FEASIBILITY OF
GROUND-WATER DEVELOPMENT
CITY OF
WEST PALM BEACH, FLORIDA

PHASE II

October 1982

Prepared for:

THE CITY OF WEST PALM BEACH
West Palm Beach, Florida

Prepared by:

GERAGHTY & MILLER, INC.
Ground-Water Consultants
West Palm Beach, Florida

TABLE OF CONTENTS

FIGURES

TABLES

APPENDICES

FEASIBILITY OF GROUND-WATER DEVELOPMENT
CITY OF WEST PALM BEACH, FLORIDA
PHASE II

INTRODUCTION

In order to determine the potential for increasing the existing municipal water supply, the City of West Palm Beach contracted Geraghty & Miller, Inc., ground-water consultants, to evaluate the potential for ground-water development. In a preliminary study, two areas were identified as having favorable hydrogeologic conditions for ground-water withdrawals (Geraghty & Miller, November 1981, "Feasibility of Ground-Water Development, City of West Palm Beach - Phase I"). These are: (1) the City-owned property in the vicinity of the Regional Wastewater Treatment Plant, and (2) the area surrounding Lake Mangonia and Clear Lake.

This report describes Phase II of the feasibility study and contains a description of the work recommended in Phase I and completed in Phase II. The investigation included the construction and testing of three test-production wells and thirty observation wells tapping the shallow aquifer. Geologic logs, well-construction details, water quality data, and hydrogeologic descriptions of the sites investigated are included. The data from the pumping tests are analyzed and estimates of the ground water available for development and the impacts of a diversion are discussed. Recommendations on future construction and operation of wells are made.

FINDINGS

Area of Regional Wastewater Treatment Plant

1. The shallow aquifer is a potential source of a major ground-water supply.

2. The aquifer coefficients of transmissivity and specific yield are estimated to be 300,000 gallons per day per foot (gpd/ft) and 0.10, respectively, based on the analysis of the test data (these coefficients are used to predict the water yield from the aquifer).

3. A poor hydraulic connection exists between the "M" canal and the shallow aquifer; therefore, pumping from the aquifer will not significantly interfere with the existing West Palm Beach water-supply system.

4. The effect of operating a ten-well field was evaluated. This well field is expected to yield 40 million gallons per day (mgd) for consumptive use.

5. The diversion of 40 million gallons per day will not reduce the water available to any adjacent, permitted ground-water user by more than ten percent.

6. The diversion of 40 million gallons per day will lower the surface-water level in the entire Water Catchment Area by about 0.046 feet.

7. The quality of ground water is generally good. State standards for public water supplies are exceeded by the color and turbidity of the water from Well PW1, and by the color, the turbidity, the stability index, and the iron concentration in the water from Well PW2. The color and turbidity might clear up with use; however, treatment for the other constituents would be required.

8. Future wells should be constructed with 24-inch-diameter casings and, if possible, an open-hole design; if testing shows that it is necessary, an 18-inch-diameter well screen can be installed below the 24-inch-diameter casing.

9. The cost of construction for ten wells should range approximately from $300,000 to $600,000. The cost of ten pumps and motors should be approximately $260,000. These estimates do not include the cost of pipelines, power lines, or treatment.

Area of Lake Mangonia and Clear Lake

1. Hydrogeologic testing supports the (Phase I) conclusion that as much as 10 million gallons per day is unavailable to the West Palm Beach water system because of seepage through the bottoms of Lake Mangonia and Clear Lake.

2. Seepage-meter and water-level monitoring, and short-term pumping tests indicate that the eastern side of Lake Mangonia is the most favorable location for the capture of lost water by wells.

3. Analyses indicate that 2.42 million gallons per day of the seepage lost along the eastern side of Lake Mangonia can be captured by three wells.

4. Seepage-capture wells must be located at distances from the lake and from each other such that induced infiltration from Lake Mangonia is minimized and salt-water intrusion from Lake Worth is prevented.

5. The aquifer coefficients of transmissivity and specific yield east of Lake Mangonia are estimated to be 280,000 gallons per day per foot and 0.10, respectively.

6. Because of its location, Test-Production Well PW3 can be used to capture seepage with an efficiency that is lower than wells at recommended locations.

7. The quality of ground water east of Lake Mangonia is good. Only the iron concentration in water from Well PW3 exceeds State standards for public water supplies and would require reduction by treatment.

SUMMARY

Investigations in the vicinity of the Regional Wastewater Treatment Plant involved the construction and testing of wells for the purpose of determining the quantity and quality of the ground water available. Two test-production wells and twelve observation wells were constructed in the shallow aquifer and confirmed the presence of a highly permeable zone of shelly sandstone between depths of 80 and 180 feet. An unconsolidated sand having a relatively low permeability is the dominant geologic component from land surface to a depth of 80 feet.

Step-rate and constant-rate pumping tests were conducted on Test-Production Wells 1 and 2 (PW1 and PW2). Water-level measurements taken before and during the constant-rate test on PW1 show that the hydraulic connection between the "M" canal and the water-producing zone is poor. The PW1 test also revealed: (1) that the aquifer responds to pumping as a water-table aquifer, (2) that the aquifer has a significantly higher horizontal than vertical permeability, and (3) that the coefficient of transmissivity is approximately 300,000 gal/day/ft. The specific yield coefficient was determined independent of the test and is estimated to be 0.10. Water-level measurements taken before and during pumping tests at the site of PW2 revealed similar hydrogeologic conditions to those at PW1.

Wells PW1 and PW2 were constructed with a low-cost, open-hole design. Both wells produced sand upon pumping. Tests show that the sanding may reduce with further pumping of the wells. Because of the potential savings in capital and operating costs, new wells should be constructed

as open-hole wells and tested. If sanding persists during an extended period of well development, then a well screen and a gravel pack would have to be installed in the well.

The quality of water produced from PW1 and PW2 was generally good; however, treatment would be required for the removal of several common constituents that are in excess of State standards for a public water supply. Potential sources of ground-water contamination were assessed and concluded to pose no significant threat to the development of a water supply.

A well field consisting of 10 wells located on City property south of the effluent disposal wells was determined to be capable of producing 40 mgd (million gallons per day) without adversely affecting neighboring, permitted ground-water users. The impact on the City's present water system, including the Water Catchment Area, would be minimal. In 1982 dollars, the construction cost of ten wells would range from $300,000 to $630,000, depending on whether well screens would be required. The cost of ten pumps and motors would be about $260,000. These figures do not include the cost of pipelines or power lines.

Part II of this investigation involved hydrogeologic testing in the vicinity of Lake Mangonia and Clear Lake. The purpose of the investigation was to locate the area of greatest seepage loss from the water-supply lakes and determine the feasibility of capturing a portion of this loss for use by the City. A total of eighteen observation wells and one test-production well was constructed in the shallow aquifer. The shallow aquifer was found to be comprised of sand, shell, and semi-consolidated sandstone. The most permeable portion of the aquifer lies generally between 80 and 200 feet below land surface.

Task 1 of the study resulted in determining the areal distribution of seepage from the lakes and was based upon: (1) the results of monitoring seepage meters installed in the bottoms of the lakes, (2) the results of monitoring water levels in wells located along the periphery of the lakes, and (3) the results of short-term pumping tests conducted on the wells on the periphery of the lakes. About 40 percent of the total water lost from the lakes was determined to be occurring along the eastern shore of Lake Mangonia. This area was concluded to be the most favorable area for the capture of seepage.

Task 2 of the study involved pumping tests on Test-Production Well 3 (PW3), analyses of these tests, an assessment of the ground-water quality, and an evaluation of the potential for capturing a portion of the water lost from the lakes. Water-level measurements taken before the pumping test at PW3 confirmed that water from the lake entered the aquifer and flowed eastward. Analysis of the constant-rate pumping test on PW3 showed that: (1) the aquifer responds to pumping as a water-table aquifer, (2) the aquifer has a higher horizontal than vertical permeability, (3) the coefficient of transmissivity is approximately 280,000 gallons/day/foot, and (4) the water pumped was a combination of the intercepted natural seepage from the lake and that which was artificially induced.

The ground-water flow from the eastern shore of Lake Mangonia to the drainage canal and Lake Worth was estimated. In order to maintain a ground-water gradient sufficient to prevent salt-water intrusion along the shore of Lake Worth, one half of the average flow to Lake Worth was concluded to be available for capture.

It was calculated that 2.42 mgd can be captured from three wells located at specific distances from each other, and at distances from the shore of Lake Mangonia that depend upon the accepted rate of induced infiltration from Lake Mangonia. A well that would capture 0.81 mgd of natural seepage and induce ten percent additional seepage would have to be located 2175 feet east of Lake Mangonia.

The quality of water pumped from PW3 is good; only treatment for the reduction of the iron concentration would be required. A potential source of ground-water contamination (the old sewage treatment plant property) can be avoided by locating seepage capture wells at least 1400 feet north or south of this property.

RECOMMENDATIONS

1. The City of West Palm Beach should undertake a cost analysis to determine the most effective manner of incorporating, within the municipal water system, the sources of ground water identified in this report.
2. In the vicinity of the Regional Wastewater Treatment Plant, wells should be located on the tract of City property south of the effluent-disposal wells.
3. Along the eastern side of Lake Mangonia, wells should be located at specific distances from each other and from the shore of Lake Mangonia, and should be pumped at specific rates; these distances and rates are given in the text.

4. The construction of wells should be preceded by the drilling of a pilot hole to determine the vertical extent of the water-producing zone. The open-hole or screened interval of the well should penetrate the full thickness of the water-producing zone.

5. In the vicinity of the Regional Wastewater Treatment Plant, new wells should be constructed as open-hole wells. Wells should have a 24-inch-diameter casing and a nominal 24-inch-diameter open hole. Wells should be tested by pumping periodically during development to determine the amount of sand produced. If the sand produced does not subside to a tolerable level after approximately 150 hours of development, an 18-inch-diameter well screen and a gravel pack should be installed.

6. Along the eastern side of Lake Mangonia, wells should have a 16-inch-diameter casing, an 8-inch-diameter well screen, and a gravel pack.

HYDROGEOLOGIC INVESTIGATIONS IN THE VICINITY OF THE REGIONAL WASTEWATER TREATMENT PLANT

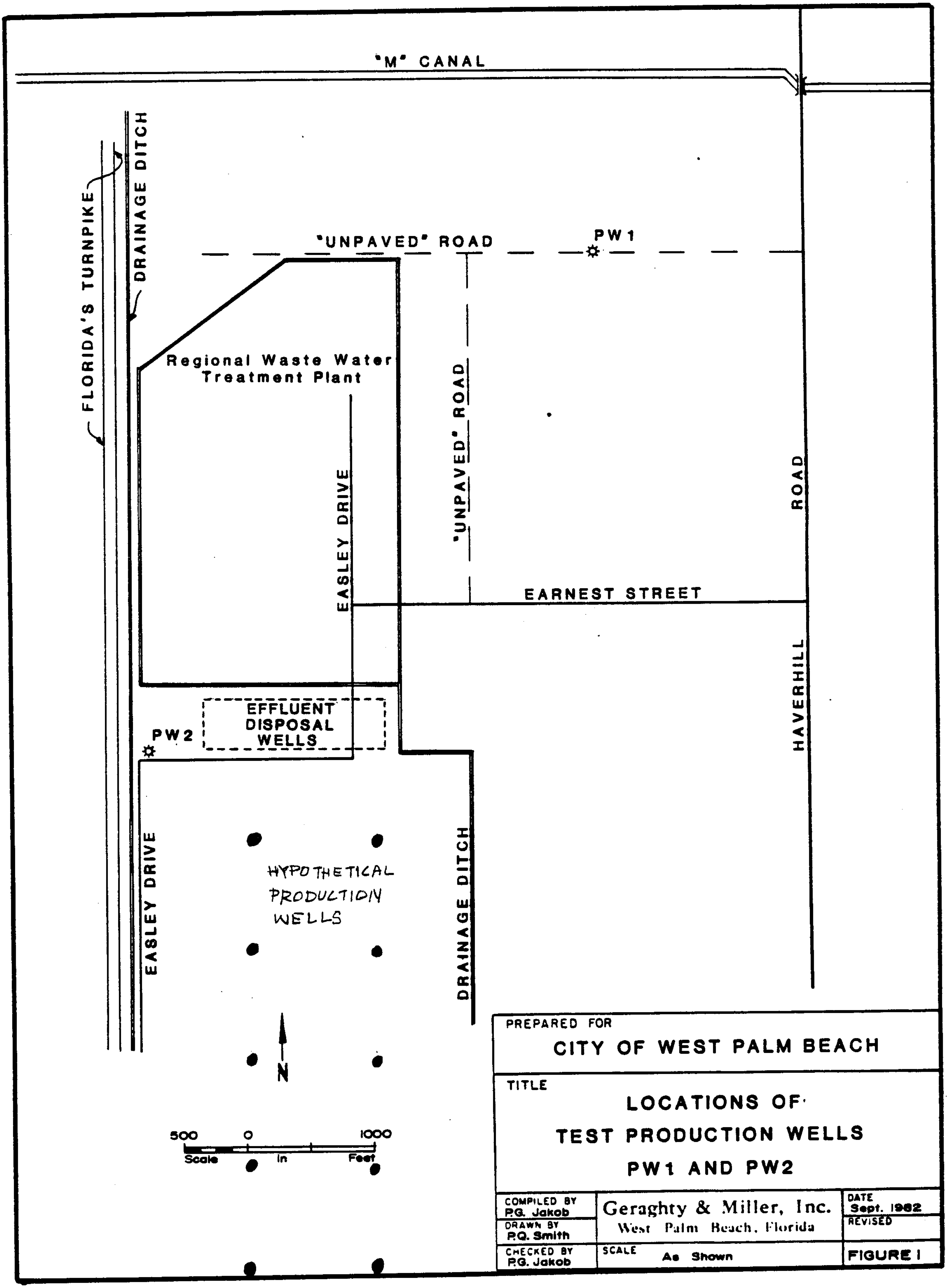
This portion of the investigation pertains to the shallow aquifer on City property in the vicinity of the Regional Wastewater Treatment Plant. The following text describes well construction, hydrogeologic conditions, the performance and results of pumping tests, and ground-water quality. This information was employed to assess the potential for ground-water development and to predict the impact of a ground-water diversion.

Drilling and Well Construction

Test-production wells meeting State standards and observation wells were constructed at the two sites shown on Figure 1. Each site is referenced by the number of its test-production well; these are PW1 and PW2. Observation wells at each site are shown on Figures 2 and 3. These sites were selected with the concurrence of the South Florida Water Management District; well construction permits were issued by the Florida Department of Environmental Regulation.

Observation Wells

A total of twelve observation wells was constructed at the two sites—ten at PW1 and two at PW2. Boreholes having a 4-5/8-inch



PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

LOCATIONS OF TEST PRODUCTION WELLS PW1 AND PW2

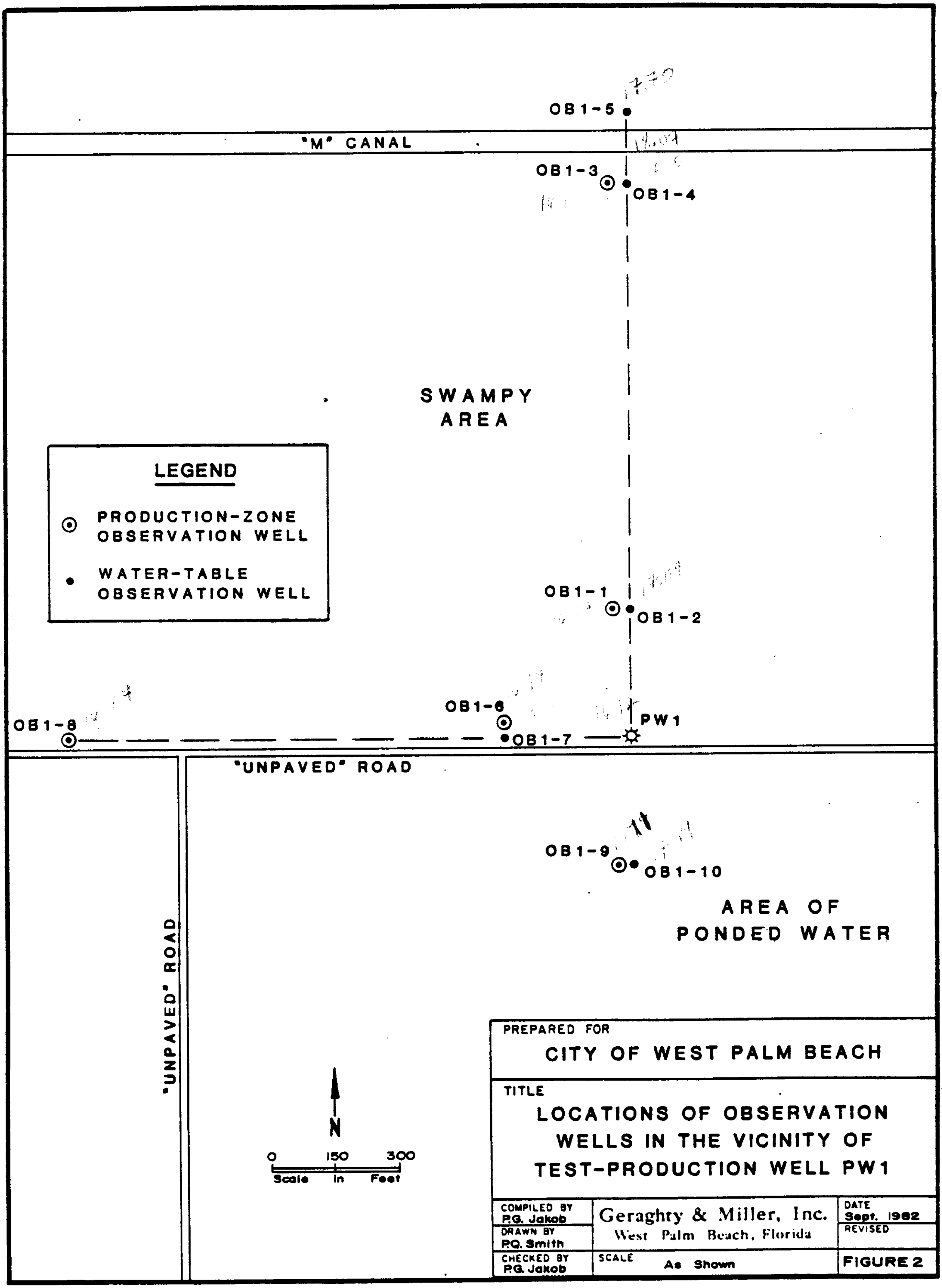
COMPILED BY P.G. Jakob
DRAWN BY P.Q. Smith
CHECKED BY P.G. Jakob

Geraghty & Miller, Inc.
West Palm Beach, Florida

SCALE As Shown

DATE Sept. 1982
REVISED

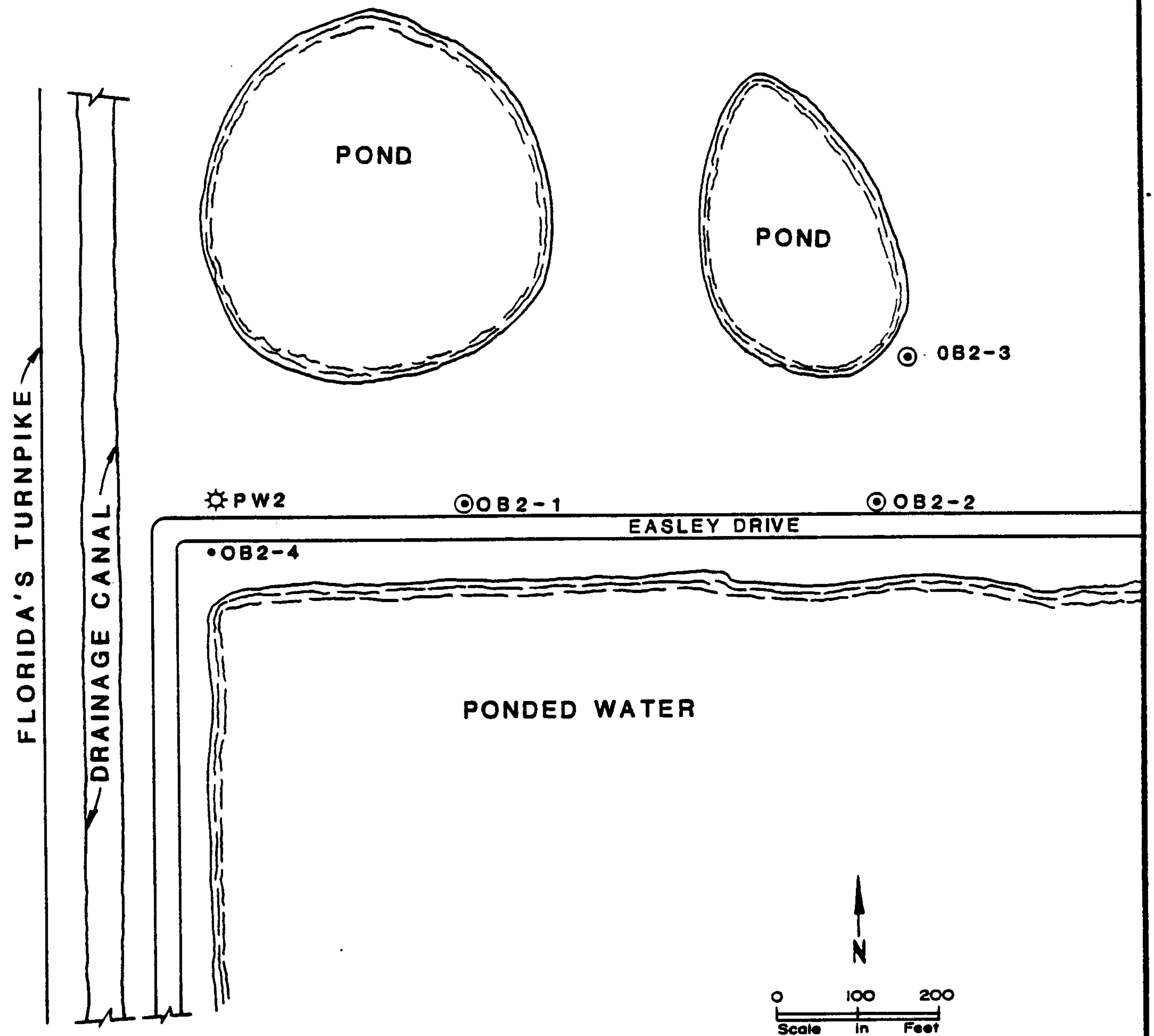
FIGURE I



PREPARED FOR
CITY OF WEST PALM BEACH

TITLE
LOCATIONS OF OBSERVATION WELLS IN THE VICINITY OF TEST-PRODUCTION WELL PW1

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE As Shown	FIGURE 2



LEGEND

⊙ PRODUCTION-ZONE OBSERVATION WELL

• WATER-TABLE OBSERVATION WELL

PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

LOCATIONS OF OBSERVATION WELLS IN THE VICINITY OF TEST-PRODUCTION WELL PW2

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE As Shown	FIGURE 3

diameter were drilled by the mud-rotary method. The observation wells were fitted with two-inch-diameter PVC casings and slotted screens in the intervals indicated on Table 1. The well screen in each observation well was packed with graded gravel to a level several feet above the top of the screen and the well was developed by surging with compressed air until the water produced was free of turbidity. The well annulus above the gravel pack was back-filled to near land surface with bentonite and well cuttings. A protective 3-inch-diameter steel sleeve was placed over the PVC casings and a 3-foot by 3-foot cement pad was poured around the sleeve at ground level. Geologic logs based upon the inspection of drill cuttings are presented in Appendix A.

At the PW1 site, five of the wells were constructed to reflect water levels in the production zone; this zone is the most permeable part of the aquifer and occurs between 80 and 150 feet below land surface. Another five wells were constructed to monitor water levels between 20 and 40 feet below the water table. Four of the five production-zone wells were paired with water-table wells at the same location to provide comparison of water levels in each zone.

At the PW2 site, two observation wells (OB2-1 and OB2-2) were constructed to monitor water levels between 80 and 150 feet. Two existing wells also were employed as observation wells. The well designated OB2-3 was constructed for a water supply during the construction of one of the effluent disposal wells at the Regional Wastewater Treatment Plant; it has an eight-inch-diameter casing, and is believed to be cased to 80 feet and completed as an open hole to 120 feet. Well OB2-4 apparently had been constructed as a shallow observation well to monitor water quality during the construction of the effluent-disposal wells; it has a two-inch-diameter PVC casing, probably 2-foot-long well screen on the bottom, and a total depth of 14.5 feet.

Test-Production Wells

Test-production Well PW1 was drilled first as a pilot hole having a 5-3/4-inch diameter to a total depth of 152 feet by the mud-rotary method. The pilot hole was geophysically logged; caliper, natural gamma ray, and electric logs were made. Based on the borehole cuttings and geophysical logs, it was decided to construct the well by the open-hole method and to set the bottom of the 12-inch-diameter casing at 80 feet. A 17-inch-diameter borehole was drilled to 80 feet; the casing was installed and cemented in place. An attempt was made to drill an open-hole by compressed-air rotary drilling from 80 to 145 feet using an 11-3/4-inch bit. A depth of 132 feet was drilled, but the open hole could not be maintained deeper than 122 feet due to the collapse and heaving of sand. To seal off any sand that might rise from the bottom

TABLE 1

CONSTRUCTION DETAILS OF WELLS ASSOCIATED WITH PW1 AND PW2 WEST PALM BEACH, FLORIDA

Well No.	Total Depth (feet)	Screened Interval (feet)	Elevation of Top of Casing (feet above NGVD)	Distance from Associated Pumping Well (feet)
PW1	150 (pilot)	80-121 (open)	18.32	--
OB1-1	154	70-150	19.14	300
OB1-2	42	20- 40	19.19	305
OB1-3	154	70-150	20.05	1300
OB1-4	42	20- 40	19.98	1300
OB1-5	42	20- 40	24.02	1470
OB1-6	154	70-150	21.12	305
OB1-7	42	20- 40	21.30	300
OB1-8	154	70-150	21.51	1300
OB1-9	154	70-150	19.04	300
OB1-10	42	20- 42	18.94	295
PW2	180 (pilot)	80-101 (open)	16.99	--
OB2-1	154	70-150	19.08	300
OB2-2	154	70-150	19.09	800
OB2-3	120*	80-120*(open)	17.33	870
OB2-4	14.5	12.5-14.5*	17.89	57

*approximate

of the borehole during pumping, three cubic feet of cement were placed at the bottom of the borehole. The completed open-hole interval from 80 to 121 feet was developed by compressed air and pumping. The geologic log of PW1 is presented in Appendix A and the geophysical logs in Appendix B.

Well log shows
7 1/2 bit

The pilot hole for Test-Production Well PW2 was drilled to a depth of 180 feet with a 5-3/4-inch-diameter bit by the mud-rotary method. The pilot-hole cuttings indicated that an open-hole design was appropriate. The 12-inch-diameter casing was set and cemented to a depth of 80 feet. An 11-3/4-inch-diameter open-hole interval was drilled from 80 to 180 feet by the mud-rotary method. Development of the open-hole interval caused the sand and sandstone to collapse and heave in the hole such that the maximum open-hole depth that could be maintained was 102 feet. The borehole bottom was sealed with three cubic feet of cement to prevent sand from rising from the bottom of the bore during pumping. The completed open-hole interval of the well was from 80 to 101 feet. A geologic log of PW2 is presented in Appendix A.

