with a permit condition or malfunction of the injection system which may cause fluid migration into or between USDWs.

Any information shall be provided orally within twenty-four (24) hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within five (5) days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause, the period of noncompliance, including exact dates and times, and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and the steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance.

e. Weekly progress reports shall be submitted throughout the construction period for IW-6. These reports shall be submitted no later than the seventh (7th) day immediately following the period of record, and shall include at a minimum the following information:

1) A cover letter summary of the daily engineer report, driller's log and a projection for activities in the next reporting period.
2) Daily engineers report and driller's/work log with detailed descriptions of all drilling progress, cementing, testing, logging, and casing installation activities.
3) Lithologic and geophysical logs and water quality test results.
4) Interpretations shall be included with all test results and logs submitted under Items ii. and iii. above.
5) Detailed description of any unusual construction-related events that occur during the reporting period.
6) Weekly water quality analysis and water levels for the four pad monitor wells. [See S.C. 1.b).]
7) A certified evaluation of all logging and test results must be submitted with test data.
8) Description of the formations and lithology encountered.
9) Details of cementing operations including the following information, for each stage of cementing: cement slurry composition, specific gravity, pumping rate, volume of cement pumped, theoretical fill depth, and actual tag depth. From both the physical tag and the geophysical logs, a percent fill shall be calculated. An explanation of any deviation between actual versus theoretical fill shall be provided. For each casing, laboratory analysis of dry cement composition of a sample taken during the neat cement stage emplaced at the base of each casing.

SPECIFIC CONDITIONS:

f. Per Rules 62-528.410(4)(c), 62-528.420(4)(c) and 62-528.605(2), F.A.C., the final selection of specific injection intervals must be approved by the Department. In order to obtain an approval, the permittee shall submit a request to the Department. The request shall be submitted concurrently to all members of the UIC-TAC and the USEPA, Region IV, Atlanta. All casing seat requests submitted in accordance with S.C. 2.g) for the injection well shall be accompanied by technical justification. To the extent possible, each casing seat request should address the following items:

1) Lithologic and geophysical logs with interpretations, as the interpretations relate to the casing seat.
2) Water quality data.
3) Identification of confining units, including hydrogeologic data and interpretations.
4) Casing depth evaluation (mechanically secure formation, potential for grout seal).
5) Lithologic drilling rate and weight on bit data, with interpretations (related to the casing seat).

g. An interpretation of all test results and geophysical logs must be submitted with all submittals.

h. The injection test request shall contain the following justifications:

1) Cement bond logs and interpretation.
2) Final downhole television survey with interpretation.
3) Radioactive tracer test results (if the test is to be run using effluent)
4) Demonstration of mechanical integrity, which shall include Items i) through iii) above, and the pressure testing and temperature logging results (if the test is to be run using effluent)
5) Reasonable assurance that adequate confinement exists.
6) Water quality analysis of injection fluid from every source.

i. Upon completion of analysis of cores and sample cuttings, the permittee shall contact the UIC Section of the Department of Environmental Protection in Tallahassee to arrange their transfer to the Florida State Geologic Survey.

j. A final report of the construction and testing of the injection well and dual zone monitor well, shall be submitted with the application for an operation permit for IW-6, pursuant to Rule 62-528.430(1)(e), F.A.C. This report shall include, at a minimum, delineation of the injection interval, all relevant confining units, the depth of the base of the USDW and all monitor zones, including all relevant data and interpretations, collected during construction and operational testing of the injection well system.

5. Operational Testing Requirements

a. The operational testing of the Class I injection well system under this permit shall not commence without written authorization from the Department.

b. Prior to operational testing, the permittee shall comply with the operational testing requirements of Rule 62-528.450(3)(a) through (c), F.A.C.

c. Prior to operational testing approval, the following items must be submitted (with the request for operational testing approval) for UIC-TAC and USEPA review and Department approval:

1) Lithologic and geophysical logs with interpretations.

2) A copy of the borehole television survey of the injection well with interpretation.

3) Certification of mechanical integrity and interpreted test data.

SPECIFIC CONDITIONS:

4) Results of the short term injection test with interpretation of the data. Each well shall first be tested for integrity of construction, and shall be followed by a short term injection test of such duration to allow for the prediction of operating pressure. The test results shall include a calculation or determination of fracture pressure of the injection formation [per Rule 62-528.410(6)(b)3., F.A.C.]. The injection test shall be conducted for a minimum of twenty-four (24) hours at a rate no less than the maximum rate at which the well is to be permitted. Pressure/water level data from the injection zone and both monitor zones shall be recorded continuously for at least twenty-four (24) hours before the test and at least twelve (12) hours following the test. The following data shall be recorded, analyzed, and reported for the duration of the injection test, i.e., all data should encompass the entire background, injection and recovery periods:

- injection flow rate (Injection Well IW-6, in MGD)
- injection pressure (Injection Well IW-6, in psig)
- pressure (psig) in Injection Wells (IW-1, IW-2, IW-3, IW-4; and IW-5, if constructed)
- injection zone pressure with no flow (shut-in pressure in psig)
- monitor well pressure (upper and lower zones of MW-1, MW-2, MW-4, and MW-3, if totally constructed)
- barometric pressure

5) A description of the actual injection procedure including the anticipated maximum pressure and flow rate at which the well will be operated under normal and emergency conditions.

6) Specification of the initial planned monthly injectivity test rates. [See S.C. 6.a)xxii).]

7) Information concerning the compatibility of the injected waste with fluids in the injection zone and minerals in both the injection zone and the confining zone.

8) Certification of completion of well construction.

9) Surface equipment (including pumping station, piping, pressure gauges and flow meters, and all appurtenances) completion certified by the Engineer of Record.

10) Draft operation and maintenance manual, including a description of water hammer control and emergency discharge management plan procedures. The emergency discharge system must be fully constructed and operational (ready to operate) prior to approval of operational testing.

11) Calibration certificates for pressure gauges and flow meters.

12) Signed and sealed record "as-built" engineering drawings of the injection well system including all well construction, the pump station, subsurface and surface piping and equipment, and appurtenances.

13) The well construction drawings shall include a geologic stratigraphic cross-section depicting the corresponding formations, the base of the USDW, and the boundaries of the confining and injection zone intervals.

14) The demonstration of confinement for the Injection Well IW-6 location, prepared providing confirmation of confinement and defining the injection and confining sequences utilizing data collected during the drilling, logging and testing of the injection well and dual zone monitor well. The report shall include the results of hydraulic testing (permeability, porosity, etc.) on the cores, and shall be reviewed and updated as appropriate after the completion of any additional injection/monitor well pairs in the future from the confining interval. This submittal shall be prepared, signed, and sealed by a Florida Registered Professional Geologist or appropriately qualified Professional Engineer.

15) The confinement report referenced above shall include local cross-sections which include information pertaining to confinement. The cross-sections shall be constructed from all of the hydrogeologic data (geophysical logs, lithologic descriptions, packer tests, core analyses, water quality data, etc.) collected during the previous construction of all of the injection wells and monitor wells completed to date at the Broward County North Regional WWTP, and shall be updated with the data collected during the drilling of Injection Well IW-6 and Monitor Well MW-4. The cross-sections shall show the hydrogeologic correlation between all the wells (IW-1, IW-2, IW-3, IW-4, MW-1, MW-2, MW-3 and MW-4) at the Broward County North Regional WWTP.

SPECIFIC CONDITIONS:

16) Wastestream analysis, sampled within six (6) months of the request for operational testing, for primary and secondary drinking water standards (62-550, F.A.C.) and minimum criteria parameters (62-520, F.A.C.) as attached.

17) Background water quality data from the monitor and injection zones, analyzed for primary and secondary drinking water standards (62-550, F.A.C.) and minimum criteria parameters (62-520, F.A.C.) as attached. Background water quality data from the monitor zones shall be obtained and reported as follows:

a) The upper and lower zones of Monitor Well MW-4 shall be sampled for the background water quality data within fifteen (15) days of completion of the subsurface construction of Monitor Well MW-4.

b) The background water quality data for MW-4 shall be submitted to the Department, each member of the UIC-TAC, and the USEPA, Region IV, Atlanta, within thirty (30) days of the sampling date.

18) Other data obtained during well construction needed by the Department to evaluate whether the well will operate in compliance with Department Rules. [Rule 62-528.450(3)(a)3.i., F.A.C.]

d. Pressure gauges and flow meters shall be installed on the injection well prior to initiating injection activities at the site.

e. Prior to the authorization of operational testing by the Department, the County shall contact the UIC Section of the Department, Southeast District, to arrange a site inspection. The inspection will determine if the conditions of the permit have been met and to verify that the injection well system is operational. During the inspection, emergency procedures and reporting requirements shall be reviewed.

6. Operational Testing Conditions

a. Upon receipt of written authorization from the Department [S.C. 5.a)], the operational testing of the injection well system shall be subject to the following conditions:

1) A qualified representative of the Engineer of Record shall be present for the start-up operations.

2) The Department shall be notified in writing of the date of commencement operations.

3) Operational testing for the system shall extend for a six (6) month period and shall be reviewed by the UIC-TAC and the USEPA at three (3) months and six (6) months after operational testing has begun. Prior to the end of the six month interval, the Department shall determine whether operational testing will be authorized to continue for a specified period of up to an additional eighteen (18) months. The Department and UIC-TAC will monitor the progress of the operational testing phase of this project. UIC-TAC meetings shall be held if necessary to aid the Department in determining if it may be necessary to modify the operational testing conditions. If requested by the Department, reports evaluating the system's progress shall be submitted to the Department, each member of the UIC-TAC, and the USEPA, Region IV, Atlanta at least two (2) weeks prior to the scheduled UIC-TAC meeting. The conditions for the operational testing period may be modified by the Department at each of these UIC-TAC review intervals.

4) Flows to the injection well shall be monitored and controlled at all times to ensure the maximum injection rate does not exceed that rate at which the well was tested.

5) Injection well system monitoring devices:

a) Pursuant to Rule 62-528.425(1)(b), F.A.C., the injection well system shall be monitored by continuous indicating, recording and totalizing devices to monitor effluent flow rate and volume, and continuous indicating and recording devices to monitor injection pressure and monitor zone pressure (or water level, as appropriate; all zones). All indicating, recording and totalizing devices shall be maintained in good operating condition and calibrated annually at a minimum.

SPECIFIC CONDITIONS:

b) Pursuant to Rule 62-600.540(4), F.A.C., the surface equipment shall be such that manual backup capability to monitor flow and pressure shall be provided for systems utilizing automatic and continuous recording equipment.

6) Pursuant to Rule 62-600.540(4)(a), F.A.C., as a minimum, the effluent pump station shall be equipped with lightning arrestors, surge capacitors or other similar devices.

7) The flow from the monitor zones during well evacuation and sampling must not be discharged to surface waters or aquifers containing a USDW.

8) Per Rule 62-600.540(1) of the Florida Administrative Code (F.A.C.), the effluent limitations for wastewaters conveyed to the injection well must meet the secondary treatment and pH limitations specified in Rule 62-600.420(1)(d), and 62-600.445, F.A.C. The domestic effluent (injectate) conveyed to the injection well shall meet the Compliance Concentrations per Rule 62-600.740(1)(b), F.A.C.

9) The ability to disinfect the effluent shall be maintained at all times in accordance with Chapter 62-600, F.A.C.

10) The wastestream shall be non-hazardous in nature at all times, as defined in 40-CFR, Part 261 and as adopted in Chapter 62-730, F.A.C.

11) In accordance with Rule 62-528.300(43), F.A.C., the definition of a municipal injection well, only fluids that have received treatment at the Broward County North Regional WWTP and purge water from the on-site monitor wells, associated with the injection well systems at the Broward County North Regional WWTP, may be discharged into this well.

12) Mechanical Integrity

a) Injection is prohibited until the permittee demonstrates that the well has mechanical integrity. Prior to operational testing the permittee shall establish, and thereafter maintain, the mechanical integrity of the well at all times.
b) If the Department determines that the injection well lacks mechanical integrity, written notice shall be given to the permittee.
c) Unless the Department requires immediate cessation of injection, within 48 hours of receiving written notice that the well lacks mechanical integrity, the permittee shall cease injection into the well unless the Department allows continued injection pursuant to (d) below.
d) The Department may allow the permittee to continue operation of a well that lacks mechanical integrity if the permittee demonstrates that fluid movement into or between USDWs is not occurring.

13) No underground injection is allowed that causes or allows movement of fluid into an underground source of drinking water.

14) The pressure at the wellhead shall be monitored and controlled at all times to ensure the maximum pressure at the wellhead casing does not exceed 66 percent (%) of the mechanical integrity test pressure. [See Specific Condition 2.n).]

15) Any failure of the Class I injection well monitoring and recording equipment for a period of more than forty-eight (48) hours shall be reported within twenty-four (24) hours to the Department. A written report describing the incident shall also be given to the Department within five (5) days of the start of the event. The final report shall contain a complete description of the occurrence, a discussion of its cause(s) and the steps being taken to reduce, eliminate, and prevent recurrence of the event, and all other information deemed necessary by the Department.

SPECIFIC CONDITIONS:

16) The injection system shall be monitored in accordance with Rules 62-528.425(1)(g) and 62-528.430(2), F.A.C. The following injection well performance and monitor zone data shall be collected and reported to the Department in Monthly Operating Reports (MORs; also see S.C. 6.a)xix) and S.C. 6.a)xx)] as indicated below. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

a) Injection well performance:

(1) Physical characteristics of the injection well:

- total daily flow to injection well (MG)
- average daily flow rate to injection well (MGD)
- daily peak hour flow rate to injection well (MGD)
- daily minimum flow rate to injection well (MGD)
- monthly average of the daily flow rates to injection well (MGD)
- monthly maximum (peak hour) flow rate to injection well (MGD)
- monthly minimum flow rate to injection well (MGD)
- monthly average of the daily flow volumes to injection well (MG)
- monthly maximum of the daily flow volumes to injection well (MG)
- monthly minimum of the daily flow volumes to injection well (MG)
- daily average injection pressure at injection well (psig)
- daily maximum sustained injection pressure at injection well (psig)
- daily minimum injection pressure at injection well (psig)
- monthly average injection pressure at injection well (psig)
- monthly maximum sustained injection pressure at injection well (psig)
- monthly minimum injection pressure at injection well (psig)
- monthly wellhead pressure with no flow (shut-in pressure, psig)

(2) Chemical characteristics of the wastestream sampled from the wet well:

Monthly sampling:

- total dissolved solids (TDS, total filterable residue) (mg/L)
- ammonia, total as N (mg/L)
- total kjeldahl nitrogen (as N) (TKN, mg/L)
- nitrate (mg/L)
- specific conductance (temperature compensated, umho/cm)
- total phosphorous as P (mg/L)
- pH (standard units)

The MORs shall indicate monthly averages for all parameters sampled daily.

b) Monitor well performance:

(1) Physical characteristics - upper and lower monitor zones potentiometric surface or water table height relative to NGVD (feet of head) or pressure (psig) referenced to NGVD:

- daily maximum pressure or water level (as appropriate)
- daily minimum pressure or water level (as appropriate)
- daily average pressure or water level (as appropriate)
- monthly maximum pressure or water level (as appropriate)
- monthly minimum pressure or water level (as appropriate)
- monthly average pressure or water level (as appropriate)

SPECIFIC CONDITIONS:

(2) Chemical characteristics of the upper and lower monitor zones (to be sampled weekly):

- total dissolved solids (TDS, total filterable residue) (mg/L)
- chloride (mg/L)
- ammonia, total as N (mg/L)
- total kjeldahl nitrogen (as N) (TKN, mg/L)
- nitrate (mg/L)
- pH (standard units)
- specific conductance (temperature compensated, umho/cm)
- fecal coliform MF (# of colonies/100 ml)
- total phosphorous as P (mg/L)
- sulfate (mg/L)

The MORs shall also indicate monthly averages for all parameters sampled weekly.

c) After the upper and lower monitor zones have been sampled weekly for at least six (6) months, the permittee may submit data for UIC-TAC and USEPA review and Department approval to demonstrate that reasonable assurance of groundwater stability has been established in justification of any request to reduce the sampling frequency to monthly. The request for reduction in sampling frequency shall be accompanied by technical justification and interpretations.

17) A minimum of three (3) well volumes of fluid shall be evacuated from the monitor systems prior to sampling for the chemical parameters listed above. All samples shall be analyzed by a State-certified laboratory.

18) All samples must be collected and analyzed in accordance with the quality assurance/quality control (QA/QC) requirements of Rule 62-160, F.A.C.

19) All injection well system data submissions including MORs [see S.C. 6.a)xvi) above] shall be clearly identified on each page with facility name, I.D. Number, permit number, operator's name, license number, daytime phone number, date of sampling/recording, and type of data. Monitor zones shall be identified by well number and depth interval. The lead plant operator or higher official must sign and date each submittal. An approved summary sheet from the FDEP Southeast District UIC Section is attached.

20) The permittee shall submit monthly to the Department the results of all injection well and monitor well data required by this permit (MORs) no later than the **twenty-eighth (28th)** day of the month immediately following the month of record. The results shall be sent to the Department of Environmental Protection's Southeast District Office (FDEP, UIC Section, P.O. Box 15425, West Palm Beach, FL 33416). A copy of this report shall also be sent to the Department of Environmental Protection, Underground Injection Control Program, MS 3530, 2600 Blair Stone Road, Tallahassee, FL 32399-2400.

21) The permittee shall calibrate all pressure gauges, flowmeters, chart recorders, and other related equipment associated with the injection well system on a annual basis, at a minimum. The permittee shall maintain all monitoring equipment and shall ensure that the monitoring equipment is calibrated and in proper operating condition at all times. Laboratory equipment, methods, and quality control will follow USEPA guidelines as expressed in Standard Methods for the Examination of Water and Wastewater. The pressure gauges, flow meter, and chart records shall be calibrated using standard engineering methods.

SPECIFIC CONDITIONS:

22) A controlled specific injectivity test (rate/pressure) shall be conducted monthly during the operational testing phase of this permit in accordance with Rule 62-528.430(2)(d), F.A.C. The specific injectivity test shall be conducted using at least three specified injection flow rates. The high rate should approach maximum design flow. [See S.C. 5.c)vi).] For reporting the injectivity test results, a summary sheet and sample graph from the FDEP Southeast District UIC Section is attached. The injectivity test results shall be reported to the Department in the MORs. The following data shall be recorded and reported at each injection rate:

- injection flow rate (MGD)
- injection pressure (psig)
- wellhead pressure with no flow (shut-in pressure in psig)
- monitor zone pressures (psig)

All readings shall be taken after a minimum five minute period of stabilized flow. Pursuant to Rule 62-528.430(2)(d), F.A.C., as part of the specific injectivity test, the well shall be shut-in for a period of time necessary to conduct a valid observation of pressure fall-off.

23) Pursuant to Rules 62-528.425(1)(a) and 62-528.450(2)(f)3., F.A.C., a wastestream analysis (24 hour composite sample) for primary and secondary drinking water standards (Chapter 62-550, F.A.C.) and minimum criteria, see attached list, shall be submitted annually (sampled in February and submitted on or before April 30).

7. Surface Equipment

a. The integrity of the monitor zone sampling systems shall be maintained at all times. Sampling lines shall be clearly and unambiguously identified by monitoring zone at the point at which samples are drawn. All reasonable and prudent precautions shall be taken to ensure that samples are properly identified by monitor zone and that samples obtained are representative of those zones. Sampling lines and equipment shall be kept free of contamination with independent discharges and no interconnections with any other lines.

b. The surface equipment for the injection well system shall maintain compliance with Chapter 62-600, F.A.C. for water hammer control, screening, access for logging and testing, and reliability and flexibility in the event of damage to the well and effluent piping. A regular program of exercising the valves integral to the well head shall be instituted. At a minimum, all valves integral to the well head shall be exercised during the regularly scheduled quarterly injectivity testing.

c. The injection well and monitor well surface equipment and piping shall be kept free of corrosion at all times.

d. Spillage onto the injection well pad shall be contained as follows:

1) During construction activities, spillage onto the injection well pad shall be contained by an impermeable wall around the edge of the pad and directed to a sump which in turn discharges to the pumping station wet well or via other approved means to the injection well system.
2) Following completion of injection well system construction activities, any waters spilled during mechanical integrity testing, other maintenance, testing or repairs to the system shall be contained by temporary containment structures. The design of the temporary containment structures shall be submitted for UIC-TAC and USEPA review and Department approval prior to a planned outage.

e. The injection well construction pad shall be maintained and retained in service for the life of the injection well. The injection and monitor well pad(s) are not, unless specific approval is obtained form the Department, to be used for storage of any material or equipment at any time.

f. The four (4) surficial aquifer monitor wells installed at the corners of the injection well pad shall be secured, maintained, and retained in service.

SPECIFIC CONDITIONS:

8. Financial Responsibility

   a. The permittee shall maintain the resources necessary to close, plug and abandon the injection and associated monitor wells, at all times [Rule 62-528.435(9), F.A.C.].

   b. The permittee shall review annually the plugging and abandonment cost estimates. An increase of ten (10) percent or more over the cost estimate upon which financial responsibility is based shall require the permittee to submit documentation to obtain an updated Certificate of Demonstration of Financial Responsibility.

   c. In the event the mechanism used to demonstrate financial responsibility should become invalid for any reason, the Permittee shall notify the Department of Environmental Protection in writing within fourteen (14) days of such invalidation. The permittee shall then within thirty (30) days of said notification submit to the Department for approval new financial documentation in order to comply with Rule 62-528.435(9), F.A.C., and the conditions of this permit.

9. Emergency Disposal

   a. All applicable federal, state, and local permits shall be in place to allow for any alternate discharges due to emergency or planned outage conditions.

   b. Any proposed changes in emergency disposal methods shall be submitted for UIC-TAC and USEPA review and Department approval prior to implementation.

   c. In the event of an emergency and/or discharge, or other abnormal event where the Permittee is temporarily unable to comply with any of the conditions of this permit due to breakdown of equipment, power outages, destruction by hazard or fire, wind, or by other cause, the Department shall be notified in person or by telephone within twenty-four (24) hours of the incident. A written report describing the incident shall also be submitted to the Department within five (5) days of the start of the incident. The written report shall contain a complete description of the emergency and/or discharge, a discussion of its cause(s), and if it has been corrected, the anticipated time the discharge is to continue, the steps being taken to reduce, eliminate, and prevent recurrence of the event, and all other information deemed necessary by the Department.

   d. The emergency disposal method consists of the following:

      1) If the emergency is limited to taking one (1) or more wells out of service, the effluent shall be diverted to the remaining permitted injection wells provided that the higher velocities are within the permitted capacities and, per Rule 62-528.415(1)(f)3., F.A.C., provided that the permittee provides the Department with reasonable assurance that the higher velocities will not compromise the integrity or operation of the wells.

      2) The emergency disposal method presented in the permit application received September 18, 1997 (Attachment G) and approved by the Department as a part of this permit shall be maintained in fully operational order at all times.

      3) Any emergency bypass of the injection well system shall be governed by Rule 62-620.610, F.A.C. and meet the conditions of the Wastewater Facilities Permit No. FL0031771-000-DW1P.

      4) Any proposed changes in emergency disposal methods shall be submitted for UIC-TAC and USEPA review and Department approval prior to implementation.

PERMITTEE:
Mr. Michael J. Scottie, Director
Environmental Operations Division
Broward Co. Office of Environmental Services

GMS I. D. NUMBER: 5006C10220
PERMIT/CERTIFICATION NUMBER: 0051336-006-UC
DATE OF ISSUE: FEB - 3 1999
EXPIRATION DATE: FEB - 2 2004

SPECIFIC CONDITIONS:

10. Permit Extension(s), Renewal(s) and Operation Permit Application(s)

a. Pursuant to Rule 62-4.080(3), a permittee may request that a permit be extended as a modification of an existing permit. A request for an extension is the responsibility of the permittee and shall be submitted to the Department before the expiration of the permit. In accordance with Rule 62-4.070(4), F.A.C., a permit cannot be extended beyond the maximum five (5) year statutory limit.

b. If injection is to continue beyond the expiration date of this permit the permittee shall apply for, and obtain an operation permit. If necessary to complete the two-year operational testing period, the permittee shall apply for renewal of the construction permit at least sixty (60) days prior to the expiration date of this permit.

11. Signatories

a. All reports and other submittals required to comply with this permit shall be signed by a person authorized under Rules 62-528.340(1) or (2), F.A.C.

b. In accordance with Rule 62-528.340(4), F.A.C., all reports shall contain the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Issued this 03 day of FEBRUARY, 1999

STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

for

Carlos Rivero-deAguilar
Director of District Management

SOUTHEAST DISTRICT UIC SECTION

SURFICIAL AQUIFER MONITOR WELL QUARTERLY REPORT

FACILITY NAME ______________________ REPORT MO/YR. ______________

OPERATOR NAME ______________________ LICENSE # ______________

I.D.NUMBER ______________________ PERMIT # ______________

INJECTION WELL # ______________________

SAMPLING DATE ______________________ TIME ______________

	PMW #1	PMW #2	PMW #3	PMW #4
LOCATION	NE CORNER	NW CORNER	SE CORNER	SW CORNER
ELEVATION OF TOC (NGVD)				
DEPTH TO WATER (TOC)				
WATER LEVEL (NGVD)				
CHLORIDES (MG/L.)				
CONDUCTIVITY (UMHOS)				
TEMPERATURE (F)				

ANALYZED BY: ______________________ SAMPLED BY: ______________

PHONE # ______________________ TITLE ______________

SITE PLAN OF PMW LOCATIONS

UNDERGROUND INJECTION CONTROL

INJECTIVITY TESTING SUMMARY SHEET

FACILITY______________________________

TIME

Deep Injection Well System
Injectivity Testing

Injection Well No. :
DATE OF TEST:
FDER PERMIT No.:

	START	SHUT-IN PRESSURE
	MINS AFTER SHUT -IN	CALIBRATED PRESSURE GAUGE AT WELL HEAD (PSI)
	10	
	20	
	30	

____
Signature of Lead Operator

Were Wellhead Valves Exercised ________YES ________NO

COLUMN: 1	2	3	4	5	6	7	8	9	10
TIME	INJECTION WELL SHUT-IN PRESSURE AFTER 30 MINUTES (PSI)	PUMP NUMBER(S) ON-LINE	INJECTION RATE (gpm) or (mgd)	Injection Pressure after 10 minutes of pumping		PRESSURE DIFFERENTIAL (Col 5 - Col 2)	INJECTIVITY INDEX (Col 4 divide by Col 7)	UPPER MONITOR ZONE IN FEET OF HEAD ABOVE NGVD (FEET)	LOWER MONITOR ZONE IN FEET OF HEAD ABOVE NGVD (FEET)
				CALIBRATED GAUGE AT INJECTION WELLHEAD (PSI)	PRESSURE RECORDER (PSI)	FROM CALIBRATED PRESSURE GAUGE AT INJECTION WELLHEAD (PSI)	FROM CALIBRATED PRESSURE GAUGE AT INJECTION WELLHEAD (GPM / PSI)		

NOTES

1. INJECTIVITY INDEX (GPM/PSI) = INJECTION RATE (GPM) (COLUMN 4) / [(INJECTION PRESSURE (PSI) (COLUMN 5) - (SHUT-IN PRESSURE (PSI) (COLUMN 2)]

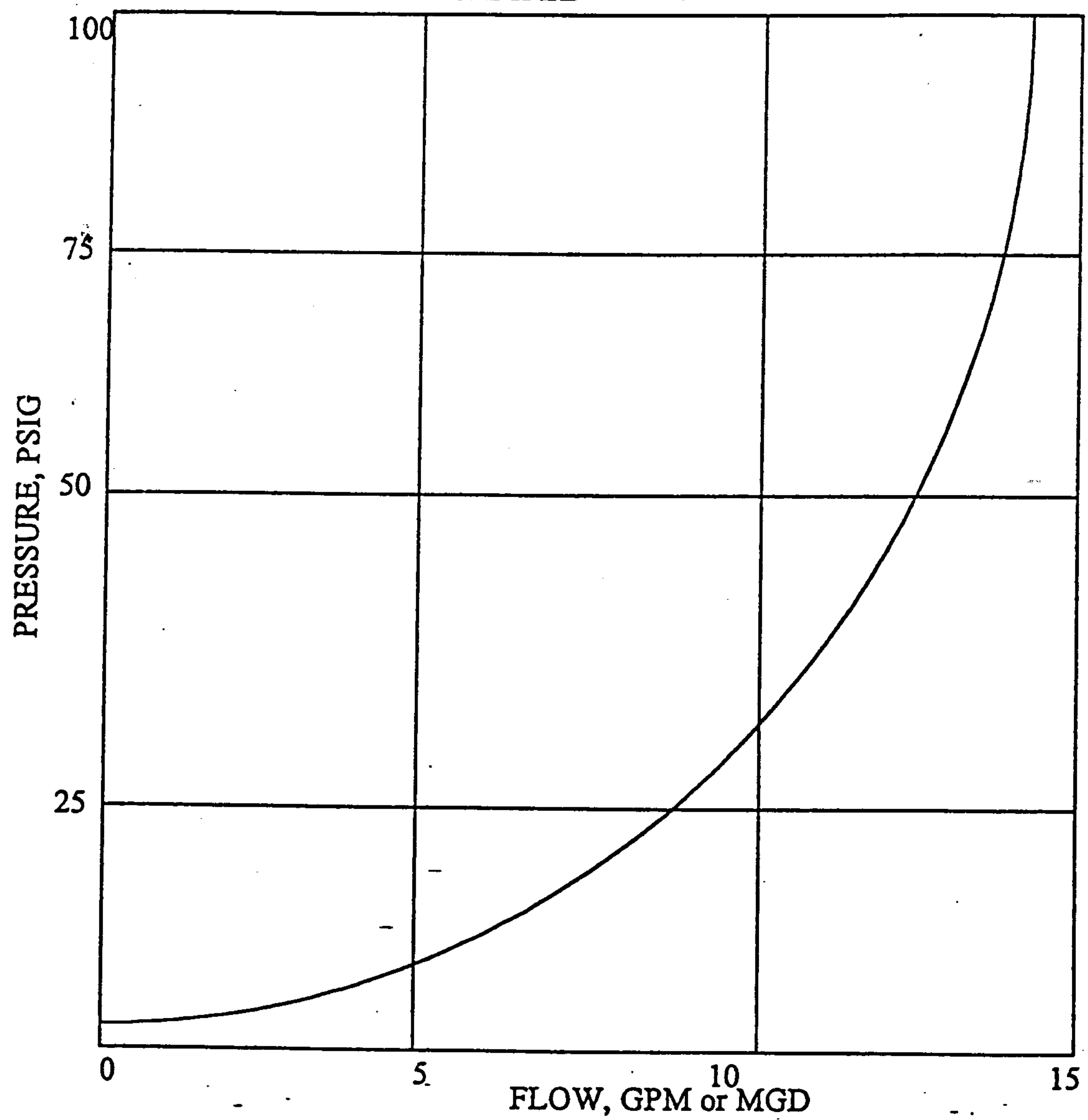
2. FOR MORE INFORMATION REGARDING EXECUTION OF THIS TEST CONSULT THE INJECTIVITY TESTING PROTOCOL IN THE O&M MANUAL

UNDERGROUND INJECTION CONTROL

DATE OF TEST :	FACILITY :
PERMIT NO. :	I.D. # :
WELL NO.	LEAD OPERATOR________________ SIGNATURE

INJECTIVITY TEST

SAMPLE



PRIMARY & SECONDARY DRINKING WATER STANDARDS & MINIMUM CRITERIA

Updated September 1998

PRIMARY DRINKING WATER STANDARDS

PARAMETER

Alachlor
Aldicarb
Aldicarb sulfoxide
Aldicarb sulfone
Aroclors (Polychlorinated Biphenyls or PCB's)
Alpha, Gross
Antimony
Arsenic
Atrazine
Barium
Benzene
Benzo(a)pyrene
Beryllium
Bis(2-ethylhexyl) adipate (Di(2-ethylhexyl) adipate)
Bis(2-ethylhexyl) phthalate (Di(2-ethylhexyl) phthalate)
Cadmium
Carbofuran
Carbon Tetrachloride (Tetrachloromethane)
Chlordane
Chlorobenzene (Monochlorobenzene)
Chloroethylene (Vinyl Chloride)
Chromium
Coliforms, Total
Cyanide
2,4-D (2,4-Dichlorophenoxyacetic acid)
Dalapon (2,2-Dichloropropionic acid)
Dibromochloropropane (DBCP)
1,2-Dibromoethane (EDB, Ethylene Dibromide)
1,2-Dichlorobenzene (o-Dichlorobenzene)
1,4-Dichlorobenzene (p-Dichlorobenzene or Para Dichlorobenzene)
1,2-Dichloroethane (Ethylene dichloride)
1,1-Dichloroethylene (Vinylidene chloride)
1,2-Dichlorethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)
cis-1,2-Dichloroethylene (1,2-Dichlorethylene)
trans-1,2-Dichloroethylene (1,2-Dichlorethylene)
Dichloromethane (Methylene chloride)
1,2-Dichloropropane
Di(2-ethylhexyl) adipate (Bis(2-ethylhexyl) adipate)
Di(2-ethylhexyl) phthalate (Bis(2-ethylhexyl) phthalate)
Dinoseb
Diquat
EDB (Ethylene dibromide, 1,2-Dibromoethane)
Endothall
Endrin
Ethylbenzene
Ethylene dichloride (1,2-Dichloroethane)
Fluoride
Glyphosate (Roundup)
Gross Alpha
Heptachlor
Heptachlor Epoxide
Hexachlorobenzene (HCB)
gamma-Hexachlorocyclohexane (Lindane)
Hexachlorocyclopentadiene
Lead

PRIMARY DRINKING WATER STANDARDS, CONT'D

PARAMETER

Lindane (gamma-Hexachlorocyclohexane)
Mercury
Methoxychlor
Methylene chloride (Dichloromethane)
Monochlorobenzene (Chlorobenzene)
Nickel
Nitrate (as N)
Nitrite (as N)
Total Nitrate + Nitrite (as N)
Oxamyl
p-Dichlorobenzene or Para Dichlorobenzene (1,4-Dichlorobenzene)
Pentachlorophenol
Perchloroethylene (Tetrachloroethylene)
Picloram
Polychlorinated biphenyl (PCB or Aroclors)
Radium
Roundup (Glyphosate)
Selenium
Silver
Silvex (2,4,5-TP)
Simazine
Sodium
Styrene (Vinyl benzene)
Tetrachloroethylene (Perchloroethylene)
Tetrachloromethane (Carbon Tetrachloride)
Thallium
Toluene
Toxaphene
2,4,5-TP (Silvex)
1,2,4-Trichlorobenzene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethylene (Trichloroethene, TCE)
Trihalomethanes, Total
Vinyl Chloride (Chloroethylene)
Xylenes (total)

SECONDARY DRINKING WATER STANDARDS

PARAMETER

Aluminum
Chloride
Color
Copper
Corrosivity
Ethylbenzene
Fluoride
Foaming Agents (MBAS)
Iron
Manganese
Odor
pH
Silver
Sulfate
Toluene
Total Dissolved Solids (TDS)
Xylenes
Zinc

MUNICIPAL WASTEWATER MINIMUM CRITERIA
GROUND WATER MONITORING PARAMETERS

INORGANICS

Ammonia
Nitrogen (organic)
Total Kjeldahl Nitrogen
Total Phosphorus (phosphate)

VOLATILE ORGANICS

Chloroethane
Chloroform
para-Dichlorobenzene (1,4 Dichlorobenzene)
1,2-Dichloroethylene (cis-1,2-Dichloroethylene or trans-1,2-Dichloroethylene)

BASE/NEUTRAL ORGANICS

Anthracene
Butylbenzylphthalate
Dimethylphthalate
Naphalene
Phenanthrene

PESTICIDES AND PCBs

Aldrin
Dieldrin
Dioxin

ACID EXTRACTABLES

2-chlorophenol
Phenol
2,4,6-trichlorophenol

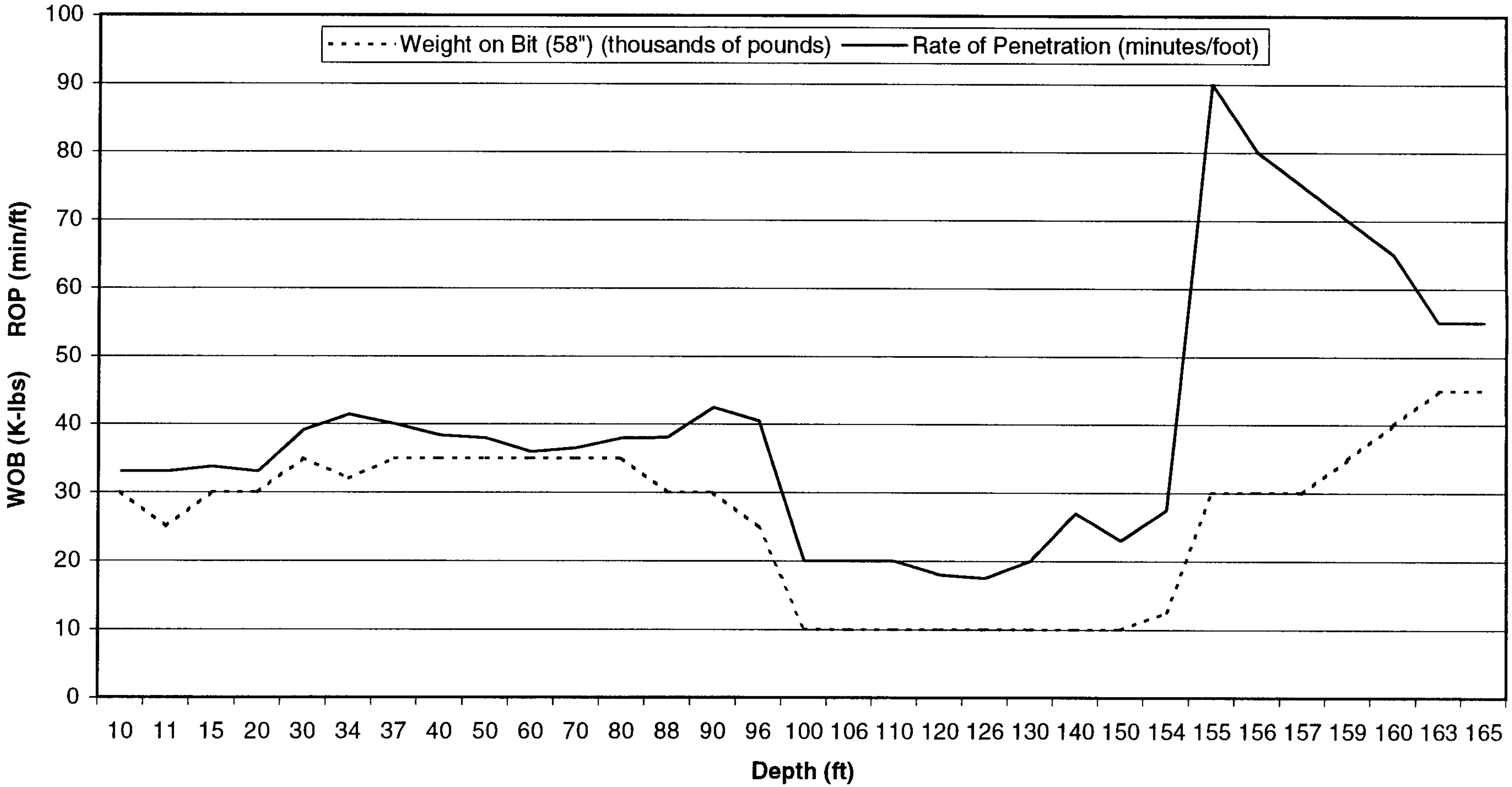
OTHER

Conductivity
Biological Oxygen Demand
Chemical Oxygen Demand
Temperature

APPENDIX B

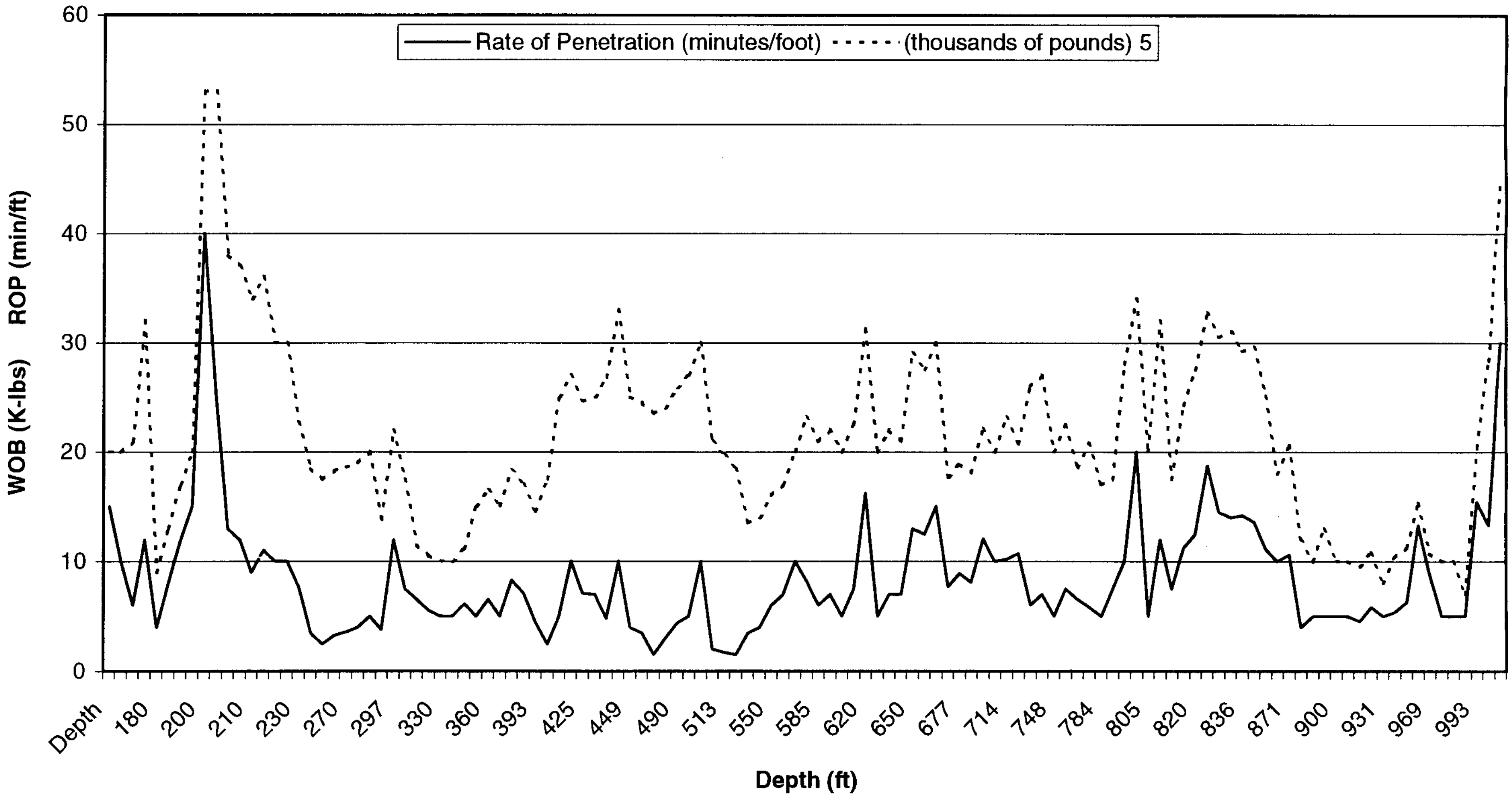
RATE OF PENETRATION AND WEIGHT ON BIT

BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
58-inch Diameter Borehole - 0 to 160 Feet BPL



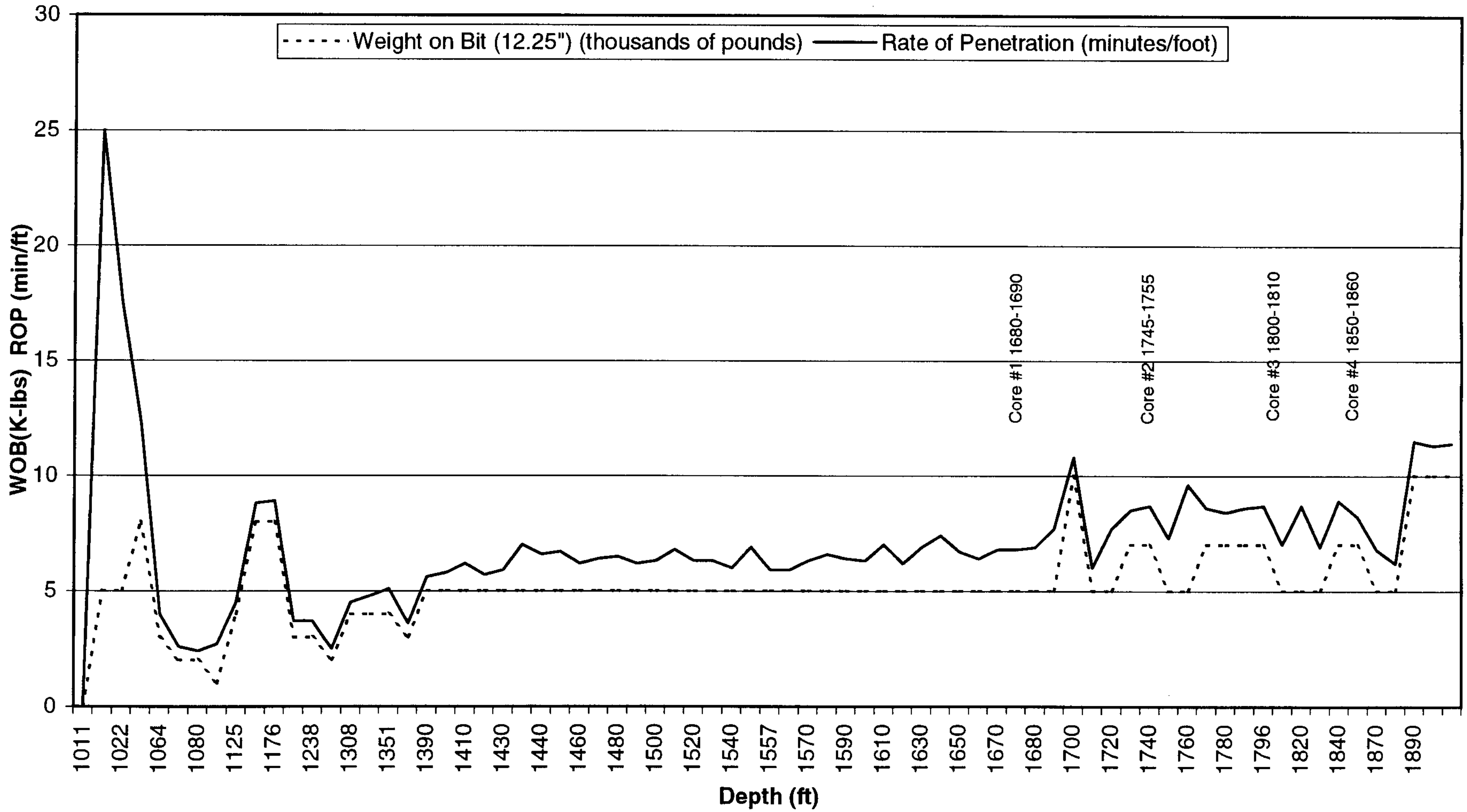
WOB-ROP IW5 0 to 160 58-in.xls

BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
50-inch Diameter Borehole - 160 to 1000 Feet BPL

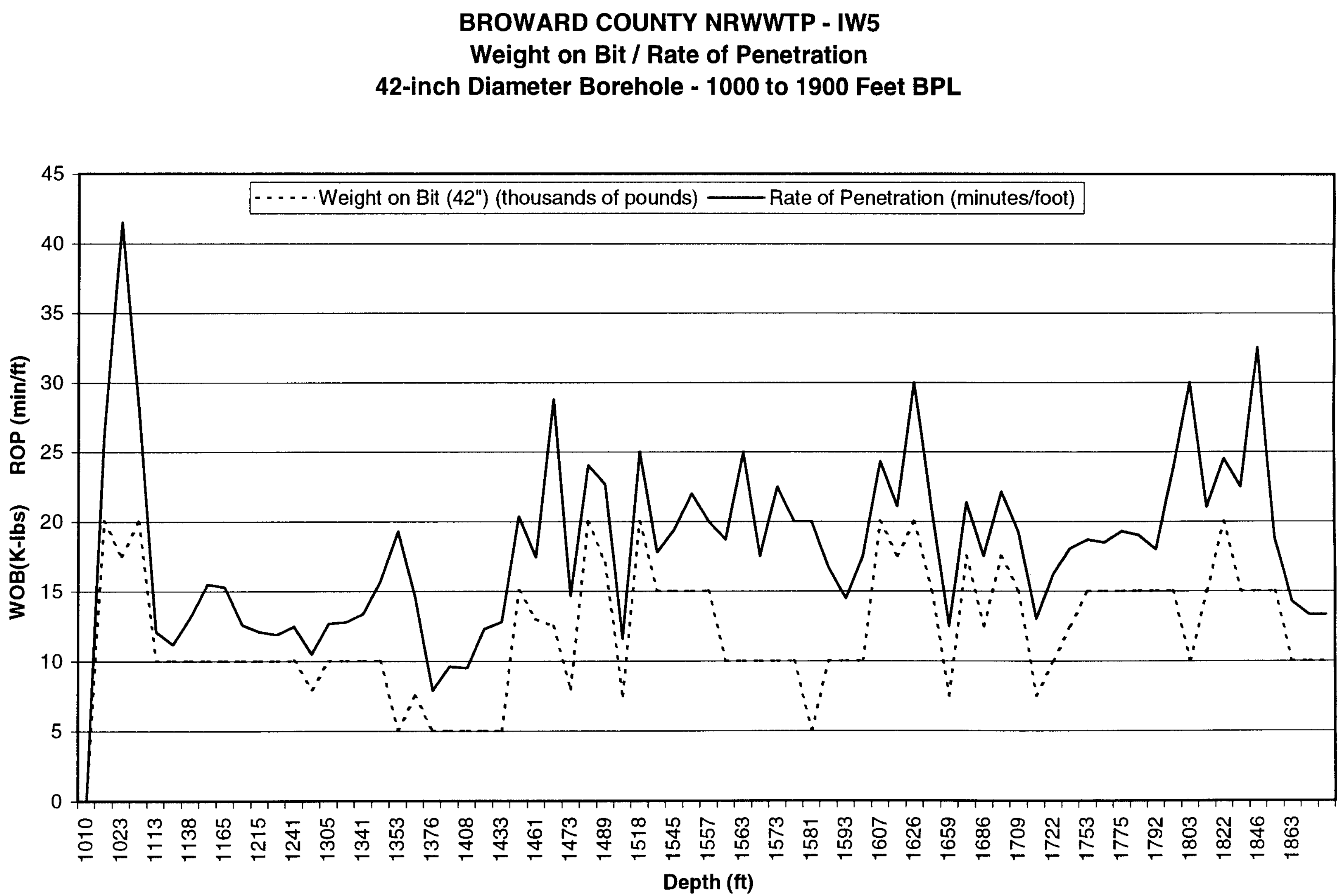


WOB-ROP IW5 160 to 1000 50-in.xls

BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
12.25-inch Diameter Borehole - 1000 to 1900 Feet BPL

