ENGINEERING REPORT

ON

DRILLING AND TESTING OF

DEEP DISPOSAL WELL

FOR

PENINSULA UTILITIES CORPORATION

CORAL GABLES, FLORIDA

SUNSET PARK

PROJECT NO. 498-70-53 FEBRUARY, 1970

BLACK, CROW AND EIDSNESS, INC.

Engineers

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SECTION 1

FOREWORD

1.01 SCOPE

This report covers the drilling and testing of an injection well just completed and intended for deep underground disposal of waste-waters from the Sunset Park Treatment Plant of the Peninsula Utilities Corporation, south of Miami, Dade County, Florida. It gives a brief description of the hydrogeological conditions of the area which, in our opinion, allow for such type of disposal. It includes the requirements established by the regulatory agencies for their approval of the operation of the facilities.

The report is divided into the following Sections:

1. Foreword
2. Deep-Well Disposal
3. Governmental Regulations
4. Well Construction
5. Injection Test
6. Monitoring System
7. Summary and Conclusions

The well was drilled in accordance with our "Specifications for Waste Disposal Facilities for the Peninsula Utilities Corporation, Coral Gables, Florida, Disposal Well," Project No. 498-69-01, dated June, 1968, as approved by the Dade County Pollution Control office and the Bureau of Sanitary Engineering, Florida State Board of Health, under Permit No. 13-7647-68.

1.02 GENERAL DESCRIPTION

Peninsula Utilities Corporation, Coral Gables, Florida, owns and operates the Sunset Park Wastewater Treatment Plant located at S. W. 83rd Street between 97th and 98th Avenues in Dade County, Florida.

The plant is solids-contact-stabilization type with a design capacity of two million gallons per day (2 mgd). Presently it is being expanded to a design capacity of 3 mgd. Such a plant will produce an effluent with 90 percent organic load reduction.

The effluent from the waste treatment plant is discharged into Snapper Creek Canal, a part of the Central and Southern Florida Flood Control District.

A preliminary conference with Mr. Ralph H. Baker, Jr., Director, Division of Wastewater, Bureau of Sanitary Engineering, Florida State Board of Health, indicated that his office would approve a deep-well disposal system, with the understanding that the effluent meet the requirement of 90 percent removal as adopted in the State's Water

Quality Standards. Further conferences with Mr. Paul W. Leach, Director of the Pollution Control Division of Dade County, resulted in the approval by his office of this method of disposal, conditioned to monitoring and operational requirements which are described in Section 3 of this report.

Plans and specifications (Black, Crow and Eidsness, Inc., 1968) were prepared for the construction of a disposal well to an estimated depth of 2,500 feet in order to determine whether a very permeable and salty limestone aquifer, referred to as the Boulder Zone, could accept this volume of waste at reasonable pressures. The well has been designed to prevent any contamination of the upper aquifers either by waters from the Boulder Zone or from the effluent discharged into it.

The Biscayne aquifer, from which the water supply of Miami is obtained, extends to a depth of approximately 100 feet. It is separated from the Floridan aquifer by an aquiclude approximately 800 feet thick. Water in the Floridan aquifer is brackish and is penetrated by only five to ten wells in the Miami area. An aquiclude, extending from a depth of 1,800 to 2,550 feet, separates the Floridan aquifer from the Boulder Zone, a highly cavernous formation with very large horizontal transmissibilities. The Boulder Zone ultimately discharges into the ocean depths of the Straits of Florida.

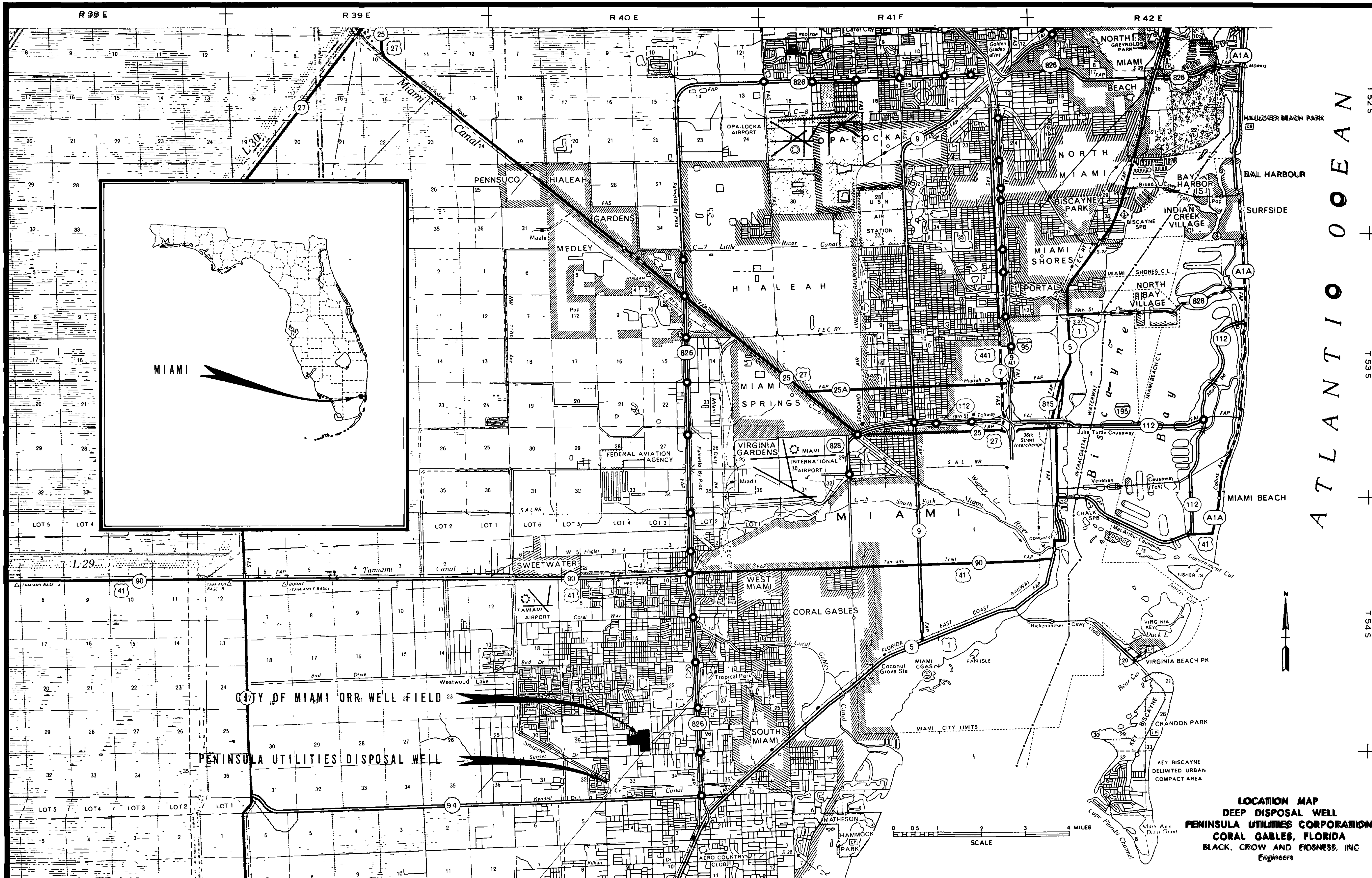
Completed disposal well extends into the Boulder Zone to a depth of 2,947 feet and is separated from the Biscayne and Floridan aquifers by cemented steel casings to prevent pollution of the upper formations. Two aquicludes, comprising a total depth of approximately 1,500 feet, separate the receiving stratum from the Biscayne aquifer.

Location of the deep-disposal well is shown on Plate 1-1 which also shows the location of the City of Miami's Alexander Orr Well Field, one of the three water-supply fields operated by the City waterworks system. All of the City's wells penetrate only the Biscayne aquifer.

1.03 ACKNOWLEDGMENTS

Close cooperation was maintained with the Bureau of Geology, Florida Department of Natural Resources, and the Subdistrict Office (Miami) of the Water Resources Division, U. S. Geological Survey. Owners and consulting engineers are very much indebted to both offices for their assistance prior to and during construction.

Dr. R. O. Vernon, Director of the Bureau of Geology, kept close contact with the engineers in the planning and prosecution of the project, studied drilling formation samples, and prepared the lithological and geological report included under Appendix A-2. Mr. C. R. Sproul, Geologist with the Bureau, logged the pilot hole to 1,970 feet and the borehole from 1,810 to 2,940 feet.


LOCATION MAP
DEEP DISPOSAL WELL
PENINSULA UTILITIES CORPORATION
CORAL GABLES, FLORIDA
BLACK, CROW AND EIDSNESS, INC
Engineers
CITY OF MIAMI ORR WELL FIELD
PENINSULA UTILITIES DISPOSAL WELL
MIAMI
R 39 E
R 40 E
R 41 E
R 42 E
T 52 S
T 53 S
T 54 S
ATLANTIC OCEAN
HIALEAH
MIAMI SPRINGS
VIRGINIA GARDENS
MIAMI INTERNATIONAL AIRPORT
OPA-LOCKA
NORTH MIAMI
NORTH MIAMI BEACH
BISCAYNE PARK
MIAMI SHORES
EL PORTAL
NORTH BAY VILLAGE
BAY HARBOR IS
INDIAN CREEK VILLAGE
BAL HARBOUR
SURFSIDE
MIAMI BEACH
HIALEAH GARDENS
MEDLEY
PENNSUCO
SWEETWATER
WEST MIAMI
CORAL GABLES
SOUTH MIAMI
TAMIAMI AIRPORT
FEDERAL AVIATION AGENCY
KEY BISCAYNE
CRANDON PARK
VIRGINIA BEACH PK
KEY BISCAYNE DELIMITED URBAN COMPACT AREA
MATHESON HAMMOCK PARK
AERO COUNTRY CLUB
Tropical Park
MIAMI CITY LIMITS
Biscayne Bay
Tamiami Canal
L-29
L-30
SCALE
0 .5 1 2 3 4 MILES

SECTION 2

DEEP-WELL DISPOSAL

2.01 HYDROGEOLOGICAL CONSIDERATIONS

Underground disposal by wells can be successfully achieved only when four general requirements are fulfilled. These requirements are:

1. There is a stratum or strata which can accept the waste.
2. The hydraulic and structural characteristics of the aquifer will not be significantly reduced by the disposal of the waste.
3. The disposal of such waste will not impair the present or future use of the water in such stratum or strata.
4. The disposal of such waste will not impair the present or future use of the water in adjoining water-bearing strata (aquifers) or surface-water supplies.

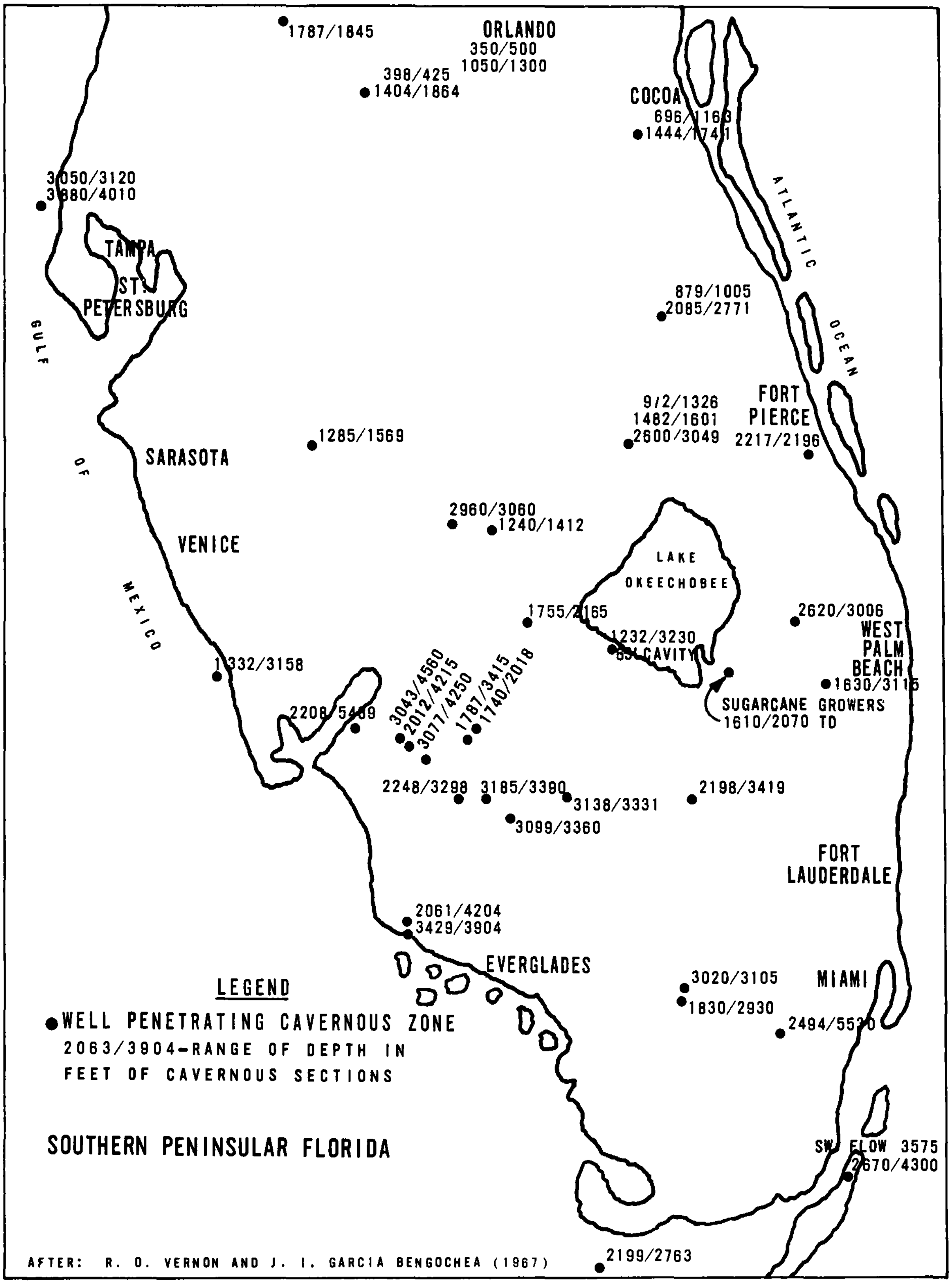
The State of Florida is underlain by one of the richest artesian aquifer systems in the world. This system is called the Floridan aquifer. It consists of a series of groundwater bearing strata of cavernous limestones and dolomites. The cavernous strata are separated by thick and practically impervious layers of marls, dense limestones, and dolomites. Deep cavernous strata are highly mineralized in most of Southern Florida. Such deep beds have been penetrated by oil exploration wells.

Drilling through the deeper and highly cavernous zones breaks off large fragments of dolomites and limestones and presents serious difficulties similar to drilling through large boulders. For this reason such strata are referred to as the "Boulder Zone." Plate 2-1 shows location of wells in the southern part of the peninsula which penetrate cavernous sections of the Floridan aquifer and the Boulder Zone. This plate indicates that the cavernous sections and the Boulder Zone extend under Central and Southern Florida.

The cavernous sections of the Floridan aquifer can either produce or accept large volumes of water. Wells penetrating those sections with appropriate borehole size yield several thousand gallons per minute. Thus, Requirement 1, above, may be easily fulfilled.

The physical and chemical qualities of the effluent to be injected in the proposed disposal well indicate that the hydraulic and structural characteristics of the aquifer will not be significantly changed. Therefore Requirement 2 is satisfied.

The Floridan aquifer is actually formed by a sequence of aquifers or zones of permeability separated by dense limestones and dolomites. Actual operation of a disposal well in Belle Glade, Palm Beach County, for three years, indicates that there is no interconnection between the upper main zone of the Floridan aquifer and the next deeper one or Boulder Zone (García-Bengochea and Vernon, 1969).



WELLS PENETRATING CAVERNOUS ZONES IN SOUTHERN FLORIDA

Water from the Floridan aquifer in Dade County is highly mineralized and chlorides increase with depth until they reach sea water concentration. The high chloride concentration of the Floridan aquifer in Dade County precludes, at this time, its use as a source of fresh water. Future use will require some demineralizing process to reduce the chloride content. Such process will remove any additional nitrates or phosphates injected into the aquifer without significant cost increase. Requirement 3 is then fulfilled.

Notwithstanding considerations in the previous paragraph, any properly designed disposal well in Dade County must be cased through the first permeable zone of the Floridan aquifer and extended into the next deeper (Boulder) zone. The deeper zone has chloride concentration approaching that of sea water and is overlain by confining beds of not less than 200 to 300 feet. This condition protects brackish waters in the upper zone of the Floridan aquifer, which is the logical source for the future, if desalinization of water for the area is ever required or considered.

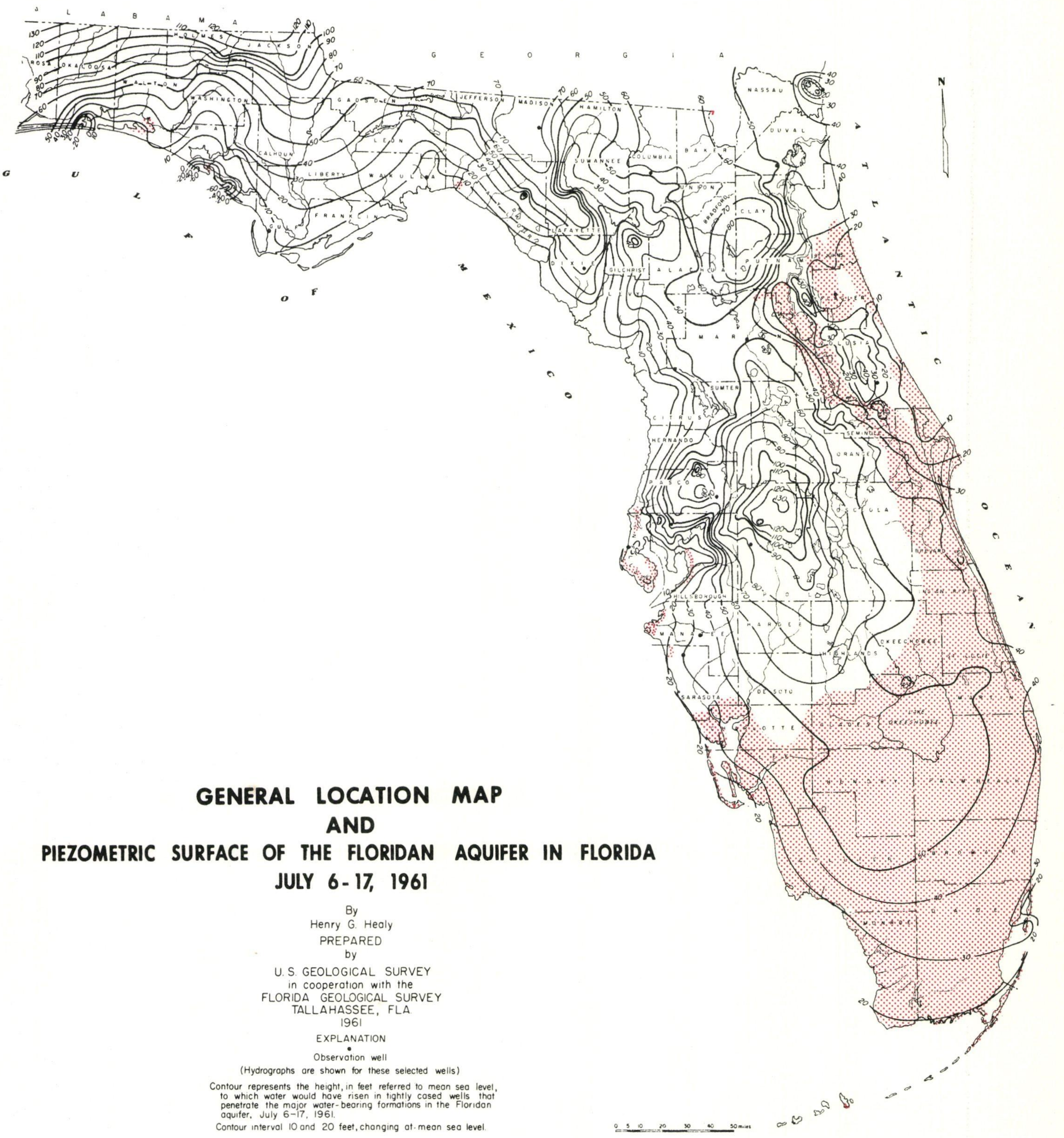
The only fresh-water aquifer in Dade County is the Biscayne aquifer which, within the area under consideration, extends to approximately 100 feet in depth below ground (Sherwood and Leach, 1962, p. 7) (Parker, et al, 1955, pp. 871-872). The Biscayne aquifer is completely separated from the top part of the Floridan aquifer by approximately 800 feet of marls, very dense limestones, and clayey sand and shells which constitute a perfect aquiclude. This is evidenced by the following fact: The Floridan aquifer in the Miami area shows chloride concentrations in excess of 1,500 mg/l with piezometric heads of more than 30 feet above mean sea level. In the same area, chloride concentrations in the Biscayne aquifer are approximately 30 to 40 mg/l, with water table contours of 2 to 4 feet above mean sea level (USGS, Miami office, 1968). The separating strata act as a perfect aquiclude. Otherwise, the brackish water under pressure in the Floridan aquifer would leak up into the Biscayne aquifer contaminating it. This condition fulfills Requirement 4.