Local Geologic Conditions

The data derived from observation wells and test-production wells agree with the hydrogeologic descriptions of the cavernous zone within the shallow aquifer reported by previous investigators. The zone is reported (Rodis, H.G., and L. F. Land, 1976. "The Shallow Aquifer - A Prime Freshwater Resource In Eastern Palm Beach County, Florida", U.S.G.S., Water-Resources Investigation 76-21) to extend two to three miles to the west of Florida's Turnpike and approximately to Military Trail on the east; the northern and southern boundaries are many miles distant, but are not well defined.

The borehole cuttings taken during well construction at the PW1 site show that between land surface and about 150 feet below, the sediments can be grouped into those that are principally unconsolidated and those that are consolidated or semi-consolidated. The boundary separating these sediments undulates in depth between 60 and 80 feet below land surface in the north-south direction, and dips locally toward the west from 75 feet at PW1 to 92 feet at OB1-8. The unconsolidated upper portion consists of a series of interbedded sand and shell beds with occasional thin stringers of poorly-cemented sandstone. The more consolidated lower portion consists predominantly of shelly sandstone that contains loose sand in void spaces created by the dissolution of the calcareous sandstone matrix. The presence of caverns in the sandstone was indicated during drilling by: (1) sudden drops of the drilling bit of as much as several inches, (2) the temporary loss of drilling fluids, and (3) by drill cuttings that contain well-formed calcite crystals. The natural gamma and electric logs, as well as the geologic log of the PW1 pilot hole, indicate that the aquifer is less permeable below 145 feet. This level is marked by a marl and fine phosphatic sand content and is considered to be the bottom of the aquifer. Several strata within the aquifer could retard the vertical movement of water; the most conspicious was a sandy clay encountered between 72 and 75 feet in PW1. This zone was not detected in other wells at the PW1 site.

Sediments encountered at the PW2 site were generally similar to those at PW1. The top of the consolidated sandstone undulated between 60 and 97 feet below land surface with no apparent trend. The unconsolidated upper portion consists of interbedded shell and sand strata, some of which contain minor amounts of silt- and clay-sized materials. Near the middle of the unconsolidated zone, a poorly- to well-cemented sandstone stringer occurs in Wells OB2-1 and OB2-2; it is thickest at OB2-2 where it occurs between 18 and 38 feet below land surface.

The consolidated lower portion of the aquifer consists of sandstone containing up to 30 percent shell and variable amounts of loose sand. The presence of caverns within the sandstone was indicated by rapidly alternating hard and soft drilling and by the loss of drilling fluids. The shelly sandstone extends to a depth of at least 180 feet; data collected in Phase I of this study indicate that the 180-foot depth is close to the bottom of the aquifer. The aquifer thickness at PW2 is at least 35 feet greater than at PW1. Minor amounts of clay- and silt-sized material occurs in both the consolidated and unconsolidated portions of the aquifer. There are, however, no strata that could be considered significant aquitards or confining beds.

Local Hydrologic Conditions

Prior to the pumping test at the PW1 site, heavy rainfall resulted in swampy conditions over practically the entire area. As much as 60 percent of the area north of Well PW1 was inundated in irregular-shaped ponds at the time of the pumping test and an extensive area of ponded water lay immediately to the south of Well PW1. Slight differences in topographic elevations indicate that a portion of the ponded water may drain toward the south. The area south of PW2 also was inundated and two large, permanent ponds lay northeast of PW2.

The direction of ground-water flow in the vicinity of sites PW1 and PW2 was determined by measuring water levels in the observation wells; elevations above NGVD (National Geodetic Vertical Datum) of the tops of casings at all wells were determined in a survey conducted by the City of West Palm Beach. Static water levels measured on June 7, 1982, before the constant-rate pumping test at PW1, reveal that water levels in the water-table wells (20 to 40 feet in depth) were between 0.17 and 0.77 feet higher than in the adjacent production-zone wells (80 to 150 feet in depth). Water ponded on the land surface at Well OB1-10 stood about 0.45 feet higher than the water table. These observations suggest that the ponded water infiltrates to the water-table zone and continues downward to recharge the production zone.

The static water-level gradient established in the shallow wells, reflecting the regime in the less permeable sediments, is relatively steep and directs flow toward the south (see Table 2). This gradient reflects a minor contribution of flow from the "M" canal to the shallow sediments. The seepage per unit area from the canal to the aquifer is marginally greater than from the surrounding ponds; this is because the canal penetrates the shallow sediments to a greater depth. The water level measured in water-table Well OB1-4, 80 feet south of the "M" canal, is 0.92 feet lower than the water level in the canal. The ground-water gradient established in the production zone is very gentle and directs ground water toward the northwest. Collectively, this information suggests that the hydraulic connection between the "M" canal and the aquifer is poor.

Static water levels measured prior to the constant-rate test at PW2 on June 14, 1982, revealed the hydraulic gradient in the production zone directs flow toward the west. Well PW2 had a water level 0.04 feet higher than water-table Well OB2-4, and 0.22 feet higher than the Turnpike drainage canal, indicating that ground water from the production zone flows westward, upward, and into the drainage canal.

About two weeks prior to the pumping test, PW2 was noted to flow at a very low rate over the top of casing, which was about six inches above ground level. Along with the difference between production-zone and water-table water levels described above, and the layered sediments observed during drilling, this flow from PW2 indicates that the vertical permeability of the aquifer is significantly lower than the horizontal permeability.

Pumping Tests

Step-rate pumping tests and constant-rate pumping tests were conducted on both PW1 and PW2. At each site, a vertical turbine pump powered by a diesel engine via a right-angle drive was installed in the test-production well and a ten-inch-diameter PVC discharge line was run to a convenient discharge point. The flow was controlled by a valve in the discharge line. An eight-inch by ten-inch-diameter orifice and a manometer tube were fitted at the end of the discharge line so that the

TABLE 2

STATIC WATER LEVELS AND WATER LEVELS AT MAXIMUM DRAWDOWN DURING CONSTANT-RATE PUMPING TESTS OF PW1 AND PW2

WEST PALM BEACH, FLORIDA

Well No.	Static Water Level (feet, NGVD)	Maximum Drawdown (in feet)	Water Level at Maximum Drawdown (feet, NGVD)
PW1	16.92	10.08	6.84
OB1-1	16.87	3.62	13.25
OB1-2	17.04	0.90	16.14
OB1-3	16.88	1.99	14.89
OB1-4	17.65	0.57	17.08
OB1-5	17.70	0.42	17.28
OB1-6	16.97	3.63	13.34
OB1-7	17.15	1.10	16.05
OB1-8	16.87	1.62	15.25
OB1-9	16.91	3.59	13.32
OB1-10	17.19	0.92	16.27
PW2	15.80	14.58	1.22
OB2-1	18.81	4.00	11.81
OB2-2	15.98	1.15	14.83
OB2-3	15.99	1.06	14.93
OB2-4	15.76	1.82	13.94

Note: Water levels are referenced to feet above NGVD (National Geodetic Vertical Datum) pumping rate could be determined. Access for water-level measurements in PW1 and PW2 was made available between the well casing and the pump column. For tests on PW1, discharge was into the swampy area to the southeast of PW1. For tests on PW2, discharge was into the drainage canal along the eastern side of Florida's Turnpike.

Step-rate tests are conducted to determine water levels in the production well at various production rates to aid in designing a permanent pump installation and to establish a baseline for future performance tests of the well and permanent pump. Step-rate test data for PW1 and PW2 are presented in Appendix C.

Constant-rate pumping tests are conducted to determine the response of the ground-water system to continuous pumping stress. In a water-table aquifer, the analyses of trends in drawdown and recovery of water levels result in the determination of the coefficients of transmissivity and specific yield of the aquifer. The aquifer transmissivity is a measure of the ease with which water passes through the aquifer. The specific yield is the ratio of the water volume that can be drained from a sample volume of aquifer, to the total volume of the sample. These parameters are used to predict water levels in the aquifer in response to long-term pumping stress and other influences on water levels such as aquifer recharge or discharge.

Test-Production Well 1 (PW1)

The constant-rate pumping test on PW1 began at 11:00 a.m. on June 7, 1982, and terminated at 11:00 a.m. on June 10, 1982. The pumping rate was maintained at 1392 gpm (gallons per minute) for the duration of the test; no rain occurred during the pumping test. The specific capacity of Well PW1 was 138 gpm/ft after 72 hours of pumping. Water levels were measured by hand-held wetted tape in all wells. In addition, water-level recorders were employed on Wells OB1-3, OB1-4, OB1-5, and OB1-8.

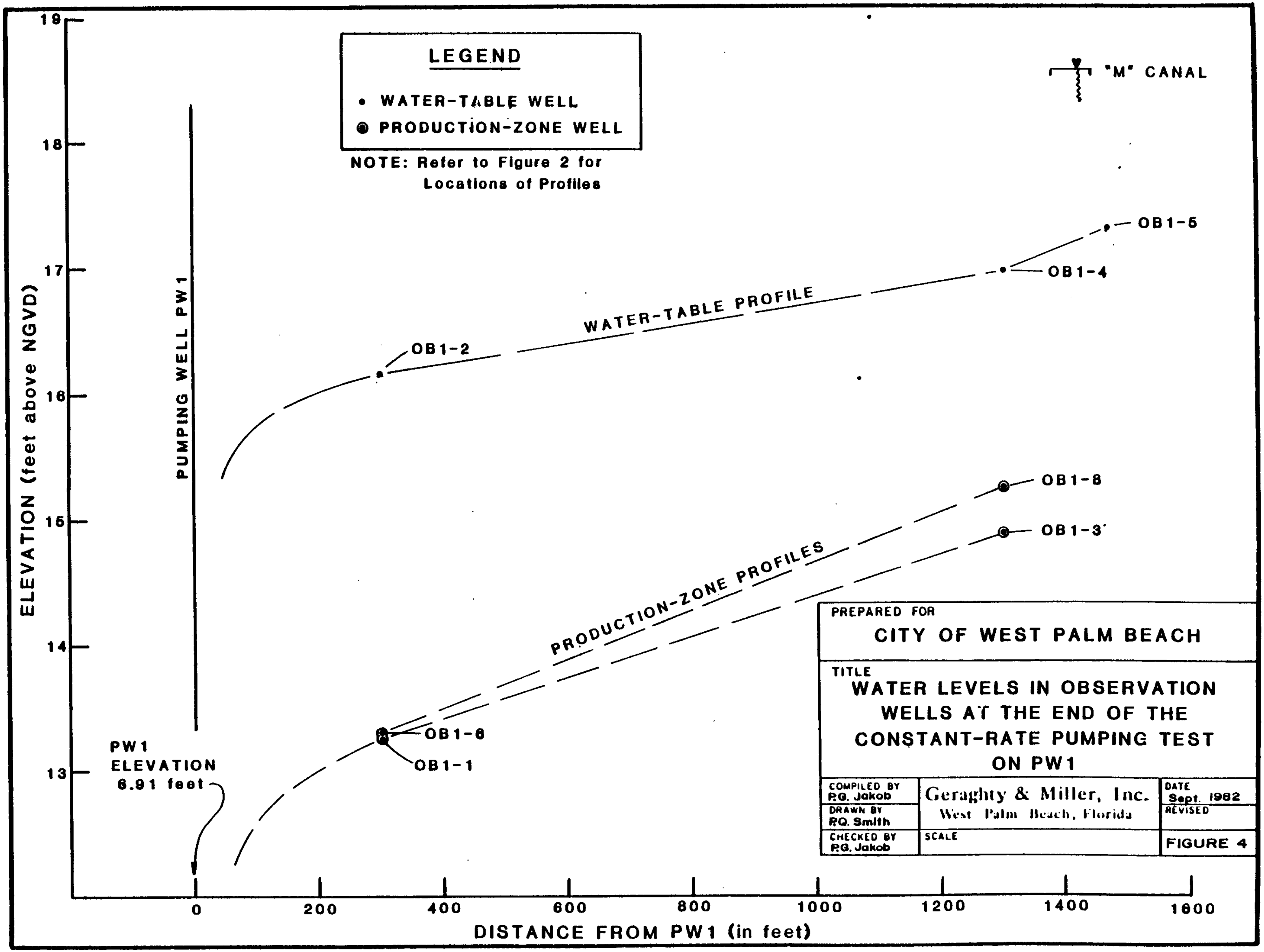
A comparison of water levels taken on May 28, 1982, with those taken before the test on June 7 indicates a decline in water levels equivalent to 0.01 foot per day in the vicinity of PW1. Because this rate of decline is small, corrections for the trend in water levels were not applied to the pumping-test data.

Drawdown and recovery data collected during the constant-rate pumping test were graphed versus time on full- and semi-logarithmic paper. Analyses of these data were made by techniques developed by Boulton ("Analysis of Data from Non-equilibrium Pumping Tests allowing for Delayed Yield from Storage," Proceedings of the Institute of Civil

Engineers. v.28, Aug. 1963) and by Cooper and Jacob ("A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-field History," American Geophysical Union Trans., v.27, No. 4, 1946, p.526-534). Inspection of the drawdown graphs (selected graphs are presented in Appendix D) shows that the aquifer responds to pumping as a water-table aquifer; these graphs show the effect of gravity drainage on drawdowns. (When drawdown is created in the production zone of a water-table aquifer, the sediments in the upper portion of the aquifer yield water under the influence of gravity. This draining of the upper sediments can take several hours to several days. As the drainage takes place, the decline of water levels in the producing zone is slowed or stopped temporarily due to the inflow of water drained from above.) Drawdowns in the production-zone observation wells (where paired with water-table wells) were approximately 3.5 times greater than in the adjacent water-table wells. This indicates that the aquifer is anisotropic (i.e., the vertical permeability of the aquifer is significantly less than the horizontal permeability) due to the layered nature of the sediments overlying the production zone.

Profiles of the water-level elevations developed in all wells at the end of the PW1 pumping test are shown on Figure 4. Inspection of this figure and relative drawdowns in wells corroborate the evidence cited above for a poor [illegible] hydraulic connection between the aquifer and the "M" canal; this is indicated by difference in slope between the north line (Well OB1-1 and Well OB1-3) and west line of production-zone wells (Well OB1-6 and Well OB1-8), and the relative levels among wells close to the canal (Wells OB1-4, and OB1-5, and OB1-3). If the "M" canal contributed a significant amount of water to the aquifer, the slope defined by elevations in production-zone water levels along the north line would be greater than along the west line. Although the slope defined between Wells OB1-5 and OB1-4 provides evidence that some water enters the shallow sediments from the canal, the large difference in water levels between the canal and the aquifer and the apparent low permeability of the shallow sediments observed during drilling indicate that the canal contribution to the aquifer is small. This finding is important to future use of the aquifer because such use will not measurably reduce water available to the present water-supply system.

Transmissivity values determined from the PW1 pumping-test analyses are shown on Table 3. Estimates of this coefficient determined from the production-zone monitor wells range from 238,000 to 456,000 gpd/ft (gallons per day per foot). Examination of the transmissivity estimates and their relationships to the observation wells reveals a pattern that explains the apparent range in values. Data from wells most distant from PW1 (OB1-3 and OB1-8) produce the highest transmissivity values. The data are affected apparently by the large areas of ponded water that lie between the observation wells and PW1.



PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

WATER LEVELS IN OBSERVATION WELLS AT THE END OF THE CONSTANT-RATE PUMPING TEST ON PW1

COMPILED BY P.G. Jakob
DRAWN BY P.Q. Smith
CHECKED BY P.G. Jakob

Geraghty & Miller, Inc.
West Palm Beach, Florida

DATE Sept. 1982
REVISED
SCALE

FIGURE 4

TABLE 3

SUMMARY OF COEFFICIENT OF TRANSMISSIVITY VALUES DETERMINED FROM CONSTANT-RATE PUMPING TEST AT PW1

WEST PALM BEACH, FLORIDA

Observation Well No.	Data Used	Analysis Type	Coefficient of Transmissivity (gallons per day per foot)
OB1-1	D	LL	242,000
	D	SL	306,000
	R	LL	275,000
	R	SL	311,000
OB1-3	D	LL	420,000
	R	SL	408,000
OB1-6	D	LL	238,000
	D	SL	272,000
	R	LL	253,000
	R	SL	294,000
OB1-8	D	LL	456,000
OB1-9	D	LL	249,000
	D	SL	306,000
	R	LL	266,000
	R	SL	306,000
PW1	D	SL	278,000

D - drawdown
R - recovery
LL - full-logarithmic analysis (from Boulton, 1963)
SL - semi-logarithmic analysis (from Cooper and Jacob, 1946)

Despite the low permeability of the shallow sediments, the slow infiltration of the ponded water over a large area is sufficient to reduce the demand for water in the production zone at the distant wells; the drawdown in the wells reflects this infiltration and the results of analysis indicate a higher transmissivity than is truly representative of the aquifer. Transmissivity estimates calculated from data derived from Wells OB1-3 and OB1-8 are therefore rejected as non-representative.

Analyses of data from wells that lie at a distance of 300 feet from PW1 also yield transmissivity values with a considerable range. The full-logarithmic analyses of drawdown and recovery data from Wells OB1-1, OB1-6, and OB1-9 indicate transmissivity values that are about 15 percent lower than semi-logarithmic analyses. It is probable that the water-level behavior was influenced by the partial penetration of PW1. Because the open-hole portion of Well PW1 penetrates approximately 60 percent of the known production-zone thickness, distortion of the flow lines can result such that the drawdown in nearby observation wells is greater than would occur if the pumping well were fully penetrating. The semi-logarithmic analyses of drawdown and recovery data are less susceptible to the effect of partial penetration and yield transmissivities in a more consistent range.

What?

The most representative transmissivity value is the average of those values that are not affected by the circumstances outlined above. Excluding the results of full-logarithmic analyses and values derived from distant wells, a representative transmissivity is concluded to be 300,000 gpd/ft.

The specific yield of water-table aquifers in South Florida ranges generally from 0.01 to 0.20. The only theoretically feasible type of analysis for an estimate of the specific yield is provided by Boulton (1963); this method requires the use of late drawdown data on a full-logarithmic graph. Estimates of the specific yield made with this method are near and less than 0.01. Because the effect of gravity drainage had not ended after 72 hours of pumping, a representative specific yield could not be determined from the test data. An estimate of the time required for gravity drainage to cease was made by using the late drawdown data and a technique described by Prickett ("Type-Curve Solution to Aquifer Tests under Water-Table Conditions", Ground Water, Vol. 3, No. 3, July 1965). The least time thus determined was 7.5 days, based on data from Well OB1-6. In other words, the pumping test would have to have been conducted for this period of time in order for the effects of gravity drainage to have dissipated.

Because the specific yield is used to determine the long-term aquifer response to pumping, an independent estimate of this parameter was made based upon the particle-size distribution of soils of the study area as minimize drawdowns by slow infiltration of water to the production zone; the transmissivity estimates based on data from these wells are believed to be deceptively high. Well OB1-1 is 300 feet from PW2 and is probably affected by the partial penetration of PW2. Because the open-hole interval of PW2 is from 80 to 101 feet and the production zone lies between 80 and at least 180 feet, PW2 penetrates no more than 20 percent of the production zone. The distortion of ground-water flow lines near PW2 could cause the drawdown in OB2-1 to be greater than it would be if PW2 fully penetrated the aquifer. The estimates of transmissivity resulting from the analysis of OB2-1 data, therefore, are concluded to be lower than the true value.

Partial penetration of PW2 affects the drawdown in PW2 similarly. The transmissivity indicated by semi-logarithmic analyses of drawdown and recovery data from PW2 are 390,000 and 212,000 gpd/ft., respectively. To a large extent, semi-logarithmic analyses for transmissivity are not affected by partial penetration because only the rate of change in drawdown is employed. Consideration of the information above leads to the conclusion that the aquifer transmissivity in the vicinity of PW2 falls between values estimated for Well OB2-1 (low) and Wells OB2-2 and OB2-3 (high). The most representative estimate is considered to be 300,000 gpd/ft.

Analytical estimates for the specific yield of this water-table aquifer were in the same range as those from Well PW1. Estimates of the time required for the effects of gravity drainage to cease were made based on the method of Prickett (1965); late drawdown data from Well OB2-2 yielded an estimate of 2.5 days - the lowest of the estimates. For determining the long-term aquifer response to pumping, a specific yield of 0.10 is considered most representative of the unconsolidated portion of the aquifer through which drainage occurs.

Test-Production Well PW2 was constructed in the open hole fashion similar to PW1. The physical characteristics of the aquifer (the presence of cavernous sandstone and loose sand in the producing zone) are also similar to the PW1 site. During the 24-hour constant-rate pumping test, the sand content of the water produced was measured twice. Four hours after the start of the test, the sand content was 835 ppm; after 23 hours of pumping, it was 402 ppm. Following the pumping test, the well was pumped at four rates between 1412 gpm and 1016 gpm and sand samples were taken at each rate. The pumping rate and sand content were: at 1412 gpm, 425 ppm; at 1302 gpm, 263 ppm; at 1080 gpm, 47 ppm; and at 1016 gpm, 18 ppm. These data suggest that the sand content would diminish to zero at a pumping rate of about 950 gpm. The options available for the use of PW2 are similar to those at PW1.

described in the "Soil Survey of Palm Beach County" (U.S. Soil Conservation Service, 1978). The particle-size distribution of the Basinger, Myakka, and the Holopaw soils (typical of those in the study area) indicates a specific yield of 0.10 or greater according to Fetter (in "Applied Hydrogeology", Charles Merrill Pub. Co., 1980). Because it is the near-surface soil and unconsolidated sand that is dewatered during pumping, a specific yield of 0.10 is concluded to be most representative of this water-table aquifer.

The open-hole type of well construction employed in Test-Production Well PW1 is used in permanent supply wells if the water-producing formation is sufficiently competent to permit pumping without collapse or producing sand; otherwise, a screen is installed. In test wells, this low-cost design is used so long as the well can produce sufficient quantities of water for test purposes without excessive sand. This design results in a highly-efficient well; as a test well, PW1 sucessfully served its purpose.

The water-producing zone near PW1 is a cavernous sandstone containing a considerable quantity of unconsolidated sand; during pumping, sand became suspended in the moving water and was slowly removed from the well. Development of PW1 was undertaken for 24 hours to reduce the sand content of the water. Because the primary purpose of constructing PW1 was to determine the hydraulic characteristics of the aquifer, which are unaffected by sand production, the constant-rate pumping test was conducted with the well producing 118 ppm (parts per million) of sand; the sand content reduced to 57 ppm by the end of the 72-hour test. The recommended maximum sand content in a municipal water system is 5 ppm (U.S. Environmental Protection Agency, Manual of Water Well Construction Practices, 1975).

At the present time, Well PW1 should be considered as an emergency supply well. It is possible that the sand content in the water will be further reduced as a result of additional pumping. Alternatively, the well could be screened to eliminate the sand at a cost of approximately $10,000, or the well could be pumped at a rate lower than the test rate and cease to produce sand. Screening the well would decrease its specific capacity (efficiency) to one-half or one-third and increase the pumping cost by as much as 50 percent.

In conclusion, analyses of the pumping test on PW1 indicate that: (1) the aquifer responds to pumping as a water-table aquifer, (2) the aquifer has a horizontal permeability that is significantly higher than the vertical permeability, (3) the "M" canal is poorly connected to the production zone and a ground-water diversion will not induce significant flow from the canal, and (4) the aquifer transmissivity and specific yield are estimated to be about 300,000 gpd/ft and 0.10, respectively.

These characteristics are favorable for the development of high capacity wells. Without interference from neighboring wells, individual wells tapping the aquifer can produce theoretically about 9 million gallons per day.

Test-Production Well 2 (PW2)

The constant-rate pumping test of PW2 began at 10:00 a.m. on June 14, 1982, and continued for 24 hours. The pumping rate was maintained at 1402 gpm for the duration; no rain occurred during the test. The specific capacity of Well PW2 was 89 gpm/ft after 24 hours of pumping. Water levels in PW2 and the observation wells were measured by the hand-held wetted tape method.

Drawdown and recovery data collected during the test were plotted on full-logarithmic and semi-logarithmic paper; selected graphs are presented in Appendix D. These graphs describe an aquifer response to pumping that is similar to that observed at PW1. Water levels in production-zone observation wells declined rapidly at first and then stabilized until about 1,000 minutes into the pumping test, when gravity drainage began to reduce and water levels resumed their decline. The maximum drawdown in Well OB2-1, located 300 feet from PW2, was four feet. The drawdown in Well OB2-4, located 57 feet from PW2, was 1.82 feet; this is significantly less than would have been expected were it deeper. On the basis of this information and the graphs in general, the aquifer is concluded to behave as a vertically anisotropic, water-table aquifer.

Table 4 is a summary of analytical solutions for the aquifer transmissivity. The range in transmissivity estimates is from 95,000 to 672,000 gpd/ft. Such wide ranging values suggest that local hydrogeologic conditions varied considerably.

Drawdowns in observation wells provide no evidence that the presence of the Turnpike drainage canal influenced the pumping test. Because the depth of the canal is greater than the nearby ponds, the hydraulic connection between the canal and the production zone is probably better than that between the ponds and the production zone. The small surface area of the canal and the presence of the relatively low-permeability sand that overlies the production zone, however, lead to the conclusion that the canal contributed only marginally more water to the production zone per equivalent surface area than the ponds.

Wells OB2-2 and OB2-3 lie east of PW2 at distances of 800 and 870 feet, respectively. The seasonally ponded water to the south and the permanent ponds north and west of these wells apparently tends to

TABLE 4

SUMMARY OF COEFFICIENT OF TRANSMISSIVITY VALUES DETERMINED FROM CONSTANT-RATE PUMPING TEST AT PW2

WEST PALM BEACH, FLORIDA

Observation Well No.	Data Used	Analysis Type	Coefficient of Transmissivity (gallons per day per foot)
OB2-1	D	LL	95,000
	R	LL	100,000
	D	SL	157,000
	R	SL	151,000
OB2-2	D	LL	406,000
	D	SL	672,000
	R	SL	638,000
OB2-3	D	LL	423,000
	R	SL	544,000
PW2	D	SL	390,000
	R	SL	212,000

D - drawdown
R - recovery
LL - full-logarithmic analysis (from Boulton, 1963)
SL - semi-logarithmic analysis (from Cooper and Jacob, 1946)

With a coefficient of transmissivity of 300,000 gpd/ft, and a specific yield of 0.10, the shallow aquifer in the vicinity of PW2 is capable theoretically of producing about 9 million gallons per day from a single well. A well-field arrangement that would allow the efficient development of ground-water supplies from the vicinity of PW1 and PW2 is presented in a subsequent section.

Water Quality

Chemical analyses of water samples from Wells PW1, PW2, OB1-3, OB1-9, OB-8, and OB2-2 were performed by the City of West Palm Beach, Water Analysis Laboratory; the results of these analyses are presented in Appendix E. Based on the reported concentrations, the ground water at both the PW1 and PW2 sites is good.

Water produced from Well PW1 had a total dissolved solids concentration of 373 mg/l (milligrams/liter) and a total hardness of 244 mg/l. Both the color and turbidity were in excess of State standards for public water supplies and would require treatment.

Water from Well PW2 had a total dissolved solids concentration of 484 mg/l and a total hardness of 320 mg/l. The color, turbidity, stability index, and iron concentration exceed State standards for public water supplies and would require reduction by treatment, although the color and turbidity levels may be reduced naturally by operating the well. The total hardness of the water in PW1 and PW2 is 244 mg/l and 320 mg/l, respectively.

WELL FIELD DEVELOPMENT POTENTIAL IN THE VICINITY OF THE REGIONAL WASTEWATER TREATMENT PLANT

Hydrogeologic conditions are highly favorable for the development of a large ground-water supply from the shallow aquifer on City property in the vicinity of the Regional Wastewater Treatment Plant. Limitations to the quantity of ground water that can be withdrawn are imposed by the presence of existing ground-water diversions in the area and the West Palm Beach Water Catchment Area. Water can be pumped from the City property to the extent that the drawdowns thus created do not materially interfere with the water available to these interests and adversely impact the Catchment Area.