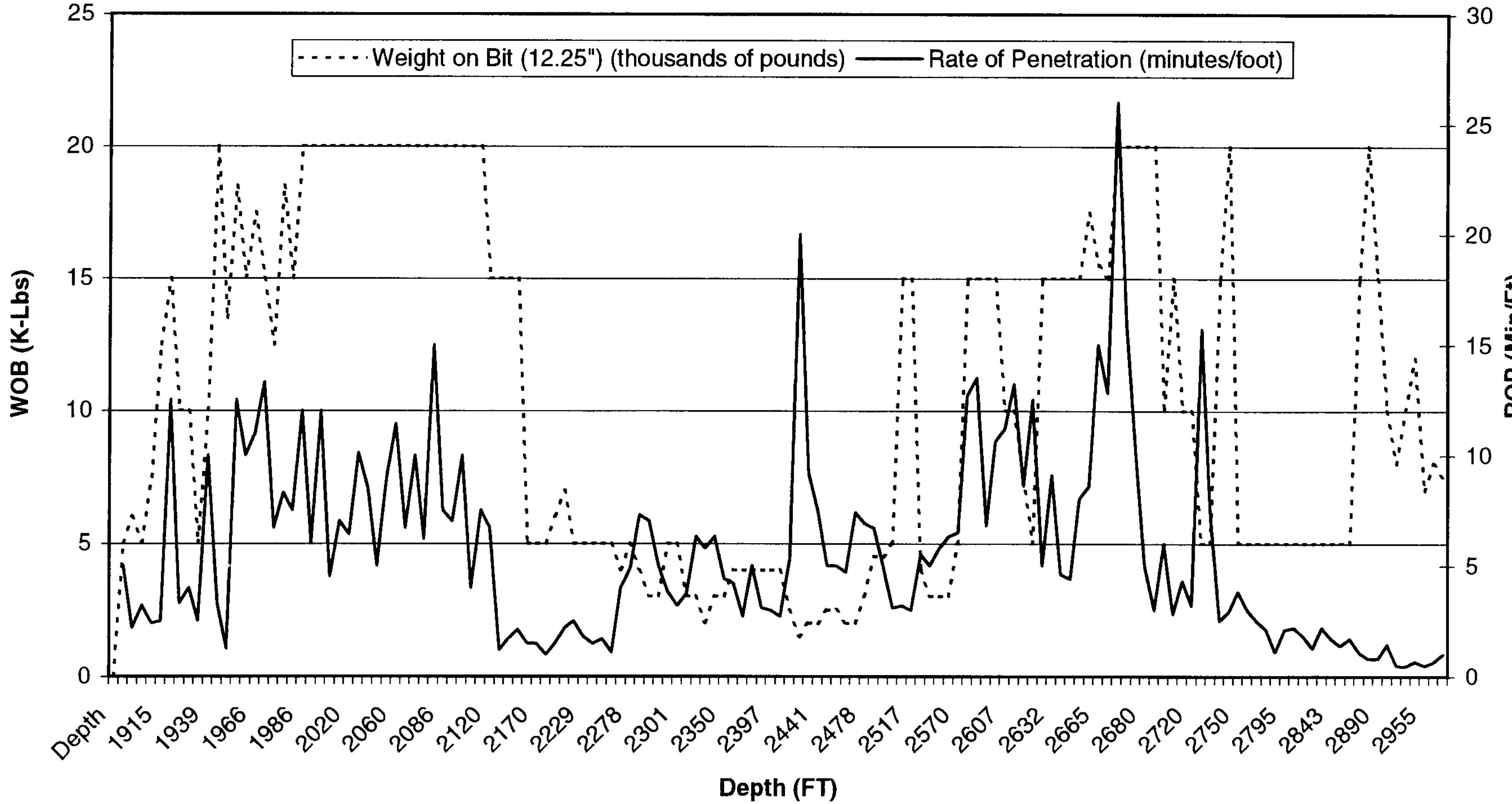


WOB-ROP IW5 1000 to 1900 12.25-in.xls



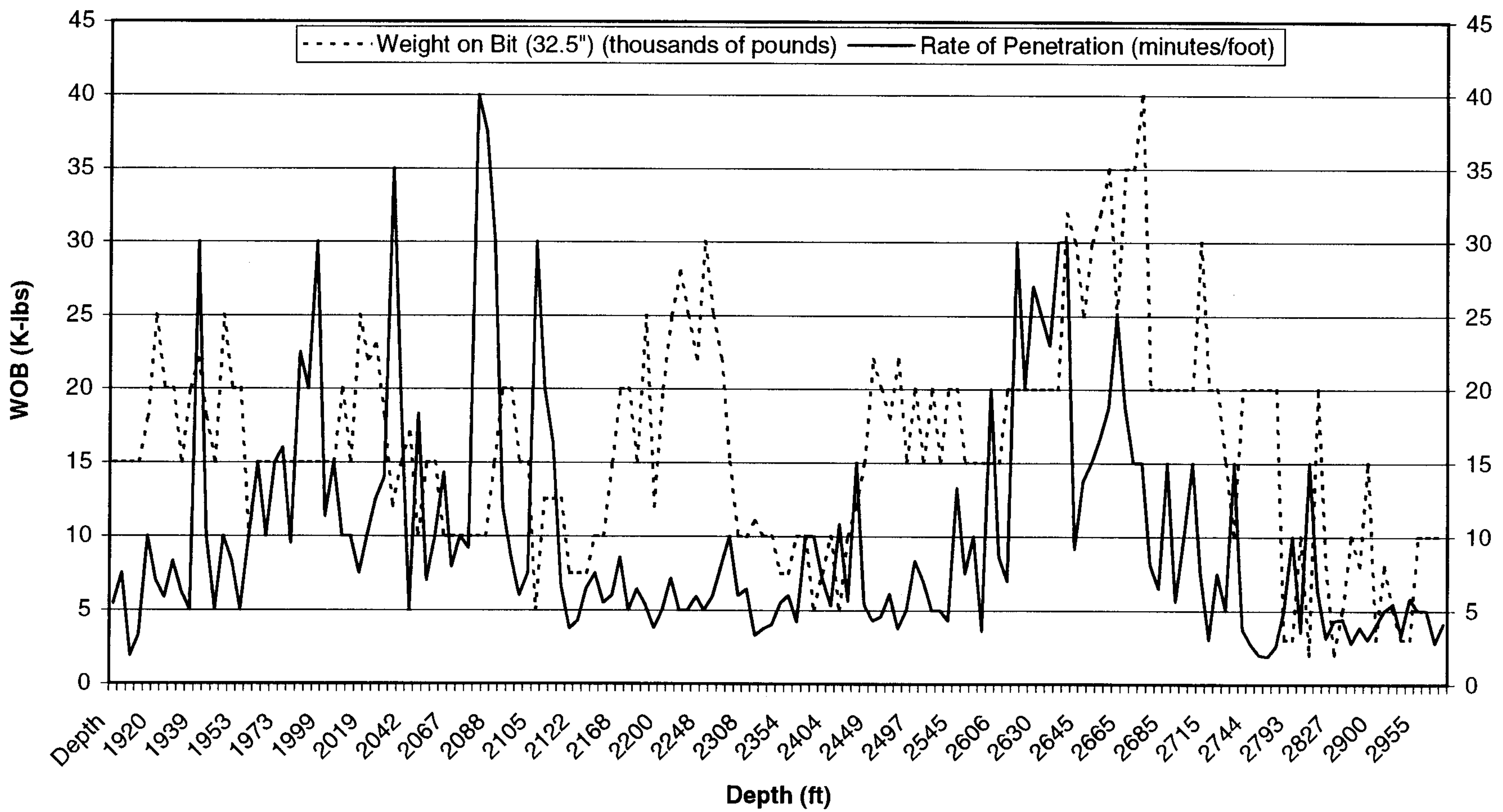
WOB-ROP IW5 1000 to 1900 42-in.xls

BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
12.25-inch Diameter Borehole - 1900 to 3000 Feet BPL



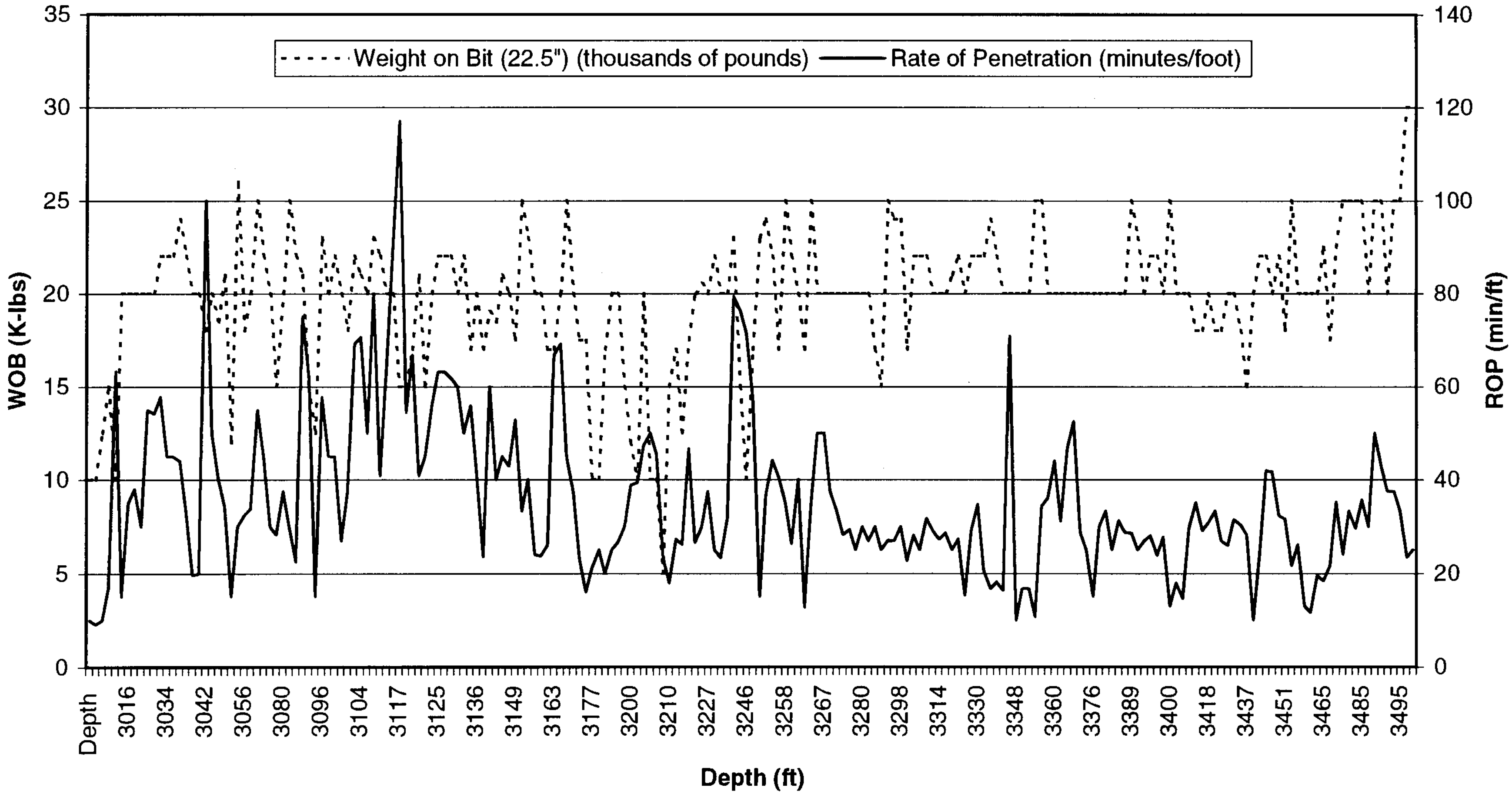
WOB-ROP IW5 1900 to 3000 12.25-in.xls

BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
34-inch Diameter Borehole - 1900 to 3000 Feet BPL



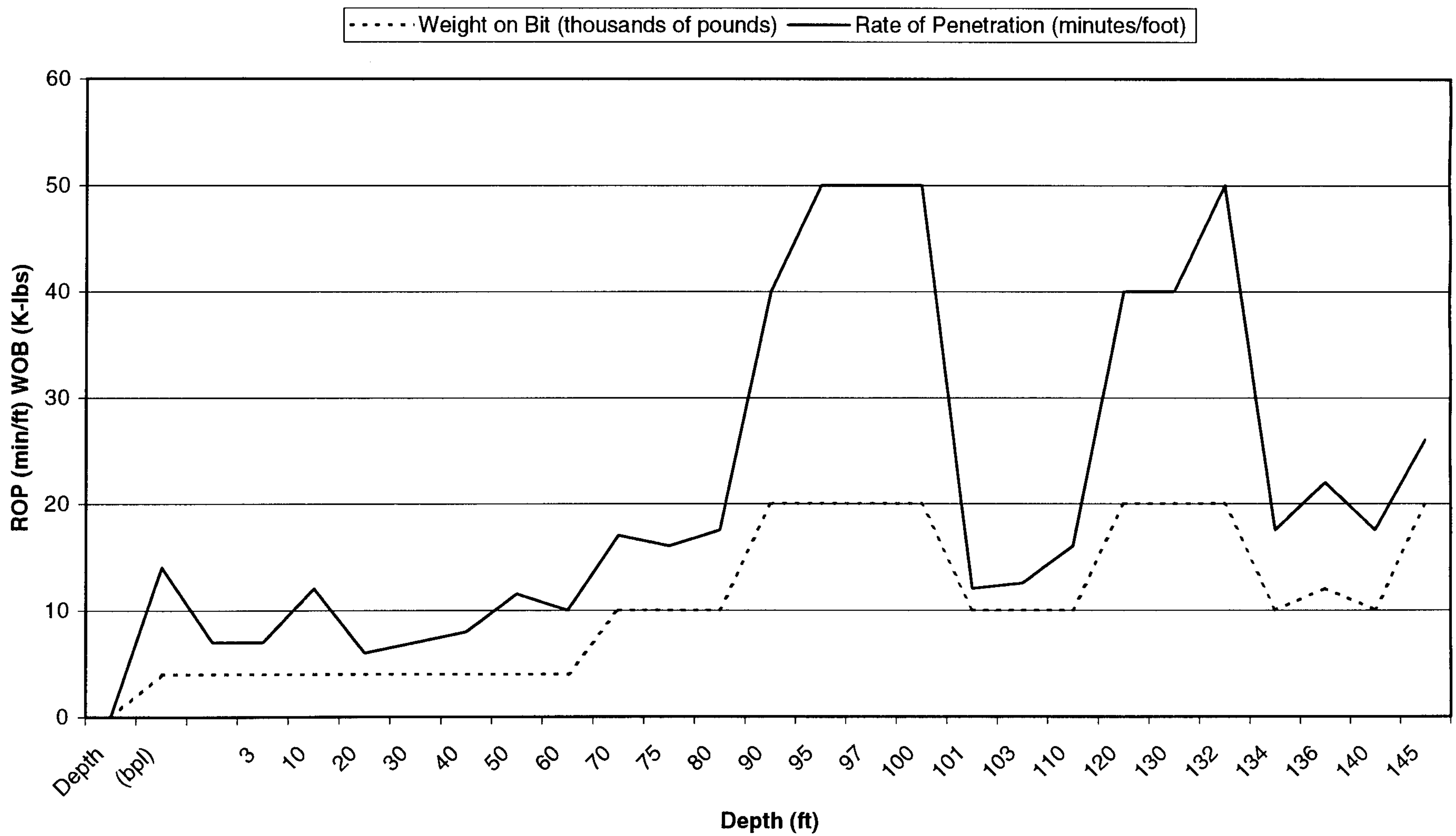
WOB-ROP IW5 1900 to 3000 32.5-in.xls

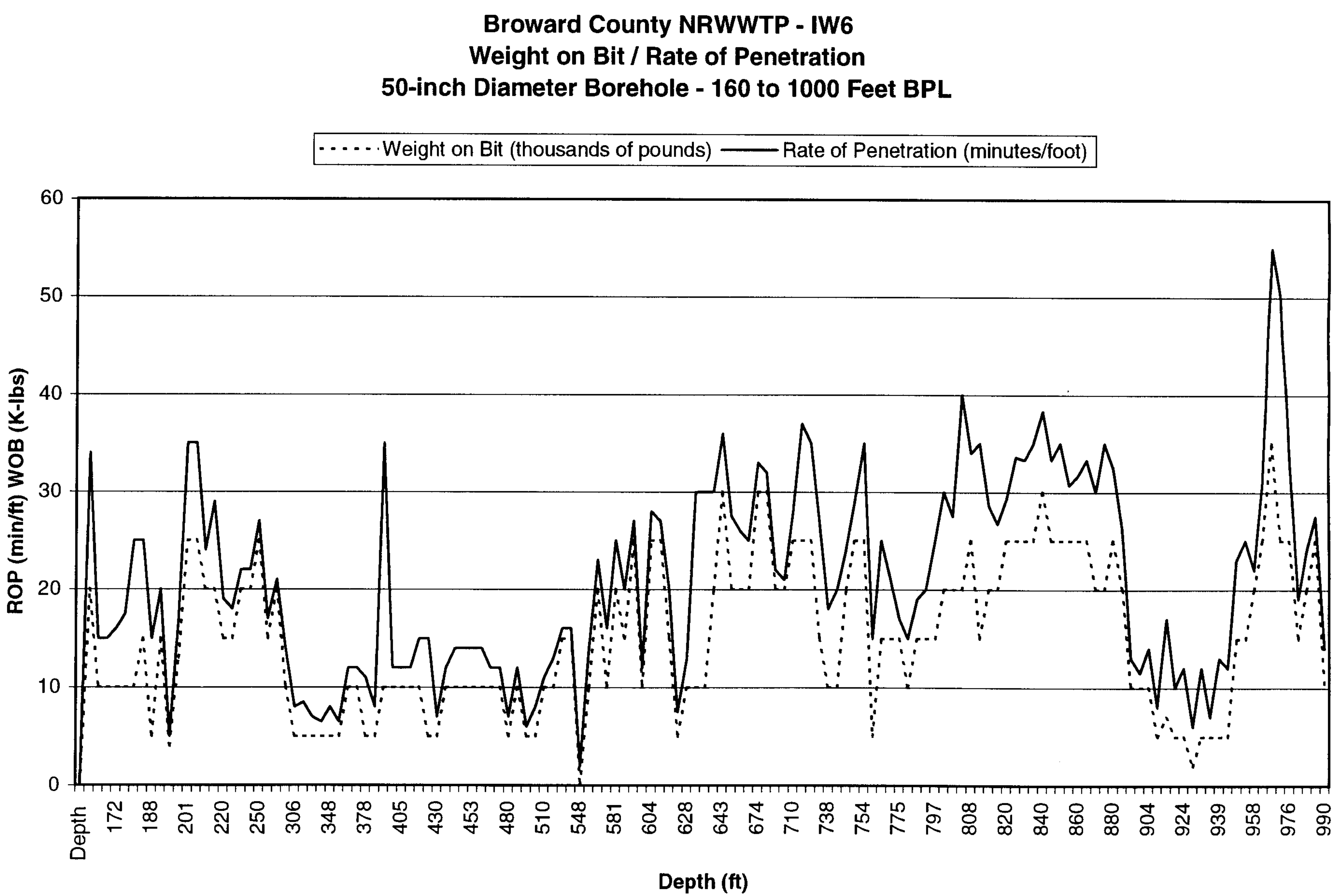
BROWARD COUNTY NRWWTP - IW5
Weight on Bit / Rate of Penetration
24-inch Diameter Borehole - 3000 to 3500 Feet BPL



WOB-ROP IW5 3000 to 3500 24-in.xls

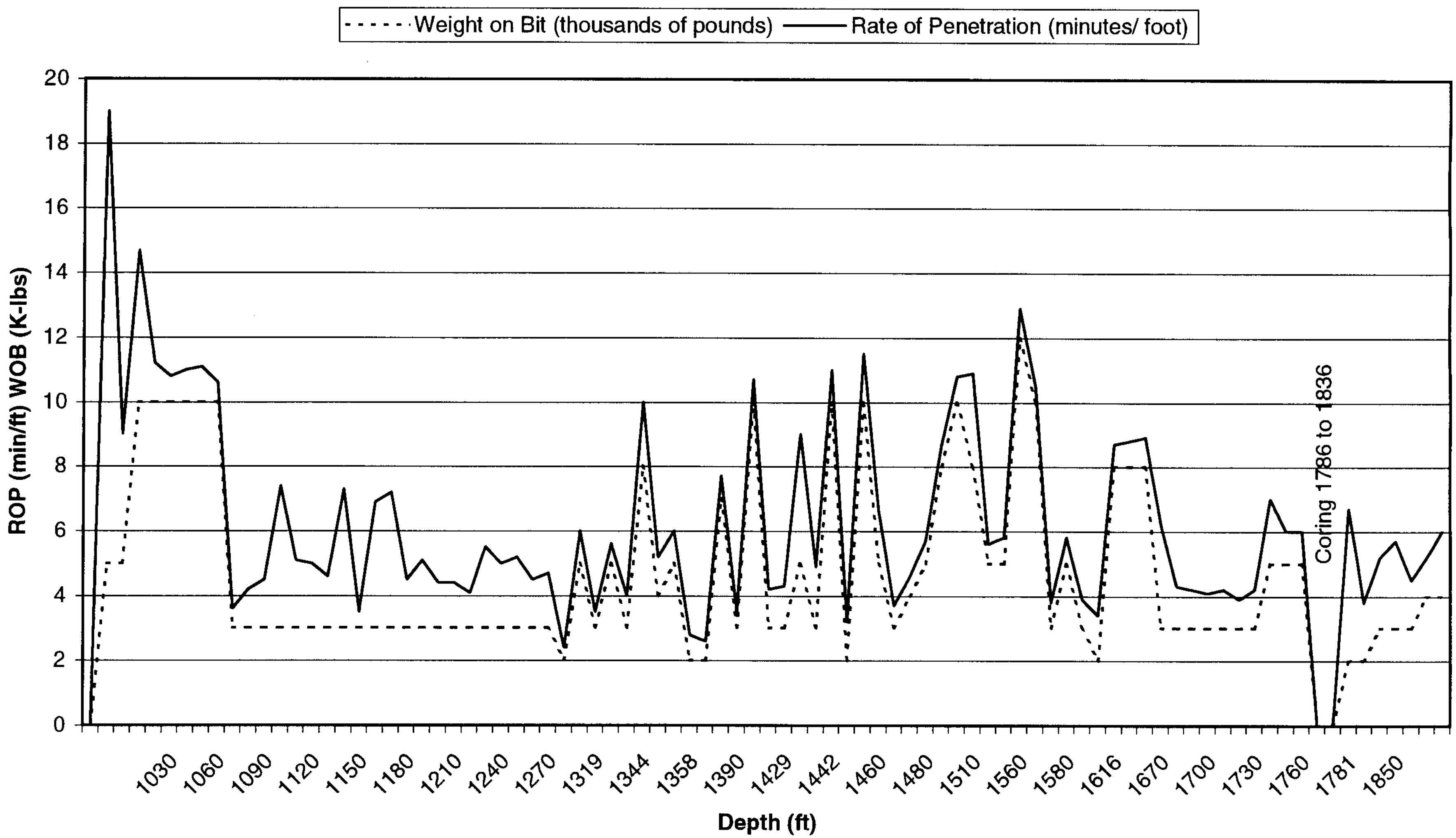
BROWARD COUNTY NRWWTP - IW6
Weight on Bit / Rate of Penetration
58-inch Diameter Borehole - 0 to 160 Feet BPL



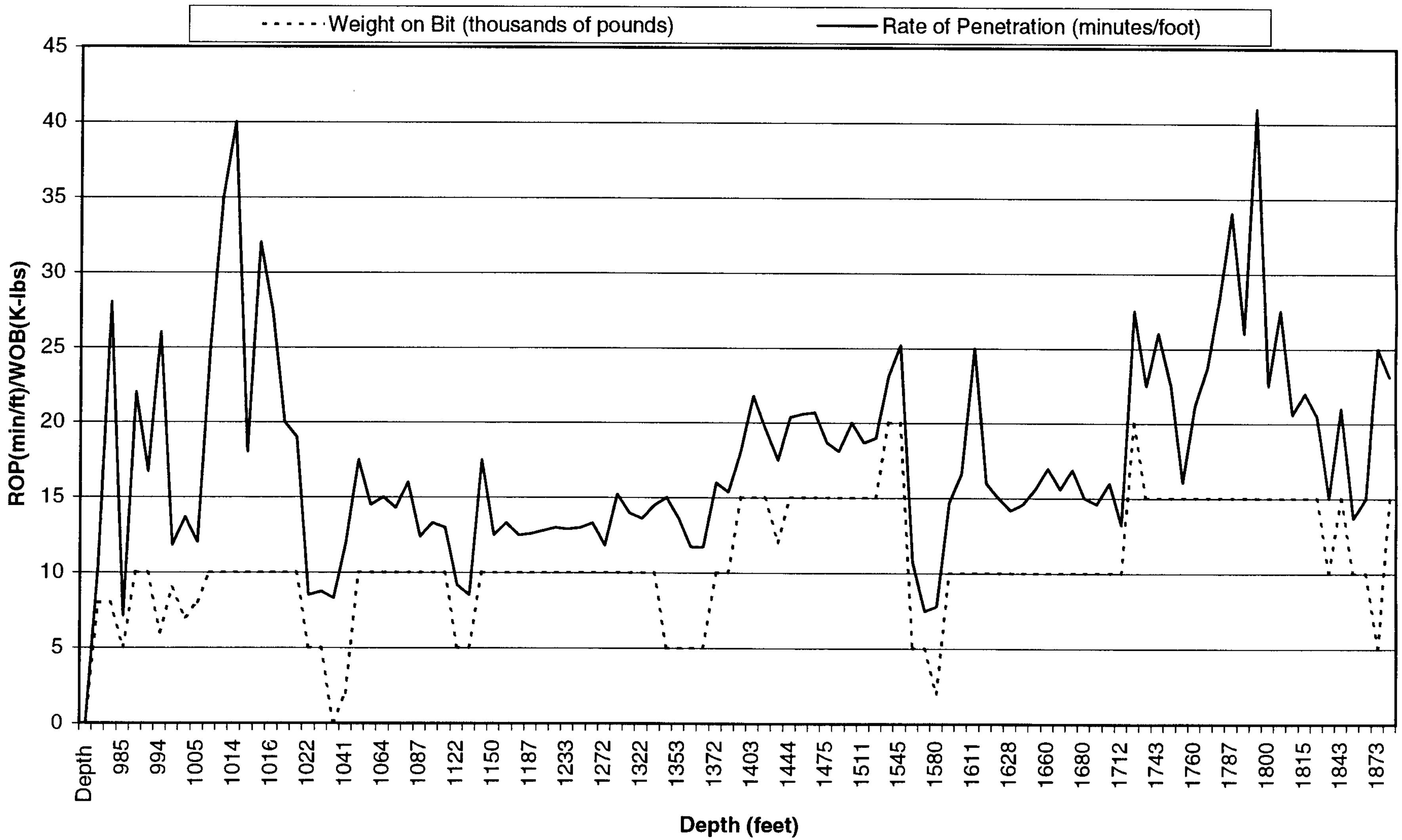


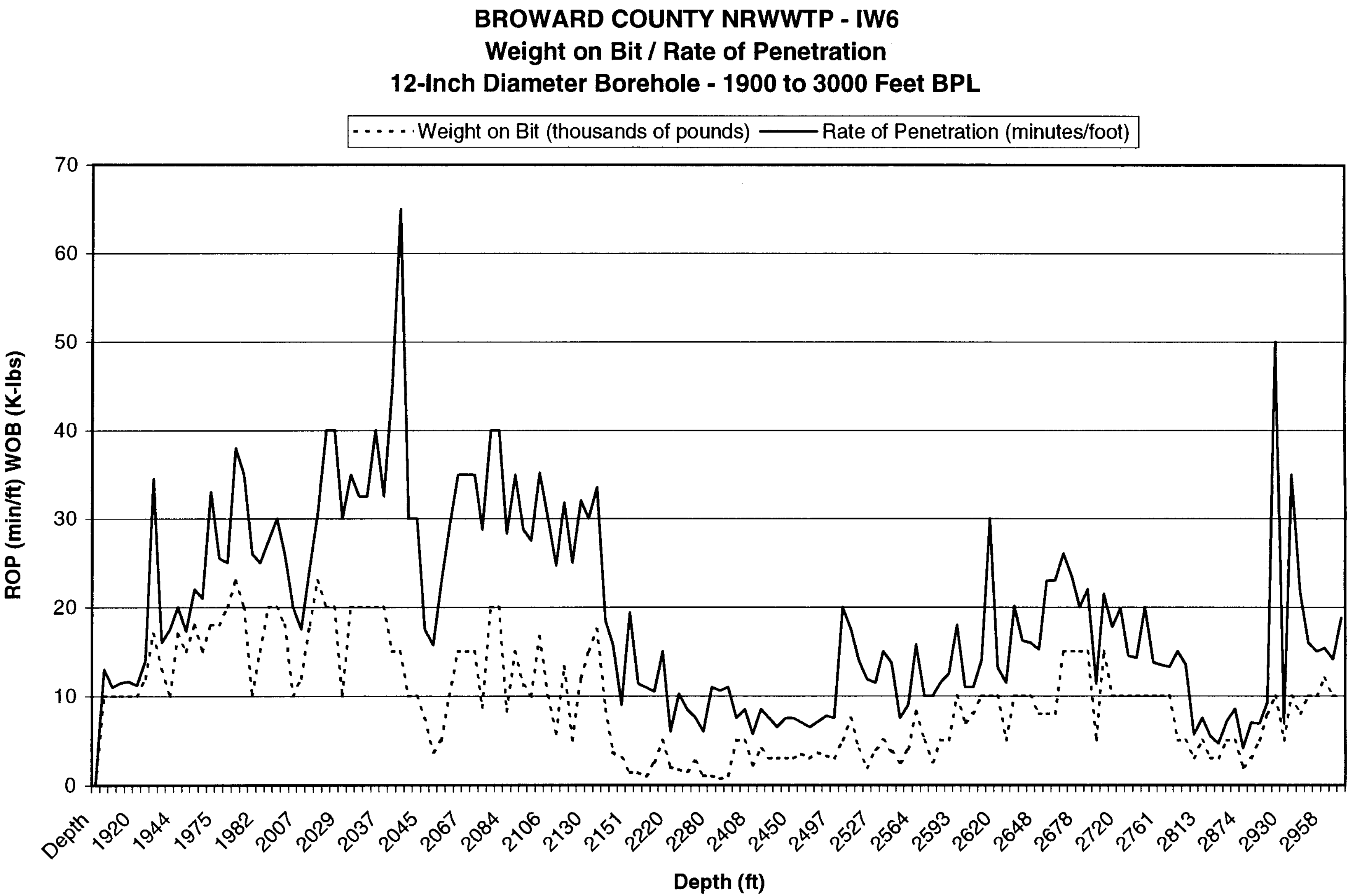
WOB-ROP IW6 160 to 1000 50-in.xls

BROWARD COUNTY NRWWTP - IW6
Weight on Bit / Rate of Penetration
12-inch Diameter Borehole - 1000 to 1900 Feet BPL

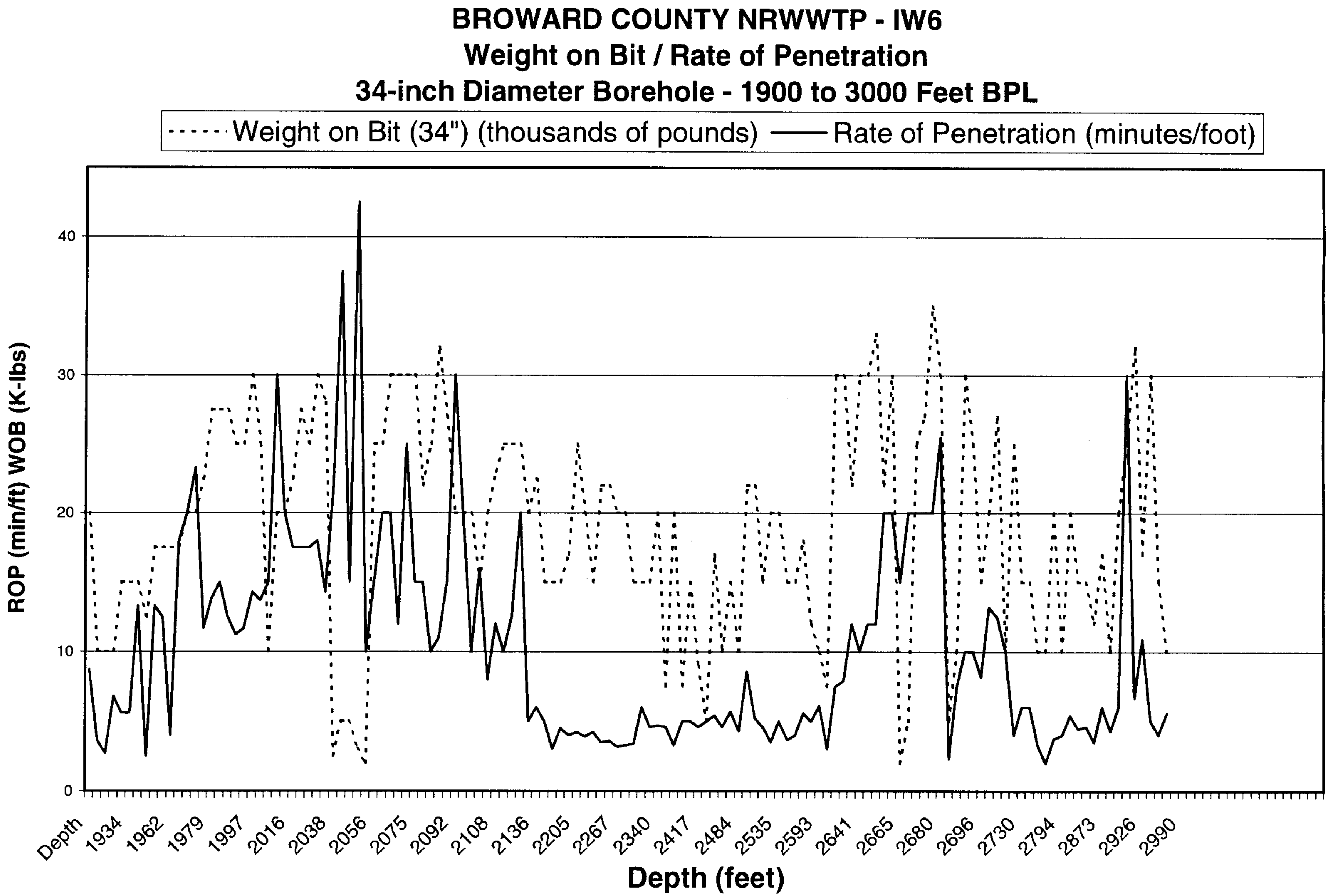


BROWARD COUNTY NRWWTP - IW6
Weight on Bit / Rate of Penetration
42-Inch Diameter Borehole - 1000 to 1900 Feet BPL



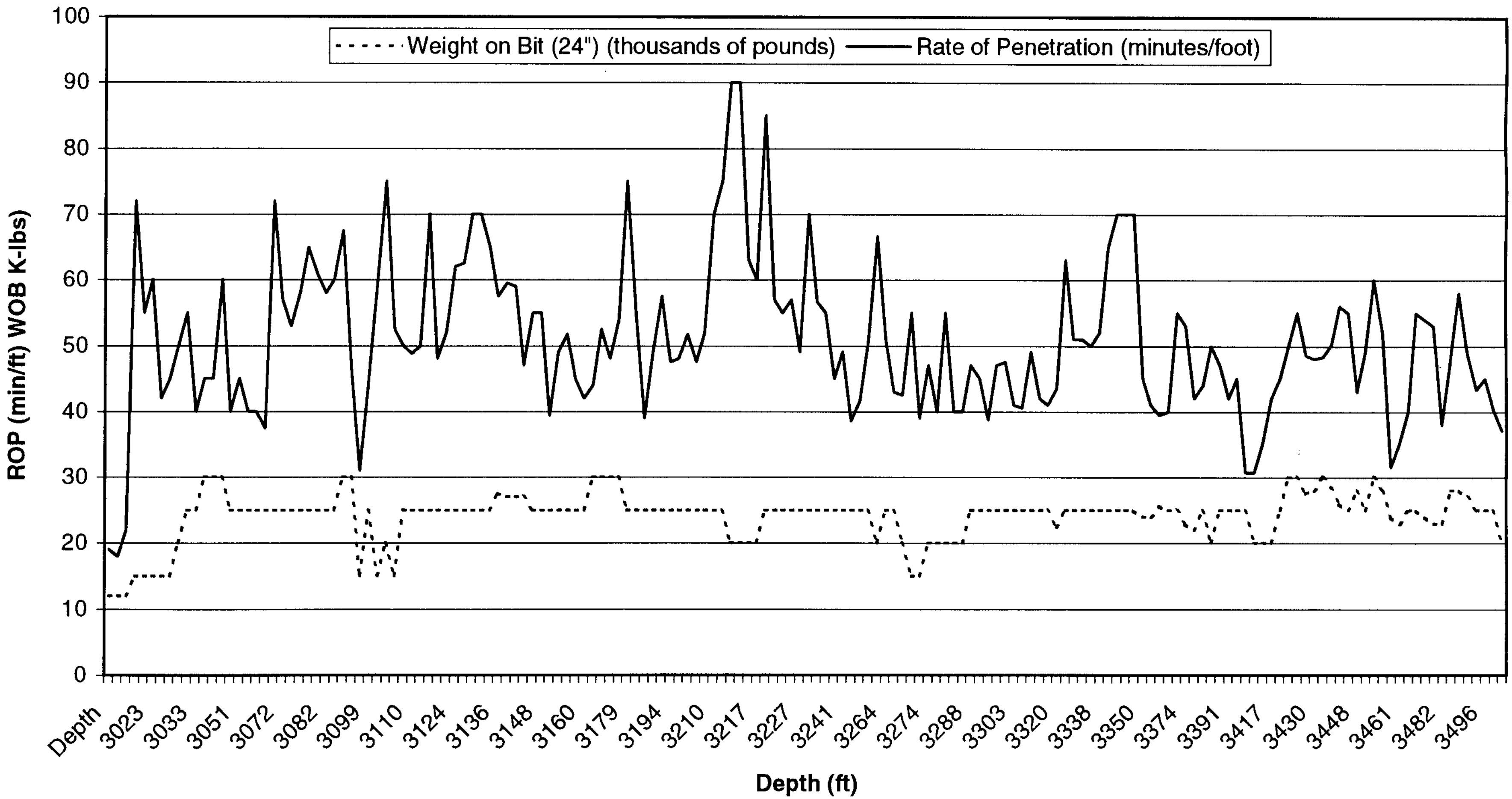


BROWARD COUNTY NRWWTP - IW6
Weight on Bit / Rate of Penetration
12-Inch Diameter Borehole - 1900 to 3000 Feet BPL
Weight on Bit (thousands of pounds)
Rate of Penetration (minutes/foot)
ROP (min/ft) WOB (K-lbs)
Depth (ft)
0
10
20
30
40
50
60
70
Depth
1920
1944
1975
1982
2007
2029
2037
2045
2067
2084
2106
2130
2151
2220
2280
2408
2450
2497
2527
2564
2593
2620
2648
2678
2720
2761
2813
2874
2930
2958



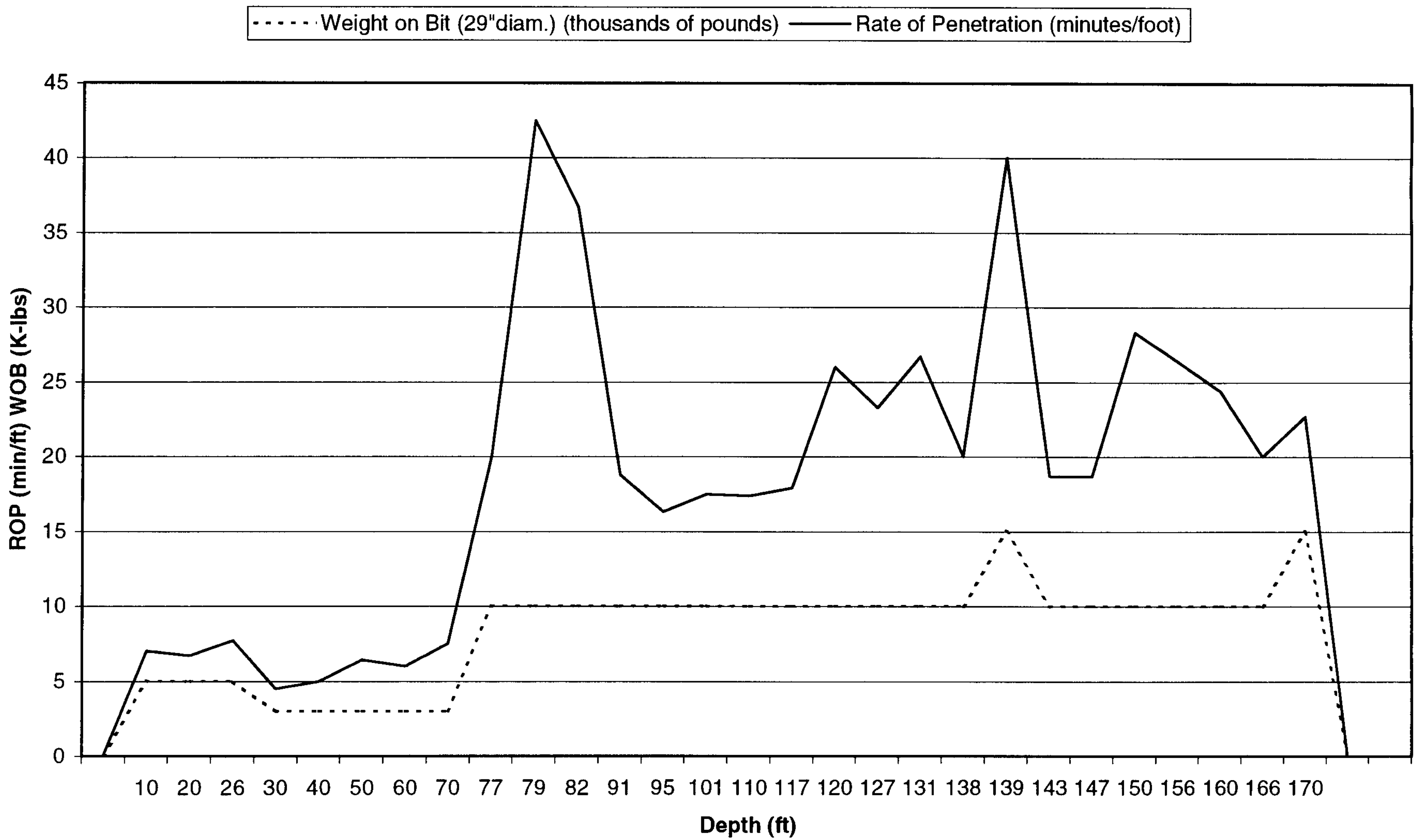
WOB-ROP IW6 1900 to 3000 34-in.xls

BROWARD COUNTY NRWWTP - IW6
Weight on Bit / Rate of Penetration
24-inch Diameter Borehole - 3000 to 3500 Feet BPL



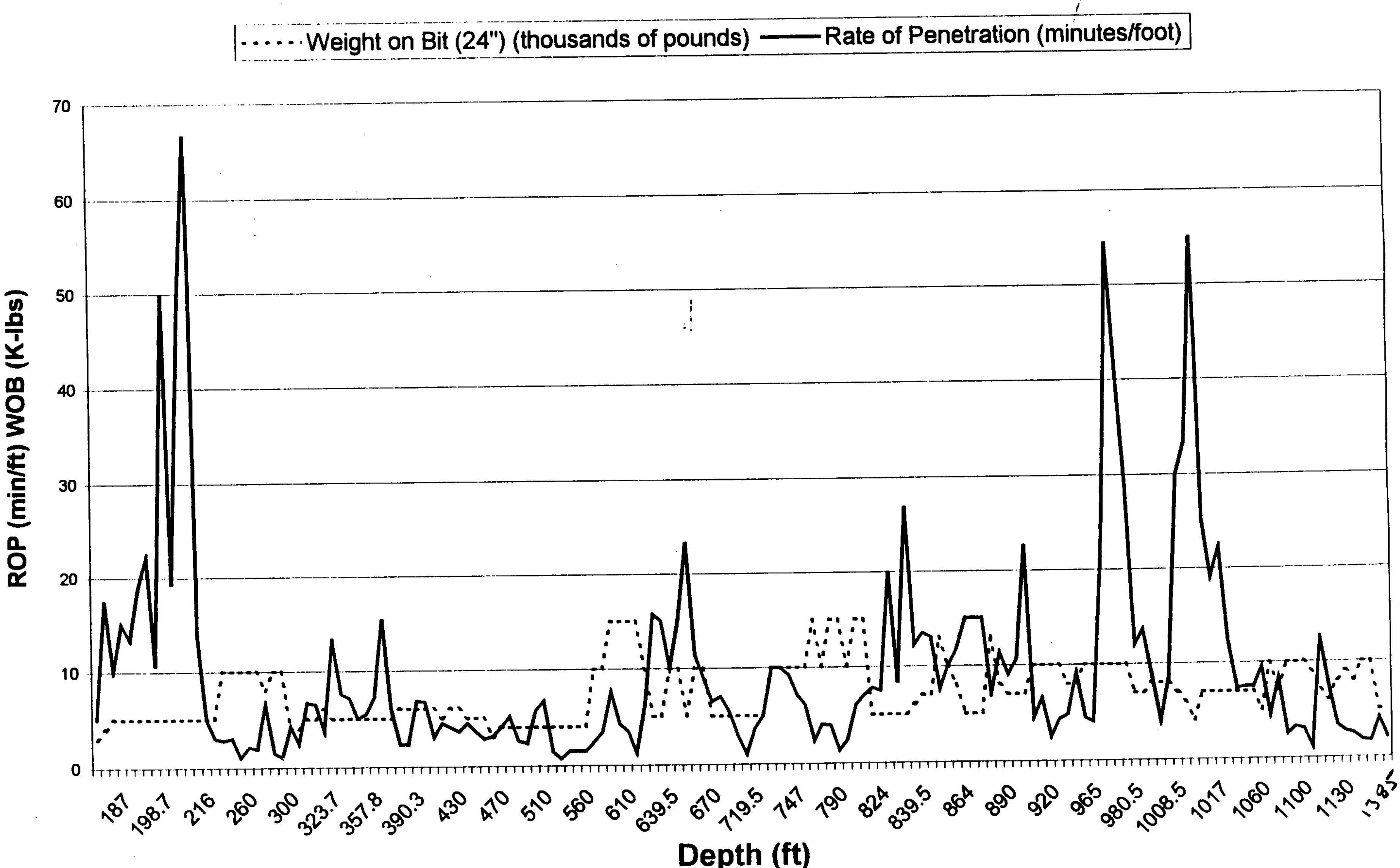
WOB-ROP IW6 3000 to 3500 24-in.xls

BROWARD COUNTY NRWWTP - MW3
Weight on Bit / Rate of Penetration
32-inch Diameter Borehole - 0 to 160 Feet BPL



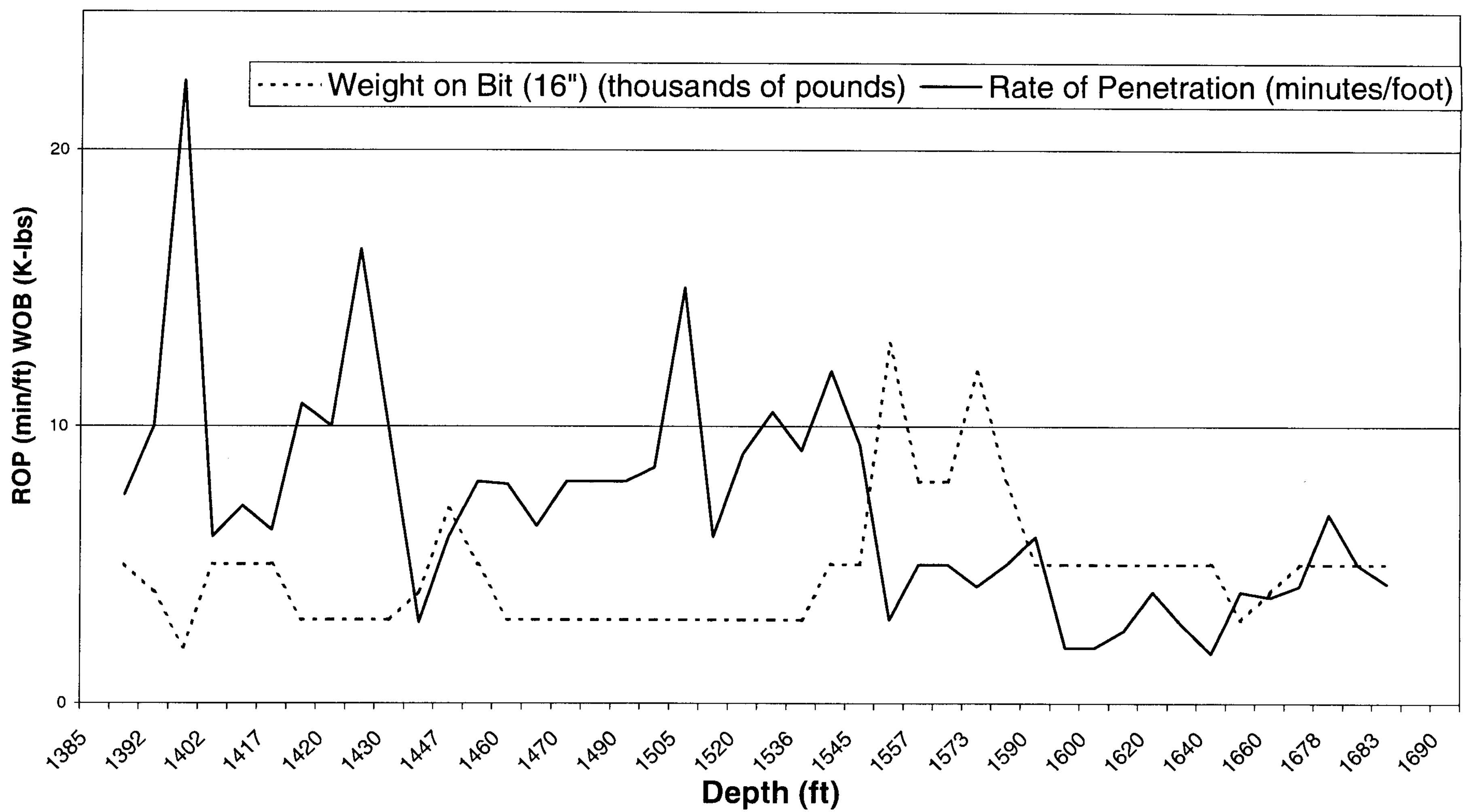
WOB-ROP MW3 0 to170 32-in .xls

BROWARD COUNTY NRWWTP - MW3
Weight on Bit / Rate of Renetration
24-inch Diameter Borehole - 170 to 1380 Feet BPL