One question the reader may ask at this time is: Where does the injected water go? Present technology does not yet offer practical and economical means to directly determine the direction of groundwater flow at considerable depth. Present knowledge of hydrogeology gives us, however, good indications of what would happen to the injected fluid.

First, we ought to consider that the fluid to be injected is fresh water with lower specific gravity (lighter) than the high chloride water in the aquifer. Mixing will occur at the start of the injection period, but thereafter a fresh-water bubble should begin to form, floating on the salty water and limited above by the confining layers. This is based on the Ghyben-Herzberg principle (Stringfield, V. T., and Cooper, H. H., 1951), which explains the relation between fresh and salt water in coastal areas. This principle allows for the recharge of fresh water into salt or brackish water aquifers as is presently being investigated by the U. S. Geological Survey in Orange County, Florida.

Second, we need to realize that groundwater moves in accordance with the hydraulic gradient, following a direction perpendicular to the piezometric contours. If the piezometric surface of the Boulder Zone resembles, as it should, that of the upper part of the Floridan aquifer (Plate 2-2), the direction of groundwater flow in Dade County is toward the Straits of Florida in the Atlantic Ocean. A hypothesis of cyclic flow by geothermal gradient proposed by Kohout (1967) suggests the possibility of inland water flow in the Boulder Zone. Hydrogeological data collected during construction and after completion of the present disposal well, in our opinion, refutes that hypothesis.

Finally, it must be considered that groundwater movement in the Floridan aquifer is very slow under natural conditions. Groundwater velocity in the Floridan aquifer of Central Florida has been estimated of the order of 20 to 30 feet per year (Hanshaw, et al, 1965). Under such conditions it would take approximately 200 years for a particle of water to move one mile, or some 7,000 years for that particle of water to reach the deepest part, or trough, of the Straits of Florida at the latitude of Miami. That trough is approximately 2,600 feet in depth and 35 miles east of our well location (Uchupi, 1968, plate 3). We believe that the Boulder Zone in the Dade County area breaks or leaks through the continental shelf at such a point in the Atlantic Ocean.



GENERAL LOCATION MAP
AND
PIEZOMETRIC SURFACE OF THE FLORIDAN AQUIFER IN FLORIDA
JULY 6-17, 1961

By
Henry G. Healy

PREPARED
by
U. S. GEOLOGICAL SURVEY
in cooperation with the
FLORIDA GEOLOGICAL SURVEY
TALLAHASSEE, FLA
1961

EXPLANATION

•
Observation well
(Hydrographs are shown for these selected wells)

Contour represents the height, in feet referred to mean sea level, to which water would have risen in tightly cased wells that penetrate the major water-bearing formations in the Floridan aquifer, July 6-17, 1961.

Contour interval 10 and 20 feet, changing at mean sea level.

DENOTES AREA OF CHLORIDE CONCENTRATION IN WATER OF 250 P. P. M. AND GREATER

SECTION 3

GOVERNMENTAL REGULATIONS

3.01 GENERAL

Permits to drill the deep disposal well were obtained prior to construction from the pertinent regulatory agencies: the Dade County Pollution Control office and what was then the Division of Industrial Waste, Bureau of Sanitary Engineering, Florida State Board of Health. Functions of the latter office have been transferred to Florida Department of Air and Water Pollution Control.

Regulatory agencies specified that no wastewaters would be permitted in any aquifer containing, or which might contaminate another aquifer containing, a chloride concentration of less than 1,500 milligrams per liter. Additional requirements established by each regulatory agency are detailed below.

3.02 FLORIDA STATE REGULATIONS

Plans to construct well approved June 5, 1969. Permit to drill well (No. 13-7728-69) issued, with requirements from the Division of Industrial Waste, Bureau of Sanitary Engineering, Florida State Board of Health (Mastro, 1969) as follows:.

"1. The discharge to this disposal well shall be tested for the following continuously by analytical devices:

Flow	pH
Pressure	Dissolved oxygen
Chlorine residual	Specific conductance

The test apparatuses (to be approved by the Bureau of Sanitary Engineering, Florida State Board of Health) shall be such that it is fully automatic.

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"2. The well constructed shall be of a three pipe design as submitted by Black, Crow & Eidsness Engineering Report of September, 1968 and as required in their specification of June, 1968 prepared and submitted for the Peninsula Utilities Corporation, Coral Gables, Florida. All test apparatus shall be as fully automatic as present technology permits. The Bureau of Sanitary Engineering, Florida State Board of Health shall be notified by telegram or telephone call of any well or operational failures.

In this event remedial measures must be taken immediately. If failure of well is not corrected and placed back in service within thirty (30) days, construction of the facilities as approved by the Division of Waste Water, Bureau of Sanitary Engineering, Florida State Board of Health, Serial #3973 AV-Add File #35667 shall begin without further delay.

"3. The annulus between the middle and the inner casing shall be monitored and an acceptable pressure indicating, recording and alarm device shall be installed on same. Any abnormal change in pressure shall be followed by an immediate cessation of injection of waste water.

"4. The owner shall provide technically competent fully qualified personnel to operate this facility at all times that it is discharging treated waste water to subterranean strata.

"5. During and after construction, a cement bond log, a caliper log and an induction-electrical log shall be obtained and copies furnished this office.

"6. A survey of the area shall be conducted to determine the location, if any, of active wells in an area of a radius of one mile showing depths, and furnished to this office and the office of the State Geologist. If, in their opinion, these wells will form a suitable monitoring network of the upper aquifer, arrangements shall be made to sample each so indicated each 24 hours and the tests under #1 shall be performed.

"7. This permit shall expire after 15 years of operation of the well or may be renewed in light of operational experience. However, it is understood that the State Board of Health reserves the right to revoke this permit at any time for failure to comply with the provisions stated herein, or if this disposal well should at any time contaminate or otherwise affect other waters in the vicinity, or for other cause.

"8. A log of the work as the drilling proceeds and/or samples at not less than each 50 feet* and/or each significant change in subsurface structure shall be furnished to Dr. Robert O. Vernon (Division Director and State Geologist) Florida Board of Conservation, Division of Geology, Florida Geological Survey, P. O. Box 631, Tallahassee, Florida, with copies to the Florida State Board of Health, Bureau of Sanitary Engineering, P. O. Box 210, Jacksonville, Florida 32201.

"9. A plot plan of the location of the well and the monitoring wells shall be submitted to this Agency in quadruplicate through the Dade County Health Department and shall indicate full approval of all concerned of these locations.

"10. The above data and measurements shall all be reported monthly on a suitable form to:

Florida State Board of Health, Bureau of Sanitary Engineering, Division of Waste Water.

Florida State Board of Health, Bureau of Sanitary Engineering, Division of Industrial Waste."

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*Modified to 10 feet (Mastro, July 18, 1969).

3.03 DADE COUNTY POLLUTION CONTROL

Plans approved March 6, 1969, with the following requirements (Leach, 1969) in addition to those stipulated in Florida State Board of Health approval:

"1. A plot plan of the location of the well and the monitoring wells (map 1" = 200 feet required) shall be submitted to this office, after their locations have been approved by this office.

"2. Audible and visual alarms shall be supplied and attached to all monitoring equipment required, set so as to activate at the levels specified and the Pollution Control Department shall be notified immediately by telephone, telegram, or by contacting the Dade County Fire Alarm office, whichever is most appropriate and all of the provisions of Section 24-37 regarding reporting shall be complied with expeditiously.

"3. All operating records shall be submitted monthly, as you have been previously notified, in a format to be approved by the Pollution Control Officer.

"4. Discharges to the Disposal well shall not be allowed during any time that the:

a. Chlorine residual is below 0.5 ppm

b. Oil and grease exceeds 15 ppm

c. pH is below 6.0 or above 8.5 units

d. Coliform exceed 50 MPN/100 ml as determined by the Multiple Tube method

e. Sulfides exceed 0.5 ppm

"5. The following analyses, on the influent to the treatment plant and the effluent to the disposal well, shall be performed by an approved laboratory not less frequently than as follows:

a. B.O.D. - twice weekly on eight-hour composite samples

b. Suspended solids - twice weekly on eight-hour composite samples

c. Flow - continuously

d. Pressure at well head - continuously

e. Chlorine residual - continuously if instrumentation is available, otherwise hourly

f. Dissolved Oxygen - continuously

g. pH - continuously

h. Total solids - twice weekly on eight-hour composite samples

These requirements are considered minimum and may require further expansion as technology permits. I am sure that you realize that this permit may be revoked at any time that any of these provisions is not met. Should this permit be revoked or the disposal well become unfeasible, you will be required to provide the necessary tertiary treatment works within one (1) year of notification to proceed by this office."

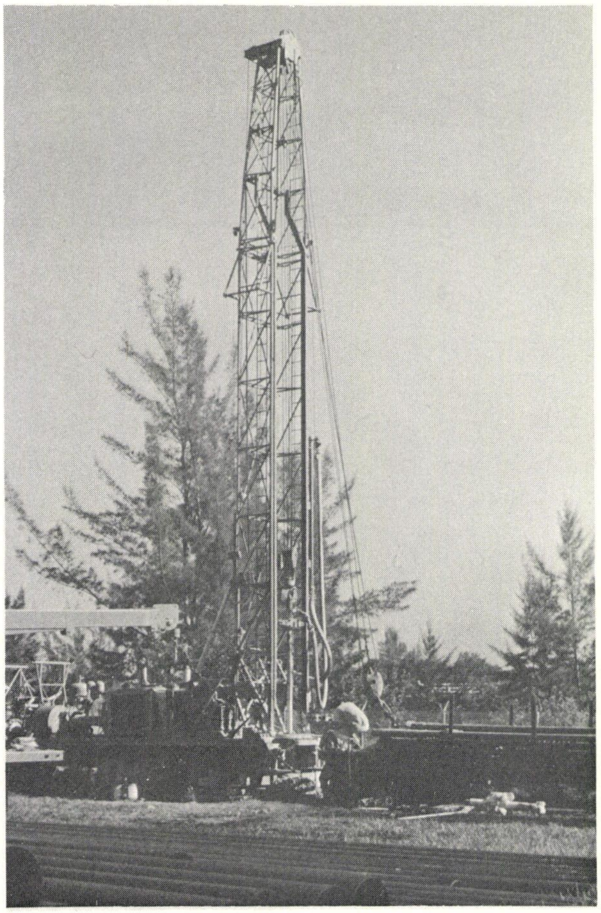
SECTION 4

WELL CONSTRUCTION

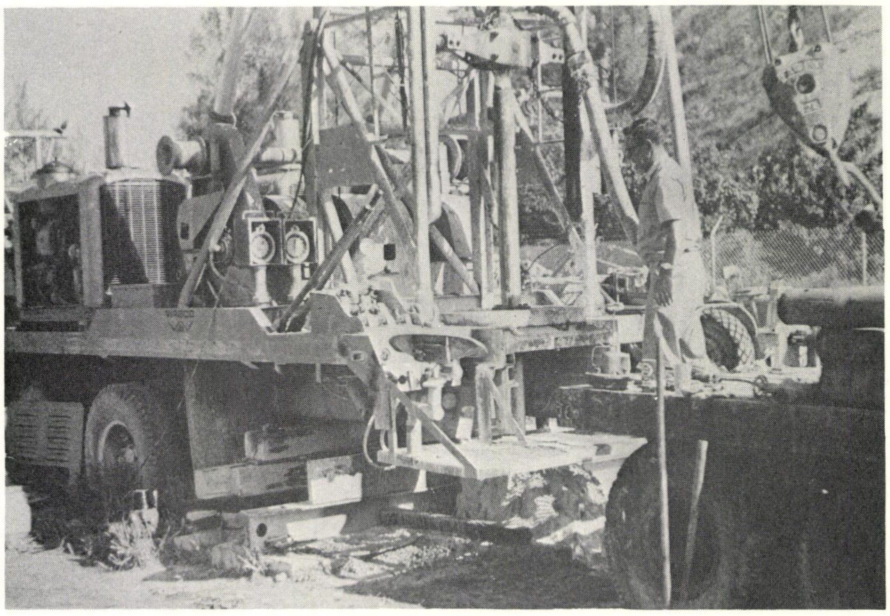
4.01 DRILLING

Rotary drilling was started June 19, 1969, with a pilot hole to determine depth required to set and cement each of the three steel casings specified. Pilot hole was drilled in stages to cover each time only that portion of the hole to be sealed off by the corresponding casing. Purpose of the pilot hole was also to collect formation samples from drilling operations and representative water samples from the artesian aquifers. Drilling was performed with straight mud circulation until fluid losses indicated water-bearing zones. Thereafter it was changed to reverse rotary to allow for the collection of water samples. Plate 4-1 shows photographs of drilling equipment and controls. Detailed driller's log as collected by Contractor, Alsay Drilling, Inc., Lake Worth, Florida, is in Appendix A-1, Well Drilling Report.

Formation samples were collected every 5 feet and delivered to the Bureau of Geology, Division of Interior Resources, Florida Department of Natural Resources. Samples were studied by Dr. R. O. Vernon, Director of the Bureau, and his detailed geological report is included in Appendix A-2. Water samples were collected every 20 feet through the artesian water-bearing zones. Field determinations were



Overall View of Drilling Equipment



Close View of Drilling Equipment and Controls made immediately after collection for temperature, specific gravity, specific conductance, and chlorides. Specific conductance and chloride determinations were rechecked in the laboratory and the remainder of each sample was delivered to the Bureau of Geology.

Casings are black steel, 0.375 inch in thickness, AWWA A100-58 and ASTM A-53B. Casing details are summarized as follows:

Diameter (inches)	Depth in Feet From Ground Level to	Cemented Section[1] in feet From	To
26	210	210	0
22	545	545	0
16	1,810	1,810	1,678

(1) With neat cement, ASTM Type II.

Plate 4-2 summarizes information collected from drilling and related operations.

The noncemented annulus between 1,678 feet and ground level will allow continuous monitoring of water quality within the brackish upper artesian aquifer. Any possible leakage from inner casing, the open hole, or the receiving zone would tend to develop in the immediate vicinity of the hole and could be detected first by monitoring the annulus.

4.02 WATER QUALITY DATA

Temperature, specific gravity, and chloride concentration determined in the field after collection of each sample are shown on Plate 4-2. Detailed record of those determinations for each sample, plus

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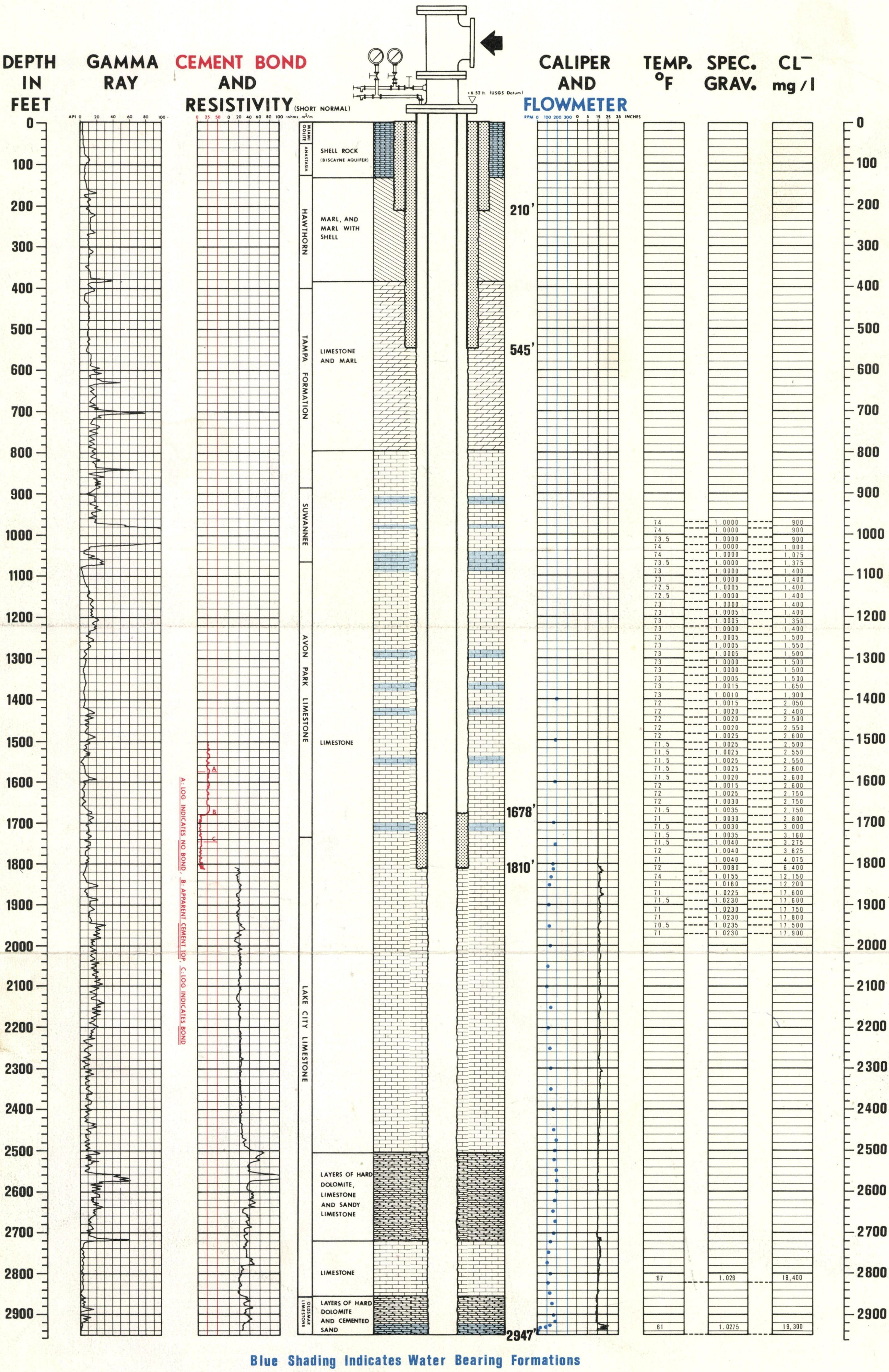
SUMMARY OF DATA FROM DRILLING AND RELATED OPERATIONS
DISPOSAL WELL, PENINSULA UTILITIES CORPORATION, CORAL GABLES, FLORIDA



TEMP. °F	SPEC. GRAV.	CL⁻ mg/l
74	1.0000	900
74	1.0000	900
73.5	1.0000	900
74	1.0000	1,000
74	1.0000	1,075
73.5	1.0000	1,375
73	1.0000	1,400
73	1.0000	1,400
72.5	1.0005	1,400
72.5	1.0000	1,400
73	1.0000	1,400
73	1.0005	1,400
73	1.0005	1,350
73	1.0000	1,400
73	1.0005	1,500
73	1.0005	1,550
73	1.0005	1,500
73	1.0000	1,500
73	1.0000	1,500
73	1.0005	1,500
73	1.0015	1,650
73	1.0010	1,900
72	1.0015	2,050
72	1.0020	2,400
72	1.0020	2,500
72	1.0020	2,550
72	1.0025	2,600
71.5	1.0025	2,500
71.5	1.0025	2,550
71.5	1.0025	2,550
71.5	1.0025	2,600
71.5	1.0020	2,600
72	1.0015	2,600
72	1.0025	2,750
72	1.0030	2,750
71.5	1.0035	2,750
71	1.0030	2,800
71.5	1.0030	3,000
71.5	1.0035	3,160
71.5	1.0040	3,275
72	1.0040	3,625
71	1.0040	4,075
72	1.0080	6,400
74	1.0155	12,150
71	1.0160	12,200
71	1.0225	17,600
71.5	1.0230	17,600
71	1.0230	17,750
71	1.0230	17,800
70.5	1.0235	17,500
71	1.0230	17,900
67	1.026	18,400
61	1.0275	19,300

Blue Shading Indicates Water Bearing Formations

4-4

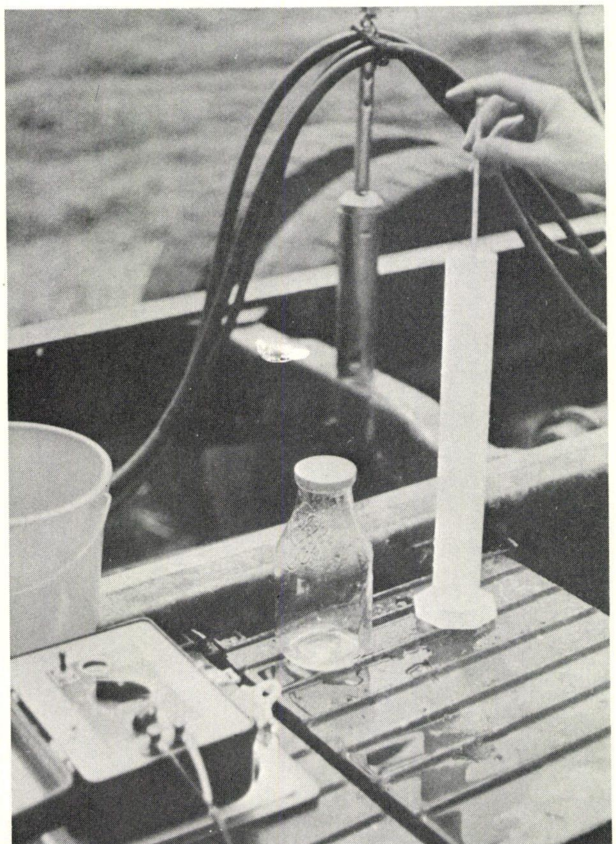
PLATE 4-2

specific conductance determined also in the field, is in Appendix A-4, Water Quality Data. Temperature and specific gravity determinations for each sample were made immediately after collection. Plate 4-3 includes photographs of the collection and field determinations of water samples.