A criterion used by the South Florida Water Management District to determine the maximum withdrawal from any well field is that the withdrawal must not decrease the water-producing capability of neighboring ground-water users by more than 10 percent (South Florida

Water Management District, "Permitting of Uses of Water - Basis of Review for Public Water System, Water Use Applications", 1980, Permit Information Manual, Vol. III-A). The water-producing capability is directly related to the available drawdown in a pumping well. Ground-water users in the vicinity of the City property that have Water Use Permits include the City of Riviera Beach and Consolidated Utility Co., Inc., to the north, and Century Utilities System and Palm Beach County to the south; the average daily diversions specified in their permits are 1.78 mgd (million gallons per day), 0.24 mgd, 1.76 mgd, and 6.50 mgd, respectively.

In order to determine the impact that pumping ground water from the City property would have on the neighboring users and the Catchment Area, a finite-difference computer model was employed. This model is capable of predicting water levels that result from ground-water pumping by the mathematical simulation of field conditions including the aquifer coefficients and the rate and duration of pumping. The aquifer coefficients estimated from the pumping tests at PW1 and PW2 were used in the model area west of a line midway between Haverhill Road and Military Trail, and north of a line 1000 feet south of the City property. The coefficient of transmissivity determined in the tests was 300,000 gpd/ft. A transmissivity of 80,000 gpd/ft was used in the eastern part of the model and a transmissivity of 600,000 gpd/ft was used in the southwestern part. These coefficients are based on results of pumping tests and specific-capacity tests conducted in the respective areas. The specific yield in the entire model was 0.10.

Conditions incorporated in the model included pumping for a 90-day period in the absence of recharge by rainfall. Drawdowns in water levels that result with this assumption are considered to be the maximum drawdowns likely to occur. The absence of recharge for a period of 90 days simulates a severe drought.

The most favorable site for a well field and that used as the center of pumping in the model is in the southernmost one-half section of land owned by the City. This portion of the City property is the greatest distance from the Dyer Boulevard landfill and the sewage-sludge disposal area near the Regional Wastewater Treatment Plant. The nearest permitted ground-water user to this area is Century Utilities System. Ten percent of the available drawdown at wells of the Century Utility System is conservatively estimated to be six feet. The well nearest to City property in this system is approximately 3600 feet south of the property line. A six-foot drawdown that would be created by a diversion on the City property at this nearest neighboring well is the maximum permissible under the criterion discussed above.

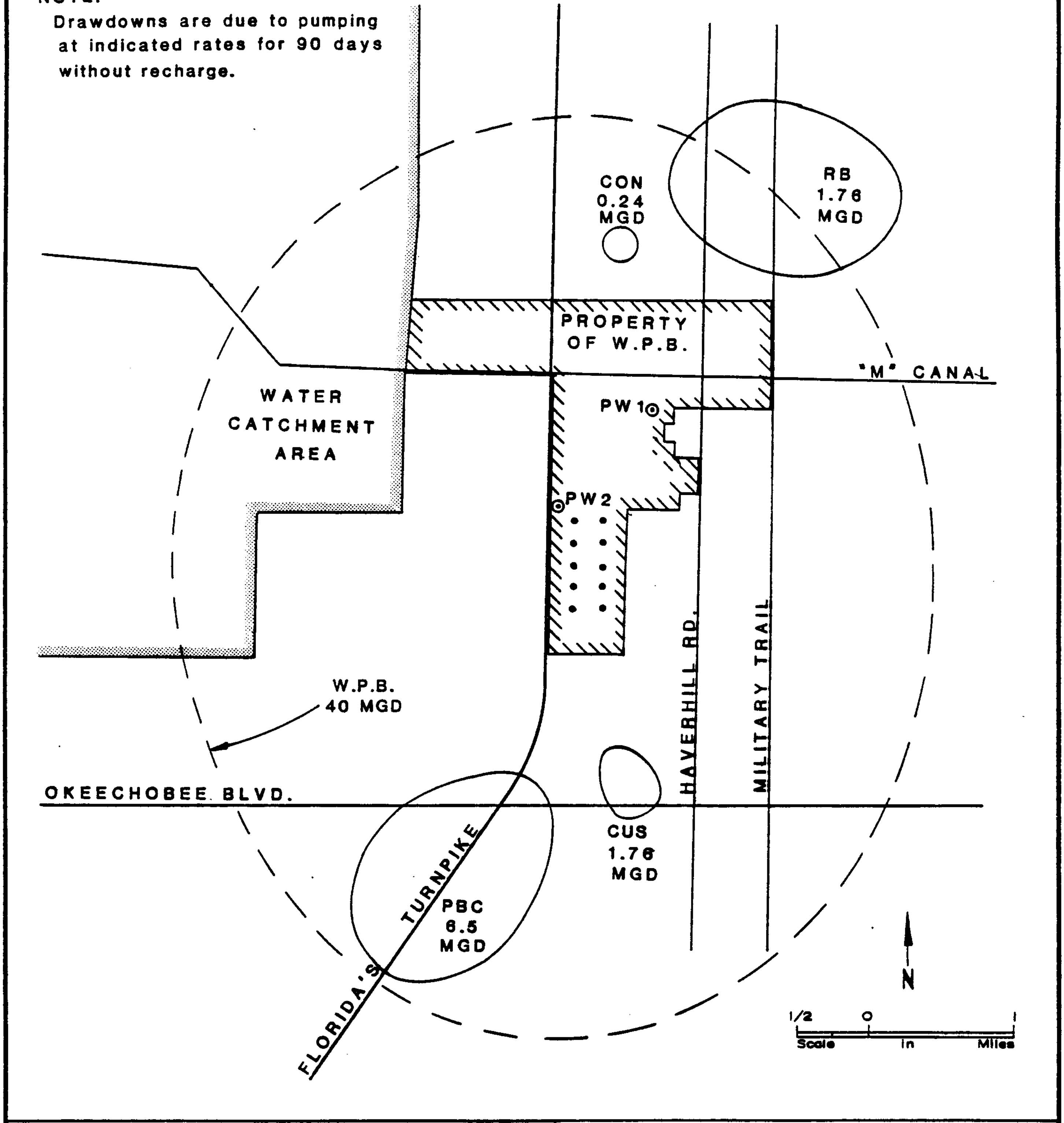
A series of computer simulations were run at various pumping rates until a rate was determined that caused a drawdown of approximately six feet at the nearest well of the Century Utility System; that rate was 40 mgd. The drawdown created at the wells of other permitted, neighboring water-users was significantly less. The approximate extent of a one-foot drawdown caused by pumping 40 mgd from the City property, and the approximate drawdowns caused by permitted, neighboring water users, are depicted on Figure 5.

The simulation shows that a diversion of 40 mgd for 90 days of no recharge causes a maximum drawdown in the aquifer beneath the eastern boundary of the Water Catchment Area of approximately 7 feet and an average drawdown of 0.46 feet beneath the entire area. The volume of surface water taken from the Catchment Area will be equal to, and replace, the volume of water taken from storage in the surficial sediments beneath the Catchment Area. Because the specific yield of the surficial sediments and the aquifer is 0.10, the actual reduction in surface-water level over the entire Catchment Area would be 0.046 feet. This is less than the water lost by evaporation from the Catchment Area during 4 days at the annual evaporation rate. If only half of the Catchment Area were inundated, the reduction in the surface-water level would be approximately 0.092 feet.

The finite difference model simulated the diversion of 40 mgd from a rectangular area having a 4000-foot side in the north-south direction and a 2000-foot side in the east-west direction. This model is not amenable to predicting the drawdowns in individual wells and the effects of mutual interference among wells. An "analytical" model, that simulates pumping and the associated drawdowns from individual wells was used to determine a configuration of wells that together produce 40 mgd within the limit of available drawdown. The available drawdown in any particular well is about 70 feet. A correction for "dewatering" the water-table aquifer (that causes a reduction in the aquifer transmissivity because of a reduction in the saturated thickness of the aquifer) was applied to the model.

A series of ten wells arranged in the rectangle shown on Figure 5 was determined to be highly efficient and meets the available-drawdown criterion. With each of ten wells pumping at a rate of 4 mgd (2776 gpm), the drawdown created in each well created by that well is 25 feet. The maximum effect of interference, the drawdown caused in the wells at the center of the pattern due to pumping the surrounding wells, is 43 feet. The maximum drawdown in the wells at the center is therefore 68 feet. The wells are spaced 750 feet apart in the north-south direction, and 1000 feet apart in the east-west direction. Orientation of the rectangle in the north-south direction allows interception of the regional ground-water flow - from west to east.

NOTE:
Drawdowns are due to pumping at indicated rates for 90 days without recharge.



LEGEND

• — HYPOTHETICAL PRODUCTION WELLS CITY OF WEST PALM BEACH

PBC — PALM BEACH COUNTY

RB — CITY OF RIVIERA BEACH

CUS — CENTURY UTILITIES SYSTEM

CON — CONSOLIDATED UTILITY CO., INC.

PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

APPROXIMATE EXTENT OF DRAWDOWNS
IN WATER LEVELS OF ONE FOOT
CAUSED BY EXISTING WATER USERS
AND HYPOTHETICAL WELLS
OF THE CITY OF WEST PALM BEACH

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE As Shown	FIGURE 5

Planning for dependable water supplies requires that system capacity and storage are sufficient to meet peak demands. The maximum yield from the shallow aquifer on City property was determined to be 40 mgd under the most severe conditions and is therefore considered dependable. Historically, the peak demand experienced by the City of West Palm Beach occurs during the dry season (November through May) and is 1.5 times the average demand. Assuming that the well field discussed above supplies a single and isolated distribution system with no outside sources to boost peak supplies, and that system storage capacity is equal to a single maximum-day demand, the average yield of the well field could be considered to be 26.7 mgd - which equals 40 mgd divided by 1.5.

Information gained during the construction and testing of Test-Production Wells PW1 and PW2 indicates that it may be possible to construct new wells with the open-hole design that would not produce sand upon pumping. Because of the potential for savings in the cost of labor and material, and because an open-hole well is likely to have a higher specific capacity (resulting in lower operating cost) than a screened and gravel-packed well, new wells should be constructed as open-hole wells with sufficient diameter to allow the installation of a large-diameter screen should sanding persist during development.

The wells should be constructed with a 24-inch-diameter casing set from land surface to a depth of approximately 80 feet. The well-intake interval (open hole or well screen length) should extend approximately between 80 feet and 180 feet below land surface. The actual casing depth and open-hole or well-screen interval should be determined during the drilling of a small-diameter (5- to 6-inch) pilot hole at the location of each production well. The well screens, if installed, should be of the wire-wound design and constructed of stainless steel. The gravel pack should be composed of a well-rounded, siliceous material. The gravel generally available in south Florida is not well rounded, however, and should not be used. The sand size to be retained by the gravel pack and screen can be determined during the construction of the pilot hole or·the development of the open hole. The slot-size opening of the screen and size distribution of the gravel pack should be selected on the basis of the sand size to be retained.

The cost of an open-hole well having a 24-inch-diameter casing set to 80 feet below grade would be approximately $30,000. A suitable pump and motor would cost approximately $26,000. Neither of these costs includes pipelines or power lines. If it were necessary to install a well screen, the cost of a well would be approximately $55,000. The labor and materials that would be necessary to test a well for its ability to produce sand-free water would add as much as $8,000 to the construction cost of each well. The total estimated cost of a gravel-packed well is

$63,000. The potential savings that may accrue with an open-hole design outweigh the cost to develop the open-hole well and check the viability of the open-hole design.

In the general vicinity of the City property, there are two potential sources of ground-water contamination; these are the Dyer Boulevard landfill and the sewage-sludge disposal site at the Regional Wastewater Treatment Plant. Another site on Haverhill Road is used to dispose of dry grass cuttings, tree limbs, and vegetation and does not threaten ground-water quality. Monitoring of ground-water quality and the leachate from the two potential sources of contamination is required by the Florida Department of Environmental Regulation (DER).

Several monitor wells beneath and immediately adjacent to the Dyer Boulevard landfill presently show indications of leachate; however, results of the monitoring activity between 1976 and 1980 have not shown definitive trends in increasing contaminant concentrations. The landfill lies about three miles north of the proposed location of City wells. Factors including aquifer recharge, chemical alteration and uptake processes, and dispersion and diffusion, would greatly reduce if not prevent the possibility of contamination in wells on the City property.

At the sewage-sludge disposal site, quarterly sampling of ground-water quality is currently conducted. No indications of leachate have been detected in nearby on-site monitor wells. Because sludge handling and sludge application rates are regulated by Florida DER, this disposal operation is not considered to pose a serious threat to ground-water use at the site.

Treated sewage effluent derived from the Century Utilities system is currently discharged to the drainage canal adjacent to Florida's Turnpike. This practice will cease in the near future when the utility is connected to the Regional Wastewater Treatment System; the potential for contamination of the shallow aquifer from this site is considered minimal.

HYDROGEOLOGIC INVESTIGATIONS IN THE VICINITY OF LAKE MANGONIA AND CLEAR LAKE

This portion of the investigation involves the construction and testing of wells located on the periphery of Lake Mangonia and Clear Lake. Water for the existing West Palm Beach water system is conveyed via the "M" canal to these lakes and drawn from these lakes for treatment and distribution. In the Phase I document, a loss of water by seepage from these water-supply lakes was estimated to be near 10 mgd. A testing program was outlined in Phase I that was designed to determine the feasibility of capturing a portion of the seepage for use in the City system. The results of this feasibility study are presented below.

TASK 1: Reconnaissance Investigation of Hydrogeologic Conditions

In this task, the areal distribution of seepage from the water-supply lakes was estimated. This was accomplished by constructing and testing eight small-diameter wells around the lakes and by monitoring six seepage meters that were installed in the lake bottoms. The wells were tested to obtain an estimate of the distribution of aquifer transmissivity and to measure the difference in water levels between the aquifer and the lakes. The seepage meters provided a direct measure of the rate of seepage loss and an indication of the distribution of this seepage. Information gained from Task 1 was then used to implement Task 2, in which the hydrogeologic parameters governing seepage were estimated. These were used to develop a plan for the efficient capture of the seepage loss.

Drilling and Well Construction

Eight wells, designated SC-1 through SC-8, were constructed along the periphery of the water-supply lakes at locations shown on Figure 6. These wells were constructed by drilling a 4-5/8-inch-diameter hole by the mud-rotary method and installing 2-inch-diameter PVC well screens and casings. The holes were drilled to a depth of 100 feet and, except for SC-7, were fitted with well screens between 50 and 100 feet below ground level. Table 5 is a summary of well-construction details. The well screens were gravel packed and the annulus was filled with cuttings and bentonite up to land surface. A 3-inch-diameter protective steel casing was placed over the PVC casing and a 3-foot-square cement pad was poured around the casing at land surface. Following construction, each well was developed using compressed air, and either a centrifugal pump or a positive displacement pump until it produced turbidity-free water.

PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

THE LOCATIONS OF "SC" WELLS AND SEEPAGE METERS

COMPILED BY P.G. Jakob

DRAWN BY P.Q. Smith

CHECKED BY P.G. Jakob

Geraghty & Miller, Inc.
West Palm Beach, Florida

SCALE 1" = 2000'

DATE Sept. 1982

REVISED

FIGURE 6

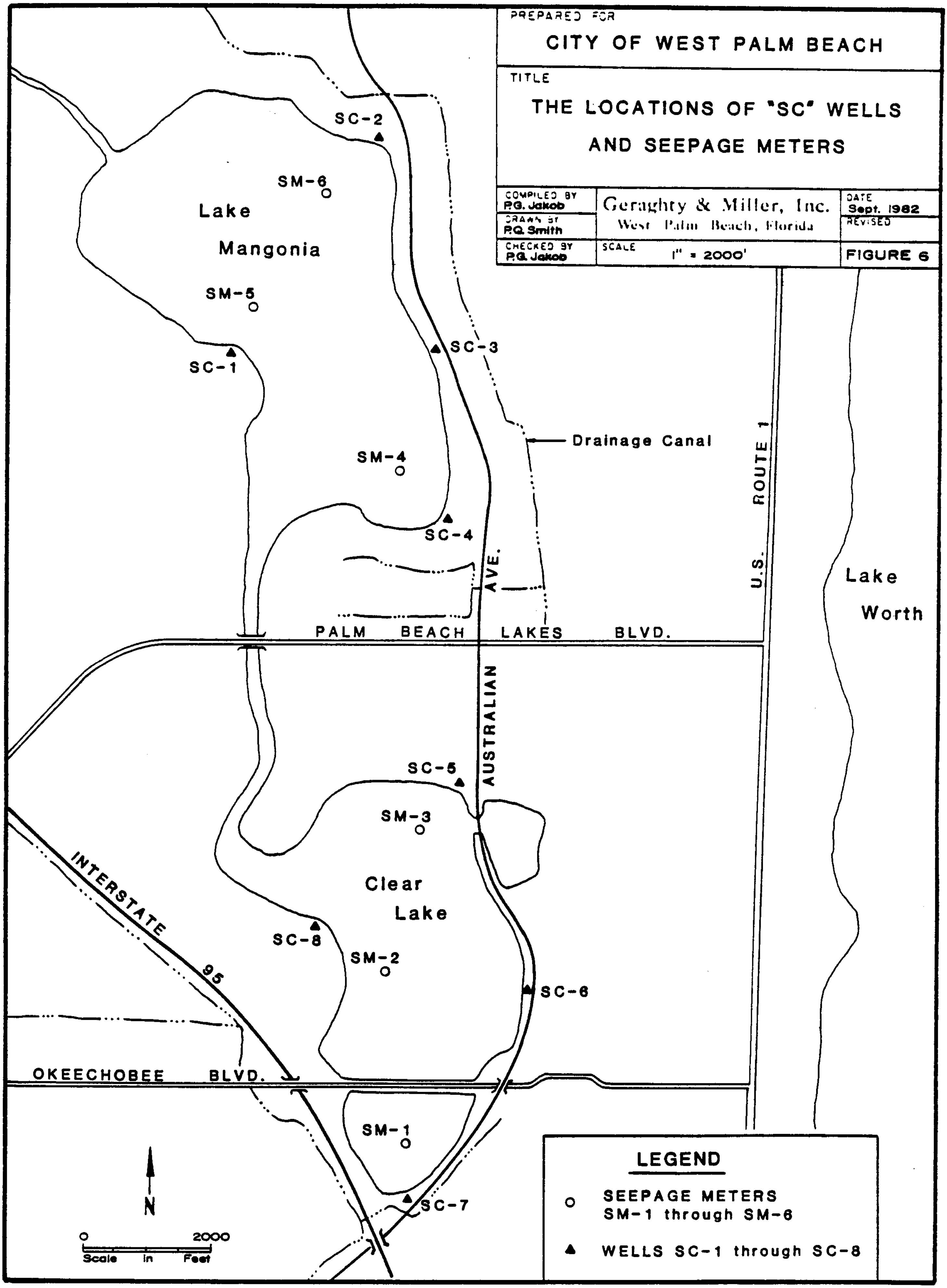


TABLE 5

CONSTRUCTION DETAILS OF WELLS ALONG THE PERIPHERY OF THE WATER-SUPPLY LAKES AND THOSE ASSOCIATED WITH PW3

WEST PALM BEACH, FLORIDA

Well No.	Drilled Depth (feet)	Screened Interval (feet)	Elevation of Top of Casing (feet above NGVD)	Distance from PW3 (feet)
SC-1	104	50-100	17.52	
SC-2	104	50-100	18.77	
SC-3	102	50-100	18.76	1300
SC-4	104	50-100	19.02	1950
SC-5	104	50-100	18.13	
SC-6	104	50-100	18.91	
SC-7	104	84-104	19.10	
SC-8	104	50-100	17.68	
PW3	200(pilot)	85-155	19.33	
OB3-1	38	23- 38	33.58	870
OB3-2	165	85-165	33.57	870
OB3-3	30	15- 30	17.68	466
OB3-4	150	70-150	17.71	466
OB3-5	30	15- 30	17.58	1240
OB3-6	195	70-150	17.56	1240
OB3-7	30	15- 30	21.54	539
OB3-8	190	70-150	21.36	539
OB3-9	30	15- 30	20.01	338
OB3-10	160	80-160	19.90	338
Lake Mangonia	-	-	-	594

Geologic logs of wells SC-1 through SC-8 are presented in Appendix A; these were prepared from examination of drill cuttings.

Seepage Investigation by Direct Measurement

In order to measure the rate of seepage through the lake bottoms, six seepage meters were constructed and installed at various locations in the lakes. By isolating a known area of the lake bottom and measuring the volume of water that enters or exits through this area with respect to time, a rate of seepage was determined. Each meter was constructed from a galvanized tub having a 2.40-square-foot open area at the top with a garden hose connecting the inside of the tub to a flexible bladder. A scuba diver placed the meter face-down on the lake bottom with the edge set about one inch into the lake bottom. The tub and bladder were weighted to prevent their movement and fitted with a valve and a system of ropes to allow servicing the meter on a weekly basis using a small boat. Upon emplacement, all air was allowed to escape from the tub, hose, and bladder, and the bladder was filled with a measured volume of water—usually five gallons. The bladder was disconnected from the hose to measure the change in volume. The meters were constructed so that they were subjected only to the force of the natural hydraulic gradient that causes water to move downward (or upward) through the known bottom area isolated by the meter. With the meter thus emplaced, the volume of any water seeping into (or out of) the lake bottom would be reflected as a loss (or gain) of water volume in the bladder.

Three meters were set in each lake at locations shown on Figure 6. During the installation of the meters on May 16, 1982, the silt thickness on the lake bottom was found to vary from 1/4 inch to 6 inches. The lake bottom is fairly flat due to previous dredging and varies in elevation from about one to four feet below sea level.

Generalized Hydrogeologic Conditions

In the vicinity of the lakes, a series of sand beds extend from land surface to depths ranging from 45 to 100 feet; these overlie a shelly sandstone bed that extends to 200 feet (see Task 2, page 26). The sand is fine- to medium-grained. Within the upper sand bed, at depths that vary between 6 and 22 feet, a silty and/or clayey sand layer of generally one foot in thickness is encountered. This layer contains up to 40 percent silt and clay, and is generally hard; it does not occur at Wells SC-5 and SC-7. Because this silty layer lies above the elevation of the lake bottoms, it does not restrict the flow of water from the lakes. Also within the sand strata, a blue-gray clayey sand with clay

TABLE 6

RATE OF SEEPAGE MEASURED IN EACH OF SIX SEEPAGE METERS PLACED AT THE BOTTOMS OF LAKE MANGONIA AND CLEAR LAKE

WEST PALM BEACH, FLORIDA

Seepage Rate
(gallons per day per square foot)

		Period Ending						Average in later 3 periods	Average per lake
	Meter Number	4-26-82	5-3-82	5-11-82	5-17-82	5-24-82	6-2-82		
Clear Lake	1	*	-.119	-.103	-.109	-.120	*	-0.115	-0.115
	2	+.305	+.224	+.228	-.203	*	-.058	-0.131	
	3	-.139	-.075	-.067	-.113	-.075	-.113	-0.100	
Lake Mangonia	4	+.079	+.062	-.036	-.072	-.081	-.072	-.075	-0.151
	5	-.297	+1.243	*	*	-.196	-.164	-.180	
	6	+1.175	*	+.265	-.200	*	-.194	-.197	

* bladder broken or missing

\+ denotes seepage into lake

\- denotes seepage from lake

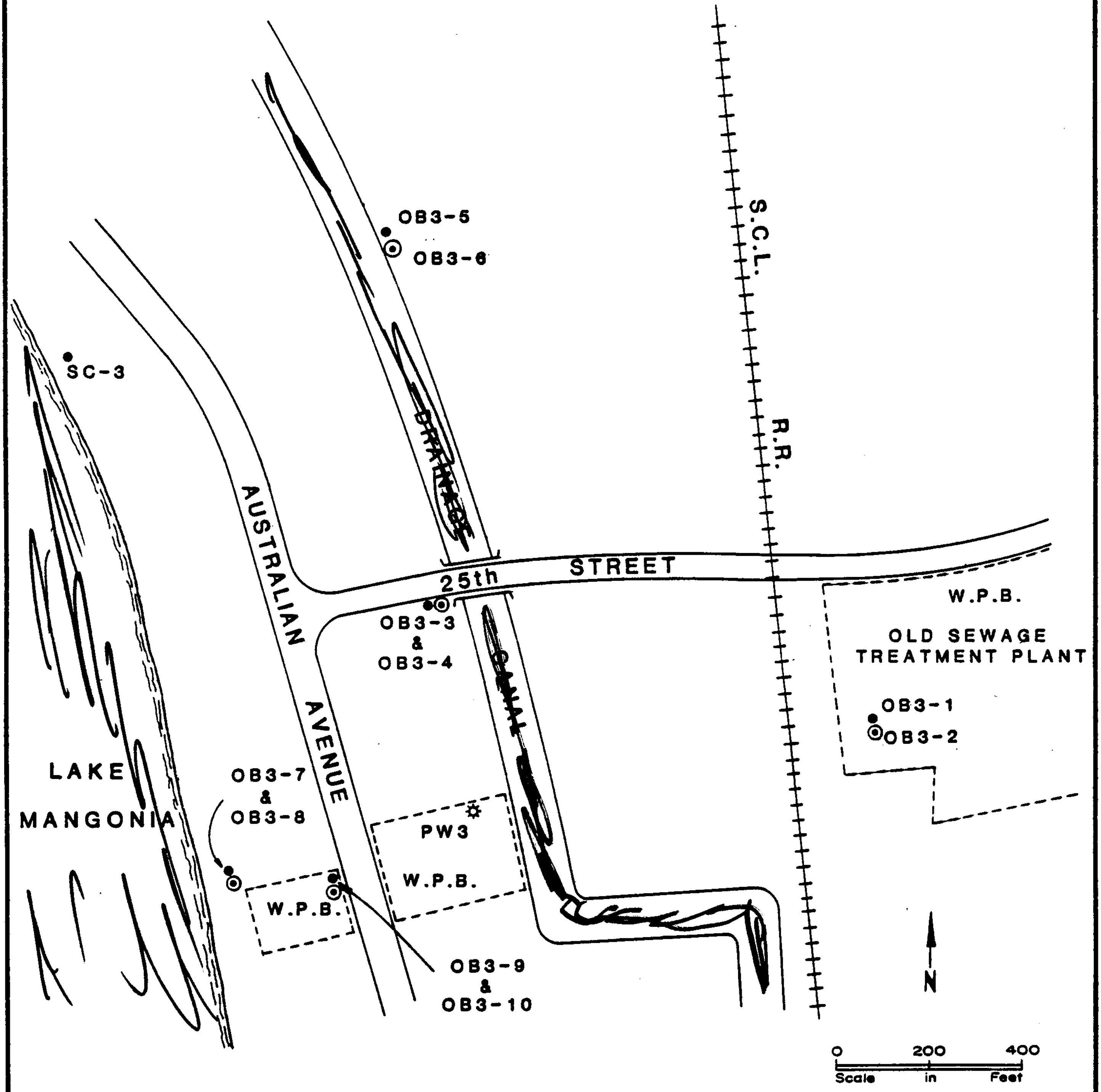
content up to 30 percent occurs in thicknesses up to 13 feet at depths between 50 and 73 feet. This clayey bed occurs at Well SC-3 (where it is 10 feet thick), Well SC-5 (3 feet), Well SC-6 (3 feet), and Well SC-8 (13 feet); it was not detected at Wells SC-1, SC-2, SC-4, and SC-7. Beneath the sand, the shelly sandstone extends to the total depth of the "SC" wells north of Well SC-5. At Wells SC-5 and those south, the sandstone thins and is underlain by shelly sand. At Well SC-7, no consolidated rock was encountered to a depth of 104 feet; marl was found in the interval between 72 and 90 feet.