WOBROP1900TO3000(34), Chart1

BROWARD COUNTY NRWWTP - MW3
Weight on Bit / Rate of Penetration
16-inch Diameter Borehole - 1380 to 1680 Feet BPL



WOB-ROP MW3 1380 to 1680 16-in .xls

APPENDIX C

INCLINATION SURVEY

Appendix C - Inclination Survey
Injection Well IW5

Depth (feet bpl)	Inclination (degrees)	Bit Size (inches)
90	0.250	58
250	0.495	48.5
340	0.300	48.5
430	0.500	48.5
520	0.750	48.5
610	0.250	48.5
700	0.500	48.5
790	0.750	48.5
880	0.375	48.5
970	0.500	48.5
1090	0.500	12.25
1180	0.488	12.25
1270	0.375	12.25
1360	0.500	12.25
1450	0.400	12.25
1540	0.250	12.25
1630	0.500	12.25
1720	0.400	12.25
1810	0.750	12.25
1900	0.750	12.25
1090	0.750	40.5
1180	0.500	40.5
1270	0.600	40.5
1360	0.250	40.5
1450	0.750	40.5
1540	0.500	40.5

Depth (feet bpl)	Inclination (degrees)	Bit Size (inches)
1630	0.250	40.5
1720	0.250	40.5
1810	0.125	40.5
1900	0.250	40.5
1990	0.500	12.25
2080	0.250	12.25
2170	0.250	12.25
2260	0.250	12.25
2350	0.500	12.25
2440	0.370	12.25
2530	0.500	12.25
2620	0.250	12.25
2710	0.250	12.25
2800	0.500	12.25
2890	0.375	12.25
2980	0.250	12.25
1985	0.125	32.5
2075	0.500	32.5
2165	0.750	32.5
2255	0.500	32.5
2345	0.250	32.5
2435	0.250	32.5
2525	0.500	32.5
2615	0.250	32.5
2705	0.250	32.5
2795	0.250	32.5
2885	0.200	32.5
2975	0.250	32.5

Appendix C - Inclination Survey
Injection Well IW6

Depth (feet bpl)	Inclination (degrees)	Bit Size (inches)
90	0.250	58
250	0.495	48.5
340	0.300	48.5
430	0.500	48.5
520	0.750	48.5
610	0.250	48.5
700	0.500	48.5
790	0.750	48.5
880	0.375	48.5
970	0.500	48.5
1090	0.500	12.25
1180	0.488	12.25
1270	0.375	12.25
1360	0.500	12.25
1450	0.400	12.25
1540	0.250	12.25
1630	0.500	12.25
1720	0.400	12.25
1810	0.750	12.25
1900	0.750	12.25
1090	0.750	40.5
1180	0.500	40.5
1270	0.600	40.5
1360	0.250	40.5
1450	0.750	40.5
1540	0.500	40.5

Depth (feet bpl)	Inclination (degrees)	Bit Size (inches)
1630	0.250	40.5
1720	0.250	40.5
1810	0.125	40.5
1900	0.250	40.5
1990	0.500	12.25
2080	0.250	12.25
2170	0.250	12.25
2260	0.250	12.25
2350	0.500	12.25
2440	0.370	12.25
2530	0.500	12.25
2620	0.250	12.25
2710	0.250	12.25
2800	0.500	12.25
2890	0.375	12.25
2980	0.250	12.25
1985	0.125	32.5
2075	0.500	32.5
2165	0.750	32.5
2255	0.500	32.5
2345	0.250	32.5
2435	0.250	32.5
2525	0.500	32.5
2516	0.250	32.5
2705	0.250	32.5
2795	0.250	32.5
2885	0.200	32.5
2975	0.250	32.5

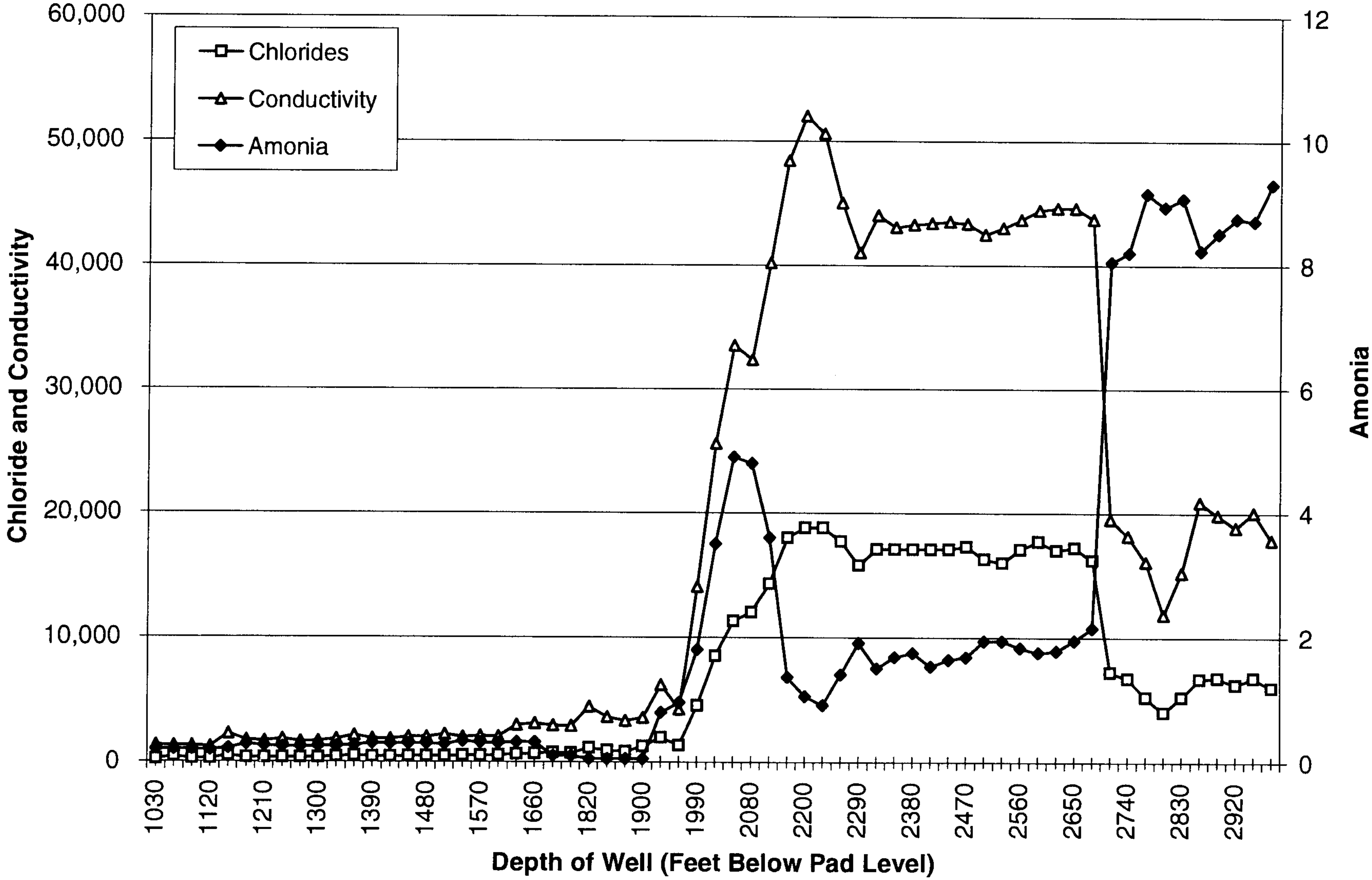
Appendix C - Inclination Survey
Monitor Well MW3

Depth (feet bpl)	Inclination (degrees)	Bit Size (inches)
90	0.125	29
250	0.250	22
340	0.375	22
430	0.250	22
520	0.250	22
610	0.250	22
700	0.175	22
790	0.250	22
880	0.200	22
970	0.250	22
1060	0.400	22
1150	0.250	22
1240	0.250	22
1330	0.375	22
1470	0.250	14
1550	0.480	14

APPENDIX D

DRILLING FLUID SAMPLE ANALYSIS

IW5 DRILLING FLUID ANALYSIS
BROWARD COUNTY NRWWTP



r:\4598\Field Data\IW5 DrillingFluidwGraph 1000-3000.xls, Chart 2

Broward County Office of Environmental Services
ANALYTICAL LABORATORY
2401 North Powerline Road
Pompano Beach, FL 33069
(954) 960-3067

BROWARD COUNTY FLORIDA

Drinking Water Certification #56074
Environmental Certification #E56441

Lab #	Group	Sample Type	Sample Location	Point	Coll Date	Chloride Data	Chloride Date	Chloride Oper	Conductivity Data	Conductivity Date	Conductivity Oper	Ammonia Data	Ammonia Date	Ammonia Oper
9907-1078	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1030'	IW5	7/26/99	220.00	7/28/99	LROSEN	1345.0	7/28/99	LROSEN	0.21	7/27/99	MITTEL
9907-1079	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1060'	IW5	7/26/99	437.50	7/28/99	LROSEN	1281.0	7/28/99	LROSEN	0.20	7/27/99	MITTEL
9907-1080	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1090'	IW5	7/26/99	240.00	7/28/99	LROSEN	1298.0	7/28/99	LROSEN	0.20	7/27/99	MITTEL
9907-1081	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1120'	IW5	7/26/99	240.00	7/28/99	LROSEN	1213.0	7/28/99	LROSEN	0.19	7/27/99	MITTEL
9907-1082	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1150'	IW5	7/26/99	492.50	7/28/99	LROSEN	2259.0	7/28/99	LROSEN	0.22	7/27/99	MITTEL
9907-1083	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1180'	IW5	7/26/99	335.00	7/28/99	LROSEN	1742.0	7/28/99	LROSEN	0.28	7/27/99	MITTEL
9907-1084	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1210'	IW5	7/26/99	332.50	7/28/99	LROSEN	1661.0	7/28/99	LROSEN	0.26	7/27/99	MITTEL
9907-1085	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1240'	IW5	7/26/99	330.00	7/28/99	LROSEN	1852.0	7/28/99	LROSEN	0.24	7/27/99	MITTEL
9907-1086	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1270'	IW5	7/26/99	317.50	7/28/99	LROSEN	1617.0	7/28/99	LROSEN	0.24	7/27/99	MITTEL
9907-1087	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1300'	IW5	7/26/99	320.00	7/28/99	LROSEN	1659.0	7/28/99	LROSEN	0.25	7/27/99	MITTEL
9907-1088	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1330'	IW5	7/26/99	400.00	7/28/99	LROSEN	1835.0	7/28/99	LROSEN	0.25	7/27/99	MITTEL
9907-1089	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1360'	IW5	7/26/99	492.50	7/28/99	LROSEN	2131.0	7/28/99	LROSEN	0.27	7/27/99	MITTEL
9907-1090	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1390'	IW5	7/26/99	420.00	7/28/99	LROSEN	1864.0	7/28/99	LROSEN	0.30	7/27/99	MITTEL
9907-1091	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1420'	IW5	7/26/99	410.00	7/28/99	LROSEN	1839.0	7/28/99	LROSEN	0.29	7/27/99	MITTEL
9907-1092	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1450'	IW5	7/26/99	450.00	7/28/99	LROSEN	2004.0	7/28/99	LROSEN	0.29	7/27/99	MITTEL
9907-1093	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1480'	IW5	7/26/99	460.00	7/28/99	LROSEN	2017.0	7/28/99	LROSEN	0.29	7/27/99	MITTEL
9907-1094	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1510'	IW5	7/26/99	465.00	7/28/99	LROSEN	2204.0	7/28/99	LROSEN	0.28	7/27/99	MITTEL
9907-1095	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1540'	IW5	7/26/99	480.00	7/28/99	LROSEN	1984.0	7/28/99	LROSEN	0.33	7/27/99	MITTEL
9907-1096	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1570'	IW5	7/27/99	492.50	7/28/99	LROSEN	2086.0	7/28/99	LROSEN	0.31	7/27/99	MITTEL
9907-1097	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1600'	IW5	7/27/99	535.00	7/28/99	LROSEN	2055.0	7/28/99	LROSEN	0.30	7/27/99	MITTEL
9907-1098	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1630'	IW5	7/27/99	642.50	7/28/99	LROSEN	2974.0	7/28/99	LROSEN	0.32	7/27/99	MITTEL
9907-1099	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1660'	IW5	7/27/99	667.50	7/28/99	LROSEN	3078.0	7/28/99	LROSEN	0.32	7/27/99	MITTEL

Approval: [signature]

Broward County Office of Environmental Services
ANALYTICAL LABORATORY
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BROWARD COUNTY FLORIDA

Drinking Water Certification #56074
Environmental Certification #E56441

Lab #	Group	Sample Type	Sample Location	Point	Coll Date	Ammonia Data	Ammonia Date	Ammonia Oper	Conductivity Data	Conductivity Date	Conductivity Oper	Chloride Data	Chloride Date	Chloride Oper
9907-1188	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1760'	IW5	7/28/99	0.10	7/30/99	MITTEL	2922.0	7/30/99	MITTEL	760.00	7/30/99	MITTEL
9907-1189	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1790'	IW5	7/28/99	0.10	7/30/99	MITTEL	2883.0	7/30/99	MITTEL	710.00	7/30/99	MITTEL
9907-1190	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1820'	IW5	7/28/99	0.05	7/30/99	MITTEL	4415.0	7/30/99	MITTEL	1130.00	7/30/99	MITTEL
9907-1191	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1850'	IW5	7/28/99	0.05	7/30/99	MITTEL	3578.0	7/30/99	MITTEL	920.00	7/30/99	MITTEL
9907-1192	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1880'	IW5	7/29/99	0.05	7/30/99	MITTEL	3278.0	7/30/99	MITTEL	820.00	7/30/99	MITTEL
9907-1193	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 1900'	IW5	7/29/99	0.05	7/30/99	MITTEL	3555.0	7/30/99	MITTEL	1270.00	7/30/99	MITTEL

Approval: Michael C. Mittel

Broward County Office of Environmental Services

ANALYTICAL LABORATORY

2401 North Powerline Road
Pompano Beach, FL 33069
(954) 960-3067

Drinking Water Certification #56074
Environmental Certification #E56441

Lab #	Group	Sample Type	Sample Location	Point	Coll Date	Chloride Data	Chloride Date	Chloride Oper	Conductivity Data	Conductivity Date	Conductivity Oper	Ammonia Data	Ammonia Date	Ammonia Oper
9909-0428	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 1930'	IW5	9/1/99	1950.00	9/8/99	MALBITE	6180.0	9/2/99	JROSSI	0.79	9/2/99	JROSSI
9909-0429	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 1960'	IW5	9/2/99	1350.00	9/8/99	MALBITE	4204.0	9/2/99	JROSSI	0.95	9/2/99	JROSSI

Approval: [signature]

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9909-0557	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 2020'	IW5	9/6/99	8500.00	9/8/99	MALBITE	25600.0	9/8/99	MALBITE	3.50	9/7/99	MALBITE
9909-0558	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 2050'	IW5	9/7/99	11300.00	9/8/99	MALBITE	33520.0	9/8/99	MALBITE	4.90	9/7/99	MALBITE
9909-0559	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 2080'	IW5	9/7/99	12000.00	9/8/99	MALBITE	32330.0	9/8/99	MALBITE	4.80	9/7/99	MALBITE
9909-0560	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 1990'	IW5	9/6/99	4500.00	9/8/99	MALBITE	14060.0	9/8/99	MALBITE	1.80	9/7/99	MALBITE
9909-0561	WASTEWATER	WW PROCESS CONTRO	IW5 Drilling Fluid 2110'	IW5	9/7/99	14300.00	9/8/99	MALBITE	40180.0	9/8/99	MALBITE	3.60	9/7/99	MALBITE

Approval: [signature]

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9909-0587	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid IW5 2170'	IW5	9/7/99	18000.00	9/8/99	MALBITE	48400.0	9/8/99	MALBITE	1.36	9/8/99	MALBITE
9909-0588	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid IW5 2200'	IW5	9/7/99	18800.00	9/8/99	MALBITE	52000.0	9/8/99	MALBITE	1.05	9/8/99	MALBITE
9909-0589	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid IW5 2230'	IW5	9/7/99	18800.00	9/8/99	MALBITE	50600.0	9/8/99	MALBITE	0.91	9/8/99	MALBITE
9909-0590	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid IW5 2260'	IW5	9/7/99	17700.00	9/8/99	MALBITE	45000.0	9/8/99	MALBITE	1.40	9/8/99	MALBITE

Approval: [signature]

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9909-0614	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2290'	IW5	9/8/99	15800.00	9/10/99	MALBITE	41000.0	9/9/99	MITTEL	1.91	9/10/99	MALBITE
9909-0615	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2320'	IW5	9/8/99	17100.00	9/10/99	MALBITE	43980.0	9/9/99	MITTEL	1.50	9/10/99	MALBITE
9909-0616	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2350'	IW5	9/9/99	17100.00	9/10/99	MALBITE	43040.0	9/9/99	MITTEL	1.68	9/10/99	MALBITE
9909-0617	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2380'	IW5	9/9/99	17100.00	9/10/99	MALBITE	43260.0	9/9/99	MITTEL	1.75	9/10/99	MALBITE
9909-0618	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2410'	IW5	9/9/99	17100.00	9/10/99	MALBITE	43370.0	9/9/99	MITTEL	1.53	9/10/99	MALBITE
9909-0619	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2440'	IW5	9/9/99	17100.00	9/10/99	MALBITE	43500.0	9/9/99	MITTEL	1.64	9/10/99	MALBITE
9909-0620	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2470'	IW5	9/9/99	17300.00	9/10/99	MALBITE	43350.0	9/9/99	MITTEL	1.68	9/10/99	MALBITE

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9909-0657	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2560'	IW5	9/9/99	17100.00	9/10/99	MALBITE	43660.0	9/10/99	JROSSI	1.83	9/10/99	MALBITE
9909-0658	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2590'	IW5	9/10/99	17700.00	9/10/99	MALBITE	44420.0	9/10/99	JROSSI	1.76	9/10/99	MALBITE
9909-0659	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2500'	IW5	9/9/99	16300.00	9/10/99	MALBITE	42440.0	9/10/99	JROSSI	1.94	9/10/99	MALBITE
9909-0660	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2530'	IW5	9/9/99	16000.00	9/10/99	MALBITE	43020.0	9/10/99	JROSSI	1.94	9/10/99	MALBITE
9909-0661	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2620'	IW5	9/10/99	17000.00	9/10/99	MALBITE	44600.0	9/10/99	JROSSI	1.76	9/10/99	MALBITE

Approval: Mike C. Miller

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9909-0732	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2650'	IW5	9/10/99	17200.00	9/13/99	MALBITE	44600.0	9/13/99	JROSSI	1.95	9/13/99	MALBITE
9909-0733	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2680'	IW5	9/10/99	16200.00	9/13/99	MALBITE	43700.0	9/13/99	JROSSI	2.15	9/13/99	MALBITE
9909-0734	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2710'	IW5	9/11/99	7200.00	9/13/99	MALBITE	19500.0	9/13/99	JROSSI	8.05	9/13/99	MALBITE
9909-0735	WASTEWATER	WW PROCESS CONTRO	IW5 DRILLING FLUID 2740'	IW5	9/11/99	6700.00	9/13/99	MALBITE	18150.0	9/13/99	JROSSI	8.20	9/13/99	MALBITE

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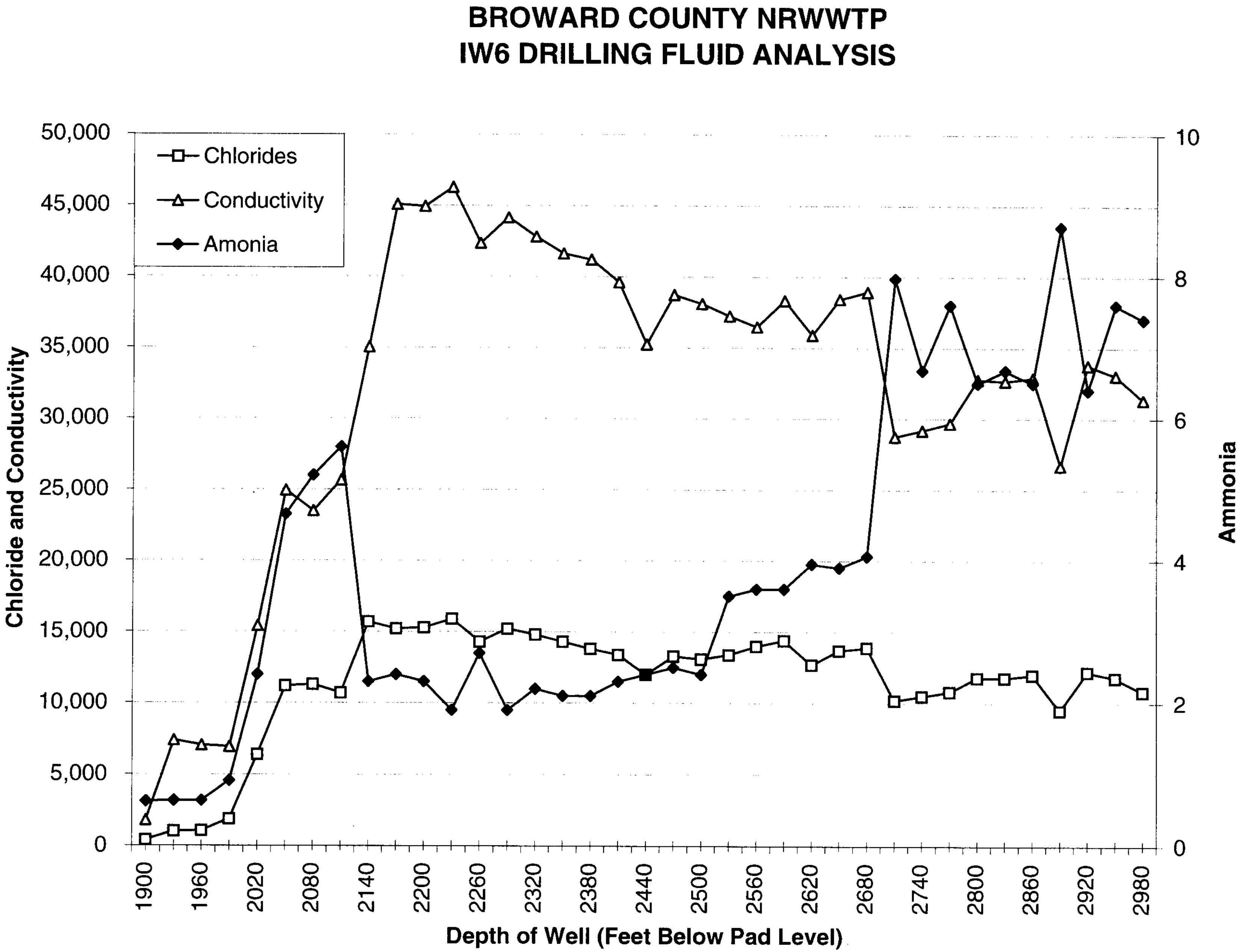
9909-0789	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2770'	IW5	9/13/99	5200.00	9/17/99	MALBITE	16100.0	9/17/99	MALBITE	9.15	9/15/99	MITTEL
9909-0790	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2800'	IW5	9/13/99	4000.00	9/17/99	MALBITE	11850.0	9/15/99	MITTEL	8.93	9/15/99	MITTEL
9909-0791	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2830'	IW5	9/13/99	5200.00	9/17/99	MALBITE	15210.0	9/15/99	MITTEL	9.07	9/15/99	MITTEL
9909-0792	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2860'	IW5	9/13/99	6650.00	9/17/99	MALBITE	20870.0	9/15/99	MITTEL	8.23	9/15/99	MITTEL
9909-0793	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2890'	IW5	9/13/99	6750.00	9/17/99	MALBITE	19850.0	9/15/99	MITTEL	8.51	9/15/99	MITTEL
9909-0794	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2920'	IW5	9/13/99	6200.00	9/17/99	MALBITE	18820.0	9/15/99	MITTEL	8.75	9/15/99	MITTEL
9909-0795	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2950'	IW5	9/13/99	6750.00	9/17/99	MALBITE	20050.0	9/15/99	MITTEL	8.71	9/15/99	MITTEL
9909-0796	WASTEWATER	WW PROCESS CONTRO	DRILLING FLUID IW5 2980'	IW5	9/13/99	5950.00	9/17/99	MALBITE	17850.0	9/15/99	MITTEL	9.30	9/15/99	MITTEL

Approval: [signature]



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BROWARD COUNTY
FLORIDA

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Environmental Certification #E56441

Lab #	Group	Sample Type	Sample Location	Point	Coll Date	Ammonia Data	Ammonia Date	Ammonia Oper	Chloride Data	Chloride Date	Chloride Oper	Conductivity Data	Conductivity Date	Conductivity Oper
9903-1260	WASTEWATER	WW PROCESS CONTRO	IW6-1030'	IW#6	3/29/99	0.45	3/31/99	MALBITE	285.00	3/31/99	LROSEN	2044.0	3/30/99	HUGHE
9903-1261	WASTEWATER	WW PROCESS CONTRO	IW6-1060'	IW#6	3/29/99	0.56	3/31/99	MALBITE	300.00	3/31/99	LROSEN	1766.0	3/30/99	HUGHE
9903-1262	WASTEWATER	WW PROCESS CONTRO	IW6-1090'	IW#6	3/29/99	0.44	3/31/99	MALBITE	240.00	3/31/99	LROSEN	1406.0	3/30/99	HUGHE
9903-1263	WASTEWATER	WW PROCESS CONTRO	IW6-1120'	IW#6	3/29/99	0.40	3/31/99	MALBITE	285.00	3/31/99	LROSEN	1652.0	3/30/99	HUGHE
9903-1264	WASTEWATER	WW PROCESS CONTRO	IW6-1150'	IW#6	3/30/99	0.43	3/31/99	MALBITE	260.00	3/31/99	LROSEN	1604.0	3/30/99	HUGHE
9903-1265	WASTEWATER	WW PROCESS CONTRO	IW6-1180'	IW#6	3/30/99	0.51	3/31/99	MALBITE	180.00	3/31/99	LROSEN	1700.0	3/30/99	HUGHE
9903-1266	WASTEWATER	WW PROCESS CONTRO	IW6-1210'	IW#6	3/30/99	0.56	3/31/99	MALBITE	185.00	3/31/99	LROSEN	1326.0	3/30/99	HUGHE
9903-1267	WASTEWATER	WW PROCESS CONTRO	IW6-1240'	IW#6	3/30/99	0.57	3/31/99	MALBITE	270.00	3/31/99	LROSEN	1216.0	3/30/99	HUGHE
9903-1268	WASTEWATER	WW PROCESS CONTRO	IW6-1270'	IW#6	3/30/99	0.57	3/31/99	MALBITE	140.00	3/31/99	LROSEN	1076.0	3/30/99	HUGHE
9903-1269	WASTEWATER	WW PROCESS CONTRO	IW6-1300'	IW#6	3/30/99	0.51	3/31/99	MALBITE	150.00	3/31/99	LROSEN	1094.0	3/30/99	HUGHE
9903-1270	WASTEWATER	WW PROCESS CONTRO	IW6-1330'	IW#6	3/30/99	0.49	3/31/99	MALBITE	155.00	3/31/99	LROSEN	966.0	3/30/99	HUGHE
9903-1271	WASTEWATER	WW PROCESS CONTRO	IW6-1360'	IW#6	3/30/99	0.51	3/31/99	MALBITE	150.00	3/31/99	LROSEN	1056.0	3/30/99	HUGHE
9903-1272	WASTEWATER	WW PROCESS CONTRO	IW6-1390'	IW#6	3/30/99	0.51	3/31/99	MALBITE	155.00	3/31/99	LROSEN	1014.0	3/30/99	HUGHE
9903-1273	WASTEWATER	WW PROCESS CONTRO	IW6-1420'	IW#6	3/30/99	0.51	3/31/99	MALBITE	160.00	3/31/99	LROSEN	1034.0	3/30/99	HUGHE
9903-1274	WASTEWATER	WW PROCESS CONTRO	IW6-1450'	IW#6	3/30/99	0.50	3/31/99	MALBITE	170.00	3/31/99	LROSEN	828.0	3/30/99	HUGHE
9903-1275	WASTEWATER	WW PROCESS CONTRO	IW6-1480'	IW#6	3/30/99	0.50	3/31/99	MALBITE	185.00	3/31/99	LROSEN	969.0	3/30/99	HUGHE
9903-1276	WASTEWATER	WW PROCESS CONTRO	IW6-1510'	IW#6	3/30/99	0.49	3/31/99	MALBITE	220.00	3/31/99	LROSEN	1120.0	3/30/99	HUGHE
9903-1277	WASTEWATER	WW PROCESS CONTRO	IW6-1540'	IW#6	3/30/99	0.49	3/31/99	MALBITE	185.00	3/31/99	LROSEN	1020.0	3/30/99	HUGHE
9903-1278	WASTEWATER	WW PROCESS CONTRO	IW6-1570'	IW#6	3/30/99	0.48	3/31/99	MALBITE	225.00	3/31/99	LROSEN	1248.0	3/30/99	HUGHE
9903-1279	WASTEWATER	WW PROCESS CONTRO	IW6-1600'	IW#6	3/30/99	0.48	3/31/99	MALBITE	190.00	3/31/99	LROSEN	1168.0	3/30/99	HUGHE
9903-1280	WASTEWATER	WW PROCESS CONTRO	IW6-1630'	IW#6	3/30/99	0.48	3/31/99	MALBITE	295.00	3/31/99	LROSEN	1134.0	3/30/99	HUGHE
9903-1281	WASTEWATER	WW PROCESS CONTRO	IW6-1660'	IW#6	3/30/99	0.48	3/31/99	MALBITE	235.00	3/31/99	LROSEN	1290.0	3/30/99	HUGHE

Approval: [signature]

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9904-0403	WASTEWATER	WW PROCESS CONTRO	IW6-1690'	IW#6	3/31/99	0.74	4/1/99	MALBITE	320.00	4/1/99	CPEREZ	1898.0	4/1/99	CPEREZ
9904-0404	WASTEWATER	WW PROCESS CONTRO	IW6-1720'	IW#6	3/31/99	0.74	4/1/99	MALBITE	310.00	4/1/99	CPEREZ	1690.0	4/1/99	CPEREZ
9904-0405	WASTEWATER	WW PROCESS CONTRO	IW6-1750'	IW#6	3/31/99	0.76	4/1/99	MALBITE	275.00	4/1/99	CPEREZ	1288.0	4/1/99	CPEREZ
9904-0406	WASTEWATER	WW PROCESS CONTRO	IW6-1780'	IW#6	3/31/99	0.76	4/1/99	MALBITE	285.00	4/1/99	CPEREZ	1585.0	4/1/99	CPEREZ

Approval: ______

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9904-0427	WASTEWATER	WW PROCESS CONTRO	IW6-1840'	IW#6	4/1/99	0.66	4/5/99	MALBITE	285.00	4/6/99	LROSEN	1420.0	4/6/99	NMEHAN
9904-0428	WASTEWATER	WW PROCESS CONTRO	IW6-1870'	IW#6	4/1/99	0.65	4/5/99	MALBITE	1380.00	4/6/99	LROSEN	4730.0	4/6/99	NMEHAN
9904-0429	WASTEWATER	WW PROCESS CONTRO	IW6-1900'	IW#6	4/1/99	0.62	4/5/99	MALBITE	415.00	4/6/99	LROSEN	1796.0	4/6/99	NMEHAN

Approval: (signature) Nmehan

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9904-1156	WASTEWATER	WW PROCESS CONTR	IW6 DRILLING FLUID 1930'	IW6	4/26/99	0.63	4/28/99	MALBITE	1025.00	4/27/99	CPEREZ	7300.0	4/27/99	CPEREZ
9904-1157	WASTEWATER	WW PROCESS CONTR	IW6 DRILLING FLUID 1960'	IW6	4/26/99	0.63	4/28/99	MALBITE	1050.00	4/27/99	CPEREZ	7030.0	4/27/99	CPEREZ

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9904-1231	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 1990'	IW6	4/28/99	1875.00	4/29/99	CPEREZ	6920.0	4/29/99	CPEREZ	0.91	5/1/99	MALBITE
9904-1232	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2020'	IW6	4/28/99	6375.00	4/29/99	CPEREZ	15420.0	4/29/99	CPEREZ	2.40	5/1/99	MALBITE
9904-1233	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2050'	IW6	4/28/99	11200.00	4/29/99	CPEREZ	24936.0	4/29/99	CPEREZ	4.65	5/1/99	MALBITE
9904-1234	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2080'	IW6	4/28/99	11300.00	4/29/99	CPEREZ	23490.0	4/29/99	CPEREZ	5.20	5/1/99	MALBITE
9904-1235	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2110'	IW6	4/29/99	10700.00	4/29/99	CPEREZ	25650.0	4/29/99	CPEREZ	5.60	5/1/99	MALBITE
9904-1236	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2140'	IW6	4/29/99	15700.00	4/29/99	CPEREZ	35040.0	4/29/99	CPEREZ	2.30	5/1/99	MALBITE
9904-1311	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2170'	IW6	4/29/99	15200.00	5/1/99	MALBITE	45070.0	5/1/99	MALBITE	2.40	5/1/99	MALBITE
9904-1312	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2200'	IW6	4/29/99	15300.00	5/1/99	MALBITE	44930.0	5/1/99	MALBITE	2.30	5/1/99	MALBITE
9904-1313	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2230'	IW6	4/29/99	15900.00	5/1/99	MALBITE	46290.0	5/1/99	MALBITE	1.90	5/1/99	MALBITE
9904-1314	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2260'	IW6	4/29/99	14300.00	5/1/99	MALBITE	42350.0	5/1/99	MALBITE	2.70	5/1/99	MALBITE
9904-1315	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2290'	IW6	4/29/99	15200.00	5/1/99	MALBITE	44160.0	5/1/99	MALBITE	1.90	5/1/99	MALBITE
9904-1316	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2320'	IW6	4/29/99	14800.00	5/1/99	MALBITE	42800.0	5/1/99	MALBITE	2.20	5/1/99	MALBITE
9904-1317	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2350'	IW6	4/29/99	14300.00	5/1/99	MALBITE	41620.0	5/1/99	MALBITE	2.10	5/1/99	MALBITE
9904-1318	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2380'	IW6	4/30/99	13800.00	5/1/99	MALBITE	41180.0	5/1/99	MALBITE	2.10	5/1/99	MALBITE
9904-1319	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2410'	IW6	4/30/99	13400.00	5/1/99	MALBITE	39600.0	5/1/99	MALBITE	2.30	5/1/99	MALBITE
9904-1320	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2440'	IW6	4/30/99	12000.00	5/1/99	MALBITE	35240.0	5/1/99	MALBITE	2.40	5/1/99	MALBITE
9904-1321	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2470'	IW6	4/30/99	13300.00	5/1/99	MALBITE	38730.0	5/1/99	MALBITE	2.50	5/1/99	MALBITE
9904-1322	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2500'	IW6	4/30/99	13100.00	5/1/99	MALBITE	38100.0	5/1/99	MALBITE	2.40	5/1/99	MALBITE

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Drinking Water Certification #56074
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Lab #	Group	Sample Type	Sample Location	Point	Coll Date	Ammonia Data	Ammonia Date	Ammonia Oper	Chloride Data	Chloride Date	Chloride Oper	Conductivity Data	Conductivity Date	Conductivity Oper
9904-1318	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2380'	IW6	4/30/99	2.10	5/1/99	MALBITE	13800.00	5/1/99	MALBITE	41180.0	5/1/99	MALBITE
9904-1319	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2410'	IW6	4/30/99	2.30	5/1/99	MALBITE	13400.00	5/1/99	MALBITE	39600.0	5/1/99	MALBITE
9904-1320	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2440'	IW6	4/30/99	2.40	5/1/99	MALBITE	12000.00	5/1/99	MALBITE	35240.0	5/1/99	MALBITE
9904-1321	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2470'	IW6	4/30/99	2.50	5/1/99	MALBITE	13300.00	5/1/99	MALBITE	38730.0	5/1/99	MALBITE
9904-1322	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2500'	IW6	4/30/99	2.40	5/1/99	MALBITE	13100.00	5/1/99	MALBITE	38100.0	5/1/99	MALBITE
9905-0433	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2530'	IW6	4/30/99	3.80	5/3/99	MALBITE	13400.00	5/3/99	MALBITE	37230.0	5/3/99	MALBITE
9905-0434	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2560'	IW6	4/30/99	3.60	5/3/99	MALBITE	14000.00	5/3/99	MALBITE	38470.0	5/3/99	MALBITE
9905-0435	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2590'	IW6	4/30/99	3.60	5/3/99	NMILLER	14400.00	5/3/99	MALBITE	38320.0	5/3/99	MALBITE
9905-0436	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2620'	IW6	5/3/99	3.95	5/5/99	MALBITE	12700.00	5/5/99	MALBITE	35890.0	5/4/99	JROSSI
9905-0437	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2650'	IW6	5/3/99	3.90	5/5/99	MALBITE	13700.00	5/5/99	MALBITE	38420.0	5/4/99	JROSSI
9905-0467	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2680'	IW6	5/3/99	4.06	5/5/99	MALBITE	13900.00	5/5/99	MALBITE	38930.0	5/4/99	JROSSI
9905-0468	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2710'	IW6	5/3/99	7.97	5/5/99	MALBITE	10200.00	5/5/99	MALBITE	28740.0	5/4/99	JROSSI
9905-0469	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2740'	IW6	5/4/99	6.68	5/5/99	MALBITE	10500.00	5/5/99	MALBITE	29190.0	5/4/99	JROSSI
9905-0470	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2770'	IW6	5/4/99	7.60	5/5/99	MALBITE	10800.00	5/5/99	MALBITE	29680.0	5/4/99	JROSSI
9905-0471	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2800'	IW6	5/4/99	6.50	5/5/99	MALBITE	11800.00	5/5/99	MALBITE	32770.0	5/4/99	JROSSI
9905-0472	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2830'	IW6	5/4/99	6.68	5/5/99	MALBITE	11800.00	5/5/99	MALBITE	32660.0	5/4/99	JROSSI
9905-0473	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2860'	IW6	5/4/99	6.50	5/5/99	MALBITE	12000.00	5/5/99	MALBITE	32900.0	5/4/99	JROSSI
9905-0546	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2890'	IW6	5/4/99	8.70	5/7/99	MALBITE	9500.00	5/6/99	CPEREZ	26700.0	5/6/99	CPEREZ
9905-0547	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2920'	IW6	5/4/99	6.40	5/7/99	MALBITE	12200.00	5/6/99	CPEREZ	33770.0	5/6/99	CPEREZ
9905-0548	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2950'	IW6	5/4/99	7.60	5/7/99	MALBITE	11800.00	5/6/99	CPEREZ	33060.0	5/6/99	CPEREZ
9905-0549	WASTEWATER	WW PROCESS CONTRO	IW6 Drilling Fluid 2980'	IW6	5/5/99	7.40	5/7/99	MALBITE	10800.00	5/6/99	CPEREZ	31330.0	5/6/99	CPEREZ

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9912-1136	WASTEWATER	WW PROCESS CONTRO	MW3 DRILLING FLUID 1000'	MW3	12/17/99	440.00	12/23/99	MITTEL	0.20	1/6/2000	NMEHAN	3150.0	12/23/99	MITTEL
9912-1137	WASTEWATER	WW PROCESS CONTRO	MW3 DRILLING FLUID 1150'	MW3	12/20/99	310.00	12/23/99	MITTEL	0.16	1/6/2000	NMEHAN	2125.0	12/23/99	MITTEL
9912-1138	WASTEWATER	WW PROCESS CONTRO	MW3 DRILLING FLUID 1210'	MW3	12/20/99	360.00	12/23/99	MITTEL	0.22	1/6/2000	NMEHAN	2450.0	12/23/99	MITTEL

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0001-0510	WASTEWATER	WW PROCESS CONTRO	MW 3 -Drilling Fluid 1030'	MW3	12/17/99	500.00	1/6/2000	NMEHAN	0.21	1/6/2000	NMEHAN	2990.0	1/6/2000	NMEHAN
0001-0511	WASTEWATER	WW PROCESS CONTRO	MW 3 -Drilling Fluid 1090'	MW3	12/20/99	420.00	1/6/2000	NMEHAN	0.14	1/6/2000	NMEHAN	2441.0	1/6/2000	NMEHAN
0001-0512	WASTEWATER	WW PROCESS CONTRO	MW 3 -Drilling Fluid 1120'	MW3	12/20/99	380.00	1/6/2000	NMEHAN	0.11	1/6/2000	NMEHAN	2219.0	1/6/2000	NMEHAN
0001-0513	WASTEWATER	WW PROCESS CONTRO	MW 3 -Drilling Fluid 1180'	MW3	12/20/99	395.00	1/6/2000	NMEHAN	0.12	1/6/2000	NMEHAN	2399.0	1/6/2000	NMEHAN
0001-0514	WASTEWATER	WW PROCESS CONTRO	MW 3 -Drilling Fluid 1270'	MW3	12/21/99	330.00	1/6/2000	NMEHAN	0.03	1/6/2000	NMEHAN	2068.0	1/6/2000	NMEHAN

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0001-0558	WASTEWATER	WW PROCESS CONTRO	MW3 Drilling Fluid 1060'	MW 3	12/18/99	530.00	1/7/2000	MITTEL	0.14	1/6/2000	NMEHAN	3025.0	1/6/2000	NMEHAN
0001-0559	WASTEWATER	WW PROCESS CONTRO	MW3 Drilling Fluid 1240'	MW 3	12/21/99	380.00	1/7/2000	MITTEL	0.14	1/6/2000	NMEHAN	2420.0	1/6/2000	NMEHAN
0001-0560	WASTEWATER	WW PROCESS CONTRO	MW3 Drilling Fluid 1300'	MW 3	12/21/99	340.00	1/7/2000	MITTEL	0.08	1/6/2000	NMEHAN	2280.0	1/6/2000	NMEHAN
0001-0561	WASTEWATER	WW PROCESS CONTRO	MW3 Drilling Fluid 1330'	MW 3	12/21/99	350.00	1/7/2000	MITTEL	0.21	1/6/2000	NMEHAN	2384.0	1/6/2000	NMEHAN
0001-0562	WASTEWATER	WW PROCESS CONTRO	MW3 Drilling Fluid 1360'	MW 3	12/21/99	300.00	1/7/2000	MITTEL	0.07	1/6/2000	NMEHAN	1917.0	1/6/2000	NMEHAN

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0001-1115	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1390'	MW-3	1/24/2000	0.15	1/26/2000	MALBITE	160.00	1/27/2000	MALBITE	2266.0	1/26/2000	MALBITE
0001-1116	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1420'	MW-3	1/24/2000	0.39	1/26/2000	MALBITE	160.00	1/27/2000	MALBITE	2103.0	1/26/2000	MALBITE
0001-1144	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1450'	MW-3	1/26/2000	0.94	1/28/2000	MALBITE	390.00	1/27/2000	MALBITE	2147.0	1/26/2000	NMEHAN
0001-1145	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1480'	MW-3	1/26/2000	0.96	1/28/2000	MALBITE	400.00	1/27/2000	MALBITE	2085.0	1/26/2000	NMEHAN
0001-1146	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1510'	MW-3	1/26/2000	0.72	1/28/2000	MALBITE	410.00	1/27/2000	MALBITE	2167.0	1/26/2000	NMEHAN
0001-1147	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1540'	MW-3	1/26/2000	0.52	1/28/2000	MALBITE	440.00	1/27/2000	MALBITE	2140.0	1/26/2000	NMEHAN
0001-1148	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1570'	MW-3	1/26/2000	0.21	1/28/2000	MALBITE	520.00	1/27/2000	MALBITE	2330.0	1/26/2000	NMEHAN
0001-1212	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1600'	MW-3	1/26/2000	0.20	1/28/2000	MALBITE	650.00	1/27/2000	MALBITE	2510.0	1/27/2000	NMEHAN
0001-1213	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1630'	MW-3	1/26/2000	0.22	1/28/2000	MALBITE	700.00	1/27/2000	MALBITE	2650.0	1/27/2000	NMEHAN
0001-1214	WASTEWATER	WW PROCESS CONTRO	Drilling Fluid MW-3 1660'	MW-3	1/26/2000	0.19	1/28/2000	MALBITE	760.00	1/27/2000	MALBITE	2790.0	1/27/2000	NMEHAN

Approval:

APPENDIX E

GEOLOGIC LOGS

Appendix E - Geologic Log
Injection Well IW5

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
0–10	10	SAND, SHELL AND ORGANICS – Sand, 90% unconsolidated, medium-grained, sub-angular, colorless quartz. Shell fragments 5%. Organic material (roots, etc) 5%.
10–40	30	SAND – 100% unconsolidated, medium grained, sub-angular, colorless quartz with trace of shell fragments.
40-70	30	SAND – 100% unconsolidated, medium to fine grained, sub-angular, colorless quartz with trace of phosphate
70-120	50	SAND AND LIMY SANDSTONE – 100% unconsolidated to moderately well-cemented with calcite, fine grained, and sub-rounded, colorless quartz sand and limy sandstone with trace of limestone, shell fragments and phosphate; shell content and calcification increases with depth
120-130	10	LIMY SANDSTONE – 100% medium gray (N5), moderately well cemented with calcite, medium to fine grained, sub-angular quartz with trace of shell fragments and phosphate.
130-140	10	SANDY LIMESTONE AND LIMY SANDSTONE – Sandy Limestone, 70% light olive gray (5Y 6/1) to yellowish gray (5Y 8/1) fine grained to micritic, fossiliferous wackstone with fine to coarse-grained sub-rounded, colorless quartz sand. Limy Sandstone, 30% medium gray (N5), medium to fine grained, sub-angular quartz, moderately well cemented with calcite; trace of shell fragments and phosphate.
140-160	20	LIMY SANDSTONE – 100% medium gray (N5), very well indurated, fine grained, sub-angular quartz and phosphate with trace yellowish gray (5Y 8/1) micritic limestone.
160-230	70	SANDY LIMESTONE – 100% greenish gray (5GY 6/1), weakly phosphatic, medium grained to micritic and fossiliferous; becomes locally coarse grained to conglomerate with abundant shell fragments and fossil tests from 170 to 200 ft; shell and fossil content decreases with depth. Dominantly fine grained to micritic from 200 to 230 ft.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
230-270	40	LIMY SANDSTONE – 100% light olive gray (5Y 6/1) to dark gray (N3), moderately indurated and cemented, medium to coarse grained, partly conglomeratic, moderately to locally poorly sorted, variable roundness and sphericity of grains with abundant shell and coral fossil fragments, generally weakly phosphatic, weakly to moderately calcareous, becoming yellowish gray (5Y 7/2) to light olive gray (5Y 6/1) from 270 to 280 ft.
270-280	10	SANDY LIMESTONE – 100% yellowish gray (5Y 8/1) to grayish yellow (5Y 7/6), dominantly fine to medium grained, locally coarse grained packstone to grainstone with abundant fine to coarse grained, generally moderately to well sorted, fossil shell fragments.
280-290	10	SANDY LIMESTONE AND SANDSTONE – Sandy limestone, 70% as above. Sandstone, 30% moderately hard to soft, partly argillaceous, medium to very fine grained.
290-320	30	LIMESTONE – 100% pale olive (10Y 6/2), moderately soft, argillaceous, weakly phosphatic, mostly very fine grained, locally sparry grainstone with trace of shell fragments.
320-330	10	SANDY CLAY – 100% grayish olive (10Y 4/2), soft, plastic, phosphatic and calcareous with medium to fine grained, sub-rounded quartz sand and minor shell fragments.
330-340	10	SANDY LIMESTONE – 100% pale olive (10Y 6/2), moderately soft, argillaceous, weakly phosphatic, mostly very fine grained, carbonate mudstone with medium to fine grained, sub-rounded quartz sand and shell fragments.
340-350	10	SANDY CLAY – 100% grayish olive (10Y 4/2), soft, plastic, phosphatic and weakly calcareous with medium to fine grained, sub-rounded quartz sand and minor shell fragments.
350-380	30	SANDY CLAY AND LIMESTONE – Sandy Clay, 70% as above. Limestone, 30% dusky yellow (5Y 6/4), brittle, weakly argillaceous, microcrystalline, carbonate mudstone. Clay content increases with depth.
380-430	50	SANDY CLAY – 100% Grayish olive (10Y 4/2), to pale olive (10Y 6/2), very soft, plastic, phosphatic, and very weakly calcareous with medium grained, subrounded quartz sand. Sand content decreases slightly with depth.
430-560	130	SANDY CLAY – 100% Grayish olive (10Y 4/2), very soft, plastic, and non-calcareous with very fine grained quartz and phosphate grains.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
560-570	10	CLAY, SANDY LIMSTONE, AND DOLOMITE – Clay, 80% yellowish gray (5Y 7/2), very soft and plastic with fine grained quartz and phosphate grains. Sandy Limestone, 10% light olive gray (5Y 6/1), hard, weakly phosphatic, microcrystalline to cryptocrystalline and sparry with abundant fossil fragments. Dolomite, 10% olive gray (5Y 3/2), hard, slightly vuggy, fine grained.
570-580	10	CLAY AND DOLOMITE – Clay, 95% yellowish gray (5Y 7/2), very soft and plastic with fine grained quartz and phosphate grains. Dolomite, 5% grayish black (N2), hard, siliceous, microcrystalline.
580-590	10	CLAY – 100% greenish gray (5GY 6/1), soft, plastic, with very fine grained quartz sand and trace of phosphate.
590-610	20	CLAY – 100%; 80% Yellowish gray (5Y 7/2), very soft, plastic, with very fine grained quartz sand and trace phosphate. 20% greenish gray (5GY 6/1), soft, plastic, as above.
610-640	30	CLAY AND LIMESTONE – Clay, 90% pale olive (10Y 6/2), soft, plastic, slightly sandy with trace of phosphate. Limestone, 10% yellowish gray (5Y 7/2), moderately soft, silty, medium to fine grained.
640-700	60	CLAY – 100% Greenish gray (5GY 6/1), moderately soft, plastic, and weakly calcareous; moderate greenish yellow (10Y7/4) to pale greenish yellow (10Y 8/2) from 680 to 690 ft and pale olive (10Y 6/2) to greenish gray (5GY 6/1) and weakly phosphatic from 690-700 ft.
700-730	30	LIMESTONE AND CLAY – Limestone, 60-70% grayish yellow green (5GY 7/2) to white (N9), unconsolidated to locally moderately indurated, microcrystalline grainstone to packstone. Clay, 30-40% grayish yellow green (5GY 7/2), very soft and plastic. Clay content increases from 720-730 ft.
730-780	50	CLAY – 100% Pale olive (10Y 6/2), soft, plastic, slightly calcareous, very slightly phosphatic, slightly gritty at 770 ft.
780-800	20	CLAY AND LIMESTONE – Clay, 70-80% pale olive (10Y 6/2), soft, plastic, slightly phosphatic. Limestone, 20-30% yellowish gray (5Y 7/2), unconsolidated, gives sample gritty feel, fine to medium sand size grains, subangular to subrounded, limestone content increases with depth.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
800-870	70	CLAY AND PHOSPHATE – Clay, 97% pale olive (10Y 6/2), to light olive gray (5Y 6/1), soft, plastic. Phosphate, 3% black (N1), fine sand size grains, rounded, unconsolidated, in clay matrix; becomes dusky yellow green (5GY 5/2) at 860 ft., with 2-5% yellowish gray (5Y 8/1) limestone fragments.
870-880	10	CLAY AND CHERT – Clay, 95% dusky yellow green (5GY 5/2) to greenish gray (5GY 6/1), soft to semi-firm, slightly phosphatic and calcareous. Chert, 5% brownish black (5YR 2/1), hard, angular.
880-900	20	CLAY AND LIMESTONE – Clay, 60 - 70% dusky yellow green (5GY 5/2) to greenish gray (5GY 6/1), soft to semi firm, somewhat plastic, phosphatic, slightly calcareous, gritty texture. Limestone, 30 - 40%, grayish orange (10YR 7/4) to yellowish gray (5Y 8/1) predominantly shell fragments, sparry calcite, trace brownish black (5YR 2/1) chert.
900-930	30	CLAY, SHELL, AND PHOSPHATE – Clay, 70% yellowish gray (5Y 8/1) to light greenish gray (5GY 8/1) to some light olive gray (5Y 6/1), soft, plastic, somewhat gritty. Shell, 25% white (N9) to yellowish gray (5Y 8/1), predominantly shell fragments. Phosphate, 5% brownish gray (5YR 4/1) to black (N1), medium to coarse sand size grains, subrounded to rounded, phosphate content decreases down hole, shell becomes predominantly foraminifera at 920 ft.
930-940	10	SHELL AND CLAY – Shell, 80% yellowish gray (5Y 8/1) to white (N1), predominantly foraminifera with a few bryozoan and bivalve fragments. Clay, 20% yellowish gray (5Y 8/1) to light gray (N7), soft, plastic. Trace phosphate, brownish black (5YR 2/1).
940-970	30	SHELL, CLAY, AND PHOSPHATE – Shell, 70% yellowish gray (5Y 8/1) to light olive gray (5Y 6/1) to some white (N9), shell fragments. Clay, 20% medium light gray (N6) to yellowish gray (5Y 8/1), semi-firm to firm, gritty. Phosphate, 10% brownish black (5YR 2/1) to dark yellowish brown (10YR 4/2), medium to coarse sand sized grains, subrounded to rounded.
970-980	10	LIMESTONE, SHELL, AND CHERT – Limestone, 93% light pale olive (5Y 7/1) to medium light gray (N6), fine grained wackstone to carbonate mudstone with poorly sorted, fine to medium grained phosphate and quartz grains in matrix. Shell, 5% (in limestone), shell molds and casts also common. Chert, 2% brownish black (5YR 2/1).
980-1010	30	LIMESTONE – 100% white (N9) to light gray (N7), sub-angular to angular, fine to medium grained, loosely consolidated, fossiliferous wackstone/packstone with shell fragments and molds, slightly phosphatic.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
1010-1020	10	LIMESTONE – 100% light gray (N7) to medium light gray (N6), fossiliferous packstone with molds, skeletal fragments, and grayish yellow (5Y 8/4), crystalline calcite filling some voids.
1020-1040	20	LIMESTONE – 100% yellowish gray (5Y 8/1) to pale olive (10Y 6/2) and minor light gray (N7), unconsolidated to loosely compacted, fossiliferous, pelloidal packstone to grainstone with bivalve molds and foraminifera.
1040-1110	70	LIMESTONE – 100% grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6), unconsolidated to poorly cemented, medium to coarse grained, fossiliferous (with forams up to 0.5 inches in diameter), peloidal packstone to grainstone; 5% medium light gray (N6), fossiliferous packstone at 1050 ft., trace of light gray (N7) limestone at 1080 ft and 5% grayish orange (10YR 7/4), hard, micritic mudstone at 1110 ft.
1110-1130	20	LIMESTONE – 100%; 85% grayish orange (10YR 7/4), unconsolidated to poorly cemented, medium to coarse grained, fossiliferous, peloidal packstone to grainstone, 10% yellowish gray (5Y 7/2), moderately hard, weakly vuggy packstone, and 5% grayish orange (10YR 7/4), hard, micritic mudstone.
1130-1140	10	LIMESTONE – 100%; 95% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), dominantly loosely consolidated, fossiliferous (foraminifera), pelloidal packstone and 5% medium light gray (N6), hard, moderately well consolidated packstone.
1140-1160	20	LIMESTONE – 100%; 50% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), dominantly loosely consolidated, fossiliferous (foraminifera), pelloidal packstone and 50% very light gray (N8) to white (N9), moderately hard, well cemented, weakly vuggy, micritic wackestone to packstone, percentage increases with depth.
1160-1180	20	LIMESTONE – 100% very pale orange (10YR 8/2) to white (N9), loosely to moderately consolidated, fossiliferous (foraminifera), pelloidal packstone with trace of white (N9) clay.
1180-1270	90	LIMESTONE – 100% very pale orange (10YR 8/2) to pale yellowish brown (10 YR 6/2), weakly to moderately cemented, medium to coarse grained, fossiliferous (foraminifera), pelloidal packstone to wackestone, with trace of white (N9) to very light gray (N8) limestone at 1200 and 1250 ft, 0.5 inch echinoid at 1220 ft.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
1270-1290	20	LIMESTONE – 100%, 90% Grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), weakly to moderately cemented, medium to coarse grained, fossiliferous (foraminifera), pelloidal packstone to wackestone and 5% Greenish gray (5GY 6/1) to light greenish gray (5GY 8/1), hard, fine to medium grained wackestone and 5% very light gray (N8) to white (N9), hard, carbonate mudstone.
1290-1380	90	LIMESTONE – 100% pale yellowish brown (10YR 6/2) to yellowish gray (5Y 8/1), moderately to poorly cemented, medium to coarse grained packstone with abundant foraminifera and trace of white (N9), hard carbonate mudstone.
1380-1390	10	LIMESTONE – 100% pale yellowish brown (10YR 6/2), soft, poorly cemented, medium grained, fossiliferous packstone.
1390-1400	10	LIMESTONE – 100%; 60% as above, 20% medium gray (N5) to light gray (N7), moderately hard, medium grained to micritic, partly vuggy packstone, 20% white (N9), moderately soft, cryptocrystalline to partly sparry, carbonate mudstone.
1400-1440	40	LIMESTONE – 100%; 60% grayish orange (10YR 8/2), poorly cemented, medium grained fossiliferous packstone/grainstone. 30% white (N9), moderately soft, cryptocrystalline, to partly sparry, carbonate mudstone. 10% medium light gray (N6), moderately hard, microcrystalline, partly vuggy, carbonate mudstone; percentage increases with depth.
1440-1470	30	LIMESTONE – 100%, 50% grayish orange (10YR 8/2), poorly cemented, medium grained fossiliferous packstone/grainstone. 30% white (N9) to very light gray (N8), moderately hard, medium grained to micritic, carbonate mudstone. 20% medium light gray (N6), moderately well cemented, medium grained to micritic wackstone/packstone, becoming more micritic with depth.
1470-1520	50	LIMESTONE – 100% very pale orange (10YR 8/2) to grayish orange (10YR 7/4), poorly cemented, medium to fine grained, fossiliferous packstone/grainstone with a minor amount of dark gray (N3), hard, limestone at 1500 ft.
1520-1540	20	LIMESTONE – 100%; 80% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately well cemented, medium to coarse grained, fossiliferous grainstone/packstone. 20% medium gray (N5), soft, fine-grained, phosphatic carbonate mudstone.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
1540-1610	70	LIMESTONE – 100%; 80% very pale orange (10YR 8/2), moderately well cemented, medium to coarse grained, fossiliferous grainstone/packstone. 20% light gray (N7), hard, micritic, partly vuggy carbonate mudstone.
1610-1620	10	LIMESTONE AND DOLOMITE – Limestone, 60% yellowish gray (5Y 8/1), moderately hard, medium to fine grained packstone/grainstone. 30% light olive gray (5Y 6/1), hard, very fine grained to cryptocrystalline, carbonate mudstone. Dolomite, 10% moderate yellowish brown (10YR 5/4), hard, microcrystalline.
1620-1650	30	LIMESTONE – 100%; 80% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately cemented, coarse to fine grained, fossiliferous grainstone/packstone. 20% light gray (N7), hard micritic carbonate mudstone; percentage decreases with depth.
1650-1680	30	LIMESTONE – 100%; 90% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), poorly cemented, medium grained, slightly dolomitic, grainstone/packstone. 10% medium dark gray (N4), hard, medium grained wackstone/packstone. Trace of chert.
1680-1690	10	See core #1 description.
1690-1700	10	LIMESTONE – 100%; 90% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, medium grained, fossiliferous grainstone. 10% medium gray (N5) to light gray (N7), microcrystalline to cryptocrystalline, slightly dolomitic carbonate mudstone.
1700-1710	10	LIMESTONE – 100%; 90% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, medium grained, fossiliferous grainstone. 10% medium gray (N5), moderately hard wackestone. Trace of dolomite.
1710-1740	30	LIMESTONE – 100%; 60% very pale orange (10YR 8/2), moderately hard, medium grained, fossiliferous grainstone. 30% yellowish gray (5Y 8/1), hard, very fine grained, carbonate mudstone, percentage decreases with depth. 10% medium gray (N5), moderately hard wackestone, percentage decreases with depth. Trace of very pale orange (10YR 8/2), laminated limestone and dolomite at 1740 ft.
1740-1745	5	LIMESTONE AND DOLOMITE – Limestone, 50%, very pale orange (10YR 8/2), moderately hard, medium grained, fossiliferous grainstone. 20% yellowish gray (5Y 8/1), hard, very fine grained, carbonate mudstone. 10% medium gray (N5), moderately hard wackestone. Dolomite, 10% dark yellowish brown (10YR 4/2), hard, medium grained to microcrystalline.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
1745-1755	10	See core #2 description.
1755-1790	35	LIMESTONE – 100%; 90% very pale orange (10YR 8/2) to yellowish gray (5Y 7/2), moderately to poorly consolidated, medium to coarse grained, fossiliferous packstone. 10% medium gray (N5) to light gray (N7), moderately hard wackestone, percentage increases with depth.
1790-1800	10	DOLOMITE AND LIMESTONE – Dolomite, 50% moderate yellowish brown (10YR 5/4), hard, weakly vuggy, sucrosic, microcrystalline. Limestone 50%; 40% very pale orange (10YR 8/2) to yellowish gray (5Y 7/2), moderately to poorly consolidated, medium to coarse grained, fossiliferous packstone. 10% medium gray (N5) to light gray (N7), moderately hard wackestone.
1800-1810	10	See core #3 description.
1810-1820	10	LIMESTONE – 100% very pale orange (10YR 8/2), moderately hard, medium grained wackestone to packstone with trace of dolomite.
1820-1850	30	LIMESTONE – 100%; 60% very pale orange (10YR 8/2), moderately hard, medium grained wackestone to packstone. 20% yellowish gray (5Y 8/1), medium grained packstone. 20% medium light gray (N6), vuggy, carbonate mudstone, some vugs filled with calcite.
1850-1860	10	See core #4 description.
1860-1880	20	LIMESTONE – 100%; 80% very pale orange (10YR 8/2), poorly consolidated, medium to coarse grained, pelloidal packstone with foraminifera. 20% white (N9) to very light gray (N8), medium to fine grained, micritic, slightly chalky wackestone.
1880-1900	20	LIMESTONE AND DOLOMITE – Limestone, 85% yellowish gray (5Y 7/2) to grayish orange (10YR 7/4), medium to coarse grained, pelloidal packstone with foraminifera. 10% white (N9) medium to fine grained, micritic, slightly chalky wackestone. Dolomite, 5% medium gray (N5) to medium dark gray (N4), moderately hard, fine to medium grained, crystalline.
1900-1920	20	LIMESTONE – 100%; 60% very pale orange (10YR 8/2), poorly cemented, partly micritic, medium to fine grained, fossiliferous wackestone to packstone. 40% medium gray (N5), hard, phosphatic, microcrystalline to cryptocrystalline, carbonate mudstone with trace of dolomitic limestone, percentage decreases with depth. Trace of coarse grained, clear calcite crystals at 1920 ft.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
1920-1950	30	LIMESTONE AND DOLOMITE – Limestone, 60% very pale orange (10YR 8/2), medium to fine grained, moderately well cemented, fossiliferous packstone to grainstone, with minor amount of medium gray (N5), hard, phosphatic, microcrystalline to cryptocrystalline, carbonate mudstone and light gray (N7), very soft carbonate mudstone. Dolomite, 40% moderate yellowish brown (10YR 5/4), hard, partly sucrosic, cryptocrystalline.
1950-1960		See Core #5 description.
1960-1970	10	DOLOMITE AND LIMESTONE – Dolomite, 40-60% pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), hard, vuggy, cryptocrystalline to medium grained crystalline with fine to medium grained, euhedral crystalline lined cavities; minor amount of medium gray (N5) to dark gray (N3), as above. Limestone, 40-60% white (N9) to very pale orange (10YR 8/2), moderately hard, cryptocrystalline, carbonate mudstone to wackestone with very fine to medium grained dolomite crystal inclusions disseminated throughout.
1970-2000	30	DOLOMITE – 100% light brown (5 YR 5/6), moderate yellowish brown (5YR 5/4), moderate brown (5YR 4/4), dark yellowish brown (10YR 4/2), and grayish brown (5YR 3/2), very hard, weakly vuggy, cryptocrystalline to very fine grained crystalline.
2000-2070	70	DOLOMITE – 100% light brown (5 YR 5/6), moderate yellowish brown (5YR 5/4), moderate brown (5YR 4/4), dark yellowish brown (10YR 4/2), and grayish brown (5YR 3/2), hard, microcrystalline to medium grained crystalline, partly sucrosic, with abundant medium grained, unconsolidated, orthorhombic crystals from 2010 to 2020 ft.
2070-2110	40	DOLOMITE – 100% light brown (5 YR 5/6), moderate yellowish brown (5YR 5/4), moderate brown (5YR 4/4), dark yellowish brown (10YR 4/2), and grayish brown (5YR 3/2) with some grayish orange (10YR 7/4) and very pale orange (10YR 8/2), very hard, dominantly microcrystalline to cryptocrystalline, locally vuggy with angular, well-healed breccia from 2070 to 2090 ft.
2110-2130	20	DOLOMITE – 100% pale yellowish brown (10YR 6/2) and grayish orange (10YR 7/4) to very pale orange (10YR 8/2), hard, dominantly microcrystalline to cryptocrystalline, locally very vuggy with vugs up to several millimeters in diameter, with minor angular, well healed breccia (<10%), becomes dominantly very pale orange (10YR 8/2) from 2120 to 2130 ft.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
2130-2132	2	DOLOMITE – 100% grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4), very hard, very well indurated, cryptocrystalline.
2132-2490	358	LIMESTONE – 100% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, very fine to medium grained, saccaroidal-pelloidal grainstone and minor wackestone; locally fossiliferous from 2180 to 2200 ft, light gray (N7) to very light gray (N8) from 2175 to 2200 ft, very coarse grained fossil casts and molds from 2230 ft down. Dolomite, trace to locally minor constituent, pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), with less very pale orange (10YR 8/2) to grayish orange (10YR 7/4), very hard, well indurated, microcrystalline to cryptocrystalline, angular. Trace of breccia at 2420 ft and 5-10% breccia at 2450 ft.
2490-2500	10	LIMESTONE AND DOLOMITE – Limestone, 60-70% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, very fine to medium grained, fossiliferous, saccaroidal grainstone, local dolomitic transition into dolomite. Dolomite, 30-40% grayish black (N2) to black (N1), and moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2), very hard, fine grained to microcrystaline, angular, with minor angular, matrix supported dolomite breccia.
2500-2520	20	LIMESTONE AND DOLOMITE - Limestone, 10-15% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, very fine to medium grained, fossiliferous, saccaroidal grainstone, local dolomitic transition into dolomite. Dolomite, 85-90% grayish orange (10YR 7/4) to dark yellowish brown (10YR 4/2), very hard and well indurated, fossiliferous (bioclast with dolomite matrix), fine grained to microcrystalline and angular with euhedral dolomite crystals up to 5 mm across lining cavities; incomplete dolomitization of limestone also present.
2520-2530	10	DOLOMITE AND LIMESTONE - Dolomite, 50% grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4); very hard and well indurated, fossiliferous (bioclast with dolomite matrix), fine grained to microcrystalline and angular with euhedral dolomite crystals up to ½ cm across lining cavities. Limestone, 50% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, very fine to medium grained, fossiliferous, pelloidal grainstone with minor carbonate mudstone and locally dolomitized.
2530-2550	20	LIMESTONE – 100% Very pale orange (10YR 8/2), moderately to poorly consolidated, pelloidal/saccaroidal, fine to medium grained packstone/grainstone with rare crystalline calcite.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
2550-2570	20	LIMESTONE AND LIMEY DOLOMITE – Limestone, 80% very pale orange (10YR 8/2), moderately to poorly consolidated, pelloidal, fine to medium grained packstone/grainstone. Limy Dolomite, 20% grayish orange (10YR 7/4), hard, well cemented dolomite grains/crystals in a limestone matrix.
2570-2600	30	DOLOMITE AND DOLOMITIC LIMESTONE – Dolomite, 70-90% yellowish brown (10YR 5/4), moderately hard, medium grained, partly limey, crystalline and dark yellowish brown (10YR 4/2), hard, few vugs, fine to medium grained, crystalline. Dolomitic Limestone, 10-30% grayish orange (10YR 7/4), moderately indurated, fine grained wackstone/packstone with abundant fine to medium grained dolomite crystals, percentage decreasing with depth.
2600-2680	80	DOLOMITE, 100% Moderate yellowish brown (10YR 5/4), moderately hard to very hard, well indurated, dominantly very fine to fine grained and angular, crystalline, less abundant micro to cryptocrystalline; rare mm-size vugs/cavities. Limestone, trace to minor constituent, mostly very pale orange (10YR 8/2), moderately hard, very fine to medium grained, saccaroidal grainstone, locally fossiliferous.
2680-2690	10	DOLOMITE AND LIMESTONE - Dolomite, 70-80% moderate yellowish brown (10YR 5/4), hard and well-indurated, fine grained to microcrystalline. Limestone, 20-30% very pale orange (10YR 8/2) to olive gray (5Y 4/1), moderately hard, very fine to fine grained carbonate mudstone/wackstone, partly glauconitic.
2690-2730	40	LIMESTONE, 100% Grayish orange (10YR 7/4), hard, well cemented, fine to medium grained packstone/grainstone and greenish gray (5GY 6/1) to yellowish gray (5y 8/1), hard, fine grained carbonate mudstone with trace, medium to coarse grained, well cemented breccia and rare grayish orange (10YR 7/4), dolomitic limestone below 2710 ft.
2730-2740	10	LIMESTONE AND DOLOMITE – Limestone, 90% mainly very pale orange (10YR 8/2), moderately hard and well indurated, very fine to medium grained, pelloidal/saccaroidal packstone/grainstone, locally dolomitic and greenish gray (5GY 6/1), hard, partly vuggy, fine grained carbonate mudstone, increasing with depth. Dolomite, 10% dark yellowish brown (10YR 4/2); very hard and well-indurated, medium grained to cryptocrystalline.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
2740-2750	10	DOLOMITIC LIMESTONE BRECCIA AND LIMESTONE – Dolomitic limestone breccia, 50% light brownish gray (5YR 6/1) and medium gray (N6) to dark gray (N3), hard, dominantly matrix-supported, cryptocrystalline with medium light gray (N6) to yellowish gray (5Y 8/1), moderately hard, irregularly-shaped, very fine to microcrystalline limestone breccia fragments. Limestone, 50% dominantly very pale orange (10YR 8/2), moderately indurated, very fine to medium grained, pelloidal grainstone.
2750-2770	20	LIMESTONE, 100% Very pale orange (10YR 8/2) to yellowish gray (5YR 8/1), moderately hard, medium grained to microcrystalline, pelloidal/saccaroidal packstone to grainstone (~80% at 2750 to 2760 ft and ~95% at 2760 to 2770 ft) and light gray (N7) to dark gray (N3), moderately soft and weakly indurated, very fine to medium grained grainstone (~20% at 2750 to 2760 ft and ~5% at 2760 to 2770 ft).
2770-2950	180	LIMESTONE, 100% Yellowish gray (5Y 7/2) to very pale orange (10YR 8/2), moderately well indurated, weakly fossiliferous (5 mm diameter bivalve at 2830 ft), fine to coarse-grained pelloidal wackstone to packstone; trace of dolomite.
2950-3000	50	LIMESTONE AND DOLOMITE – Limestone, 50% very pale orange (10YR 8/2), moderately well indurated, weakly fossiliferous, fine to coarse-grained pelloidal/saccaroidal wackstone to packstone. Dolomite, 50% pale yellowish brown (10YR 6/2), very hard, microcrystalline to cryptocrystalline; microcrystalline dolomite is subhedral and sucrosic, becomes light olive gray (5Y 6/1) between 2980 to 2990 ft, less abundant from 2990 to 3000 ft.
3000-3010	10	DOLOMITE AND LIMESTONE – Dolomite 60-70% pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), hard, well indurated, very fine to medium grain and microcrystalline. Limestone, 30-40% white (N9) to very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard and fairly well indurated, microcrystalline to fine grained, pelloidal packstone to grainstone, locally with healed fractures of dolomite.
3010-3020	10	DOLOMITE AND LIMESTONE – Dolomite, 90% very pale orange (10YR 8/2) to pale yellowish brown (10YR 6/2), hard, well-indurated, microcrystalline to cryptocrystalline. Limestone, 10% dominantly white (N9), moderately hard and fairly well indurated, microcrystalline to fine grained, pelloidal/saccaroidal packstone to grainstone.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
3020-3030	10	DOLOMITE – 100% very pale orange (10YR 8/2) to grayish orange (10YR 7/4), very hard, well indurated, microcrystalline to locally coarse grained, angular, crystalline; rare medium gray (N5), hard, very fine grained to microcrystalline.
3030-3050	20	DOLOMITE – 100% pale yellowish orange (10YR 6/2) to grayish orange (10YR 7/4) with some very light gray (N8), very hard, well indurated, microcrystalline to cryptocrystalline and angular. Mostly moderate yellowish brown (10YR 5/4) with trace of medium gray (N5), partly vuggy, fine grained to microcrystalline dolomite and breccia from 3050 to 3060 ft.
3060-3070	10	DOLOMITE – 100%, 50-60% moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2), 30-40% dusky yellowish brown (10YR 2/2) to grayish black (N2), and 10% very pale orange (10YR 7/4) ~10%, very hard, well indurated, generally microcrystalline to cryptocrystalline with very fine to medium grained euhedral dolomite crystals lining open vugs up to 2cm across; trace of breccia.
3070-3080	10	DOLOMITE – 100% pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), very hard, well indurated, microcrystalline to cryptocrystalline.
3080-3090	10	DOLOMITE – 100% pale yellowish brown (10YR 6/2) 50% and light olive gray (5Y 6/1) 50%, very hard, well indurated, microcrystalline to cryptocrystalline and angular.
3090-3100	10	DOLOMITE – 100% grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4), very hard, well indurated, microcrystalline to cryptocrystalline (similar to previous 20 ft) with minor matrix-supported breccia hosting angular, very pale orange (10YR 8/2) breccia fragments.
3100-3110	10	DOLOMITE AND DOLOMITE BRECCIA – Dolomite, 65-85% yellowish gray (5Y 8/1) to white (N9) to very pale orange (10YR 8/2), and grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4), hard, well indurated, microcrystalline to cryptocrystalline, weakly fossiliferous with dolomitized shell fragments in dolomite and breccia fragments. Dolomite breccia, 15-35% variably colored as above with lighter colored, angular fragments in a darker colored matrix, (matrix > clast supported), fragments exhibit fracturing and healing with multiple phases of brecciation.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
3110-3230	120	DOLOMITE – 100% yellowish gray (5Y 8/1) to grayish orange (10YR 7/4) with occasional light gray (N7) and moderate yellowish brown (10YR 5/4), very hard, well indurated, angular, microcrystalline to cryptocrystalline, locally sucrosic, (some dolomite breccia present, mostly light colored).
3230-3250	20	DOLOMITE – 100%, 50% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), hard, angular, microcrystalline to cryptocrystalline, 40% medium gray (N5) to light gray (N7), hard, angular, cryptocrystalline, 5% dark yellowish brown (10YR 4/2), hard, angular, crystalline to microcrystalline, euhedral crystals, some dolomite breccia containing the above lithologies and colors, well healed, 5% very light gray (N8), brittle, fine grained, calcareous.
3250-3330	80	DOLOMITE – 100% yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), hard, sucrosic, microcrystalline to cryptocrystalline. Trace of light gray (N4), brittle, moderately soft, medium to fine grained limy dolomite.
3330-3340	10	DOLOMITE – 100%; mostly pale yellowish brown (10YR 6/2), hard, finely crystalline to cryptocrystalline with rare to moderate amount of fine grained, crystalline lined cavities and some dark yellowish brown (10YR 4/2), hard, microcrystalline to cryptocrystalline.
3340-3350	10	DOLOMITE – >95% dark yellowish gray (10YR 4/2) hard, cryptocrystaline and pale yellowish brown (10YR 6/2), hard, finely crystalline to cryptocrystalline. Dolomite breccia, <5% hard, finely crystalline to cryptocrystalline with light colored, angular to subangular, matrix supported fragments.
3350-3360	10	DOLOMITE – 100% medium gray (N5) to medium light gray (N6) and moderate yellowish brown (10YR 4/2) to dark yellowish brown (10YR 4/2), hard, sucrosic, microcrystalline to cryptocrystalline.
3360-3380	20	DOLOMITE – 100% mostly dark yellowish brown (10YR 4/2), hard, finely crystalline to cryptocrystalline with pale yellowish brown (10YR 6/2), hard, finely crystalline to cryptocrystalline with a few fine grained, crystalline lined cavities.
3380-3410	30	DOLOMITE – 100% dark yellowish brown (10YR 4/2), hard, partly vuggy, finely crystalline to cryptocrystalline.
3410-3430	20	DOLOMITE – 100% mostly pale yellowish brown (10YR 6/2), hard, microcrystalline to cryptocrystalline and moderate yellowish brown (10YR 5/4), hard, vuggy, finely crystalline with trace to 20% olive black (5Y 2/1), hard, finely crystalline, percentage increases with depth.

Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW5
3430-3440	10	DOLOMITE – 100% mostly pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR5/4), hard, finely crystalline to microcrystalline and dark moderate yellowish brown (10YR 5/4), hard, finely crystalline with some medium dark gray (N3) to olive black (5Y 2/1), hard, finely crystalline.
3440-3450	10	DOLOMITE – 100% dominantly olive gray (5Y 4/1) and medium dark gray (N4) to grayish black (N2), hard, very fine grained to microcrystalline with trace of moderate olive brown (5Y 4/4), hard, very fine grained to microcrystalline.
3450-3460	10	DOLOMITE – 100%; 60% olive gray (5Y 4/1), hard, well indurated, fine grained to microcrystalline and 40% olive black (5Y 2/1) to dark gray (N3), hard, fine grained to microcrystalline.
3460-3470	10	DOLOMITE – 100%; 75-85% grayish orange (10YR 7/4) to yellowish gray (5Y 8/1) and 15-25% olive black (5Y 2/1) to dark gray (N3), hard, well indurated, very fine grained to dominantly microcrystalline.
3470-3480	10	DOLOMITE – 100%; 90-95% pale yellowish brown (10YR 6/2) to light olive gray (5Y 6/1) and 5-10% olive black (5Y 2/1) to dark gray (N3), hard, well indurated, very fine grained to dominantly microcrystalline to cryptocrystalline.
3480-3500	20	DOLOMITE – 100% dominantly dark yellowish brown (10YR 4/2) and rarely pale yellowish brown (10YR 6/2) to olive gray (5Y 4/1), hard, very well indurated, micro- to cryptocrystalline, with trace of grayish black (N2), vuggy, finely crystalline.
3500-3505 TD	5	DOLOMITE – 100%; 60-70% various shades of yellowish brown (10YR 6/2) to olive gray (5Y 4/1) and 30-40% olive black (5Y 2/1) to grayish black (N2), hard, well indurated, very fine grained to microcrystalline.

Appendix E - Geologic Log
Injection Well IW6

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
0-10	10	SAND, SHELL AND ORGANICS - Sand, 90% colorless quartz, medium grained, subangular, well sorted. Shell, 5%. Organics, 5% dusky yellowish brown (10YR 2/2) to black (N1), fibrous.
10-20	10	SAND AND SHELL - Sand, 90% colorless quartz, fine to coarse grained, angular, poorly sorted. Shell, 10% trace organics.
20-60	40	SAND AND SHELL - Sand, 95% colorless quartz, fine to coarse grained, well sorted, subangular. Shell, 5%.
60-75	15	SAND, LIMESTONE, AND PHOSPHORITE - Sand, 90% clear quartz, subangular, well sorted. Limestone, 5% light tan, well cemented, fine grained. Phosphorite, 5%.
75-90	15	LIMESTONE AND SAND - Limestone, 80% light gray (N7) to medium light gray (N6), fine grained, Phosphatic. Sand, 20% colorless quartz, coarse grained, subangular, trace shell.
90-110	20	SANDY LIMESTONE - Limestone, 90% light gray (N7) to medium light gray (N6), phosphatic, fine to medium grained, poorly to well cemented, phosphatic. Sand, 10% colorless quartz, medium grained, subangular.
110-150	40	SANDY LIMESTONE - Limestone, 100% light gray (N7) to medium light gray (N6), phosphatic, fine to medium grained, moderately to well cemented, trace shell.
150-170	20	LIMESTONE - 100% light gray (N7), phosphatic, fine-grained, well cemented, trace shell.
170-200	30	LIMESTONE - Limestone, 50% yellowish gray (5Y 8/1), medium grained. micritic, angular, phosphatic, hard some sparry calcite, Limestone, 50% medium gray (N5), mudstone micrite, firm to occasionally friable.
200-210	10	LIMESTONE - 100% yellowish gray (5Y 8/1) to light gray (N7), medium to fine grained, angular, hard, phosphatic; silt sized phosphate grains, trace shell fragments.
210-220	10	LIMESTONE - 100% yellowish gray (5Y 8/1) to medium light gray (N6), medium grained, angular, slightly phosphatic, trace shell fragments.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
220-230	10	LIMESTONE - 100% yellowish gray (5Y 8/1) to very light gray (N8), angular, hard, trace phosphate, trace shell.
230-240	10	LIMESTONE - 100% yellowish gray (5Y 8/1) to medium light gray (N6), medium grained, angular, phosphatic, trace colorless calcite.
240-250	10	LIMESTONE AND SHELL - Limestone, 95% yellowish gray (5Y 8/1) to medium light gray (N6), medium grained, angular, phosphatic. Shell, 5% moderate orange pink (5YR 8/4), trace colorless calcite.
250-260	10	LIMESTONE - 100% light olive gray (5Y 6/1) to medium gray (N5), medium to coarse grained, angular, phosphatic, trace shell and colorless calcite.
260-270	10	LIMESTONE AND SHELL - Limestone, 95% medium gray (N5) to yellowish gray (5Y 8/1), medium to coarse grained, angular, phosphatic. Shell, 5% trace colorless calcite.
270-280	10	LIMESTONE AND SHELL - Limestone, 60% yellowish gray (5Y 8/1) to medium gray (N5), medium grained, angular, phosphatic. Shell, 40% yellowish gray (5Y 8/1) to colorless.
280-290	10	LIMESTONE AND SHELL - Limestone, 60% yellowish gray (5Y 8/1), medium to coarse grained, angular. Limestone, 20% medium gray (N5), medium grained, angular, phosphatic. Shell, 20% yellowish gray (5Y 8/1) to colorless. Trace sand sized phosphate grains.
290-320	30	LIMESTONE - 100% pale olive (10Y 6/2) to very light olive gray (5Y 5/1), mostly very fine grained, some coarse fragments, angular, slightly sparry with calcite, slightly phosphatic and argillaceous, sparse shell fragments, white (N9) to colorless.
320-340	20	LIMESTONE AND SHELL - 95% pale olive (10Y 6/2) to very light olive gray (5Y 5/1), mostly very fine grained, some coarse fragments, slightly sparry with calcite, angular, slightly phosphatic and argillaceous. Shell Fragments, 5% white (N9) to colorless.
340-350	10	LIMESTONE AND SHELL - Limestorne, 90% pale olive (10Y 6/2) to very light olive gray (5Y 5/1), mostly very fine grained, some coarse fragments, slightly sparry with calcite, angular, slightly phosphatic and argillaceous. Shell Fragments, 10% white (N9) to colorless, branch coral, tests, etc.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
350-380	30	LIMESTONE AND SHELL - 95% pale olive (10Y 6/2) to very light olive gray (5Y 5/1), mostly very fine grained, some coarse fragments, angular, slightly sparry with calcite, slightly phosphatic and argillaceous. Shell 5% light olive gray (5Y 6/1) to colorless mostly tests.
380-400	20	LIMESTONE, SILTY SAND AND SHELL – Limestone 85% pale olive (10Y 6/2) to very light olive gray (5Y 5/1)), mostly very fine grained, some coarse fragments, angular, slightly sparry with calcite, slightly phosphatic and argillaceous. Silty Sand, 10% very fine to fine grained. Shell Fragments, 5% light olive gray (5Y 6/1) to white (N9), mostly tests.
400-410	10	CLAYEY LIMESTONE, CLAY AND SHELL - Clayey Limestone, 75% light olive gray (5Y 6/1) to grayish olive (10Y 4/2), very fine grained, slightly sparry with angular calcite, slightly phosphatic, Clay, 20% light grayish olive (10Y 5/2), silty. Shell Fragments, 5% white (N9) to light olive gray (5Y 6/1), some coarse fragments up to 12 mm, mostly tests.
410-420	10	LIMESTONE, CLAY AND SHELL- Limestone, 60% light olive gray (5Y 6/1) to light grayish olive (10Y 5/2), very fine grained, slightly sparry with angular calcite, slightly phosphatic. Clay, 35% light grayish olive (10Y 5/2), silty. Shell Fragments, 5% light olive gray (5Y 6/1) to white, (N9) some coarse fragments, mostly tests.
420-430	10	LIMESTONE, SHELL AND SAND - Limestone, 90% very light gray (N8) to light grayish olive (10Y 5/2), medium to coarse grained, angular, slightly sparry with calcite, slightly phosphatic and siliceous. Shell Fragments, 5% light olive gray (5Y 6/1) to off white, mostly tests. Sand, 5% light gray (N7) to colorless, medium grained, subangular.
430-440	10	CLAYEY LIMESTONE, CLAY AND SHELL – Limestone, 75% very light gray (N8) to light olive gray (5Y 6/1), very fine grained, poorly consolidated in clay matrix, slightly sparry with angular calcite, slightly phosphatic. Clay, 20% light grayish olive (10Y 5/2), silty, slightly phosphatic. Shell Fragments, 5% light olive gray (5Y 6/1) to white (N9) tests.
440-450	10	LIMESTONE AND CLAY - Limestone, 60% very light gray (N8) to grayish olive (10Y 4/2), very fine grained, slightly sparry with angular calcite, slightly phosphatic. Clay, 40% grayish olive (10Y 4/2), silty. Trace shell tests, white (N9) to light olive gray (5Y 6/1).

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
450-570	120	CLAY - 100% grayish olive (10Y 4/2), soft, plastic, slightly phosphatic.
570-720	150	CLAY - 100% yellowish gray (5Y 8/1) to pale olive (10Y 6/2), soft, plastic
720-730	10	LIMESTONE AND CLAY - Limestone, 50% very light gray (N8), friable. Clay, 50% yellowish gray (5Y 8/1), soft, plastic. Interbedded
730-740	10	CLAY - 100% pale olive (10Y 6/2), plastic, soft
740-810	70	CLAY - 100% pale olive (10Y 6/2), soft to moderately firm, plastic.
810-850	40	Clay, 100% light pale olive (5Y 7/1), soft, plastic.
850-860	10	CLAY AND SAND - Clay, 80% light pale olive (5Y 7/1), soft, plastic. Sand, 20% medium gray (N5) to light brownish gray (5YR 6/1), very fine to fine grained, slightly phosphatic, trace brownish black (5YR 2/1) chert.
860-870	10	CLAY AND SAND - Clay, 95% yellowish gray (5Y 8/1) to light pale olive (5Y 7/1), soft, plastic. Sand 5% medium gray (N5) to light brownish gray (5YR 6/1), very fine to fine grained, slightly phosphatic, trace brownish black (5YR 2/1) chert.
870-890	20	CLAY - 100% yellowish olive (10Y 5/2), soft and plastic, trace sand and chert as above.
890-900	10	CLAY AND SHELLY LIMESTONE - Clay, 70% moderate olive brown (5Y 4/4), moderately firm to firm, plastic. Limestone, 30% yellowish gray (5Y 8/1) to very light gray (N8) mostly shell, brittle.
900-910	10	CLAY AND LIMESTONE - Clay, 50% light olive gray (5Y 6/1), soft to semi firm, plastic. Limestone, 50% light olive gray (5Y 6/1), medium to coarse grained, hard, phosphatic, fossiliferous.
910-920	10	LIMESTONE AND CLAY - Limestone, 75% light olive gray (5Y 6/1), medium to coarse grained, hard, phosphatic, fossiliferous. Clay, 25% pale olive (10Y 6/2), plastic, soft. Trace chert.
920-930	10	LIMESTONE AND CLAY - Limestone, 85% light gray (N7) to pale olive (10Y 6/2), coarse grained, hard to poorly consolidated, phosphatic, fossiliferous, foraminiferal. Clay, 15% grayish olive (10Y 4/2) to olive gray (5Y 4/1), very firm, micritic. Trace chert.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
930-940	10	LIMESTONE AND CLAY - Limestone, 90% yellowish gray (5Y 8/1) to light gray (N7), hard, shelly, foraminiferal. Clay, 10% pale olive (10Y 6/2), plastic, soft to firm.
940-950	10	LIMESTONE AND CLAY - Limestone, 85% light olive gray (5Y 6/1) to light gray (N7), medium to coarse grained, hard, grainstone, fossiliferous, foraminiferal. Clay, 15% grayish olive (10Y 4/2), very firm to brittle.
950-960	10	SANDY LIMESTONE AND SHELL - Sandy Limestone, 95% light olive gray (5Y 6/1) to light greenish gray (5GY 8/1), very fine grained, moderately to poorly sorted, with fine to very coarse grained quartz and phosphorite sand particles throughout, micritic. Shell fragments, 5% light olive gray (5Y 6/1) to light pale grayish orange (10YR 6/2), up to 1 cm across, mostly tests. Trace brownish black (5YR 2/1) Chert
960-970	10	SANDY LIMESTONE, CLAY AND SHELL - Sandy limestone, 90% light olive gray (5Y 6/1) to light greenish gray (5GY 8/1), very fine grained, moderate to poorly sorted, with fine to coarse grained quartz and phosphorite sand particles, variably rounded, in micritic matrix. Clay, 8% light grayish olive (10Y 5/2), up to 0.2" thick. Shell Fragments, ~2% yellowish gray (5Y 8/1) to light pale grayish orange (10YR 6/2), up to 0.5" across, mostly tests with some molds and casts, trace brownish black (5YR 2/1) Chert.
970-980	10	SANDY LIMESTONE, SHELL AND CHERT - Sandy limestone, 95% light pale olive (5Y 7/1) to medium light gray (N6), very fine grained, moderate to poorly sorted, with fine to medium grained quartz and phosphorite sand particles in micritic matrix. Abundant molds and casts. Shell, 3%. Chert, 2% brownish black (5YR 2/1).
980-1000	20	LIMESTONE - 100% very light gray (N8) to light gray (N7), fine grained, with minor interbedded sandy limestone (as above), fossiliferous with mostly shell molds and casts, less common shell tests, micritic.
1000-1010	10	LIMESTONE - 70% light gray (N7), sandy, poorly cemented. 30% medium gray (N5), fine grained, moderately hard, phosphatic.
1010-1030	20	LIMESTONE - 100% light gray (N7), moderately hard, micrite, sparry in part.
1030-1050	20	LIMESTONE - 100% medium gray (N5), fine grained, moderately hard.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
1050-1110	60	LIMESTONE - 100% yellowish gray (5Y 8/1), fine to medium grained, soft, fossiliferous, sparry.
1110-1120	10	LIMESTONE - 100% pale yellowish brown (10YR 6/2), very fine grained, hard, micritic, occasional voids.
1120-1150	30	LIMESTONE – 100% pale yellowish brown (10YR 6/2), medium grained, medium hard, fossiliferous
1150-1160	10	LIMESTONE - 100%; 70% pale yellowish brown (10YR 6/2), medium grained, medium hard, fossiliferous. Limestone, 30% yellowish gray (5Y 8/1), medium grained tests and casts, medium hard, sparry.
1160-1170	10	LIMESTONE - 100%; 90% light yellowish gray (5Y 8/1), fine grained, hard, micritic, 10% pale yellowish brown (10YR 6/2), medium grained, medium hard, fossiliferous, and sparry.
1170-1190	20	LIMESTONE - 100%; 70% light yellowish gray (5Y 8/1), fine grained, hard. 30% pale yellowish brown (10YR 6/2), medium grained, hard, fossiliferous.
1190-1210	20	LIMESTONE - 100%; 70% pale yellowish brown (10YR 6/2), medium grained, moderately hard, fossiliferous, 30% light yellowish gray (5R 8/1), fine grained, hard. Trace Dolomitic Limestone.
1210-1280	70	LIMESTONE - 100%; 90% pale yellowish brown (10YR 6/2), fine grained, medium hard to hard, micritic, 10% light yellowish gray (5R 8/1), fine grained, soft.
1280-1300	20	LIMESTONE - 100% pale yellowish brown (10YR 6/2), medium to fine grained, moderately hard to hard micritic.
1300-1330	30	LIMESTONE - 100% pale yellowish brown (10YR 6/2), fine to medium grained, moderately hard, fossiliferous in parts.
1330-1350	20	LIMESTONE - 100% pale yellowish brown (10YR 6/2), fine to medium grained, poorly cemented, fossiliferous, Trace Dolomitic Limestone.
1350-1360	10	LIMESTONE - 100%; 80% very pale orange (10YR 8/2), medium grained, moderately hard, micritic, 20% pale yellowish brown (10YR 6/2), fine to medium grained, poorly cemented, fossiliferous, Trace dolomite.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
1360-1390	30	LIMESTONE - 100%; 70% pale yellowish brown (10YR 6/2), medium grained, poorly cemented, fossiliferous. 30% very pale orange (10YR 8/2), medium grained, moderately hard, micritic.
1390-1420	30	LIMESTONE - 100%; 60% grayish orange (10YR 7/4), medium to coarse grained, poorly cemented, fossiliferous. 25% very pale orange (10YR 8/2), medium grained, moderately hard to hard, micritic. 15% yellowish gray (5Y 8/1) to medium gray (N5), medium grained, hard, slightly phosphatic.
1420-1470	50	LIMESTONE - 100%; 55% white (N9) to very light gray (N8), fine grained, micritic, moderately hard. 35% grayish orange (10YR 7/4), medium to coarse grained, poorly consolidated, fossiliferous. 10% medium light gray (N6), sucrosic, micritic, slightly vuggy.
1470-1530	60	LIMESTONE - 100%; 75% grayish orange (10YR 7/4), fine to coarse grained, poorly consolidated to some well cemented, fossiliferous, grainstone. 15% medium light gray (N6) to light gray (N7), hard, micritic. 10% white (N9), fine grained, hard, micritic.
1530-1600	70	LIMESTONE – 100%; 50% yellowish gray (5Y 8/1) to white (N9), fine to very fine grained, well cemented, hard, fossiliferous, micritic. 50% very pale orange (10YR 8/2) to grayish orange (10YR 7/4), medium to coarse grained, moderately to poorly cemented, fossiliferous. Trace, medium light gray (N6), hard, micritic mudstone.
1600-1620	20	LIMESTONE - 100%; 70% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), medium to coarse grained, moderately well cemented, fossiliferous, (forams). 20% medium light gray (N6), fine to very fine grained, hard, micritic. 10% grayish orange (10YR 7/4), well cemented, very hard, micritic mudstone.
1620–1660	40	LIMESTONE - 100%; 80% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), medium to coarse grained very poorly consolidated, foraminifera. 10% medium light gray (N6), hard, micritic. 10% very light gray (N8) to light gray (N7), fine grained, very hard micritic mudstone.
1660-1670	10	LIMESTONE - 100% grayish orange (10YR 7/4), medium to coarse grained, unconsolidated, foraminifera. Trace limestone, medium gray (N5).