It is most interesting to note a slight drop in temperature (from 74° F to 71° F) between 968 and 1,970 feet in depth; another drop (from 71° F to 67° F) between 1,970 and 2,820 feet; and then an abrupt drop (from 67° F to 61° F) between 2,820 feet and the bottom of the well (2,930 - 2,947 feet). Such temperature drops are contrary to the normal groundwater geothermal gradient of approximately 1° F increase per 50 to 100 foot increase in depth. Temperature gradient anomaly is caused, in our opinion, by heat transfer from the aquifer groundwater into the cold, deep water of the Straits of Florida. Temperatures below 2,000 feet of depth in the Straits range between 45 and 50° F (Kohout, 1965, p. 266).

Table 4-1 shows a comparison between the chemical composition of the water from the Biscayne (shallow) aquifer at the disposal well site; of the water from the disposal well (Boulder Zone); and the average composition of sea water at Miami Beach. Comparison shows that the chemical composition of the water from the disposal well is practically the same as that from the sea water in the Atlantic Ocean at Miami Beach.

Collection of Water Samples from Reverse-Circulation Discharge



Field Determinations on Water Samples

TABLE 4-1

COMPARISON OF CHEMICAL ANALYSES

Constituent	Biscayne Aquifer (1)	Disposal Well (2)	Sea Water Miami Beach (3)
Total dissolved solids	285	33,900	35,800
Chlorides, as Cl	11	19,300	19,770
Sulfate, as SO_4	18	2,660	2,750
Bicarbonate, as $CaCO_3$	212	117	121
Calcium, as $CaCO_3$	228	1,140	1,120
Magnesium, as $CaCO_3$	20	5,320	5,430
Sodium, as Na	ND	10,800	10,970
Potassium, as K	ND	415	429

(1) Biscayne aquifer, shallow well at Sunset Park Plant, 73 feet deep, November 6, 1969, analysis by Black, Crow and Eidsness, Inc.

(2) Peninsula disposal well, 2,947 feet in depth at Sunset Park Plant, December, 1969, analysis by U. S. Geological Survey.

(3) Sea water, average composition at Miami Beach, as reported by Parker, et al, 1955. (U. S. Geological Survey Water Supply Paper 1255, Table 65, p. 572).

ND-Not determined.

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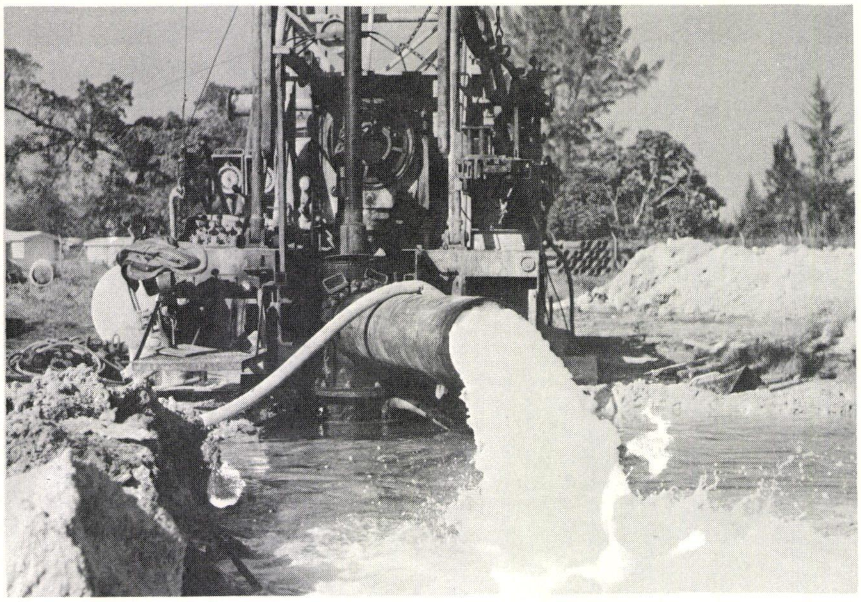
4.03 WELL LOGGING

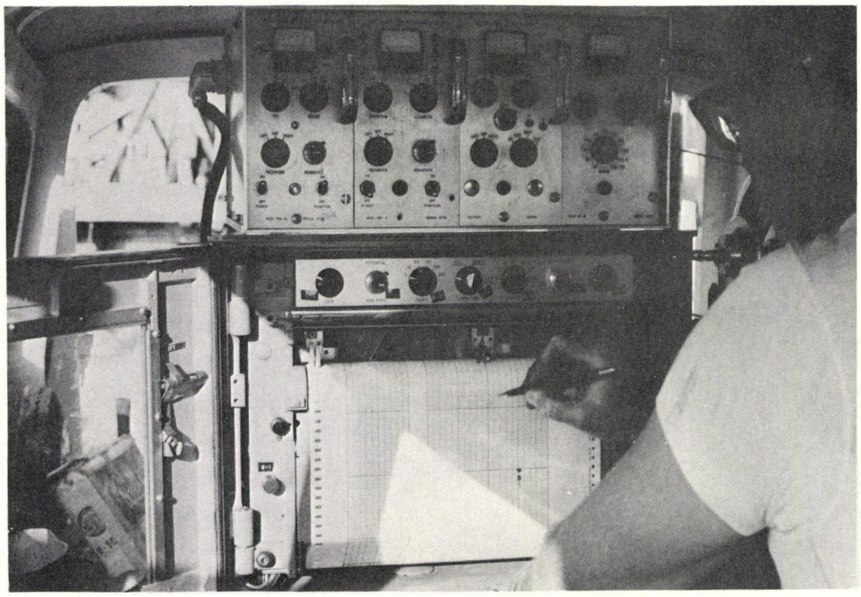
The decision to set the bottom of the inner casing (16" OD) at 1,810 feet in depth was based on the marked change in chlorides between 1,785 and 1,870 feet in depth; on the driller's log; on examination of formation samples; and on borehole logging of the pilot hole to 1,970 feet in depth. Borehole logging of that part of the well was performed by Mr. C. R. Sproul, Geologist, Bureau of Geology, Florida Department of Natural Resources. Logs from those operations are on record at the Bureau of Geology.

Additional logging was performed after completion of the well and results are summarized on Plate 4-2. On the right-hand side of Plate 4-2 the caliper and flowmeter or fluid velocity logs appear. These logs were also performed by Mr. Sproul. The caliper log shows a plot of the actual diameter of the well versus depth. The flowmeter log (blue circles on the graph) shows the revolutions per minute of a propeller-type meter suspended at different depths in the well while this was pumped with air for development. Pumping rate was estimated at approximately 2,500 gallons per minute. These two logs clearly indicate that practically all the water was coming from the large expanded section of the hole (possibly a cavity) between 2,920 and 2,940 feet in depth. Photographs of development and some of above logging operations are shown on Plate 4-4.



Well Discharge During Development

Vertical Flowmeter for Well Logging



Recording Well Logging Operations

Logging for gamma ray, electrical induction, and cement bond were performed in the well after completion. This logging was done by the Schlumberger Well Services, Houston, Texas, and Laurel, Mississippi. Results of Schlumberger logging are shown on the left side of Plate 4-2. Gamma ray logging is a graph of gamma radiation versus depth. Clays, phosphatic sands, marls, and occasionally dolomites show high gamma ray counts. Gamma radiation penetrates through casing and cement, although it is partially dampened by the presence of multiple cemented casings (545 feet up).

Induction-electrical logging is run only through uncased sections of the well. It includes spontaneous potential and resistivity. Because of the high chloride content of the well water, spontaneous potential showed no significant variation and this logging is not shown on Plage 4-2. Results of the resistivity logging are shown on the left side of Plate 4-2 from 1,810 feet down. This log indicates a significant change in formation from 2,500 feet down, which confirms the driller's report. The length of the probe used for this logging prevented our obtaining a graph below 2,930 feet in depth.

The cement-bond log reported by Schlumberger is shown in red on the same graph as the resistivity but from 1,810 feet up. This log, based on the attenuation (as measured indirectly by the amplitude) of acoustic signals, indicated the presence of cement behind the casing and bonded to it. Results of the cement-bond log indicate bonded cement from the bottom (1,810 feet) of the inner casing up to 1,678 feet, or 132 feet. Thus a good seal is formed at the bottom of the inner casing. Geological studies of formation samples indicates that section of the well as being composed of fine grain limestone, with very low permeability and some dolomitization (Vernon, Appendix A-2).

SECTION 5

INJECTION TEST

5.01 PURPOSE

After completion of drilling operations a pumping (injection) test was planned to determine:

1. Injection capacity of the well;
2. Pressures at the well head while injecting at different flow rates;
3. Injection pressures at the receiving aquifer while injecting at different flow rates;
4. Effect of the injection pressure on the annulus pressure (a measure of the head in the upper part of the Floridan aquifer).

The differences between the pressures under 2 and 3 above are caused by the friction losses through the casing and borehole from the well head at ground level to the injection stratum at approximately 2,930 feet in depth. Pressures at the injection stratum were read through 2,900 feet of 3-inch diameter drill rods temporarily installed in the well during the test to serve as a piezometer.

5.02 SOURCE OF WATER FOR TEST

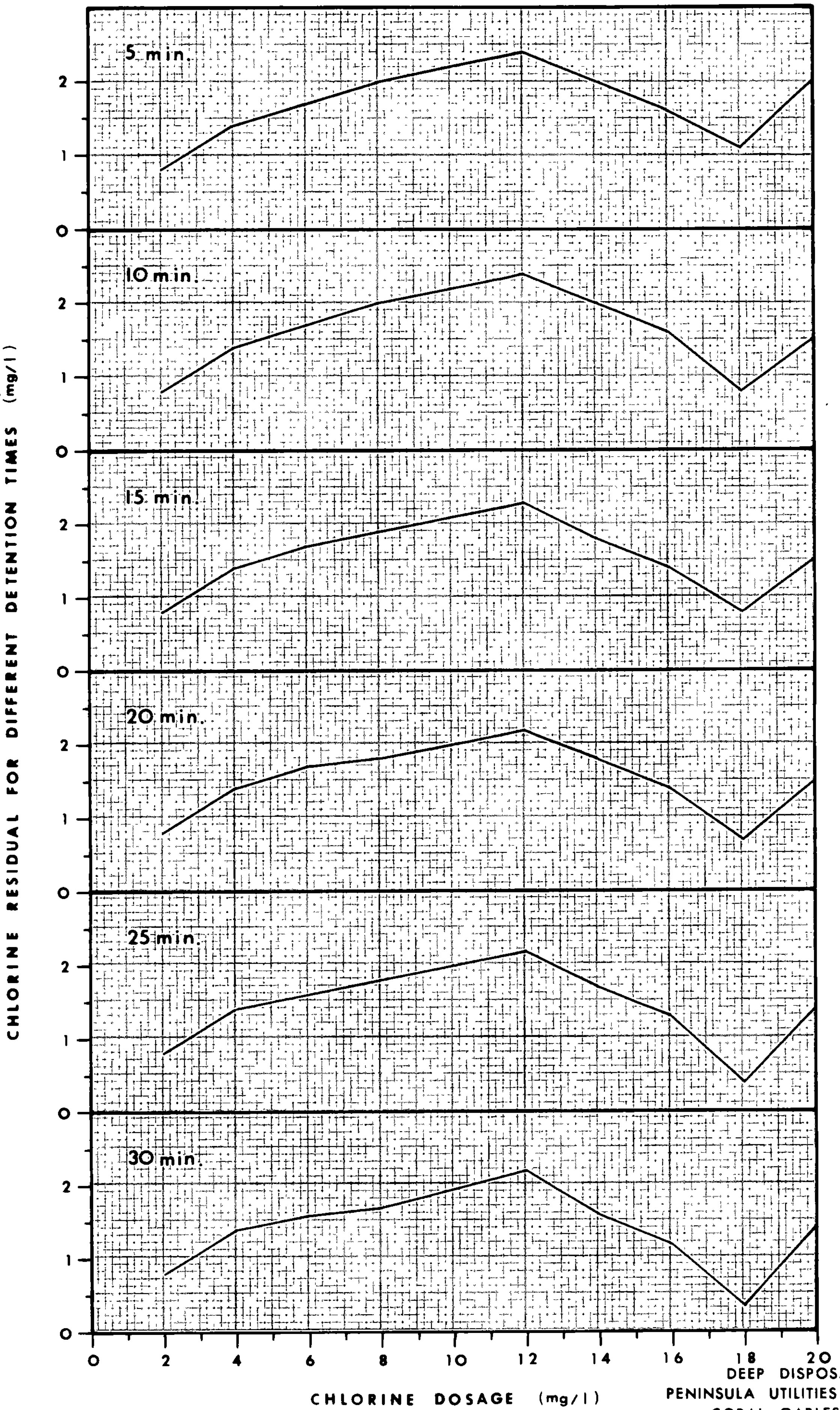
It was necessary to obtain a reliable source of water to supply (on a 24-hour basis) not less than 3,000 gallons per minute (gpm) and preferably up to 4,000 gpm. Snapper Creek Canal, a part of the Central and Southern Florida Flood Control District, is adjacent to the well and discharges more than enough water to supply the flow. A permit was obtained from that agency for the withdrawal.

The Dade County Pollution Control office required that the water to be injected into the well from the canal be chlorinated to maintain a minimum chlorine residual of 0.5 milligrams per liter (mg/l) with a minimum contact time of 30 minutes (Leach, December, 1969), or be chlorinated beyond breakpoint (Leach, January, 1970). The latter option was followed and a chlorine demand study of the canal water was made prior to the test by the Aquachem Company, Inc., of Coral Gables. Graph summarizing their results is shown on Plate 5-1. It was decided to chlorinate with 20 mg/l to insure a chlorine residual of not less than 1.0 mg/l after a detention time of approximately 6 minutes provided by the inner casing of the well at the rate of 3,000 gpm. A chlorine residual record was kept during injection tests as is described further below.

5.03 EQUIPMENT AND PROCEDURES

Equipment and procedures were planned for the collection of all data necessary for the purpose outlined above. Equipment included:

> Three (3) horizontal centrifugal high-pressure irrigation pumps with internal combustion engines. Each pump was provided with its own independent suction and connected in parallel to a common discharge header;
>
> Discharge piping, 12 and 16 inches in diameter, connecting the pumps with the well head; and



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BLACK, CROW AND EIDSNESS, INC
Engineers

Instrumentation to measure flow rates and pressures as indicated on Plate 5-2.

Flow rates were measured with an orifice plate and differential manometer. Orifice details and discharge graph are included in Appendix A-3, Pumping Test Report.

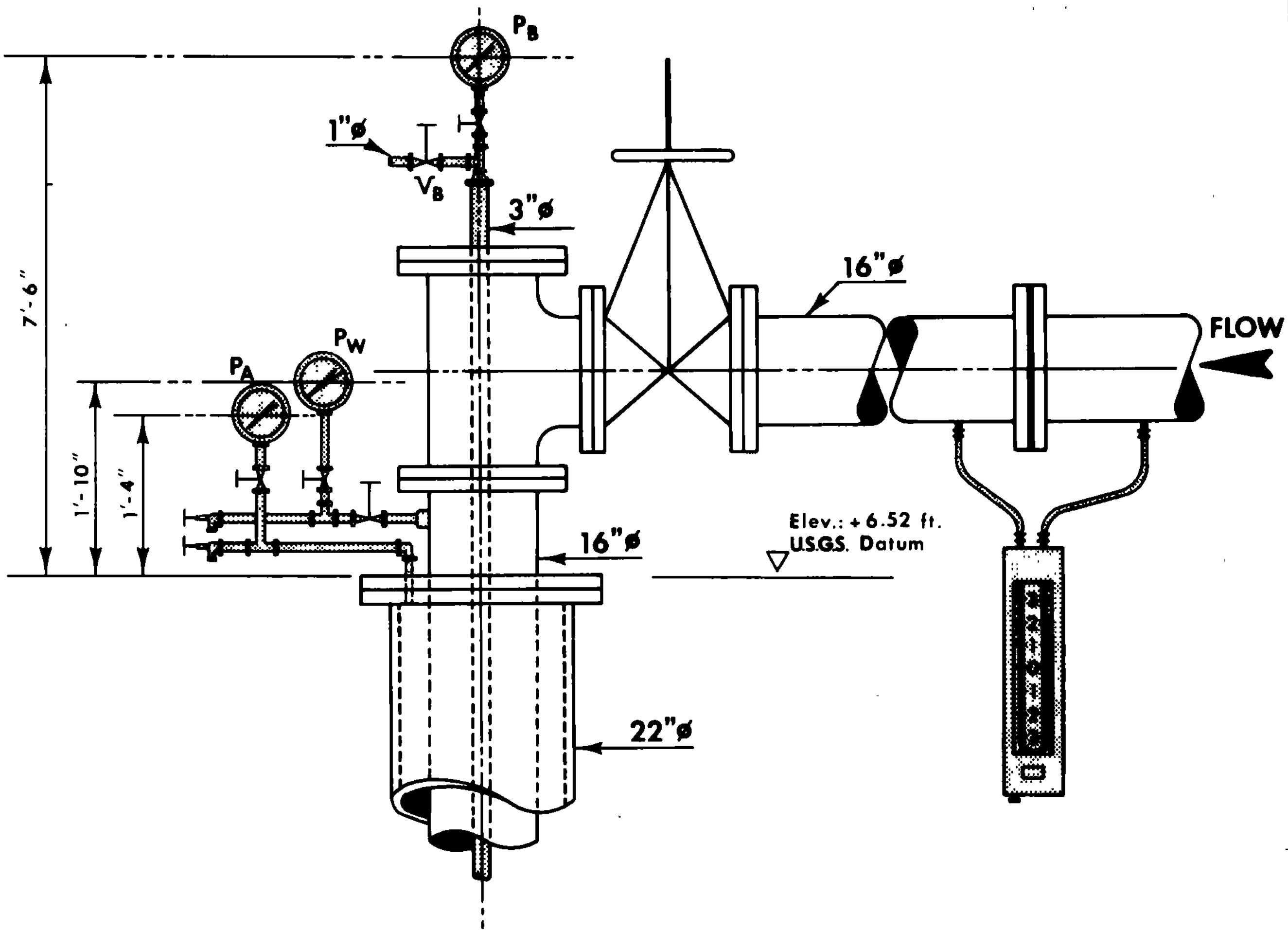
Pressure gage P_b (Plate 5-2) was connected to the top of a 3-inch drill rod extending to 2,900 feet in depth. Flowmeter logging on Plate 4-2 indicates that practically all the water produced (or received) by the well was below 2,920 feet. Increase in pressure at P_b due to pumping into the well indicates the net increase in pressure at the receiving stratum, independent of the friction losses in the casing and borehole.

Pressure gage P_w measures the pressure at the well head, which is the sum of the increase in pressure at the receiving stratum plus friction losses through casing and borehole. Under test conditions, with the 3-inch piping in the hole, friction is slightly higher (plus or minus 2.4 feet at 3,000 gpm) than under normal operating conditions when the drill rod would not be present.

Pressure gage P_a indicates the pressure in the annulus (see Plate 4-2). Any significant leak through the 16-inch casing, through the cement seal at its bottom, or through natural channels would cause a change in the artesian pressure of the annulus.

Procedure details are included in Appendix A-3, Pumping Test Report.

INSTRUMENTATION LAYOUT FOR INJECTION TEST



NOTES:

DRAWING NOT TO SCALE.

HEIGHTS OF PRESSURE GAGES ABOVE TOP OF 22" FLANGE ARE ACTUAL TEST MEASUREMENTS.

TOP OF 22" FLANGE IS APPROXIMATELY AT GROUND LEVEL.

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It is most interesting to mention that because of the specific gravity (1.027) of the cool salt water in the column formed by the well, the water level in the well stays approximately at ground level. The same phenomenon was observed in the 3-inch drill rod. The artesian head then increases to 31.3 psi or 72 feet above land surface when fresh water, with a specific gravity of slightly less than 1.000 is injected into the 3-inch drilling rod at a very slow rate to displace the salt water in the corresponding column. As expected, the displacement of the salt water within the casing and borehole would take a considerably larger volume of fresh water than in the 3-inch drill rod but would produce identical results. Such phenomenon is the reason for Step 2.3 in the Procedure (Appendix A-3).

Photographs of the injection pumps, flowmetering equipment, and pressure gages used during test are shown on Plate 5-3.

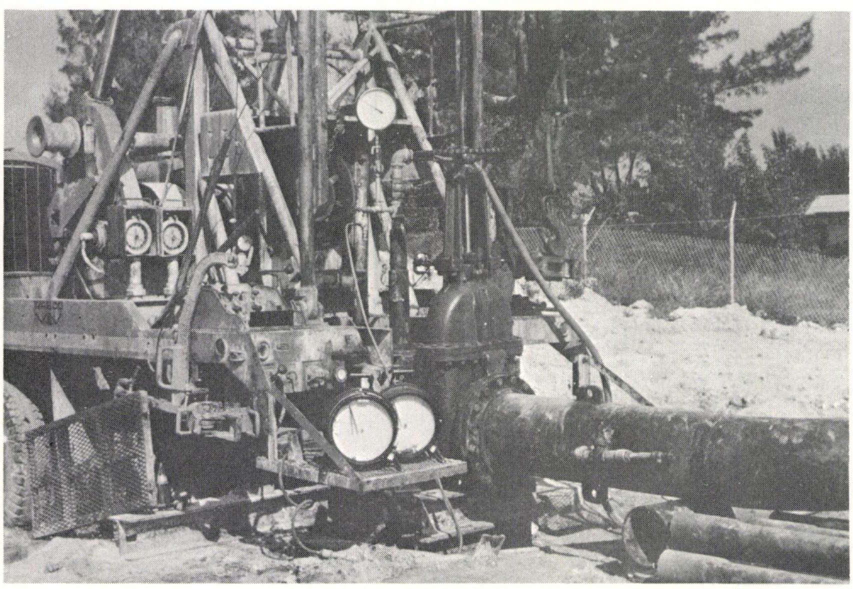
5.04 PUMPING TEST

Several preliminary tests of short duration were conducted prior to a final injection test, which started January 27 and ran continuously for 26 hours and 21 minutes. Preliminary tests were conducted to check (and correct whenever necessary) pumping equipment, suction and discharge piping, chlorination facilities, and instrumentation.

Water was pumped into the well from Snapper Creek Canal at flow rates of approximately 1,000, 2,000, 3,000, and 4,000 gallons per

Injection Test Pumps
and
Gas Chlorinators

Orifice Plate and
U-Tube for Flow
Rate Determinations



Pressure Gages
During Injection Test

minute (gpm). Pressures were recorded in accordance with test procedures outlined in Paragraph 5.03. Breakpoint chlorination was maintained throughout the test with a dosage of 20 milligrams per liter (mg/l). Chlorine residuals were determined and recorded throughout the test.

All data collected during the final pumping test are included in Appendix A-3, Pumping Test Report. Summary of data is in Table 5-1 below. All pressures in Table 5-1 are referred to top of 22-inch casing flange which is a permanent mark.

TABLE 5-1

SUMMARY OF INJECTION TEST DATA

(All pressures are referred to top of 22-inch casing flange.)

		Pressure Readings in psi		
Flow Rate gpm	Test Period hours	P_a Annulus	P_w Well Head	P_b Bottom
0	-	16	31.8*	31.8
1,050	3	16	35	32.8
2,050	3	16	37	32.9
3,100	17	16	43	33.0
3,970	3	16	51	33.5

*From P_b under static conditions.

Results indicate that, after each increase in flow, equilibrium was achieved very rapidly. Annulus pressure, P_a, remained constant at

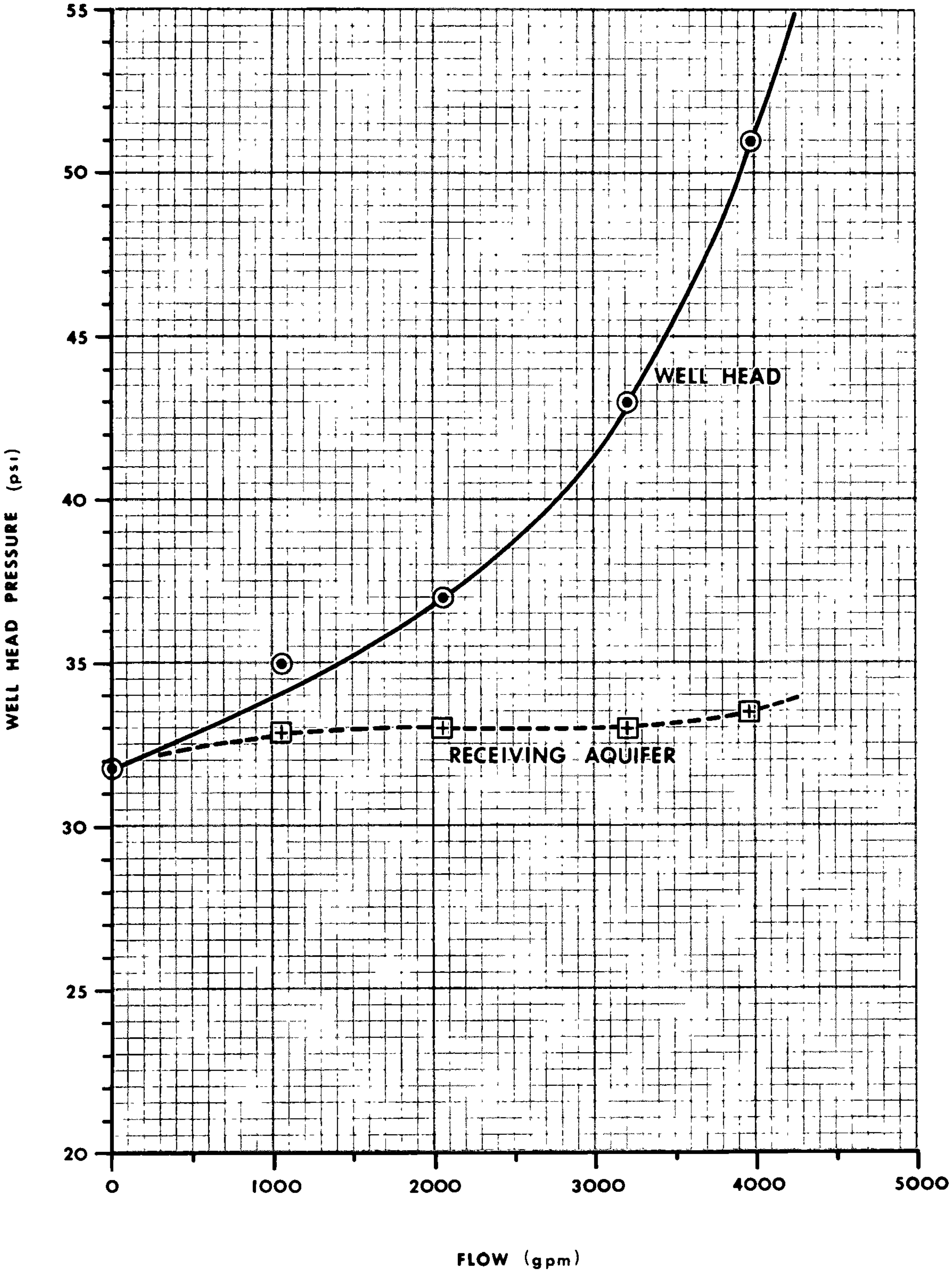
16 psi throughout the test. This indicates that no significant leak exists between the bottom hole or the 16-inch casing and the upper aquifer.

The small increase in the injection pressure at the receiving stratum, P_b, near the hole bottom, indicates the extremely high permeability or transmissibility of the formation.

Plate 5-4 graphically shows the relationship between the injection pressures at the well head and the receiving aquifer versus the injection flow rate.

Attention should be called to the fact that although the static pressure in the well head or in the receiving aquifer was 31.8 psi (referred to the top of the 22-inch casing flange), it does not necessarily mean a higher piezometric head than that of the annulus, i.e., 16 psi. The specific gravity of the water in the annulus is higher than 1.000 and varies with depth (see Plate 4-2), while that in the well during the test was slightly less than 1.000. In order to establish a comparison between piezometric heads, the specific gravity of the water in the annulus and in the well has to be identical for the same column length.

Small variations in pressure during the day in both the well head and the bottom of borehole seem to be related to slight changes in the specific gravity of the liquid injected, caused by changes in water temperature due to sunlight.



INJECTION PRESSURES vs. FLOW RATES

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Note: All pressures are referred to top of 22-inch casing flange.

SECTION 6

MONITORING SYSTEM

6.01 GENERAL

A comprehensive system to monitor the operation of the disposal well and any possible effect such operation may have on the groundwater quality of the upper aquifer (artesian) and of the shallow Biscayne aquifer (water table) should include surveillance of:

1. Quality and pressure of the fluid being injected into the well;
2. Quality and pressure of the brackish water in the upper aquifer (artesian);
3. Quality of the fresh water in the shallow Biscayne aquifer, under water-table conditions.

It is our opinion that the best location to monitor the quality and pressure of the upper part of the Floridan aquifer is from the annulus between the inner and middle casings (16-inch and 22-inch OD). This will allow for the quickest detection of any leakage through the cement seal at the bottom of the inner casing (16-inch OD) or through the casing itself. In addition, any upward leakage through the 700 feet or more of the dense limestone overlying the receiving aquifer would have a greater tendency to develop near the well itself, as this is the point of highest pressure increase caused by the injection.

The surveillance under 1 and 2 above can be best done at the well site as described below.

6.02 MONITORING SYSTEM AT WELL SITE

System is designed to provide for continuous recording of the following variables:

Effluent Flow to Well:

Flow rate	0-7 mgd (million gallons per day)
Injection pressure*	0-100 psi (pounds per square inch)
Chlorine residual*	0-5 mg/l (milligrams per liter)
pH	6-9
Dissolved oxygen	0-10 mg/l
Specific conductance	5-500 micromhos per centimeter

Sample Stream from Annulus:

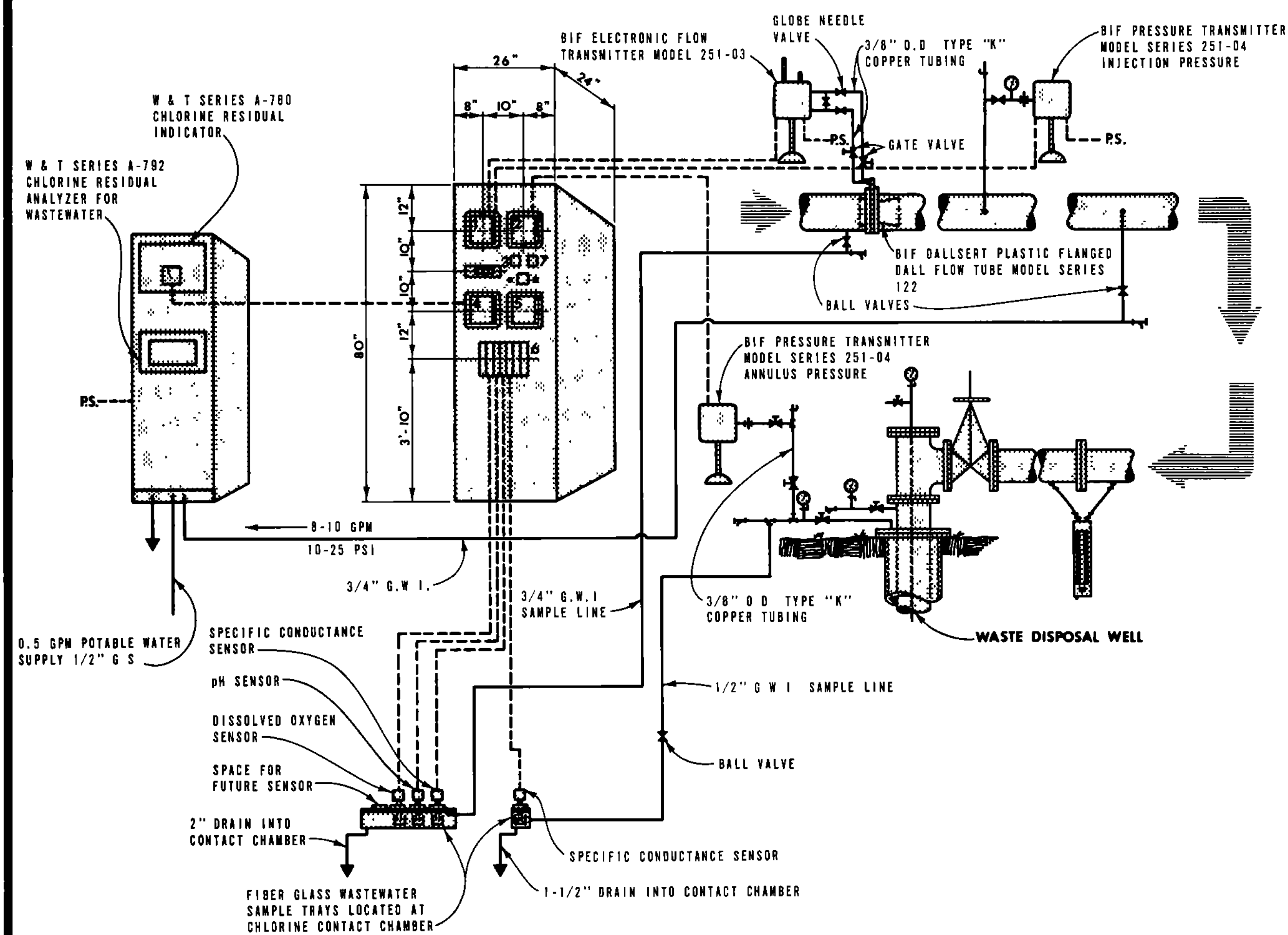
Pressure*	0-30 psi
Specific conductance	200-20,000 micromhos per centimeter

System will provide a visual and audible alarm plus injection pump shut down for variables marked above with an asterisk (*) in the event any one of them exceeds or falls below the limits established by the regulatory agencies.

Plate 6-1 shows a diagram of the proposed instrumentation and its connection to the well head.

Above system will cover the determinations to be made on a continuous and automatic basis as established by the regulatory agencies.

INSTRUMENTATION SYSTEM SCHEMATIC



Equipment Legend For Metering Panel

1.	STRIP CHART RECORDER BIF MODEL 257-02, 2 PEN DISCHARGE PRESSURE 0-100 PSI, FLOW 0-7 MGD
2.	STRIP CHART RECORDER BIF MODEL 257-02, 2 PEN ANNULUS PRESSURE 0-30 PSI, SPECIFIC CONDUCTANCE 200-20 000 MICROMHOS/CM.
3.	7 DIGIT TOTALIZER BIF MODEL 258-03
4.	STRIP CHART RECORDER BIF MODEL 257-02 2 PEN DISCHARGE Cl_2 RESIDUAL 0-5 mg/l, DISSOLVED OXYGEN 0-10 mg/l
5.	STRIP CHART RECORDER BIF MODEL 257-02, 2 PEN DISCHARGE pH 6-9, SPECIFIC CONDUCTANCE 5-500 MICROMHOS/CM
6.	UNION CARBIDE WATER QUALITY MONITOR SYSTEM WITH RACK, POWER SUPPLY, AND SIGNAL CONDITIONERS FOR STRIP CHART RECORDERS LISTED ABOVE.
7.	SCAM DE-LINE MODULAR ANNUNCIATOR, SERIES-10, MODEL 11, SEQUENCE AF, WITH PLUG-IN MODEL ACS-8 RELAY, MODEL HSA HORN, MODEL ACSF-1 FLASHER, ALARM SILENCING PUSHBUTTON AND PUSH TO TEST SWITCH ALARM FUNCTIONS AS FOLLOWS: (1) HIGH INJECTION PRESSURE, (2) LOW CHLORINE RESIDUAL, (3) HIGH ANNULUS PRESSURE

PROPOSED MONITORING SYSTEM

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All others are to be made by the Sunset Park Wastewater Treatment Plant laboratory facilities at the intervals required by the agencies.

6.03 MONITORING SYSTEM IN THE AREA

Requirement 6 established by the former Division of Industrial Waste, Bureau of Sanitary Engineering, Florida State Board of Health, and quoted on page 3-2 of this report, calls for a survey of the area to determine the location, if any, of active wells in the upper aquifer within a radius of one mile. If, in the opinion of the State Geologist (presently Director of the State Bureau of Geology), these wells form a suitable monitoring network of the upper aquifer (upper part of the artesian or Floridan aquifer), arrangements shall be made to sample and test each well selected every 24 hours.

The required survey was conducted during the summer of 1969 by the Bureau of Geology, Florida State Board of Conservation, and reported by their geologist, Mr. C. R. Sproul (October, 1969). From last reference we quote: "The closest wells to the disposal well site are Wells 54-41-25 dd and 54-40-46 c which are respectively 5 miles east and 6 miles north of the plant." Data collected for the survey conducted by the Bureau of Geology are summarized in Table 6-1.

Any possible leakage through the inner casing, through a break in the bottom cement seal, or through natural channels can be picked up through the annulus monitoring before it even attempts to leak

TABLE 6-1

SUMMARY OF DATA ON DEEP WELLS IN THE VICINITY OF MIAMI, FLORIDA

Number	Description	Location	Total Depth feet	Casing Size Inches	Casing Length feet	Water Quality Specific Con-ductance	Water Quality Cl mg/l	Date	Remarks
52-42-34cc1	Indian Creek Country Club	Golf Course	906	8	876	NR	2100	7-2-69	Leaking underground 150-200 gpm. Does not flow at surface.
52-42-34cc2	Indian Creek Country Club	Golf Course	945	8	NR	6800	2050	7-2-69	Used for irrigation after blending with City water
53-41-36ad	City Ice and Fuel Company	NW Miami Court and 14th Street	1088	12	730	NR	2800	4-29-59	Abandoned. Could not obtain sample.
53-41-36cb	Gas Plant	1600 N. Miami Avenue	1300	12-10	NR	NR	1590	4-29-59	Abandoned. New construction at well site. Covered well.
53-41-40cb	Deering Estate	3250 S. Miami Avenue	980	8	NR	NR	970	10-15-18	Did not recover well during this inventory.
53-42-14ac	LaGorce Country Club	Golf Course	885	8	NR	NR	3750	5-20-69	Wild flow.
53-42-34da	Miami Beach	11th Street & Jefferson Ave.	1501	NR	NR	NR	NR	NR	Not recovered during this inventory--buried.
53-42-15dd	LaGorce Country Club	Blackhawk Ave. & West 51st Terrace	1000	8	NR	NR	1850	NR	Not recovered during this inventory--buried.
54-40-4bc	Church	8618 West Flagler	817	6	798	5200	1410	7-12-69	Used for lawn irrigation.
54-41-10bc	City of Miami	SW 16th Terrace & 24th Avenue	990	6	NR	NR	1790	4-30-59	Not recovered during this inventory--buried.
54-41-25dd	Hurricane Lodge Motel	8100 South Dixie Highway	1065	6	480	4900	1350	5-69	Used to fill pool.
54-41-37db	Gardner	47 NW 6th Street	1165	10	NR	NR	1500	5-29-59	Not recovered during this inventory.
54-42-5bb	Miami Beach	Palm Island at Palm Ave.	1000	8	NR	NR	1450	1940	Well abandoned and capped.
55-40-12ca	Warwick	Killian Dr. & Ludlum Rd.	5430	NR	NR	NR	1865	4-13-40	Not recovered during this inventory--buried under pavement.
55-42-6bb	Matheson	Key Biscayne	957	4	NR	NR	1400	5-1-59	Not recovered during this inventory.
--	Grossman	Grossman Hammock	1259	12	487	4800	1300	6-11-69	Recreation area

through the upper aquiclude toward the Biscayne aquifer. It is our opinion then, that the monitoring system proposed at the well site is the best and most reliable system that can be provided and that no further sampling is necessary from a practical operational point of view. We believe then, that surveillance under 3 (quality of the water in the Biscayne aquifer), paragraph 6.01, is unnecessary.

SECTION 7

SUMMARY AND CONCLUSIONS

7.01 SUMMARY

This report presents the data obtained from drilling and testing an injection well for deep disposal of treated wastewater from the Peninsula Utilities Corporation Sunset Park Plant south of Miami, Dade County, Florida. The plant (solids-contact type) is being expanded to a design capacity of 3 million gallons per day (mgd) and can produce effluent with 90 percent organic load reduction.

Drilling and testing have been directed to meet requirements established by County and State regulatory agencies. Planning and prosecution of the project have been done with the cooperation of the Bureau of Geology, Florida Department of Natural Resources, and the Subdistrict Office (Miami) of U. S. Geological Survey.

Well penetrates through the shallow Biscayne aquifer (approximately 100 feet in depth), source of fresh water for the City of Miami. Biscayne aquifer is protected at the well by three steel casings (0.375 inch thick) and two cemented annuli, each approximately 2 inches thick. The outer casing (26 inches outside diameter) extends 210 feet in depth, is cemented outside and inside, and penetrates the underlying aquiclude. This aquiclude is formed by marl and a combination of marl and limestone. It is approximately 800 feet thick and separates the Biscayne aquifer from the upper part of the Floridan, which contains artesian brackish water. Middle casing (22 inches outside diameter) penetrates, and is cemented to, 545 feet in depth, protecting the softer part of the aquiclude. The inner casing (16 inches outside diameter) extends 1,810 feet into the second confining layer which separates the upper part of the Floridan aquifer from another highly permeable zone appearing in this well at 2,920 feet. The inner casing is cemented from 1,810 to 1,678 feet. Exposed annulus between 1,678 and 545 feet is open to the different water-bearing strata between 900 and 1,600 feet, with chloride concentrations ranging between 900 and 2,800 milligrams per liter (mg/l) and a piezometric head of 16 pounds per square inch (psi) above land surface.

The receiving aquifer is a cavernous dolomite and limestone strata with high-chloride water under pressure referred to as the Boulder Zone. It was reached in this well at 2,920 feet in depth and has been penetrated by practically all deep oil wells drilled in southern Florida. Drilling through the highly cavernous zones breaks off large fragments of dolomites and limestones. This presents serious difficulties similar to drilling through large boulders (origin of the term "Boulder Zone"). In this well Boulder Zone is separated from the upper part of the Floridan aquifer by approximately 700 feet of dense limestones which act as an aquiclude.

An injection test was conducted for 26 consecutive hours with the following results:

Flow Rate		Test Period	Pressure Readings in psi		
gpm	mgd	hours	P_a Annulus	P_w Well Head	P_b Bottom
0	-	-	16	31.8*	31.8
1,050	1.51	3	16	35	32.8
2,050	1.95	3	16	37	32.9
3,100	4.46	17	16	43	33.0
3,970	5.72	3	16	51	33.5

*From P_b under static conditions.

All pressures are referred to top flange of 22-inch casing which is approximately land surface level.

7.02 CONCLUSIONS

(1) Results of injection test indicate that the receiving aquifer can accept high rates of flow with only a slight increase in pressure (less than 2 psi at approximately 4,000 gpm).

(2) Physical and chemical quality of effluent from a solids-contact stabilization plant shows no constituent which may significantly reduce the hydraulic and/or structural characteristics of the receiving aquifer or the exposed confining layer.

If these characteristics are not changed, the receiving aquifer can accept flow rates of the magnitude tested for indefinite periods of time.

(3) Disposal of proposed effluent into the receiving aquifer will not impair the present or any foreseeable use of the aquifer. With water quality practically identical to that of sea water, present use of this aquifer is nonexistent.

(4) Well construction, hydrology of the area, and proposed monitoring system can prevent or detect any possible leakage of the effluent to the upper part of the Floridan aquifer. The possibility of contaminating the Biscayne aquifer from the proposed well, under proper operation, is inconceivable.

(5) Injection of the fresh water effluent into an aquifer containing salt water may lead to the formation of an enormous fresh-water bubble at the top of the deeper aquifer which would be under the normal artesian pressure. Such volume of water could be used for irrigation or for future water supply when shortage of present fresh water sources would justify cost of treating and reclaiming the stored water. Some research is presently being done elsewhere on such a possibility, but further discussion of this subject falls beyond the scope of our report.

(6) In any event, the injected effluent, in our opinion, will tend to move at a very slow rate (a matter of a few feet per year) toward the surrounding seas and will enter them at considerable depth (more than 2,500 feet) some 30 miles from the shoreline. The water level in the completed well stands approximately at land surface (6 feet above mean sea level) under static conditions and when containing high-chloride water (19,000 mg/l). The above hypothesis on the direction of flow and emergence at sea of the groundwater in the receiving aquifer is substantiated by foregoing fact (indicating a hydraulic gradient toward the sea), and the following:

(a) The similarity between water quality of the receiving water and that of sea water at Miami Beach (see Table 4-1)

(b) The abnormal geothermal gradient in the well which resembles that in the nearby Florida Straits (Kohout, 1965, p. 266)

(c) The geology of South Florida, idealized in the cross-sectional view on Plate 7-1 (Raiz, 1964, p. 6).

Idealized Geological Cross Section Of Southern Florida

(Raisz, 1964, p.6)

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APPENDIX A-1

WELL DRILLING REPORT

BLACK, CROW AND EIDSNESS, INC.
Engineers
Gainesville, Florida

WELL DRILLING REPORT

Disposal Well — Peninsula Utilities

By Alsay Drilling, Inc.
Lake Worth, Florida

Depth (feet)	Description
	Start Drilling
0-5	Light brown shell rock and coral (soft texture)
5-10	" " " " " " " "
10-15	" " " " " " " "
15-20	" " " " " " " "
20-25	" " " " " " " "
25-30	White shell rock and coral (fine texture)
30-35	" " " " " " "
35-40	" " " " " " "
40-45	" " " " " " "
45-50	" " " " " " "
50-55	" " " " " " "
55-59	" " " " " " "
59-61	White shell rock and coral (very hard texture)
61-65	White shell rock with intermittent hard and soft layers
65-70	" " " " " " " " "
70-75	" " " " " " " " "
75-80	" " " " " " " " "
80-85	" " " " " " " " "
85-90	White shell rock - very soft with layers of marl - grey in color
90-95	" " " " " " " " " " " "
95-100	" " " " " " " " " " " "
100-105	" " " " " " " " " " " "
105-110	" " " " " " " " " " " "
110-115	" " " " " " " " " " " "
115-120	" " " " " " " " " " " "
120-125	" " " " " " " " " " " "
125-130	" " " " " " " " " " " "
130-135	" " " " " " " " " " " "
135-140	Small shell and large amounts of marl - green in color - small hard streaks at 139'-0"
140-145	Small shell and green marl
145-150	" " " " "
150-155	" " " " "
155-160	" " " " "
160-165	Marl with shell and coral (harder texture)
165-170	" " " " " " "
170-175	Very soft green marl with intermittent layers of shell, varying hardness
175-180	" " " " " " " " " " "
180-185	" " " " " " " " " " "
185-190	" " " " " " " " " " "
190-195	At 190' material became very soft - almost pure marl - green in color (slight traces of shell and coral)

Depth (feet)	Description
195-200	Green marl with slight traces of shell and coral
200-205	" " " " " " " " "
205-210	" " " " " " " " "
210-215	" " " " " " " " "
215-220	" " " " " " " " "
220-224	" " " " " " " " "
224-230	" " " " " " " " "
230-235	" " " " " " " " "
235-240	" " " " " " " " "
240-245	Green marl with increase in amount of shell rock, some sandstone (harder texture)
245-250	" " " " " " " " " " "
250-255	" " " " " " " " " " "
255-260	" " " " " " " " " " "
260-265	Green marl, soft with small amount of shell rock
265-270	Green marl with shell rock, some sandstone, intermittent layers of marl and rock
270-275	" " " " " " " " "
275-280	" " " " " " " " "
280-285	" " " " " " " " "
285-290	" " " " " " " " "
290-295	" " " " " " " " "
295-300	" " " " " " " " "
300-305	" " " " " " " " "
305-310	" " " " " " " " "
310-315	Green marl with shell rock, some sandstone -- layers of rock and marl
315-320	" " " " " " " " " " " "
320-325	" " " " " " " " " " " "
325-330	" " " " " " " " " " " "
330-335	" " " " " " " " " " " "
335-340	" " " " " " " " " " " "
	(Material very soft beginning at 339')
340-345	" " " " " " " " " " " "
345-350	" " " " " " " " " " " "
350-355	" " " " " " " " " " " "
355-360	" " " " " " " " " " " "
360-365	" " " " " " " " " " " "
365-370	" " " " " " " " " " " "
370-375	" " " " " " " " " " " "
375-379	" " " " " " " " " " " "
379-385	Marl with large amounts of rock and shell. Hardest formation since 190'.

Depth (feet)	Description
385-390	Limestone (white in color) with slight traces of soft marl
390-395	" " " " " " " " " "
395-400	" " " " " " " " " "
400-405	" " " " " " " " " "
405-410	Limestone slightly harder in texture, with traces of shell
410-415	Limestone with intermittent hard and soft streaks--some layers of marl
415-420	" " " " " " " " " " "
420-425	" " " " " " " " " " "
425-430	" " " " " " " " " " "
430-435	" " " " " " " " " " "
435-440	" " " " " " " " " " "
440-445	" " " " " " " " " " "
445-450	" " " " " " " " " " "
450-455	" " " " " " " " " " "
455-460	" " " " " " " " " " "
460-465	" " " " " " " " " " "
465-470	" " " " " " " " " " "
470-475	Marl
475-480	Limestone with intermittent hard and soft streaks; some marl blue in color
480-485	Fine texture lime rock with traces of marl
485-490	" " " " " " " "
490-495	" " " " " " " "
495-500	" " " " " " " "
500-505	" " " " " " " "
505-510	" " " " " " " "
510-515	" " " " " " " "
515-520	" " " " " " " "
520-525	" " " " " " " "
525-530	Soft marl, white in color
530-535	" " " " "
535-540	" " " " "
540-545	" " " " "
545-550	" " " " "
550-555	" " " " "
555-560	" " " " "
560-565	" " " " "
565-570	" " " " "
570-575	Marl and limestone, both white in color
575-580	Very sandy limestone
580-585	Limestone and marl, both white in color
585-590	" " " " " " "
590-595	" " " " " " "

BLACK, CROW AND EIDSNESS, INC.
Engineers
Gainesville, Florida

WELL DRILLING REPORT

Disposal Well – Peninsula Utilities

By Alsay Drilling, Inc.
Lake Worth, Florida

Depth (feet)	Description
595-600	Limestone and marl (sandy) white in color
600-605	" " " " " " "
605-610	Limestone and marl, brownish white in color
610-615	" " " " " " "
615-620	" " " " " " "
620-625	" " " " " " "
625-630	" " " " " " "
630-635	" " " " " " "
635-640	" " " " " " "
640-645	" " " " " " "
645-650	" " " " " " "
650-655	" " " " " " "
655-660	" " " " " " "
660-665	" " " " " " "
665-670	" " " " " " "
670-675	" " " " " " "
675-680	" " " " " " "
680-685	Limestone and marl, tan in color
685-690	" " " " " "
690-695	" " " " " "
695-700	Limestone and marl with increase in white marl
700-705	" " " " " " " "
705-710	" " " " " " " "
710-715	" " " " " " " "
715-720	" " " " " " " "
720-725	" " " " " " " "
725-730	" " " " " " " "
730-735	" " " " " " " "
735-740	" " " " " " " "
740-745	" " " " " " " "
745-750	" " " " " " " "
750-755	" " " " " " " "
755-760	Very soft sandy limestone and marl with traces of shell
760-765	" " " " " " " " " "
765-770	" " " " " " " " " "
770-780	" " " " " " " " " "
780-785	" " " " " " " " " "
785-790	" " " " " " " " " "
790-795	" " " " " " " " " "
795-800	Very hard limestone
800-805	" " "
805-810	" " "
810-815	" " "

By Alsay Drilling, Inc.
Lake Worth, Florida

Depth (feet)	Description
815-820	Very hard limestone
820-825	Medium hard limestone
825-830	" " "
830-835	" " "
835-840	Very hard limestone
840-845	Medium hard limestone
845-865	" " "
865-885	" " "
885-905	Limestone, very hard
905-925	Medium soft sandy lime. Picked first artesian flow.
925-945	Soft to medium sandy lime, with shell
945-965	Start reverse-air drilling. Soft to medium sandy lime with shell
965-970	Medium hard lime and shell
970-975	Medium hard lime and shell with streaks of marl
975-980	Medium hard limestone, gray
980-985	Soft to medium limestone, white. Picked more water last 10 feet.
985-990	Shell rock and soft lime
990-995	Medium hard gray lime
995-1000	Brown dolomite, medium hard white lime
1000-1005	Brown lime and fine shell
1005-1010	Brown lime
1010-1015	Brown lime and rock
1015-1020	Brown lime, rock and shell
1020-1025	Gray dolomite and brown lime
1025-1030	Brown lime medium
1030-1035	" " "
1035-1040	Brown lime medium (broken)
1040-1045	" " " "
1045-1050	Medium-hard limestone, brown. Picked up more water last 10'.
1050-1055	Medium limestone, brown
1055-1060	" " "
1060-1065	Gray Dolomite, hard. Picked up water last 4 feet.
1065-1070	Brown lime and some shell
1070-1075	Brown lime, a lot of shell
1075-1080	Brown lime medium
1080-1085	" " "
1085-1090	" " " Picked up flow last 30 feet.
1090-1095	" " "
1095-1100	" " "
1100-1105	" " "
1105-1110	" " "
1110-1115	" " "
1115-1120	" " "

Depth (feet)	Description
1120-1125	Gray lime medium (turned fluid purple)
1125-1130	Brown lime medium
1130-1135	" " "
1135-1140	" " "
1140-1145	" " "
1145-1150	" " "
1150-1155	" " "
1155-1160	" " "
1160-1165	" " "
1165-1170	" " "
1170-1175	" " "
1175-1180	Brown lime and white mixed
1180-1185	" " " " "
1185-1190	Brown lime medium
1190-1195	Brown lime medium and white mixed
1195-1200	Brown lime medium
1200-1205	Brown lime medium and white mixed
1205-1210	Brown lime and white mixed
1210-1215	Brown lime
1215-1220	" "
1220-1225	Gray lime, hard
1225-1230	Gray lime, medium
1230-1235	" " "
1235-1240	" " "
1240-1245	" " "
1245-1250	Brown lime
1250-1255	" "
1255-1260	Light brown lime
1260-1265	Brown lime
1265-1270	" "
1270-1275	Brown lime, light
1275-1280	" " "
1280-1285	" " "
1285-1290	Light brown lime
1290-1295	" " "
1295-1300	" " "
1300-1305	" " " Picked up water last 20 feet.
1305-1310	" " "
1310-1315	" " "
1315-1320	" " "
1320-1325	" " "
1325-1330	" " "
1330-1335	" " "

Depth (feet)	Description	
1335-1340	Light brown lime	
1340-1345	" " "	
1345-1350	" " "	
1350-1355	" " "	
1355-1360	" " "	
1360-1365	" " "	
1365-1370	Brown lime, medium	
1370-1375	" " "	
1375-1380	White lime, medium	
1380-1385	Brown lime, medium	Picked up water last 20 feet.
1385-1390	" " "	
1390-1395	" " "	
1395-1400	" " "	
1400-1405	Gray lime, hard	
1405-1410	Small intermediate layers of light brown, white and gray lime	
1410-1415	" " " " " " " " " "	
1415-1420	" " " " " " " " " "	
1420-1425	" " " " " " " " " "	
1425-1430	Brown lime (medium)	
1430-1435	Light brown and gray dolomite, lime mixed (very hard)	
1435-1440	White lime and light brown lime mixed (medium)	
1440-1445	Brown lime (medium)	Picked up a little water last 20 feet.
1445-1450	Brown lime medium	
1450-1455	" " "	
1455-1460	Gray lime medium	
1460-1465	Brown lime medium	
1465-1470	" " "	
1470-1475	" " "	
1475-1480	" " "	
1480-1485	White lime medium	
1485-1490	Brown lime medium	
1490-1495	Brown lime	
1495-1500	Intermediate layers gray and brown	
1500-1505	" " " " "	
1505-1510	Brown lime, medium	
1510-1515	" " "	
1515-1520	" " "	
1520-1525	Gray lime, very hard	
1525-1530	Gray and light brown mixed, medium	
1530-1535	" " " " " "	
1535-1540	" " " " " "	
1540-1545	Gray lime	

By Alsay Drilling, Inc.
Lake Worth, Florida

Depth (feet)	Description	
1545-1550	Brown and white lime mixed, medium	
1550-1555	" " " " " "	
1555-1560	Brown lime medium	
1560-1565	" " "	Picked up water last 20 feet.
1565-1570	" " "	
1570-1575	" " "	
1575-1580	" " "	
1580-1585	Brown and gray lime mixed	
1585-1590	Light brown lime medium	
1590-1595	Light brown lime medium	
1595-1600	" " " "	
1600-1605	" " " "	
1605-1610	Gray lime soft	
1610-1615	Gray lime medium	
1615-1620	" " "	
1620-1625	Light brown lime soft	
1625-1630	White and gray lime mixed (soft medium)	
1630-1635	Light brown and gray lime mixed (medium)	
1635-1640	Gray lime (medium)	
1640-1645	Gray sandy lime (medium-hard)	
1645-1650	Light brown and white lime mixed (medium)	
1650-1655	Light brown lime (medium)	
1655-1660	" " " "	
1660-1665	" " " "	
1665-1670	Brown sandy lime medium	
1670-1675	Brown and white sandy lime medium	
1675-1680	Brown and grey sandy lime medium	
1680-1685	" " " " " "	
1685-1690	Brown sandy lime	
1690-1695	Dark gray and brown sandy lime	
1695-1700	" " " " " "	
1700-1705	Brown sandy lime	
1705-1710	Brown sandy lime medium	
1710-1715	" " " "	
1715-1720	Gray sandy lime medium	
1720-1725	Brown sandy lime medium	(Last 20 feet porous material, picked up flow.)
1725-1730	Brown and gray lime medium, mixed	
1730-1735	" " " " " "	
1735-1740	Brown and gray sandy lime mixed, medium	
1740-1745	Brown and gray lime mixed, medium	
1745-1750	Brown sandy lime medium	
1750-1755	" " " "	

By Alsay Drilling, Inc.
Lake Worth, Florida

Depth (feet)	Description
1755-1760	Brown and gray sandy lime, medium
1760-1765	Gray and brown lime, sandy (medium)
1765-1770	Brown sandy lime (medium)
1770-1775	" " " "
1775-1780	" " " "
1780-1785	Brown sandy lime (medium) and a little gray
1785-1790	Brown lime, sandy
1790-1795	" " "
1795-1800	" " "
1800-1805	" " "
1805-1810	Brown lime and gray dolomite (medium)
1810-1815	Light brown medium lime
1815-1820	" " " "
1820-1825	" " " "
1825-1830	Impervious (medium hard lime) Last 20 feet impervious layer, causing decrease in fluid pressure. Long time for fluid to clear up before water sample can be taken. Last 20 feet impervious as a whole.
1830-1835	White lime - medium-hard and medium intermediate layers
1835-1840	" " " " " " " "
1840-1845	Light brown lime - medium-hard and medium intermediate layers
1845-1850	Brown lime - medium-hard and medium intermediate layers Last 20 feet pressure still low
1850-1855	Gray and brown lime, medium and medium-hard layers
1855-1860	" " " " " " " " "
1860-1865	" " " " " " " " "
1865-1870	" " " " " " " " "
1870-1875	Brown lime medium (Water surface approximately level with top of rod.
1875-1880	" " "
1880-1885	Brown and gray lime medium to medium-hard layers
1885-1890	" " " " " " " " "
1890-1895	Brown lime medium to medium-hard (Water level below top of rod.)
1895-1900	Brown and white lime medium to medium-hard
1900-1905	Gray and white lime medium to medium-hard
1905-1910	" " " " " " " "
1910-1915	Gray and brown lime medium to medium-hard
1915-1920	" " " " " " " "
1920-1925	" " " " " " " "
1925-1930	Brown lime medium to medium-hard
1930-1935	" " " " " "
1935-1940	Brown and gray lime medium to medium-hard
1940-1945	" " " " " " " "

Depth (feet)	Description
1945-1950	Brown lime medium to medium hard (Water level in rod is 7.6 feet below land surface.)
1950-1955	Gray and brown lime, medium to medium-hard
1955-1960	Brown dolomite, very hard 2 foot layer.
1960-1965	Brown and gray lime, medium to medium-hard
1965-1970	White, gray, brown lime with hard brown rock
1970-1975	Light brown sandy lime, medium soft
1975-1980	White lime, soft
1980-1985	Light brown, sandy lime, medium
1985-1990	" " " " "
1990-1995	" " " " "
1995-2000	" " " " "
2000-2005	Brown lime, sandy, mixed with gray lime
2005-2010	" " " " " " "
2010-2015	" " " " " " "
2015-2020	" " " " " " "
2020-2025	Brown lime with streaks of gray
2025-2030	" " " " " "
2030-2035	" " " " " "
2035-2040	" " " " " "
2040-2045	" " " " " "
2045-2050	
2050-2055	" " " " " "
2055-2060	" " " " " "
2060-2065	Brown lime with a little gray, medium
2065-2070	" " " " " " "
2070-2075	" " " " " " "
2075-2080	" " " " " " "
2080-2085	Brown and gray lime mixed, medium hard
2085-2090	" " " " " " "
2090-2095	Brown lime, medium
2095-2100	" " "
2100-2105	Brown and gray rock, hard
2105-2110	Brown and gray sandy lime, medium
2110-2115	" " " " " "
2115-2120	" " " " " "
2120-2125	Brown and gray sandy lime with soft streaks of gray and white lime
2125-2130	" " " " " " " " " " " " " "
2130-2135	Brown and gray sandy lime with soft streaks of gray and white lime; hard streak 2130-2131'.
2135-2140	Brown and gray sandy lime with soft streaks of gray and white lime

Depth (feet)	Description
2140-2145	Brown sandy lime, medium
2145-2150	" " " "
2150-2155	" " " "
2155-2160	" " " "
2160-2165	White lime, medium soft
2165-2170	" " " "
2170-2175	White and brown lime, medium
2175-2180	" " " " "
2180-2185	Brown lime, medium
2185-2190	White, Brown, gray lime, medium
2190-2195	" " " " "
2195-2200	Brown lime and sandy, medium
2200-2205	White lime, medium soft to medium
2205-2210	Brown sandy lime, medium
2210-2215	Gray, white and brown lime, medium
2215-2220	Brown and gray lime, medium
2220-2225	Gray with a little light brown lime, medium
2225-2230	" " " " " " " "
2230-2235	" " " " " " " "
2235-2240	Brown with a little gray, medium
2240-2245	Brown, white and gray lime, medium
2245-2250	" " " " " "
2250-2255	" " " " " "
2255-2260	" " " " " "
2260-2265	Grayish white, medium
2265-2270	" " "
2270-2275	" " "
2275-2280	" " "
2280-2285	Brown, white and gray lime, medium
2285-2290	" " " " " "
2290-2295	" " " " " "
2295-2300	" " " " " "
2300-2305	Light brown lime with a little gray, medium
2305-2310	" " " " " " "
2310-2315	" " " " " " "
2315-2320	" " " " " " "
2320-2325	Brown and white lime, medium
2325-2330	" " " " "
2330-2335	" " " " "
2335-2340	" " " " "
2340-2345	Brown, white and gray lime, medium
2345-2350	" " " " " "
2350-2355	" " " " " "

Depth (feet)	Description
2355-2360	Brown with a little gray, medium
2360-2365	Brown lime, medium
2365-2370	" " "
2370-2375	Brown lime; last 12" brown dolomite; hard
2375-2380	Intermediate layer of dolomite and brown sandy lime
2380-2385	White, brown, with a little gray lime, medium
2385-2390	" " " " " " " "
2390-2395	" " " " " " " "
2395-2400	" " " " " " " "
2400-2405	Light brown and white lime, medium
2405-2410	" " " " " "
2410-2415	" " " " " "
2415-2420	" " " " " "
2420-2425	" " " " " "
2425-2430	" " " " " "
2430-2435	" " " " " "
2435-2440	" " " " " "
2440-2445	" " " " " "
2445-2450	Light brown and white lime, medium, with 4" layers of medium hard gray lime
2450-2455	" " " " " " " " " " "
2455-2460	" " " " " " " " " " "
2460-2465	" " " " " " " " " " "
2465-2470	" " " " " " " " " " "
2470-2475	Brown-gray lime (medium 4" of hard gray dolomite)
2475-2480	" " " " " " " " "
2480-2485	White lime, medium
2485-2490	Brown lime with intermediate layers of hard, gray dolomite
2490-2495	Very hard gray dolomite
2495-2500	" " " "
2500-2505 2505-2510 2510-2515 2515-2520	Medium hard brown rock in first 3.5'; next 2' was darker, almost green; next foot very hard gray, then back to brown, almost 3' thick; then a soft layer about 2.5' thick. Black rock for 4", then back to black-brown. Beginning in intermediate layers of medium-white, hard brown, hard gray and hard dark gray streaks. Cemented sand at 2512 feet.
2520-2525	Dark brown to black dolomite, hard
2525-2530	Dark brown to black dolomite, hard; and light brown sandy lime, medium hard
2530-2535	Hard brown and gray dolomite and light brown sandy lime, medium
2535-2540	Light brown sandy lime with intermediate layers of hard gray
2540-2545	Light brown lime, medium

Depth (feet)	Description
2545-2550	White lime, medium
2550-2555	Last 8' started with gray and brown cemented sand then found intermediate layers of brown, black, and gray dolomite, multi-colored rock and various colors of sand, consistent in different layers
2555-2560	Black and gray dolomite, hard

Jim Kern, Alsay driller, reports that since 7:00 a.m. this morning to noon, he has been able to drill only 4 ft.; formation very hard. Drilling rate this week is as follows:

Monday, 11-3-69	60 feet
Tuesday, 11-4-69	30 feet
Wednesday, 11-5-69	25 feet
Thursday, 11-6-69	10 feet

We should be hitting top of Boulder Zone.

2560-2565	Black and gray dolomite, hard
2565-2570	Black, gray, light brown dolomite, very hard
2570-2575	Black, gray, brown, white intermediate layers. Medium soft layers
2575-2580	Medium soft layers black; characteristics of rotten wood
2580-2585	Gray and brown lime, medium
2585-2590	Brown lime, medium
2590-2595	Brown and gray lime; medium soft to medium
2595-2600	Brown and gray lime, medium soft to medium
2600-2605	Light brown lime; medium soft to medium
2605-2610	Light brown lime, medium soft to medium
2610-2615	Gray and brown lime; medium soft to medium
2615-2620	" " " " " " " "
2620-2625	Brown and gray lime, medium; hard porous rock
2625-2630	Brown and gray lime, intermediate layers; medium hard to hard
2630-2635	" " " " " " " " " "
2635-2640	" " " " " " " " " "
2640-2645	Brown lime, medium
2645-2650	" " "
2650-2655	Brown and gray lime, medium
2655-2660	Brown and gray with few hard streaks, medium
2660-2665	Brown, medium to hard; layers hard dolomite
2665-2670	Brown and gray lime, medium to hard; layers of hard dolomite
2670-2675	" " " " " " " " " " "
2675-2680	" " " " " " " " " " "
2680-2685	Intermediate layers of hard brown and gray lime
2685-2690	Hard to medium hard layers of brown and gray lime
2690-2695	" " " " " " " " " "

Depth (feet)	Description
2695-2700	Hard to medium hard layers of brown and gray lime
2700-2705	" " " " " " " " " "
2705-2710	" " " " " " " " " "
2710-2715	" " " " " " " " " "
2715-2720	" " " " " " " " " "
2720-2725	White sandy lime, medium
2725-2730	" " " "
2730-2735	" " " "
2735-2740	" " " "
2740-2745	White lime, sandy, medium to medium soft
2745-2750	" " " " " " "
2750-2755	" " " " " " "
2755-2760	" " " " " " "
2760-2765	" " " " " " "
2765-2770	" " " " " " "
2770-2775	" " " " " " "
2775-2780	" " " " " " "
2780-2785	" " " " " " "
2785-2790	" " " " " " "
2790-2795	Light brown lime, sandy, medium
2795-2800	" " " " "
2800-2805	White lime, medium to medium soft
2805-2810	" " " " " "
2810-2815	" " " " " "
2815-2820	" " " " " "
2820-2825	White lime with intermediate layers of hard white lime
2825-2830	" " " " " " " " "
2830-2835	" " " " " " " " "
2835-2840	" " " " " " " " "
2840-2845	" " " " " " " " "
2845-2850	" " " " " " " " "
2850-2855	" " " " " " " " "
2855-2860	Gray, brown, white and pink hard layers of rock
2860-2865	" " " " " " " " "
2865-2870	" " " " " " " " "
2870-2875	White lime and layers of various colored rock
2875-2880	White lime and layers of various colored rock; last 2 ft. very hard dolomite
2880-2885	Brown dolomite first 2 ft.; then white medium sandy lime
2885-2890	Intermediate layers of hard brown dolomite
2890-2895	" " " " " "
2895-2900	White lime, medium hard with streaks of very hard brown dolomite
2900-2906	" " " " " " " " " " "

Depth (feet)	Description
2906-2911	Intermediate layers of brown, white, and cemented sand
2911-2916	White lime, medium hard, broken
2916-2921	" " " " "
2921-2926	White lime and cemented sand, medium hard
2926-2931	Gray and brown rock, hard
2931-2936	Brown cemented sand, medium hard, broken
2936-2941	" " " " " "
2941-2946	" " " " " "
2947-----	Stuck for 6 hours with broken material; got free; stopped drilling

APPENDIX A-2

GEOLOGIC REPORT

(Courtesy of Dr. R. O. Vernon)

W-10245
WDd-54S-40E-32 d
R. O. Vernon 3/11/70

PERMIT #	: 13-7728-69
OWNER	: Peninsula Utilities Corp.,
	: Coral Gables - Injection Snapper Creek Canal Plant
LOCATION	: SW 97th Ave. & SW 83rd S Miami
COUNTY	: Dade
ELEVATION	:
DRILLER	: Alsay Drilling Company
DEPTH	: 2941'
CASING	: 26" at 220' - surface 22" at 820' - middle 16" at 1810' - end casing 8" at 1970' - pilot hole
USE	: Disposal plant
REMARKS	: 170 samples rec'd 9/3/69 (0-845') and 177 samples rec'd 2/13/70 (1975'-2841'

PLEISTOCENE EPOCH = Miami Oolite

0-50 samples 5' intervals	Sandy, oolitic CALCARENITE, hard, very porous and permeable, light yellow orange to light gray drusy crystals indicate crystals cavities. Seams of fine to medium, clear quartz, CALCAREOUS sand with less porosity and permeability.

PLEISTOCENE EPOCH (?) - Anastasia Formation (?)

50-59	SAME AS ABOVE, finely crystalline, harder and dense.
59-61	SAME AS ABOVE, shell, whole and broken, mollusks, medium to coarse quartz.
61-65-105 samples 5' intervals	SANDY CALCILUTITE, slighty phosphoritic, light yellow orange to light gray, very fine to medium quartz grading to CALCAREOUS, shelly sandstone, poor to excellent porosity and permeability. Seams of bioclastics. Some of the SANDY CALCILUTITE has appearance of Tampa Formation.
105-110	Bioskeletal CALCIRUDITE in CALCILUTITE, light gray, sandy. Shark's teeth, Flood of Pecten.

W-10245
WDd-54S-40E-32 d

110-115,120	SAME AS ABOVE, (61-65) some medium gray, very sandy, phosphoritic, finely crystalline CALCILUTITE.
120-125,130	SAME AS ABOVE, much bioclastic remains.

MIDDLE MIOCENE: Hawthorn Formation

130-170 samples 5' intervals	SAME AS ABOVE, increase of phosphorite grain size and change to greenish brown, fine grained CLAYEY CALCILUTITE. A fine to coarse quartz and phosphorite in a light-greenish-brown CALCILUTITE. Seams of sandstone, CALCAREOUS, medium, gray, fine to coarse, rounded quartz, shelly, phosphoritic.
170-190 samples 5' intervals	A mixture of lithologies up the hole but continuing the CALCILUTITE, sandy, medium gray, fine to coarse quartz, slighty phosphoritic - grades to CALCAREOUS sandstone.
190-225 samples 5' intervals	CALCAREOUS CLAY and CLAYEY CALCILUTITE, very silty and sandy, fine to very fine quartz, slightly phosphoritic, greenish-gray-brown.
225-230,235	SANDY CALCILUTITE, and crystalline CALCARENITE, light gray to white, hard, tough, medium porosity and permeability, slightly phosphoritic - *Archaias* and *Sorites*, finely recrystalline and bioclastic in part. Considerable sandy, oolitic textured.
235-237,340 samples 5' intervals	CALCARENITE - light gray with residual textures of oolites and only the crystalline CALCILUTITE matrix remaining. Very poor porosity and permeability throughout section. The quartz is clear, sub-rounded, and fine to medium coarse. Unwashed samples show very fine quartz sand with minor foraminifera in a CALCAREOUS greenish-brown clayey matrix - interval probably sandy greenish-brown shell CALCILUTITE with lenses of harder sandy CALCILUTITE and CALCARENITE above.
340-355 samples 5' intervals	Increased percentages of hard rock above.
355-60,65, 70,75, & 79	Greenish-brown clayey CALCILUTITE and seams of rock, AS ABOVE, CALCARENITE, shows less leaching, but hard and dense. Much fine quartz sand in CALCILUTITE.

379-385	AS ABOVE, and CALCAREOUS, brown, hard, finely crystalline, dense clay (?)
385-400 samples 5' intervals	CALCILUTITE, finely sandy, hard, dense, light gray. Rock above and bioclastic; phosphoritic, Sorites sp. Poor porosity and permeability.

MIDDLE MIOCENE: Tampa Formation

400-405	CALCARENITE, light yellow orange to gray, quartz sand, fine to very fine, phosphoritic, good to poor porosity and permeability. Some typical Tampa.
405-520 samples 5' intervals	AS ABOVE, increased hardness and sand, poor porosity & permeability. Some fragments show relic oolitic structures. Contains increasing fragments of Tampa Formation lithology, with depth.
520-555 samples 5' intervals	CALCARENITIC CALCILUTITE, light brownish-gray, fine grained, slightly phosphoritic, Eponides Camerinid, Echinoid plates and spines. Scattered large pebbles of phosphorite and quartz.
555-60, 65, 68, 75	CALCARENITE, very fine grained, light brown to light yellow orange, poor porosity and permeability, CALCILUTITIC and fragments of rock above.
575-580	CALCARENITE, fine to medium, loose quartz sand, fine to medium - caving?
580-600 samples 5' intervals	CALCARENITE, as above, and much large bioclastic fragments, sandy, light yellow orange, poor porosity and permeability, Archaias sp.
600-660 samples 5' intervals	Mixture of sandy CALCILUTITE of Tampa lithology, relic oolitic CALCARENITE seams and rock above. Poor porosity and permeability. Some drusy CALCILUTITE.
660-745 samples 5' intervals	AS ABOVE, increase in large bioclastic fragments - less quartz, fine to coarse, probably good porosity & permeability and CALCARENITE, light yellow orange, coarse to fine grained, soft - fragments increase toward base. Many large bioclastic fragments. Archaias sp., many barnacles, echinoides etc. sandy seams. Quartz coarse to fine, good porosity and permeability.

745-845 samples 5' intervals	SANDY CALCARENITE, CALCILUTITE, light yellow orange, poor porosity and permeability, quartz coarse to very fine, ranges to CALCAREOUS sandstone - seams of good porosity and permeability.
845-885 samples 5' intervals	Bioclastic CALCIRUDITE, in a CALCARENITIC CALCILUTITE composed of a broken shell-hash, good porosity and permeability and rock above.

OLIGOCENE - Suwannee Limestone

885-930 samples 5' intervals	AS ABOVE, much more granulated and CALCARENITIC, coarse to fine, loose, good porosity & permeability. Eponides sp., Amphistegina sp. First "cones" noted at 900 feet. Rare Ostrocads. First Miogypsina at 920'.
930-960 samples 5' intervals	CALCARENITIC CALCILUTITE, as above, poor porosity and permeability.
960-970	CALCARENITIC CALCILUTITE, poor porosity & permeability, light yellow orange to brown, many large bioclastic fragments - Miogypsina, "cones". Some finely crystalline, light brown, porous, poorly permeable, soft CALCARENITE.
970-995 samples 5' intervals	Bioclastic CALCIRUDITE, good porosity and permeability, large broken mollusk shells; CALCARENITIC CALCILUTITE, as above. Much of the porosity filled by crystals of calcite and some cuttings show quartz and phosphorite. Limestone is vuggy and drusy, rare seams of phosphoritic, sandy, crystalline, light brown, partially recrystallized CALCARENITE, tight and hard. Phosphorite probably source of high gamma ray anomoly and high fluorides. First flow as above 988 feet.
995-1010 samples 5' intervals	CALCARENITE, fine to medium grained, light yellow orange, fair porosity and permeability, soft; and DOLOSTONE, light brown, finely crystalline. Numerous Miogypsina and Heterostegina, camerinids, matrix is fine to very fine grained, loose and soft. Some drusy calcite.
1010-1040 samples 5' intervals	AS ABOVE, with fine grains of phosphorite. Rare to common exo-skeletal fragments of echinoids and mollusks. Seams of crystalline CALCARENITE, hard, dense.
1040-1055 samples 5' intervals	CALCARENITE, leached, micromoldic, soft, light gray, fair porosity and permeability, numerous allochems, loosely cemented and good porosity and permeability.
1055-1060	DOLOMITIC CALCARENITE, light brownish gray, soft, residual CALCILUTITE, finely crystalline dolomite, Heterostegina,

camerinids, allochems, Discorinopsis gunteri.

1060-1065	Crystalline CALCARENITE, medium gray, macromoldic, good porosity & permeability, hard, slightly phosphoritic.

UPPER MIDDLE EOCENE - Avon Park Limestone

1065-1070	CALCARENITE, fine to coarse grained, loosely cemented, fair porosity & permeability, light yellow orange, soft, Amphistegina, rare "cones".
1070-1075	SAME AS ABOVE, 1060 and 65, numerous barnacle plates, allochems, seams of good porosity & permeability.
1075-1115 samples 5' intervals	SAME AS ABOVE, 1065, excellent porosity & permeability, soft, "cones", algae. Discorinopsis gunteri, Peronella.
1115-1120	AS ABOVE, slightly crystallized and crystalline CALCARENITE, light gray, fair porosity & permeability, micromoldic.
1120-1155 samples 5' intervals	CALCARENITE, same as above, 1075 with slight crystallization of grains, and matrix, moderately well cemented, fair porosity & permeability. A microcoquina of Coskinolina - Dictyoconus.
1155-1165 5' intervals	Dolomitic CALCARENITE, light brown, hard, dense, cryptocrystalline CALCARENITE grains, fine to coarse, visible upon wetting.
1165-1180 samples 5' intervals	CALCARENITE, same as above, (1120), Peronella many allochems, some filled by crystalline calcite.
1180-1185	CALCARENITE, fine to medium grained, light tan, CALCILUTITE matrix, fair porosity & permeability.
1185-1220 Samples 5' intervals	Crystalline CALCARENITE, tan to light yellow orange, poor to fair porosity & permeability, in part good porosity & permeability, loosely cemented, many "cones", Lituonella.
1220-1225	CALCILUTITE, light yellow orange, hard, dense, brittle.

1225-1265 samples 5' intervals	CALCARENITE, fine to coarse grained, light yellow orange, soft, loosely cemented, good porosity & permeability, and CALCARENITE, micromoldic, hard, poor porosity and permeability, light tannish-gray; incipient calcite filling of pores - interbedded - Avon Park fauna.
1265-70, 75	CALCILUTITE, light gray, silt sized, soft, porous, low permeability, many "cones".
1275-80	Same as above, numerous Peronella.
1280-1285	CALCARENITE in CALCILUTITE matrix, numerous "cones", soft, fair porosity & permeability, light gray.
1285-1300 samples 5' intervals	SAME AS ABOVE, 1265'
1300-1320 5' intervals	CALCARENITE, fine to coarse, good porosity & permeability, soft, Peronella, "cones". A microcoquina in part.
1320-25, 30	SAME AS ABOVE, 1265, light gray.
1330-35, 40	Crystalline CALCILUTITE, light gray, hard, dense, poor porosity & permeability with seams of 1300.
1340-45	CALCARENITE, well cemented, light gray, fine to medium grained, fair porosity & permeability - Peronella.
1345-1400	CALCARENITE, fine to coarse, microcoquina of "cones" and other porous. Excellent porosity & permeability, soft, light yellow orange to tan, seams of 1340-45.
1400-30	Crystalline CALCARENITE, hard, dense, light gray, poor porosity & permeability. In the hard rock cones intermixed, possibly caved, interbedded with CALCARENITE, fine grained, soft, poor porosity & permeability, light yellow orange.
1430-45 5' intervals	AS ABOVE, and crystalline CALCILUTITE, hard, dense, medium gray, poor porosity & permeability, brittle, micromoldic.
1445-50, 55	CALCARENITE, fine to medium, good porosity & permeability, microcoquina of "cones", light yellow orange to tan.
1455-60, 65	SAME AS ABOVE, 1430-35.
1465-70, 75	CALCARENITE, fine to very fine grained, soft, good porosity, poor permeability, light yellow orange, rare organic seams, similar to top of Lake City up the Peninsula.

1475-80, 85	Mixture of CALCARENITE, fine to coarse, many cones, good porosity & permeability, light yellow orange and crystalline CALCILUTITE, hard, dense, light green.
1485-90, 95, 1500	SAME AS ABOVE, 1465-70, slightly more cemented, many organic bands.
1500-05,	Dolomitic CALCARENITE, residual fine to coarse grains, light brown, hard, fine crystalline matrix.
1505-10, 15	CALCARENITE as above 1445-50, plus lithologies between.
1515-85 5' intervals	CRYSTALLINE CALCARENITE and CALCILUTITE, light gray to brown, hard, dense, some indications of Lepidocyclina - like forms, seams of fair permeability and porosity, moderately cemented.
1585-90, 95, 1600	Crystalline CALCILUTITE, medium gray, hard, dense, brittle poor porosity & permeability and lithologies above. Increase in percent of CALCARENITE in lower normals.
1600-05	Crystalline CALCILUTITE, brittle, hard, dense, brown to medium gray, poor porosity & permeability and lithologies above.
1605-10, 15, 20	AS ABOVE, micromoldic, finely crystalline, with only matrix left in some beds. Drusy CALCILUTITE, light yellow orange to gray, poor porosity and permeability.
1620-25	CALCARENITE, fine to coarse, microcoquina, one fragment peat flecked CALCILUTITE.
1625-30, 35, 40, 45	SAME AS ABOVE, 1600-05 - Discorinopsis gunteri, much medium gray, hard, brittle, dense CALCILUTITE.
1645-50, 55, 60, 65	Partially recrystallized CALCARENITE in CALCILUTITE matrix, poor porosity and permeability, pale gray to light yellow orange, soft micromoldic, rare to common Discorinopsis gunteri.
1665-1700 5' intervals	CALCARENITE, fine to coarse in CALCILUTITE matrix, light brown gray to light yellow orange, poor porosity and permeability, Discorinopsis gunteri. Seams of incipient dolomite crystals.
1700-25 5' intervals	CALCARENITE, fine to coarse, loosely cemented, good porosity and permeability, light yellow orange, soft. Seams of partially recrystallized CALCARENITE, gray,

	hard, fairly dense.
1725-30, 35	CALCARENITE, fine to coarse, loose, microcoquina of "cones", good porosity and permeability, soft. _Discorinopsis gunteri_ and others.

MIDDLE EOCENE: Lake City Limestone

1735-40	CALCILUTITE, studded with CALCILUTITE grains and fossils, light gray, laminated by organic soft layers, poor porosity and permeability.
1740-45	Mixtures of 1725-30 and 1735-40 but primarily 1725-30.
1745-75 5' intervals	Essentially SAME AS ABOVE, 1735-40, slight increase of CALCARENITE. _Dictyoconus americanus_ rare to common.
1775-95 5' intervals	CALCARENITE, fine to coarse, soft, loosely cemented, coquina of "cones", _Dictyoconus americanus_. Tan, good porosity and permeability and rock as above.
1795-1800, 1805	Mixtures SAME AS ABOVE 1740-45.
1805-10	SAME AS ABOVE, and DOLOSTONE, gray, hard, dense, crystallines.
1810-25 5' intervals	CALCARENITE, a "cone" microcoquina, light tan, good porosity and permeability, possibly caved. Some DOLOSTONE, _Dictyoconus americanus_ (megaspheric form).
1825-50 5' intervals	DOLOSTONE, dense to micromoldic, light gray to brown and CALCARENITE, fine to coarse, well cemented in CALCILUTITE, hard with some recrystallized, poor porosity and permeability, light gray, drusy calcite indicates cavities. _Dictyoconus americanus_ & _Discorinopsis gunteri._
1850-55	SAME AS 1735-40.
1855-60	CALCARENITE in CALCILUTITE, light gray to tan, partially leached, and some rock of 1825-30.

1860-1980 samples 5' intervals	CALCARENITE, fine to coarse grained, microcoquina, light tan, partially recrystallized, good porosity and permeability, soft, and fairly cemented.
1980-2010 5' intervals	CALCARENITE in a CALCILUTITE matrix, light gray to light yellow orange, soft. Poor porosity and permeability, and minor crystalline calcite. Seams of more porous microcoquina CALCARENITE.
2010-15	CALCARENITE same as above 1860-65 and DOLOSTONE, brown, hard, dense, finely crystallines.
2015-35 5' intervals	AS ABOVE, more cemented, DOLOSTONE, rare to common.
2035-65 5' intervals	CALCARENITE, fine to medium in CALCILUTITE tan to light yellow orange to light gray, soft. Fair porosity and permeability. Seams of DOLOSTONE, hard, dense, finely to cryptocrystalline.
2065-85 5' intervals	CALCILUTITE, silt sized, light gray, poor porosity and permeability, soft, dense laminae of organics and DOLOSTONE, as above.
2085-2125 5' intervals	SAME AS ABOVE, 2035-40, some of the grains of CALCARENITE crystalline and seams of micromoldic CALCARENITE where all the grains have been leached, tan to light yellow orange, soft. Poor to fair porosity and permeability, DOLOSTONE above, rare - "cones".
2125-35	NO SAMPLES
2135--40,45	CALCARENITE, fine to coarse, moderately cemented, tan to light gray and DOLOSTONE, hard, dense, crypto and finely crystalline, some micromoldic.
2145-50	NO SAMPLE
2150-55	SAME AS ABOVE, 2135-40, DOLOSTONE rare to absent. Seams of crystalline CALCILUTITE, hard, dense, finely crystalline.
2155-2180	NO SAMPLES
2180-85,90	SAME AS ABOVE 2065-70.

2190-95	NO SAMPLE
2195-2200	Partially Recrystallized CALCILUTITE, micromoldic, light gray, soft, poor porosity and permeability with seams of fine grained CALCARENITE, poor porosity and permeability, soft, light yellow orange.
2200-05	DOLOSTONE, hard, dense, cryptocrystalline, light tan to brown, low porosity and permeability.
2205-10,15	DOLOSTONE, and fine-grained CALCARENITE as above, some of it micromoldic and partially recrystallized.
2215-2300 samples 5' intervals	CALCARENITE, light yellow orange, soft, microcoquina of "cones", good porosity and permeability, some Partially Recrystallized. Seams of Partially Recrystallized CALCILUTITE
2300-50 5' intervals	CALCARENITE and rock as above, fine grained light gray to light yellow orange, soft, good porosity and permeability. Seams of light gray, CALCILUTITE, soft, poor porosity and permeability.
2350-55,60	CALCARENITE and CALCILUTITE, as above and Dolomitized CALCARENITE, hard, dense, light gray.
2360-65	CALCARENITE, same as above 2300-05.
2365-75	SAME AS ABOVE, and DOLOSTONE, hard, dense, finely crystalline tan to light gray - last 12" of 2375 is DOLOSTONE, hard, dense, finely crystalline, vuggy, light brown.
2375-2465 5' intervals	CALCARENITE and CALCILUTITE same as above, 2195-2300, with seams of recrystallized CALCARENITE, and dark gray, hard, dense, finely crystalline DOLOSTONE, (a 3 foot seam cut at about 2465)
2465-70	DOLOSTONE as above and recrystallized CALCARENITE, fine to medium grained, medium hard, light yellow orange, some micromoldic porosity, poor porosity and permeability.
2470-85 5' intervals	CALCARENITE, same as above 2295-2300.

2485-2525 samples 5' intervals	CALCARENITE, fine to coarse, soft to medium hard, poor porosity and permeability and DOLOSTONE, brown-gray to dark gray, hard, dense, finely crystalline and cryptocrystalline. Samples increase in DOLOSTONE content until all of sample is DOLOSTONE and contain some drusy and free-growing crystals. A dense zone occurs on the electric log 2490-2580.
2525-40 5' intervals	DOLOSTONE, as above and seams of CALCILUTITE, organic laminae, fine silt sized, soft, light yellow orange. Some of the CALCILUTITE show free growing crystals of dolomite.
2540-45,50	CALCILUTITE, white to light yellow orange, fine grained to finely crystalline, soft, poor porosity and permeability, veins of irregular dolomitization and CALCARENITE, fine to coarse, light yellow orange, soft, good porosity and permeability. Thin beds.
2550-80 5' intervals	DOLOSTONE, tan, and dark gray, brown-gray, hard, dense, finely crystalline with seams of free crystal growth and drusy DOLOMITE. A dense layer is portrayed on the electric log from 2552 to 2560. Seams of CALCARENITE, fine to coarse, soft, light yellow orange, good porosity and permeability and CALCILUTITE, fine grained, light gray, poor porosity and permeability, soft.
2580-85,90	Partially Recrystallized CALCARENITE soft, poor porosity and permeability, light yellow orange with seams of CALCILUTITE as above, rare "cones", Discorinopsis gunteri.
2590-95,2600	CALCILUTITE, light brown-gray, laminated by organic residues, soft, porous, poor permeability. Seams of rock of 2580-85.
2600-30 5' intervals	Partially Recrystallized CALCARENITE, hard, dense, residual fine to coarse grains, poor porosity and permeability and rock above. Seams of dark gray, brown fine crystalline, to cryptocrystalline hard, dense, DOLOSTONE. The fauna is Lake City.
2630-35,40	Essentially DOLOSTONE as above with various percentages of sediment as above. Many free crystal growths.
2640-60 5' intervals	CALCARENITE, fine to medium, light yellow orange, soft, loosely cemented, fair porosity and permeability and seams of DOLOSTONE, hard, dense, cryptocrystalline to finely crystalline, light brown gray to brown. Dictyoconus.

2660-65, 70	DOLOSTONE, tan to light gray-brown, hard, dense, very finely crystalline. Seams of CALCARENITE above.
2670-75, 80	Partially Recrystallized CALCARENITE, white to light gray, fine to medium, with finely crystalline matrix. Poor intergranular porosity and permeability. Slightly moldic. Few, if any, "cones".
2680-85, 90	DOLOSTONE of 2660-70, few fragments 2670-75.
2690-2710 samples 5' intervals	CALCARENITE of 2660-70, few fragments of DOLOSTONE. Rare "cones". Some seams of Partially Recrystallized CALCARENITE, hard, dense, light yellow orange to tan. One fragment (2705-10) of brown, fissle clay.
2710-15, 20	CALCARENITE above and DOLOSTONE, hard, dense, crypto to finely crystalline, poor porosity and permeability, brown to dark gray. Pyrite crystals in DOLOSTONE and "cones" common in CALCARENITE. Some gypsum in pores.
2720-2855, 5' intervals 2855-58	Partially Recrystallized CALCARENITE of 2670-75, few "cones". A tight zone present from 2762-80 approaches a CALCILUTITE and at 2780 the bed grades into a CALCILUTITE with seams of CALCARENITE, rare cones and gypsum.

LOWER EOCENE - Oldsmar Limestone

2858-60	CALCARENITE as above, seams of gypsum, and of Partially Recrystallized CALCARENITE, hard, dense, light yellow orange, poor porosity and permeability. DOLOSTONE, fine crystalline seams.
2860-65	DOLOSTONE, finely crystalline, brown-gray to tan, hard, dense, gypsum seams and impregnated. Vuggy dolomite, seams of rock above.
2865-90 5' intervals	DOLOSTONE, tan cryptocrystalline, hard, dense, impregnated by gypsum.
2890-95	CALCARENITE, Partially Recrystallized, fine to medium, light yellow orange to near white - dolomite and DOLOSTONE as above, cement grout.

2895-2900, 06,11	SAME AS ABOVE, 2860-70 with some 2890-95.
2911-21,26	SAME AS 2890 with some of 2865-70.
2929-31,36, 41	DOLOSTONE, hard, dense, light gray to brown, finely crystalline to coarsely crystalline, drusy becoming increasingly so toward base where a large cavity was entered. Many, large, free dolomite crystals.

APPENDIX A-3

PUMPING TEST REPORT

PUMPING TEST REPORT

DISPOSAL WELL FOR PENINSULA UTILITIES CORPORATION

Construction Project No. 498-68-01 Report Project No. 498-70-53

1. EQUIPMENT

1.1 Three pumps and engine drives with minimum capacity of 3,000 gpm at 100 psi injection pressure (231 feet of head), continuous output.

1.2 Orifice plate and differential manometer to indicate maximum flow of 4,000 gpm and minimum of 720 gpm. Calibration curve on page A3-3.

1.3 Pressure recorder, 12" diameter dial, 0-150 psi, equal to Foxboro 612734, to be installed on injection head (P_w).*

1.4 Pressure gage, 6" diameter dial, 0-60 psi, equal to Helicoid Type 410, to be installed on tap at casing annulus (22"-16") (P_a).*

1.5 Pressure gage, 8-1/2" diameter dial, 0-100 psi, equal to Helicoid 410T (test), to be installed on top of 3" diameter drill rod (P_b).* Drill rod to extend to 100 feet above bottom of well.

1.6 Piping, fitting, valves, and appurtenances to obtain water from Snapper Creek Canal and inject it into well.

2. PROCEDURE

2.1 Leave bottom of drilling rod at approximately 2,900 feet in depth. depth.

2.2 Install equipment and well head fittings as per attached drawing.*

2.3 Inject fresh water through top of 3" drill rod until pressure gage reaches a maximum pressure under normal flow. Shut off valve (V_b) and observe pressure for a period of 5 minutes. Pressure should decrease slightly immediately after shutting off valve, and thereafter remain constant (approximately 20 psi). Repeat operation to double check this pressure. Then, open valve (V_b) slowly and a little at a time until next pressure increase. Strangle valve to last setting which did not increase pressure. Leave valve in that position for duration of test. Pressure indicated by gage P_b is static pressure at bottom of drilling rod.

2.4 Start pumping into well at rate of 1,000 gpm, and keep record as per attached table, "Pumping Test Data," (pp. A3-5 through A3-8). Record pressure exactly every minute for first fifteen (15) minutes, and flows every five (5) minutes. Thereafter, record all variables at time intervals during

*See instrumentation Layout Diagram on page A3-4.

2. PROCEDURE - (continued)

which pressures in gages P_a and P_b would not vary more than 1 psi nor longer than 5 minutes.

2.5 Once pressure in gages P_a and P_b have remained constant for a period of one (1) hour, increase pumping rate to 2,000 gpm and repeat Procedure 2.2.

2.6 Once pressure in gages P_a and P_b have remained constant for a period of one hour, increase pumping rate to 3,000 gpm and repeat Procedure 2.3.

2.7 Once pressure in gages P_a and P_b have remained constant for a period of one (1) hour, increase pumping rate to maximum pumping capacity and repeat Procedure 2.4.

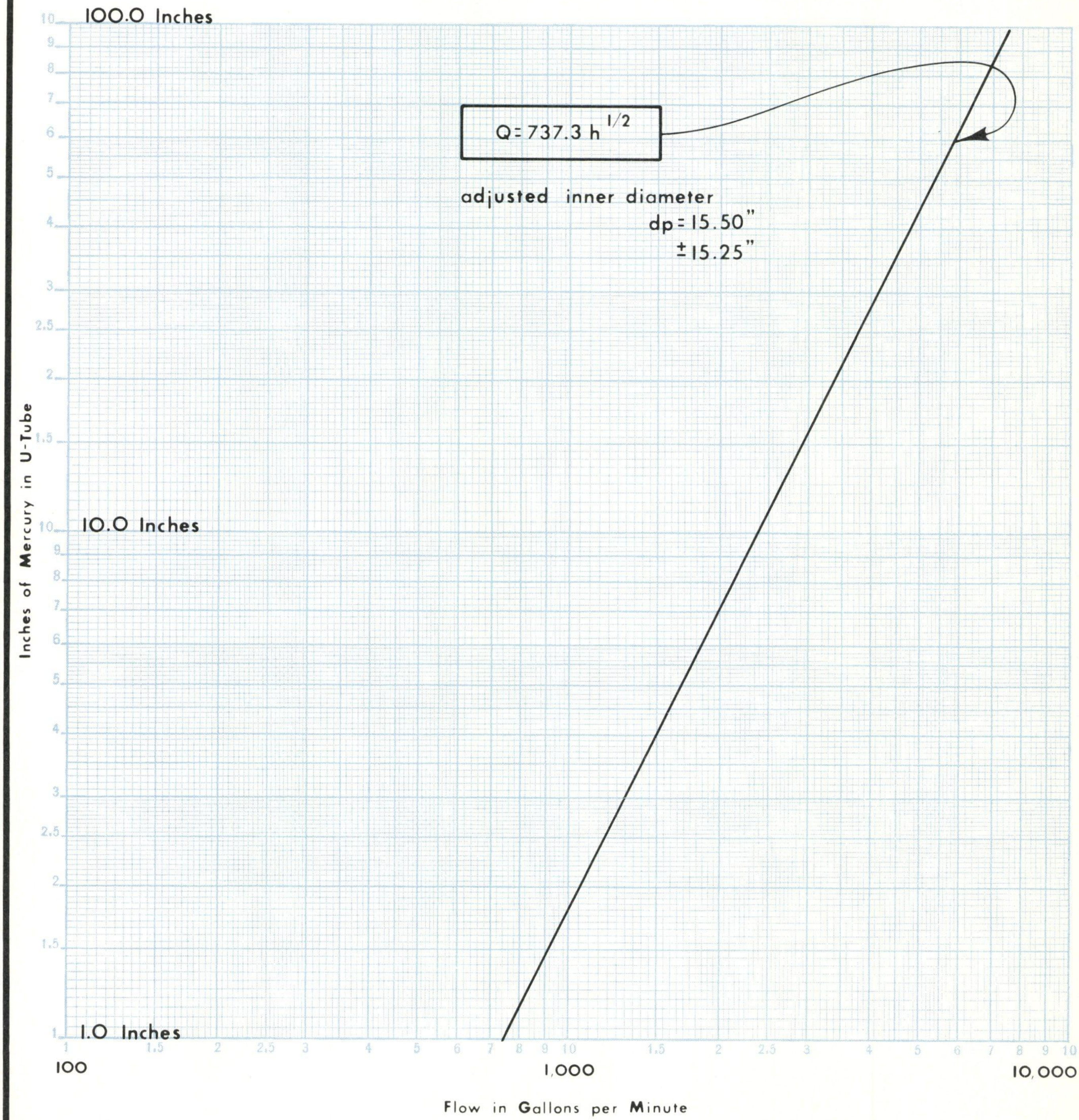
2.8 Once pressure in gages P_a and P_b have remained constant for at least a period of four (4) hours, shut off pumping and read pressures P_a, P_b, and P_w every minute for first fifteen (15) minutes, and every five (5) minutes for the next 45 minutes.

End of test.

CALIBRATION OF U-TUBE CONNECTED TO ORIFICE PLATE

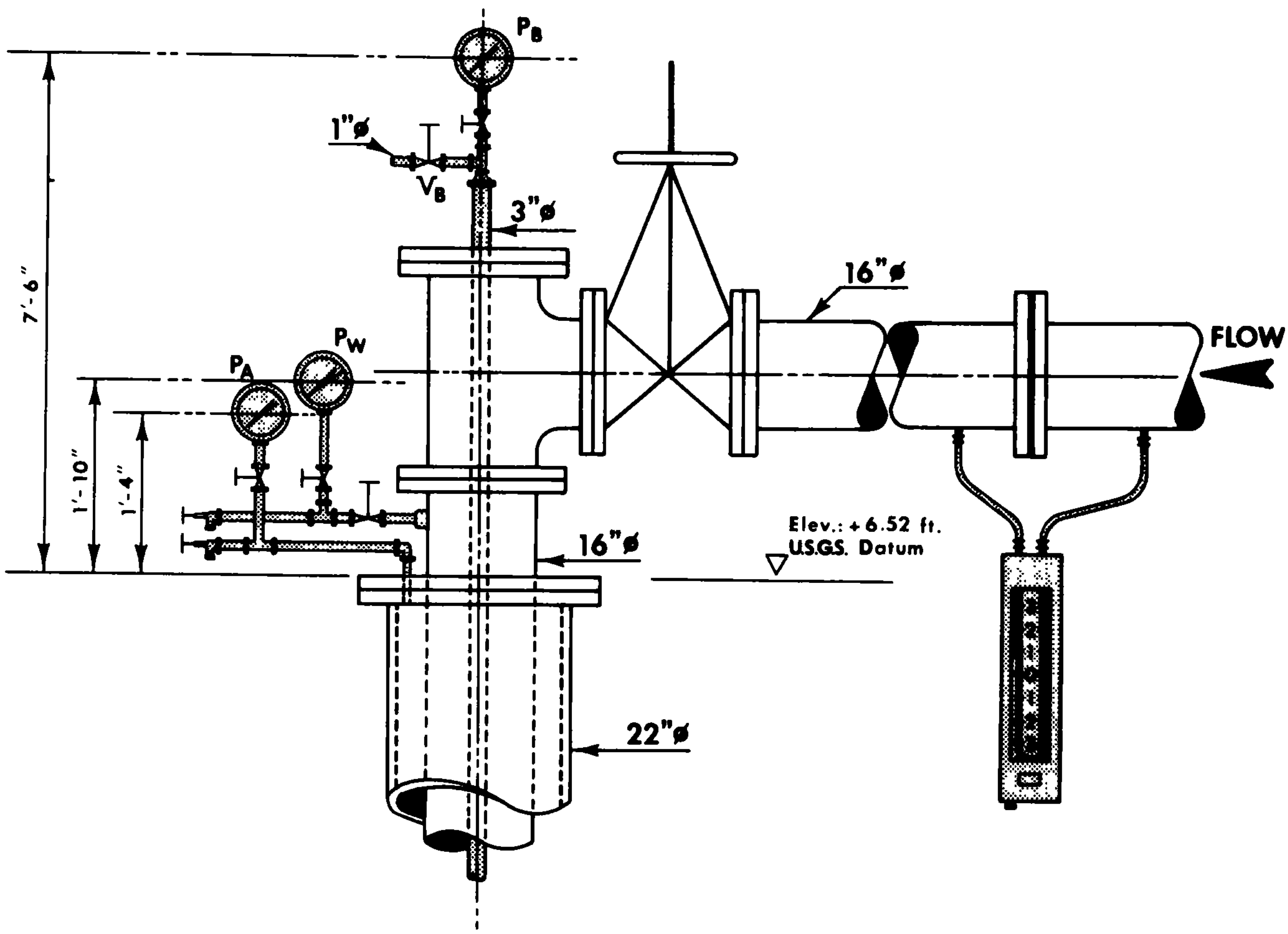
Orifice coefficient: 0.50 **Orifice diameter:** 7.625" I.D.

Pipe diameter: 16" O.D. **Specific gravity of mercury:** 13.58



DEEP DISPOSAL WELL
PENINSULA UTILITIES CORPORATION
CORAL GABLES, FLORIDA
BLACK, CROW AND EIDSNESS, INC.
Engineers

INSTRUMENTATION LAYOUT FOR INJECTION TEST



NOTES:

DRAWING NOT TO SCALE.

HEIGHTS OF PRESSURE GAGES ABOVE TOP OF 22" FLANGE ARE ACTUAL TEST MEASUREMENTS.

TOP OF 22" FLANGE IS APPROXIMATELY AT GROUND LEVEL.

DEEP DISPOSAL WELL
PENINSULA UTILITIES CORPORATION
CORAL GABLES, FLORIDA
BLACK, CROW AND EIDSNESS, INC.
Engineers

BLACK, CROW AND EIDSNESS, INC.
Engineers

PUMPING TEST DATA
PENINSULA UTILITIES CORPORATION
PROJECT NO. 498-70-53

Started January 27, 1970

Actual Time	Time Since Pumping Started (minutes)	Pressures in psi: P_A Annulus	P_W Well Head	P_B Bottom	Injection Flow Rate: Inches of Hg	GPM	Chlorine: Feed lbs/day	Residual mg/l	Remarks
8:35 am	-			28.6	0	0	-	-	Static
8:40	-	15	21	28.7	0	0	-	-	Static; water in drill rods; water temperature 74° F; TDS 140 ppm
9:19	0	15	21	28.6	0	0	-	-	Barometer 30.16"
9:20	1	15	22	28.5	1.5	895	240	-	One pump-adjusting flow
9:21	2	15	24	28.4	2.4	1130	-	-	" "
9:22	3	15	24	28.4	1.7	950	-	-	" "
9:23	4	15	24	28.4	1.7	950	-	-	" "
9:24	5	15	24	28.4	2.6	1170	-	3.0+	" "
9:25	6	15	24	28.4	2.1	1050	-	-	
9:26	7	15	25	28.4	2.6	1170	-	-	
9:27	8	15	27	28.4	2.0	1030	-	-	
9:28	9	15	27	28.4	2.0	1030	-	-	
9:29	10	15	27	28.4	2.0	1030	-	3.0+	
9:30	11	15	27	28.4	2.2	1080	-	-	
9:31	12	15	27	28.4	-	-	-	-	
9:32	13	15	27	28.4	1.8	980	-	-	
9:33	14	15	27	28.4	1.8	980	-	-	
9:34	15	15	27	28.4	1.5	895	-	3.0+	30 psi orifice upstream
9:39	20	15	32	28.4	2.0	1030	-	3.0+	
9:44	25	15	34	28.5	2.0	1030	-	3.0+	
9:49	30	15	34	28.6	2.0	1030	-	3.0+	
9:54	35	15	34	28.6	2.1	1050	-	3.0+	
9:59	40	15	34	28.8	2.0	1030	-	3.0+	
10:04	45	15	34	28.8	2.0	1030	-	3.0+	
10:09	50	15	34	28.8	2.0	1030	-	3.0+	
10:14	55	15	34	28.8	2.0	1030	-	3.0+	
10:19	60	15	34	28.9	2.0	1030	-	3.0+	
10:24	65	15	34	28.9	2.0	1030	-	3.0+	
10:29	70	15	34	29.0	2.0	1030	-	3.0+	
10:35	75	15	34	29.0	2.2	1080	240	3.0+	
10:40	80	15	34	29.1	2.1	1050	-	3.0+	
10:45	85	15	34	29.1	2.1	1050	-	3.0+	
10:50	90	15	34	29.1	2.1	1050	-	3.0+	
10:55	95	15	34	29.1	2.1	1050	-	-	
11:00	100	15	34	29.1	2.2	1080	-	-	
11:05	105	15	34	29.1	2.2	1080	-	-	
11:10	110	15	34	29.2	2.2	1080	-	3.0+	
11:15	115	15	34	29.2	2.1	1050	-	3.0+	
11:20	120	15	34	29.4	2.1	1050	-	3.0+	Gage tapped prior to reading
11:25	125	15	34	38.2	2.1	1050	-	3.0+	Recharge drill rods
11:30	130	15	34	29.6	2.0	1030	-	3.0-	Rods recharged
11:35	135	15	34	29.6	2.1	1050	-	3.0+	
11:40	140	15	34	29.6	2.1	1050	-	3.0-	
11:45	145	15	34	29.6	2.1	1050	-	3.0+	
11:50	155	15	34	29.6	2.2	1080	-	3.0+	Snapper Creek water 73.4° F
11:55	160	15	34	29.6	2.1	1050	-	3.0+	TDS 320 ppm, Snapper Creek water
12:00 n	165	15	34	29.6	2.2	1080	-	3.0+	
12:10 pm	170	15	34	29.6	2.1	1050	-	3.0+	
12:15	175	15	34	29.6	2.1	1050	-	3.0+	
12:20	180	15	34	29.7	2.2	1080	-	3.0+	
12:25	185	15	34	29.7	2.1	1050	-	3.0+	
12:28	188	15	36	29.7	8.5	2130	480	-	Changing to 2000 gpm
12:29	189	15	36	29.7	7.2	1960	-	-	
12:30	190	15	36	29.7	7.6	2000	-	3.0+	

BLACK, CROW AND EIDSNESS, INC.
Engineers

PUMPING TEST DATA
PENINSULA UTILITIES CORPORATION
PROJECT NO. 498-70-53

Actual Time	Time Since Pumping Started (minutes)	Pressures in psi: P_A Annulus	Pressures in psi: P_W Well Head	Pressures in psi: P_B Bottom	Injection Flow Rate: Inches of Hg	Injection Flow Rate: GPM	Chlorine: Feed lbs/day	Chlorine: Residual mg/l	Remarks
12:31 pm	191	15	36	29.7	7.6	2000	-	-	
12:32	192	15	36	29.7	7.7	2030	-	-	
12:33	193	15	36	29.7	7.7	2030	-	-	
12:34	194	15	36	29.7	7.7	2030	-	-	
12:35	195	15	36	29.7	7.7	2030	-	3.0+	
12:36	196	15	36	29.7	7.7	2030	-	-	
12:37	197	15	36	29.7	7.7	2030	-	-	
12:38	198	15	36	29.7	7.7	2030	-	-	
12:39	199	15	36	29.7	7.7	2030	-	-	
12:40	200	15	36	29.7	7.7	2030	-	3.0+	
12:41	201	15	36	29.7	7.7	2030	-	-	
12:42	202	15	36	29.7	7.7	2030	-	-	
12:43	203	15	36	29.7	7.7	2030	-	-	
12:48	208	15	36	29.8	7.8	2040	-	3.0+	
12:53	213	15	36	29.8	7.9	2050	-	3.0+	
12:58	218	15	36	29.8	7.9	2050	-	3.0+	
1:03	223	15	36	29.8	7.9	2050	-	3.0+	
1:08	228	15	36	29.8	7.9	2050	-	3.0+	
1:13	233	15	36	29.8	7.9	2050	-	3.0+	
1:18	238	15	36	29.8	7.9	2050	-	3.0+	
1:23	243	15	36	29.8	7.9	2050	-	3.0+	
1:28	248	15	36	29.8	7.9	2050	-	3.0+	
1:33	253	15	35	29.8	7.9	2050	-	3.0+	
1:38	258	15	36	29.8	7.9	2050	480	3.0+	
1:43	263	15	36	29.3	7.9	2050	-	3.0+	
1:48	268	15	36	29.8	7.9	2050	-	3.0+	
1:53	273	15	36	29.8	7.9	2050	-	3.0+	
1:58	278	15	36	29.8	7.9	2050	-	3.0+	
2:03	283	15	36	29.8	7.9	2050	-	3.0+	
2:08	288	15	36	29.8	7.9	2050	-	3.0+	
2:13	293	15	36	38.4	7.9	2050	-	-	Charging drill rods
2:20	300	15	36	39.1	8.0	2070	-	3.0+	Charging drill rods
2:25	305	15	36	29.8	7.9	2050	-	3.0+	
2:30	310	15	36	29.7	7.9	2050	-	-	
2:35	315	15	36	29.7	7.9	2050	-	3.0+	
2:40	320	15	36	29.8	7.9	2050	480	-	
2:45	325	15	36	29.7	7.9	2050	-	3.0+	
2:50	330	15	36	29.7	7.9	2050	-	-	
2:55	335	15	36	29.7	7.9	2050	-	3.0+	
3:00	340	15	36	29.8	7.9	2050	-	-	
3:05	345	15	36	29.8	7.9	2050	-	3.0+	
3:10	350	15	36	29.7	7.9	2050	-	-	
3:15	355	15	36	29.7	7.8	2040	-	-	
3:20	360	15	36	29.7	7.9	2050	-	3.0+	
3:23	363	15	36	29.7	4.5	1550	-	-	Adding third pump
3:25	365	15	37	29.8	9.5	2250	-	-	
3:26	366	15	42	29.8	18.0	3110	-	-	
3:27	367	15	42	29.8	17.5	3080	-	-	
3:28	368	15	42	29.8	17.7	3090	-	-	
3:29	369	15	42	29.8	18.1	3120	-	-	
3:30	370	15	42	29.8	18.1	3120	-	3.0+	
3:31	371	15	42	29.8	18.1	3120	-	-	
3:32	372	15	42	29.8	18.1	3120	-	-	
3:33	373	15	42	29.8	18.1	3120	-	-	
3:34	374	15	42	29.8	18.1	3120	-	-	
3:35	375	15	42	29.8	18.1	3120	-	-	
3:36	376	15	42	29.8	18.1	3120	-	-	
3:37	377	15	42	29.8	18.1	3120	-	-	
3:38	378	15	42	29.8	18.1	3120	-	-	
3:39	379	15	42	29.8	18.1	3120	-	-	

BLACK, CROW AND EIDSNESS, INC.
Engineers

PUMPING TEST DATA
PENINSULA UTILITIES CORPORATION
PROJECT NO. 498-70-53

Actual Time	Time Since Pumping Started (minutes)	Pressures in psi P_A Annulus	P_W Well Head	P_B Bottom	Injection Flow Rate Inches of Hg	GPM	Chlorine Feed lbs/day	Residual mg/l	Remarks
3:40	380	15	42	29.8	18.0	3110	-	3.0+	
3:45	385	15	42	29.8	18.0	3110	-	-	
3:50	390	15	42	29.8	18.0	3110	-	3.0+	
3:55	395	15	42	29.8	18.0	3110	-	-	
4:00	400	15	42	29.8	18.0	3110	-	3.0+	
4:05	405	15	42	29.8	18.0	3110	-	-	
4:10	410	15	42	29.8	18.1	3120	720	3.0+	
4:15	415	15	42	29.8	18.1	3120	-	-	
4:20 pm	420	15	42	29.8	18.1	3120	-	3.0+	
4:25	425	15	42	29.8	18.1	3120	-	-	
4:30	430	15	42	29.8	18.1	3120	-	3.0+	
4:35	435	15	42	29.8	18.1	3120	-	-	
4:40	440	15	42	29.8	18.1	3120	-	3.0+	
4:45	445	15	42	29.8	18.1	3120	-	-	
4:50 pm	450	15	42	29.8	18.1	3120	-	-	
4:55	455	15	42	29.8	18.1	3120	-	3.0+	
5:00	460	15	42	29.8	18.1	3120	-	-	
5:15	475	15	41	29.7	18.1	3120	-	-	
5:30	490	15	42	29.8	18.1	3120	-	-	
5:45	505	15	42	29.7	18.3	3140	-	-	
6:00	520	15	42	29.7	18.4	3150	720	3.0+	
6:15	535	15	42	29.8	18.3	3140	720	3.0±	
6:30	550	15	42	29.7	18.4	3156	720	3.0±	
6:45	565	15	42	29.8	18.4	3110	720	-	
7:00	580	15	42	29.8	18.5	3120	720	3.0-	
7:15	595	15	42	29.8	18.5	3120	720	3.0±	
7:30	610	15	42	29.8	18.4	3110	720	3.0+	
7:45	625	15	42	29.8	18.4	3110	720	3.0+	
8:00	640	15	42	29.8	18.5	3120	720	3.0+	
8:15	655	15	42	29.8	18.4	3110	720	3.0+	
8:30	670	15	42	29.8	18.4	3110	720	3.0-	
8:45	685	15	42	29.8	18.4	3110	720	3.0±	
9:00	700	15	42	29.8	18.4	3110	720	3.0-	
9:15	715	15	42	29.8	18.4	3110	720	3.0+	
9:30	730	15	42	29.8	18.4	3110	720	3.0+	
9:45	745	15	42	29.8	18.4	3110	720	3.0-	
10:00	760	15	42	29.8	18.4	3110	720	3.0-	
10:15	775	15	42	29.7	18.5	3120	720	3.0+	
10:30	790	15	42	29.8	18.5	3120	720	3.0+	
10:45	805	15	42	29.8	18.4	3110	720	3.0+	
11:00	820	15	42	29.8	18.4	3110	720	3.0+	
11:15	835	15	42	29.8	18.4	3110	720	3.0+	
11:30	850	15	42	29.7	18.3	3100	720	3.0-	
11:45	865	15	42	29.7	18.4	3110	720	3.0+	
12:00 mn	880	15	42	29.7	18.0	3040	720	3.0+	
12:15 am	895	15	42	29.7	18.0	3080	720	3.0+	
12:30	910	15	42	29.7	18.0	3030	720	3.0+	
12:45	925	15	42	29.7	18.0	3080	720	3.0+	
1:00	940	15	42	29.7	18.0	3030	720	3.0+	
1:15	955	15	42	29.7	18.0	3080	720	3.0+	
1:30	970	15	42	29.7	18.0	3080	720	3.0+	
1:45	985	15	42	29.7	18.0	3080	720	3.0+	
2:00	1000	15	42	29.7	18.0	3080	720	3.0+	
2:15	1015	15	42	29.7	18.0	3080	720	3.0+	
2:30	1030	15	42	29.7	18.0	3080	720	3.0+	
2:45	1045	15	42	29.7	18.0	3030	720	3.0+	
3:00	1060	15	42	29.7	18.0	3080	720	3.0+	
3:15	1075	15	42	29.7	18.0	3040	720	3.0+	
3:30	1090	15	42	29.7	18.0	3080	720	3.0+	
3:45	1105	15	42	29.7	17.9	3070	720	3.0+	

BLACK, CROW AND EIDSNESS, INC.
Engineers

PUMPING TEST DATA
PENINSULA UTILITIES CORPORATION
PROJECT NO. 498-70-53

Ended January 28, 1970

Actual Time	Time Since Pumping Started (minutes)	Pressures in psi: P_A Annulus	P_W Well Head	P_B Bottom	Injection Flow Rate: Inches of Hg	GPM	Chlorine: Feed lbs/day	Residual mg/l	Remarks
4:00 am	1120	15	42	29.7	18.0	3080	720	3.0+	
4:15	1135	15	42	29.6	18.0	3080	720	3.0+	
4:30	1150	15	42	29.6	18.0	3080	720	3.0+	
4:45	1165	15	42	29.6	18.0	3080	720	3.0+	
5:00	1180	15	42	29.6	18.0	3080	720	3.0+	
5:15	1195	15	42	29.6	18.0	3080	720	3.0+	
5:30	1210	15	42	29.6	18.0	3080	720	3.0+	
5:45	1225	15	42	29.6	18.0	3080	720	3.0+	
6:00	1240	15	42	29.6	18.0	3080	720	3.0+	
6:15	1255	15	42	29.6	18.0	3080	720	3.0+	
6:30	1270	15	42	29.6	18.0	3080	720	3.0+	
6:45	1285	15	42	29.6	18.0	3080	720	3.0+	
7:00	1300	15	42	29.6	18.1	3120	720	3.0+	
7:15	1315	15	42	29.6	18.0	3110	720	3.0+	
7:17									Purged drill rod
7:20									Stopped purging; P_B 29.6
7:30	1330	15	42	29.6	18.0	3110	720	3.0+	
7:45	1345	15	42	29.6	18.0	3110	720	3.0+	
8:00	1360	15	42	29.6	18.0	3110	720	3.0+	
8:15	1375	15	42	29.6	18.0	3110	720	3.0+	
8:20	1380	15	42	29.6	18.0	3110	720	-	23 hrs. pumping
8:24	1384	15	43	29.7	19	3200	-	-	Pump #1 up to max.
8:25	1385	15	50	29.8	29	3970	-	3.0+	
8:26	1386	15	50	29.8	29.3	4000	-	-	Diesel up to max.
8:27	1387	15	50	29.8	29.2	3990	-	-	Maximum
8:28	1388	15	50	29.8	29.1	3980	-	-	
8:29	1389	15	50	29.8	29.1	3980	960	-	
8:30	1390	15	50	29.8	29.1	3980	-	3.0+	
8:31	1391	15	50	29.8	29.0	3970	-	-	
8:32	1392	15	50	29.8	29.1	3980	-	-	
8:33	1393	15	50	29.8	29.0	3970	-	-	
8:34	1394	15	50	29.8	29.0	3970	-	-	
8:35	1395	15	50	29.8	29.0	3970	-	3.0+	
8:36	1396	15	50	29.8	29.0	3970	-	-	
8:37	1397	15	50	29.8	29.0	3970	-	-	
8:38	1398	15	50	29.8	29.0	3970	-	-	
8:39	1399	15	50	29.8	29.0	3970	-	3.0+	
8:45	1405	15	50	29.8	29.0	3970	-	-	Whirlpool on suction lines
8:50	1410	15	50	29.9	29.0	3970	-	3.0+	
8:55	1415	15	50	29.9	29.0	3970	-	-	
9:00	1420	15	50	29.9	29.0	3970	-	3.0+	
9:05	1425	15	50	29.9	29.0	3970	-	-	
9:10	1430	15	50	29.9	29.0	3970	-	3.0+	
9:15	1435	15	50	29.9	29.1	3980	-	-	
9:20	1440	15	50	29.9	29.0	3970	-	3.0+	
9:25	1445	15	50	29.9	29.0	3970	-	-	
9:30	1450	15	50	29.9	29.0	3970	-	3.0+	
9:45	1465	15	50	29.9	29.0	3970	-	3.0+	
10:00	1480	15	50	29.9	28.9	3960	-	3.0+	
10:15	1495	15	50	29.9	29.0	3970	-	3.0+	
10:30	1510	15	50	30.1	28.9	3960	-	3.0+	
10:45	1525	15	50	29.9	28.0	3900	-	3.0+	
11:00	1540	15	50	30.1	27.6	3870	-	3.0+	Intake screen fouled
11:15	1555	15	51	30.2	29.0	3970	-	3.0+	Screen cleared
11:20	1560	15	51	30.2	29.0	3970	-	-	
11:30	1570	15	51	30.2	29.0	3970	-	3.0+	Drill rods recharged
11:40	1580	--	-	-	-	-	-	-	End of Test

APPENDIX A-4

WATER QUALITY DATA

DEEP - WELL WATER QUALITY DATA

Black, Crow and Eidsness, Inc.

Project: Peninsula Utilities Corporation — No. 498-68-1

Well: Waste Disposal Well No. 1

Location: Snapper Creek Canal Plant

Driller: Alsay Drilling, Inc. — Determinations by A. Perez

Date	Time	Depth Feet From/To	Temp. of (1)	Specific Gravity (2)	Specific Conductance (3)	Chloride Cl⁻ mg/l
9/2/69	10:55	968	74	1.0000	3,800 (5)	900
"	12:45	985	74	1.0000	~~3,900 (5)~~	900
"	2:10	1005	73.5	1.0000	3,900(5)	900
"	2:10	1005	73.5	1.0000	3,000	900
"	3:35	1025	74	1.0000	4,000	1000
"	4:40	1045	74	1.0000	4,500	1075
"	5:45	1065	73.5	1.0000	5,000	1375
9/3/69	7:40	1065	73	Before drilling started		
"	9:15	1085	73	1.0000	5,000	1400
"	10:40	1105	73	1.0000	5,200	1400
"	12:05	1125	72.5	1.0005	5,100	1400
"	1:20	1145	72.5	1.0000	5,200	1400
"	2:35	1165	73	1.0000	5,200	1400
"	3:30	1185	73	1.0005	5,200	1400
9/4/69	7:40	1205	73	1.0005	4,800	1350
"	8:45	1225	73	1.0000	5,000	1400
"	9:45	1245	73	1.0005	5,400	1500
"	10:35	1265	73	1.0005	5,400	1550
"	11:25	1285	73	1.0005	5,400	1500
"	12:10	1305	73	1.0000	5,400	1500
"	1:05	1325	73	1.0000	5,500	1500
"	2:00	1345	73	1.0005	5,500	1500
"	2:50	1365	73	1.0015	5,800	1650
"	3:35	1385	73	1.0010	6,600	1900
"	4:30	1405	72	1.0015	7,000	2050
9/5/69	8:30	1425	72	1.0020	7,900	2400
"	9:20	1445	72	1.0020	8,100	2500
"	10:05	1465	72	1.0020	8,200	2550
"	10:50	1485	72	1.0025	8,400	2600
"	11:40	1505	71.5	1.0025	8,400	2500
"	12:30	1525	71.5	1.0025	8,400	2550
"	1:20	1545	71.5	1.0025	8,300	2550

Notes: (1) Measured immediately after collection by air-reverse rotary method
(2) At temperature under (1)
(3) In micromhos per cm. at 25°C (77°F)
(4) Estimated artesian flow in gpm
(5) 2X cell constant; all others 20X cell constant.

BLACK, CROW AND EIDSNESS, INC. - ENGINEERS

DEEP - WELL WATER QUALITY DATA

Black, Crow and Eidsness, Inc.

Project: Peninsula Utilities Corporation **No.** 498-68-1

Well: Waste Disposal Well # 1

Location: Snapper Creek Canal Plant

Driller: Alsay Drilling, Inc. **Determinations by** A. Perez

Date	Time	Depth Feet From/To	Temp. of (1)	Specific Gravity (2)	Specific Conductance (3)	Chloride Cl⁻ mg/l
9/5/69	2:10	1565	71.5	1.0025	8,500	2600
"	3:05	1585	71.5	1.0020	8,600	2600
"	4:05	1605	72	1.0015	8,500	2600
9/8/69	8:45	1625	72	1.0025	8,500	2750
"	3:20	1645	72	1.0030	8,900	2750
"	4:10	1665	71.5	1.0035	8,900	2750
"	5:05	1685	71	1.0030	9,100	2800
9/9/69	8:45	1705	71.5	1.0030	8,500	3000
"	9:45	1725	71.5	1.0035	9,400	3160
"	10:45	1745	71.5	1.0040	9,900	3275
"	11:45	1765	72	1.0040	10,800	3625
"	12:45	1785	71	1.0040	11,800	4075
"	2:00	1810	72	1.0080	18,200	6400
"	3:35	1830	74	1.0155	30,000	12,150
"	4:45	1850	71	1.0160	32,000	12,200
9/10/69	8:30	1870	71	1.0225	38,000	17,600
"	9:50	1890	71.5	1.0230	42,000	17,600
"	10:50	1910	71	1.0230	43,000	17,750
"	12:00	1930	71	1.0230	42,000	17,800
"	1:10	1950	70.5	1.0235	42,000	17,500
"	2:40	1970	71	1.0230	42,000	17,900
9/11/69	9:05	From annular space	71	1.0050	11,100	4100
11/28/69	10:10	2820	67	1.026	41,000	18,400
12/17/69	10:15	2947 (6)	61	1.0275	45,000	19,300

Notes:
(1) Measured immediately after collection by air-reverse rotary method
(2) At temperature under (1)
(3) In micromhos per cm. at 25°C (77°F)
(4) Estimated artesian flow in gpm
(5) 2X cell constant; all others 20X cell constant.
(6) Sample collected while pumping well with air at approximately 3,000 gpm.

BLACK, CROW AND EIDSNESS, INC. - ENGINEERS