Following development of Wells SC-1 through SC-8, each well (except Well SC-7) was pumped, and recovery tests were conducted. Semi-logarithmic plots of the water-level data were analyzed to determine the aquifer transmissivity. These data and specific-capacity type data collected by the SFWMD (South Florida Water Management District, unpublished map) were used to construct a map showing the distribution of the aquifer transmissivity in the vicinity of the lakes (see Figure 7). An assessment of data from a short-term pumping test conducted at the Good Samaritan Hospital (data from the files of the SFWMD) suggests that the transmissivity could be as great as 1,000,000 gpd/ft. Collectively, these data indicate that the aquifer transmissivity increases eastward from the water-supply lakes.

Water levels were measured in Wells SC-1 through SC-8 during a four-week period following well construction. These levels and the lake level are shown on Figure 8. The data indicate that water flowed from the lake to the shallow aquifer at certain times, and from the aquifer to the lake at other times. Seepage into the lake was caused by heavy rainfall during April, which temporarily raised water levels in several parts of the aquifer to above lake level; this occurred at Wells SC-5, SC-6, and SC-8. With the exception of the period from April 26 to May 8, 1982, the trends in water levels with time and the difference between water levels in the aquifer and the lake were fairly consistent. Following the first week of May, seepage-meter monitoring also showed consistent water loss from the lakes due to the lack of rainfall.

The combined results of seepage-meter monitoring, the results of water-level monitoring in the monitor wells, and the distribution of aquifer transmissivity were used to estimate the distribution of seepage losses.

The rates of seepage measured by the meters are shown on Table 6. The first three periods of monitoring indicate water seeping both into and from the lake. The later three periods show water consistently seeping from the lake and are considered representative of the long-term average condition. The results indicate that the seepage rate from Lake Mangonia is, on average, 31 percent greater than that from Clear Lake.



LEGEND

W.P.B.	PROPERTY OF CITY OF WEST PALM BEACH
⊙	PRODUCTION-ZONE OBSERVATION WELL
●	WATER-TABLE OBSERVATION WELL

PREPARED FOR
CITY OF WEST PALM BEACH

TITLE
LOCATIONS OF OBSERVATION
WELLS IN THE VICINITY OF
TEST-PRODUCTION WELL PW3

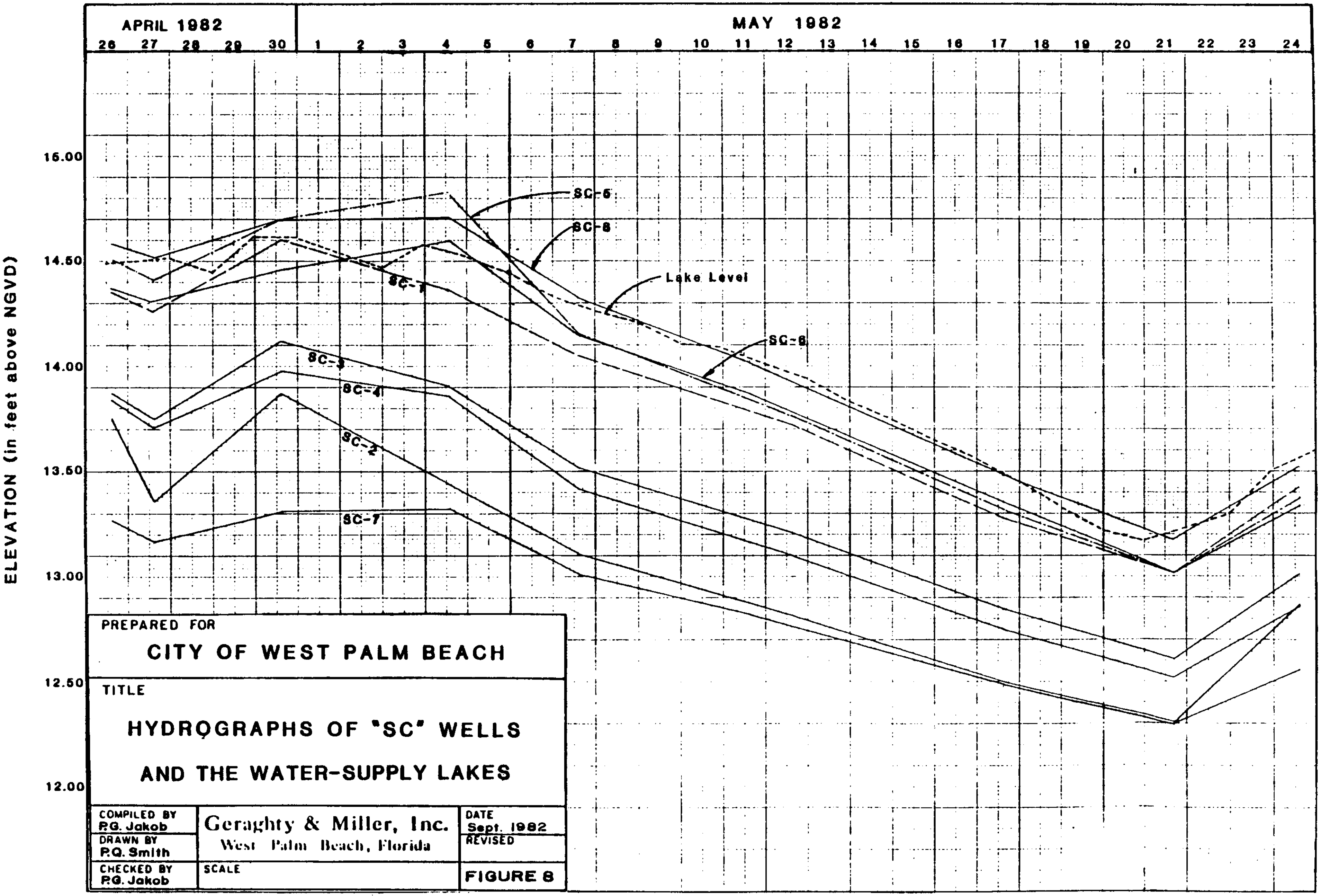
COMPILED BY P.G. Jakob
DRAWN BY P.G. Smith
CHECKED BY P.G. Jakob

Geraghty & Miller, Inc.
West Palm Beach, Florida

SCALE As Shown

DATE Sept. 1982
REVISED

FIGURE 9



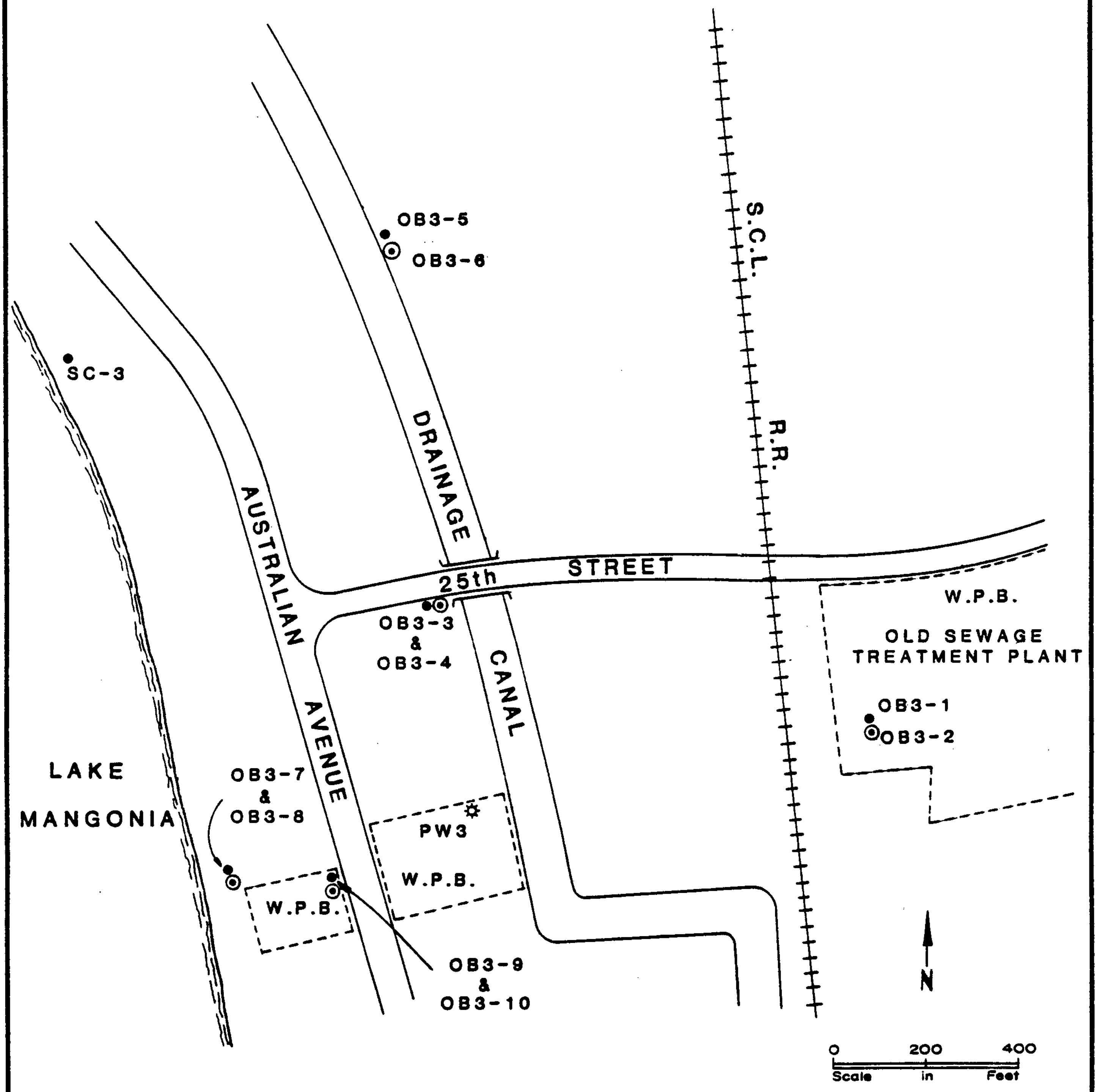
PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

HYDROGRAPHS OF "SC" WELLS AND THE WATER-SUPPLY LAKES

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE	FIGURE 8



LEGEND

W.P.B.	PROPERTY OF CITY OF WEST PALM BEACH
◎	PRODUCTION-ZONE OBSERVATION WELL
●	WATER-TABLE OBSERVATION WELL

PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

LOCATIONS OF OBSERVATION WELLS IN THE VICINITY OF TEST-PRODUCTION WELL PW3

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE As Shown	FIGURE 9

Because the area of Lake Mangonia comprises 60 percent of the total area of both lakes, it is calculated that 66 percent of the total seepage lost from both lakes occurs from Lake Mangonia.

The results of water-level monitoring indicate that the greatest differences in water levels between the aquifer and the lakes occur in the vicinities of Wells SC-2, SC-3, SC-4 (along the eastern shore of Lake Mangonia), and SC-7 (at the southern tip of Clear Lake). The general vicinity of Lake Mangonia, especially the eastern portion, has been previously shown (Figure 7) to be the area of the shallow aquifer having the highest transmissivity. Making the reasonable assumption that the permeabilities of the bottom sediments of the lakes are generally equal (the bottoms of both lakes were dredged to flat surfaces in the early 1960's), the distribution of differences in water levels (ground water vs. lake) and the distribution of transmissivity of the shallow aquifer indicate that: (1) a dominant portion of seepage loss occurs along the eastern side of Lake Mangonia, and (2) the flow direction of this loss is eastward. These findings corroborate the results of seepage-meter monitoring. Consequently, the optimal area for wells that would capture the greatest portion of seepage loss is the eastern side of Lake Mangonia.

TASK 2: Detailed Hydrogeologic Investigation Along the Eastern Shore of Lake Mangonia

A test-production well and ten observation wells were constructed to determine hydraulic gradients, and a 72-hour pumping test was conducted to determine the hydrogeologic parameters controlling lake seepage. A parcel of land east of Lake Mangonia, owned by the City of West Palm Beach, situated 500 feet south of 25th Street on the eastern side of Australian Avenue was selected for the construction of Test-Production Well PW3.

Drilling and Well Construction

At the locations shown on Figure 9, observation wells were constructed with the dimensions shown on Table 5. Geologic logs prepared by the inspection of drill cuttings are presented in Appendix A. Five of the observation wells were constructed to reflect water levels in the potential production zone - the most permeable part of the aquifer. Co-located with these wells were five shallow observation wells constructed to reflect water levels at and near the water table. The wells were drilled and completed in the same manner as the "SC" wells.

Test-Production Well PW3 was first drilled as a 7-7/8-inch-diameter pilot hole by the mud-rotary method to a total depth of 200 feet. Geophysical surveys were conducted in the pilot hole, producing the caliper, natural gamma and the electric logs shown in Appendix B. The drilling data suggested that Well PW3 might be completed as an open hole. A 17-inch-diameter borehole was drilled and the casing was installed and cemented in place at a depth of 85 feet. An 11-3/4-inch-diameter bit was used to drill to a total depth of 200 feet by the mud-rotary method. During development, the open hole collapsed, requiring the installation of a screen and gravel pack. A 6-inch-diameter, 0.040-inch slot, wire-wound stainless steel screen was set between 85 feet and 155 feet below grade. A six-inch-diameter riser pipe was connected to the top of the screen and extended to land surface temporarily to facilitate emplacement of the gravel pack and well development. Twenty feet of the riser pipe was left in place on top of the well screen. A gravel pack consisting of "6-20" graded silica sand was washed through a tremie pipe and into the annulus between the open hole and the well screen. Development of the well was accomplished by surging with compressed air and horizontal jetting into the screen with water. A total of 84.5 hours was devoted to well development before sand-free water was produced from the well.

Local Hydrogeologic Conditions

Within the uppermost 100 feet, sediments encountered during the drilling of Well PW3 and associated observation wells were similar to those found in Wells SC-3 and SC-4. Between 100 and 200 feet below grade, the sediments can be described generally as a sequence of sand and sandstone beds having various admixtures of shell, silt, and clay. The shallowest depth to sandstone was 35 feet at Well OB3-2, located 865 feet east of PW3 on the western slope of the coastal ridge. From 59 to 60 feet at Well OB3-8 and from 57 to 58 feet at PW3, a silty and sandy clay layer occurs; this layer was not detected in other observation wells surrounding PW3.

For several weeks before the constant-rate pumping test, water levels were measured manually in observation wells and with a water-level recorder on Well OB3-6 (elevations of the tops of well casings were determined by the City of West Palm Beach). The data showed narrow-ranged fluctuations in water levels with time. The water-level recorder showed evidence of pumping from a nearby well, although the change in water level was very small—about 0.05 feet. Water levels declined approximately 0.02 feet per day during this period when there was no significant rainfall. The relatively stable water-level regime indicates that inflow from the "M" canal to the lakes was nearly equal to the sum of evaporation, seepage from the lakes, and withdrawals from the lakes.

Water level data collected immediately before the pumping test were used to determine directions of ground-water movement. The gradient defined by a line connecting the static water levels in Wells OB3-10 and OB3-2 (Figure 9) is 0.0018 ft/ft; this gradient directs flow from Lake Mangonia to Lake Worth. If extended eastward from the shore of Lake Mangonia, this gradient would intersect sea level at a distance of 7200 feet—the approximate distance to Lake Worth. A steeper gradient of 0.0021 ft/ft exists between Lake Mangonia and the drainage canal measured in Wells OB3-10 and OB3-4, indicating that a portion of the ground-water flow is diverted into the drainage canal.

The difference in water levels between Lake Mangonia and the nearest production-zone well (OB3-8) is 0.48 feet, indicating the movement of water out of the lake and into the aquifer. The differences in water-level elevations between the wells in deep-shallow pairs indicate that water is moving upward from the production zone to the water-table according to data from well pairs OB3-9/OB3-10, OB3-5/OB3-6, and to a lesser extent, at OB3-3/OB3-4. Water-level elevations in wells tapping the production zone are higher than those in wells tapping the water table. Well pairs OB3-3/OB3-4 and OB3-5/OB3-6 indicate components of ground-water flow directed to the drainage canal. The water level elevations in pair OB3-1/OB3-2 show the downward movement of water from the water-table zone to the production zone. With the exception of well pair OB3-9/OB3-10, the elevation differences in water levels confirm that water migrates from the lake to the aquifer and from the aquifer to the drainage canal and Lake Worth.

Pumping Tests on Test-Production Well 3 (PW3)

Step- and constant-rate pumping tests were conducted at PW3. A vertical turbine pump powered by a diesel engine via a right-angle drive was installed in the well and a 6-inch-diameter discharge line was run to the drainage canal approximately 100 feet east of PW1. The flow was controlled by a valve attached to the right-angle drive. A five- by six-inch-diameter orifice and a manometer tube were fitted to the end of the discharge line to determine the pumping rate. Access for water-level measurements in PW3 was available between the pump column and well casing. Step-rate test data are included in Appendix C.

The constant-rate pumping test on PW3 began on July 29, 1982 and ended 72 hours later on August 1, 1982. The pumping rate fluctuated regularly in a range of about 100 gpm in the first two hours of the test but averaged approximately 600 gpm. The fluctuations were due to an unidentified engine malfunction. After the first two hours and for the duration of the test, the pumping rate was maintained at a steady 602 gpm. The weather during the test was fair and no rain occurred. Water levels were measured by hand-held wetted tape in all observation wells and by an "electric tape" in PW3.

Significant drawdowns in water-table Wells OB3-3, OB3-7, and OB3-9 indicate that the aquifer responds as a water-table aquifer. Drawdowns in the water-table wells responded more slowly to pumping than the production-zone wells. Graphs of drawdown data from production-zone wells show the effect of gravity drainage that is characteristic of water-table aquifers. The period during which gravity drainage significantly affects drawdowns is short, however, and water levels in production-zone wells are concluded to have stabilized before the end of the test. Drawdowns that may have occurred in well pair OB3-1/OB3-2 were indistinguishable from background trends or "noise" in water levels. Drawdowns in well pair OB3-5/OB3-6 were greatly influenced by water in the adjacent drainage canal and could not be analyzed. Selected graphs are shown in Appendix D.

Water intercepted by PW3 during the test was derived from the surrounding aquifer and a combination of water flowing naturally from the lake and water induced to flow from the lake. The induced component of flow was caused by the drawdown beneath the lake as a result of pumping PW3. In the absence of recharge by rainfall, water derived from the lake must have caused water levels to stabilize during the test. What appears to be a continuation of drawdown during the last day of the test (see Appendix D) is attributed to the effects of pumping from nearby lawn-irrigation wells and the background trend in water levels. Because of minor fluctuations in water levels before the test, the background trend was judged to be unreliable and was not used to correct drawdowns in observation wells.

The results of pumping-test analyses are shown on Table 7. Analyses of full-logarithmic and semi-logarithmic plots of the early drawdown and recovery data versus time result in estimates of the transmissivity from 184,000 to 1,528,000 gpd/ft; the higher values result from the influence of the lake acting as a recharge boundary, and to a lesser extent the drainage canal 100 feet east of PW3. Water from the lake reduces the water demand within the aquifer resulting in reduced drawdowns and higher apparent transmissivities. Although water seeped into the canal under static conditions, pumping from PW3 caused water levels in the aquifer to decline beneath the water level in the canal, forcing water to seep from the canal and influencing water-level behavior.

Estimates of transmissivity influenced by the presence of nearby surface-water bodies include those derived from Well OB3-8 and Well

TABLE 7

SUMMARY OF COEFFICIENT OF TRANSMISSIVITY VALUES DETERMINED FROM CONSTANT-RATE PUMPING TEST AT PW3

WEST PALM BEACH, FLORIDA

Observation Well No.	Data Used	Analysis Type	Coefficient of Transmissivity (gallons per day per foot)
OB3-4	D	LL	184,000
	D	SL	331,000
	R	LL	271,000
	R	SL	338,000
OB3-8	D	LL	600,000
	D	SL	1,292,000
	R	LL	841,000
	R	SL	1,528,000
OB3-10	D	LL	314,000
	D	SL	589,000
	R	LL	271,000
	R	SL	548,000
OB3-6			N.A.
OB3-2			N.A.
PW3			N.A.

N.A. - sufficient data not available
D - drawdown
R - recovery
LL - full-logarithmic analysis (from Boulton, 1963)
SL - semi-logarithmic analysis (from Cooper and Jacob, 1946)

OB3-10. Eliminating estimates from these wells and averaging the estimates from Well OB3-4 results in a transmissivity value of 280,000 gpd/ft. This value is considered most representative of the aquifer near PW3 because surface-water influence is not significant in the early drawdown and recovery data from Well OB3-4.

The stabilization of drawdowns during the test precludes analytical determination of the specific yield. Because water levels due to pumping will stabilize as they did during the pumping test, the predictions of aquifer yield and drawdown in the aquifer do not depend on the specific yield coefficient. The actual value of the specific yield is estimated to be 0.10.

In summary, testing along the eastern shore of Lake Mangonia shows that a high percentage of total seepage from the water-supply lakes occurs through this area. A portion of this water can be captured for use by the City. The aquifer is highly permeable and therefore conducive to ground-water development. The rate of infiltration from the lake in conjunction with aquifer characteristics, however, indicates that wells would have to be located at a considerable distance from the eastern shore of the lake to intercept the seepage already occurring and to minimize an increase in the rate of loss. Details of a well system designed to intercept seepage without adverse impacts are contained in a subsequent section.

Water Quality

Chemical analyses of water samples from Wells SC-1 through SC-8, and PW3, were performed by the City of West Palm Beach, Water Analysis Laboratory; the results of these analyses are presented in Appendix E. Generally, the quality of ground water in the vicinity of the water-supply lakes is good, and reflects the quality of the lake water.

Samples taken from wells in the "SC" series show a relatively consistent water quality. The chloride concentration of the eight samples ranged from 65 to 99 mg/l (milligrams/liter) and the conductivity ranged from 603 to 697 umhos/cm (micromhos/centimeter). A water sample taken from PW3 following one day of pumping was of better quality than water in any of the "SC" wells. This sample had a chloride concentration of 50 mg/l, and a conductivity of 475 umhos/cm. The total hardness of the sample from PW3 was 170 mg/l, which is approximately the same as the water in the water-supply lakes. The iron concentration, however, is 0.46 mg/l and exceeds the State standard for public water supplies. Treatment would be required for iron removal.

WELL-FIELD DEVELOPMENT POTENTIAL ALONG THE EASTERN SHORE OF LAKE MANGONIA

Data indicate that the area east of Lake Mangonia has the greatest potential for the capture of the seepage loss. Wells that would capture the seepage loss would have to be located and pumped at rates that take into account hydrogeologic constraints including: (1) the prevention of salt-water intrusion from Lake Worth, (2) minimizing induced infiltration from Lake Mangonia, and (3) minimizing the impact on existing ground-water users.

The first of these constraints requires that a sufficient flow of ground water be allowed to reach Lake Worth. Several reports published by the U. S. Geological Survey, including the report by Rodis and Land (1976), indicate that the ground-water gradient between Lake Mangonia and Lake Worth is approximately twice that in other coastal areas of Palm Beach County. Therefore, a reduction of flow to Lake Worth by one half would be a reasonable and conservative criteria upon which to estimate the water available to seepage-capture wells. The total flow of water that enters Lake Worth is a composite of the flow from lake seepage and local recharge. The width of aquifer along a north-south line that is influenced by flow from both sources is about 7000 feet - somewhat longer than the eastern shore of Lake Mangonia. The average east-west distance between the drainage canal and Lake Worth is about 5000 feet; recharge over this distance flows ultimately to Lake Worth. Recharge to the aquifer by the infiltration of rainfall within this area is estimated to be about 12 inches annually because of the degree of urbanization and associated runoff from paved surfaces. The total annual recharge to the area east of the drainage canal is estimated to be 262 million gallons (5000 ft x 7000 ft x 1 ft x 7.48 gallons/cubic ft); this is equivalent on a daily basis to 0.72 mgd. The flow due to seepage within the 7000 feet of aquifer width is approximately 4.12 mgd (0.0021 ft/ft x 280,000 gpd/ft x 7000 ft). Using the criterion that half of the flow from seepage and half of the recharge must be allowed to enter Lake Worth in order to maintain a ground-water gradient similar to other coastal areas within Palm Beach County, then half of the sum of 4.12 mgd and 0.72 mgd is available for withdrawal; this amount equals 2.42 mgd. To divert this quantity of ground water, wells should be located along a line parallel to the lake shore to distribute the effect of pumpage and maintain ground-water discharge to the lake. This will minimize salt-water intrusion.

The second constraint requires that the drawdown beneath Lake Mangonia created by pumping be minimized in order to avoid increasing seepage loss. The natural flow of water from the lake can be captured continuously under a steady-state pumping condition. A well yielding a practical supply from the capture of seepage only, however, theoretically would have to be located near Lake Worth. A well can be located closer to Lake Mangonia, but a certain rate of induced infiltration would have to be accepted. The method selected to determine the percentage of water that is induced to flow from the lake (greater than what normally occurs) relies on a comparison of the ground-water gradient that exists due to natural seepage and the gradient that would be created by a pumping well. For example, if the gradient at the lake shore created by pumping is 10 percent greater than the existing natural gradient, then 10 percent of the water pumped from the hypothetical well is concluded to be induced from the lake.

The capture of 2.42 mgd from the area between Lake Mangonia and Lake Worth could be accomplished by constructing a line of three wells placed at the relative distances from the shore of Lake Mangonia shown on Table 8. The setback distances shown in the table cover a practical range. The construction of fewer wells that would pump at higher rates should not be considered because a high rate of pumping from one or two wells may cause local salt-water intrusion as the ground-water flow east of the well is curtailed to an excessive degree. The construction of more wells that would pump at lower rates than indicated on the table is considered impractical because of construction costs for additional wells and pipelines. The figures shown in Table 8 reflect the capture of 2.42 mgd plus a specified percentage of water induced to flow from the lake beyond that which occurs naturally. The amount of water induced (above natural losses) obviously is taken from the existing water supply and does not represent a gain in available water.

The distance between wells noted on Table 8 (2732 feet) was derived using a formula (for a well pumping under steady-state conditions from an aquifer with a sloping water table) given by Kruseman and DeRidder ("Analysis and Evaluation of Pumping Test Data", International Institute for Land Reclamation and Improvement, Wageningen, Netherlands, Bull. 11, 1976). This formula yields a solution for the distance along the lake front (Lake Mangonia) within which all of the lake seepage flowing eastward is captured by a well. This distance (D, in feet), is equal to the rate of diversion from a well (Q, in gpm) divided by the gradient of the sloping water table (g, in ft/ft) and the aquifer transmissivity (T, in gpd/ft). After substituting the constants "g" and "T", the formula applied to the study area is $D = 2.44Q$. If 2.42 mgd (1680 gpm) is captured from three wells, the diversion from a single well is 560 gpm and the distance D is 1366 feet. For each distance D, along the lake front, an equal distance between wells is provided where no seepage capture is attempted. The distance between wells is therefore 2 x 1366 feet, or 2732 feet. This distributes the effects of pumping and minimizes salt-water intrusion.

TABLE 8

PUMPING RATES AND SET-BACK DISTANCES OF PRODUCTION WELLS FOR CONDITIONS WITH VARIOUS PERCENTAGES OF INDUCED SEEPAGE FROM LAKE MANGONIA

WEST PALM BEACH, FLORIDA

Percentage of Pumped Water Induced From Lake	Number of Wells	Pumping Rate Per Well (gpm)	Total Pumped (gpm)	Setback Distance of Well From Eastern Lake Shore (feet)
10	3	622	1866	2175
15	3	659	1977	1450
20	3	700	2100	1087

NOTES:

- the total rate of water salvaged equals 1680 gpm (2.42 mgd) in all cases
- the distance between wells in a north-south direction is 2732 feet in all cases

The location of Well PW3 is approximately 600 feet from the eastern shore of Lake Mangonia. This setback distance is less than any of those outlined on Table 8. The constraints on well location discussed above dictate that pumping PW3 at a rate of 407 gpm will create a gradient at the shore of the lake equal to 20 percent of the natural gradient; the seepage induced from the lake would be 20 percent of 407 gpm, or 81 gpm. Utilization of PW3 as one of the three wells in the network (each well capturing 560 gpm of natural lake seepage), would entail pumping PW3 at 761 gpm; the induced seepage would be 36 percent.