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
1670-1680	10	LIMESTONE - 100%; 60% yellowish gray (5Y 8/1) to grayish orange (10YR 7/4), medium to coarse grained, moderately consolidated, fossiliferous, 40% yellowish gray (5Y 8/1), angular, well cemented, hard, micritic mudstone.
1680-1710	30	LIMESTONE - 100%; 70% pale yellowish brown (10YR 6/2), medium to fine grained, poorly cemented. 20% light gray (N7), fine grained, soft, micritic, 10% dark gray (N2), medium grained, hard.
1710-1750	40	LIMESTONE - 100%; 80% pale yellowish brown (10YR 6/2). 20% light gray (N7) to very light gray (N8), medium to fine grained, micritic, dolomitic in part. Trace dolomite.
1750-1760	10	LIMESTONE AND DOLOMITE – Limestone 95% pale yellowish brown (10YR 6/2) to light gray (N7), medium to fine grained, micritic, dolomitic in parts. Dolomite, 5% dusky brown (5YR 2/2), fine grained, well cemented, hard.
1760-1770	10	LIMESTONE - 100%; 50% grayish orange (10YR 7/4), fine to medium grained, poorly cemented. 50% very pale orange (10YR 8/2), fine grained, moderately hard, micritic, trace dolomite.
1770-1786	16	LIMESTONE – 100%; 40% grayish orange (10YR 7/4), fine grained, poorly cemented. 40% very pale orange (10YR 8/2), fine grained, moderately hard, micritic. 20% medium dark gray, very fine grained, hard, micritic.
1786-1836	50	Cores taken, see core descriptions.
1836-1840	4	LIMESTONE AND DOLOMITE - Limestone, 60% yellowish gray (5Y 8/1), fine grained, hard. Limestone, 30% very pale orange (10YR 8/2), fine to medium grained. Dolomite, 10% moderate brown (5YR 3/4), medium grained, well cemented.
1840-1850	10	LIMESTONE - 100% grayish orange (10YR 7/4), medium to fine grained, moderately hard, fossiliferous.
1850-1890	40	LIMESTONE - 100%; 50% yellowish gray (5Y 8/1), packstone, hard 50% pale yellowish brown (10YR 6/2), medium grained, moderately well cemented, slightly dolomitic. Trace Limestone, light gray (N7), hard, micritic.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
1890-1900	10	DOLOMITIC LIMESTONE AND LIMESTONE - Dolomitic Limestone, 50% pale yellowish brown (10YR 6/2), medium to fine grained, moderately hard. Limestone, 40% yellowish gray (5Y 8/1), medium grained. 10% medium gray (N5), medium grained, fossiliferous, micritic.
1900-1930	30	LIMESTONE - 100% grayish orange (10YR 7/4), moderately hard, well indurated fossiliferous, foraminiferal. Trace dolomite, moderate brown (5YR 3/4), cryptocrystalline hard.
1930-1965	35	LIMESTONE AND DOLOMITE - Limestone, 50% yellowish gray (5Y 8/1), medium grained, moderately hard, micritic. Dolomite, 50% moderate brown (5YR 3/4) to grayish brown (5YR 3/2) to black (N1), cryptocrystalline to microcrystalline, angular hard.
1965-1975	10	Core taken, see core descriptions.
1975-1987	7	DOLOMITE - 100% moderate brown (5YR 3/4) to dark yellowish brown (10YR 4/2) to black (N1), cryptocrystalline to finely crystalline angular, hard.
1982-1996	14	Core taken, see core descriptions.
1996-2030	34	DOLOMITE - 100% moderate brown (5YR 3/4) to dark yellowish brown (10YR 4/2) to black (N1), cryptocrystalline to finely crystalline angular, hard.
2030-2130	100	DOLOMITE - 100% moderate brown (5YR 3/4) to dark yellowish brown (10YR 4/2), microcrystalline to finely crystalline, angular hard with occasional light olive gray (5Y 6/1) cryptocrystalline.
2130-2140	10	DOLOMITIC LIMESTONE - 100% very pale orange (10YR 8/2) to grayish orange (10YR 7/4), pinkish gray (5YR 8/1) and very light gray (N8), very fine grained to cryptocrystalline, well to very well indurated locally with rounded and angular, light gray (N7) to light brown (5YR 6/4) inclusions.
2140-2210	70	LIMESTONE - 100% Yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), fine to very fine grained, weakly to moderately indurated, commonly with pelloidal texture (grainstone), fossils locally abundant (2180-2190). Trace dolomite, pale to moderate yellowish brown (10YR 6/2 - 10YR 5/4), very fine grained to cryptocrystalline, angular, well indurated.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
2210-2230	20	DOLOMITE AND LIMESTONE - Dolomite, 50% to grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4), fine grained to cryptocrystalline, angular very well indurated, grains anhedral, euhedral dolomite rhombohedron crystals, well cemented with trace limestone and glassy gray to brown inclusions. Limestone, 50% yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), fine to very fine grained, weakly to moderately indurated identical to above limestone.
2230-2500	270	LIMESTONE - 100% yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), very fine to medium grained, weakly to moderately indurated, commonly with pelloidal texture (grainstone), grains subangular to well rounded, mostly well sorted, locally fossiliferous, with molds, tests, and casts, (2250-2270). Trace to minor dolomite, yellowish brown (10YR 5/2) and shades of gray, very fine grained to cryptocrystalline, angular well indurated, hard.
2500-2510	10	DOLOMITE - 100% moderate yellowish brown (10YR 5/4) and black (N1), sucrosic to microcrystalline, angular, well indurated hard.
2510-2520	10	DOLOMITE AND LIMESTONE - Dolomite, 90% moderate yellowish brown (10YR 5/4) to dusky yellowish brown (10YR 2/2), sucrosic to microcrystalline, angular, hard. Limestone, 10% very pale orange (10YR 8/2), moderately hard to friable packstone.
2520-2600	80	LIMESTONE, 100% very pale orange (10YR 8/2), fine to medium grained, pelloidal, moderately consolidated some translucent calcite.
2600-2620	20	DOLOMITE AND LIMESTONE - Dolomite, 60% moderate yellowish brown (10YR 5/4), sucrosic to microcrystalline, hard, well indurated. Dolomite, 10% dark yellowish brown (10YR 4/2) to olive gray (5Y 4/1), sucrosic, hard. Limestone, 30% yellowish gray (5Y 8/1), medium to coarse grained, pelloidal packstone moderate to good induration.
2620-2640	20	DOLOMITE AND LIMESTONE - Dolomite, 70% moderate yellowish brown (10YR 5/4), sucrosic to microcrystalline, hard. Limestone, 30% yellowish gray (5Y 8/1), medium to coarse grained, pelloidal, moderately hard, packstone.
2640-2670	30	DOLOMITE AND LIMESTONE - Limestone, 50% yellowish gray (5Y 8/1) pelloidal, moderately to poorly indurated, loosely consolidated, packstone. Dolomite, 50% yellowish brown (10YR 5/2), sucrosic to microcrystalline, moderately hard, content and angularity increase with depth.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
2670-2690	20	DOLOMITE AND LIMESTONE - Dolomite, 80% dark yellowish brown, (10YR 4/2), sucrosic to microcrystalline, hard. Limestone, 20% yellowish gray (5Y 8/1), well cemented pelloidal packstone.
2690-2700	10	LIMESTONE AND DOLOMITE - Limestone, 70% yellowish gray, (5Y 7/2), medium to fine grained, pelloidal moderately well cemented to very well cemented, hard, packstone, Dolomite, 30% dark yellowish brown, (10YR 4/2), sucrosic to microcrystalline, hard. Trace dark gray (N5) medium grained angular, well cemented quartz sandstone.
2700-2730	30	LIMESTONE AND DOLOMITE - Limestone, 90% yellowish gray, (5Y 7/2), to light gray (N7), fine to medium grained, pelloidal packstone with some light gray (N7) soft mudstone. Dolomite, 10% dark yellowish brown, (10YR 4/2), sucrosic to microcrystalline, hard.
2730-2750	20	LIMESTONE - 100% pale yellowish brown (10YR 6/2), to very pale orange (10YR 8/2), medium grained, micritic, moderately well to poorly cemented, hard.
2750-2760	10	LIMESTONE AND DOLOMITE – Limestone, 95% medium dark gray (N4) to medium gray (N3), hard micrite, and very pale orange (10YR 8/2) medium grained, hard, glauconitic in part. Dolomite 5% light brown (5 YR 5/6) fine grained, sucrosic, hard.
2760-2770	10	LIMESTONE – 100% pale yellowish brown (10 YR 6/2) to very pale orange (10YR 8/2) fine to medium grained, moderately hard to soft, packstone. Trace Dolomite
2770-2930	60	LIMESTONE – 100% very pale orange (10YR 8/2), medium to fine grained, moderately to poorly cemented. Trace Dolomite.
2930-2950	20	LIMESTONE AND DOLOMITE – Limestone, 75% very pale orange (10YR 8/2), pelloidal, moderately to poorly cemented, packstone. Dolomite 25% moderate yellowish brown (10YR 5/4) to olive gray (5Y 4/1), microcrystaline to sucrosic, hard to very hard.
2950-2960	10	DOLOMITE AND LIMESTONE – Dolomite, 35% yellowish gray (5Y 8/1), cryptocrystalline to microcrystalline, angular, hard, 15% moderate yellowish brown (10YR 5/4) to olive gray (5Y 4/1) sucrosic to microcrystaline, angular, hard. Limestone 50% very pale orange (10YR 8/2), pelloidal, moderately to poorly cemented, packstone,

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
2960-2970	10	LIMESTONE AND DOLOMITE - Limestone, 75% very pale orange (10YR 8/2), to white (N9), pelloidal moderately hard, packstone. Dolomite, 25% olive gray (5Y 4/1) to moderate yellowish brown (10YR 5/4), sucrosic, hard.
2970-2980	10	LIMESTONE AND DOLOMITE – Limestone, 90% very pale orange (10YR 8/2), medium grained, pelloidal, moderately well cemented packstone. Dolomite 10% light olive gray (5Y 5/2) medium grained, angular, hard.
2980-3000	20	LIMESTONE AND DOLOMITE – Limestone, 70% very pale orange (10YR 8/2), medium grained pelloidal moderately well cemented packstone, and moderate yellowish brown (10YR 5/4) microcrystaline, hard, vuggy micrite, Dolomite, 30% dusky yellowish brown (10YR 2/2) fine to medium grained, hard.
3000-3010	10	DOLOMITE AND DOLOMITIC LIMESTONE – Dolomite, 80% pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2) medium to fine grained, angular to subangular, hard. Dolomitic Limestone 20% very pale orange (10YR 8/2), pelloidal.
3010-3020	10	DOLOMITE – 100% pale yellowish brown (10YR 6/2) to moderate yellowish brown (10YR 5/4), medium to fine grained, angular, hard.
3020-3030	10	DOLOMITE – 100% dark yellowish brown (10YR 4/2), very fine grained to cryptocrystaline, angular, hard.
3030-3040	10	DOLOMITE – 100% yellowish brown (10YR 6/2) to dark yellowish orange (10YR 6/6), very fine grained to cryptocrystaline, angular, hard.
3040-3060	20	DOLOMITE – 100% light gray (N7) to grayish orange (10YR 7/4), very fine grained to cryptocrystaline, angular, hard.
3060-3100	40	DOLOMITE – 100%; 45% dark yellowish brown (10YR 4/2), to grayish orange (10YR 7/4) sucrosic, subangular, 40% very light gray (N8) to light gray (N7) sucrosic to fine grained, subangular, hard, 15% olive gray (5Y 4/1), sucrosic, subangular, hard.
3100-3110	10	DOLOMITE – 100%; 60% moderate yellowish brown (10YR 5/4), medium to fine grained, angular, hard, 30% pale yellowish brown (10YR 6/2) fine grained, subangular, hard, 10% dusky yellowish brown (10YR 2/2) cryptocrystaline hard

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
3110-3120	10	DOLOMITE – 100%; 70% pale yellowish brown (10YR 6/2) fine grained, subangular, hard, 20% moderate yellowish brown (10YR 5/4), medium to fine grained, angular, hard 10% dusky yellowish brown (10YR 2/2) cryptocrystaline hard
3120-3160	40	DOLOMITE – 100%; 70% light olive gray (5Y 6/1), fine grained, angular, hard, 30% dark yellowish brown (10YR 4/2) fine grained, subangular, hard
3160-3210	50	DOLOMITE – 100%; 70% pale yellowish brown (10YR 6/2) medium to fine grained, subangular, hard, occasional vugs increasing with depth. 20% moderate yellowish brown (10YR 5/4), medium to fine grained, angular, hard, 10% very light gray (N8) fine grained, hard.
3210-3230	20	DOLOMITE – 100%; 40% pale yellowish brown (10YR 6/2) coarse to fine grained, subangular, hard, 70% light olive gray (5Y 6/1), cryptocrystaline, with some bedding, hard, 30% light gray (N7) cryptocrystaline, calcareous.
3230-3260	30	DOLOMITE – 100%; 70% light gray (N7) to medium dark gray (N4) and very pale orange (10 YR 8/2) to moderate yellowish brown (10YR 5/4), fine to cryptocrystaline, hard with trace crystal lined cavities. 30% Dolomite Breccia, angular to subangular, dominant light colored dolomite fragments, matrix supported, light colored dolomite commonly fractured and healed, gray dolomite slightly calcareous.
3260-3270	10	DOLOMITE – 100%; 80% dark yellowish brown (10YR 4/2) fine grained to cryptocrystaline, hard, 20% light gray (N7), cryptocrystaline, calcareous.
3270-3350	80	DOLOMITE – 100%, pale yellowish brown, (10YR 6/2), cryptocrystalline, hard, to dark yellowish brown (10YR 4/2), fine to cryptocrystalline, hard, with some olive gray (5Y 4/1), cryptocrystalline exhibiting molds
3350-3370	20	DOLOMITE – 100%; 95%, pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), and medium light gray (N6) to grayish black (N2), finely crystalline to cryptocrystalline, hard, minor to moderate amount of fine grained crystalline lined cavities. Dolomite Breccia, 5%, as above, angular to subangular, light colored dolomite fragments, matrix supported, commonly occurs with vuggy dolomite.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Injection Well IW6
3370-3390	20	DOLOMITE, – 100%; 80%, moderate yellowish brown (10YR 5/4), fine grained to cryptocrystalline, hard, 20% pale yellowish brown (10YR 6/2), finely crystalline to cryptocrystalline, moderate amount of crystalline lined vuggy cavities, vugs decrease with depth. Trace grayish orange (10YR 7/4), cryptocrystalline, hard.
3390-3440	50	DOLOMITE, – 100%, olive gray (5Y 4/1) to light olive gray (5Y 6/1), fine grained to microcrystalline, vuggy in part; Grayish black (N2), very fine grained, angular, hard, grayish black percentage increasing with depth (~10% at 3440); Grayish orange (10YR 7/4), to dark yellowish orange (10YR 4/2), very fine grained, hard, weakly porous from 3430-3440`bpl (~5% at 3440)
3440-3450	10	DOLOMITE – 100%; dominantly olive gray (5Y 4/1) and medium gray (N5) to grayish black (N2), very fine grained to microcrystalline; hard trace moderate olive brown (5Y 4/4), very fine grained to microcrystalline, hard.
3450-3460	10	DOLOMITE – 100%; 80% yellowish gray (5Y 7/2) to light olive gray (5Y 6/1), cryptocrystalline to very fine grained, angular, hard. 10% dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4), very fine grained to sucrosic, angular, hard. 10% dark yellowish brown (10YR 4/2), microcrystalline to very fine grained, angular, hard.
3460-3485	25	DOLOMITE – 100%; 70%, pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), sucrosic to microcrystalline, some euhedral dolomite rhombs, subangular to angular hard. 10% dark yellowish orange (10YR 6/6), increasing down section (20% from 3470-3480` bpl) microcrystalline to cryptocrystalline, less commonly fine grained, sucrosic, and finely (<1mm) vuggy crystalline lined cavities comprising <1% by volume, slightly calcareous.
3500-3510 TD	10	DOLOMITE, 100%; 85-90% pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), very fine grained to cryptocrystalline, hard, 10-15% medium gray (N5) to grayish black (N2), fine grained to microcrystalline; hard. Trace breccia, light colored, subangular to subrounded, matrix supported fragments, (up to 0.5 inches)

Appendix E - Geologic Log
Monitor Well MW3

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
0–10	10	SAND, SHELL AND ORGANICS – Sand 80%; poorly consolidated, medium to coarse grained, subrounded, colorless quartz grains in carbonate matrix. Shell fragments 10%. Organic material (roots, etc) 10%.
10–40	30	SAND – 100% unconsolidated, medium grained, subrounded to subangular, colorless quartz with trace of shell fragments.
40-50	10	SAND – 100% mainly unconsolidated, fine to medium grained, subangular, colorless quartz with trace of phosphate.
50-60	10	SAND – 100% unconsolidated, fine grained, subangular, colorless quartz.
60-70	10	SAND AND LIMY SANDSTONE – 100% fine to medium grained, subrounded, colorless quartz, unconsolidated to moderately well cemented with calcite; trace of limestone, shell fragments, and phosphorite.
70-80	10	LIMY SANDSTONE – 100%; 90% medium gray (N5) to medium dark gray (N4), very coarse to mainly medium grained subangular to rounded grains of colorless to light gray (N7) quartz moderately cemented with calcite; 10% fossil/shell fragments; trace of phosphorite
80-100	20	LIMY SANDSTONE – 100%; 95% greenish gray (5G 6/1) and very light gray (N8) to medium light gray (N6), fine to coarse grained, subangular to rounded grains of colorless to light gray (N7) quartz moderately well cemented with calcite; 5% fossil/shell fragments; trace of phosphorite.
100-120	20	LIMY SANDSTONE AND SANDY LIMESTONE - Limy Sandstone, 85-90%; greenish gray (5G 6/1) and very light gray (N8) to medium light gray (N6), moderately well cemented with calcite, fine to coarse grained, subangular to rounded, grains of colorless to light gray (N7) quartz, fossil/shell fragments, and trace phosphorite. Sandy Limestone, 10-15%, medium light gray (N6) to medium dark gray (N4), moderately well indurated, fine grained to microcrystalline, locally sparry with fine to medium grained, subrounded to subangular grains of clear quartz and phosphorite, percentage increases with depth.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
120-140	20	LIMY SANDSTONE AND SANDY LIMESTONE - Limy Sandstone, 50-60%; greenish gray (5G 6/1) and very light gray (N8) to medium light gray (N6), moderately well cemented with calcite, fine to coarse grained, subangular to rounded grains of colorless to light gray (N7) quartz, fossil/shell fragments, and trace phosphorite. Sandy Limestone, 40-50%, medium light gray (N6) to medium dark gray (N4), moderately well indurated, fine grained to microcrystalline, locally sparry with fine to medium grained, subrounded to subangular grains of clear quartz and phosphorite, percentage decreases with depth.
140-150	10	LIMY SANDSTONE – 100% Medium gray (N5) to medium light gray (N6), very well indurated, medium to fine grained, subangular grains of quartz and phosphate well cemented with calcite; trace of yellowish gray (5Y 8/1) microcrystalline Limestone.
150-180	30	SANDY LIMESTONE AND SANDSTONE – Sandy Limestone 80-90%; light olive gray (5Y 6/1) to yellowish gray (5Y 8/1), fine grained to microcrystalline, locally sparry, with fine to medium grained, subrounded to subangular grains of clear quartz; fossiliferous, percentage increases with depth. Sandstone 10-20%; medium gray (N5) to medium light gray (N6), very well indurated, phosphatic, medium to fine grained, subangular clear quartz well cemented with calcite.
180-220	40	SANDY LIMESTONE – 100%; yellowish gray (5Y 8/1) to medium light gray (N6), moderately well indurated, fine grained to microcrystalline, locally sparry, with fine to medium grained, subrounded to subangular grains of clear to milky quartz sand and trace phosphorite; fossiliferous with shell fragments, casts, and molds.
220-270	50	LIMY SANDSTONE – 100%; light olive gray (5Y 6/1) to medium gray (N5), moderately to well indurated and cemented, phosphatic, medium to coarse grained, moderately sorted, variable roundness and sphericity of grains and partly conglomeratic with abundant shell and coral fragments.
270-280	10	SANDY LIMESTONE – 100%; yellowish gray (5Y 8/1), fine to medium grained, packstone/grainstone with abundant shell fragments.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
280-320	40	LIMY SANDSTONE AND SANDY LIMESTONE - Limy Sandstone 80%; dusky yellow (5Y 6/4), moderately soft, argillaceous, poorly indurated, fine to very fine grained; with trace of phosphorite. Sandy Limestone 20%; yellowish gray (5Y 8/1), fine to medium grained, packstone/grainstone with abundant shell fragments.
320-330	10	LIMY SANDSTONE – 100%; pale olive (10Y 6/2) to yellowish gray (5Y 7/2), weakly to moderately indurated, very fine to medium grained, variable roundness and sphericity of grains, moderately to locally poorly sorted with large cm sized shell fragments, partly argillaceous with trace of phosphorite.
330-350	20	SANDY CLAY AND LIMY SANDSTONE – Sandy Clay 50-60%; pale olive gray (10Y 6/2), soft, with very fine to fine grained sand and abundant fossil shell and coral fragments, clay content increasing with depth. Limy Sandstone 20-30%; pale olive (10Y 6/2) to yellowish gray (5Y 7/2), weakly to moderately indurated, very fine to medium grained, moderately to locally poorly sorted with large cm sized shell fragments, variable roundness and sphericity of grains, partly argillaceous. Trace to 20% phosphorite
350-370	20	SANDY CLAY - 100%; pale olive gray (10Y 6/2) to yellow gray (5Y 7/2), soft with very fine to fine grained sand and abundant fossil shell and coral fragments; trace of phosphorite.
370-390	20	SANDY CLAY AND LIMY SANDSTONE – Sandy Clay 60-70%, light olive gray (5Y 5/2) to grayish olive (10Y 4/2), soft with very fine to fine grained sand and abundant fossil shell and coral fragments. Limy Sandstone 30%; light olive gray (5Y 5/2) to grayish olive (10Y 4/2), weakly to moderately indurated, very fine to medium grained, subangular to subrounded, moderately sorted; trace of phosphorite.
390-430	40	SANDY CLAY – 100%; pale olive gray (10Y 6/2) to grayish olive (10Y 4/2), soft with very fine to fine grained sand and abundant fossil shell and coral fragments; trace of phosphorite.
430-550	120	SANDY CLAY – 100%; grayish olive (10Y 4/2), soft and plastic, with very fine grained sand to silt size quartz and minor amounts of shell and coral fragments; trace of phosphorite. Trace of Sandy Limestone below 520 feet.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
550-560	10	CLAY AND LIMSTONE – Clay 90%; olive gray (5Y 4/1), soft to medium firm and plastic with fine grained quartz sand and phosphorite. Limestone 10%; light olive gray (5Y 6/1), fine grained to cryptocrystalline with occasional crystal lined vugs. Minor amounts of Sandy Limestone, light olive gray (5Y 5/2), cryptocrystalline, well indurated with medium to fine grained quartz sand.
560-570	10	CLAY, LIMESTONE, AND SANDSTONE – Clay 80%; olive gray (5Y 4/1), soft to medium firm and plastic with fine grained quartz sand and phosphorite. Limestone 10%; yellowish gray (5Y 8/1), medium grained, well-indurated packstone, partly sandy. Sandstone 10%; light olive gray (5Y 5/2), medium grained, poorly indurated with shell fragments.
570-580	10	CLAY AND SANDY LIMESTONE – Clay 75%; pale olive (10Y 6/2), moderately firm with fine grained quartz sand and trace of phosphorite. Sandy Limestone 25%; light olive gray (5Y 6/1), microcrystalline to cryptocrystalline, hard, locally sparry, fossiliferous and phosphatic; trace of dolomitized coral, black (N2) pyritic Chert, and dark greenish gray (5GY 4/1) to light bluish gray (5B 7/1) porcellanite.
580-590	10	CLAY, SANDY LIMESTONE, AND DOLOMITE – Clay 90%; pale olive (10Y 6/2), moderately firm with fine grained quartz sand and trace of phosphorite. Sandy Limestone 5%; light olive gray (5Y 6/1), fine grained, soft with fine grained quartz sand. Dolomite 5% brownish gray (5YR 4/1), fine grained, hard; trace of chert and porcellanite.
590-600	10	CLAY - 100%; pale olive (10Y 6/2), moderately firm with fine grained quartz sand and trace of phosphorite; trace of sandy limestone.
600-620	20	CLAY – 100%; 80% yellowish gray (5Y 7/2), soft and plastic with very fine grained quartz and phosphorite; 20% pale olive (10Y 6/2), moderately firm with fine grained quartz sand and minor amounts of phosphorite.
620-700	80	SANDY CLAY – 100%; pale olive (10Y 6/2), soft and plastic with silt to very fine grained quartz sand and trace of phosphorite, yellowish gray (5Y 7/2) from 640 to 660 feet. Pale greenish yellow (10Y 8/2) to moderate greenish yellow (10Y 7/4) from 680 to 690 feet. 3-5% Limestone and minor very fine grained Sandstone from 690 to 700 feet.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
700-720	20	SANDY CLAY, SANDY LIMESTONE, AND LIMY SANDSTONE – Sandy Clay 50%; pale greenish yellow (10Y 8/2) to pale olive (10Y 6/2), soft, plastic, with silt to very fine quartz sand. Sandy Limestone 30-40% yellowish gray (5Y 8/1) to white (N9), moderately indurated, micritic with very fine to medium grained sand. Limy Sand 10-20%; mostly pale olive (10Y 6/2), soft, weakly indurated, very fine to medium grained with some shell fragments and trace phosphorite.
720-740	20	SANDY CLAY, SANDY LIMESTONE AND LIMY SANDSTONE – Sandy Clay 70-80%; pale greenish yellow (10Y 8/2) to pale olive (10Y 6/2), soft, plastic, with silt to very fine grained quartz sand. Sandy Limestone 10-15%; yellowish gray (5Y 8/1) to white (N9), moderately indurated, microcrystalline, with very fine to medium grained sand. Limy Sand 10-15%; mostly pale olive (10Y 6/2), soft, weakly indurated, very fine to medium grained, with some shell fragments and trace of phosphorite and yellowish gray (5Y 7/2), medium grained packstone.
740-780	40	CLAY AND LIMESTONE. – Clay 80%; yellowish gray (5Y 7/2), firm, plastic, and slightly calcareous with very fine-grained sand, slightly phosphatic. Limestone 20%; yellowish gray (5Y 7/2), sparry packstone, percentage increasing with depth. Trace of dolomite and dolomitic limestone at 770 feet.
780-790	10	CLAY - 100%; yellowish gray (5Y 7/2), plastic, slightly calcareous with very fine-grained sand, slightly phosphatic. Trace of moderate brown (5YR 3/4), phosphatic limestone.
790-800	10	CLAY AND PHOSPHORITE – Clay 90%; yellowish gray (5Y 7/2), firm, plastic, and slightly calcareous with very fine-grained sand. Phosphorite 5%; black (N1), fine-grained.
800-810	10	CLAY AND LIMESTONE – Clay 70%; light olive gray (5Y 5/2), firm, slightly phosphatic. Limestone 30%; yellowish gray (5Y 8/1), soft, medium grained mudstone/wackestone.
810-880	70	CLAY – 100%; light olive gray (5Y 5/2) to pale olive (10Y 6/2), firm, calcareous, with fine grained sand, slightly phosphatic.
880-900	20	CLAY, AND LIMESTONE –Clay 50%; greenish gray (5GY 6/1), soft to moderately firm, slightly calcareous and phosphatic. Limestone 50%; very pale orange (10YR 8/2), moderately hard, sparry with abundant shell fragments, trace of Dolomitic Limestone and Dolomite.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
900-920	20	CLAY, LIMESTONE, AND PHOSPHORITE – Clay 50%; yellowish gray (5Y 7/2) to light greenish gray (5GY 8/1), soft. Limestone 35%; yellowish gray (5Y 8/1), cryptocrystalline with shell fragments, partly dolomitic. Phosphorite 15%; brownish gray (5YR 4/1) to black (N1), medium grained, subrounded to rounded grains.
920-940	20	SANDY LIMESTONE, LIMESTONE AND CLAY – Sandy Limestone 80%; yellowish gray (5Y 7/2), soft to moderately hard, medium grained wackestone, partly dolomitic. Limestone 10%; yellowish gray (5Y 8/1), cryptocrystalline with shell fragments, partly dolomitic. Clay 10%; yellowish gray (5Y 7/2) to light greenish gray (5GY 8/1), soft. Trace of olive black (5Y 2/1), medium grained, fossiliferous Dolomite.
940-970	30	SANDY LIMESTONE, SHELL, CLAY, AND DOLOMITE – Sandy Limestone 70%; yellowish gray (5Y 7/2); moderately hard, phosphatic wackestone. Shell fragments 10%; yellowish gray (5Y 8/1) to white (N9). Clay 10%; yellowish gray (5Y 7/2) to light greenish gray (5GY 8/1); soft. Dolomite 10%; olive black (5Y 2/1), medium grained, fossiliferous.
970-980	10	LIMESTONE, SHELL, AND CHERT – Limestone 90%; pale olive (10 Y 6/2) to light olive gray (5Y 5/2), hard, fine grained to cryptocrystalline, phosphatic with abundant shell casts. Shell fragments 7%; yellowish gray (5Y 8/1) to white (N9), commonly in limestone matrix. Chert 3%; dark yellowish brown (10YR 4/2).
980-1020	40	LIMESTONE, SANDY LIMESTONE, AND SHELL – Limestone 90%; very light gray (N8) to yellowish gray (5Y 8/1) to light bluish gray (5B 7/1), moderately hard, moderately indurated, very fine grained to cryptocrystalline wackestone/packstone with abundant shell molds and casts. Sandy Limestone 5%; light gray (N7) to medium light gray (N6), moderately hard, well indurated, cryptocrystalline packstone with very fine to medium grained sand; shell molds and casts decreasing with depth. Shell fragments 5%; white (N9) to very light gray (N8) to light bluish gray (5B 7/1), hard, commonly well cemented in sandy limestone and limestone, percentage increases with depth.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
1020-1030	10	LIMESTONE, SANDY LIMESTONE, AND SANDSTONE – Limestone 40%; light bluish gray (5B 7/1), moderately hard, cryptocrystalline to microcrystalline carbonate mudstone. Sandy Limestone 30%; light gray (N7) to medium light gray (N6), moderately hard, well indurated, cryptocrystalline packstone with very fine to medium grained sand, shell molds and casts. Sandstone 30%; olive gray (5Y 4/1), fine to very fine grained, subangular, moderately cemented with medium grained phosphorite.
1030-1060	30	LIMESTONE – 100%; 70-90% grayish orange (10YR 7/4), moderately soft, moderately to well indurated, mainly medium to fine grained packstone, moderate amount of foraminfera from 1030 to 1040 ft. 20-5% yellowish gray (5Y 7/2), hard, medium grained mudstone/wackestone, partly sandy and phosphatic. 10-5% light bluish gray (5B 7/1), cryptocrystalline to microcrystalline, moderately hard, carbonate mudstone.
1060-1100	40	LIMESTONE – 100%; grayish orange (10YR 7/4), moderately soft, medium grained packstone with a few foraminifera, hardness and induration increases with depth. Trace of light gray (N7), hard, fine-grained limestone from 1080 - 1100 feet.
1100-1150	50	LIMESTONE – 100%; 90% grayish orange (10YR 7/4), moderately soft, medium to fine grained packstone. 10% grayish orange (10 YR 7/4), hard, microcrystalline to cryptocrystalline carbonate mudstone with rare fossils. Trace light gray (N7), hard, fine-grained Limestone.
1150-1225	75	LIMESTONE – 100%; white (N9) to very light gray (N8), soft, microcrystalline to cryptocrystalline carbonate mudstone with rare shell casts and molds and very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately soft, microcrystalline to fine grained packstone with rare shell fragments. Color grades downward into dominantly yellowish gray (5Y 8/1) from 1170 to 1190 ft and to very pale orange (10YR 8/2) from 1190 to 1225 ft, percentage of packstone increases with depth.
1225-1340	115	LIMESTONE – 100%; dominantly grayish orange (10YR 7/4), moderately soft, microcrystalline to medium grained packstone, with rare shell casts and molds, pelloidal from 1260 to 1270 ft.
1340-1390	50	LIMESTONE – 100%; grayish orange (10YR 7/4) to very pale orange (10YR 8/2), moderately soft, fine-grained packstone with rare foraminifera, trace of dolomitic limestone.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
1390-1420	30	LIMESTONE – 100%; 60-70% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1) and 30-40% very light gray (N8) to medium light gray (N6), moderately indurated, fine to locally medium grained packstone, locally fossiliferous with rare sea urchin tests, shell fragments, and microscopic to mm sized crystalline lined vugs
1420-1450	30	LIMESTONE AND SILTSTONE – Limestone 70%; very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately indurated, fine to medium grained, fossiliferous packstone/grainstone, locally vuggy and sparry. Siltstone, 30% dark greenish gray (5GY 4/1), moderately soft, phosphatic, percentage decreasing with depth. Trace of Dolomitic Limestone
1450-1490	40	LIMESTONE – 100%; 60% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, medium to fine-grained packstone/grainstone, fossiliferous, locally vuggy and micritic. 40% light olive gray (5Y6/1) to medium dark gray (N4), hard, fine grained to microcrystalline,. fossiliferous carbonate mudstone, locally vuggy.
1490-1510	20	LIMESTONE – 100%; 70% very pale orange (10YR 8/2) to grayish orange (10YR 7/4); moderately hard and indurated, medium grained, packstone/grainstone with a few radiolarian. 30% greenish gray (5GY 6/1), hard, fine to medium grained carbonate mudstone with medium sized grains of phosphorite. Trace of Dolomitic Limestone.
1510-1540	30	LIMESTONE – 100%, 50% yellowish gray (5Y 8/1), moderately soft, vuggy, medium to fine grained grainstone/packstone. 50% medium gray (N5) to medium dark gray (N4), hard, carbonate mudstone.
1540-1590	50	LIMESTONE – 100%; dominantly very pale orange (10YR 8/2) to grayish orange (10YR 7/4) and white (N8), moderately soft, moderately indurated, locally finely vuggy, fine to medium grained, fossiliferous packstone and minor mudstone with disk shaped tests up to ½ in. across common at 1540 to 1550 ft and 1580 to 1590 ft. 30-40% light gray (N7) to medium gray (N5) gray, finely vuggy breccia/conglomerate at 1570 ft.
1590-1600	10	LIMESTONE – 100%; 70% grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), moderately hard and indurated, generally medium grained packstone with minor amounts of carbonate mudstone. 30% medium dark gray (N4), hard, coarse to fine grained packstone.

Interval Depth (feet bpl)	Thickness (feet)	Sample Geologic Description Monitor Well MW3
1600-1610	10	LIMESTONE – 100%; 90% very pale orange (10YR 8/2), well indurated, moderately hard, medium to coarse-grained, fossiliferous packstone/grainstone, locally micritic. 10% light olive gray (5Y 5/2), hard, vuggy carbonate mudstone.
1610-1620	10	LIMESTONE AND DOLOMITE – Limestone 60%; yellowish gray (5Y 8/1), moderately hard, medium to fine grained packstone/grainstone and 30% light olive gray (5Y 6/1), hard, fine grained to microcrystalline carbonate mudstone. Dolomite 10%; dark yellowish brown (10YR 4/2), hard, cryptocrystaline to microcrystalline.
1620-1630	10	LIMESTONE – 100%; 90% very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately soft, coarse to fine grained, fossiliferous packstone/grainstone. 10% light gray (N7), hard, carbonate mudstone.
1630-1660	30	DOLOMITIC LIMESTONE AND LIMESTONE – Dolomitic Limestone 50%; moderately yellowish brown (10YR 5/4), soft, poorly indurated, fine to medium grained packstone. Limestone 40%; very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately soft, coarse to fine grained, fossiliferous packstone/grainstone. 10% light gray (N7), hard, carbonate mudstone.
1660-1680 TD	20	LIMESTONE – 100%; 70% grayish orange (10YR 7/4), moderately soft to moderately hard, medium grained grainstone/packstone. 20% very pale orange (10YR 8/2), hard, vuggy, carbonate mudstone. 10% light gray (N7), hard, carbonate mudstone.

APPENDIX F

CORES

Ardaman & Associates, Inc.

Geotechnical, Environmental and
Materials Consultants

November 15, 1999
File Number 99-142

Youngquist Brothers, Inc.
15465 Pine Ridge Road
Fort Myers, Florida 33908

Attention: Mr. Edward McCullers

Subject: Laboratory Testing, Rock Core Specimens, Broward County North Regional Wastewater Treatment Plant IW-5

Gentlemen:

As requested, permeability, unconfined compression and specific gravity tests have been completed on 20 rock core samples provided for testing by your firm from the Broward County North Regional Wastewater Treatment Plant IW-5. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter" using the constant-head (Method A) and falling-head with increasing tailwater level (Method C) test methods. The unconfined compression tests were performed in general accordance with ASTM Standard D 2938 "Unconfined Compressive Strength of Intact Rock Core Specimens". The specific gravity was determined in general accordance with ASTM Standard D 854 "Specific Gravity of Soils". Due to the irregular shape and short length of the core samples, each of the requested tests (i.e., vertical permeability test, horizontal permeability test and unconfined compression test) could not be performed on each sample.

Permeability Tests

The permeability test results are presented in Table 1. The core samples provided for testing were too short to obtain separate vertically and horizontally oriented specimens. Accordingly, the vertical permeability tests were performed first on specimens maintained at the as-received diameter and cut to lengths of 9.4 to 10.6 cm. After completing the vertical permeability tests, horizontal permeability test specimens were obtained by coring 5.0 cm diameter cylinders from the vertical specimens. The horizontal specimens were then trimmed to lengths of 6.5 to 7.9 cm to provide flat, parallel ends. Since the vertical permeability test specimens were cored upon completion of testing to obtain horizontal permeability test specimens, the final moisture contents of the vertical test specimens were not measured. The dry densities and degrees of saturation of the vertical permeability test specimens, therefore, were estimated using final moisture contents from the corresponding horizontal permeability test specimens.

The permeability test specimens were air-dried, deaired under vacuum, and then saturated with deaired tap water from the bottom upward while still under vacuum. After testing, the vertical specimens were maintained submerged in water until cored for horizontal specimens and retested for measurement of the horizontal hydraulic conductivity. Each specimen was mounted in a triaxial-type permeameter and encased within a latex membrane. The specimens were confined using an average isotropic effective confining stress of 20 lb/in^2 and permeated with deaired tap water under back-pressures of 70 to 169 lb/in^2. Satisfactory saturation was verified by a B-factor equal to or greater than 95%, or a B-factor that remained relatively constant for two consecutive increments of applied cell pressure. The inflow to and outflow from each specimen were monitored with time, and the hydraulic conductivity was calculated for each recorded flow increment. The tests were

8008 S. Orange Avenue (32809), Post Office Box 593003, Orlando, Florida 32859-3003 Phone (407) 855-3860 FAX (407) 859-8121
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continued until steady-state flow conditions were obtained, as evidenced by an outflow/inflow ratio between 0.75 and 1.25, and until stable values of hydraulic conductivity were measured. The final degree of saturation was calculated upon completion of testing using the final dry mass, moisture content and volume, and the measured specific gravity. Although some of the calculated final degrees of saturation are low (i.e., less than 95%), the B-factors indicate satisfactory saturation. The calculated final degrees of saturation are potentially affected by occluded voids within the specimens, surface irregularities, and the use of final moisture contents for the vertical permeability specimens from the corresponding horizontal permeability specimens.

Specific Gravity Tests

The specific gravity of each core sample was determined on a representative approximately 100 gram specimen ground to pass the U.S. Standard No. 40 sieve. The specific gravity measured on each sample is presented in Table 1.

Porosity

The total porosity, n, of each permeability test specimen was calculated using the measured dry density, γ_d, and measured specific gravity, G_s, from the equation: $n = 1 - (\gamma_d/(G_s)(\gamma_w))$ where γ_w = unit weight of water. The calculated total porosities are presented in Table 1.

Unconfined Compression Tests

Sufficient core lengths were provided to perform unconfined compression tests on 5 of the samples. The tests were performed on specimens cored to a diameter of 3.3 cm and trimmed to lengths of 6.2 to 6.5 cm to provide a length to diameter ratio of approximately 2, and then capped with a sulfur capping compound. The specimens were loaded at a constant rate of axial deformation of 0.013 cm/minute. The specimens failed between 2 and 5 minutes in general compliance with the ASTM Standard D 2938 criteria of between 2 and 15 minutes. The unconfined compressive strengths and Young's modulus determined from the tests are summarized in Table 2. The stress-strain curves are presented in Figures 1 through 5.

If you have any questions or require additional testing services, please contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Shawkat Ali

Shawkat Ali, Ph.D., P.E.
Geotechnical Engineer

Thomas S. Ingra

Thomas S. Ingra, P.E.
Senior Project Engineer
Florida Registration No. 31987

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Table 1

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

Core No.	Depth Interval (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Hydraulic Conductivity k_{20} (cm/sec)
					Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft^3)	n					w_c (%)	γ_d (lb/ft^3)	S (%)	
1	1680.0 to 1680.6	Vertical	C	2.66	10.28	9.92	22.2	104.5	0.37	20	80	97	2	22.2†	104.5	100	$2.3x10^{-4}$
		Horizontal	A		7.20	4.98	22.2	104.5	0.37	20	169	96	37	22.2	104.5	100	$3.4x10^{-4}$
	1681.8 to 1682.3	Vertical	C	2.66	10.46	9.99	23.3	102.1	0.39	20	80	97	2	23.3†	102.1	99	$9.6x10^{-5}$
		Horizontal	C		7.70	4.99	23.3	102.5	0.38	20	80	94**	2	23.3	102.5	100	$2.3X10^{-4}$
	1685.0 to 1685.4	Vertical	A	2.66	9.44	10.05	15.5	117.3	0.29	20	169	98	26	15.5†	117.3	99	$4.7x10^{-5}$
		Horizontal	A		6.98	5.00	15.5	117.5	0.29	20	169	96	14	15.5	117.5	100	$2.9x10^{-4}$
	1685.9 to 1686.4	Vertical	C	2.71	10.09	9.85	24.4	100.0	0.41	20	70	80**	0.5	24.4†	100.0	96	$1.0x10^{-3}$
		Horizontal	C		7.34	4.98	24.3	100.1	0.41	20	80	93**	3	24.4	100.1	96	$1.5x10^{-3}$
2	1745.3 to 1745.8	Vertical	A	2.72	10.00	9.68	23.9	100.7	0.41	20	169	98	21	23.9†	100.7	95	$1.9x10^{-4}$
		Horizontal	C		6.69	5.00	23.9	100.9	0.41	20	80	92**	3	23.9	100.9	95	$1.3x10^{-3}$
	1746.8 to 1747.5	Vertical	C	2.72	10.60	9.75	25.1	99.2	0.42	20	80	84**	2	25.2†	99.2	97	$3.1x10^{-5}$
		Horizontal	A		6.49	4.91	25.2	99.8	0.41	20	169	99	21	25.2	99.8	98	$2.2X10^{-4}$
	1747.65 to 1748.4	Vertical	A	2.67	9.96	9.88	20.3	108.0	0.35	20	169	98	17	20.3†	108.0	100	$2.2x10^{-5}$
		Horizontal	A		6.96	5.01	20.3	107.6	0.35	20	169	97	22	20.3	107.6	99	$5.9X10^{-5}$
	1752.3 to 1752.8	Vertical	C	2.72	9.81	9.62	26.5	96.4	0.43	20	70	93**	0.5	26.5†	96.4	95	$1.0x10^{-3}$
		Horizontal	C		6.63	4.98	26.0	96.9	0.43	20	80	87**	3	26.5	96.9	96	$1.4X10^{-3}$
3	1800.3 to 1800.8	Vertical	A	2.67	10.34	9.58	15.8	116.9	0.30	20	169	98	17	15.8†	116.9	99	$2.4x10^{-6}$
		Horizontal	A		6.79	5.03	15.8	116.2	0.30	20	169	95	27	15.8	116.2	98	$7.6X10^{-6}$
	1801.3 to 1802.2 (Top)	Vertical	A	2.69	10.59	9.81	8.0	140.3	0.18	20	169	97	23	8.0†	140.3	100	$1.8x10^{-7}$
		Horizontal	A	(2.74)	7.10	5.00	8.0	140.3	0.18	20	169	74**	27	8.0	140.3	100	$6.0X10^{-7}$
	1801.3 to 1802.2 (Bottom)	Vertical	A	2.78	10.07	10.08	3.3	157.8	0.10	20	169	95**	33	4.0†	157.8	100	$7.4x10^{-9}$
		Horizontal	A	(2.81)	7.49	5.02	4.0	157.7	0.10	20	169	98	57	4.0	157.7	100	$4.9x10^{-9}$
	1802.7 to 1803.5	Vertical	A	2.70	10.42	9.97	18.4	110.7	0.34	20	169	93**	21	18.5†	110.7	95	$1.6x10^{-6}$
		Horizontal	A		6.92	5.01	18.5	110.8	0.34	20	169	97	16	18.5	110.8	96	$5.1X10^{-6}$
	1809.4 to 1810.0	Vertical	A	2.73	9.69	9.86	18.4	112.4	0.34	20	169	97	17	18.4†	112.4	97	$3.4x10^{-5}$
		Horizontal	A		7.43	4.94	18.4	113.2	0.34	20	169	93**	14	18.4	113.2	99	$4.9x10^{-5}$
4	1850.0 to 1850.8	Vertical	C	2.68	9.71	10.03	20.1	105.4	0.37	20	80	74**	2	20.1†	105.4	92	$8.2x10^{-4}$
		Horizontal	A		6.77	5.02	20.1	108.6	0.35	20	169	98	19	20.1	108.6	100	$3.0x10^{-5}$
	1853.7 to 1854.3	Vertical	A	2.72	10.06	9.74	21.8	106.7	0.37	20	80	85**	12	21.8†	106.7	100	$8.2x10^{-5}$
		Horizontal	A		7.44	5.04	21.7	103.0	0.39	20	169	98	20	21.8	103.0	91	$1.2x10^{-4}$
	1855.5 to 1856.0	Vertical	C	2.68	9.71	10.44	25.8	94.6	0.43	20	80	78**	2	25.8†	94.6	90	$4.8x10^{-4}$
		Horizontal	C		7.27	4.97	25.8	97.7	0.42	20	80	89**	3	25.8	97.7	97	$8.8x10^{-4}$
	1857.3 to 1857.9	Vertical	C	2.71	10.24	10.02	14.3	118.7	0.30	20	80	83**	1	14.3†	118.7	91	$3.9x10^{-4}$
		Horizontal	A		7.16	5.00	14.3	120.2	0.29	20	80	97	16	14.3	120.2	96	$1.8x10^{-4}$

Table 1 (Continued)

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

Core No.	Depth Interval (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in²)	u_b (lb/in²)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Hydraulic Conductivity k_{20} (cm/sec)
					Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft³)	n					w_c (%)	γ_d (lb/ft³)	S (%)	
5	1951.4 to 1952.05	Vertical	A	2.79	10.34	10.09	5.7	149.6	0.14	20	169	89**	45	5.8†	149.6	99	1.6×10^{-9}
		Horizontal	C		7.93	5.02	5.7	146.1	0.16	20	169	78**	3	5.8	146.1	85	1.5×10^{-3}
	1953.95 to 1954.55	Vertical	A	2.73	9.67	9.99	12.8	121.7	0.29	20	169	96	9	13.9†	121.7	95	1.4×10^{-5}
		Horizontal	A		7.03	5.03	12.2	122.2	0.28	20	169	98	23	13.9	122.2	96	1.5×10^{-5}
	1955.25 to 1955.9	Vertical	A	2.82	9.62	9.96	11.5	127.8	0.27	20	169	98	15	12.4†	127.8	93	1.4×10^{-5}
		Horizontal	A		6.68	5.00	11.3	125.9	0.28	20	169	95	18	12.4	125.9	88	1.5×10^{-5}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity (except for Core 3, 1801.3 to 1802.2 feet (top) and Core 3, 1801.3 to 1802.2 feet (bottom) for which specific gravities of 2.74 and 2.81, respectively, were used to yield meaningful degrees of saturation).

* Method A = Constant-head test; Method C = Falling-head test with increasing tailwater level.
** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.
† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal permeability test specimen.

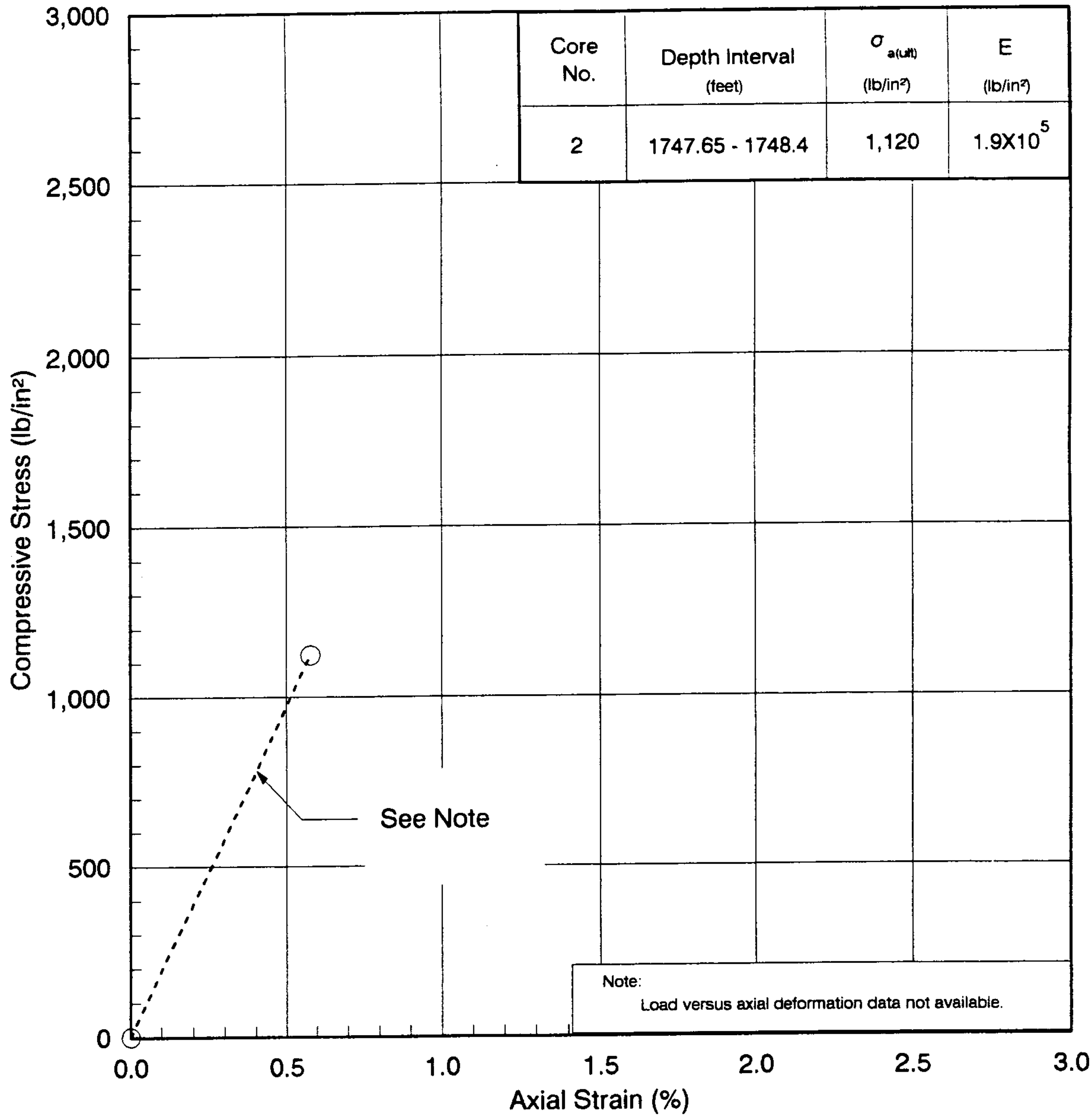
Table 2

UNCONFINED COMPRESSION TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

Core No.	Depth Interval (feet)	Specimen Dimensions			w_c (%)	γ_d (lb/ft^3)	Loading Rate (cm/min)	t_f (min)	Unconfined Compressive Strength, σ_a(ult) (lb/in^2)		Young's Modulus E(lb/in^2)**
		Length L (cm)	Diameter D (cm)	L/D					Measured	Corrected*	
2	1747.65 to 1748.4	6.28	3.28	1.92	10.5	109.2	0.013	2.9	1,120	1,120	1.9×10^5
3	1802.7 to 1803.5	6.19	3.28	1.89	9.8	111.9	0.013	3.4	2,120	2,110	4.5×10^5
4	1850.0 to 1850.8	6.32	3.28	1.92	11.2	108.3	0.013	2.1	560	560	1.9×10^5
5	1951.4 to 1952.05	6.23	3.28	1.90	1.1	156.8	0.013	4.6	5,880	5,850	7.6×10^5
	1955.25 to 1955.9	6.45	3.27	1.97	0.2	122.0	0.013	4.0	3,260	3,250	5.2×10^5

Where: w_c = Moisture content; γ_d = Dry density; and t_f = Time to failure.

* Unconfined compressive strength corrected to L/D ratio of 2 in accordance with ASTM Standard D 2938-86.
** Young's modulus calculated from slope of the straight-line portion of the stress-strain curve.



Core No.	Depth Interval (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
2	1747.65 - 1748.4	1,120	$1.9X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

YOUNGQUIST BROTHERS, INC.

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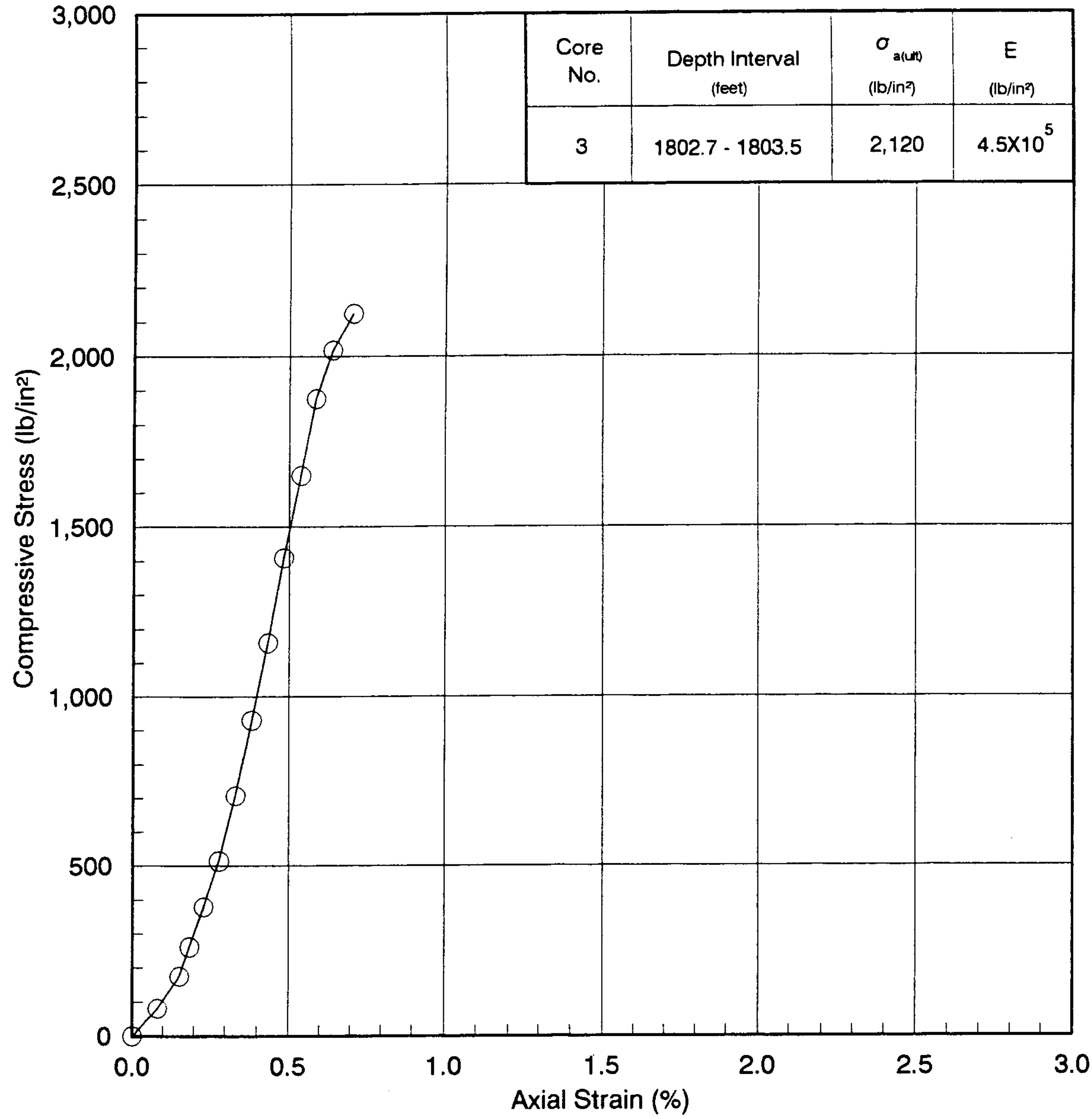
FILE NO.: 99-142	APPROVED BY: [signature]	FIGURE: 1



Core No.	Depth Interval (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
3	1802.7 - 1803.5	2,120	$4.5X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

YOUNGQUIST BROTHERS, INC.

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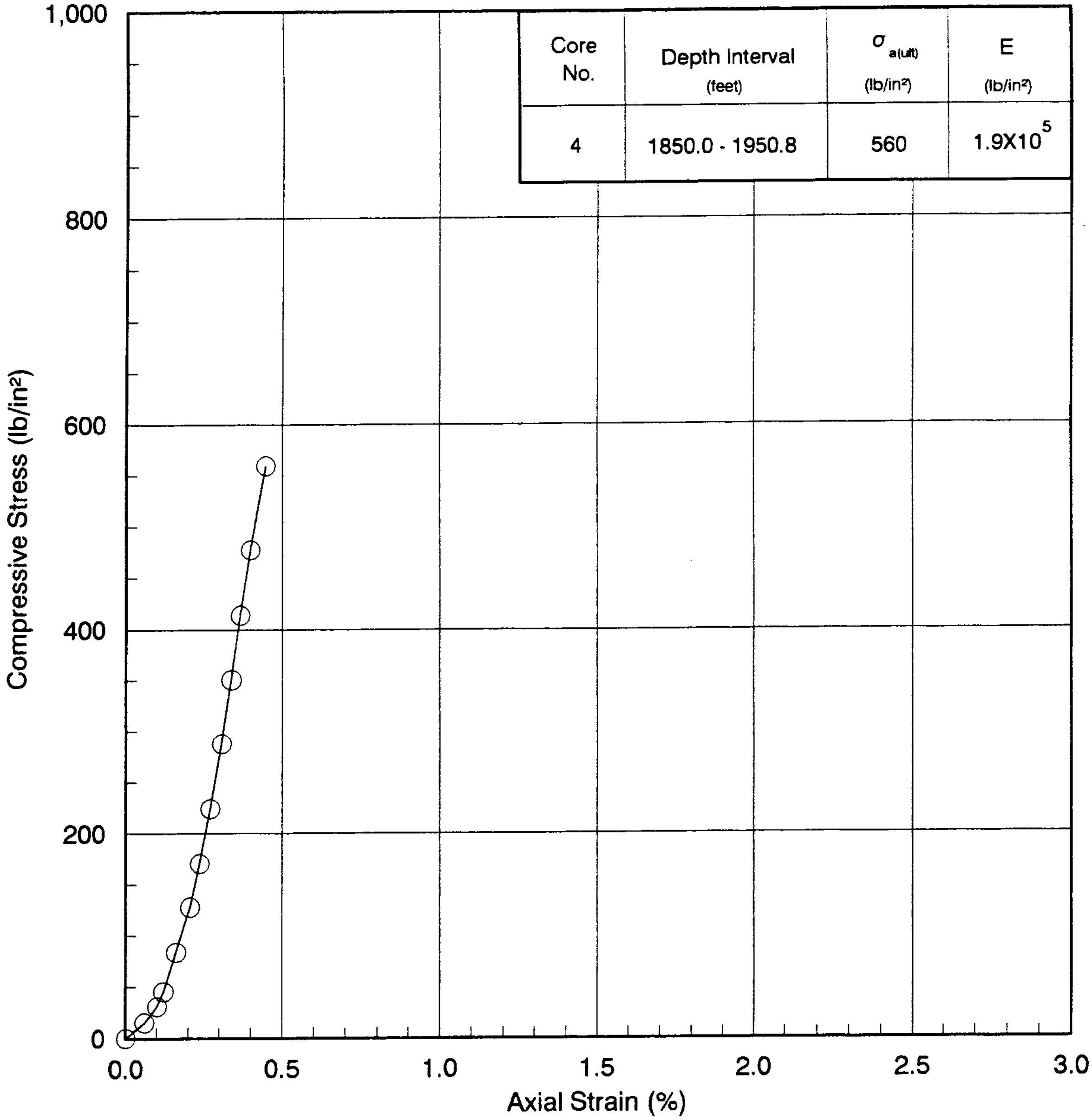
FILE NO.: 99-142	APPROVED BY: [signature]	FIGURE: 2



Core No.	Depth Interval (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
4	1850.0 - 1950.8	560	$1.9X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

YOUNGQUIST BROTHERS, INC.

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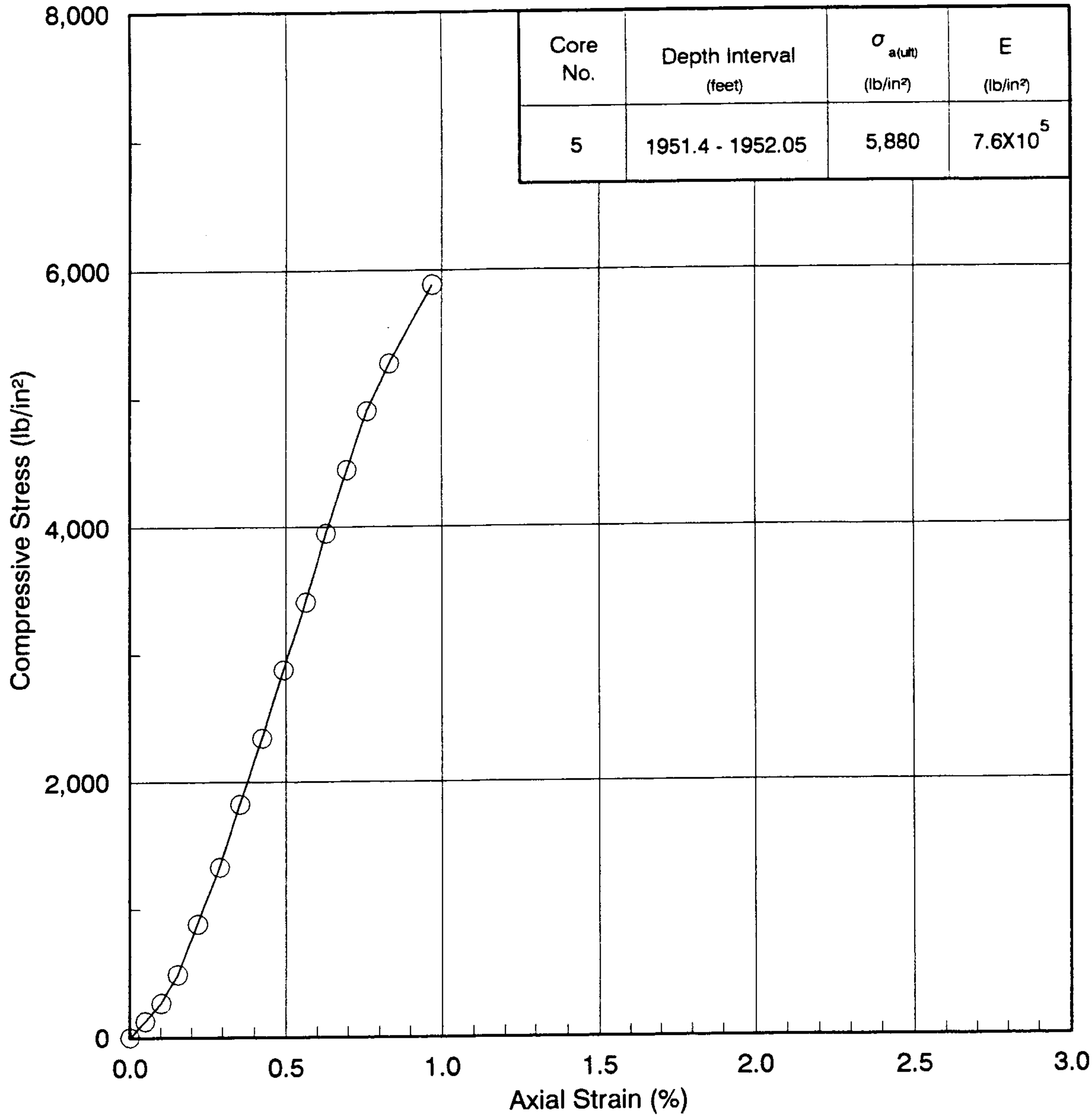
99-142	[signature]	3



Core No.	Depth Interval (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
5	1951.4 - 1952.05	5,880	$7.6X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

YOUNGQUIST BROTHERS, INC.

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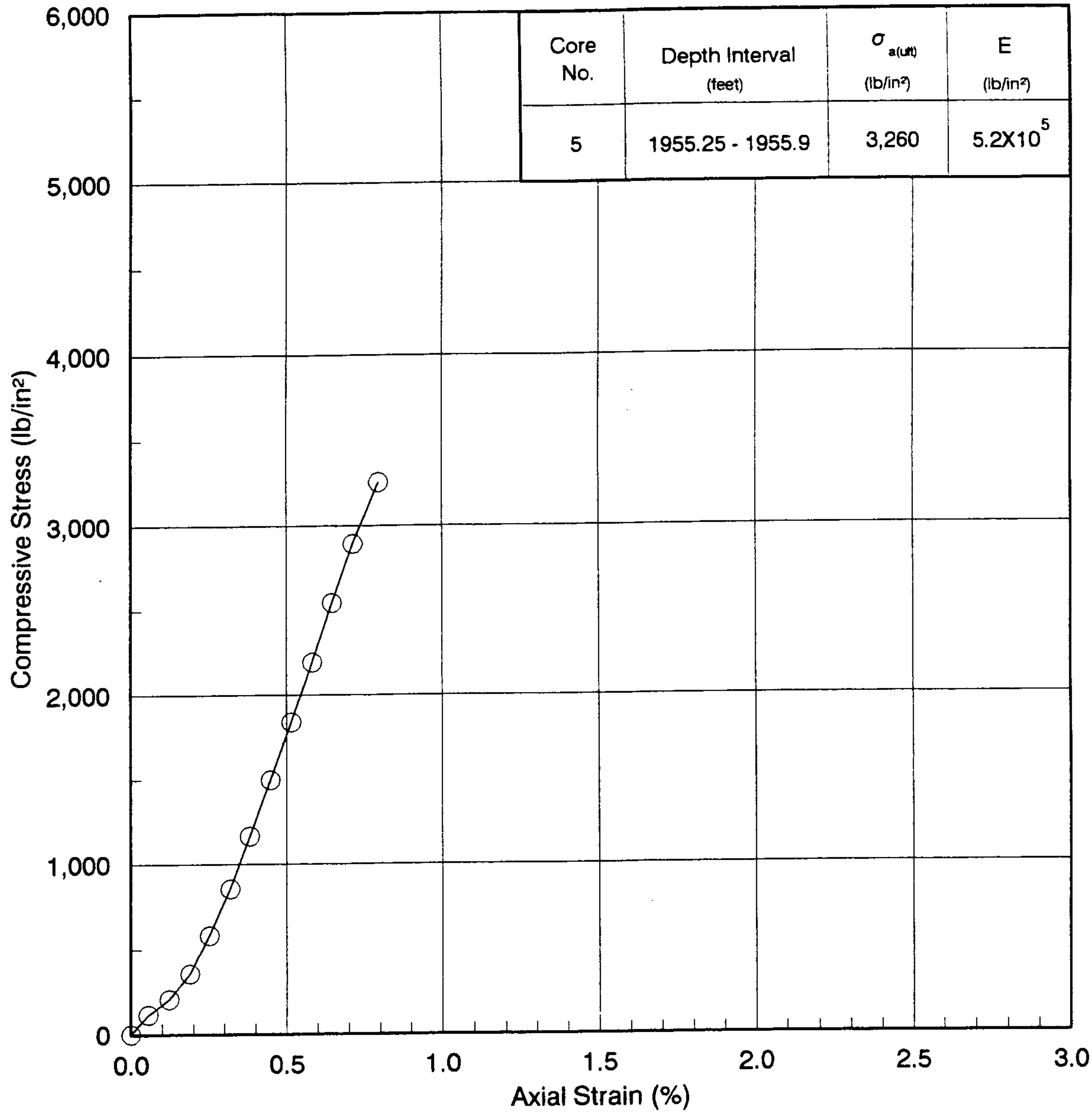

Core No.	Depth Interval (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
5	1955.25 - 1955.9	3,260	$5.2X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WASTEWATER TREATMENT PLANT IW-5

YOUNGQUIST BROTHERS, INC.

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Appendix F - Cores
IW5 Core Description

Depth Interval (feet bpl)	Description IW5 Core 1, 1680 to 1690 feet bpl
1680.0 - 1681.05	LIMESTONE (100%), very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately well indurated, generally massive, fine to very coarse grained with small pebble sized clasts, fossiliferous packstone; faint horizontal bedding features in lower portion with fossil shell fragments up to 2cm in length, increase in dark gray (N3) clastic material near base; sharp wavy lower contact.
1681.05 - 1681.3	LIMESTONE (100%), very pale orange (10YR 8/2) to light gray (N7), moderately well indurated, horizontally laminated to thinly bedded, weakly to locally highly porous/vuggy with vugs up to 5mm, most <1mm, microcrystalline to dominantly cryptocrystalline, carbonate mudstone; sharp, irregular lower contact.
1681.3 - 1684.65	LIMESTONE (100%), very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately well indurated, dominantly massive with local faint bedding features exhibited by color variations, grain sorting, and weakly vuggy intervals, dominantly fine to medium grained, fossiliferous packstone with coarse to very coarse grained particles and fossil fragments scattered throughout section, weakly vuggy 1681.8 to 1681.9 feet with vugs up to 3mm across; base of section from 1684.5 to 1684.65 feet consists of mottled limestone, as above, and light medium gray (N6) carbonate mudstone with possible load cast structures, sharp wavy lower contact.
1684.65 - 1685.3	LIMESTONE (100%), very light gray (N8) to yellowish gray (5Y 8/1), moderately well indurated, dominantly massive, very fine grained to microcrystalline carbonate mudstone with some burrow tubes up to 4mm in diameter; sharp, irregular lower contact.
1685.3 - 1687.8	LIMESTONE (100%), very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately well indurated, generally massive, fine to very coarse grained, fossiliferous packstone with pebble sized grains of fossil fragments (dominantly coral) poorly sorted and scattered throughout section; lower 0.1 to 0.15 feet especially abundant with coral and shell fragments; sharp, irregular lower contact.
1687.8 - 1687.95	LIMESTONE (100%), medium light gray (N6) to medium gray (N5), well indurated, dominantly massive, microcrystalline to dominantly cryptocrystalline carbonate mudstone with burrow tubes up to ½ inch in diameter; sharp, irregular lower contact.

Depth Interval (feet bpl)	Description IW5 Core 1, 1680 to 1690 feet bpl
1687.95 - 1688.6	LIMESTONE (100%), very pale orange (10YR 8/2) to light gray (N7), moderately to well indurated, thin horizontal bedding (faint), microcrystalline to medium grained, fossiliferous wackestone to packstone with some very coarse grained particles scattered throughout section; generally grades downward from light colored, fine to medium grained packstone into darker colored microcrystalline to medium grained wackestone; sharp wavy lower contact.
1688.6 - 1689.45	LIMESTONE (100%), very pale orange (10YR 8/2) to very light gray (N8), moderately indurated, massive, very fine to medium grained, fossiliferous wackestone to packstone.

Depth Interval (feet bpl)	Description IW5 Core 2, 1745 to 1755 feet bpl
1745 - 1746.3	LIMESTONE (100%), upper half consists of very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately well indurated, weakly to moderately vuggy, cryptocrystalline to very fine grained, fossiliferous carbonate mudstone; lower half consists of similar color with medium to dark gray (N3 - N5), thinly bedded bands near base, moderately well indurated, very fine to medium grained grading down to very coarse grained, fossiliferous packstone; very sharp wavy lower contact marked by well cemented carbonate mudstone layer 1 - 3mm thick.
1746.3 - 1747.25	LIMESTONE (100%), very pale orange (10YR 8/2) to very light gray (N7), moderately indurated, faintly bedded and finely vuggy/porous, very fine to very coarse grained, fossiliferous packstone; gradational, coarse to very fine grained, lower contact.
1747.25 - 1748.5	LIMESTONE (100%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately well indurated, dominantly massive, locally vuggy, cryptocrystalline to very coarse grained, fossiliferous wackestone to packstone; relatively sharp, irregular lower contact.
1748.5 - 1749.2	DOLOMITE (100%), yellowish gray (58/1) to mostly dark gray (N3) to grayish black (N2), very well indurated, crudely layered, locally vuggy, very fine grained to cryptocrystalline, matrix supported breccia-conglomerate, fragments/clasts up to 5 mm in length, some at moderate to low angles (10 - 45 degrees) to core axis; vugs irregularly shaped up to 3 cm across and commonly lined with fine grained crystalline dolomite; very sharp, nearly horizontal lower contact; unit is weakly to moderately calcareous.
1749.2 - 1749.85	LIMESTONE (100%), very light gray (N8) to yellowish gray (5Y8/1), locally medium dark gray (N4), moderately well indurated but partly friable, moderately to locally strongly vuggy, highly porous, faintly bedded, cryptocrystalline, carbonate mudstone; sharp lower contact.
1749.85 - 1751.6	LIMESTONE (100%), very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately well indurated, generally massive, fine to very coarse grained, fossiliferous packstone with abundant pebble sized clasts of coral and shell fragments poorly sorted throughout section; bottom 0.2 feet of section consist of matrix and clast supported conglomerate-breccia with clasts up to 3 cm in length; sharp, very irregular lower contact.
1751.6 - 1752.15	LIMESTONE (100%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately well indurated but partly friable, moderately to strongly vuggy, highly porous, cryptocrystalline fossiliferous carbonate mudstone with coarse grained fossil fragments scattered throughout.

Depth Interval (feet bpl)	Description IW5 Core 2, 1745 to 1755 feet bpl
1752.15 - 1753.0	LIMESTONE (100%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately well indurated, generally massive, fine to very coarse grained, fossiliferous wackestone to packstone with pebble sized fossil fragments scattered throughout section; very sharp, wavy, irregular lower contact.
1753.0 - 1753.25	LIMESTONE (100%), light gray (N7) to yellowish gray (5Y 8/1), well indurated, weakly to moderately vuggy, finely porous, fossiliferous, cryptocrystalline carbonate mudstone to wackestone with scattered very coarse sand size fossil fragments throughout section.

Depth Interval (feet bpl)	Description IW5 Core 3, 1800 to 1810 feet bpl
1800 - 1800.15	DOLOMITE AND LIMESTONE: Dolomite (60 - 70%), brownish gray (5Y 4/1), well indurated, crudely layered, microcrystalline to very fine grained, crystalline dolomite with conglomeratic base of dominantly carbonate mudstone fragments up to 1.5 cm in length; conglomerate marks transition into underlying limestone. Limestone (30 - 40%), yellowish gray (5Y 8/1), well indurated, cryptocrystalline to very fine grained wackestone.
1800.15 - 1801.65	LIMESTONE (100%), dominantly very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately indurated, laminated and thinly bedded to massive, cryptocrystalline to medium grained, carbonate mudstone to wackestone; laminated to very thinly bedded in upper 0.5 feet part of section grading into pale yellowish brown (10YR 6/2), massive, partly dolomitized base, transitional into underlying dolomite.
1801.65 - 1802.2	DOLOMITE AND LIMESTONE: Limestone (5 - 10%), consists of lighter colored, transitional (limestone to dolomite) top portion of interval from 1801.65 - 1801.8, well indurated, dominantly fine grained wackestone with very coarse sand size to pebble size bioclasts of coral up to 1 cm across dominantly oriented horizontally; vugs in dolomite appear to be leached coral bioclasts in transitional limestone - dolomite zone. Dolomite (90 - 95%), pale yellowish brown (10YR 6/2) to mostly dark yellowish brown (10YR 4/2), hard, very well indurated, weakly to moderately vuggy (1801.8 to 1802.2 feet), fine grained to cryptocrystalline with vugs rounded to sub-angular and elongated horizontally up to 1 cm across; base of dolomite consists of limestone bioclast conglomerate ~10 mm thick with sharp lower contact.
1802.2 - 1803.8	LIMESTONE (100%), yellowish gray (5Y 8/1) to very pale orange (10YR 8/2) in top 0.5 feet of interval, very pale orange (10YR 8/2) to grayish orange (10YR 7/4) in remainder of interval, generally well indurated throughout, laminated to thinly bedded, dominantly cryptocrystalline to fine grained, carbonate mudstone and wackestone; top 0.1feet consists of cryptocrystalline carbonate mudstone, underlying 0.4feet consists of laminated to thinly bedded, alternating and variably vuggy/porous layers of cryptocrystalline to medium grained and rarely coarse grained carbonate mudstone and wackestone, locally with wavy bedding; interval is transitional over 0.1 feet into laminated to thinly bedded, cryptocrystalline to dominantly fine grained carbonate mudstone, sandy mudstone, and wackestone with wavy bedding and soft sediment deformation features near base; lower 0.05 - 0.1 feet consists of partly deformed, laminated to thinly bedded, microcrystalline to medium grained, locally conglomeratic wackestone to packstone; sharp, irregular lower contact.

Depth Interval (feet bpl)	Description IW5 Core 3, 1800 to 1810 feet bpl
1803.8 - 1807.7	LIMESTONE (100%), very pale orange (10YR 8/2) to grayish orange (10YR 7/4), moderately well indurated, dominantly massive, generally microcrystalline to coarse grained wackestone to packstone with very coarse grained to rarely pebble size fossil fragments scattered throughout section; grades downward from highly vuggy with macroporosity in top 0.1 feet into moderately porous rock units with microporosity throughout majority of section; lower portion from 1807.2 to 1807.5 feet consists of massive, cryptocrystalline to very fine grained wackestone with fewer fossil fragments and patchy dolomitization; base of section from 1807.5 to 1807.7 feet consists of crudely layered, microcrystalline to very coarse grained, conglomeratic, partly dolomitized packstone with dominantly coral bioclasts; transitional lower contact over ~0.05 feet into underlying dolomite.
1807.7 - 1808.05	DOLOMITE AND LIMESTONE: Dolomite (97 - 98%), pale yellowish brown (10YR 6/2) to dominantly dark yellowish brown (10YR 4/2), hard, very well indurated, weakly to locally moderately vuggy, fine grained to cryptocrystalline; vugs mostly rounded to less commonly sub-angular and elongated sub-horizontally up to 10 mm across, larger vugs tend to be irregularly shaped, very angular and commonly lined with fine grained euhedral dolomite crystals. Limestone (2 - 3%), white (N9) to yellowish gray (5Y 8/1), soft to moderately hard, cryptocrystalline with partly dissolved bioclast up to 3 cm across hosted in upper and lower 0.05 to 0.08 feet of section; sharp, irregular lower contact.
1808.5 - 1809.65	LIMESTONE AND DOLOMITE: Limestone (90 - 95%), yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), moderately well to locally very well indurated, thinly bedded (upper 0.6 feet), to dominantly massive (lower 1.0 feet), generally weakly vuggy (upper 0.4 feet), cryptocrystalline to very coarse grained packstone with rare pebble size fossil fragments scattered throughout section up to 2 cm across (especially in lower 0.3 feet); upper 0.1 feet consists of well indurated, vuggy carbonate mudstone, partly dolomitized. Dolomite (5 - 10%), medium gray (N5) and grayish orange (10YR 7/4), well indurated, fine to microcrystalline, consisting of irregular shaped bedding-controlled lenses and stringers distributed throughout section but dominantly in top 0.3 feet of interval; also occurs locally as a fracture filling.

Depth Interval (feet bpl)	Description IW5 Core 4, 1850 to 1860 feet bpl
1850 - 1852.25	LIMESTONE (100%), yellowish gray (5Y 8/1), poorly indurated, massive, moderately vuggy with mm-size boreholes, medium grained, carbonate mudstone to wackestone with trace of medium gray (N5), carbonate mudstone inclusions/clasts.
1852.25 - 1852.85	LIMESTONE (100%), yellowish gray (5Y 8/1), poorly indurated, massive, medium grained micritic wackestone, with abundant vugs and boreholes approximately 1 mm in diameter and rare fossil shell casts.
1852.85 - 1854.3	LIMESTONE (100%), very pale orange (10YR 8/2), poorly indurated, massive, vuggy, medium to coarse grained pelloidal wackstone with trace medium gray (N5) medium grained angular inclusions/clasts; sharp horizontal lower contact.
1854.3 - 1855.0	LIMESTONE (100%), 80% very pale orange (10YR 8/2), poorly indurated, massive, vuggy, medium grained pelloidal wackestone with 20% medium gray (N5), micritic limestone inclusions.
1855.0 - 1856.5	LIMESTONE (100%), very pale orange (10YR 8/2), moderately indurated, generally massive, medium grained wackestone. Sharp horizontal lower contact.
1856.5 - 1857.1	LIMESTONE (100%), very pale orange (10YR 8/2), moderately well indurated, massive, medium to coarse grained mudstone to wackestone; locally vuggy with vugs ~5 mm in diameter.
1857.1 - 1859.7	LIMESTONE (100%), very pale orange (10YR 8/2), moderately well indurated, massive, medium grained fossiliferous packstone, fossil content increases with depth.
1859.7 - 1860.0	LIMESTONE (100%), very pale orange (10YR 8/2), well indurated, massive, medium grained micritic grainstone with a few widely spaced thin beds.

Depth Interval (feet bpl)	Description IW5 Core 5, 1950 to 1960 feet bpl
1950 - 1950.3	LIMESTONE (100%), very pale orange (10YR 8/2), moderately hard, massive, medium to coarse grained, fossiliferous, pelloidal wackestone to packstone with faint laminations (~1mm) in lower part of section.
1950.3 - 1950.45	DOLOMITIC LIMESTONE (100%), very pale orange (10YR 8/2) to moderate yellowish brown (10YR 5/4) limestone at top of interval grading to darker colored dolomitic limestone down section; moderately hard, massive, well indurated, medium to coarse grained with scattered, angular limestone fragments (~1mm) imbedded in the dolomite in lower part of section. Gradational upper and lower contacts.
1950.45 - 1950.85	DOLOMITE (100%), moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2), very hard, massive, well indurated, cryptocrystalline to microcrystalline, sucrosic, very slightly vuggy from 1950.45 to 1950.6 ft and moderately vuggy from 1950.6 to 1950.75 ft, vugs are 1 - 3 mm in diameter and irregularly shaped.
1950.85 - 1951.0	DOLOMITE BRECCIA (100%), 50% dark yellowish brown (10YR 4/2), hard, very slightly vuggy, cryptocrystalline to microcrystalline with sucrosic texture; 50% medium dark gray (N4), very hard, massive, cryptocrystalline with irregularly shaped fragments up to 0.25 inches across and vugs up to 0.5 inches across distributed throughout section, and very low to low apparent macroporosity. Sharp lower contact.
1951.0 - 1951.3	DOLOMITE AND LIMESTONE: Limestone (15%), very pale orange (10YR 8/2), moderately hard packstone in top 0.05 to 0.01 ft of section grading down section into dolomite. Dolomite (85%); (35%), medium light gray (N6), moderately hard, cryptocrystalline to microcrystalline in top 0.05 to 0.15 ft of section with wavy bedding features. Dolomite (50%), moderate yellowish brown (10YR 5/4), moderately hard and vuggy, locally fractured, cryptocrystalline to microcrystalline with faint bedding features in lower part of section.
1951.3 - 1951.4	DOLOMITE (100%), moderate yellowish brown (10YR 5/4), soft, friable, poorly consolidated, crystalline.
1951.4 - 1951.9	DOLOMITE (100%), moderate yellowish brown (10YR 5/4), hard, generally massive and slightly vuggy in top 0.3 feet of section grading down section into dark yellowish brown (10YR 4/2), very hard, cryptocrystalline to microcrystalline with faint bedding features in lower 0.1 to 0.2 ft of section. Gradational lower contact.

Depth Interval (feet bpl)	Description IW5 Core 5, 1950 to 1960 feet bpl
1951.9 - 1952.38	DOLOMITE AND LIMESTONE: Dolomite (90%), dark yellowish brown (10YR 4/2) to dusky yellowish brown (10YR 2/2), very hard, faintly bedded, cryptocrystalline to microcrystalline with prominent bedding features in top 0.1 feet of section consisting of millimeter size laminations of darker colored dolomite; dusky yellowish brown (10YR 2/2), cryptocrystalline, weakly calcareous and slightly vuggy with vugs up to 3mm across in lower 0.25 feet of section. Limestone (10%), very pale orange (10YR 8/2), angular, dolomitic fragments ~1mm across scattered throughout upper 0.25 feet of section and up to 3mm across scattered in lower 0.15 ft. Irregular lower contact.
1952.38 - 1953.3	DOLOMITE (100%), dark yellowish brown (10YR 4/2) to dusky yellowish brown (10YR 2/2), very hard, dense, very well indurated, very slightly calcareous, cryptocrystalline, and slightly vuggy with sparse vugs up to 5 mm in diameter. Sharp lower contact.
1953.3 - 1953.55	DOLOMITE AND LIMESTONE: Dolomite (65%), dark yellowish brown (10YR 4/2), moderately hard, cryptocrystalline to microcrystalline, crudely interbedded with Limestone. Limestone (35%), very pale orange (10YR 8/2) to very light gray (N8), hard, well indurated, dolomitic wackestone. Sharp, irregular lower contact.
1953.55 - 1953.85	LIMESTONE (100%), very pale orange (10YR 8/2), moderately to poorly consolidated, chalky, very fine grained wackstone/carbonate mudstone with trace euhedral dolomite crystals.
1953.85 - 1954.0	LIMEY DOLOMITE (100%), grayish orange (10YR 7/4), moderately hard, massive, microcrystalline, calcareous. Trace very pale orange (10YR 8/2), dolomitic limestone. Sharp, irregular lower contact.
1954.0 - 1954.55	LIMESTONE AND DOLOMITE: Limestone (95%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, well indurated, massive, very slightly vuggy, fine to medium grained pelloidal packstone, locally dolomitic. Dolomite (5%), grayish orange (10YR 7/4), consisting of scattered, dolomitic limestone patches distributed throughout section.
1954.55 - 1955.55	LIMESTONE (100%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, well indurated, massive, very slightly vuggy, fine to medium grained, fossiliferous, pelloidal packstone to wackestone, gradational into dolomitic limestone in bottom 0.1 foot of section.
1955.55 - 1955.9	DOLOMITIC LIMESTONE (100%), grayish orange (10YR 7/4) to yellowish gray (5Y 8/1), hard, well indurated, microcrystalline to fine grained, gradational into dolomite in lower part of interval.

Depth Interval (feet bpl)	Description IW5 Core 5, 1950 to 1960 feet bpl
1955.9 - 1956.25	DOLOMITE AND LIMESTONE: Dolomite (80%), grayish orange (10YR 7/4), hard, well indurated, massive, very slightly vuggy microcrystalline to cryptocrystalline. Limestone (20%), very pale orange (10YR 8/2), consisting of angular fragments scattered throughout interval, but decrease in abundance down section. Gradational lower contact.
1956.25 - 1956.65	DOLOMITE AND LIMESTONE: Dolomite (90%), pale yellowish brown (10YR 6/2) to grayish orange (10YR 7/4) and scattered medium gray (N5) to dark gray (N4), hard, well indurated, massive, vuggy, sucrosic, cryptocrystalline with vugs up to 3mm in diameter, many in the shape of shell molds, and rarely up to ~ 0.01 ft across lined with euhedral dolomite crystals. Limestone (10%), very pale orange (10YR 8/2), consisting primarily of irregularly shaped clasts and fossil fragments scattered throughout section.

Ardaman & Associates, Inc.

Geotechnical, Environmental and Materials Consultants

July 26, 1999
File Number 99-063

Youngquist Brothers, Inc.
15465 Pine Ridge Road
Fort Myers, Florida 33908

Attention: Mr. Edward McCullers

Subject: Laboratory Tests, Rock Core Specimens, Broward County North Regional WWTP, Injection Well No. 6

Gentlemen:

As requested, permeability, unconfined compression and specific gravity tests have been completed on 18 core samples provided for testing by your firm from the Broward County North Regional WWTP Injection Well No. 6. As directed by the project hydrogeologist, Hazen & Sawyer, tests were performed on each rock type in samples that contained more than one rock type (i.e., cores 5, 8 and 10) when possible. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter" using the constant-head (Method A) and falling-head with increasing tailwater level (Method C) test methods. The unconfined compression tests were performed in general accordance with ASTM Standard D 2938 "Unconfined Compressive Strength of Intact Rock Core Specimens". The specific gravity was determined in general accordance with ASTM Standard D 854 "Specific Gravity of Soils". Due to the irregular shape and short length of some of the core samples, each of the requested tests (i.e., vertical permeability test, horizontal permeability test and unconfined compression test) could not be performed on each sample.

Permeability Tests

The permeability test results are presented in Table 1. The core samples provided for testing were typically too short to obtain separate vertically and horizontally oriented specimens. Accordingly, the vertical permeability tests were typically performed first on specimens maintained at the as-received diameter and cut to lengths of 8.0 to 12.7 cm. After completing the vertical permeability tests, horizontal permeability test specimens were typically obtained by coring 5.1 cm diameter cylinders from the vertical specimens. The horizontal specimens were then trimmed to lengths of 6.1 to 8.1 cm to provide flat, parallel ends. Since the vertical permeability test specimens typically were cored upon completion of testing to obtain horizontal permeability test specimens, the final moisture contents of the vertical specimens were not measured. The dry densities and degrees of saturation of the vertical permeability test specimens, therefore, were estimated using the final moisture contents from the corresponding horizontal permeability test specimens.

The permeability test specimens were air-dried, deaired under vacuum, and then saturated with deaired tap water from the bottom upward while still under vacuum. Each specimen was then mounted in a triaxial-type permeameter and encased within a latex membrane. The specimens were confined using an average isotropic effective confining stress of 20 lb/in^2 and permeated with deaired tap water under back-pressures of 70 to 169 lb/in^2. Satisfactory saturation was verified by a B-factor equal to or greater than 95%, or a B-factor that remained relatively constant for two consecutive increments of applied cell pressure. The inflow to and outflow from each specimens were monitored with time, and the hydraulic conductivity was calculated for each recorded flow increment. The tests were continued until steady-state flow conditions were obtained, as

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Youngquist Brothers, Inc.
File Number 99-063
July 26, 1999

Table 1

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL No. 6 CORE SAMPLES

Core No.	Depth (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions: Length (cm)	Initial Conditions: Diameter (cm)	Initial Conditions: w_c (%)	Initial Conditions: γ_d (lb/ft^3)	Initial Conditions: n	$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	B Factor (%)	Average Hydraulic Gradient	Final Conditions: w_c (%)	Final Conditions: γ_d (lb/ft^3)	Final Conditions: S (%)	Saturated Hydraulic Conductivity k_{20} (cm/sec)
1	1787.6-1788.3	Vertical	C	2.71	8.00	9.80	22.9	103.1	0.39	20	80	85**	2.2	23.0†	103.1	97	1.9×10^{-4}
		Horizontal	C		7.68	5.00	23.0	103.2	0.39	20	80	93**	2.5	23.0	103.2	97	2.5×10^{-4}
2	1790.0-1791.0	Vertical	A	2.71	10.43	9.66	21.2	107.0	0.37	20	79	88**	13	21.2†	107.0	99	1.1×10^{-4}
		Horizontal	A		6.60	5.02	21.1	106.1	0.37	20	79	87**	23	21.2	106.1	97	2.0×10^{-4}
3	1793.0-1793.7	Vertical	A	2.70	8.60	9.83	23.5	100.2	0.41	20	169	98	25	23.5†	100.2	93	7.5×10^{-5}
		Horizontal	A		7.28	4.98	23.4	101.9	0.40	20	169	98	25	23.5	101.9	97	6.3×10^{-5}
4	1797.0-1798.0	Vertical	A	2.70	10.86	9.70	19.7	109.9	0.35	20	79	85**	9	19.8	109.9	100	8.1×10^{-6}
		Horizontal	A		6.72	5.01	18.1	112.0	0.34	20	79	92**	21	18.1	112.0	97	8.5×10^{-6}
5	1799.3-1800.4 (Top)	Vertical	A	2.83	12.21	9.93	9.5	138.1	0.22	20	169	97	10	9.7†	138.1	99	1.8×10^{-6}
		Horizontal	A		7.61	5.01	9.7	136.1	0.23	20	169	98	16	9.7	136.1	93	1.6×10^{-6}
	1799.3-1800.4 (Bottom)	Vertical	A	2.74	12.72	9.96	11.5	129.0	0.25	20	79	93**	16	11.5†	129.0	97	1.2×10^{-6}
		Horizontal	A		6.81	5.02	11.5	128.9	0.25	20	169	97	39	11.5	128.9	97	1.8×10^{-6}
6	1801.7-1802.6	Vertical	A	2.84	8.41	10.06	6.3	148.6	0.16	20	169	95**	40	6.6†	148.6	98	4.3×10^{-9}
		Horizontal	A		7.52	5.03	6.6	148.9	0.16	20	169	95	46	6.6	148.9	99	4.0×10^{-9}
7	1806.0-1806.6	Vertical	A	2.70	8.32	9.69	16.6	114.6	0.32	20	79	90**	19	16.6†	114.6	95	6.4×10^{-6}
		Horizontal	A		6.63	5.03	16.6	115.2	0.32	20	169	95	20	16.6	115.2	97	1.2×10^{-5}
8††	1806.6-1807.6 (Top)	Vertical	A	2.74	9.52	9.94	13.5	122.8	0.28	20	79	85**	17	13.5†	122.8	95	1.4×10^{-6}
		Horizontal	A		6.50	5.02	13.5	122.8	0.28	20	169	96	27	13.5	122.8	94	2.2×10^{-6}
	1806.6-1807.6 (Bottom)	Vertical	A	2.81	9.41	10.09	3.0	160.7	0.08	20	169	98	17	3.0†	160.7	93	1.0×10^{-8}
		Horizontal	A		7.54	5.04	3.0	161.6	0.08	20	167	97	53	3.0	161.6	100	1.0×10^{-8}
9	1810.5-1811.2	Vertical	A	2.71	9.41	9.30	17.9	113.8	0.33	20	79	95	13	17.9†	113.8	100	1.1×10^{-4}
		Horizontal	A		6.36	5.02	17.9	113.3	0.33	20	80	--	12	17.9	113.3	98	1.3×10^{-4}
10††	1816.4-1816.9	Vertical	A	2.74 (Top)	10.28	9.85	9.6	138.2	0.21	20	169	90**	15	9.6†	138.2	100	1.1×10^{-7}
		Horizontal	A	2.85 (Bottom)	7.55	5.02	9.6	135.9	0.21	20	169	99	15	9.6	135.9	100	3.9×10^{-6}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity (except for Core No. 10 for which specific gravities of 2.82 and 2.76 were assumed for the vertical and horizontal specimens, respectively).

* Method A = Constant-head test; Method C = Falling-head test with increasing tailwater level.
** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.
† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal permeability test specimen.
†† Top and bottom of samples consisted of limestone and dolomite, respectively.

Youngquist Brothers, Inc.
File Number 99-063
July 26, 1999

Table 1 (Continued)

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL No. 1 CORE SAMPLES

Core No.	Depth (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in²)	u_b (lb/in²)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Saturated Hydraulic Conductivity k_{20} (cm/sec)
					Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft³)	n					w_c (%)	γ_d (lb/ft³)	S (%)	
11	1835.3-1836.0	Vertical	A	2.72	11.27	9.76	21.7	106.6	0.37	20	79	93**	10	21.7†	106.6	100	2.8×10^{-5}
		Horizontal	A		6.07	5.01	21.7	105.5	0.38	20	79	91**	21	21.7	105.5	97	3.8×10^{-5}
12	1966.0-1966.4	Vertical	A	2.73	9.32	10.04	12.8	122.4	0.28	20	169	89**	19	12.8†	122.4	89	2.2×10^{-6}
		Horizontal	A		6.95	5.01	12.6	125.4	0.26	20	169	99	25	12.8	125.4	98	3.9×10^{-6}
13	1966.5-1967.7 (Top)	Vertical	A	2.78	9.55	9.94	9,2	135.9	0.22	20	169	98	11	9.2†	135.9	93	2.0×10^{-6}
		Horizontal	A		7.98	5.02	9.2	136.7	0.21	20	169	98	19	9.2	136.7	95	1.5×10^{-6}
	1966.5-1967.7 (Bottom)	Vertical	A	2.84	8.98	10.11	3.2	162.0	0.09	20	169	73**	18	3.2†	162.0	96	3.8×10^{-8}
		Horizontal	A		8.08	5.04	3.2	161.8	0.09	20	169	95	50	3.2	161.8	94	2.8×10^{-8}
14	1968.0-1968.5	Vertical	A	2.72	8.30	9.95	12.3	124.8	0.26	20	169	95**	18	12.3†	124.8	93	3.1×10^{-6}
		Horizontal	A		6.74	4.99	12.3	124.4	0.27	20	169	99	28	12.3	124.4	92	4.2×10^{-6}
15	1988.0-1989.4	Vertical	A	2.85	9.65	10.12	2.8	163.0	0.08	20	169	96	29	2.9	163.0	92	3.1×10^{-9}
		Horizontal	A		7.39	5.03	3.0	162.9	0.08	20	169	96	21	3.0	162.9	93	2.0×10^{-8}
16	1989.3-1991.0	Vertical	A	2.84	10.23	10.10	4.2	156.4	0.12	20	169	96	13	4.6	156.4	98	1.9×10^{-7}
		Horizontal	A		7.24	5.04	3.8	158.0	0.11	20	169	80**	24	4.2	158.0	98	3.9×10^{-7}
17	1993.5-1994.0	Vertical	A	2.84	10.56	10.11	12.9	129.9	0.27	20	70	96	0.3	12.9†	129.9	100	1.4×10^{-3}
		Horizontal	C		6.86	5.03	12.9	127.6	0.28	20	80	95	0.9	12.9	127.6	94	1.9×10^{-3}
18	1995.3-1996.0	Vertical	A	2.88	8.58	10.12	2.9	161.6	0.10	20	169	94**	24	3.0†	161.6	76	9.6×10^{-9}
		Horizontal	A		8.11	5.04	2.8	165.4	0.08	20	169	97	30	3.0	165.4	99	2.7×10^{-8}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity.

* Method A = Constant-head test; Method C = Falling-head test with increasing tailwater level.
** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.
† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal permeability test specimen.

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Youngquist Brothers, Inc.
File Number 99-063
July 26, 1999

Table 2

UNCONFINED COMPRESSION TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL No. 6 CORE SAMPLES

Core No.	Depth (feet)	Specimen Dimensions			w_c (%)	γ_d (lb/ft^3)	Loading Rate (cm/min)	t_f (min)	Unconfined Compressive Strength, σ_a(ult) (lb/in^2)		Young's Modulus E(lb/in^2)**
		Length L (cm)	Diameter D (cm)	L/D					Measured	Corrected*	
1	1787.6-1788.3	9.20	5.04	1.82	0.3	117.3	0.013	4.5	2,140	2,120	$4.4x10^5$
2	1790.0-1791.0	9.79	5.04	1.94	0.3	119.1	0.013	4.8	2,380	2,370	$4.6x10^5$
3	1793.0-1793.7	10.42	5.03	2.07	0.3	118.6	0.013	5.4	2,430	2,440	$4.9x10^5$
4	1797.0-1798.0	10.10	5.05	2.00	0.2	122.8	0.013	5.6	3,070	3,070	$5.3x10^5$
6	1801.7-1802.6	8.68	5.03	1.73	0.4	156.6	0.013	8.3	8,590	8,430	$7.5x10^5$
7	1806.0-1806.6	9.76	5.05	1.93	0.2	126.5	0.013	4.4	3,220	3,210	$5.4x10^5$
13	1966.5-1967.7	9.95	5.05	1.97	0.2	165.2	0.013	9.7	9,510	9,490	$8.4x10^5$
15	1988.0-1989.4	10.40	5.04	2.06	0.4	167.6	0.013	13.2	13,600	13,650	$8.6x10^5$
16	1989.3-1991.0	11.03	5.05	2.19	0.8	161.8	0.013	8.5	8,550	8,640	$9.4x10^5$
18	1995.3-1996.0	10.39	5.04	2.06	2.0	160.7	0.013	13.2	13,720	13,770	$8.6x10^5$

Where: w_c = Moisture content; γ_d = Dry density; and t_f = Time to failure.

* Unconfined compressive strength corrected to L/D ratio of 2 in accordance with ASTM Standard D 2938-86.
** Young's modulus calculated from slope of the straight-line portion of the stress-strain curve.