The third constraint does not pose an additional limit to ground-water diversions beyond those discussed immediately above. The area between the lakes is served by the municipal water system with the notable exception of the Good Samaritan Hospital. The Hospital operates wells that are about 70 feet deep and within one city block of the western shore of Lake Worth. It is reported (letter report from the files of the SFWMD) that the chloride content of ground water is 250 mg/l at a depth of about 170 feet. The unusually great thickness of fresh water overlying salty water so close to a salty surface-water body is due in part to the large flow of ground water that enters the aquifer from Lake Mangonia. Water withdrawals described above are not expected to affect the Hospital supply or other ground-water user in the vicinity with the possible exception of private lawn-irrigation wells. Any effect on private lawn-irrigation wells would depend on their distance from a seepage-capture well.

A potential source of contamination to wells constructed east of Lake Mangonia is the site of the old West Palm Beach sewage treatment plant at the southwest corner of 25th Street and Tamarind Avenue. This site has been used successively for the disposal of garbage and sewage sludge. Wells should be at least 1400 feet either north or south of this site to be out of the zone that may be influenced by leachate. Well PW3 is located about 800 feet west of this site but because the ground-water gradient directs flow towards the east, water underlying the site will not flow towards PW3. Theoretically, if 1 mgd is pumped from PW3, a stagnation point will be established about 300 feet east of PW3; from this point, water will flow west to PW3 and east to Lake Worth.

Information gained from the construction and testing of PW3 indicates that production wells located between Lake Mangonia and Lake Worth would have to be large-diameter wells constructed with a well screen and gravel pack because the sand is unconsolidated. The large well diameter would also minimize friction loss (head loss) in the well by providing a large intake area. For the rates projected for the recommended seepage-capture system, an 8-inch-diameter well screen of approximately 100 feet in length should be installed in a 16-inch-diameter borehole through the full thickness of the production zone. A 16-inch-diameter casing should be installed and cemented from a depth of about 85 feet (the top of the production zone) to land surface. The cost of each well should be about $40,000 (1982 dollars) The exact thickness and depth of the production zone, and the well screen and gravel-pack design, should be determined by drilling a pilot hole of approximately 5 inches in diameter.

The potential for capturing seepage east of Clear Lake can be estimated using criteria similar to those east of Lake Mangonia. If the gradient directing seepage from Clear Lake to Lake Worth is assumed to be 0.0021 ft/ft and the average transmissivity is assumed to equal 100,000 gpd/ft (see Figure 7), then 0.68 mgd is concluded to be the salvageable seepage along the eastern shore of Clear Lake (approximately 6500 feet long). In this location and the remaining periphery of the water-supply lakes (excluding the eastern shore of Lake Mangonia), the flow from seepage is diffuse and not amenable to capture from wells having a practical producing capability. The capture of seepage in these areas would have to be accomplished by a large number of wells, each pumping at relatively low rates.

In summary, wells can be constructed along the eastern shore of Lake Mangonia that together can capture 2.42 mgd; this is water that presently flows to Lake Worth and is lost. A ground-water diversion of this magnitude should not cause salt-water intrusion nor adversely affect existing ground-water users. Depending upon well-site locations, a system of seepage-capture wells would cause an increased seepage loss from Lake Mangonia equal to between 10 and 20 percent of the total amount withdrawn from wells. Consequently, to produce a net gain of 2.42 mgd, a greater quantity would have to be pumped.

Respectfully submitted,
GERAGHTY & MILLER, INC.

Paul G Jakob
Paul G. Jakob
Senior Scientist

Vincent P. Amy
Vincent P. Amy
Principal

15 October 1982

APPENDIX A

Geologic Logs of Test-Production and Observation Wells

West Palm Beach Water-Supply Study
West Palm Beach, Florida

GEOLOGIC LOG OF
TEST - PRODUCTION WELL 1 (PW1)
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, very pale yellow brown, fine- to medium-grained, unconsolidated.	0- 4	4
SANDY SHELL - Shell, 80%, bleached, whole and broken, unconsolidated; Sand, 20%, quartz, pale yellow brown, fine- to medium-grained.	4- 11	7
SHELLY SAND - Sand, 70% quartz, very pale gray to clear, fine- to medium-grained, unconsolidated; Shell, 30%, bleached, broken fragments.	11- 14	3
SAND - Sand, 100%, quartz, pale brown, fine- to medium-grained, unconsolidated.	14- 19	5
SAND - Sand, 100%, quartz, grayish brown, fine- to medium-grained, unconsolidated.	19- 28	9
SAND - Sand, 100%, quartz, pale brown, fine- to medium-grained, unconsolidated.	28- 42	14
SHELLY SANDSTONE - Sandstone, 70%, quartz, light gray to clear, fine- to medium-grained, well cemented in calcareous matrix; Shell, 30%, bleached, broken fragments.	42- 48	6
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, well sorted, unconsolidated.	48- 56	8
SAND - Sand, 100%, quartz, light gray, fine- to medium-grained, very well sorted, unconsolidated.	56- 64	8
SHELLY SAND - Sand, 80%, quartz, light gray to clear, fine- to medium-grained, unconsolidated; Shell, 20%, bleached, thin broken fragments.	64- 72	8

Geologic Log of
Test - Production Well 1 (PW1)
West Palm Beach, Florida

Sample Description	Depth Interval (feet)	Thickness (feet)
SANDY CLAY - Clay, 50%, blue green, plastic, soft; Sand, 50%, quartz, light gray to clear, fine- to medium-grained, well sorted, interbedded with clay.	72- 75	3
SHELLY SANDSTONE - Sand, 70%, quartz, light gray, fine- to medium-grained, well cemented in calcareous matrix; Shell, 30%, bleached, crushed fragments.	75- 79	4
SANDSTONE - Sand, 90%, quartz, light gray, fine- to medium-grained, moderately well cemented in calcareous matrix; Shell, 10%, very pale orange to light gray, fine gragments.	79- 91	12
SANDSTONE - Sand, 95%, quartz, medium light to medium dark gray, moderately soft, cemented in calcareous matrix; Shell, trace, fine fragments.	91- 99	8
SANDSTONE - Sand, 95%, quartz, medium light to medium dark gray, moderately hard, cemented in calcareous matrix; Shell, trace, fine fragments.	99- 108	9
SHELLY SANDSTONE - Sand, 70%, quartz, moderately light gray, fine- to medium-grained, poorly cemented in calcareous matrix; Shell, 25%, very pale orange to light gray, fine fragments; Calcite crystals, trace.	108- 118	10
SHELLY SANDSTONE - Sand, 65%, quartz, light gray to grayish brown, fine - to medium-grained; Shell, 30%, very pale orange to white, fine to medium fragments; Calcite, trace; Marl, trace, blue gray.	118- 152	34+
TOTAL DEPTH:	152	

GEOLOGIC LOG OF
TEST - PRODUCTION WELL 2 (PW2)
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 90%, quartz, pale yellow brown, fine- to medium-grained, sub-rounded; Shell, 10%, bleached, broken fragments.	0- 6	6
SHELLY SAND - Sand, 70%, quartz, pale yellow brown, fine- to medium-grained, sub-rounded; Shell, 30%, bleached whole and broken fragments.	6- 14	8
SHELL - Shell, 80%, bleached and black stained, mostly whole; Sand, 10%, quartz, light gray to gray brown, fine- to medium-grained, well sorted; Silt, 10%, light gray, well consolidated with sand.	14- 22	8
SAND - Sand, 90%, quartz, light gray to gray brown, fine- to medium-grained, sub-rounded, unconsolidated; Shell, 10%, bleached and black stained, crushed fragments.	22- 28	6
SANDY SHELL - Shell, 60%, bleached and black stained, mostly broken fragments, unconsolidated; Sand, 40%, quartz, light gray, fine- to medium-grained, sub-rounded.	28- 56	28
SHELL - Shell, 90%, bleached and black stained, mostly broken fragments, unconsolidated; Sand, 5%, quartz, light gray, fine- to medium-grained, sub-rounded; Clay, 5%, blue green, slightly plastic, well consolidated with sand.	56- 66	10
SHELL - Shell, 80%, bleached, mostly whole; Sand, 20%, quartz, light gray to pale brown, fine- to medium-grained, well consolidated with shell.	66- 72	6

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SANDSTONE - Sandstone, 70%, quartz, light gray, fine- to medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 30%, bleached, broken fragments distributed throughout.	72- 80	8
SHELLY SANDSTONE - Sandstone, 70%, quartz, light gray to clear, medium- to coarse-grained, sub-rounded, well cemented in calcareous matrix; Shell, 20%, bleached and colored, broken fragments; Sand, 10%, light gray, quartz, fine- to medium-grained, sub-rounded, interbedded with shell.	80-120	40
SHELLY SAND - Sand, 70%, quartz, light pale brown, fine- to medium-grained, well rounded, minor cementation; Shell, 30%, bleached egg shell, broken fragments.	120-132	12
SHELLY SANDSTONE - Sandstone, 80%, quartz, light gray to clear, fine- to medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 20%, bleached, broken fragments, cemented with sandstone.	132-180	48+
TOTAL DEPTH:	180	

GEOLOGIC LOG OF
OBSERVATION WELL OB1-1
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 80%, quartz, pale yellowish brown, fine- to medium-grained, sub-rounded, unconsolidated; Shell, 20%, bleached, broken fragments; Organics, trace.	0- 8	8
SHELLY SAND - Sand, 60%, quartz, grayish orange, fine- to medium-grained, sub-rounded; Shell, 40%, bleached, broken fragments, poorly sorted.	8- 22	14
SAND - Sand, 100%, quartz, grayish brown, fine- to medium-grained, rounded, well sorted, unconsolidated.	22- 52	30
SAND - Sand, 90%, quartz, grayish orange to clear, fine- to medium-grained, sub-rounded, poorly sorted, unconsolidated; Shell, 10%, bleached, crushed fragments, evenly distributed.	52- 62	10
SANDY SHELL - Shell, 70%, bleached, broken fragments, poorly sorted; Sand, 30%, quartz, pale yellow brown, fine- to medium-grained, well sorted, unconsolidated.	62- 78	16
SANDSTONE - Sandstone, 90%, quartz, light gray to clear, fine- to medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 10%, bleached, crushed fragments, cemented with sandstone.	78-155	77+
TOTAL DEPTH:	155	

GEOLOGIC LOG OF
OBSERVATION WELL OB1-3
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 60%, quartz, light brown to pale yellow brown, fine- to medium-grained, sub-rounded, well sorted; Shell, 40%, bleached, broken fragments, evenly distributed.	0- 20	20
SAND - Sand, quartz, grayish brown, fine-grained, rounded, well sorted, unconsolidated.	20- 40	20
SHELLY SAND - Sand, 60%, quartz, moderate brown, fine-grained, rounded, unconsolidated; Shell, 40%, bleached, broken fragments, poorly sorted.	40- 50	10
SHELLY SANDSTONE - Sand, 70%, quartz, light gray to clear, fine- to coarse-grained, poorly cemented in calcareous matrix; Shell, 30%, bleached, crushed fragments, cemented with sandstone.	50- 70	20
SANDSTONE - Sand, 90%, quartz, light gray to clear, fine- to medium-grained, well cemented in calcareous matrix; Shell, 10%, bleached, crushed fragments, cemented with sandstone.	70-155	85+
TOTAL DEPTH:	155	

GEOLOGIC LOG OF
OBSERVATION WELL OB1-5
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 80%, quartz, pale yellow brown, fine- to medium-grained, rounded, well sorted, unconsolidated; Shell, 20%, bleached, whole; Organics, trace.	0- 20	20
SILTY SAND - Sand, 80%, quartz, pale brown, fine-grained, rounded, well sorted, unconsolidated; Silt, 20%, dark brown, non-plastic.	20- 35	15
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, subrounded, well sorted, unconsolidated.	35- 42	7+
TOTAL DEPTH:	42	

GEOLOGIC LOG OF
OBSERVATION WELL OB1-8
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 80%, quartz, moderate yellowish brown, medium-grained, sub-rounded; Shell, 20%, bleached, mostly whole, poorly sorted.	0- 13	13
SANDY SHELL - Shell, 60%, bleached, mostly whole; Sand, 40%, quartz, pale yellowish brown, fine-grained, well sorted; Silt, trace, light gray.	13- 18	5
SAND - Sand, 80%, quartz, moderate dark brown, fine- to medium-grained, sub-angular, unconsolidated; Shell, 10%, bleached, mostly whole.	18- 29	11
SAND - Sand, 90%, quartz, moderate yellowish brown, fine- to medium-grained, unconsolidated; Shell, 10%, bleached, whole.	29- 42	13
SAND - Sand, 90%, quartz, pale yellowish brown, medium-grained, well consolidated; Shell, 10%, bleached, whole and broken fragments, well sorted.	42- 46	4
SANDSTONE - Sand, 90%, quartz, clear to light gray, medium-grained, sub-rounded, moderately well cemented in calcareous matrix; Shell, 10%, bleached, crushed fragments, cemented with sandstone.	46- 58	12
SHELLY SAND - Sand, 80%, quartz, grayish pink, medium-grained, sub-angular, poorly cemented; Shell, 20%, bleached, whole and broken fragments, distributed throughout sand.	58- 71	13

Sample Description	Depth Interval (feet)	Thickness (feet)
SANDSTONE - Sand, 90%, quartz, light gray to clear, medium-grained, sub-angular, well cemented in calcareous matrix; Shell, 10%, bleached, mostly broken fragments.	71- 79	8
SHELLY SAND - Sand, 80%, quartz, pale yellowish brown, medium-grained, sub-angular; Shell, 20%, bleached, broken fragments.	79- 92	13
SANDSTONE - Sand, 90%, quartz, light gray to clear, medium-grained, sub-angular, well cemented in calcareous matrix; Shell, 10%, bleached, broken fragments, evenly distributed.	92-100	8
SHELLY SAND - Sand, 60%, quartz, light gray to clear, fine-grained, sub-rounded, well sorted, poorly cemented; Shell, 35%, bleached, crushed and broken fragments, well sorted; Silt, 5%, light gray; Phosphate, trace.	100-110	10
SHELL - Shell, 90%, bleached and colored, mostly broken fragments; Sand, 10%, quartz, gray, fine-grained, sub-rounded, well sorted, poorly cemented; Phosphate, trace.	110-155	45+
TOTAL DEPTH:	155	

GEOLOGIC LOG OF
OBSERVATION WELL OB1-9
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SANDY SHELL - Shell 60%, bleached and colored; Sand, 40%, quartz, grayish orange, fine- to medium-grained, sub-rounded, unconsolidated.	0- 20	20
SAND - Sand, 100%, quartz, grayish brown, fine- to medium-grained, rounded, well sorted, unconsolidated.	20- 40	20
SHELLY SAND - Sand, 60%, quartz, gray to pale yellow brown, fine- to medium-grained, sub-rounded, well sorted; Shell, 40%, bleached, broken fragments, evenly distributed, unconsolidated.	40- 60	20
SANDSTONE - Sand, 90%, quartz, gray to clear, fine- to medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 10%, bleached, crushed fragments, cemented in sandstone.	60-100	40
SANDSTONE - Sand, 80%, quartz, light gray to clear, fine- to medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 10%, bleached, crushed fragments, cemented in sandstone; Marl, 10%, white, interbedded throughout sandstone.	100-155	55+
TOTAL DEPTH:	155	

GEOLOGIC LOG OF
OBSERVATION WELL OB2-1
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 60%, quartz, pale yellow brown to gray, fine- to medium-grained, sub-angular to sub-rounded, poorly sorted; Shell, 40%, bleached, whole and broken fragments; Trace organics.	0- 10	10
SANDY SHELL - Shell, 60%, bleached and colored, broken fragments; Sand, 40%, quartz, light gray to pale yellow brown, fine- to medium-grained, sub-angular to sub-rounded.	20- 30	10
SHELLY SANDSTONE - Sandstone, 80%, quartz, light gray to clear, fine- to coarse-grained, angular to sub-rounded, moderately well cemented in calcareous matrix; Shell, 20%, bleached, crushed fragments.	30- 40	10
SHELL - Shell, 90%, colored and bleached, whole and broken fragments; Sand, 10%, light gray to pale yellow brown, fine- to medium-grained, sub-rounded to rounded, consolidated.	40- 60	20
SHELLY SANDSTONE - Sandstone, 80%, quartz, light gray to clear grains, fine- to medium-grained, sub-rounded to rounded, moderately well cemented in calcareous matrix; Shell, 20%, broken, colored and black stained, distributed throughout sandstone.	60-100	40
SILTY SANDSTONE - Sandstone, 70%, quartz, pale yellowish brown, fine- to medium-grained, sub-rounded to rounded, poorly cemented in calcareous matrix; Silt, 20%, gray; Shell, 10%, broken fragments, bleached and colored, well distributed in sandstone.	100-150	50+
TOTAL DEPTH:	150	

GEOLOGIC LOG OF
OBSERVATION WELL OB2-2
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 80%, quartz, dark yellowish brown, fine- to medium-grained, sub-rounded to rounded; Shell, 10%, bleached, small broken fragments; Silt, 10%, gray brown, slightly plastic.	0- 5	5
SANDY SHELL - Shell, 60%, broken, bleached; Sand, 40%, quartz, grayish orange, fine- to coarse-grained, sub-rounded, unconsolidated.	5- 13	8
SHELLY SAND - Sand, 80%, quartz, clear to pale yellow brown, medium-grained, sub-rounded, unconsolidated; Shell, 20%, whole, bleached.	13- 18	5
SANDSTONE - Sand, 90%, quartz, light gray to clear, medium-grained, sub-rounded, well cemented in calcareous matrix; Shell, 10%, bleached, broken fragments, distributed throughout sandstone.	18- 38	20
SHELLY SAND - Sand, 60%, quartz, pale yellow brown, medium-grained, sub-rounded, unconsolidated; Shell, 40%, bleached, broken fragments.	38- 50	12
SANDY SHELL - Shell, 60%, bleached, crushed fragments, well sorted; Sand, 40%, quartz, clear to frosted, medium-grained, poorly cemented in calcareous matrix; Phosphate, trace, black.	50- 82	32
SHELLY SAND - Sand, 70%, quartz and phosphate, clear to black, fine- to medium-grained, sub-rounded; Shell, 30%, bleached, whole and crushed fragments.	82- 97	15

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SANDSTONE - Sand, 80%, quartz, light gray to clear, fine- to coarse-grained, sub-angular, unevenly cemented in calcareous matrix; Shell, 20%, bleached, egg shell, distributed throughout sandstone.	97-148	51
SHELLY SANDSTONE - Sandstone, 70%, quartz, light gray to clear, fine- to medium-grained, sub-rounded, poorly cemented in calcareous matrix; Shell, 20%, bleached, crushed fragments, evenly distributed; Silt, 10%, light gray.	148-155	7+
TOTAL DEPTH:	155	

GEOLOGIC LOG OF
WELL SC-1
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, pale yellow brown, fine to medium-grained, sub-angular to rounded; Organics, trace.	0 - 6	6
SILTY SAND - Sand, 60%, quartz, moderate brown, fine- to medium-grained, sub-rounded to sub-angular; Silt, 40%, dark brown, well consolidated with sand.	6 - 6.5	0.5
SAND - Sand, 100%, quartz, pale gray to pale yellow brown, fine- to medium-grained, rounded to sub-angular, sucrosic texture.	6.5 - 12	5.5
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, sub-angular, granular texture.	12 - 40	28
SHELLY SAND - Sand, 80%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to rounded, poorly sorted; Shell, 20%, white, eggshell fragments.	40 - 85	45
SANDSTONE AND SHELL (interbedded) - Sandstone, 70%, quartz, pale yellow brown, fine- to medium-grained, poorly cemented in calcareous matrix; Shell, 30%, bleached & colored, whole & fragments.	85 -104	19+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-2
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, pale yellow brown, quartz, fine- to medium-grained, sub-rounded to rounded, poorly sorted.	0- 8	8
SAND - Sand, 100%, very pale gray to clear quartz, fine- to medium-grained, sub-rounded to rounded, well sorted, sucrosic texture.	8- 15.5	7.5
SILTY SAND (hardpan) - Sand, 80%, moderate brown, quartz, fine- to medium-grained, sub-angular to rounded, well consolidated; Silt, 20%, moderate brown, well compacted with sand.	15.5- 16	.5
SAND - Sand, 100%, pale yellow brown, quartz, fine- to coarse-grained, angular to rounded, poorly sorted, uncemented.	16 - 85	69
SHELLY SANDSTONE - Sandstone, 80%, pale yellow brown, quartz, fine- to medium-grained, sub-rounded to rounded, moderately well cemented in calcareous matrix; Shell, 20%, mostly bleached, broken fragments.	85 - 104	19+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-3
WEST PALM BEACH, FLORIDA

SAMPLE DESCRIPTION	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to rounded, well sorted; Organics, trace.	0- 14	14
SAND - Sand, 100%, quartz, pale gray to clear, fine- to medium-grained, well rounded to sub-rounded, sucrosic texture.	14- 21	7
SILTY SAND, (hardpan) - Sand, 70%, quartz, moderate brown, fine- to medium-grained, sub-rounded to sub-angular, well sorted; Silt, 30%, moderate brown, well compacted with sand.	21- 22	1
SAND - Sand, 100%, quartz, pale yellow brown to light brown, medium- to coarse-grained, granular texture.	22- 50	28
SAND AND CLAY (interbedded) - Sand, 80%, quartz, pale gray, fine- to medium-grained, rounded to sub-angular, well sorted; Clay, 20%, blue green, slightly plastic.	50- 60	10
SAND - Sand, 100%, quartz, clear to pale yellowish orange, fine- to medium-grained, sub-angular to sub-rounded; Silt, trace, medium light gray.	60- 65	5
SAND - Sand, 90%, quartz, clear to pale yellowish orange, very fine- to medium-grained, sub-angular to rounded; Shell, 10%, white, fine fragments.	65- 76	11

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 80%, quartz, clear to pale yellowish orange, very fine- to medium-grained; Shell, 10%, very pale orange to white, fine fragments; Sandstone, 10%, medium light gray, soft, friable, fine quartz and shell cemented in a very fine grained calcareous matrix.	76- 82	6
SAND AND SANDSTONE - Sand, 60%, quartz, clear to pale yellowish orange, fine- to medium-grained; Sandstone, 25%, medium light gray, fine- to medium-grained, moerately soft, fine quartz in calcareous matrix; Shell, 15%, very pale orange to grayish orange, fine- to medium fragments.	82-102	20+
TOTAL DEPTH:	102	

GEOLOGIC LOG OF
WELL SC-4
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, poorly sorted.	0- 7	7
SILTY SAND, (hardpan) - Sand, 70%, quartz, moderate brown, fine- to medium-grained sub-angular to rounded; Silt, 30%, moderate brown, well compacted with sand.	7- 8	1
SAND - Sand, 100%, quartz, pale gray, fine- to medium-grained, rounded to sub-angular, sucrosic texture.	8- 16	8
SAND - Sand, 100%, quartz, pale yellow brown, fine- to coarse-grained, sub-angular to rounded, granular texture.	16- 24	8
SAND - Sand, 100%, quartz, pale gray, fine- to medium-grained, rounded to sub-angular, sucrosic texture.	24- 45	21
SHELLY SANDSTONE - Sandstone, 70%, quartz, bluish green, fine- to medium-grained, sub-rounded to sub-angular, well cemented with calcareous matrix; Shell, 30%, bleached, broken fragments, cemented with sand.	45- 62	17
SHELLY SANDSTONE - Sandstone, 80%, quartz, pale yellow brown, fine- to medium-grained, sub-rounded to sub-angular, poorly sorted, calcareous matrix; Shell, 20%, bleached broken fragments.	62- 104	42+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-5
WEST PALM BEACH, FLORIDA

SAMPLE DESCRIPTION	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 90%, quartz, dark yellowish brown, fine- to medium-grained, sub-rounded to sub-angular, well sorted, unconsolidated; Organics, 10%, root and decayed leaves.	0- 4	4
SAND AND CLAY (interbedded) - Sand, 90%, quartz, grayish orange pink- to pale gray, fine- to medium-grained, well rounded to sub-angular, sucrosic texture; Clay, 10%, gray, non-plastic, thin stringers.	4- 16	12
SAND- Sand, 100%, quartz, moderate yellowish brown, fine- to medium-grained, sub-rounded, moderately well sorted.	16- 55	39
SANDSTONE AND CLAY (interbedded) - Sandstone, 80%, very pale orange, quartz, fine- to medium-grained, sub-rounded, to sub-angular, moderate well cemented in calcareous matrix; Clay, 10%, medium bluish gray, slightly plastic, interbedded in sandstone; Silt and Shell, 10%, pale yellowish brown, very fine-grained, well worn fragments.	55- 58	3
SANDSTONE - Sandstone, 100%, quartz, very pale orange, fine- to medium-grained, with fine shell fragments moderately well cemented in calcareous matrix.	58- 90	32
SHELLY SAND - Sand, 80%, quartz, pale yellowish brown, sub-rounded to rounded, well sorted, poorly cemented; Shell, 20%, colored, whole and broken fragments, distributed throughout sand.	90- 104	14+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-6
WEST PALM BEACH, FLORIDA

SAMPLE DESCRIPTION	Depth Interval (feet)	Thickness (feet)
SAND WITH GRAVEL - Sand, 90%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to rounded, well sorted; Gravel, 10%, very pale yellow, microcrystalline, limestone, distributed throughout sand.	0- 8	8
SILTY SAND (hardpan) - Sand, 70%, quartz, dark brown, fine- to medium-grained, well rounded to sub-angular; Silt, 30%, dark brown, slightly plastic, thin lenses.	8- 8.5	.5
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to sub-rounded, well sorted, unconsolidated.	8.5- 18	9.5
SAND AND CLAY (interbedded) - Sand, 80%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to sub-rounded; Clay, 20%, dusky brown, slightly plastic.	18- 22	4
SAND - Sand, 100%, quartz, pale grey to very pale yellow brown, very fine- to medium-grained, rounded to sub-rounded, very well sorted, sucrosic texture.	22- 55	33
SAND AND CLAY (interbedded) - Sand, 70%, quartz, pale yellow brown, fine- to medium-grained, sub-rounded to sub-angular; Clay, 30%, blue green, plastic.	55- 58	3
SAND - Sand, 100%, quartz, very pale yellow brown, fine- to medium-grained, well rounded to sub-angular, sucrosic texture, unconsolidated.	58- 75	17
SANDSTONE - Sandstone, 90%, quartz, pale yellow brown to gray, fine- to medium-grained, sub-rounded to rounded, poorly cemented in calcareous matrix; Shell, 10%, bleached, broken fragments, distributed throughout sand.	75- 78	3