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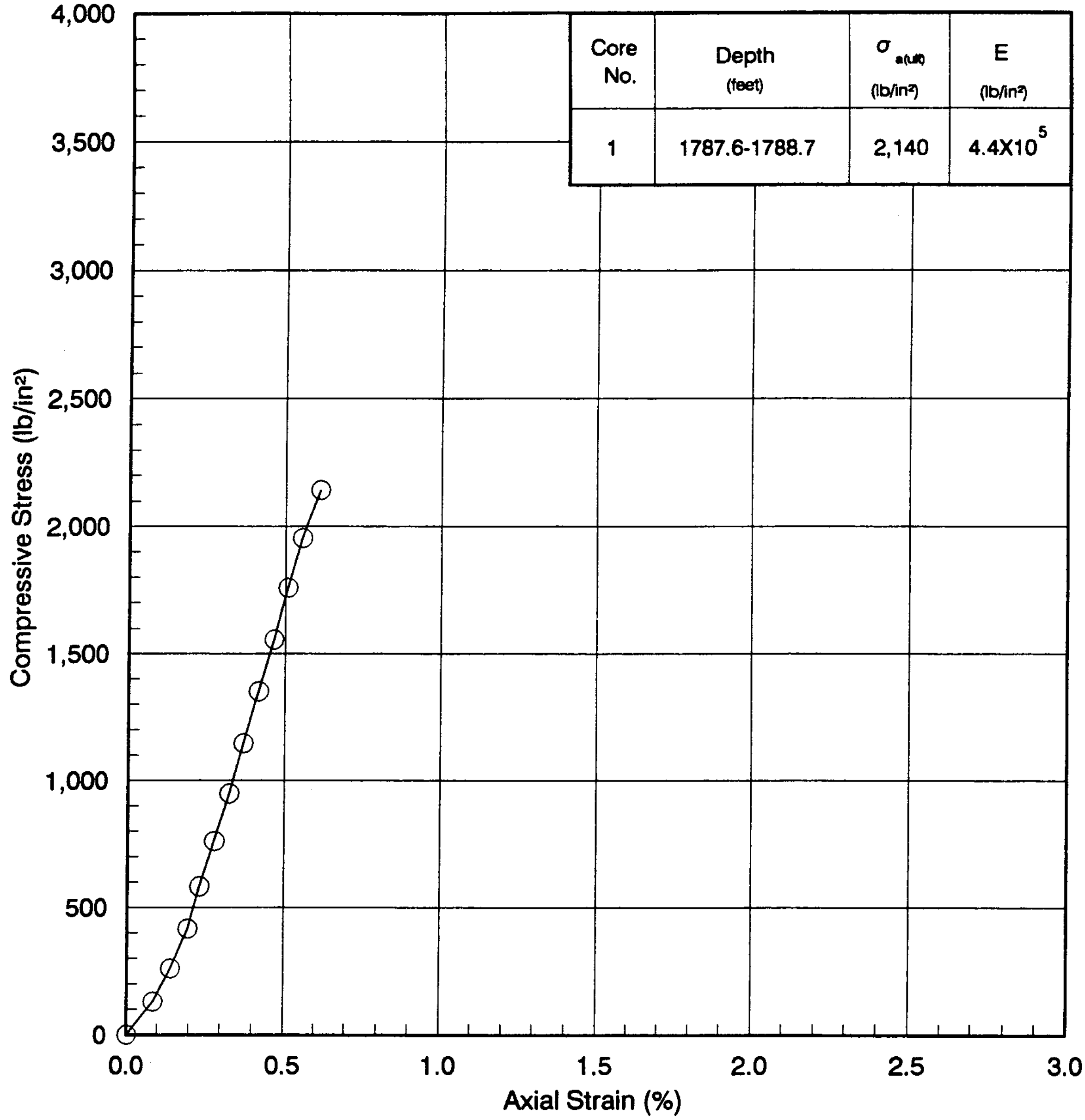

Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
1	1787.6-1788.7	2,140	$4.4X10^5$

UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY NORTH REGIONAL WWTP
INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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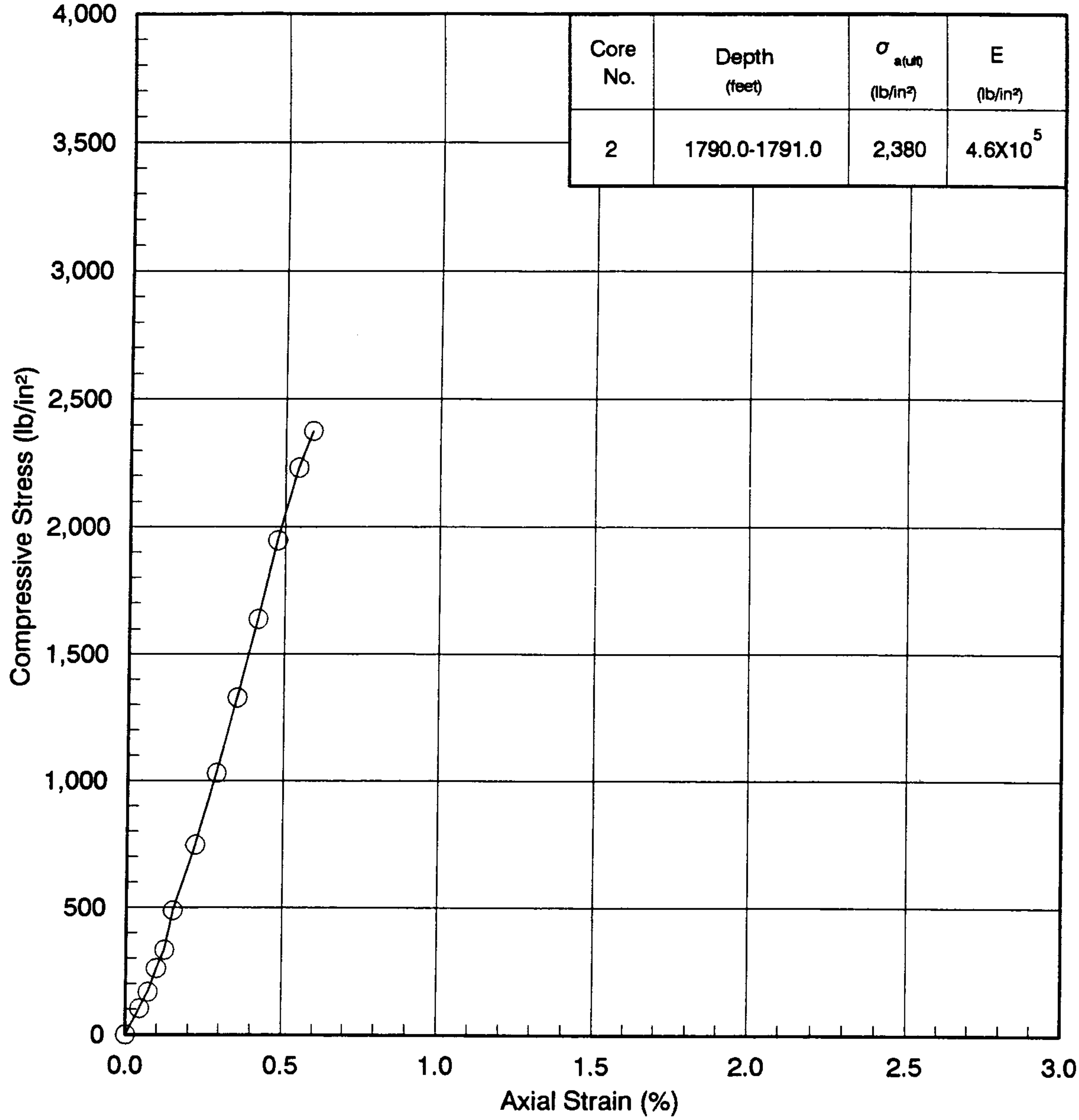
FILE NO.: 99-063	APPROVED BY:	FIGURE: 1



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
2	1790.0-1791.0	2,380	$4.6X10^5$

UNCONFINED COMPRESSION TEST

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INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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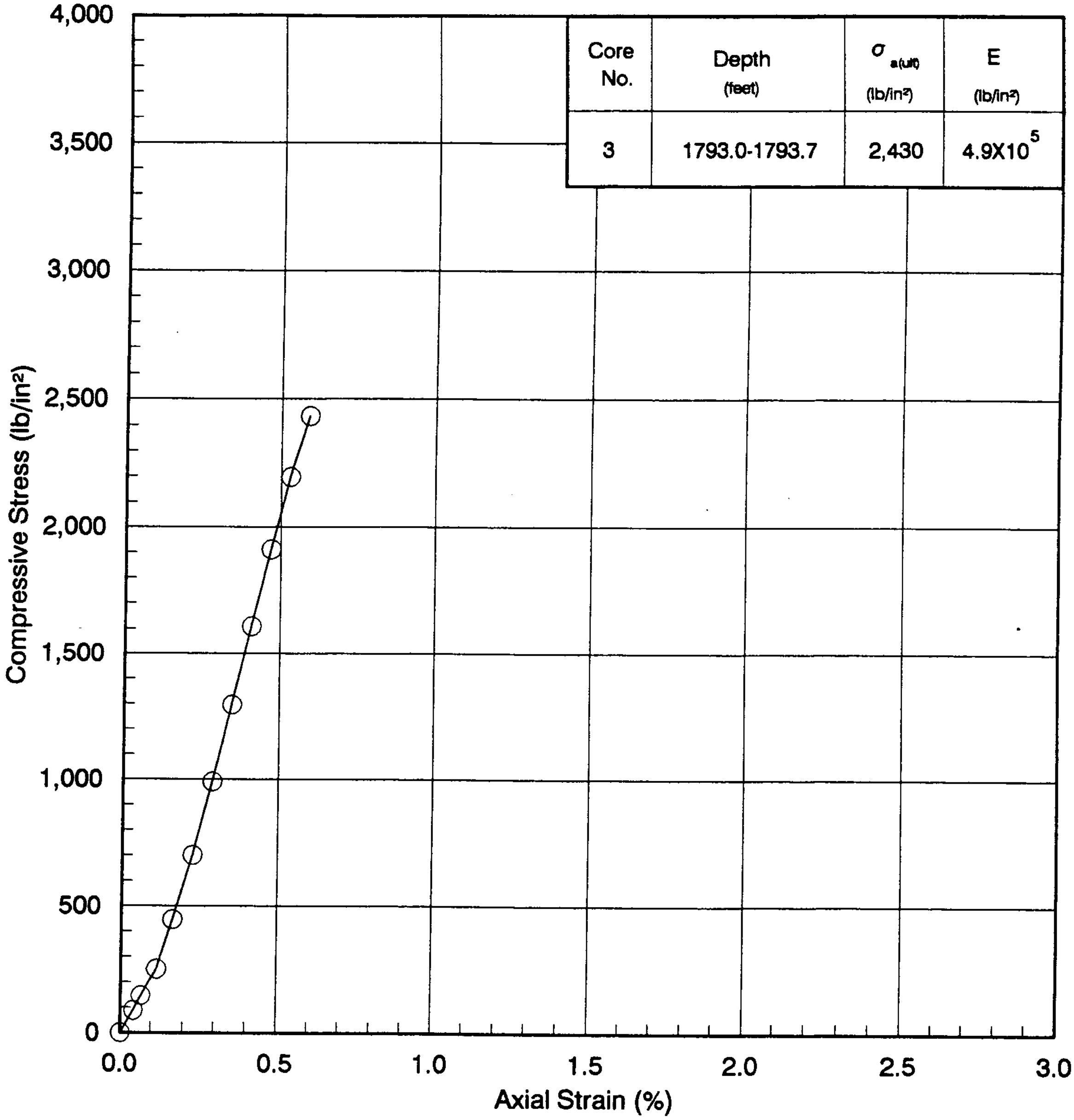
FILE NO.: 99-063	APPROVED BY: [signature]	FIGURE: 2



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
3	1793.0-1793.7	2,430	$4.9X10^{5}$

UNCONFINED COMPRESSION TEST

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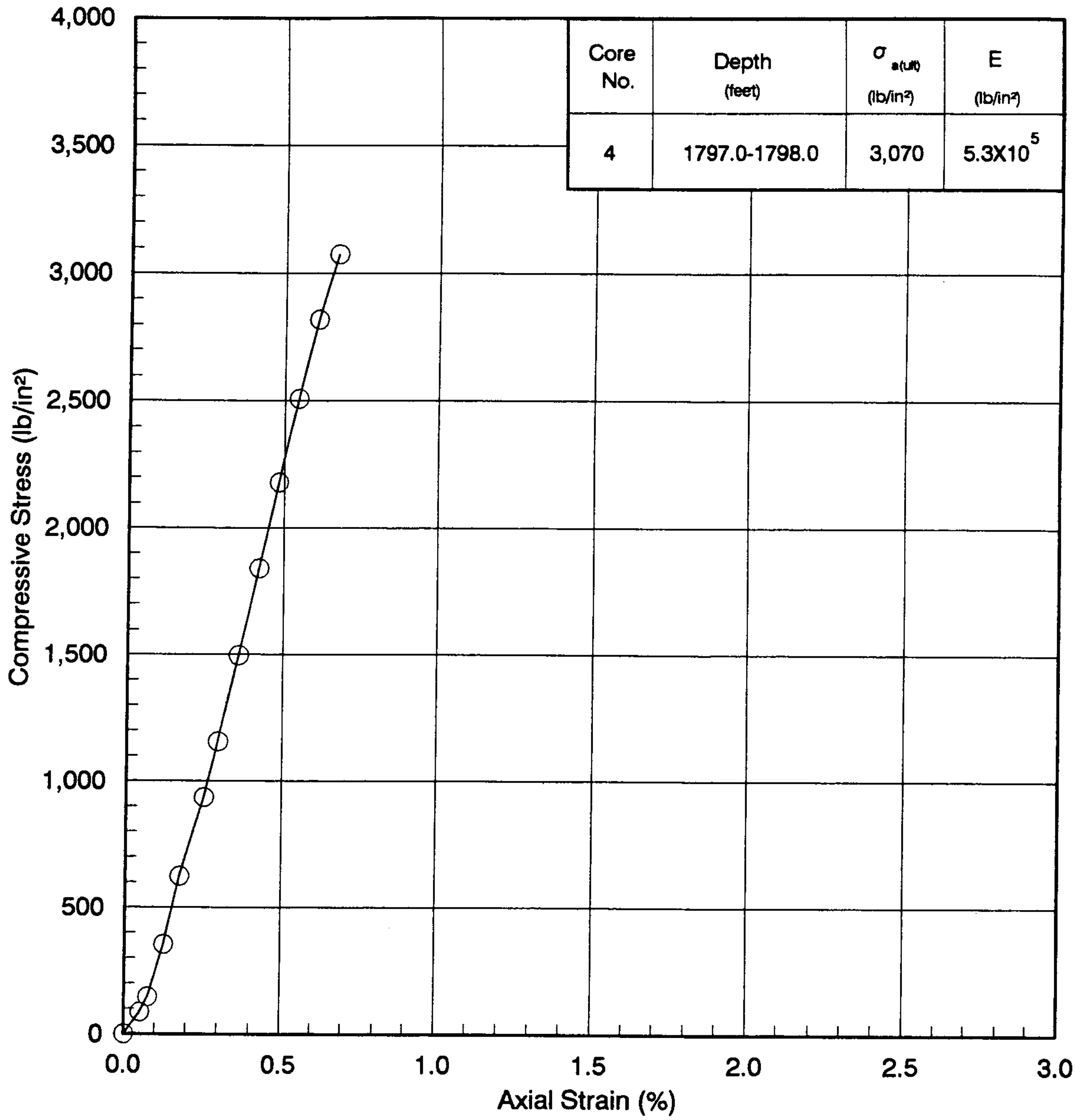
BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

DRAWN BY: SA	CHECKED BY: SA	DATE: 07-14-99
FILE NO.: 99-063	APPROVED BY:	FIGURE: 3



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
4	1797.0-1798.0	3,070	$5.3X10^5$

UNCONFINED COMPRESSION TEST

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INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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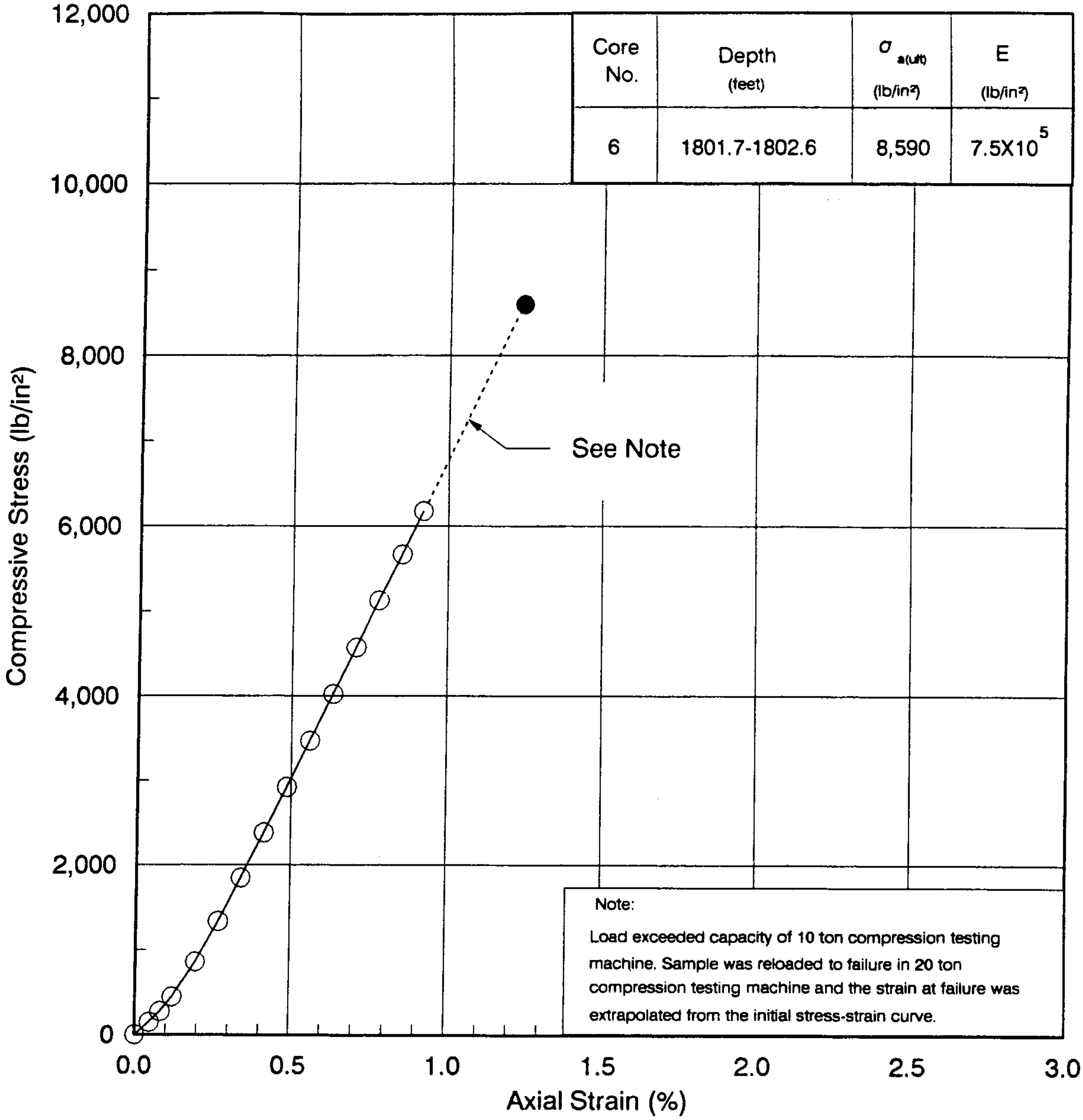
FILE NO.: 99-063	APPROVED BY: [signature]	FIGURE: 4



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
6	1801.7-1802.6	8,590	$7.5X10^5$

UNCONFINED COMPRESSION TEST

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BROWARD COUNTY NORTH REGIONAL WWTP
INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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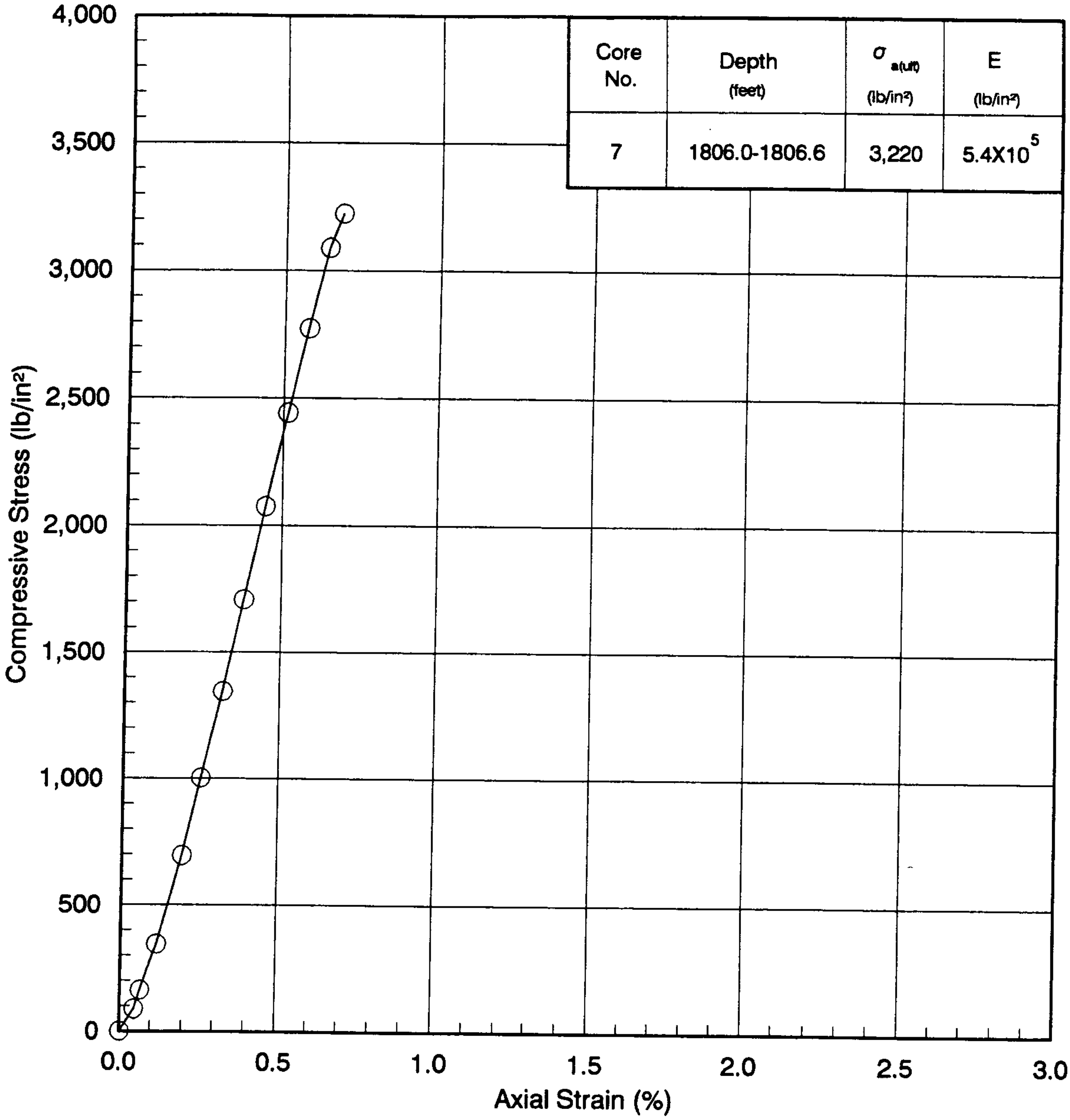
FILE NO.: 99-063	APPROVED BY: [signature]	FIGURE: 5



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
7	1806.0-1806.6	3,220	$5.4X10^5$

UNCONFINED COMPRESSION TEST

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BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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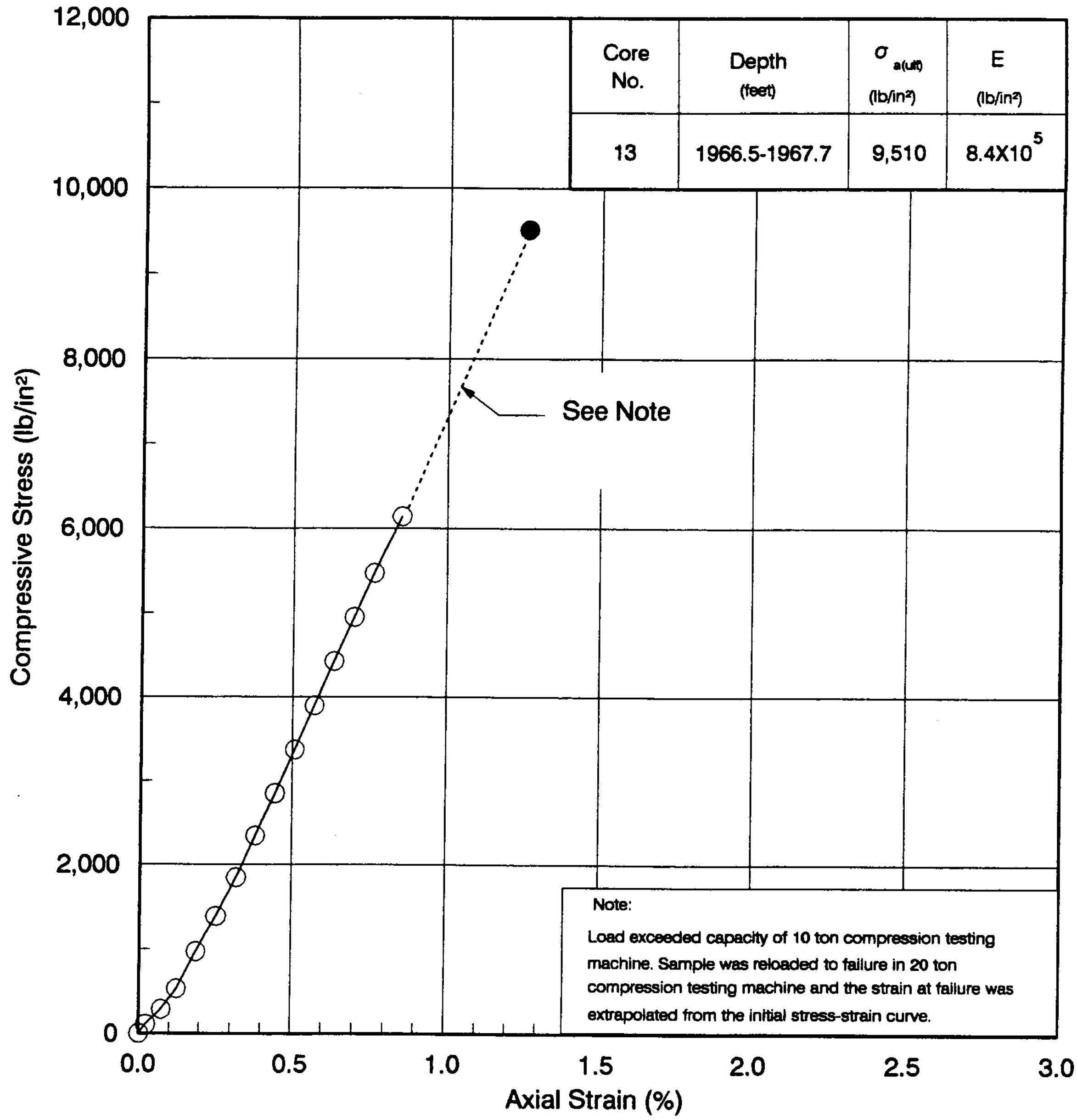
FILE NO.: 99-063	APPROVED BY:	FIGURE: 6



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INJECTION WELL NO. 6

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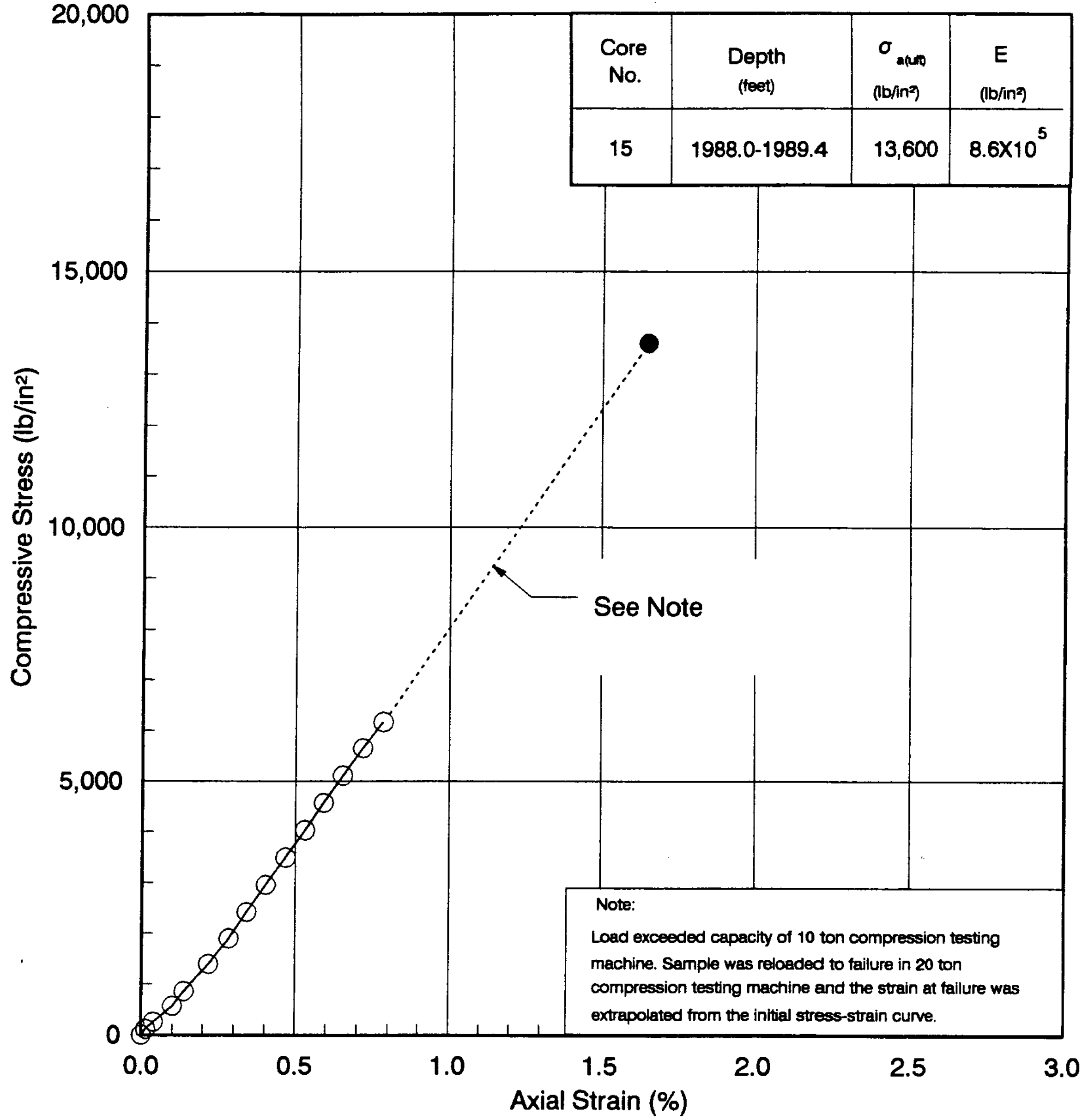
DRAWN BY: SA	CHECKED BY: SA	DATE: 07-14-99
FILE NO.: 99-063	APPROVED BY: Thomas Ahogen	FIGURE: 7



UNCONFINED COMPRESSION TEST

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BROWARD COUNTY NORTH REGIONAL WWTP
INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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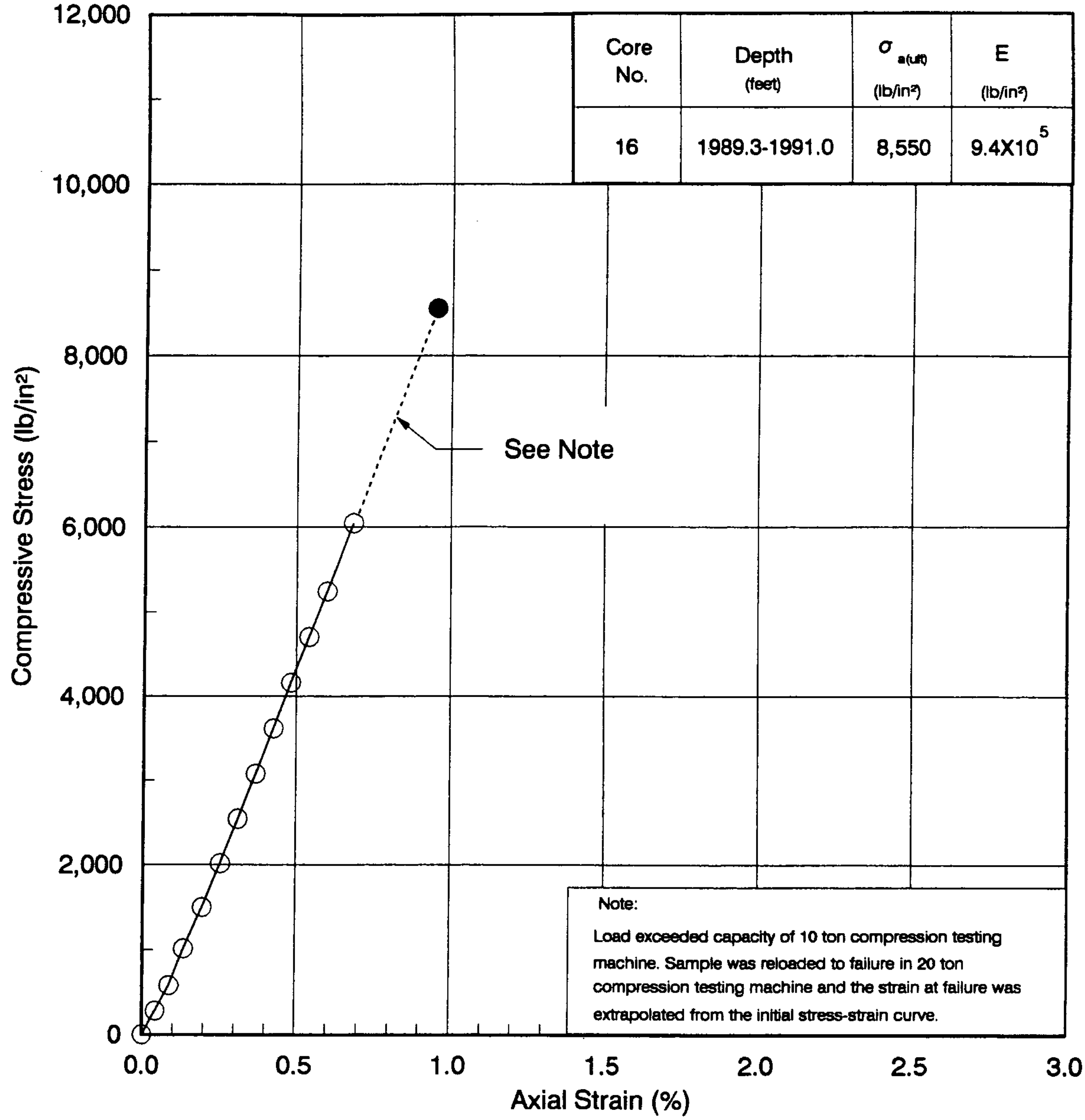
FILE NO.: 99-063	APPROVED BY:	FIGURE: 8



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
16	1989.3-1991.0	8,550	$9.4X10^5$

UNCONFINED COMPRESSION TEST

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BROWARD COUNTY NORTH REGIONAL WWTP
INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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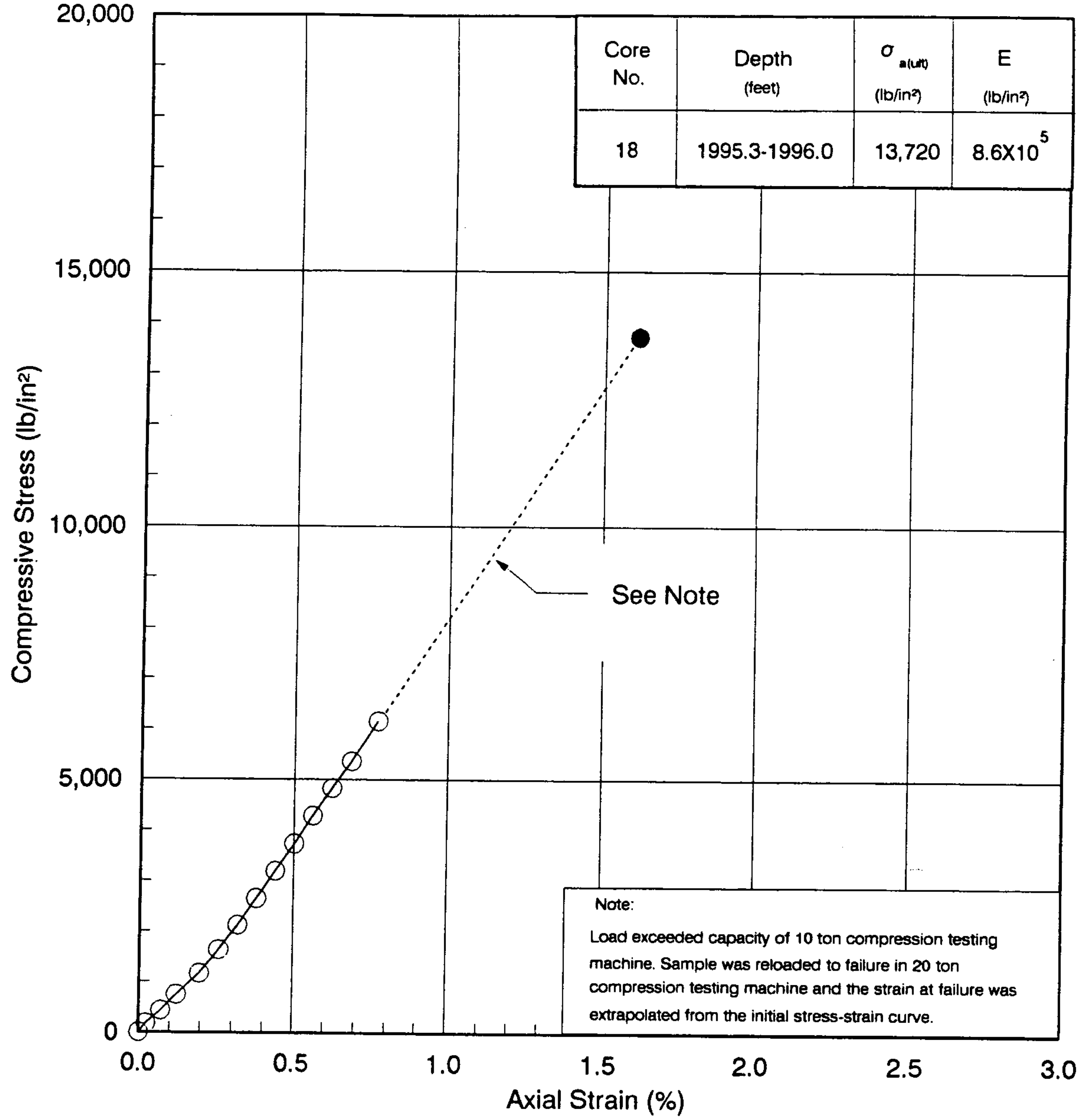
FILE NO.: 99-063	APPROVED BY: [signature]		FIGURE: 9



Core No.	Depth (feet)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
18	1995.3-1996.0	13,720	$8.6X10^5$

Note:

Load exceeded capacity of 10 ton compression testing machine. Sample was reloaded to failure in 20 ton compression testing machine and the strain at failure was extrapolated from the initial stress-strain curve.

UNCONFINED COMPRESSION TEST

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BROWARD COUNTY NORTH REGIONAL WWTP
INJECTION WELL NO. 6

YOUNGQUIST BROTHERS, INC.

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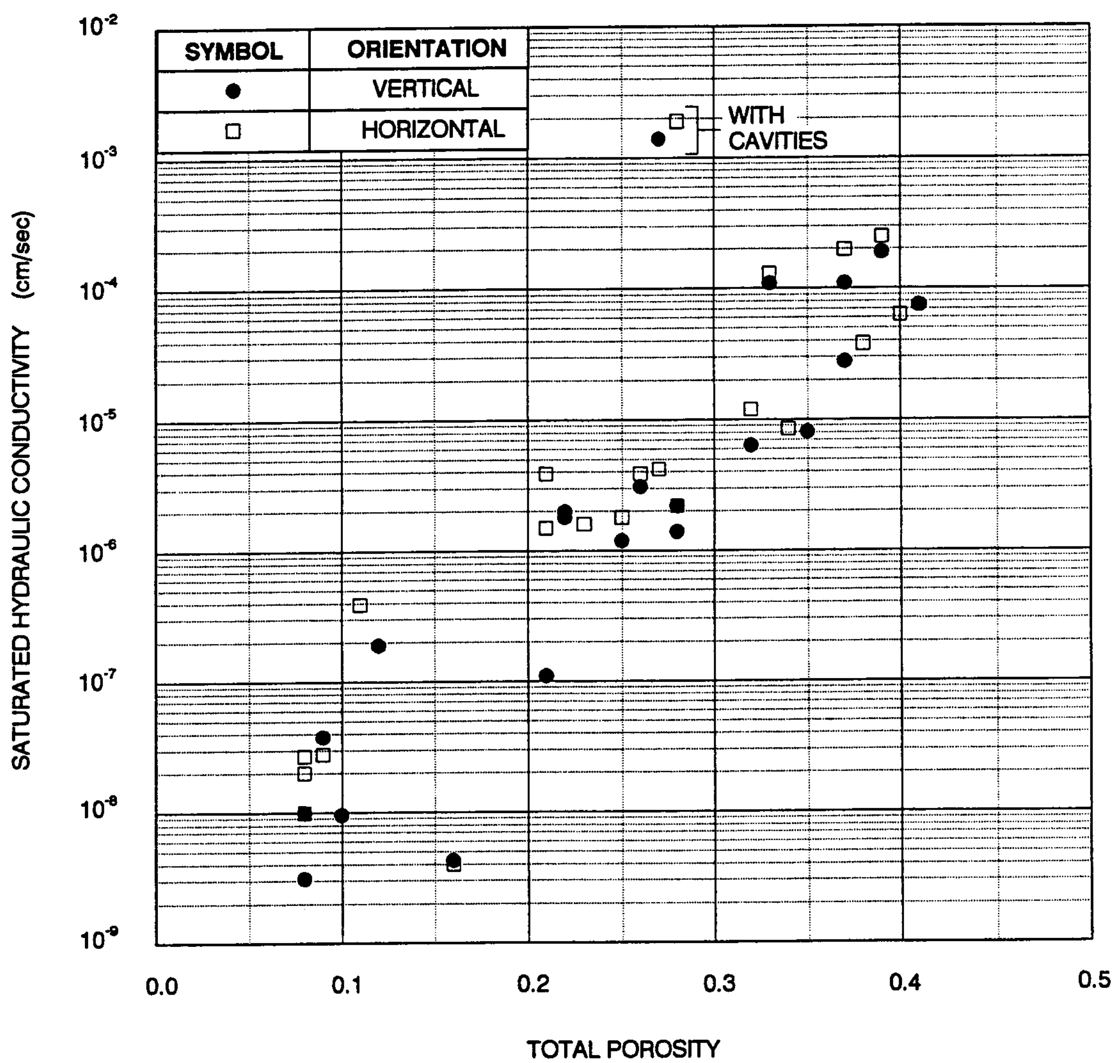
FILE NO.: 99-063	APPROVED BY: [signature]	FIGURE: 10



HYDRAULIC CONDUCTIVITY VERSUS TOTAL POROSITY

Ardaman & Associates, Inc. Geotechnical, Environmental and Materials Consultants		
BROWARD COUNTY NORTH REGIONAL WWTP INJECTION WELL NO. 6		
YOUNGQUIST BROTHERS, INC.		
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FILE NO.: 99-063	APPROVED BY:	FIGURE: 11

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Appendix F - Cores
IW6 Core Description

Depth Interval (feet bpl)	Description IW6 Core 1, 1786 to 1796 feet bpl
1786.0 – 1786.4	LIMESTONE (100%), pale yellowish gray (5Y 8/2), thinly bedded, vuggy, fine grained, fossiliferous packstone with sparse light olive gray (5Y 6/1), medium to coarse grained laminations.
1786.4 – 1788.8	LIMESTONE (100%), very pale orange (10YR 8/2), massive, fine grained, fossiliferous packstone.
1788.8 – 1789.4	LIMESTONE (100%), very pale orange (10YR 8/2), fine to coarse grained, fossiliferous packstone with light gray (N7), soft, fine grained limestone and sparse, dusky yellowish brown (10YR 2/2) to moderate brown (5YR ¾), hard, fine grained dolomite inclusions.
1789.4 – 1792.5	LIMESTONE AND DOLOMITE: <u>Limestone</u> (95 - 97%), pale yellowish brown (10YR 6/2), fine to medium grained, fossiliferous packstone; <u>Dolomite</u> (2 - 5%), dark yellowish brown (10YR 4/2), fine grained crystalline; percentage increases down section.
1792.8 – 1794.7	LIMESTONE (100%), very pale orange (10YR 8/2), massive, fine to medium grained, fossiliferous packstone.
1794.7 – 1795.4	LIMESTONE (100%), yellowish gray (5Y 8/1), very fine to medium grained, micritic packstone with abundant vugs and bore holes.
1795.6 – 1796.0	LIMESTONE (100%), very pale orange (10YR 8/2), massive, fine-grained packstone.

Depth Interval (feet bpl)	Description IW6 Core 2, 1796 to 1805 feet bpl
1796.0 – 1796.2	DOLOMITE AND LIMESTONE: Dolomite (95%), dark yellowish brown (10YR 4/2), hard, finely crystalline with sparse small vugs. Limestone (5%), consisting of very pale orange (10YR 8/2), fine grained laminations.
1796.2 – 1796.6	DOLOMITE AND LIMESTONE: Dolomite (95%), pale yellowish brown (10YR 6/2), hard, vuggy, mostly medium grained to finely crystalline. Limestone (5%), very pale orange (10YR 8/2), fine-grained carbonate mudstone (micrite). Sharp lower contact.
1796.6 – 1796.8	LIMESTONE (100%), very pale orange (10YR 8/2), fine-grained, fossiliferous packstone.
1796.8 – 1797.1	LIMESTONE (100%), light gray (N7), fine-grained wackstone and very pale orange (10YR 8/2), fossiliferous packstone.
1797.1 – 1798.5	LIMESTONE (100%), very pale orange (10YR 8/2), massive, fine to medium grained, fossiliferous packstone.
1798.5 – 1798.8	LIMESTONE (100%), light gray (N7), vuggy, fine-grained carbonate mudstone (micrite).
1798.8 – 1799.0	LIMESTONE (100%), very pale orange (10YR 8/2), massive, fine to medium grained, packstone with sparse brownish gray (5YR 4/1) dolomite laminations in upper portion of section.
1799.0 – 1799.9	DOLOMITE AND LIMESTONE: Dolomite (95%), dark yellowish brown (10YR 4/2), hard, massive, vuggy, finely crystalline. Limestone (5%), very pale orange (10YR 8/2), soft, fine-grained, wackstone/packstone in lower portion of section.
1799.9 – 1802.0	DOLOMITE AND LIMESTONE: Limestone (95%), very pale orange (10YR 8/2), massive, moderately hard, medium grained, fossiliferous packstone. Dolomite (5%), consisting of dark yellowish brown (10YR 4/2), hard, finely crystalline inclusions.
1802.0 – 1803.2	DOLOMITE AND LIMESTONE: Dolomite (95%), dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4), hard, vuggy (up to 5mm across), fine to very finely crystalline. Limestone (5%), consisting of very pale orange (10YR 8/2), fine grained laminations.

Depth Interval (feet bpl)	Description IW6 Core 3, 1805 to 1815 feet bpl
1805.0 – 1805.4	DOLOMITE AND LIMESTONE: Dolomite (95%), dark yellowish brown (10YR 4/2), very hard, vuggy, fine to very finely crystalline. Limestone (5%), consisting of very pale orange (10YR 8/2), fine grained laminations.
1805.4 – 1807.1	LIMESTONE AND DOLOMITE: Limestone (95%), very pale orange (10YR 8/2), soft, fine to medium grained, fossiliferous packstone/carbonate mudstone with Dolomite. Dolomite (5%) laminations from 1805.6 to 1806.1 ft.
1807.1 – 1807.5	DOLOMITE AND LIMESTONE: Dolomite (90%), dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4), very hard, vuggy, fine grained, crystalline. Limestone (10%), consisting of very pale orange (10YR 8/2), fine-grained laminations in lower portion of section.
1807.5 – 1811.8	LIMESTONE (100%), very pale orange (10YR 8/2), soft, massive, fine to medium grained, fossiliferous packstone/carbonate mudstone; vuggy in upper portion of interval from 1807.5 to 1807.8 ft.
1811.8 – 1812.2	DOLOMITE AND LIMESTONE: Dolomite (80%), dark yellowish brown (10YR 4/2), hard, fine grained, crystalline. Limestone (20%), consisting of very pale orange (10YR 8/2), fine-grained laminations.
1812.2 – 1813.4	LIMESTONE AND DOLOMITE: Limestone (95%), very pale orange (10YR 8/2), moderately hard, fine to medium grained, packstone. Dolomite (5%), dusky brown (5YR 2/2), hard, fine-grained, crystalline.

Depth Interval (feet bpl)	Description IW6 Core 4, 1815 to 1836 feet bpl
1815.0 – 1816.5	DOLOMITIC LIMESTONE (100%), very pale orange (10YR 8/2) to yellowish gray (5Y 8/1), moderately hard, medium to coarse grained, sub-angular, packstone; crudely bedded and variably dolomitized from 1815.0 to 1815.25 ft. Dominantly massive, moderately indurated limestone from 1815.25 to 1815.5 ft.
1816.5 – 1817.2	LIMEY DOLOMITE (100%), light brown (5YR 5/6), hard, locally sucrosic, microcrystalline to cryptocrystalline; partly vuggy and dark gray (N3) laminations in lower part of section.
1817.2 – 1817.9	DOLOMITE (100%), medium gray (N5), hard, extremely vuggy, crystalline to cryptocrystalline with fine to medium grained, euhedral dolomite crystals lining irregularly-shaped vugs up to 2.2 cm across, grades into limestone below 1817.9 ft.
1817.9 – 1820.0	DOLOMITIC LIMESTONE (95%), yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), mostly massive, moderately hard to friable, fossiliferous packstone with light olive brown (5Y 5/6), irregularly-shaped dolomite lenses (5%) in the upper 0.6 ft of the interval, decreasing in abundance down section.
1820.0 – 1820.2	LIMESTONE (100%), very light gray (N8) to medium light gray (N6), hard, weakly to moderately porous, carbonate mudstone (micrite) with sharp upper, and gradational lower contact.
1820.2 – 1820.6	DOLOMITIC LIMESTONE (100%), light olive brown (5Y 5/6) to yellowish gray (5Y 8/1), medium to coarse-grained packstone with gradational upper, and sharp, irregular lower contact.
1820.6 – 1820.7	LIMESTONE (100%), medium gray (N5), friable, medium grained wackstone.
1820.7 – 1822.3	LIMESTONE (100%), yellowish gray (5Y 8/1), moderately hard to friable, thinly bedded, moderately porous, fine to medium grained, very weakly phosphatic, fossiliferous packstone with very light gray (N8) laminations.

Depth Interval (feet bpl)	Description IW6 Core 5, 1965 to 1975 feet bpl
1965.0 – 1965.6	DOLOMITE AND LIMESTONE: Dolomite (90%); (75%), dusky yellowish brown (10YR 2/2) to dark yellowish brown (10YR 4/2), hard, well indurated, microcrystalline with irregular-shaped vugs. Dolomite (15%), light olive brown (5Y 5/6), hard, microcrystalline. Limestone (10%), yellowish gray (5Y 8/1), occurring as fine, irregularly spaced laminations.
1965.6 – 1966.4	DOLOMITIC LIMESTONE (100%), yellowish gray (5Y 8/1) to very pale orange (10YR 8/2), well indurated, fine to medium grained, fossiliferous wackstone/packstone, approximately 10% dolomitized.
1966.4 – 1966.7	DOLOMITIC LIMESTONE (100%), yellowish gray (5Y 8/1), hard, well-indurated, fine to medium grained, wackstone/packstone with microcrystalline dolomitization on 20-25% of limestone grains.
1966.7 – 1967.0	LIMEY DOLOMITE (100%), yellowish gray (5Y 8/1) to grayish orange (10YR 7/4), hard, well indurated, medium to coarse grained, less commonly microcrystalline; angular limestone inclusions near top of section, dolomitization increases with depth.
1967.0 – 1967.6	DOLOMITE AND LIMESTONE: Dolomite (90%), moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2), very hard, well indurated, fine grained to cryptocrystalline with 2-3mm vugs. Limestone (10%), occurs as yellowish gray (5Y 8/1) laminations spaced 1-2mm a part.
1967.6 – 1967.7	DOLOMITE AND LIMESTONE: Dolomite (80%), moderate yellowish brown (10YR 5/4), hard, crystalline and black (N1), hard, interbedded sucrosic. Limestone (20%), yellowish gray (5Y 8/1), soft to moderately hard, chalky, micritic wackstone.
1967.7 – 1968.0	LIMESTONE (100%), yellowish gray (5Y 8/1), moderately hard and indurated, chalky, very fine to medium grained, vuggy/porous, fossiliferous, peloidal wackstone/packstone with local areas of grayish orange (10YR 7/4) dolomitization.
1968.0 – 1968.3	LIMESTONE (100%), yellowish gray (5Y 8/1), well indurated, generally massive with laminations in lower part of section, trace of grayish orange (10YR 7/4) microcrystalline Dolomite.
1968.3 – 1968.9	LIMESTONE (100%), yellowish gray (5Y 8/1), soft to moderately hard, chalky, generally massive, vuggy, slightly fossiliferous, peloidal packstone with trace of grayish orange (10YR 7/4) microcrystalline Dolomite.

Depth Interval (feet bpl)	Description IW6 Core 5, 1965 to 1975 feet bpl
1968.9 – 1969.1	LIMESTONE (100%), yellowish gray (5Y 8/1), moderately hard and indurated, slightly chalky, massive, medium to coarse grained, weakly fossiliferous, peloidal packstone.
1969.1 – 1969.3	DOLOMITIC LIMESTONE (100%), grayish orange (10YR 7/4) to yellowish gray (5Y 8/1), moderately hard and indurated, massive, medium to coarse-grained, dolomitized packstone.

Depth Interval (feet bpl)	Description IW6 Core 6, 1982 to 1996 feet bpl
1982.0 – 1982.2	DOLOMITE AND LIMESTONE: Dolomite (95-97%), pale yellowish brown (10YR 6/2) and black (N1), hard, well indurated, vuggy, fine to very fine grained crystalline with irregularly shaped vugs up to 5mm across, rarely 2cm across. Limestone (3-5%), consisting of faint bluish white (5B 9/1) to yellowish gray (5Y 8/1), discontinuous, mm-size, horizontal, lamina interbedded with grayish black (N2) dolomite in less vuggy portions of interval.
1982.2 – 1983.5	DOLOMITE AND LIMESTONE: Dolomite (90-95%), medium light gray (N6) to grayish black (N2), very hard, well indurated, very fine grained to cryptocrystalline; partly vuggy (5%) dominantly near base with irregularly-shaped vugs up to 2.5 cm across lined with fine to medium grained, anhedral to euhedral rhombohedron dolomite crystals. Limestone (5-10%), consisting of interbedded, bluish white (5B 9/1) to yellowish gray (5Y 8/1), discontinuous, mm-size, horizontal lamina and rounded inclusions up to 2.5 mm across. Sharp lower contact.
1983.5 – 1986.4	DOLOMITE AND LIMESTONE: Dolomite (90-95%), dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4), hard, well indurated, vuggy, fine to very fine grained crystalline; vugs irregularly-shaped up to 5mm across. Limestone (5-10%), consisting of interbedded, bluish white (5B 9/1) to yellowish gray (5Y 8/1), discontinuous, mm-size, lamina and locally abundant rounded inclusions up to 2mm across (1984.0 ft and 1985.5 to 1986.4 ft). Sharp, wavy lower contact. Two fractures perpendicular to each other cut across lower contact at 30 degrees to core axis.
1986.4 – 1988.0	DOLOMITE (100%), yellowish gray (5Y 8/1) to pale yellowish brown (10YR 6/2), very hard, very well indurated, mostly massive, moderately vuggy, very fine grained to cryptocrystalline, vugs irregularly-shaped up to 10mm across lined with very fine to medium grained, anhedral to euhedral rhombohedron dolomite crystals; sharp, very wavy lower contact displays mm to cm-size load cast structures.
1991.7 – 1992.5	DOLOMITE BRECCIA CONGLOMERATE (100%), grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6), weakly to moderately indurated and medium light gray (N6) to black (N1), well indurated; overall very fine grained to cryptocrystalline, dominantly matrix supported with fragments/clasts up to 2 cm across, and partly vuggy with irregularly-shaped vugs generally <10 mm across, but up to 2.5 & 3.0 cm in length at 1992.0 ft. Sharp, very irregular lower contact.

Depth Interval (feet bpl)	Description IW6 Core 6, 1982 to 1996 feet bpl
1992.7 – 1993.4	DOLOMITE AND LIMESTONE: Dolomite (97–98%), pale yellowish brown (10YR 6/2) to dark yellowish brown (10YR 4/2), very hard and well indurated, mostly massive, weakly vuggy, fine to very fine grained crystalline with irregularly-shaped vugs up to 4mm across. Limestone (2-3%), consisting of sparse bluish white (5B 9/1) to yellowish gray (5Y 8/1), rounded to angular inclusions throughout section.

RECEIVED
HAZEN AND SAWYER, P.C.
Hollywood, Florida

Ardaman & Associates, Inc.

Geotechnical, Environmental and Materials Consultants

SEP 29 1997

September 22, 1997
File Number 97-128

JOB No. 4548A / 6.6

RECEIVED SEP 24 1997

Youngquist Brothers, Inc.
15465 Pine Ridge Road
Fort Myers, Florida 33908

Attention: Mr. Ed McCullers
Drilling Superintendent

Subject: Laboratory Test Results on Rock Core Specimens, Broward County North Regional Waste Water Treatment Plant Monitor Well No. 4

Gentlemen:

Permeability, unconfined compression and specific gravity tests have been completed on 23 rock core samples provided by your firm from the Broward County North Regional Waste Water Treatment Plant Monitor Well No. 4. The permeability tests were performed in general accordance with ASTM Standard D 5084 "Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible-Wall Permeameter" using the constant-head (Method A) and falling-head with increasing tailwater level (Method C) test methods. The unconfined compression tests were performed in general accordance with ASTM Standard D 2938 "Unconfined Compressive Strength of Intact Rock Core Specimens". The specific gravity was determined in general accordance with ASTM Standard D 854 "Specific Gravity of Soils". Due to the short length of the samples unconfined compression tests could not be performed on all of the samples, as requested, but only on five of the samples.

Permeability Tests

The permeability test results are presented in Table 1. The core samples provided for testing were too short to obtain separate vertically and horizontally oriented specimens. Accordingly, the vertical permeability tests were performed first on specimens maintained at the as-received diameter and cut to lengths of 6.5 to 13.0 cm. After completing the vertical permeability tests, horizontal permeability specimens were obtained by coring 5.1 cm diameter cylinders from the vertical specimens. The horizontal specimens were then trimmed to lengths of 6.2 to 8.1 cm to provide flat, parallel ends. Since the vertical permeability test specimens were cored upon completion of testing to obtain horizontal permeability test specimens, the final moisture contents of the vertical specimens were not measured. The dry densities and degrees of saturation of the vertical permeability specimens, therefore, were estimated using the final moisture contents from the corresponding horizontal permeability test specimens.

Each permeability test specimen was air-dried, deaired under vacuum, and then saturated with deaired tap water from the bottom upward while still under vacuum. Each specimen was then mounted in a triaxial-type permeameter and encased within a latex membrane. The specimens were confined using an average isotropic effective confining stress of 20 lb/in^2 and permeated with deaired tap water under back-pressures of 80 or 169 lb/in^2. Satisfactory saturation was verified by a B-factor equal to or greater than 95%, or a B-factor that remained relatively constant for two consecutive increments of applied cell pressure. The inflow to and outflow from each specimen were monitored with time, and the coefficient of permeability was calculated for each recorded flow increment. The tests were continued until steady-state flow conditions were obtained, as evidenced by an outflow/inflow ratio between 0.75 and 1.25, and until stable values of the coefficient of permeability were measured. The final degree of saturation was calculated upon completion of testing using the final dry mass, moisture content and volume, and the measured specific gravity. Although some of the calculated final degrees of saturation are low, the B-factors indicate satisfactory saturation. The calculated final degrees of saturation are potentially affected by occluded voids within the specimens, surface irregularities, and the use of final moisture contents for the vertical permeability test specimens from the corresponding horizontal permeability test specimens.

Specific Gravity Tests

The specific gravity of each sample was determined on a representative approximately 100 gram specimen ground to pass the U.S. Standard No. 40 sieve. The specific gravity measured on each sample is presented in Table 1.

Porosity

The porosity, n, of each permeability test specimen was calculated using the measured dry density, γ_d, and measured specific gravity, G_s, from the equation: $n = 1 - (\gamma_d/(G_s)(\gamma_w))$ where γ_w = unit weight of water. The calculated porosities are presented in Table 1.

Unconfined Compression Tests

The unconfined compression tests were performed on 3.2 to 5.1 cm diameter specimens cored from the samples. The specimens were trimmed to lengths of 7.8 to 9.8 cm to provide a length to diameter ratio of approximately 2 and then capped with a sulfur capping compound. The specimens were loaded at constant rate of deformation of 0.0076 cm/minute to achieve a time to failure between 2 and 15 minutes. The compressive strengths and Young's modulus determined from the unconfined compression tests are summarized in Table 2. The stress-strain curves are presented in Figures 1 through 5.

If you have any questions or require additional testing services, please contact us.

Very truly yours,
ARDAMAN & ASSOCIATES, INC.

Shawkat Ali, Ph.D.
Geotechnical Engineer

Thomas S. Ingra, P.E.
Senior Project Engineer
Florida Registration No. 31987

SA/TSI/jo

cc: Hazen and Sawyer
Michael Wengrenovich

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Youngquist Brothers, Inc.
File Number 97-128
September 22, 1997

Table 1

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTE WATER TREATMENT PLANT MONITOR WELL NO. 4

Core Depth (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Coefficient of Permeability (cm/sec)
				Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft^3)	n					w_c (%)	γ_d (lb/ft^3)	S (%)	
1520.90 -	Vertical	C	2.70	10.46	9.68	27.0	95.6	0.43	20	80	96	1.5	27.0†	95.6	95	2.0×10^{-3}
1521.36	Horizontal	C		7.68	5.07	26.8	95.8	0.43	20	80	94**	2.2	27.0	95.8	96	2.3×10^{-3}
1522.00 -	Vertical	C	2.71	9.54	9.77	24.5	97.4	0.42	20	80	95	1.9	24.6†	97.4	91	1.4×10^{-4}
1522.42	Horizontal	C		7.68	5.05	24.2	99.0	0.41	20	80	84**	2.1	24.6	99.0	94	3.8×10^{-4}
1523.00 -	Vertical	C	2.70	6.54	9.86	17.7	107.8	0.36	20	80	74**	2.5	18.4†	107.8	89	3.4×10^{-4}
1523.42	Horizontal	C		6.21	5.09	17.8	110.6	0.34	20	80	93**	2.7	18.4	110.6	95	4.9×10^{-4}
1526.75 -	Vertical	C	2.70	9.17	9.90	21.8	104.2	0.38	20	80	88**	1.8	21.8†	104.2	95	9.0×10^{-4}
1527.25	Horizontal	C		7.97	5.07	21.5	105.3	0.38	20	80	91**	2.1	21.8	105.3	98	9.5×10^{-4}
1546.35 -	Vertical	C	2.72	12.28	8.71	27.6	92.2	0.46	20	80	92**	1.4	27.6†	92.2	89	2.2×10^{-3}
1546.85	Horizontal	C		6.27	5.09	27.5	94.4	0.44	20	80	94**	2.9	27.6	94.4	94	1.6×10^{-3}
1547.58 -	Vertical	C	2.71	12.68	8.77	24.2	97.7	0.42	20	80	98	1.5	24.2†	97.7	90	1.2×10^{-4}
1548.10	Horizontal	C		6.48	5.09	24.0	100.7	0.40	20	80	98	3.0	24.2	100.7	95	5.8×10^{-5}
1548.54 -	Vertical	C	2.73	12.59	8.90	25.9	97.5	0.43	20	80	97	1.4	26.0†	97.5	95	1.5×10^{-3}
1549.10	Horizontal	C		6.75	5.10	25.5	97.9	0.43	20	80	95	2.9	26.0	97.9	96	1.2×10^{-3}
1551.00 -	Vertical	C	2.70	11.08	9.17	21.5	99.2	0.41	20	80	92**	1.5	24.1†	99.2	93	2.2×10^{-3}
1551.50	Horizontal	C		6.69	5.09	24.0	99.4	0.41	20	80	100	2.6	24.1	99.4	94	2.0×10^{-3}
1650.00 -	Vertical	C	2.69	9.87	9.76	25.6	99.2	0.41	20	80	86**	1.8	25.7†	99.2	100	2.5×10^{-4}
1650.57	Horizontal	C		7.94	5.06	25.6	98.8	0.41	20	80	91**	2.2	25.7	98.8	99	3.8×10^{-4}
1652.12 -	Vertical	C	2.71	8.85	9.94	18.2	111.0	0.34	20	80	88**	2.1	18.2†	111.0	94	5.6×10^{-5}
1652.55	Horizontal	A		7.75	5.08	18.2	112.4	0.34	20	169	100	15	18.2	112.4	98	6.4×10^{-5}
1653.08 -	Vertical	A	2.69	8.10	9.93	25.9	97.8	0.42	20	169	92**	12	25.9†	97.8	97	4.8×10^{-5}
1653.76	Horizontal	A		7.98	5.09	25.9	98.5	0.41	20	169	98	18	25.9	98.5	99	1.4×10^{-4}
1654.66 -	Vertical	C	2.71	8.17	9.90	25.1	98.2	0.42	20	80	94**	2.3	25.1†	98.2	94	8.2×10^{-5}
1655.32	Horizontal	A		7.91	5.05	25.1	99.1	0.41	20	169	97	12	25.1	99.1	97	9.4×10^{-5}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity.

* Method A = Constant-head test; Method C = Falling-head test with increasing tailwater level.

** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.

† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal test specimen.

Youngquist Brothers, Inc.
File Number 97-128
September 22, 1997

Table 1 (Continued)

PERMEABILITY TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTE WATER TREATMENT PLANT MONITOR WELL NO. 4

Core Depth (feet)	Test Specimen Orientation	D-5084 Test Method*	G_s	Initial Conditions					$\bar{\sigma}_c$ (lb/in^2)	u_b (lb/in^2)	B Factor (%)	Average Hydraulic Gradient	Final Conditions			Coefficient of Permeability (cm/sec)
				Length (cm)	Diameter (cm)	w_c (%)	γ_d (lb/ft^3)	n					w_c (%)	γ_d (lb/ft^3)	S (%)	
1658.75 -	Vertical	A	2.69	7.98	9.94	23.7	100.4	0.40	20	169	98	4.5	23.7†	100.4	95	4.8×10^{-5}
1659.50	Horizontal	A		7.95	5.09	23.7	101.5	0.40	20	169	97	16	23.7	101.5	98	6.0×10^{-5}
1711.00 -	Vertical	C	2.68	13.00	9.63	24.3	99.4	0.41	20	80	89**	1.4	24.4†	99.4	96	3.5×10^{-4}
1711.75	Horizontal	C		7.78	5.07	24.1	100.9	0.40	20	80	93**	2.2	24.4	100.9	99	2.9×10^{-4}
1712.50 -	Vertical	C	2.69	8.50	9.74	22.0	100.4	0.40	20	80	75**	2.0	23.1†	100.4	93	9.2×10^{-5}
1713.00	Horizontal	A		8.14	5.08	21.8	102.2	0.39	20	169	97	18	23.1	102.2	97	7.9×10^{-5}
1715.90 -	Vertical	C	2.71	10.88	9.80	24.7	100.7	0.40	20	80	92**	1.6	24.7†	100.7	99	3.5×10^{-4}
1716.40	Horizontal	C		7.80	5.08	24.7	100.0	0.41	20	80	98	2.2	24.7	100.0	97	4.0×10^{-4}
1717.15 -	Vertical	C	2.70	11.14	9.44	21.5	102.8	0.39	20	80	85**	1.7	22.1†	102.8	93.	2.2×10^{-4}
1717.65	Horizontal	C		7.52	5.09	21.6	104.2	0.38	20	80	85**	2.3	22.1	104.2	96	2.4×10^{-4}
1718.15 -	Vertical	C	2.69	10.87	9.44	16.7	112.1	0.33	20	80	97	1.5	16.8†	112.1	91	3.4×10^{-4}
1718.65	Horizontal	C		7.46	5.10	16.6	113.1	0.33	20	80	95	2.5	16.8	113.1	93	7.5×10^{-5}
1887.90 -	Vertical	C	2.70	8.35	9.66	27.1	94.6	0.44	20	80	96	2.0	27.1†	94.6	94	3.4×10^{-4}
1888.50	Horizontal	C		7.23	5.06	26.8	97.3	0.42	20	80	91**	2.4	27.1	97.3	100	4.7×10^{-4}
1889.75 -	Vertical	C	2.68	10.04	9.74	23.7	100.3	0.40	20	80	73**	1.8	23.7†	100.3	95	5.3×10^{-4}
1890.25	Horizontal	C		7.61	5.09	23.6	102.1	0.39	20	80	95	2.3	23.7	102.1	99	3.6×10^{-4}
1890.25 -	Vertical	A	2.69	9.35	9.60	20.8	102.6	0.39	20	169	90**	18	22.4†	102.6	95	1.4×10^{-4}
1890.85	Horizontal	C		7.77	5.10	21.5	103.3	0.38	20	80	86**	2.3	22.4	103.3	96	1.2×10^{-4}
1891.00 -	Vertical	C	2.70	8.80	9.64	22.3	100.8	0.40	20	80	85**	2.0	22.8†	100.8	92	2.0×10^{-4}
1891.50	Horizontal	C		7.80	5.05	22.4	103.7	0.38	20	80	89**	2.3	22.8	103.7	98	3.6×10^{-4}
1894.75 -	Vertical	A	2.71	7.96	9.84	20.2	102.1	0.40	20	169	90**	13	21.1†	102.1	87	7.4×10^{-5}
1895.40	Horizontal	A		7.64	5.10	19.7	103.2	0.39	20	169	95	16	21.1	103.2	90	3.1×10^{-5}

Where: w_c = Moisture content; γ_d = Dry density; G_s = Specific gravity; n = Porosity; $\bar{\sigma}_c$ = Average isotropic effective confining stress; u_b = Back-pressure; and S = Calculated degree of saturation using measured specific gravity.

* Method A = Constant-head test; Method C = Falling-head test with increasing tailwater level.

** B-Factor remained relatively constant for two consecutive increments of applied cell pressure.

† Vertical permeability test specimen was cored upon completion of testing to obtain horizontal permeability test specimen. The final moisture content of the vertical test specimen was not measured, and was assumed to be the same as the horizontal test specimen.

Youngquist Brothers, Inc.
File Number 97-128
September 22, 1997

Table 2

UNCONFINED COMPRESSION TEST RESULTS
BROWARD COUNTY NORTH REGIONAL WASTE WATER TREATMENT PLANT MONITOR WELL No. 4

Sample Depth (feet)	Specimen Dimensions			w_c (%)	γ_d (lb/ft^3)	Loading Rate (cm/min)	t_f (min)	Unconfined Compressive Strength, σ_a(ult) (lb/in^2)		Young's Modulus E(lb/in^2)**
	Length L (cm)	Diameter D (cm)	L/D					Measured	Corrected*	
1653.08-1653.76	9.79	5.08	1.93	22.1	102.6	0.0076	7.7	1329	1323	3.1×10^5
1654.66-1655.32	9.62	5.10	1.89	23.0	101.0	0.0076	6.1	1412	1402	3.5×10^5
1658.75-1659.50	9.77	5.10	1.92	20.5	105.2	0.0076	6.8	1427	1420	3.7×10^5
1890.25-1890.85	8.07	3.26	2.47	19.3	107.0	0.0076	4.6	1303	1334	4.6×10^5
1894.75-1895.40	7.76	3.24	2.39	19.3	105.7	0.0076	4.5	878	896	3.0×10^5

Where: w_c = Moisture content; γ_d = Dry density; and t_f = Time to failure.

* Unconfined compressive strength corrected to L/D ratio of 2 in accordance with ASTM Standard D 2938.
** Young's modulus calculated from the slope of the straight-line portion of the stress-strain curve.

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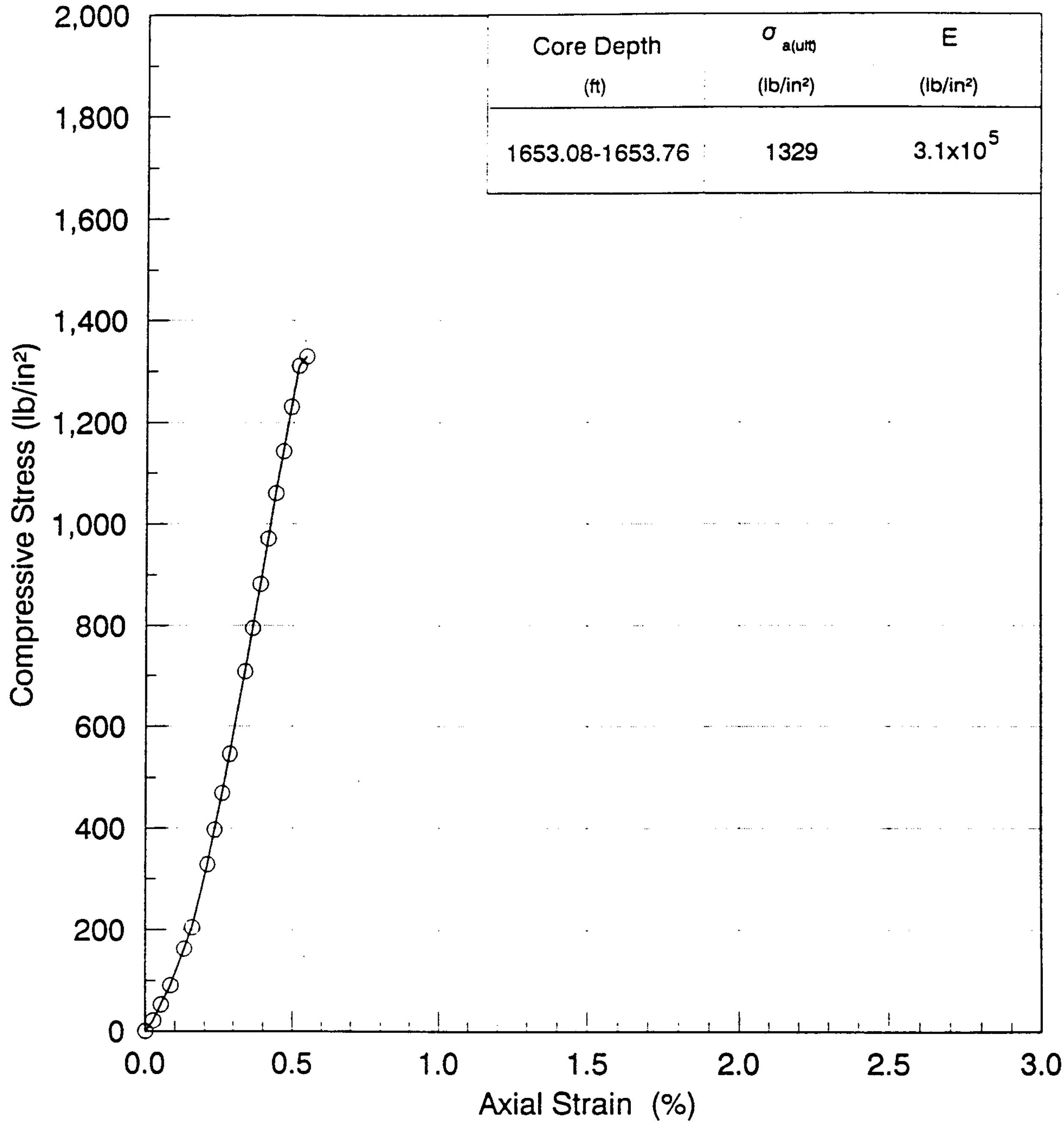


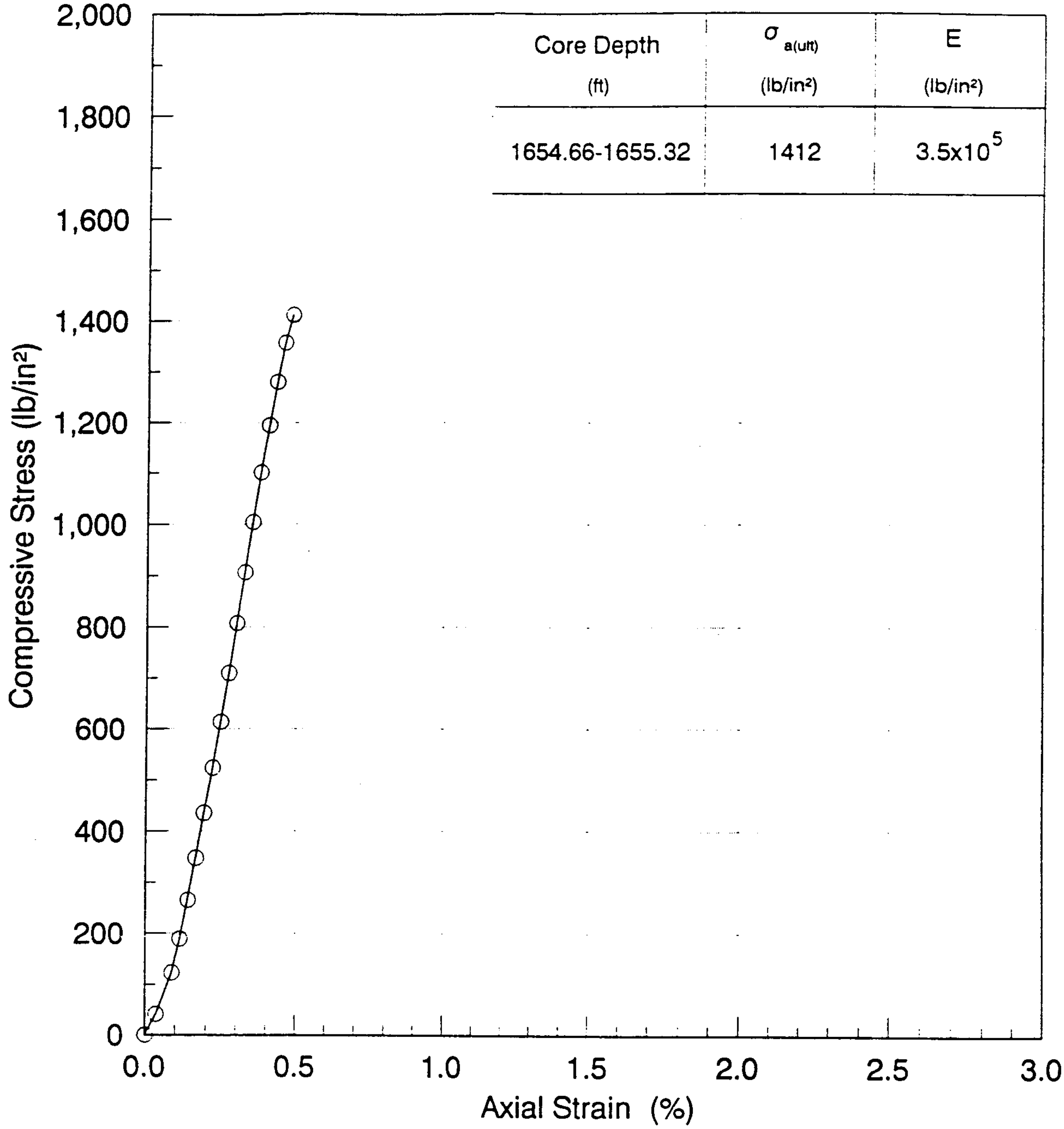
UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY
MONITOR WELL NO. 4

YOUNGQUIST BROTHERS, INC.

DRAWN BY: SA	CHECKED BY: SA	DATE: 09-17-97
FILE NO.: 97-128	APPROVED BY: Thomas J. Braga	FIGURE: 1



Core Depth (ft)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
1654.66-1655.32	1412	3.5×10^5

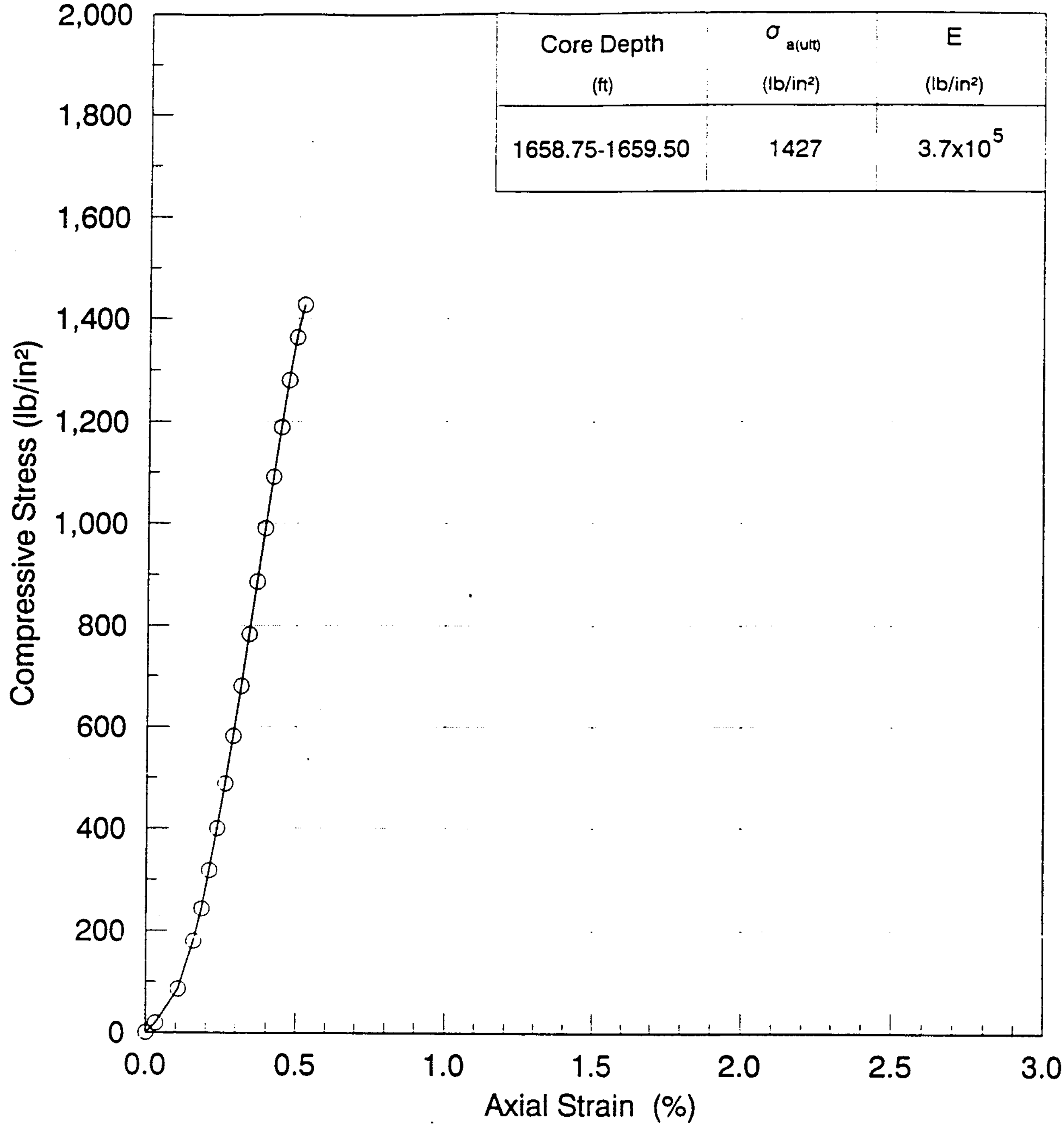
UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY
MONITOR WELL NO. 4

YOUNGQUIST BROTHERS, INC.

DRAWN BY: SA	CHECKED BY: SA	DATE: 09-17-97
FILE NO.: 97-128	APPROVED BY: [signature]	FIGURE: 2



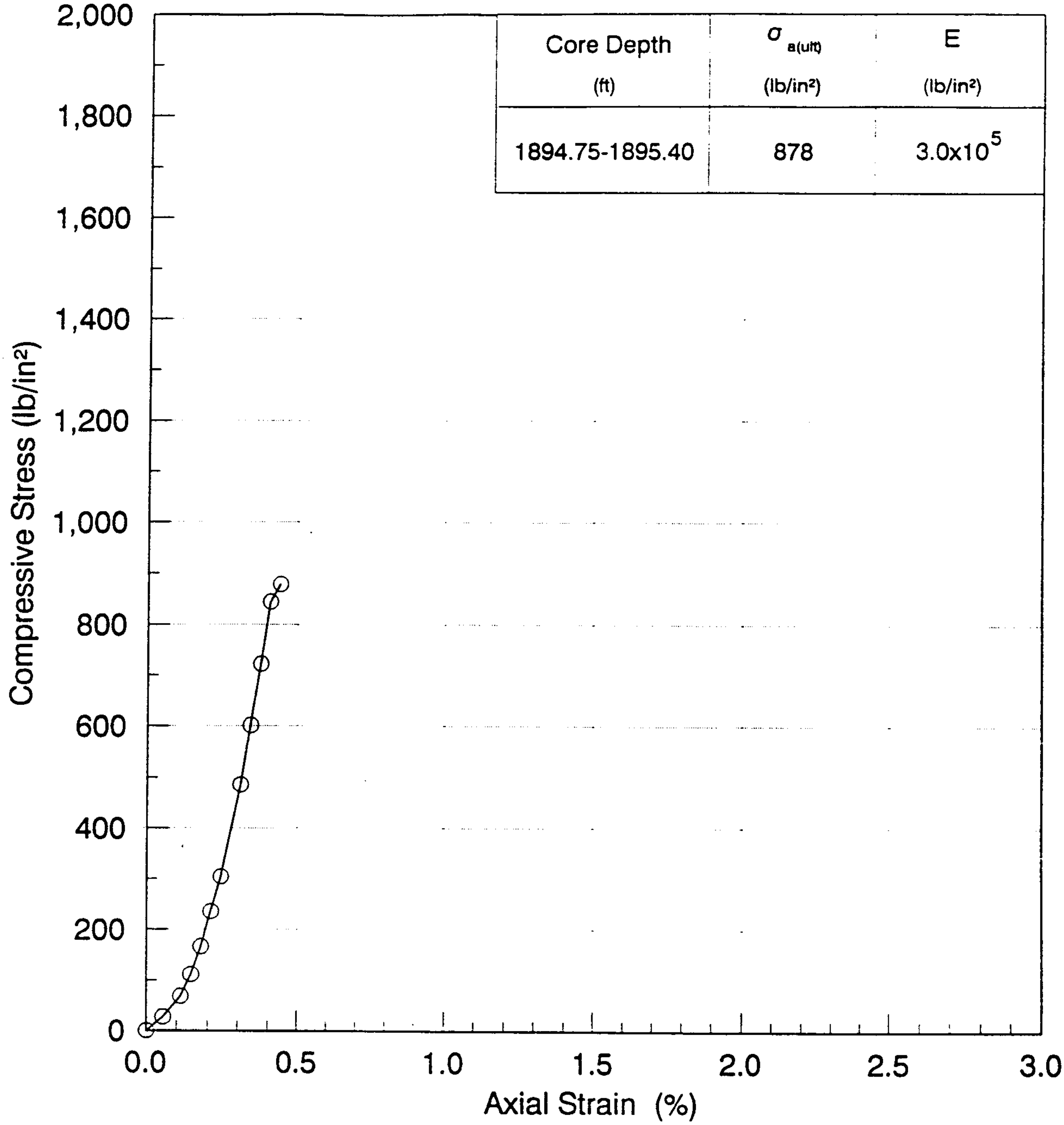
UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY
MONITOR WELL NO. 4

YOUNGQUIST BROTHERS, INC.

DRAWN BY: SA	CHECKED BY: SA	DATE: 09-17-97
FILE NO.: 97-128	APPROVED BY: [signature]	FIGURE: 3



Core Depth (ft)	$\sigma_{a(ult)}$ (lb/in²)	E (lb/in²)
1894.75-1895.40	878	$3.0x10^5$

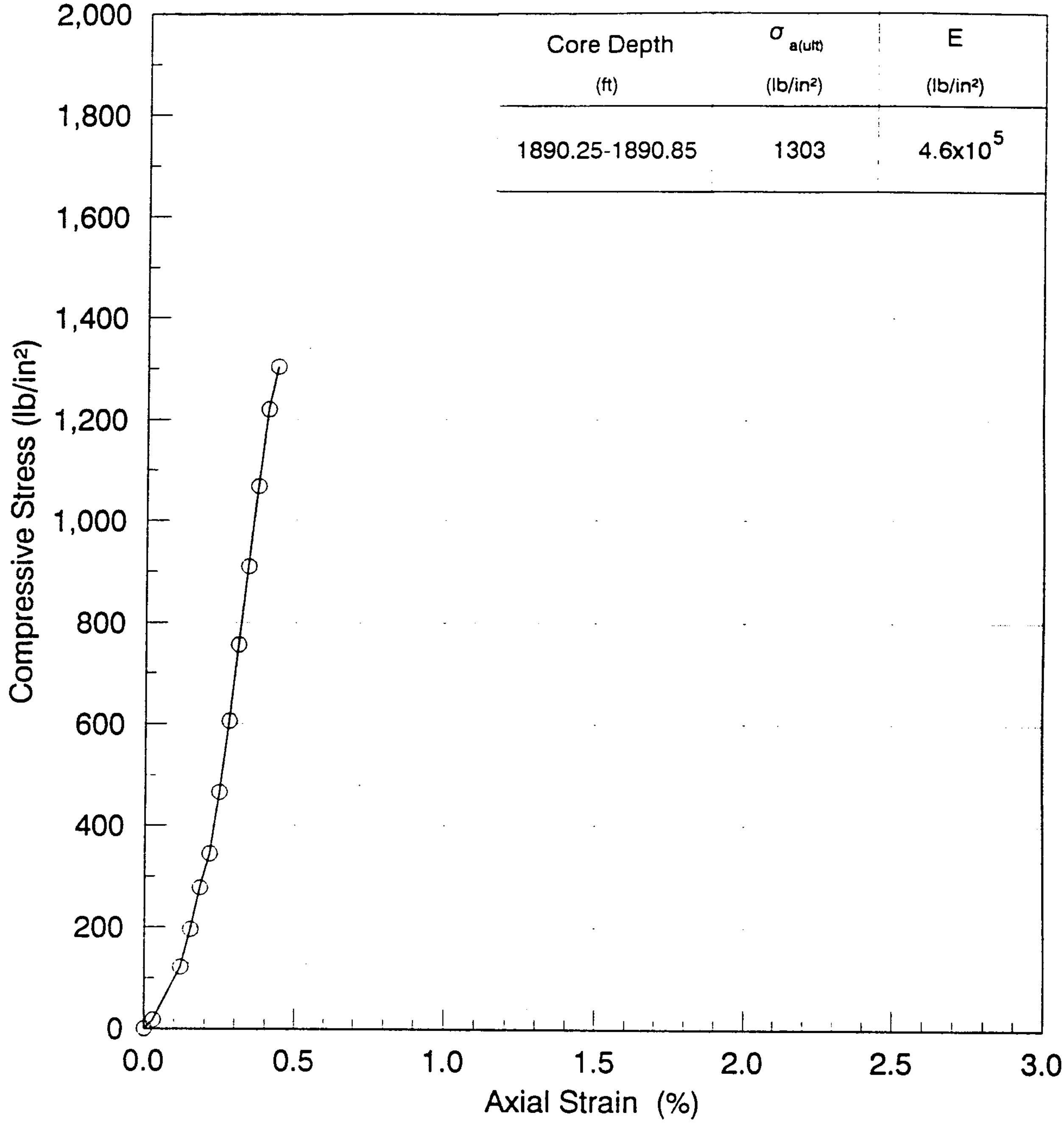
UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY
MONITOR WELL NO. 4

YOUNGQUIST BROTHERS, INC.

DRAWN BY: SA	CHECKED BY: SA	DATE: 09-17-97
FILE NO.: 97-128	APPROVED BY: [signature]	FIGURE: 5



UNCONFINED COMPRESSION TEST

Ardaman & Associates, Inc.
Geotechnical, Environmental and Materials Consultants

BROWARD COUNTY
MONITOR WELL NO. 4

YOUNGQUIST BROTHERS, INC.

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FILE NO.: 97-128	APPROVED BY: [signature]	FIGURE: 4

APPENDIX G

GEOPHYSICAL LOGS

Appendix G – Geophysical Logs
Log Index

Well	Log	Date	Interval (feet bpl)	Borehole Diameter (inches)
IW5	X-Y Caliper / Gamma Ray	Jul-13-99	surface – 165	58
IW5	Temperature - High Resolution	Jul-13-99	surface – 165	58
IW5	X-Y Caliper / Gamma Ray	Jul-22-99	165 – 1010	50
IW5	Temperature - High Resolution	Jul-22-99	165 – 1010	50
IW5	X-Y Caliper / Gamma Ray	Jul-29-99	950 – 1898	12 ¼
IW5	Dual Induction LL3 / SP	Jul-29-99	950 – 1898	12 ¼
IW5	Borehole Compensated Sonic / VDL	Jul-29-99	950 – 1898	12 ¼
IW5	Borehole Televiewer	Jul-29-99	1008 – 1898	12 ¼
IW5	Flowmeter	Jul-30-99	1640 – 1898	12 ¼
IW5	Fluid Conductivity / Temperature	Jul-30-99	1640 – 1898	12 ¼
IW5	X-Y Caliper / Gamma Ray	Aug-26-99	950 – 1900	42
IW5	Temperature - High Resolution	Aug-26-99	950 – 1900	42
IW5	Cement Top Temperature	Aug 31-99	surface – 1900	34[a]
IW5	Flowmeter	Sep-16-99	1890 – 3000	12 ¼
IW5	X-Y Caliper / Gamma Ray	Sep-16-99	1890 – 3000	12 ¼
IW5	Borehole Compensated Sonic / VDL	Sep-16-99	1890 – 3000	12 ¼
IW5	Dual Induction LL3 / SP	Sep-16-99	1890 – 3000	12 ¼
IW5	Borehole Televiewer	Sep-16-99	1900 – 2980	12 ¼
IW5	Fluid Conductivity / Temperature	Sep-17-99	1890 – 3000	12 ¼
IW5	X-Y Caliper / Gamma Ray	Oct-4-99	1890 – 2995	34
IW5	Cement Top Temperature	Oct-6-99	surface – 2995	24[a]
IW5	Fluid Conductivity / Temperature	Nov-3-99	2990 – 3507	24
IW5	Fluid Conductivity – Linear Presentation	Nov-3-99	2990 – 3507	24
IW5	X-Y Caliper / Gamma Ray	Nov-3-99	2990 – 3507	24
IW5	Dual Induction LL3 / SP	Nov-3-99	2990 – 3507	24

Well	Log	Date	Interval (feet bpl)	Borehole Diameter (inches)
IW6	Dual Induction LL3 / SP	Jun-22-99	2950 – 3510	24
IW6	Borehole Compensated Sonic / VDL	Jun-22-99	2950 – 3510	24
IW6	Cement Bond Log	Jun-22-99	surface – 2950	24[a]
IW6	Borehole Televiewer	Jul-13-99	2985 – 3508	24
IW6	Temperature - High Resolution	Mar-7-00	2850 – 3510	24
IW6	Flowmeter	Jun-8-00	2990 – 3510	24
IW6	Temperature - High Resolution	Jun-8-00	2990 – 3510	24

Well	Log	Date	Interval (feet bpl)	Borehole Diameter (inches)
MW3	X-Y Caliper / Gamma Ray	Dec-9-99	surface – 170	32
MW3	Temperature - High Resolution	Dec-9-99	surface – 170	32
MW3	X-Y Caliper / Gamma Ray	Dec-22-99	160 – 1382	24
MW3	Fluid Conductivity / Temperature	Dec-22-99	160 – 1382	24
MW3	Dual Induction LL3 / SP	Dec-22-99	160 – 1383	24
MW3	Borehole Compensated Sonic / VDL	Dec-22-99	160 – 1383	24
MW3	Borehole Televiewer	Dec-23-99	160 – 1383	24
MW3	Cement Top Temperature	Jan-19-00	25 – 1383	16[a]
MW3	Cement Bond Log / VDL	Jan-27-00	300 – 1390	16
MW3	X-Y Caliper / Gamma Ray	Jan-27-00	1380 – 1683	16
MW3	Dual Induction LL3 / SP	Jan-27-00	1380 – 1683	16
MW3	Borehole Compensated Sonic / VDL	Jan-27-00	1380 – 1683	16
MW3	Borehole Televiewer	Jan-27-00	1380 – 1683	16
MW3	Fluid Conductivity / Temperature	Jan-28-00	1380 – 1683	16
MW3	Flowmeter	Jan-28-00	1380 – 1683	16
MW3	Cement Top Temperature	Feb-9-00	10 – 1633	6-5/8[a]
MW3	Cement Bond Log	Feb-14-00	1300 – 1633	6-5/8[a]

[a] = *Casing Diameter*
[b] = *Casing Diameter (surface – 2990 feet bpl) Plus Open Hole (2990 – 3506 feet bpl).*
[c] = *Casing Diameter (surface – 2990 feet bpl) Plus Open Hole (2990 – 3510 feet bpl).*

Note: Geophysical logs are boxed separately.

Appendix G – Geophysical Logs
Final Logs - Box 1

Well	Log	Interval (feet bpl)	Borehole Diameter (inches)
IW5	X-Y Caliper / Gamma Ray	surface – 165	58
IW5	Temperature - High Resolution	surface – 165	58
IW5	X-Y Caliper / Gamma Ray	165 – 1010	50
IW5	Temperature - High Resolution	165 – 1010	50
IW5	X-Y Caliper / Gamma Ray	950 – 3507	12 ¼ - 24
IW5	Dual Induction LL3 / SP	950 – 3507	12 ¼ - 24
IW5	Borehole Televiewer	1008 – 3507	12 ¼ - 24
IW5	Flowmeter	1640 – 1898	12 ¼
IW5	Fluid Conductivity / Temperature	1640 – 1898	12 ¼
IW5	X-Y Caliper / Gamma Ray	950 – 1900	42
IW5	Temperature - High Resolution	950 – 1900	42
IW5	Cement Top Temperature	surface – 1900	34[a]
IW5	Flowmeter	1890 – 3000	12 ¼
IW5	Fluid Conductivity / Temperature	1890 – 3000	12 ¼
IW5	X-Y Caliper / Gamma Ray	1890 – 2995	34
IW5	Cement Top Temperature	surface – 2995	24[a]
IW5	Fluid Conductivity / Temperature	2990 – 3507	24
IW5	Fluid Conductivity - Linear Presentation	2990 – 3507	24
IW5	Cement Bond Log	surface – 3017	24[a]
IW5	Temperature - High Resolution	casing – 3507	24
IW5	Radioactive Tracer Survey	1990 – 2990	24
IW5	Flowmeter	2900 – 3507	24
IW5	Fluid Conductivity / Temperature	2900 – 3507	24
IW5	Temperature - High Resolution	2900 – 3507	24
IW5	Borehole Compensated Sonic / VDL	950 – 3507	12 ¼ - 24
IW5	Television Survey (Tape 1 of 2)	1042-1897	12 ¼
IW5	Television Survey (Tape 2 of 2)	1042-1897	12 ¼

[a] = *Casing Diameter*

Appendix G – Geophysical Logs
Final Logs - Box 2

Well	Log	Interval (feet bpl)	Borehole Diameter (inches)
IW6	X-Y Caliper / Gamma Ray	surface – 170	58
IW6	Temperature - High Resolution	surface – 170	58
IW6	X-Y Caliper / Gamma Ray	surface – 1005	50
IW6	Temperature - High Resolution	surface – 1005	50
IW6	Cement Top Temperature	surface – 1000	42[a]
IW6	Fluid Conductivity / Temperature	880 – 1900	12 ¼
IW6	X-Y Caliper / Gamma Ray	950 – 3510	12 ¼
IW6	Dual Induction LL3 / SP	950 – 3510	12 ¼
IW6	Borehole Compensated Sonic / VDL	950 – 3510	12 ¼
IW6	Fluid Conductivity / Temperature	1650 – 1900	12 ¼
IW6	Flowmeter	1650 – 1900	12 ¼
IW6	X-Y Caliper / Gamma Ray	975 – 1900	42
IW6	Temperature - High Resolution	975 – 1900	42
IW6	Cement Top Temperature	surface – 1900	34[a]
IW6	Fluid Conductivity / Temperature	1893 – 2998	12 ¼
IW6	Flowmeter	1893 – 2998	12 ¼
IW6	X-Y Caliper / Gamma Ray	1800 – 2990	34
IW6	Cement Top Temperature	surface – 2971	24[a]
IW6	Radioactive Tracer Survey	2850 – 3510	24
IW6	Cement Bond Log	surface – 2950	24[a]
IW6	Temperature - High Resolution	2850 – 3510	24
IW6	Flowmeter	2990 – 3510	24
IW6	Temperature - High Resolution	2990 – 3510	24
IW6	Borehole Televiewer	950 – 3510	12 ¼
IW6	Television Survey	1665-1900	12 ¼
IW6	Television Survey (Tapes 1 & 2)	1900-3000	12 ¼
IW6	Television Survey	0-3500	24

[a] = *Casing Diameter*

Appendix G – Geophysical Logs
Final Logs - Box 3

Well	Log	Interval (feet bpl)	Borehole Diameter (inches)
MW3	X-Y Caliper / Gamma Ray	surface – 170	32
MW3	Temperature - High Resolution	surface – 170	32
MW3	X-Y Caliper / Gamma Ray	160 – 1382	24
MW3	Fluid Conductivity / Temperature	160 – 1382	24
MW3	Dual Induction LL3 / SP	160 – 1383	24
MW3	Borehole Compensated Sonic / VDL	160 – 1383	24
MW3	Cement Top Temperature	25 – 1383	16[a]
MW3	X-Y Caliper / Gamma Ray	1380 – 1683	16
MW3	Dual Induction LL3 / SP	1380 – 1683	16
MW3	Borehole Compensated Sonic / VDL	1380 – 1683	16
MW3	Cement Bond Log / VDL	300 – 1390	16[a]
MW3	Fluid Conductivity / Temperature	1380 – 1683	16
MW3	Flowmeter	1380 – 1683	16
MW3	Cement Top Temperature	10 – 1633	6-5/8[a]
MW3	Cement Bond Log	1300 – 1633	6-5/8[a]
MW3	Borehole Televiewer	160 – 1683	24 - 16
IW5	Television Survey (Tape 1 of 2)	1895-2995	12 ¼
IW5	Television Survey (Tape 2 of 2)	2995-1895	12 ¼
IW5	Television Survey	5-3506	24

[a] = *Casing Diameter*