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 90%, quartz, pale yellow brown to gray, fine- to medium-grained, sub-rounded to rounded, poorly to well consolidated; Shell, 10%, white, broken fragments, distributed throughout sand.	78-104	26+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-7
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND AND GRAVEL - Sand, 90%, quartz, dark yellowish brown, fine- to medium-grained, sub-rounded- to sub-angular, well sorted, unconsolidated; Gravel, 10%, very pale orange, vugular, micritic.	0- 8	8
SAND - Sand, 100%, quartz, pale yellowish brown, fine- to medium-grained, sub-angular to sub-rounded, clear to frosted grains, well sorted.	8- 46	38
SAND - Sand, 100%, quartz, very pale yellow- to pale grey, very fine-grained, rounded to sub-rounded, very well sorted, sucrosic texture.	46- 72	26
MARLY SAND - Sand, 80%, quartz, pale yellow, fine- to medium-grained, rounded to sub-angular, poorly sorted; Marl, 15%, white, very fine-grained, micrite in silty matrix, unconsolidated; Silt, 5%, very fine-grained, mixed with marl layers.	72- 90	18
SHELLY SAND - Sand, 70%, quartz, pale yellow brown, medium- to coarse-grained, angular to sub-rounded, poorly sorted; Shell, 30%, colored and bleached, fine broken fragments.	90-104	14+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
WELL SC-8
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 95%, quartz, pale gray to pale orange, fine- to medium-grained, well rounded to sub-angular, sucrosic texture, well sorted; Organics, 5%, root stems and leaves.	0- 6	6
SILTY SAND (hardpan) - Sand, 60%, quartz dark brown, fine- to medium-grained, rounded to sub-angular; Silt, 40%, dark brown, well consolidated with sand.	6- 7	1
SAND - Sand, 100%, quartz, pale gray to pale orange, fine- to medium-grained, well rounded- to sub-angular, well sorted, sucrosic texture; Shell, trace, fine white fragments.	7- 54	47
SAND - Sand, 95%, quartz, dark yellowish brown, very fine- to fine-grained, well rounded, very well sorted, unconsolidated; Silt, 5%, pale brown, very fine-grained, very well sorted.	54- 60	6
SAND AND CLAY (interbedded) - Sand, 70%, quartz, pale yellowish brown, fine- to medium-grained, sub-rounded to rounded, sucrosic texture; Clay, 30%, bluish gray, slightly plastic; Shell, trace, white, fine-grained broken fragments.	60- 73	13
SHELLY SANDSTONE- Sand, 50%, quartz, clear to light gray, fine- to medium-grained, sub-angular to sub-rounded, poorly sorted, moderately well cemented, calcareous matrix; Shell, 50%, colored and black, whole and broken, well rounded, interbedded in sandstone.	73- 85	12

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 70%, clear and frosted to light gray, fine- to medium-grained, well rounded to sub-angular, poorly cemented in calcareous matrix; Shell, 30%, mostly broken, bleached and stained.	85-104	19+
TOTAL DEPTH:	104	

GEOLOGIC LOG OF
TEST - PRODUCTION WELL 3 (PW3)
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)	
SAND - Sand, 100%, quartzitic, very pale yellow brown, fine- to medium-grained, well sorted, loose.	0- 8	8	
CLAYEY SILT - Silt, 60%, dark brown, well compacted, slightly plastic; Clay, 40%, dark brown, slightly plastic.	8- 9	1	Low Perm Zone
SAND - Sand, 100%, quartzitic, very pale yellow brown to off white, fine- to medium-grained, sub-rounded, well sorted, sucrosic texture, loose.	9- 57	48	
SILTY CLAY- Clay, 60%, blue green, non-plastic, interbedded with silt; Silt, 40%, pale yellow brown, loose.	57- 58	1	Low Perm Zone
SAND - Sand, 100%, quartzitic, pale yellow brown, fine- to medium-grained, well sorted, loose.	58- 64	6	
SHELLY SAND - Sand, 60%, quartzitic, pale yellow brown, fine- to medium-grained, poorly cemented in calcareous matrix; Shell, 40%, bleached, crushed, interbedded with sand.	64- 82	18	PZ Top
SHELLY SANDSTONE - Sandstone, 70%, quartzitic, light gray to clear, fine- to medium-grained, well cemented in calcareous matrix; Shell, 30%, bleached and colored, crushed and broken fragments.	82-155	73	PZ Bottom
SHELLY SILTY SANDSTONE - Sandstone, 70%, quartzitic, light gray to clear, fine- to medium-grained, moderately well cemented in calcareous matrix; Silt, 15%, light gray, well sorted, cemented with sand; Shell, 15%, bleached and colored, whole and broken fragments, cemented with sand.	155-185	30	

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY LIMESTONE - Limestone, 80%, yellow brown, rounded, coarse sand size, poorly cemented; Shell, 20%, bleached, broken fragments, rounded.	185-200	15+
TOTAL DEPTH:	200	

GEOLOGIC LOG OF
OBSERVATION WELL OB3-2
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 60%, dusky yellowish brown to clear, quartz, medium- to coarse-grained, sub-angular to sub-rounded; Shell, 20%, tan, white, medium sized fragments; Inorganic and organic domestic wastes, 20%.	0- 20	20
SHELLY SAND - Sand, 70%, moderate brown, quartz, medium-grained, sub-angular to sub-rounded; Shell, 30%, white, tan, small to medium fragments.	20- 35	15
SHELLY SANDSTONE AND SHELLY SAND (interbedded) - Sandstone, 40%, dusky yellowish brown, quartz, fine- to medium-grained, sub-angular to sub-rounded, well cemented, in matrix with shells; Sand, 30%, light olive gray, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded; Shell, 30%, tan, white, gray, small to medium fragments.	35- 65	30
SHELLY SANDSTONE, CLAY AND SHELLY SAND (interbedded) - Sand, 30%, dusky yellowish brown, quartz, fine- to medium-grained, sub-angular to sub-rounded, well cemented, in matrix with shells; Clay, 30%, light gray, plastic; Sand, 20%, light olive gray, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded; Shell, 20%, tan, white, medium sized fragments; Silt, trace.	65- 80	15
SHELLY SAND - Sand, 70%, light olive gray to clear, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded; Shell, 30%, tan, white, gray, medium sized fragments.	80-158	78

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 80%, dark yellowish brown, quartz, medium-grained, sub-angular to sub-rounded; Shell, 20%, tan, white, gray, medium-sized fragments.	158-165	7+
TOTAL DEPTH:	165	

GEOLOGIC LOG OF
OBSERVATION WELL OB3-4
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, light gray, fine- to medium-grained, sub-angular to sub-rounded.	0- 5	5
SAND - Sand, 100%, quartz, brown, medium-grained, sub-angular to sub-rounded (hardpan).	5- 11	6
SAND - Sand, 100%, quartz, very pale orange to clear, fine- to medium-grained, sub-angular.	11- 22	11
SAND - Sand, 100%, quartz, very pale orange to clear, coarse-grained, sub-angular to sub-rounded, sucrosic.	22- 30	8
SAND - Sand, 100%, quartz, very pale orange to clear, fine- to coarse-grained, sub-angular to sub-rounded.	30- 60	30
SHELLY SAND - Sand, 70%, quartz and phosphatic, light olive gray to clear, fine- to medium-grained, sub-rounded; Shell, 30%, white, tan, gray, small to medium fragments.	60- 85	25
SHELLY SAND AND SANDSTONE - Sand, 70%, quartz, light olive gray, medium- to coarse-grained, unconsolidated; Shell, 20%, white, tan, small to medium fragments; Sandstone, 10%, light olive gray, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded, poorly cemented with shells; Clay, trace, gray, plastic; Silt, trace.	85-105	20

SAMPLE DESCRIPTION	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 75%, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded; Shell, 25%, white, tan, medium-sized fragments.	135-150	15+
TOTAL DEPTH:	150	

GEOLOGIC LOG OF
OBSERVATION WELL OB3-6
WEST PALM BEACH, FLORIDA

SAMPLE DESCRIPTION	Depth Interval (feet)	Thickness (feet)
CLAY AND SHELLY SAND (interbedded) - Clay, 50%, light gray, plastic; Sand, 40%, dark yellowish brown, quartz, fine- to coarse-grained, sub-angular to sub-rounded; Shell, 10%, white, tan, small to medium fragments; Silt, trace.	0- 5	5
SHELLY SAND - Sand, 85%, quartz, pale yellowish brown, fine- to medium-grained, sub-angular to sub-rounded; Shell, 15%, small fragments.	5- 30	25
SHELLY SAND - Sand, 85%, quartz, yellowish gray, fine- to medium-grained, sub-angular to sub-rounded; Shell, 15%, small fragments.	30- 50	20
SANDY SHELL - Shell, 85%, white, tan, medium fragments; Sand, 15%, quartz, yellowish gray, fine- to medium-grained, sub-angular to sub-rounded.	50- 60	10
SHELLY SAND - Sand, 90%, quartz, yellowish gray, fine- to medium-grained, sub-angular to sub-rounded; Shell, 10%, tan, white, small and medium fragments.	60- 85	25
SHELLY SAND AND SANDSTONE - Sand, 40%, quartz, dark brownish gray, fine- to medium-grained, sub-angular to sub-rounded, unconsolidated; Shell, 30%, white, tan, small to medium fragments; Sandstone, 30%, olive gray, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded, well cemented in calcareous matrix.	85-120	35

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND - Sand, 60%, quartz, light gray, fine- to medium-grained, sub-angular to sub-rounded; Shell, 20%, tan, white, medium fragments; Clay, 10%, light gray, plastic; Sandstone, 10%, olive gray, quartz and phosphatic, fine- to medium-grained, sub-angular to sub-rounded, well cemented in calcareous matrix; Silt, trace.	120-145	25
SHELLY SAND AND SANDSTONE (interbedded)-Sand, 75%, dark brownish gray, quartz, fine- to medium-grained, sub-angular to sub-rounded; Shell, 15%, tan, white, gray, medium fragments; Sandstone, 10%, dark brownish gray, quartz, and phosphatic, fine- to medium-grained, sub-angular to sub-rounded, well cemented in calcareous matrix.	145-180	35
SHELLY SAND AND LIMESTONE - Sand, 50%, quartz, grayish olive to clear, fine- to coarse-grained, sub-angular to sub-rounded; Shell, 30%, tan, white, gray, very fine to medium fragments, well rounded; Limestone, 20%, grayish orange and dark yellowish brown, cryptocrystalline, very small fragments, rounded.	180-195	15+
TOTAL DEPTH:	195	

GEOLOGIC LOG OF
OBSERVATION WELL OB3-8
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 95%, quartz, grayish orange pink, fine- to medium-grained, sub-angular to sub-rounded, poorly sorted; Organics, 5%, trace.	0- 5	5
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, sub-angular to sub-rounded, well sorted, sucrosic texture.	5- 14	9
SANDY SILT (Hardpan) - Silt, 60%, dark brown, slightly plastic; Sand, 40%, quartz, dark brown, fine- to medium-grained, sub-rounded, poorly sorted.	14- 15	1
SAND - Sand, 100%, quartz, very pale yellowish brown, fine- to medium-grained, sub-rounded, well sorted, sucrosic texture, loose.	15- 29	14
SAND - Sand, 100%, quartz, dark brown, fine- to coarse-grained, sub-angular, loose, granular texture.	29- 34	5
SAND - Sand, 100%, quartz, medium yellowish brown, fine- to medium-grained, sub-rounded, loose, poorly sorted.	34- 45	11
SAND - Sand, 100%, quartz, pale yellow brown, fine- to medium-grained, sub-rounded, poorly sorted, loose.	45- 59	14
SANDY SILT- Silt, 60%, blue green, non-plastic; Sand, 40%, quartz, fine- to medium-grained, interbedded with silt.	59- 60	1

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 100%, quartz, pale yellowish brown, fine- to medium-grained, sub-rounded, loose.	60- 72	12
SHELLY SANDSTONE - Sandstone, 80%, quartz, light gray, fine- to medium-grained, poorly cemented in calcareous matrix; Shell, 20%, bleached, broken and crushed fragments, cemented in sandstone.	72-110	38
SHELLY SILTY SAND - Sand, 50%, quartz, light gray to clear, fine- to medium-grained, sub-rounded, well sorted; Silt, 30%, light gray, non-plastic, well consolidated with sand; Shell, 20%, bleached, broken and crushed fragments interbedded with silty sand.	110-190	80+
TOTAL DEPTH:	190	

GEOLOGIC LOG OF
OBSERVATION WELL OB3-10
WEST PALM BEACH, FLORIDA

Sample Description	Depth Interval (feet)	Thickness (feet)
SAND - Sand, 90%, quartz, moderate yellowish brown, fine- to medium-grained, sub-angular to sub-rounded; Shell, 10%, white and gray fragments, medium sized fragments.	0- 8	8
SAND - Sand, 100%, quartz, moderate yellowish brown, fine- to medium-grained, sub-angular to sub-rounded.	8- 58	50
CLAYEY SAND - Sand, 70%, quartz, moderate yellowish brown, fine- to medium-grained, sub-angular to sub-rounded; Clay, 30%, gray, plastic; Silt, trace.	58- 68	10
CLAYEY SANDY SHELL - Shell, 40%, white and gray, small to medium sized fragments; Sand, 30%, light olive gray to clear, quartz, fine- to medium-grained, sub-angular to sub-rounded; Clay, 30%, greenish gray, plastic; Silt, trace.	68- 75	7
SHELLY SANDSTONE, SANDY SHELL AND CLAY (interbedded) - Sandstone, 40%, quartz and phosphatic, light olive gray, fine- to medium-grained, sub-angular to sub-rounded, shelly, moderately hard, fairly well cemented; Shell, 30%, white, tan, gray, small to medium fragments; Sand, 15%, quartz, light olive gray, fine- to medium-grained, sub-angular to sub-rounded; Clay, 15%, light gray, plastic; Silt, trace.	75- 80	5
SHELLY SAND - Sand, 60%, quartz, pale yellowish brown to clear, fine- to medium-grained, sub-angular to sub-rounded; Shell, 40%, white, tan, gray, small to medium sized fragments.	80- 97	17

Sample Description	Depth Interval (feet)	Thickness (feet)
SHELLY SAND AND SANDSTONE - Sand, 50%, quartz, pale yellowish brown to clear, fine- to medium-grained, sub-angular to sub-rounded, well cemented; Shell, 30%, tan, white, gray, medium sized fragments; Sandstone, 20%, quartz and phosphatic, pale yellowish brown to clear, small- to medium-grained, sub-angular to sub-rounded.	97-103	6
SHELLY SAND - Sand, 80%, quartz, pale yellowish brown to clear, small to medium-grained, sub-angular to sub-rounded; Shell, 20%, white to tan, small to medium fragments.	103-143	40
SHELLY SAND AND SANDSTONE - Sand, 60%, quartz, pale yellowish brown to clear, small- to medium-grained, sub-angular to sub-rounded; Shell, 20%, white and tan, small fragments; Sandstone, 20%, quartz and phosphatic, pale yellowish brown to clear, small- to medium-grained, sub-angular to sub-rounded.	143-160	17+
TOTAL DEPTH:	160	

APPENDIX B

Geophysical Logs of
Test-Production Wells PW1 and PW3

West Palm Beach Water-Supply Study
West Palm Beach, Florida

GERAGHTY & MILLER, INC.

CALIPER

P358L01-51

COMPANY DRILLING SERVICES INC.
WELL PW1
LOCATION W.P.B. SEWAGE TREATMENT PLANT

COMPANY DRILLING SERVICES INC.
WELL PW1
FIELD W.P.B. TREATMENT PLANT
COUNTY PALM BEACH STATE FL.

LOCATION:
SEC. TWP. RGE.

OTHER SERVICES

PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

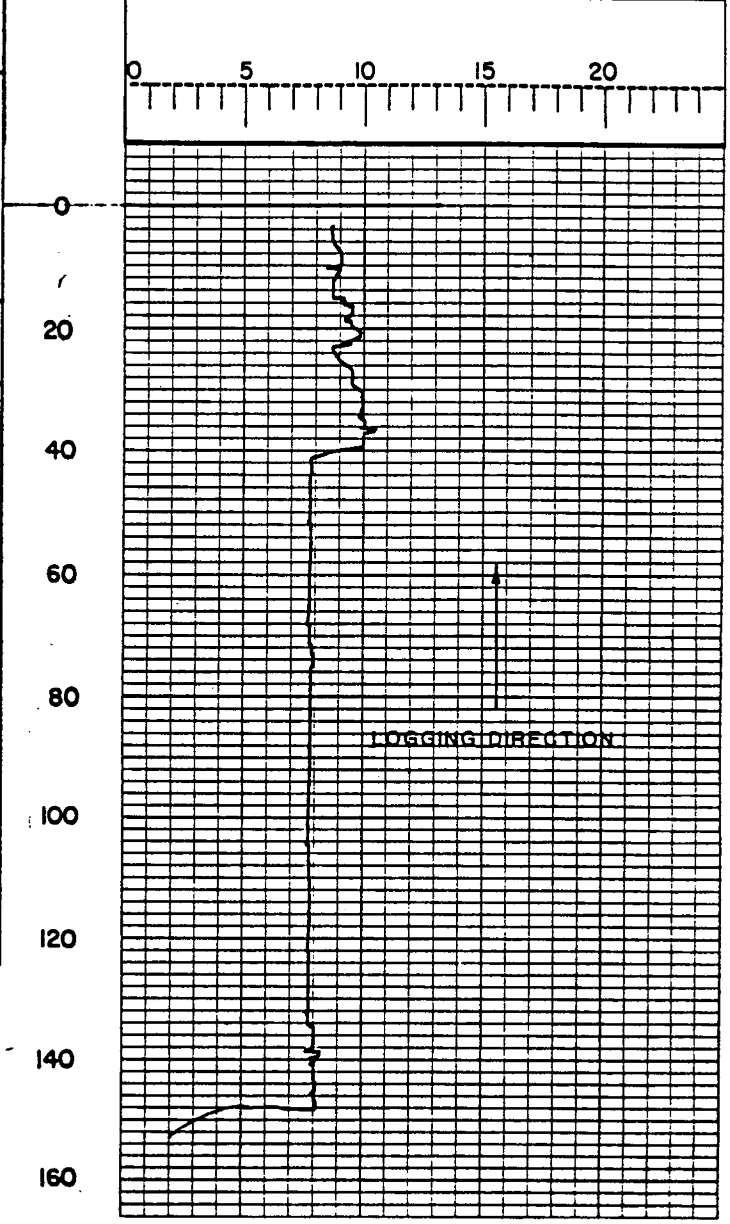
DATE	6-11-82			
RUN No.	ONE			
TYPE LOG	CALIPER			
DEPTH - DRILLER	162'			
DEPTH - LOGGER	163'			
BTM. LOG INTER.	163'			
TOP LOG INTER.	0'			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP.- °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	D. WHITE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
ONE	7-7/8"	0'	162'				

Caliper

5 inches per inch

18 F.P.M.



GERAGHTY & MILLER, INC.

ELECTRIC

P358L01-51

COMPANY DRILLING SERVICES INC.
WELL PW1
LOCATION W.P.B. SEWAGE TREATMENT PLANT

COMPANY DRILLING SERVICES INC.

WELL PW1

FIELD W.P.B. TREATMENT PLANT

COUNTY PALM BEACH STATE FL.

LOCATION:

SEC. TWP. RGE.

OTHER SERVICES

PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

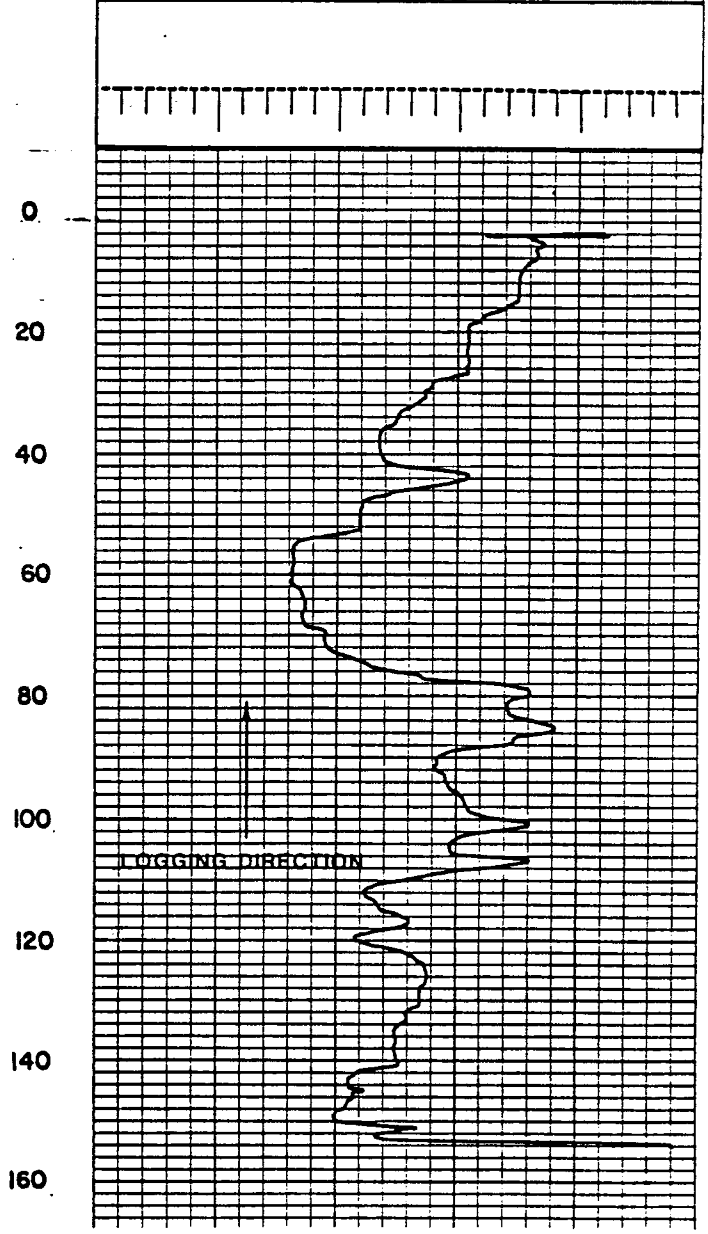
DATE	6-11-82			
RUN No.	ONE			
TYPE LOG	RESISTIVITY			
DEPTH - DRILLER	162'			
DEPTH - LOGGER	163'			
BTM. LOG INTER.	163'			
TOP LOG INTER.	0'			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP. - °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	D. WHITE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
ONE	7-7/8"	0'	162'				

Resistivity

10 Ohms/inch

13 F.P.M.



GERAGHTY
& MILLER, INC.

GAMMA RAY

P358L01-51

COMPANY DRILLING SERVICES INC.
WELL PW1
LOCATION W.P.B. SEWAGE TREATMENT PLANT

COMPANY DRILLING SERVICES INC.

WELL PW1
FIELD W.P.B. TREATMENT PLANT
COUNTY PALM BEACH STATE FL.

LOCATION:
SEC. TWP. RGE.

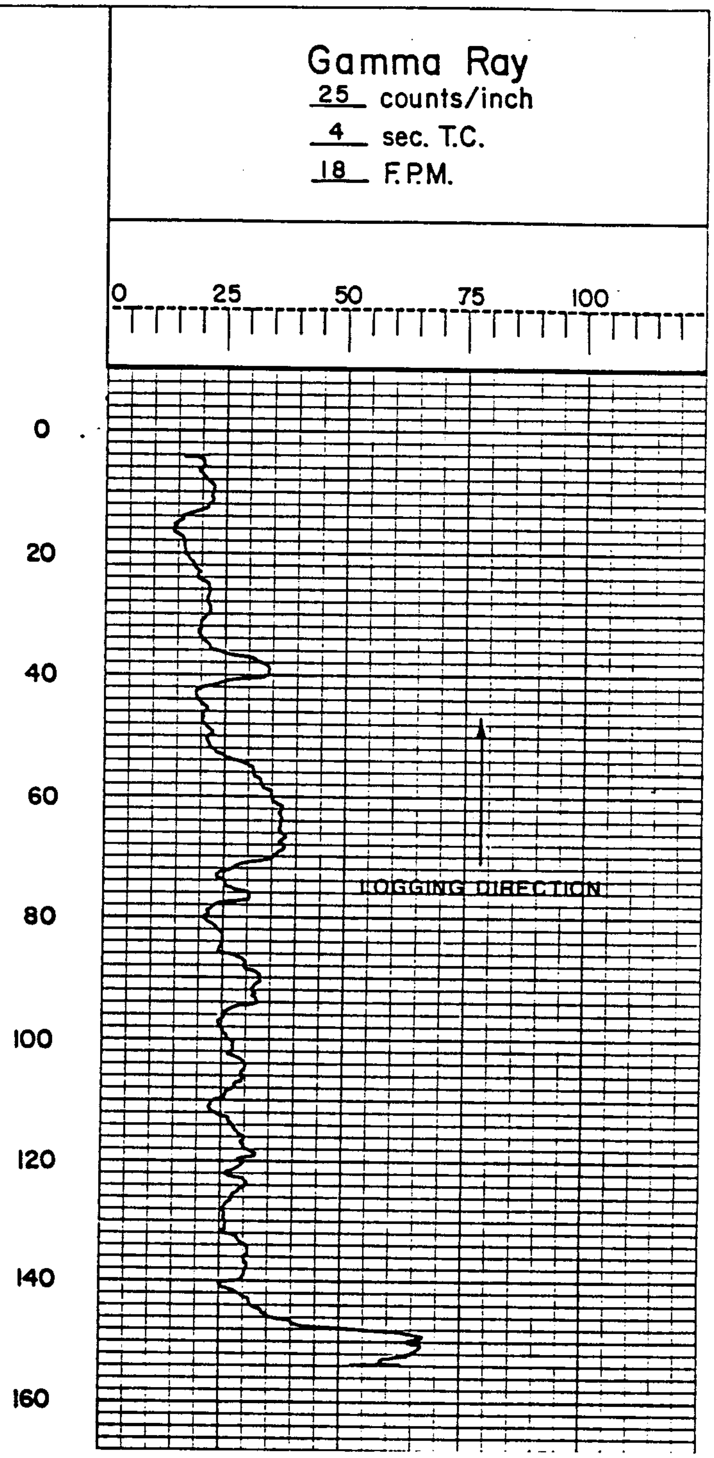
OTHER SERVICES

PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft. above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

DATE	5-11-82			
RUN No.	ONE			
TYPE LOG	GAMMA			
DEPTH - DRILLER	152'			
DEPTH - LOGGER	153'			
BTM LOG INTER.	153'			
TOP LOG INTER.	0'			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP. - °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	D. WHITE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
ONE	7-7/8"	0'	152'				



GERAGHTY & MILLER, INC.

CALIPER

P358L01-54

COMPANY DRILLING SERVICES, INC.
WELL PW-3
LOCATION AUSTRALIAN S. of 25th ST.

COMPANY DRILLING SERVICES, INC.
WELL PW-3
FIELD AUSTRALIAN S. of 25th ST.
COUNTY PALM BEACH STATE FL.

LOCATION:
SEC. TWP. RGE.

OTHER SERVICES

PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

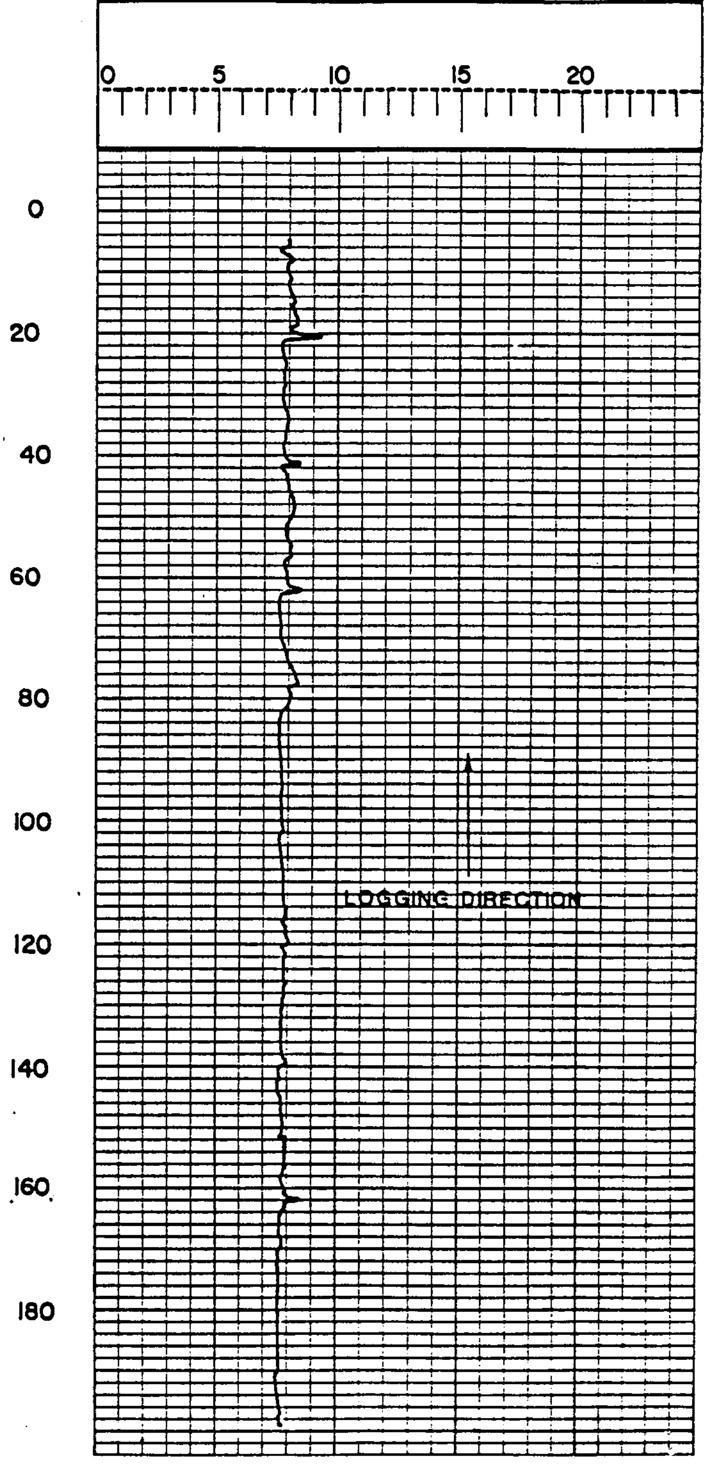
DATE	6-20-82			
RUN No.	ONE			
TYPE LOG	CALIPER			
DEPTH - DRILLER	200'			
DEPTH - LOGGER	200'			
BTM. LOG INTER.	200'			
TOP LOG INTER.	0'-G.L.			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP. - °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	T. LAWRENCE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
ONE	7-1/2"	0'	200'				

Caliper

5 inches per inch

25 F.P.M.



GERAGHTY & MILLER, INC.

FORMATION RESISTIVITY

P358L01-54

COMPANY DRILLING SERVICES, INC.
WELL PW-3
LOCATION AUSTRALIAN S. of 25th ST.

COMPANY DRILLING SERVICES INC.

WELL PW-3
FIELD AUSTRALIAN S. of 25th ST.
COUNTY PALM BEACH STATE FL.

LOCATION:
SEC. TWP. RGE.

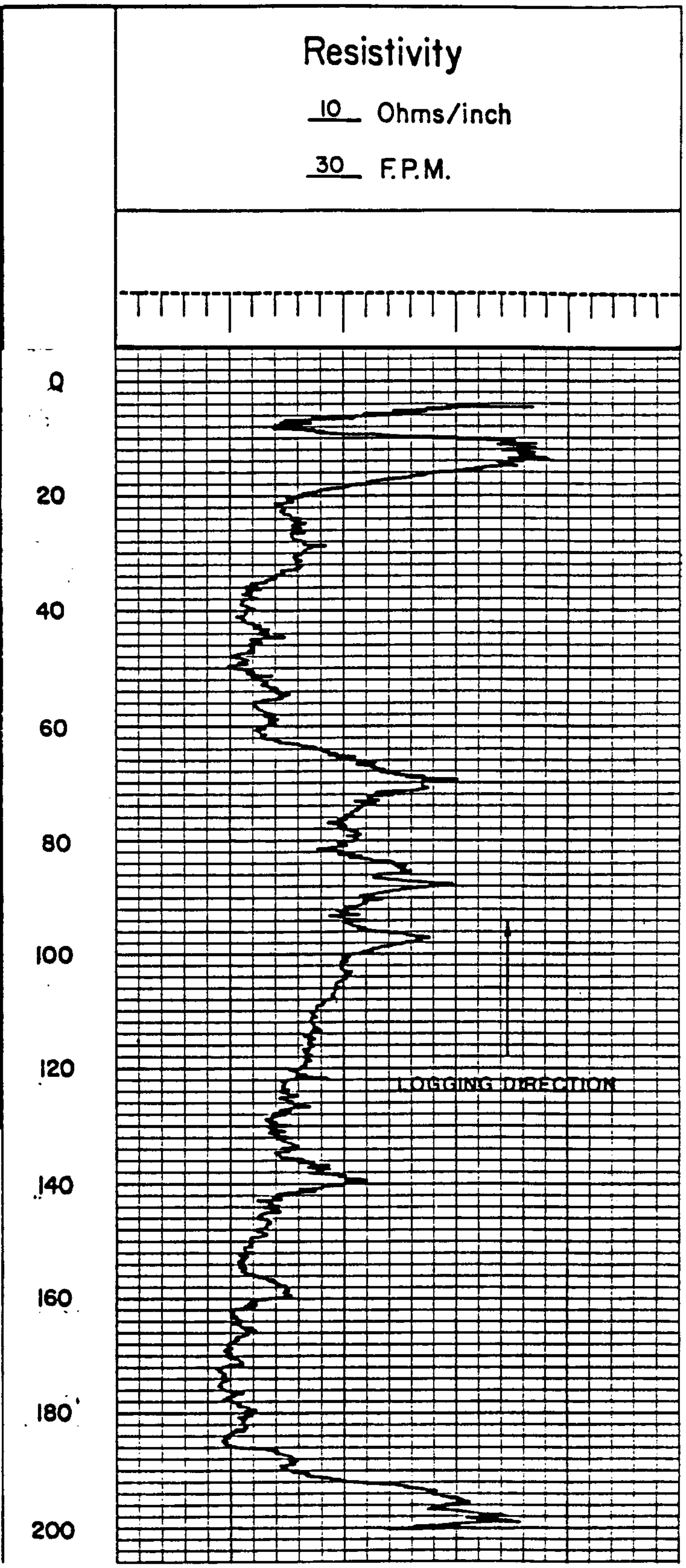
OTHER SERVICES

PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

DATE	6-20-82			
RUN No.	TWO			
TYPE LOG	RESISTIVITY			
DEPTH - DRILLER	200'			
DEPTH - LOGGER	200'			
BTM LOG INTER.	200'			
TOP LOG INTER.	0'-G.L.			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP. - °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	T. LAWRENCE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
TWO	7-1/2"		200'				



GERAGHTY & MILLER, INC.

GAMMA RAY

P358L01-54

COMPANY DRILLING SERVICES, INC.
WELL PW-3
LOCATION AUSTRALIAN S. of 25th ST.

COMPANY DRILLING SERVICES, INC.
WELL PW-3
FIELD AUSTRALIAN S. of 25th ST.
COUNTY PALM BEACH STATE FL.

LOCATION:
SEC. TWP. RGE.

OTHER SERVICES

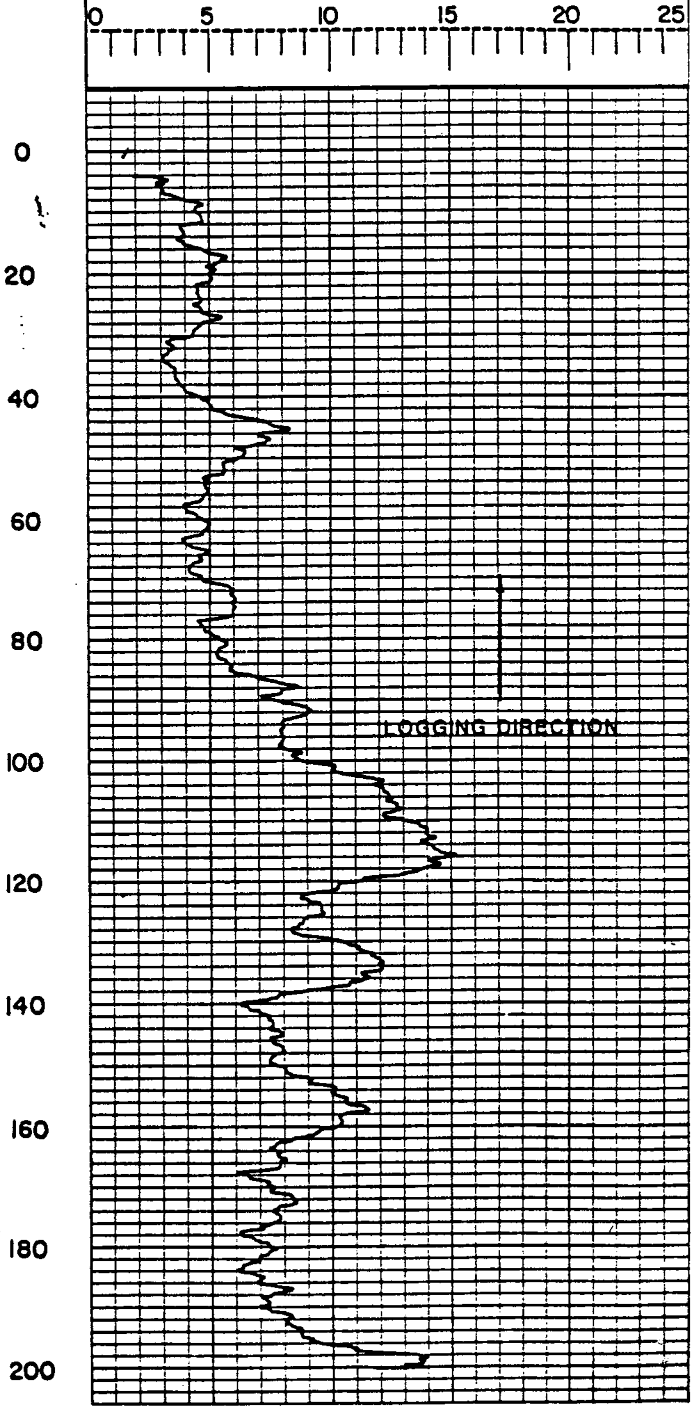
PERMANENT DATUM G.L. ELEV.
LOG MEASURED FROM G.L. ft. above perm. datum
DRILLING MEASURED FROM G.L.

ELEV. K.B.
D.F.
G.L.
T.O.C.

DATE	8-20-82			
RUN No.	ONE			
TYPE LOG	GAMMA			
DEPTH - DRILLER	200'			
DEPTH - LOGGER	200'			
BTM. LOG INTER.	200'			
TOP LOG INTER.	0'-G.L.			
TYPE FLUID IN HOLE	MUD			
SALINITY ppm Cl				
DENSITY lb/gal				
LEVEL				
MAX. REC. TEMP. - °F				
OPER. RIG TIME				
RECORDED BY	J. ROLAND			
WITNESSED BY	T. LAWRENCE			

RUN No.	BORE HOLE RECORD			CASING RECORD			
	BIT	FROM	TO	SIZE	WGT.	FROM	TO
ONE	7-1/2"	0'	200'				

Gamma Ray
5 counts/inch
4 sec. T.C.
30 F.P.M



APPENDIX C

Data from Step-Drawdown Test
on Test-Production Wells PW1, PW2, and PW3

West Palm Beach Water-Supply Study
West Palm Beach, Florida

TEST-PRODUCTION WELL PW1

Step	Pumping Rate (gallons per minute)	Drawdown (feet)	Specific Capacity (gallons per minute per foot of drawdown)
1	1613	11.19	144.15
2	1395	9.23	151.04
3	1176	7.29	161.32
4	1140	6.87	165.93

TEST-PRODUCTION WELL PW2

1	1600	16.60	96.39
2	1390	14.17	100.28
3	1302	12.89	101.01

TEST-PRODUCTION WELL PW3

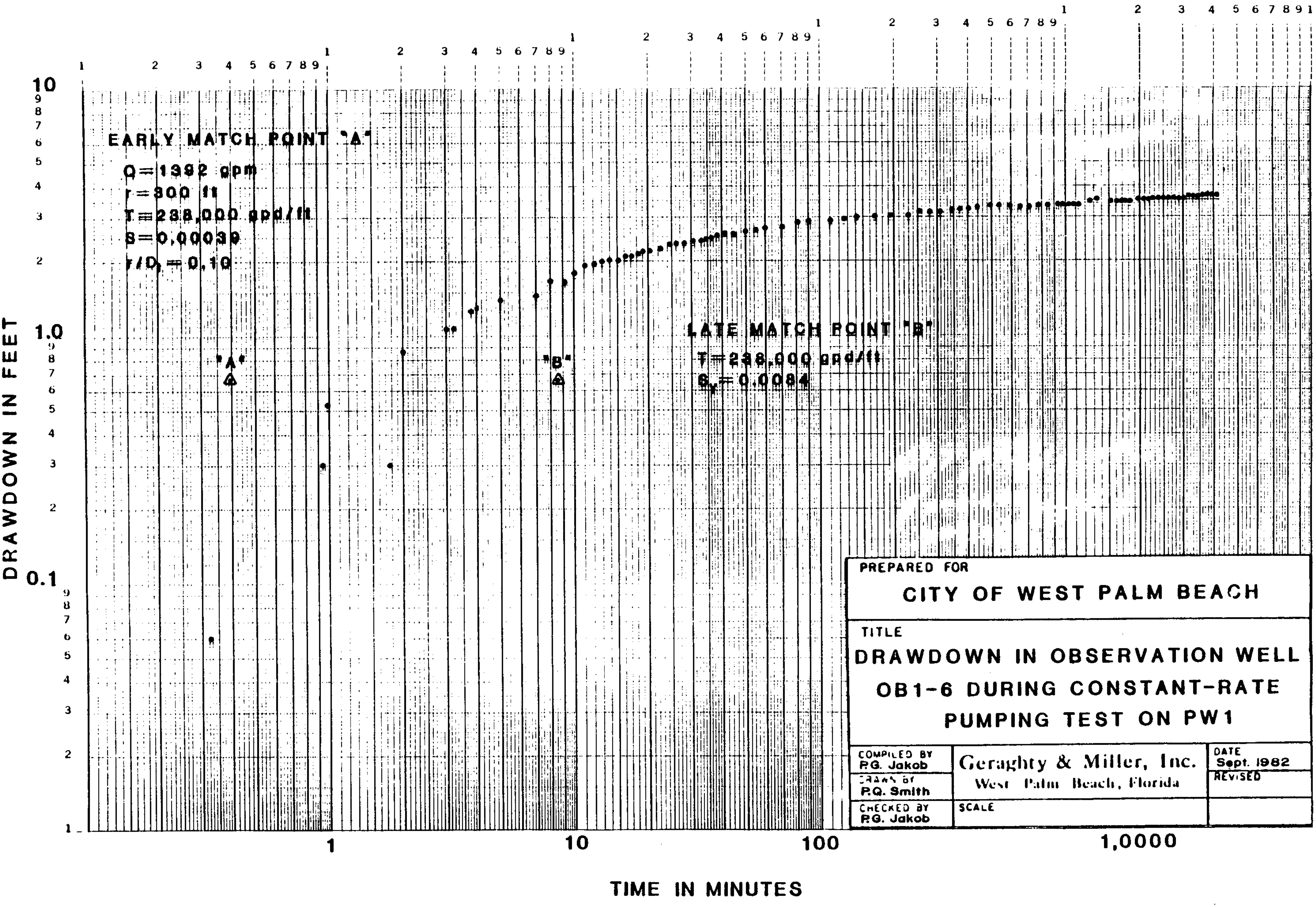
1	726	51.13	14.20
2	608	42.03	14.47
3	510	34.95	14.59
4	280	18.12	15.45

NOTE: Pumping and recovery steps were 30 minutes each

APPENDIX D

Selected Graphs of Data From
Constant-Rate Pumping Tests on
Test-Production Wells PW1, PW2, and PW3

West Palm Beach Water-Supply Study
West Palm Beach, Florida



PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

DRAWDOWN IN OBSERVATION WELL OB1-6 DURING CONSTANT-RATE PUMPING TEST ON PW1

COMPILED BY R.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY R.Q. Smith		REVISED
CHECKED BY R.G. Jakob	SCALE	

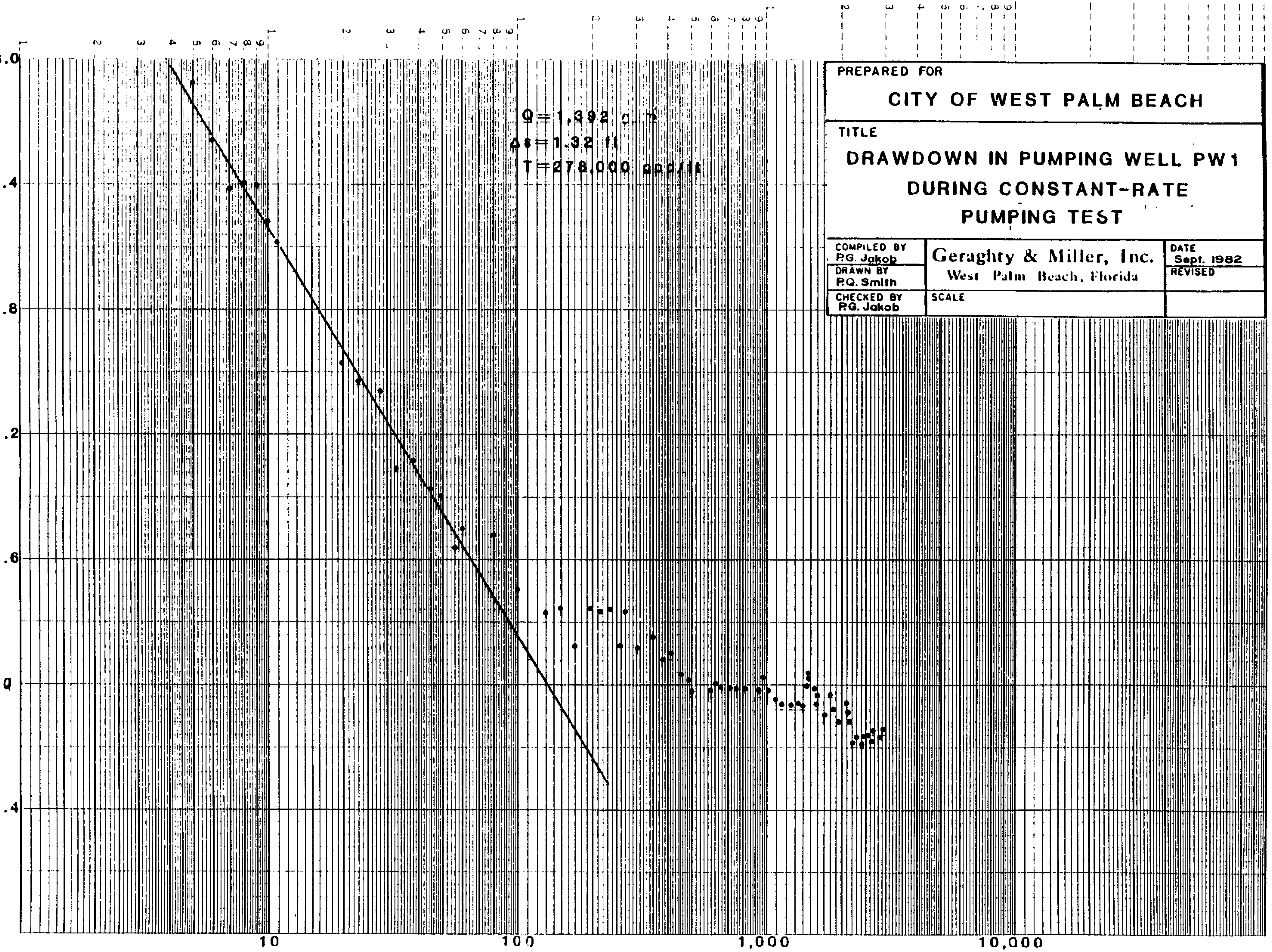
PREPARED FOR

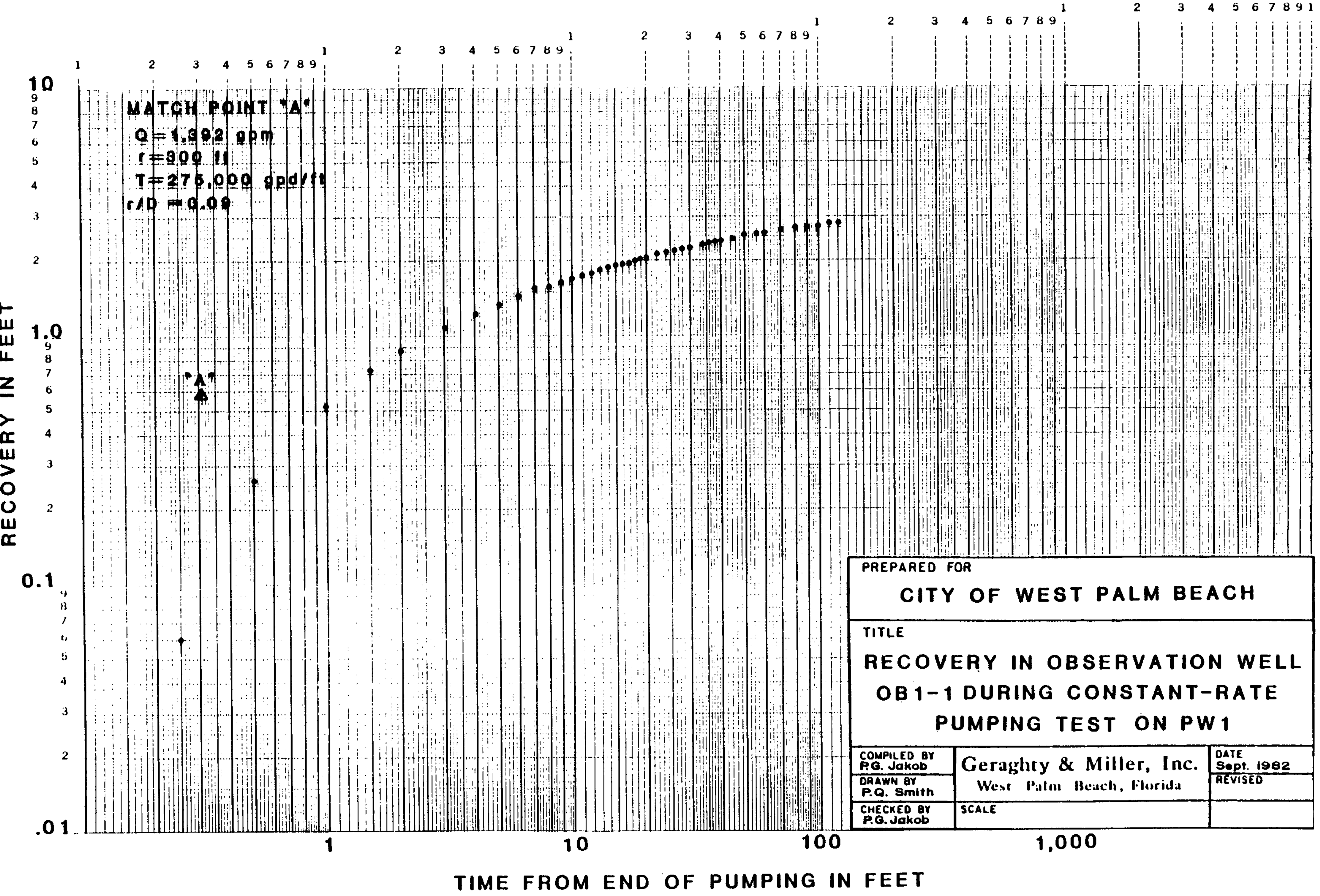
CITY OF WEST PALM BEACH

TITLE

DRAWDOWN IN PUMPING WELL PW1 DURING CONSTANT-RATE PUMPING TEST

COMPILED BY P.G. Jakob	**Geraghty & Miller, Inc.** West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE	





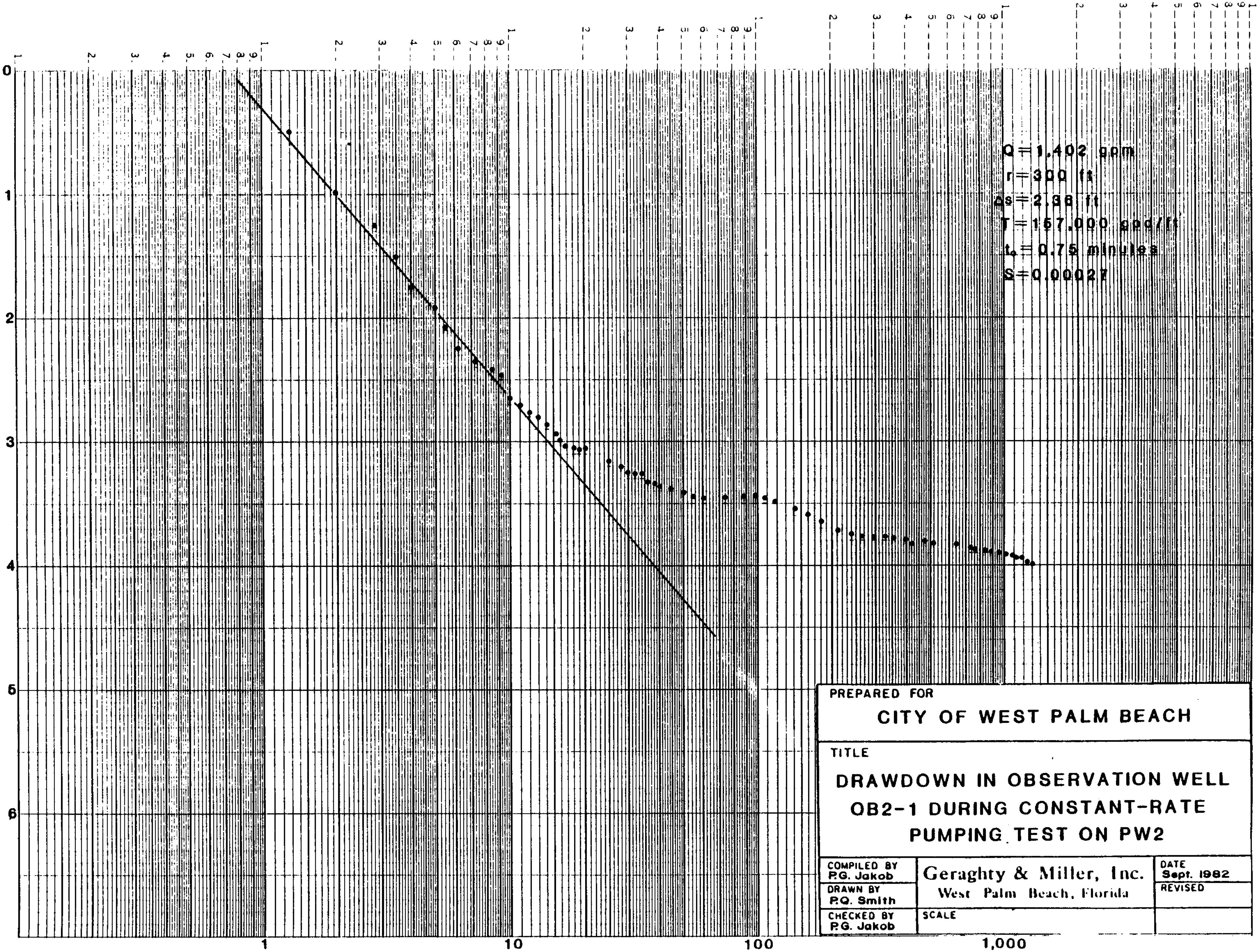
PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

RECOVERY IN OBSERVATION WELL OB1-1 DURING CONSTANT-RATE PUMPING TEST ON PW1

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE	



Q = 1,402 gpm
r = 300 ft
$\Delta s = 2.36$ ft
T = 157,000 gpd/ft
$t_o = 0.75$ minutes
S = 0.00027

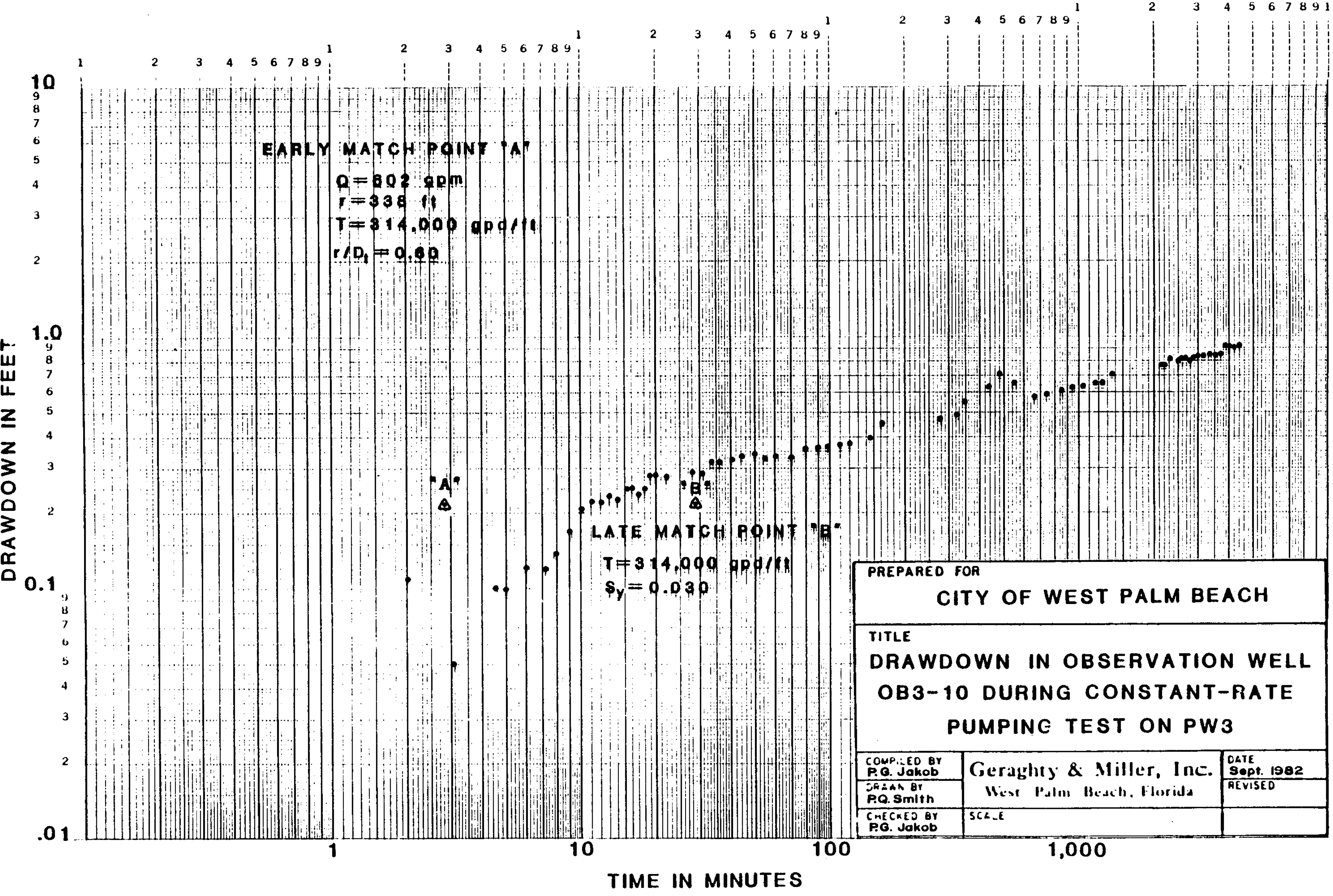
PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

DRAWDOWN IN OBSERVATION WELL OB2-1 DURING CONSTANT-RATE PUMPING TEST ON PW2

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE	



EARLY MATCH POINT "A"

$Q = 602$ gpm
$r = 338$ ft
$T = 314{,}000$ gpd/ft
$r/D_t = 0.60$

LATE MATCH POINT "B"

$T = 314{,}000$ gpd/ft
$S_y = 0.030$

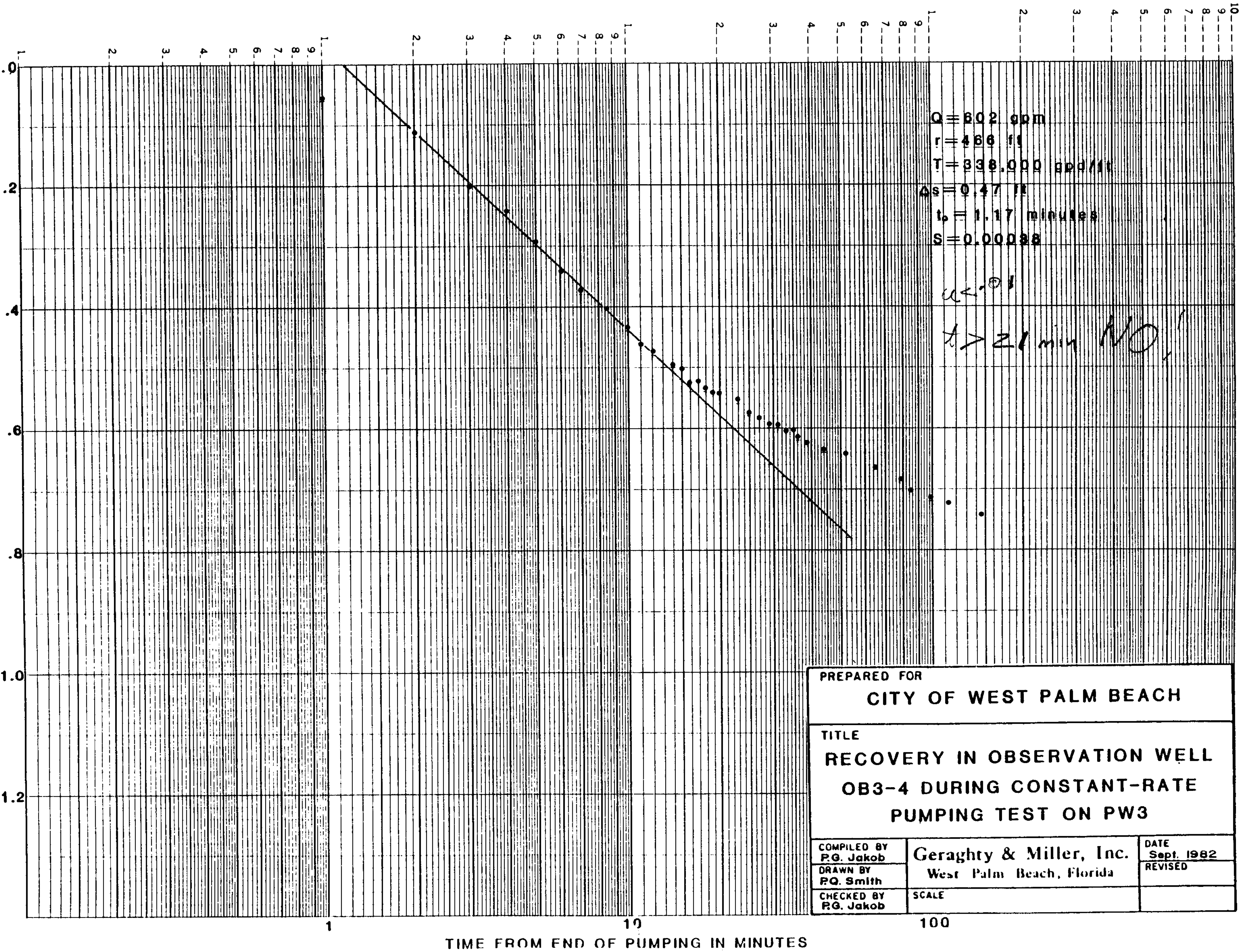
PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

DRAWDOWN IN OBSERVATION WELL OB3-10 DURING CONSTANT-RATE PUMPING TEST ON PW3

COMPILED BY P.G. Jakob	Geraghty & Miller, Inc. West Palm Beach, Florida	DATE Sept. 1982
DRAWN BY P.Q. Smith		REVISED
CHECKED BY P.G. Jakob	SCALE	



Q = 602 gpm
r = 466 ft
T = 338,000 gpd/ft
Δs = 0.47 ft
t_o = 1.17 minutes
S = 0.00088

u<.01

t>21 min NO!

PREPARED FOR

CITY OF WEST PALM BEACH

TITLE

RECOVERY IN OBSERVATION WELL OB3-4 DURING CONSTANT-RATE PUMPING TEST ON PW3

COMPILED BY P.G. Jakob

DRAWN BY P.Q. Smith

CHECKED BY P.G. Jakob

Geraghty & Miller, Inc.
West Palm Beach, Florida

SCALE

DATE Sept. 1982

REVISED

APPENDIX E

Water-Quality Data on Test-Production and Observation Wells

West Palm Beach Water-Supply Study
West Palm Beach, Florida

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: PW-1

County: Palm Beach

Collector: T. Lawrence

Address

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 06-10-82 @ 1000 hrs.

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS				SECONDARY STANDARDS				GENERAL		
PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	ANALYSIS	RESULT
Arsenic as As			BDL	Chloride as Cl			45	Total Hardness as $CaCO_3$ (c)		244
Barium as Ba			BDL	Color*			23	Total Alkalinity as $CaCO_3$		240
Cadmium as Cd			BDL	Copper as Cu			BDL	N.C.H. as $CaCO_3$ (c)		4
Chromium as Cr			BDL	Corrosivity*				Bicarbonate as HCO_3 (c)		
Lead as Pb			BDL	Foaming Agents			BDL	Calcium as Ca		100
Mercury as Hg			BDL	H_2S				Magnesium as Mg		2.9
Selenium as Se			BDL	Iron as Fe			0.25	Carbon Dioxide as CO_2 (c)		
Silver as Ag			BDL	Manganese as Mn			0.02	Bicarbonate as $CaCO_3$ (c)		
Nitrate as N			BDL	Odor*			1	Carbonate as $CaCO_3$ (c)		240
Fluoride as F			0.25	pH*			7.60	Hydroxide as $CaCO_3$ (c)		
Turbidity,* NTU			3.5	Sulfate as SO_4			1.8	Sodium as Na		30
				TDS			373	Potassium as K		1.2
Endrin			BDL	Zinc as Zn			BDL	pHs* (c)		7.48
Lindane			BDL	Conductivity			587	Stability Index* 2pHs-pH (c)		
Methoxychlor			BDL					Saturation Index* pH-pHs (c)		+0.12
Toxaphene			BDL					INTERPRETATION: Stable		
2 4-D			BDL					Corrosive		
2 4-5 TP Silvex			BDL					[✓ Scale Forming]		
Trihalomethanes										

Total Coliform Density (per 100 ml) = +4
Gross Alpha particle activity (pCi/l) = 3.0±2.0

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
* BDL = Below detection limit, see reverse side

Date and Time Received: 06-10-82 @1452 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-21-82

Remarks: C-1283
B-1495

Analysts: Mark S Davis

Mark S. Davis, Chemist I

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY
P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: OB1-3
County: Palm Beach
Collector: T.L.
Address:
Sample Site:
Raw or Treated: Raw
Date and Time Collected: 05-07-82 @ 1130 hrs.
Field Chlorine, mg/l:
Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			84
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.16
Manganese as Mn			
Odor*			
pH*			8.22
Sulfate as SO_4			5.8
TDS			
Zinc as Zn			BDL
Conductivity			652

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		224
Total Alkalinity as $CaCO_3$		210
N.C.H. as $CaCO_3$ (c)		14
Bicarbonate as HCO_3 (c)		
Calcium as Ca		89
Magnesium as Mg		3.4
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		210
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		51
Potassium as K		1.3
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 05-07-82 @ 1355 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:
C-1010

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: OB1-8

County: Palm Beach

Collector: T.L.

Address:

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 05-07-82 @ 1100

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one: 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			57
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.1
Manganese as Mn			
Odor*			
pH*			8.11
Sulfate as SO_4			3.8
TDS			
Zinc as Zn			BDL
Conductivity			652

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		228
Total Alkalinity as $CaCO_3$		248
N.C.H. as $CaCO_3$ (c)		0
Bicarbonate as HCO_3 (c)		
Calcium as Ca		96
Magnesium as Mg		3.7
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		228
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		35
Potassium as K		1.2
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 05-07-82 @ 1355 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:
C-1012

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: OB1-9 County: Palm Beach Collector: T.L.

Address:

Sample Site: Raw or Treated: Raw

Date and Time Collected: 05-07-82 @ 1030 hrs. Field Chlorine, mg/l: Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4 D			
2 4 5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			69
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.1
Manganese as Mn			
Odor³			
pH*			7.92
Sulfate as SO_4			3.7
TDS			
Zinc as Zn			BDL
Conductivity			778

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		252
Total Alkalinity as $CaCO_3$		284
N.C.H. as $CaCO_3$ (c)		0
Bicarbonate as HCO_3 (c)		
Calcium as Ca		110
Magnesium as Mg		5.5
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		252
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		54
Potassium as K		1.3
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 05-07-82 @ 1355 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: PW-2

County: Palm Beach

Collector: HVM & JR

Address:

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 06-15-82 @ 0955 hrs.

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS				SECONDARY STANDARDS				GENERAL		
PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	ANALYSIS	RESULT
Arsenic as As			BDL	Chloride as Cl			65	Total Hardness as $CaCO_3$ (c)		320
Barium as Ba			BDL	Color*			30	Total Alkalinity as $CaCO_3$		310
Cadmium as Cd			BDL	Copper as Cu			BDL	N.C.H. as $CaCO_3$ (c)		10
Chromium as Cr			BDL	Corrosivity*				Bicarbonate as HCO_3 (c)		
Lead as Pb			BDL	Foaming Agents				Calcium as Ca		210
Mercury as Hg			BDL	H_2S				Magnesium as Mg		6.2
Selenium as Se			BDL	Iron as Fe			0.43	Carbon Dioxide as CO_2 (c)		
Silver as Ag			BDL	Manganese as Mn			0.02	Bicarbonate as $CaCO_3$ (c)		
Nitrate as N			BDL	Odor*			1	Carbonate as $CaCO_3$ (c)		310
Fluoride as F			0.28	pH*			7.43	Hydroxide as $CaCO_3$ (c)		
Turbidity,* NTU			10	Sulfate as SO_4			2.3	Sodium as Na		50
				TDS			484	Potassium as K		1.3
Endrin			BDL	Zinc as Zn			BDL	pHs* (c)		7.07
Lindane			BDL	Conductivity			745	Stability Index* 2pHs-pH (c)		
Methoxychlor			BDL					Saturation Index* pH-pHs (c)		+0.36
Toxaphene			BDL					INTERPRETATION: Stable		
2 4-D			BDL					Corrosive		
2 4 5 TP Silvex			BDL					[✓ Scale Forming]		
Trihalomethanes										

Total Coliform Density (per 100ml) = -1
Gross Alpha Particle Activity (pCi/l) = 6.0 ± 5.0
Radium -226 (pCi/l) = 0.9 ± 0.1

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 06-15-82 @ 1238 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-21-82

Analysts: Mark S Davis
Mark S. Davis, Chemist I

Remarks:
C-1302
B-1537

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: OB2-2 County: Palm Beach Collector: T.L.

Address:

Sample Site: Raw or Treated: Raw

Date and Time Collected: 05-07-82 @ 1215 hrs. Field Chlorine, mg/l: Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one: 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS			
PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4 5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS			
PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			54
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.23
Manganese as Mn			
Odor*			
pH*			8.36
Sulfate as SO_4			3.1
TDS			
Zinc as Zn			BDL
Conductivity			776

GENERAL		
PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		300
Total Alkalinity as $CaCO_3$		302
N.C.H. as $CaCO_3$ (c)		0
Bicarbonate as HCO_3 (c)		
Calcium as Ca		116
Magnesium as Mg		5.8
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		300
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		45
Potassium as K		1.2
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 05-07-82 @ 1355 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts: Mark S Davis

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY
P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: PW-3
County: Palm Beach
Collector: Client
Address:
Sample Site:
Raw or Treated: Raw.
Date and Time Collected: 07-30-82 @ 1235 hrs.
Field Chlorine, mg/l:
Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS				SECONDARY STANDARDS				GENERAL		
PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	ANALYSIS	RESULT
Arsenic as As			BDL	Chloride as Cl			50	Total Hardness as $CaCO_3$ (c)		170
Barium as Ba			BDL	Color*			15	Total Alkalinity as $CaCO_3$		158
Cadmium as Cd			BDL	Copper as Cu			BDL	N.C.H. as $CaCO_3$ (c)		12
Chromium as Cr			BDL	Corrosivity*				Bicarbonate as HCO_3 (c)		
Lead as Pb			BDL	Foaming Agents			BDL	Calcium as Ca		59
Mercury as Hg			BDL	H_2S				Magnesium as Mg		3.0
Selenium as Se			BDL	Iron as Fe			0.46	Carbon Dioxide as CO_2 (c)		
Silver as Ag			BDL	Manganese as Mn			0.02	Bicarbonate as $CaCO_3$ (c)		
Nitrate as N			BDL	Odor*			1	Carbonate as $CaCO_3$ (c)		158
Fluoride as F			0.11	pH*			7.93	Hydroxide as $CaCO_3$ (c)		
Turbidity,* NTU			0.88	Sulfate as SO_4			3.2	Sodium as Na		27
				TDS			236	Potassium as K		1.2
Endrin			BDL	Zinc as Zn			BDL	pHs* (c)		7.87
Lindane			BDL	Conductivity			475	Stability Index* 2pHs-pH (c)		
Methoxychlor			BDL					Saturation Index* pH-pHs (c)		+0.06
Toxaphene			BDL					INTERPRETATION: Stable		
2 4-D			BDL					Corrosive		
2 4 5 TP Silvex			BDL					[✓ Scale Forming]		
Trihalomethanes										

Total Coliform Density (per 100ml) = -1
Gross Alpha Particle Activity (pCi/l) = 3.0 ± 2.0

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 07-30-82 @ 1300 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-21-82

Remarks:
B-1910

Analysts:
Mark S. Davis, Chemist I

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY
P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-1
County: Palm Beach
Collector: T.L.

Address:

Sample Site:
Raw or Treated: Raw

Date and Time Collected: 04-22-82 @ 1350 hrs.
Field Chlorine, mg/l:
Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2, 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			92
Color*			
Copper as Cu			0.01
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.9
Manganese as Mn			
Odor*			
pH*			7.39
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			697

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		190
Total Alkalinity as $CaCO_3$		172
N.C.H. as $CaCO_3$ (c)		18
Bicarbonate as HCO_3 (c)		
Calcium as Ca		55
Magnesium as Mg		13.4
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		172
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		69
Potassium as K		5.3
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
* BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1610 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-2 County: Palm Beach Collector: T.L.

Address:

Sample Site: Raw or Treated: Raw

Date and Time Collected: 04-22-82 @ 1300 hrs. Field Chlorine, mg/l: Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			85
Color*			
Copper as Cu			0.01
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.8
Manganese as Mn			
Odor*			
pH*			7.33
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			624

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		169
Total Alkalinity as $CaCO_3$		164
N.C.H. as $CaCO_3$ (c)		5
Bicarbonate as HCO_3 (c)		
Calcium as Ca		55
Magnesium as Mg		5.8
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		164
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		69
Potassium as K		1.8
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1610 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-3
County: Palm Beach
Collector: T.L.

Address:

Sample Site:
Raw or Treated: Raw

Date and Time Collected: 04-22-82 @ 1515 hrs.
Field Chlorine, mg/l:
Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS				SECONDARY STANDARDS				GENERAL		
PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	ANALYSIS	RESULT
Arsenic as As				Chloride as Cl			83	Total Hardness as $CaCO_3$ (c)		166
Barium as Ba				Color*				Total Alkalinity as $CaCO_3$		154
Cadmium as Cd				Copper as Cu			0.01	N.C.H. as $CaCO_3$ (c)		12
Chromium as Cr				Corrosivity*				Bicarbonate as HCO_3 (c)		
Lead as Pb				Foaming Agents				Calcium as Ca		63
Mercury as Hg				H_2S				Magnesium as Mg		4.4
Selenium as Se				Iron as Fe			0.65	Carbon Dioxide as CO_2 (c)		
Silver as Ag			BDL	Manganese as Mn				Bicarbonate as $CaCO_3$ (c)		
Nitrate as N				Odor*				Carbonate as $CaCO_3$ (c)		154
Fluoride as F				pH*			7.75	Hydroxide as $CaCO_3$ (c)		
Turbidity,* NTU				Sulfate as SO_4				Sodium as Na		60
				TDS				Potassium as K		1.8
Endrin				Zinc as Zn			BDL	pHs* (c)		
Lindane				Conductivity			603	Stability Index* 2pHs-pH (c)		
Methoxychlor								Saturation Index* pH-pHs (c)		
Toxaphene								INTERPRETATION: Stable		
2 4-D								Corrosive		
2 4 5 TP Silvex								Scale Forming		
Trihalomethanes										

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1610 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts: Neil S Davis

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY
P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-4

County: Palm Beach

Collector: T.L.

Address:

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 04-22-82 @ 1630 hrs.

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one: 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS			
PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4 5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS			
PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			87
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.87
Manganese as Mn			
Odor*			
pH*			7.59
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			606

GENERAL		
PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		166
Total Alkalinity as $CaCO_3$		148
N.C.H. as $CaCO_3$ (c)		18
Bicarbonate as HCO_3 (c)		
Calcium as Ca		56
Magnesium as Mg		9.8
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		148
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		63
Potassium as K		5.0
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 0930 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-5

County: Palm Beach

Collector: T.L.

Address:

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 04-21-82 @ 1145 hrs.

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one: 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS				SECONDARY STANDARDS				GENERAL		
PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	METHOD†	ANALYSIS	RESULT	PARAMETER	ANALYSIS	RESULT
Arsenic as As				Chloride as Cl			76	Total Hardness as $CaCO_3$ (c)		218
Barium as Ba				Color*				Total Alkalinity as $CaCO_3$		216
Cadmium as Cd				Copper as Cu			BDL	N.C.H. as $CaCO_3$ (c)		2
Chromium as Cr				Corrosivity*				Bicarbonate as HCO_3 (c)		
Lead as Pb				Foaming Agents				Calcium as Ca		87
Mercury as Hg				H_2S				Magnesium as Mg		3.6
Selenium as Se				Iron as Fe			2.49	Carbon Dioxide as CO_2 (c)		
Silver as Ag			BDL	Manganese as Mn				Bicarbonate as $CaCO_3$ (c)		
Nitrate as N				Odor*				Carbonate as $CaCO_3$ (c)		216
Fluoride as F				pH*			7.67	Hydroxide as $CaCO_3$ (c)		
Turbidity,* NTU				Sulfate as SO_4				Sodium as Na		48
				TDS				Potassium as K		2.0
Endrin				Zinc as Zn			BDL	pHs* (c)		
Lindane				Conductivity			636	Stability Index* 2pHs-pH (c)		
Methoxychlor								Saturation Index* pH-pHs (c)		
Toxaphene								INTERPRETATION: Stable		
2,4-D								Corrosive		
2,4,5 TP Silvex								Scale Forming		
Trihalomethanes										

Note: All results in mg/liter except those denoted

†List of methods available on request

(c) = Calculated value

BDL = Below detection limit, see reverse side

Date and Time Received: 04-21-82 @ 1145 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:
C-886

Analysts: Mark S Davis

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-8

County: Palm Beach

Collector: T.L.

Address

Sample Site:

Raw or Treated: Raw

Date and Time Collected: 04-22-82 @ 1010 hrs.

Field Chlorine, mg/l:

Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			65
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.9
Manganese as Mn			
Odor*			
pH*			7.45
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			564

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		164
Total Alkalinity as $CaCO_3$		158
N.C.H. as $CaCO_3$ (c)		6
Bicarbonate as HCO_3 (c)		
Calcium as Ca		63
Magnesium as Mg		3.7
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		158
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		45
Potassium as K		1.4
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: *All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1610 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts:

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY
P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

System Name: SC-6
County: Palm Beach
Collector: TL
Address:
Sample Site:
Raw or Treated: Raw
Date and Time Collected: 04-21-82 @ 1545 hrs.
Field Chlorine, mg/l:
Field pH:

Circle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

Circle one: 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4-5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			88
Color*			
Copper as Cu			BDL
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			1.09
Manganese as Mn			
Odor*			
pH*			7.78
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			655

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		166
Total Alkalinity as $CaCO_3$		168
N.C.H. as $CaCO_3$ (c)		0
Bicarbonate as HCO_3 (c)		
Calcium as Ca		56
Magnesium as Mg		8.6
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		166
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		70
Potassium as K		3.8
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1600 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Analysts: Mark S Davis

Remarks:
C-887

CITY OF WEST PALM BEACH
WATER ANALYSIS LABORATORY

P.O. Box 3506
West Palm Beach, FL 33402

DRINKING WATER CHEMICAL ANALYSIS

ystem Name: SC-7
County: Palm Beach
Collector: T.L.

ddress:

ample Site:
Raw or Treated: Raw

ate and Time Collected: 04-22-82 @ 0945 hrs.
Field Chlorine, mg/l:
Field pH:

ircle one: 40. Community public water system 41. Non-community public water system 42. Other public water system 43. Private water system

ircle one. 1. Compliance 2. Recheck 3. Complaint (Describe)

PRIMARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Arsenic as As			
Barium as Ba			
Cadmium as Cd			
Chromium as Cr			
Lead as Pb			
Mercury as Hg			
Selenium as Se			
Silver as Ag			BDL
Nitrate as N			
Fluoride as F			
Turbidity,* NTU			
Endrin			
Lindane			
Methoxychlor			
Toxaphene			
2 4-D			
2 4 5 TP Silvex			
Trihalomethanes			

SECONDARY STANDARDS

PARAMETER	METHOD†	ANALYSIS	RESULT
Chloride as Cl			99
Color*			
Copper as Cu			0.02
Corrosivity*			
Foaming Agents			
H_2S			
Iron as Fe			0.85
Manganese as Mn			
Odor*			
pH*			7.87
Sulfate as SO_4			
TDS			
Zinc as Zn			BDL
Conductivity			689

GENERAL

PARAMETER	ANALYSIS	RESULT
Total Hardness as $CaCO_3$ (c)		164
Total Alkalinity as $CaCO_3$		152
N.C.H. as $CaCO_3$ (c)		12
Bicarbonate as HCO_3 (c)		
Calcium as Ca		47
Magnesium as Mg		14
Carbon Dioxide as CO_2 (c)		
Bicarbonate as $CaCO_3$ (c)		
Carbonate as $CaCO_3$ (c)		152
Hydroxide as $CaCO_3$ (c)		
Sodium as Na		73
Potassium as K		6.3
pHs* (c)		
Stability Index* 2pHs-pH (c)		
Saturation Index* pH-pHs (c)		
INTERPRETATION: Stable		
Corrosive		
Scale Forming		

Note: All results in mg/liter except those denoted
†List of methods available on request

(c) = Calculated value
BDL = Below detection limit, see reverse side

Date and Time Received: 04-22-82 @ 1610 hrs.

Laboratory I.D. No.: 56098

Date Reported: 09-09-82

Remarks:

Analysts: