
N

Figure 2CC-223 Location of Units 6 & 7 Construction Dewatering Cut-Off Walls

FPLNNP-09-0664 - Turkey Point 6 & 7 APT Data Request

Water quality sampling through grab sampling was performed during drilling of the boreholes on site and from the production (PW-1) and monitoring wells through the duration of the APT. Field water quality data was obtained on a regular frequency of every half hour from the monitoring wells, Biscayne Bay and the Industrial Wastewater Facility using Aqua Trolls (In-Situ Corporation) installed in each well and the surface water bodies. An Aqua Troll was installed in the test production well PW-1, but the instrument malfunctioned at the beginning of the APT. Turbulence in the well from pumping was believed to be the cause of the instrument malfunction, therefore a decision was made not to replace the instrument but to rely on the daily grab samples obtained from PW-1during the pumping phase of the APT. Background data (pre-test) from the Aqua Troll for PW-1 is available but was not included in the APT report since a full data set (pre, during, post APT) was not available for this instrument. The following table summarizes the Aqua Troll data for all of the monitoring points, and the attached graphs show the salinity and specific conductance background data for PW-1 added to the graphs.

As stated in the APT report, the data show the highest conductivity and salinity at the Industrial Wastewater Facility canal, and the lowest at monitoring well MW-1-SS (shallow well at nest MW-1). The average salinity in monitoring wells (excluding MW-1 SS) ranged from approximately 35 to 38 PSU, or roughly that of seawater, for the combined pre, during, and post test period. The salinity in PW-1 as measured with the Aqua Troll during the pre-test background period also ranged from 35 to 38 PSU.

The results of the grab sample analyses for PW-1 are included in Appendix G of the APT report, and graphically in Figure 6.4 of the report. The laboratory analytical data for TDS, chloride, and other analytes are included in Figure 6.4. Salinity data from the PW-1 grab samples were not utilized since the values were not consistent with the chloride and TDS values in the samples. TDS values in the grab samples ranged from 30,400 to 36,400 mg/l, with an average value of 33,931 mg/l. Chloride in the grab samples ranged from 12,300 to 23,300 with an average chloride concentration of 19,400 mg/l. If the 12,300 mg/l value is considered an anomaly, the range of chloride is then 16,800 to 23,300 mg/l, with an average of 19, 954 mg/l.

The average chloride concentration was converted to salinity based on the empirical relationship S (ppt)=1.80655 x Cl (ppt) (from Duxbury 1977). Using the average of 19,400 mg/l gives a value of 35 PSU, which is similar to the average of 36 PSU using the Aqua Troll background period data. If 19,954 mg/l is used the calculated salinity is 36 PSU, which is equal to the average of 36 PSU using the Aqua Troll background period data.

Reference: Duxbury, A.C, *The Earth and it's Oceans*, Addison-Wesley Publishing Company, Inc., 1977.

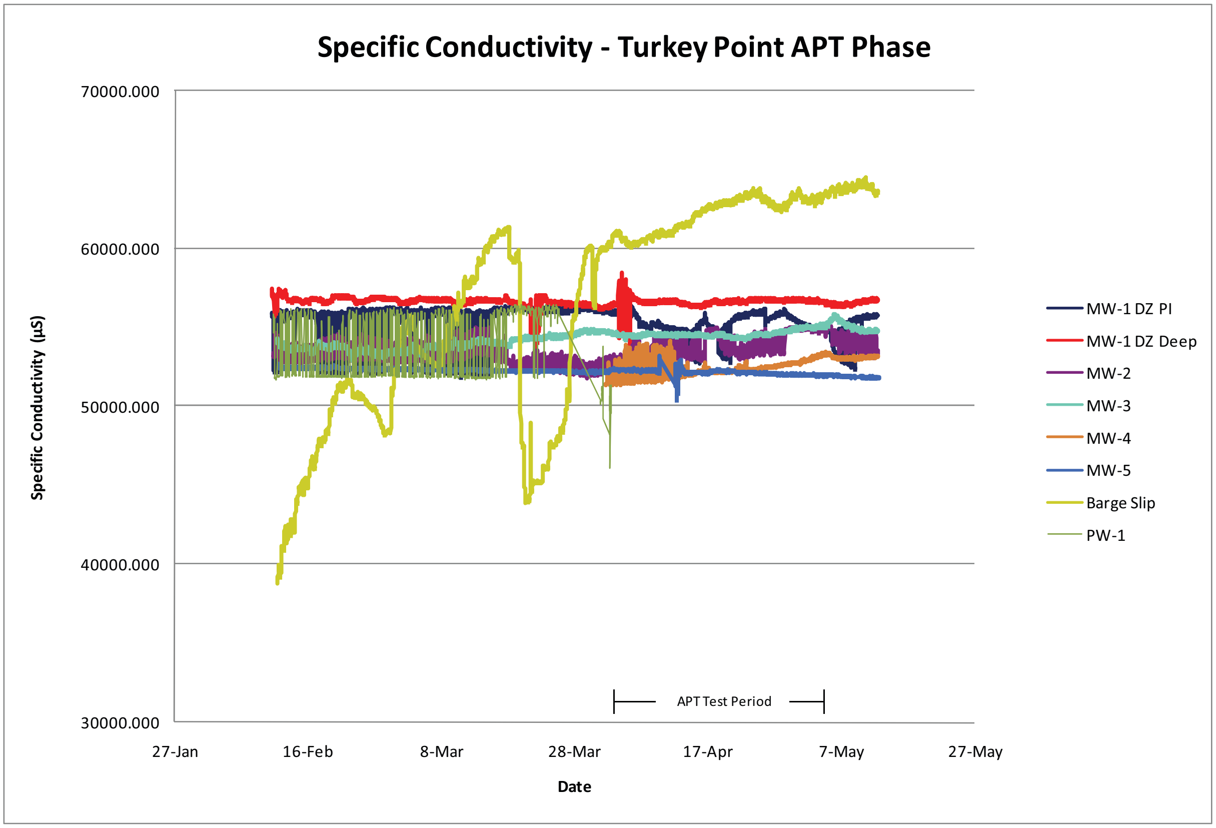
Aqua Troll Conductivity Data Summary (uS)

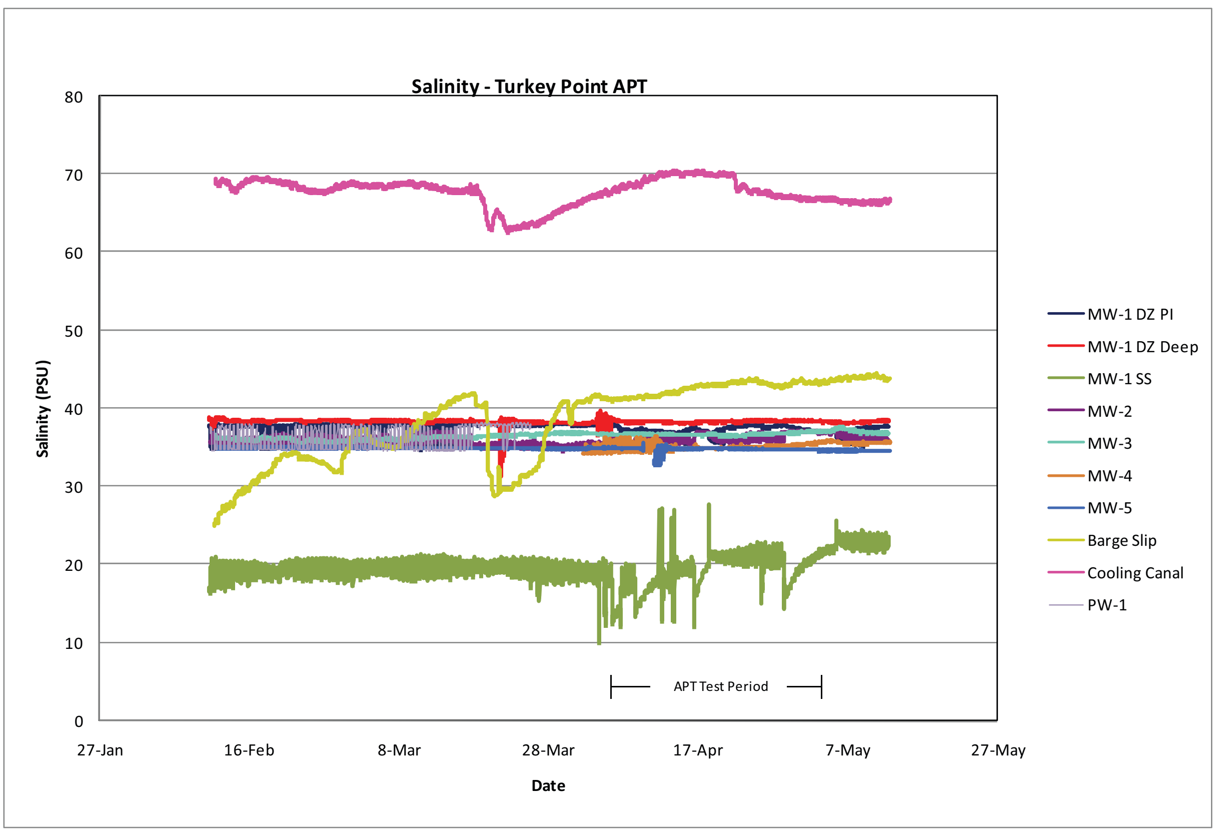
	MW-1 DZ PI	MW-1 DZ Deep	MW-1 SS	MW-2	MW-3	MW-4	MW-5	PW-1	Barge Slip	IWW Canal
avg	55,499	56,649	31,072	53,500	54,351	52,562	52,220	53,896	56,800	92,919
max	56,665	58,453	42,560	55,126	55,900	54,153	53,210	56,433	64,482	95,914
min	51,894	53,230	19,896	51,751	52,928	51,352	50,420	46,087	38,768	87,067

Aqua Troll Salinity Data Summary (PSU)

	MW-1 DZ PI	MW-1 DZ Deep	MW-1 SS	MW-2	MW-3	MW-4	MW-5	PW-1	Barge Slip	IWW Canal
avg	37	38	20	36	37	35	35	36	38	68
max	38	40	28	37	38	36	36	38	45	71
min	35	31	10	35	35	34	33	35	25	63

Note: Monitoring period for PW-1: February 10 to April 2, 2009; Monitoring period for all other stations: February 10 to May 12, 2009


Specific Conductivity - Turkey Point APT Phase
70000.000
60000.000
50000.000
40000.000
30000.000
Specific Conductivity (µS)
27-Jan
16-Feb
8-Mar
28-Mar
17-Apr
7-May
27-May
Date
APT Test Period
MW-1 DZ PI
MW-1 DZ Deep
MW-2
MW-3
MW-4
MW-5
Barge Slip
PW-1


Salinity - Turkey Point APT
80
70
60
50
40
30
20
10
0
Salinity (PSU)
27-Jan
16-Feb
8-Mar
28-Mar
17-Apr
7-May
27-May
Date
APT Test Period
MW-1 DZ PI
MW-1 DZ Deep
MW-1 SS
MW-2
MW-3
MW-4
MW-5
Barge Slip
Cooling Canal
PW-1

REPORT

2010 ANNUAL REPORT GROUND-WATER MONITORING PROGRAM

Florida Power & Light Company
Turkey Point Plant
Miami-Dade County, Florida

Submitted To: Florida Power & Light Company
Turkey Point Nuclear Plant
700 Universe Boulevard
Juno Beach, Florida 33408

Submitted By: Golder Associates Inc.
3730 Chamblee Tucker Road
Atlanta, Georgia 30341 USA
Certificate of Authorization Number: 1670

HAROLD A. FREDIANI, JR. ★ ENGINEER
LICENSE No. 36394 ★ STATE OF FLORIDA
PROFESSIONAL

Harold A. Frediani, Jr.

Harold A. Frediani, Jr., PE 36394

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August 30, 2010

10390259

A world of capabilities delivered locally

Golder Associates

August 30, 2010 10390259

Mr. John Jones
Florida Power & Light Company
Environmental Affairs Department
Post Office Box 078768
West Palm Beach, Florida 33407-0768

RE: 2010 ANNUAL REPORT
GROUND-WATER MONITORING PROGRAM
TURKEY POINT PLANT
DADE COUNTY, FLORIDA

Dear Mr. Jones:

Golder Associates Inc. (Golder) is pleased to submit this Annual Report on the Ground-Water Monitoring Program at the Turkey Point Generating Station for the period of July 2009 through June 2010.

Rainfall totals for the 2009-2010 monitoring year were below the average year at S-20, but above the average year at S-20F. Rainfall data reported as S-20 from March 2008 onward is actually from FPL's meteorological tower near the Land Use Building.

Ground-water levels remained generally within historical limits, generally between 1 and 3.5 feet Mean Sea Level (MSL). Ground-water temperatures were generally within the historical envelope, but all wells had minor excursions of up to about 1°C. Ground-water salinity exceeded historical envelope levels at lower levels during all months for all wells, by up to as much as 10 PPT in well L-3, up to 11 PPT in well L-5, up to about 13 PPT in well G-28, and up to about 6 PPT for well G-21.

The Interceptor Ditch Program is continuing to be responsive and effective in performing its design function, which is to maintain a seaward gradient from the L-31 Canal towards the Interceptor Ditch at all times..

If you have any questions concerning this Annual Report, please do not hesitate to call.

Sincerely,

GOLDER ASSOCIATES INC.

Harold A Frediani Jr

Harold A. Frediani, Jr., PE
Senior Water Resources Engineer

HAF/kpl

X:\Clients\Florida Power and Light\10390259 Turkey Pt\250_Final Reports\100826_10390259_2010 GW Annual Report-HAF-2.docx

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1.0 INTRODUCTION

This is the 2010 Annual Report of the Ground-Water Monitoring and Interceptor Ditch Programs related to the cooling canal system at Florida Power & Light's (FPL's) Turkey Point Power Plant. This report is submitted in compliance with the Agreement between FPL and the South Florida Water Management District (SFWMD), dated July 15, 1983. Although SFWMD and FPL modified the agreement on October 14, 2009, to expand the monitoring plan, installation of that expansion is not yet complete. Therefore, this report is being prepared according to the July 15, 1983, format.

The purpose of the Ground-Water Monitoring Program is to monitor the ground-water levels, conductivities, and temperatures in the Biscayne aquifer west of the cooling canal system, and to determine the operational characteristics of the Interceptor Ditch. The Interceptor Ditch Program was established to control the westward seepage of saline water from the cooling canal system. The system is underlain by the brackish portion of the Biscayne aquifer classified as G-III (unconfined), as differentiated from the potable section of the Biscayne aquifer west of the canal system. Since April 1972, up to 83 wells (G-, L-, X-, ID-, F-, and E-Series wells) around the cooling canal system have been used to monitor, for various lengths of time, the ground-water conditions in the upper 60 feet of the aquifer (Figure 1). The results of these programs were reported quarterly to SFWMD in January, April, July, and October from 1972 through July 1976, semi-annually in January and July from August 1976 through July 1979, and annually thereafter. In addition, a summary report was submitted in March 1976 that presented the initial four years of G-Series well monitoring data.

Through July 15, 1983, the results of the Ground-Water Monitoring and Interceptor Ditch Programs led to two general conclusions:

1. Construction and operation of the cooling canal system resulted in no significant impact to the potable section of the Biscayne aquifer located to the west of the system; and
2. Operation of the Interceptor Ditch protected the potable sections of the Biscayne aquifer from saltwater intrusion.

It was concluded from the monitoring data that construction of the cooling canal system had a localized effect similar to moving the shoreline of Biscayne Bay to the western edge of the cooling canal system as, in effect, the top of the saltwater wedge has moved to the western edge of the cooling canal system. Some slight landward movement of the toe of the saltwater wedge was observed through the brackish sections of the Biscayne aquifer underlying the cooling canal system; however, water quality of the potable sections of the Biscayne aquifer west of the system was not affected. Saltwater wedge movement typically is seasonal in response to variations in rainfall and water levels.

The Interceptor Ditch operation is designed to prevent any seasonal inland movement of the saltwater into the potable portion of the Biscayne aquifer west of the site. The saline ground water is intercepted by the ditch and returned to the cooling canal system during the dry season when natural freshwater hydraulic gradients are low and the potential for saltwater intrusion exists.

The July 15, 1983, Agreement was executed on the general conclusion that movement of the saltwater wedge was confined to the western boundary of the cooling canal system by the operation of the Interceptor Ditch through a wide range of hydrometeorological conditions (with the exception of hurricanes). This continued high level of documented performance of the system justified reducing the ground-water monitoring requirements. The revised Ground-Water Monitoring Program requires the monitoring of water levels, temperature, and conductivity in Wells L-3, L-5, G-21, and G-28 on a quarterly basis (typically in October, January, April, and July). These wells are located west of the cooling canal system (as shown on Figure 2) to monitor any landward movement of the saltwater wedge. Since the 2009 report was issued, FPL has agreed to include monitoring at well G-35, which is the western-most well shown on Figure 1. The Interceptor Ditch Program was not altered by the July 15, 1983, Agreement. A description of the Interceptor Ditch operation is contained in that Agreement, and is also presented in Appendix B.

In March 1985 the USGS modified Well G-21 by installing a two-inch casing inside the well for point sampling the aquifer below the -45 feet MSL elevation. Thus, Well G-21 was no longer suitable for monitoring the ground-water conditions to the west of the cooling canal system as required by the Agreement. During the April and July 1985 quarterly monitoring period, Well G-6 was monitored as an alternate for Well G-21. A new and identically constructed well was installed by FPL at the G-21 location in July 1985. Data derived from this new well is presented as Well G-21 in all ground-water monitoring reports since that time.

After the January 1989 sampling, the upper section of the USGS Well G-28 collapsed. The well was subsequently appropriately abandoned by grouting and sealing the entire length of the well. On January 17 through 19, 1989, a new replacement well was constructed to the same specifications as its predecessor. Specifically, the two-inch diameter well was installed to a maximum depth of about 70 feet. The upper 15 feet of well was cased with Schedule 40 PVC pipe, and the remaining 55 feet of well was screened (0.010 slot width). The annular space between the screen and the well was filled with 20/30 silica sand.

2.0 OPERATIONAL OR STRUCTURAL CHANGES

During the period July 1, 2009, through June 30, 2010, no operational or structural changes were made. However, the Interceptor Ditch Pumps Nos. 1 and 2 were replaced with new pumps.

Because SFWMD abandoned the rain gage located at S-20 in March of 2008, the rainfall quantities reported for S-20 from that month forward are taken from the records of FPL's meteorological tower near the Land Use Building (see Figure 3).

3.0 CLIMATOLOGICAL CONDITIONS

Daily rainfall data has been historically recorded by SFWMD at structures S-20 and S-20F, located along the Levee 31 Borrow Canal. However, the rain gage at S-20 was taken offline in March, 2008. Rainfall data from FPL's meteorological tower near the Land Use building has been used as a surrogate for the S-20 gage from March, 2008 forward in this report. S20 and S20F data are available from SFWMD via their DBHydro browser. Historical monthly rainfall data collected since 1968 are presented in Figure 4 for S-20 and Figure 5 for S-20F.

The rainfall measured for the 2009 – 2010 monitoring period was below the 1968 to 2007 average for the area for Station S-20[1] and above the 1968 to 2009 average for the area for Station S-20F. The rain gauge at structure S-20F recorded 49.5 inches of precipitation from July 2008 to June 2009. The rainfall total at S-20F for this monitoring year is approximately 3.7 inches above the average values for the prior monitoring years. The annual total recorded on a monthly basis at structure S-20F is presented in Table 1 and compared to an updated historical average for the 1968 to 2009 yearly reporting period. The historical average annual rainfall amount for structure S-20F is 45.8 inches per year. The rainfall total at S-20 for this monitoring year is approximately 29 inches below the average values for the prior monitoring years. The annual total recorded on a monthly basis at structure S-20 is presented in Table 1 and compared to the historical average for the 1969 to 2008 yearly reporting period. The historical average annual rainfall amount for structure S-20 is 45.8 inches per year.

As shown in Figures 4 and 5, the rainfall distribution for this past year was concentrated in the months of September, 2009 and April and June 2010 for S-20F; and July, August, and November, 2009 for S-20. These are all months historically designated as during the wet season, except for April, 2010 for S-20F and November, 2009, for S-20. During an average year, approximately 74 percent of the precipitation occurs during the wet season with the remainder occurring during the six-month-long dry season (November to April). During this past year, approximately 53 and 59 percent of the annual rainfall occurred during the wet season at S-20 and S-20F, respectively. Rainfall at S-20F was above average for September, November, and December, 2009, and February and April, 2010, about average in March, 2010, and below average the other six months. Rainfall at S-20 was slightly above average during November, 2009, and below average the other eleven months.

The 2009 and 2010 hurricane seasons produced no significant storms during the monitoring period.

[1] Rainfall data reported as S-20 from March 2008 onward is actually from FPL's meteorological tower near the Land Use Building.

4.0 DATA REVIEW

4.1 Ground-Water Levels

Ground-water levels are measured quarterly in Wells L-3, L-5, G-21, G-28, and G-35 usually near the start of July, October, January, and April. The maximum and minimum levels recorded during the historical period, are shown on Figure 6. The start dates for the historical period for each well are as follows:

- L-3; April, 1974
- L-5; January, 1976
- G-21; April, 1972
- G-28; April, 1972
- G-35; April, 1972

The end date of the historical period is April, 1990, for the four wells L-3, L-5, G-21, and G-28. Data were not recorded for well G-35 between 1983 and this monitoring period; therefore, no historical envelopes have been presented for this well.

The ground-water levels measured during this monitoring period are also shown on Figure 6. These levels were in the upper part of the range between the historical maximums and minimums for the wells L-3, L-5, G-21, and G-28 (the "traditional" wells), except for L-5. Water levels generally ranged between about 1 and 2.5 feet MSL for the traditional wells, and were higher during October. Water levels in well G-35 ranged between about 2 to 3.5 feet MSL, and was highest in April. Water levels in the G wells were generally slightly higher than those in the L wells.

4.2 Ground-Water Temperatures

Ground-water temperatures are measured on a quarterly basis at one-foot intervals throughout the water column in all wells. The temperatures recorded during this monitoring period for the four traditional wells (Figures 7 through 10) are compared with the historical envelope data. The historical envelope represents both the highest and lowest temperatures recorded during the period July, 1981, through June, 1991. The historical period represents the time during which the cooling canal system came to equilibrium.

With the exception of minor excursions in well L-3, only well L-5 of the traditional wells had excursions in temperature in July and October, 2009 from the ground to -15 MSL, above the historical respective maxima. All of the wells had excursions below the historical respective minima. Well L-3 had excursions below the minima of up to about 4.0° C for January, in the 0 to -25 feet MSL elevation interval. Well L-5 had excursions below the minima of up to about 1.5 degrees C for October and July, in the -5 to -15 feet MSL elevation interval. Well G-21 had excursions below the minimum of up to 2 degrees C from elevation 0 to elevation -9 feet MSL in January, 2010, and Well G-28 was slightly below the minimum in

January and April of 2010 in the elevation interval between 0 and -5 feet MSL. Temperature variations in Wells L-3 and L-5 (both located near the cooling canal system) historically tend to respond to pumping activities in the Interceptor Ditch area while temperature variations in Well G-21 and Well G-28 are thought to change more in response to ground-water levels and rainfall quantities.

Figure 11 shows the ground-water temperatures in well G-35.

Overall the data indicate that temperatures are following the normal seasonal trends.

4.3 Ground-Water Chloride Contents

The procedure to determine the chloride level is to measure conductivity at one foot intervals in the entire water column in each well. The conductivity data are then converted to chloride values according to the procedures outlined in the Agreement. The chloride values have been compared to the historical range of values for the four traditional wells, which cover the same periods as described for the historical temperature envelope in 4.2 above. These comparisons are presented graphically in Figures 12 through 15.

None of the upper level recorded chloride data reported are outside the respective historical occurrence envelopes, down to the following elevations:

- L-3: -20 feet MSL
- L-5: -17 feet MSL
- G-21: -37 feet MSL
- G-28: -13 feet MSL

For well G-21, chloride exceeds the maximum historical envelope for the interval below elevation -38/-42 feet MSL, up to a maximum of about 5.6 parts per thousand (PPT) in July, 2009. Chloride at depth below about elevation -20/-29 in L-3 exceeds the historical envelope values by up to about 10 PPT during all sampling episodes. Chloride at depth below about -17 feet MSL in L-5 exceeds the historical envelope values by up to about 8 PPT to about 10 PPT. Chloride in G-28 exceeded the historical envelope by about 2 PPT between elevations -13 to about -28 feet MSL, and by up to about 9 to 13 PPT at depths below elevation -28 feet MSL.

Chloride values in well G-35 are shown in Figure 16.

In every case the chloride exceedances of the historical envelope within the four traditional wells increase with increasing depth.

4.4 Surface Water Levels and Interceptor Ditch Operation

Surface water levels have been historically measured in the Levee 31E Borrow Canal (L-31E), the Interceptor Ditch (ID), and Cooling System Canal 32 (C-32) as required by the Interceptor Ditch Operation criteria outlined in Appendix B. The water levels are measured in these canals at pumping Lines A, B, C, D, and E as shown on Figure 17. Water levels recorded during the past 12-month monitoring period are presented on Figures 18 through 22. Operation of the ID pumps is shown on Figure 23, along with the measured rainfall.

Figure 18 shows the water levels along Line A. Water levels in L-31E at Line A exceeded water levels in the ID for the entire year, and exceeded water levels in C-32 except brief periods in March, April, and May, 2010. The head difference between L-31E and C-32 varied from 0.92 to -0.4 feet. The head difference between L-31E and the ID varied between 0.89 and 0.16 feet.

Figure 19 shows the water levels along Line B. Water levels in L-31E at Line B exceeded water levels in the ID for the entire year, and exceeded water levels in C-32 except in March and April, 2010. The head difference between L-31E and C-32 varied from 0.97 to -0.32 feet. The head difference between L-31E and the ID varied between 0.76 and 0.14 feet.

Figure 20 shows the water levels along Line C. Water levels in L-31E at Line C exceeded water levels in the ID for the entire year, and exceeded water levels in C-32 except briefly in April, 2010. The head difference between L-31E and C-32 varied from 0.98 to -0.07 feet. The head difference between L-31E and the ID varied between 0.41 and 0.14 feet.

Figure 21 shows the water levels along Line D. Water levels in L-31E at Line D exceeded water levels in both the ID and in C-32 for the entire year. The head difference between L-31E and C-32 varied from 1.06 to 0.34 feet. The head difference between L-31E and the ID varied between 0.47 and 0.12 feet.

Figure 22 shows the water levels along Line E. Water levels in L-31E at Line E exceeded water levels in both the ID and in C-32 for the entire year. The head difference between L-31E and C-32 varied from 1.06 to 0.52 feet. The head difference between L-31E and the ID varied between 0.47 and 0.1 feet.

Pump 1 was operated during March, 2010 (8.7 days), April, 2010 (3.2 days), and May, 2010 (15 days) to maintain the seaward gradient between L-31E and the ID. Pump 2 was operated for 15 days starting in March through April, 2010, due to the installation of the Pump 1 flow meter. Pumps 3 and 4 were not operated in the 2009-2010 monitoring period.

4.5 Data Interpretation

Rainfall recorded during the 2009/2010 monitoring period was below average (see Figures 4 and 5, and Table 1) at S-20[1] and above average at S-20F. Rainfall was concentrated in the months of September, 2009 and April and June 2010 for S-20F; and July, August, and November, 2009 for S-20, reflecting a slightly higher than average differential between wet versus dry season rainfall distribution. Rainfall during the dry season months was significantly less than the historical average for these months.

Ground-water levels during this monitoring year were highest during the wet season month of October and lowest during the month of April, 2010 for the four traditional wells. The maximum water level in well G-35 occurred in April, 2010.

No temperature excursions above historical levels were recorded in Wells G-21 and G-28. However, minimal excursions were recorded in well L-3 at depths between -0 and -3 feet during July, 2009, and excursions of up to 1.5 degrees C at for Well L-5 at depths between -6 and -15 during July and October 2009.

No excursions of chloride outside of historical limits were evident in the reported data at elevations above -12 feet MSL (-37 feet for Well G-21). The monitoring data also indicate that no apparent increase in elevation of the fresh/salt water transition zone has occurred in any of the wells during the July 2009 to June 2010 monitoring period.

The Interceptor Ditch Program is continuing to be responsive and effective in performing its design function, which is to maintain a seaward gradient from the L-31 Canal towards the Interceptor Ditch at all times . With respect to whether movement of saline water westward of Levee 31E was restricted to those amountswhich would occurwithout the existence of the Cooling Canal System (CCS) , analysis of historical data is required. Figure 2 of the FGS Information Circular No. 9 (see Appendix C) shows the 1,000-ppm isochlor was about 6.5 miles west of the CCS in 1951. All five of the monitoring wells are seaward of the 1,000-ppm isochlor. The 2010 data show the 1,000 ppm isochlor in the G wells at depths of about 40 feet at G-35,and G-21, and 13 feet in G-28. The 2010 data show the 1,000-ppm isochlor in the L wells at about -9 feet MSL in L-3 and about -16 feet in L-5. These data are all consistent with Figure 2 of the FGS Information Circular no. 9, which indicates all five wells are significantly seaward (more than 1.5 miles) from the 1,000-ppm isochlor depicted therein for 1951.

[1] Rainfall data reported as S-20 from March 2009 onward is actually from FPL's meteorological tower near the Land Use Building.

5.0 SUMMARY AND CONCLUSIONS

Rainfall totals for the 2009-2010 monitoring year were below the average year at S-20[1], but above the average year at S-20F.

Ground-water levels remained generally within historical limits, generally between 1 and 3 feet MSL. Ground-water temperatures were within the historical envelope, except in well L-5, which had minor excursions of up to about 1.5°C. Ground-water salinity exceeded historical envelope levels at lower levels during all months for all wells, by up to as much as 10 PPT in wells L-3, L-5, and G-28, and up to about 5 PPT for well G-21.

The Interceptor Ditch Program is continuing to be responsive and effective in performing its design function of maintaining a seaward gradient between L-31E and the Interceptor Ditch. Although there has been public speculation that movement of saline water westward of Levee 31E has not been restricted to those amounts which would occur without the existence of the Cooling Canal System (CCS), comparison of the 2010 data to historical chloride levels before the CCS was constructed indicates that such is not the case.

[1] Rainfall data reported as S-20 from March 2009 onward is actually from FPL's meteorological tower near the Land Use Building.

TABLES

Table 1

Monthly Rainfall Data

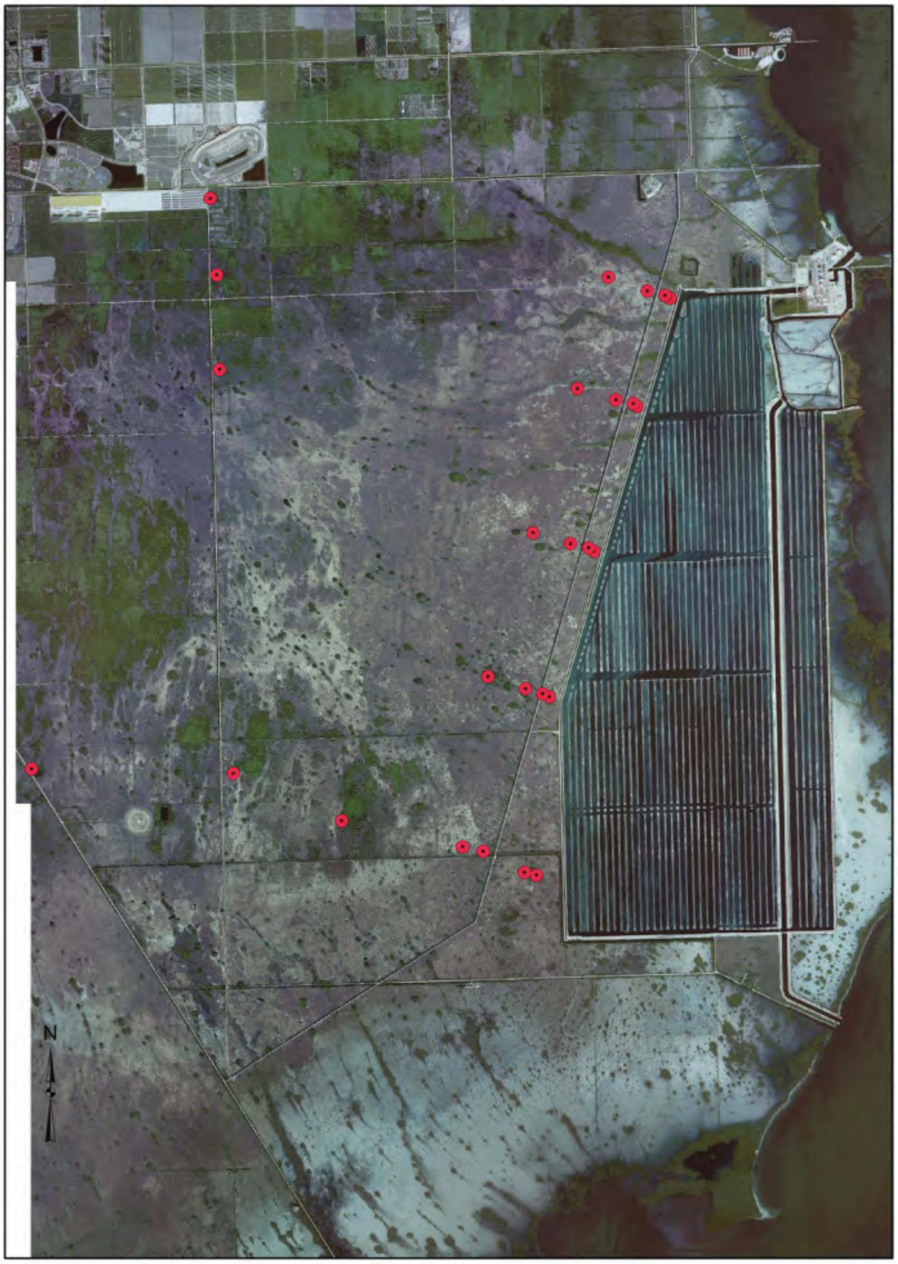
(2009-2010) vs. (1968-2009)

Turkey Point, Florida

Month	Station S-20 Rainfall (inches)*		Station S-20F Rainfall (inches)	
	2009-2010	**1968-2009**	**2009-2010**	**1968-2009**
July, 2009	2.38	4.65	3.78	4.87
August, 2009	2.37	6.50	4.29	5.84
September, 2009	1.39	6.39	11.50	6.51
October, 2009	0.61	4.96	1.98	5.10
November, 2009	2.76	2.63	4.43	2.63
December, 2009	1.38	1.70	3.27	1.53
January, 2010	0.60	1.74	0.96	1.72
February, 2010	1.30	1.58	3.22	1.60
March, 2010	0.87	1.78	1.73	1.88
April, 2010	0.85	2.16	6.59	2.10
May, 2010	1.22	4.23	1.38	4.31
June, 2010	0.79	7.15	6.38	7.73
TOTALS:	**16.5**	**45.5**	**49.5**	**45.8**

* FPL Land Use Meteorological Tower data used from March, 2008, onward

FIGURES



LEGEND

Monitoring Wells

0 1,050 2,100 4,200 Meters

FPL

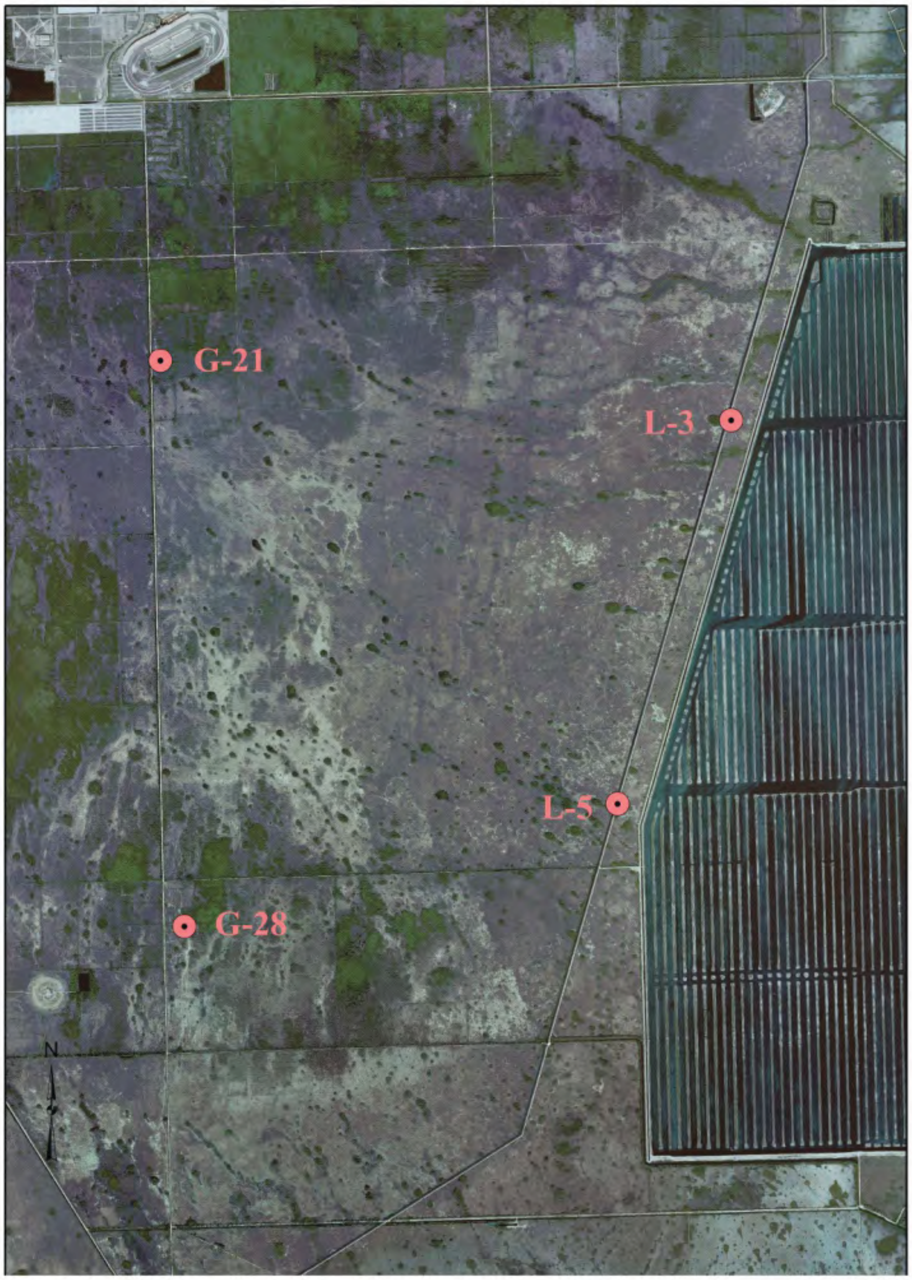
Golder Associates

Atlanta, Georgia

TITLE

Original Monitoring Program Well Locations

CLIENT/PROJECT	DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
FPL/2010 Annual Report Groundwater Monitoring Program/FL	CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
	REVIEWED HF	FILE NO. 10390259 Figure 1	SUBTITLE	FIGURE NO. 1



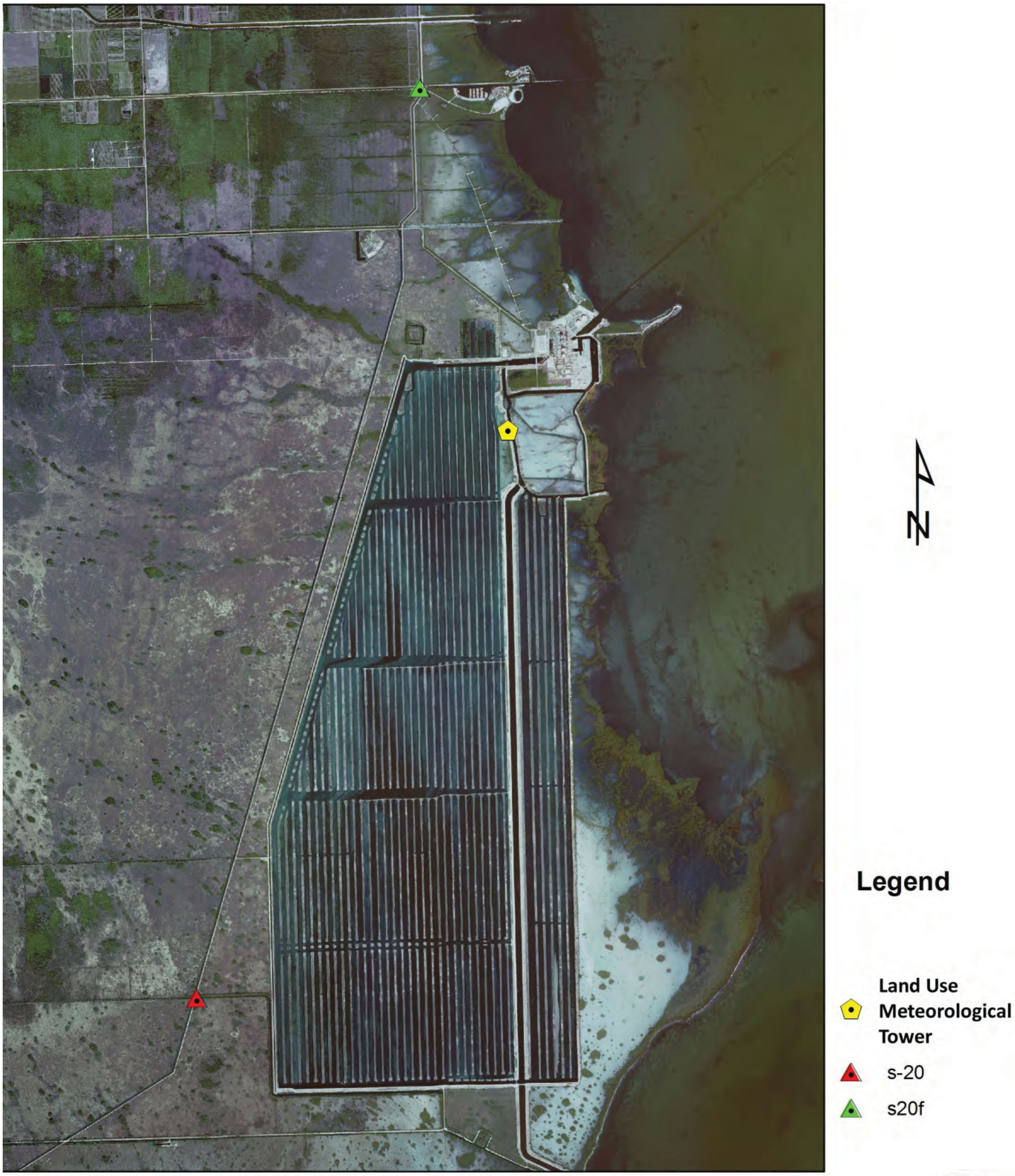
LEGEND

0 37.5 75 150 Mile

Monitoring Wells

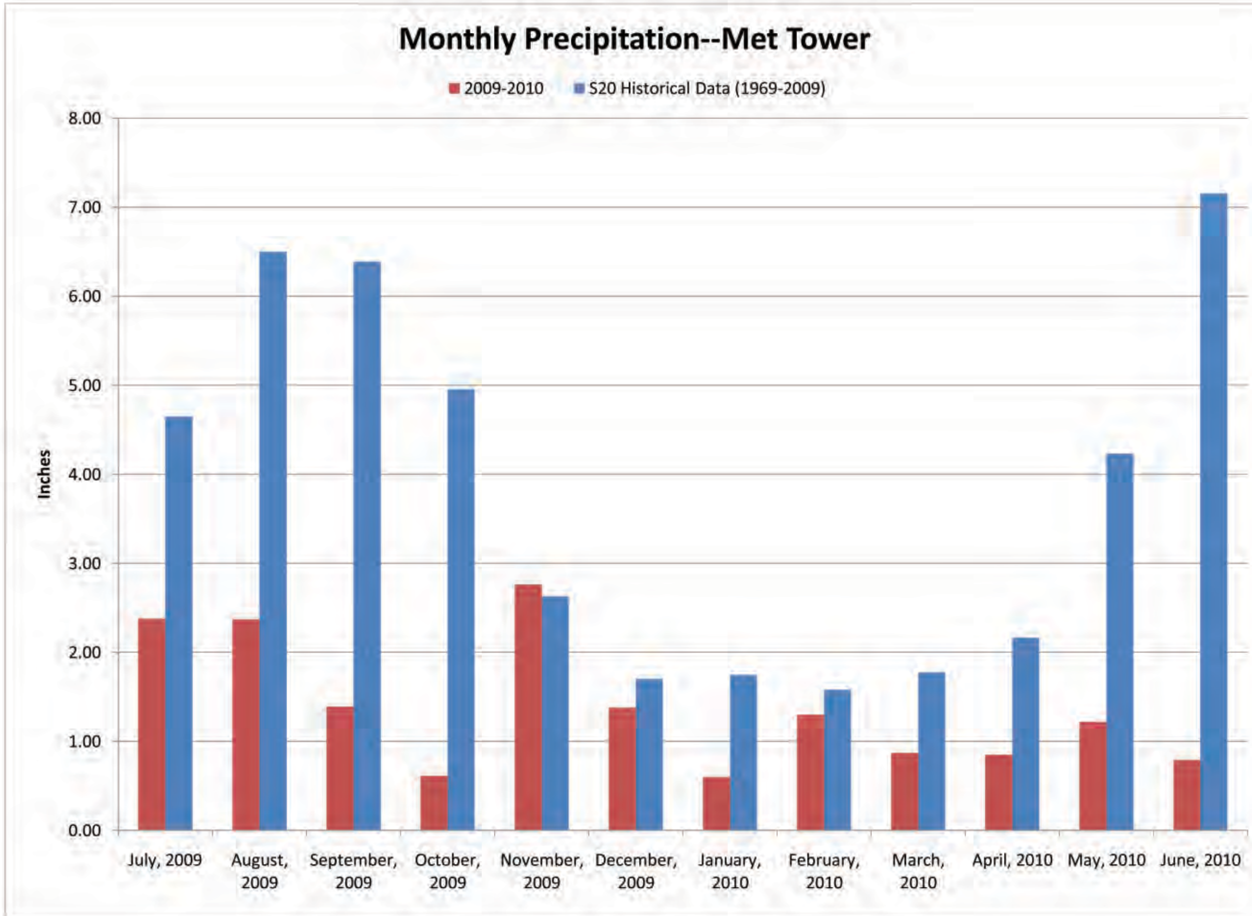
FPL

Golder Associates Atlanta, Georgia		TITLE Present Ground Water Monitoring Locations		
CLIENT/PROJECT FPL/2010 Annual Report Groundwater Monitoring Program/FL	DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
	CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
	REVIEWED HF	FILE NO. 10390259 Figure 2	SUBTITLE	FIGURE NO. 2



Note:
Rainfall data reported as S-20 from March 2008 onward is actually from FPL's Meteorological Tower near the Land Use Building.

Golder Associates Atlanta, Georgia	TITLE Location of FPL's Meteorological Tower near the Land Use Building			
CLIENT/PROJECT FPL/2010 Annual Report Groundwater Monitoring Program/FL	DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
	CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
	REVIEWED HF	FILE NO. 10390259 Figure 3	SUBTITLE	FIGURE NO. 3

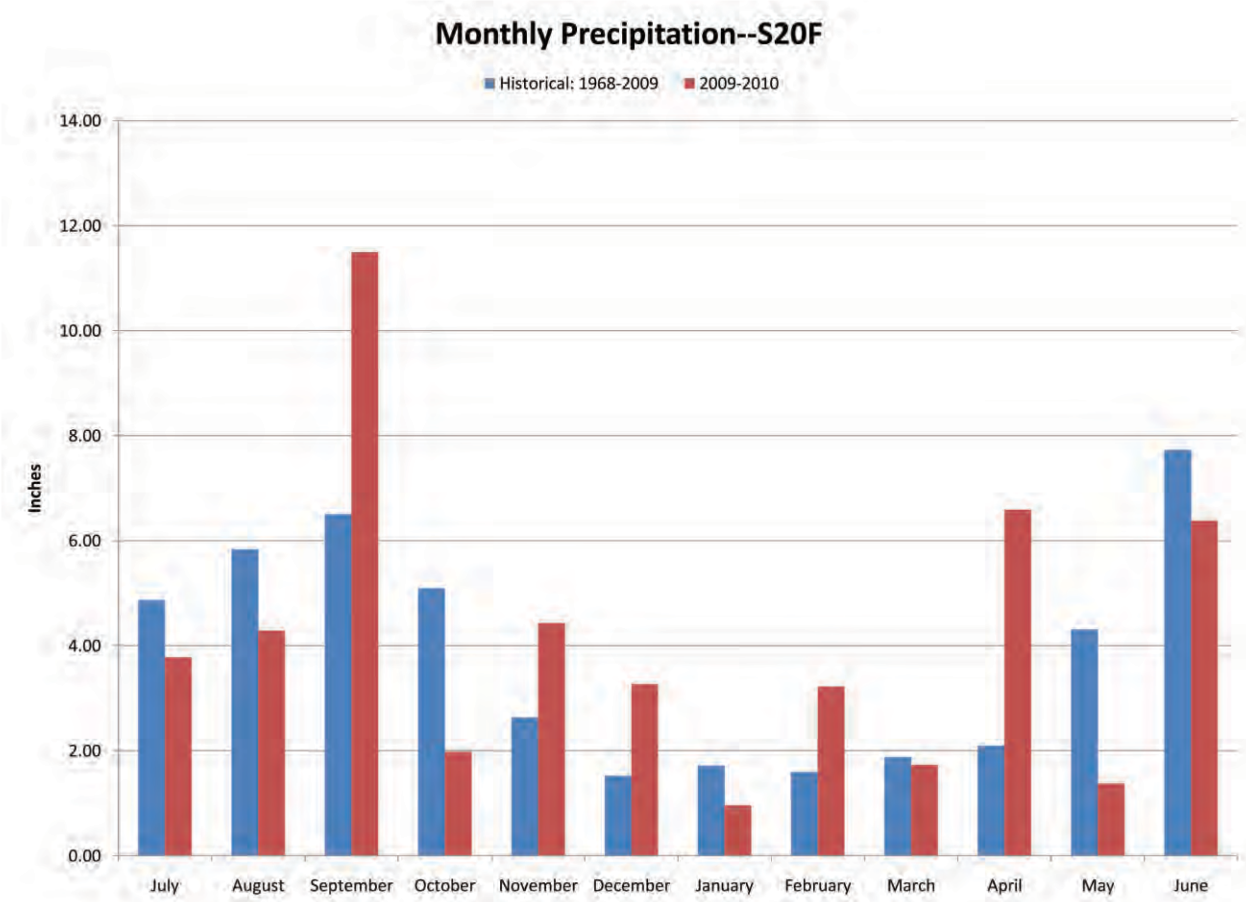


Note:
Rainfall data reported as S-20 from March 2008 onward is actually from FPL's Meteorological Tower near the Land Use Building.

Golder Associates

Atlanta, Georgia

CLIENT/PROJECT: FPL/2010 Annual Report Groundwater Monitoring Program/FL	TITLE: Rainfall at Gage S-20				
DRAWN	MAT	DATE	8/26/10	JOB NO.	10390259
CHECKED	SM	SCALE	NTS	DWG. NO.	REV. NO.
REVIEWED	HF	FILE NO.	10390259 Figure 4	SUBTITLE	FIGURE NO. 4



Golder Associates

Atlanta, Georgia

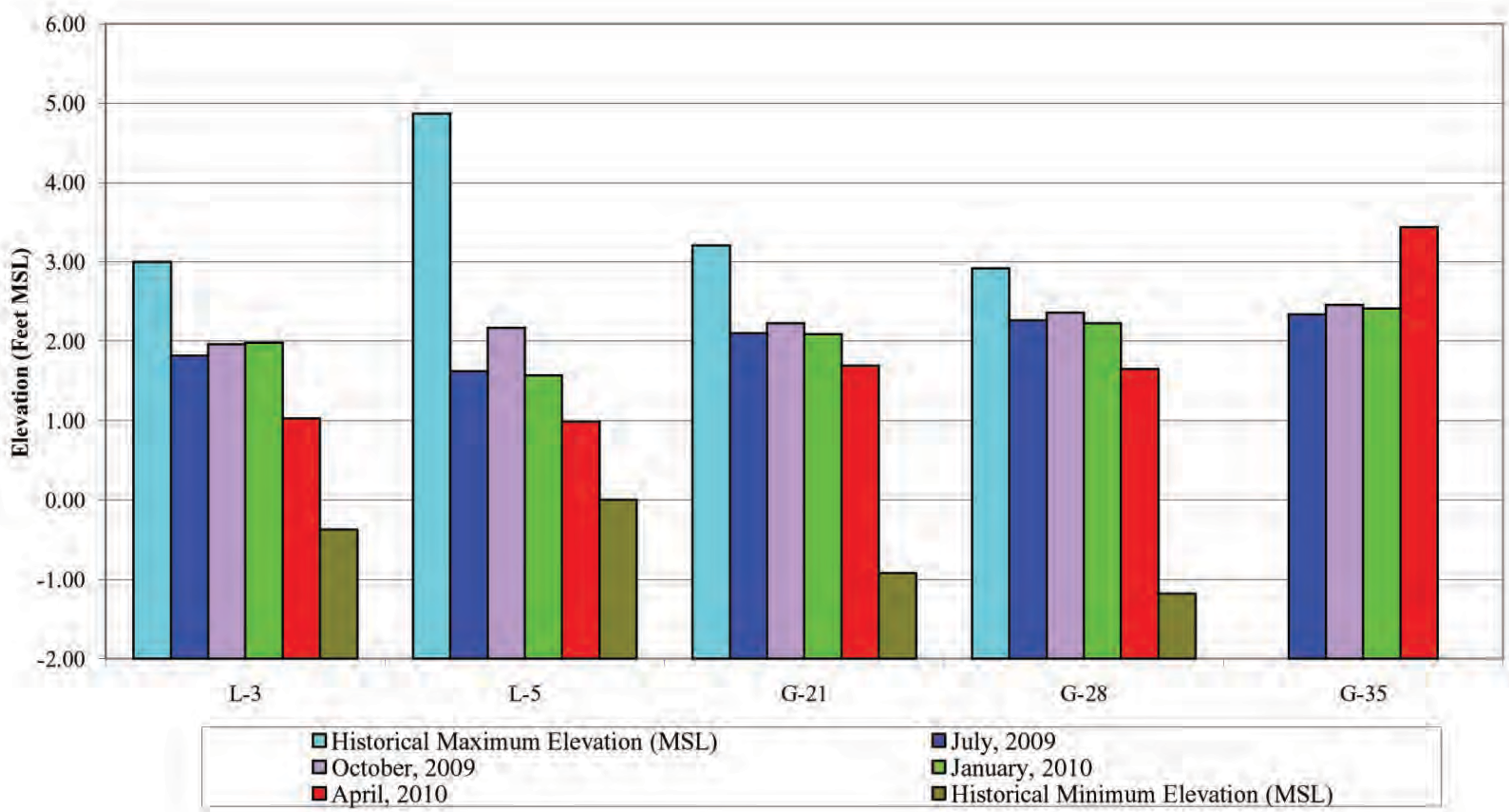
TITLE

Rainfall at Gage S-20F

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MAT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 5	SUBTITLE	FIGURE NO. 5



Golder Associates

Atlanta, Georgia

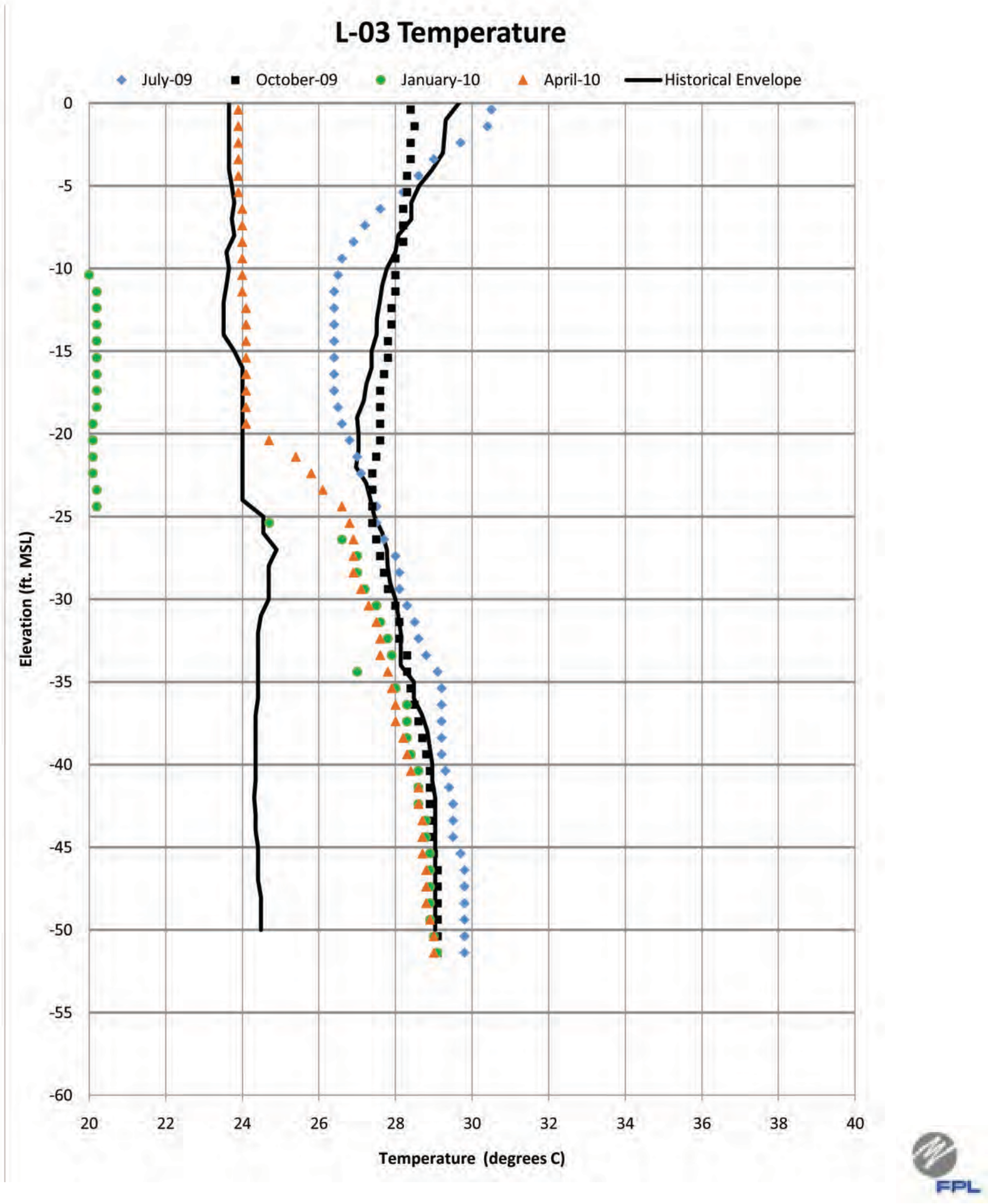
TITLE

Ground-Water Levels

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MAT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 6	SUBTITLE	FIGURE NO. 6



Golder Associates

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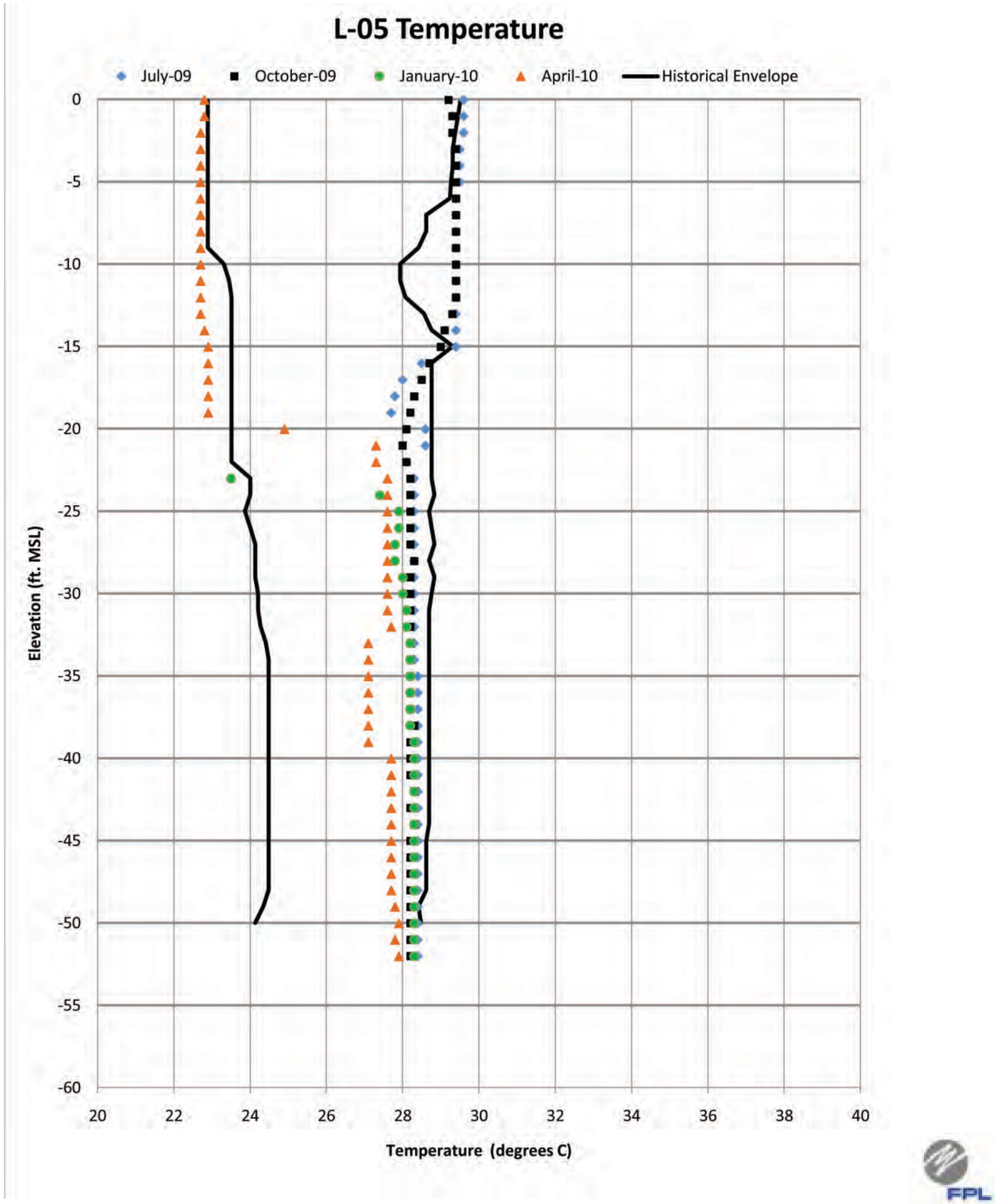
TITLE	L-3 Temperature		
DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 7	SUBTITLE	FIGURE NO. 7

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL



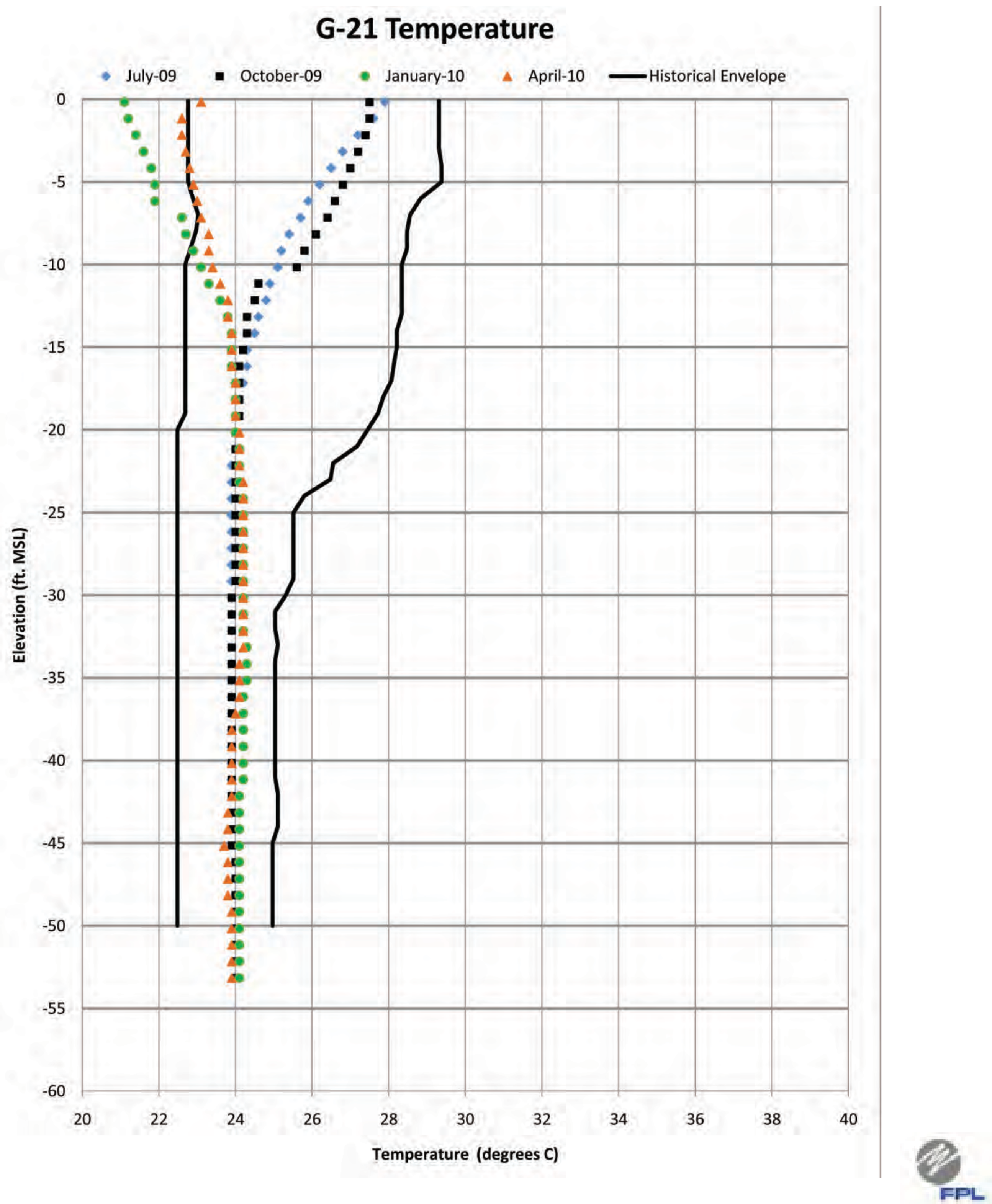
Golder Associates

Atlanta, Georgia

TITLE

L-5 Temperature

CLIENT/PROJECT FPL/2010 Annual Report Groundwater Monitoring Program/FL	DRAWN MT	DATE 8/26/10	JOB NO. 10390259
	CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
	REVIEWED HF	FILE NO. 10390259 Figure 8	SUBTITLE	FIGURE NO. 8



Golder Associates

Atlanta, Georgia

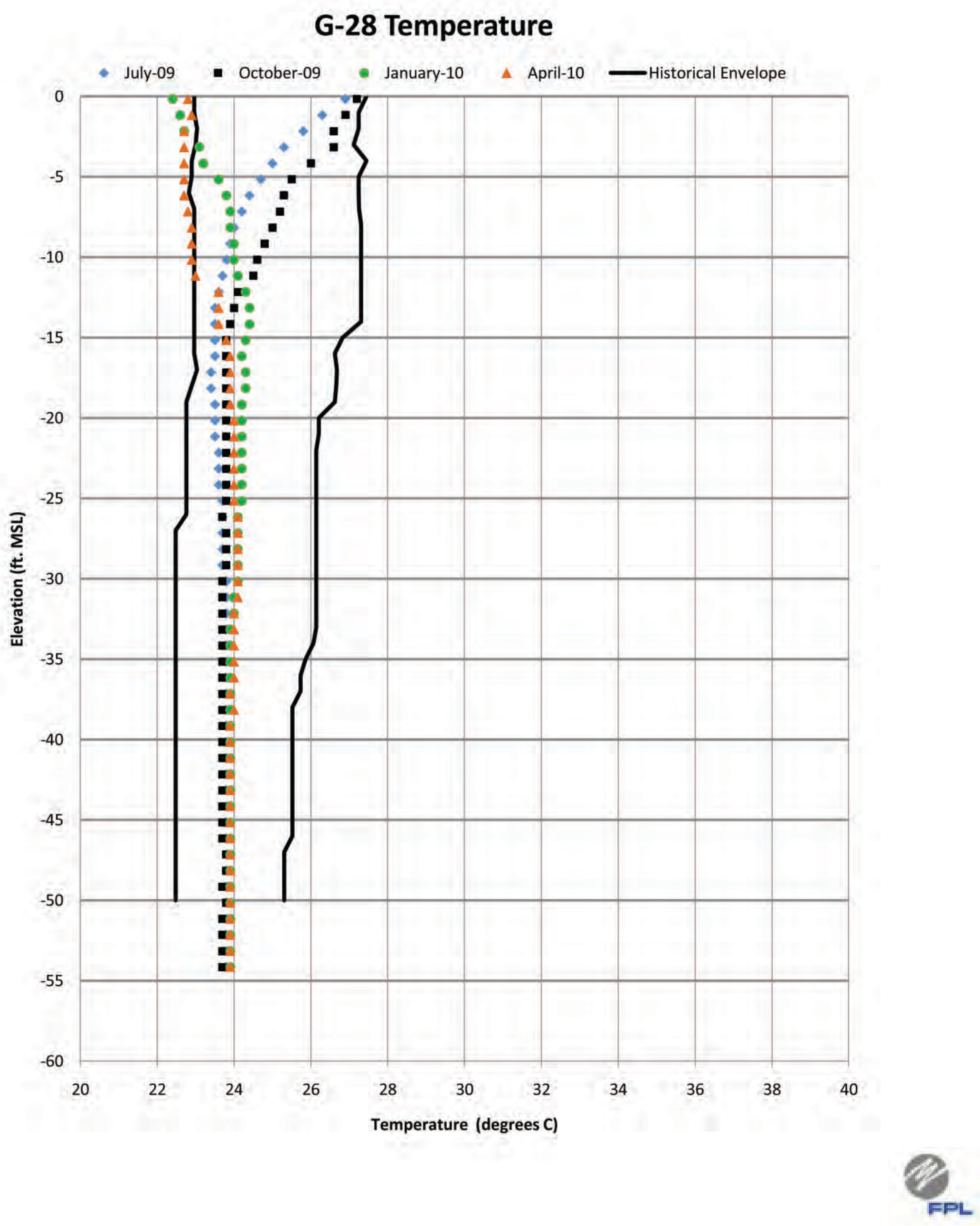
TITLE

G-21 Temperature

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

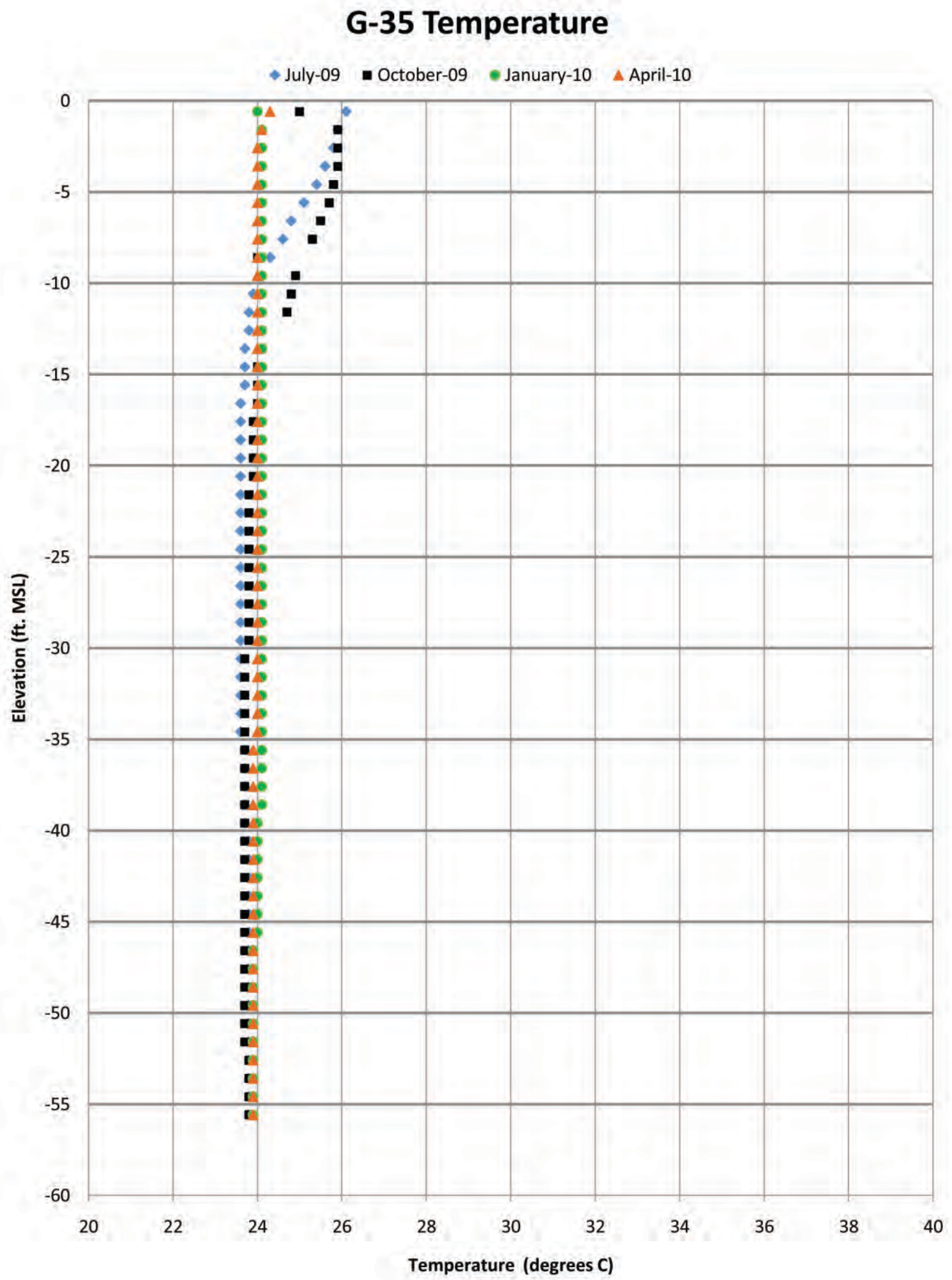
DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 9	SUBTITLE	FIGURE NO. 9



Golder Associates

Atlanta, Georgia

TITLE	G-28 Temperature
CLIENT/PROJECT	FPL/2010 Annual Report Groundwater Monitoring Program/FL
DRAWN	MT
DATE	8/26/10
JOB NO.	10390259
CHECKED	SM
SCALE	NTS
DWG. NO.	
REV. NO.	
REVIEWED	HF
FILE NO.	10390259 Figure 10
SUBTITLE	
FIGURE NO.	10



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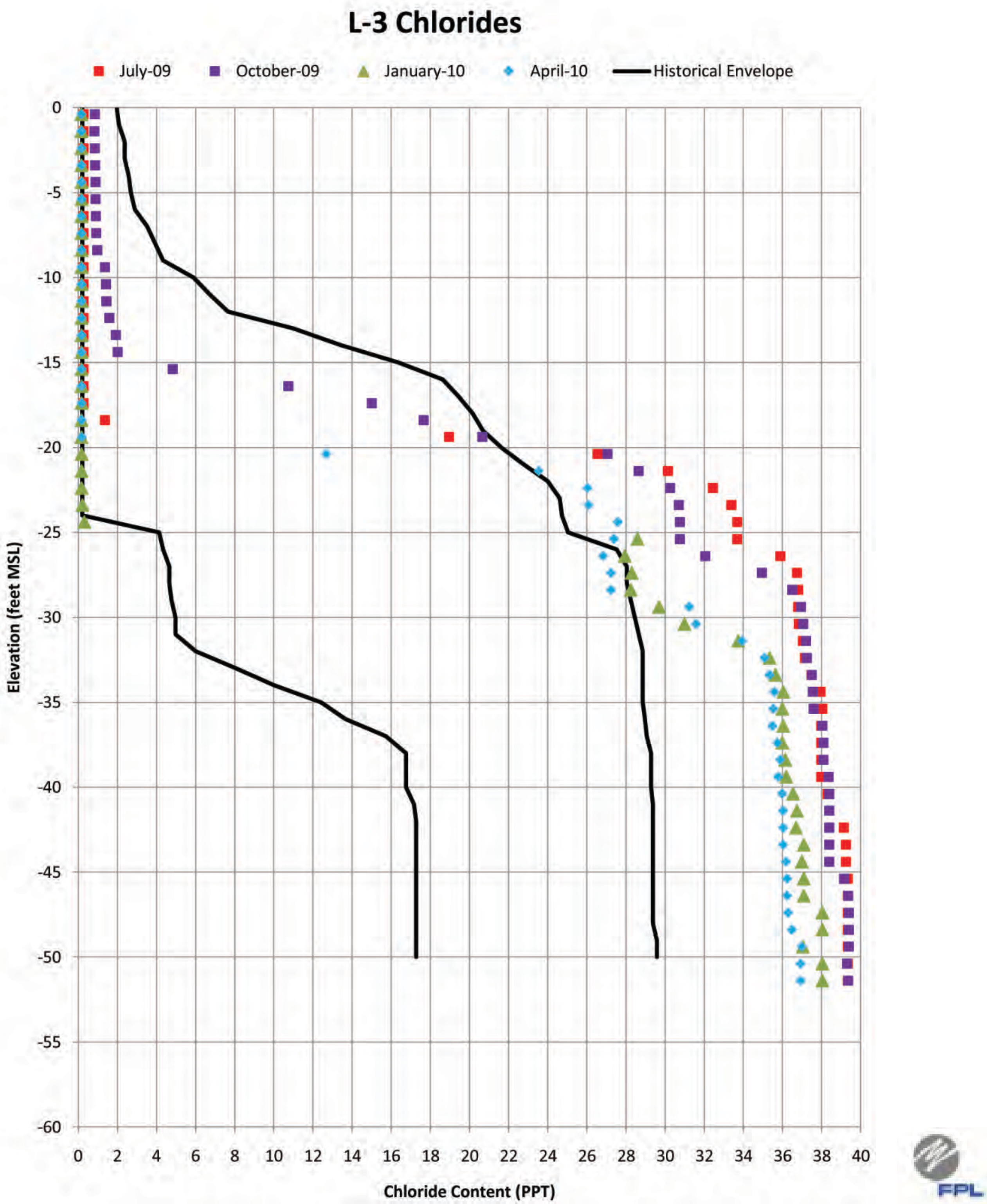


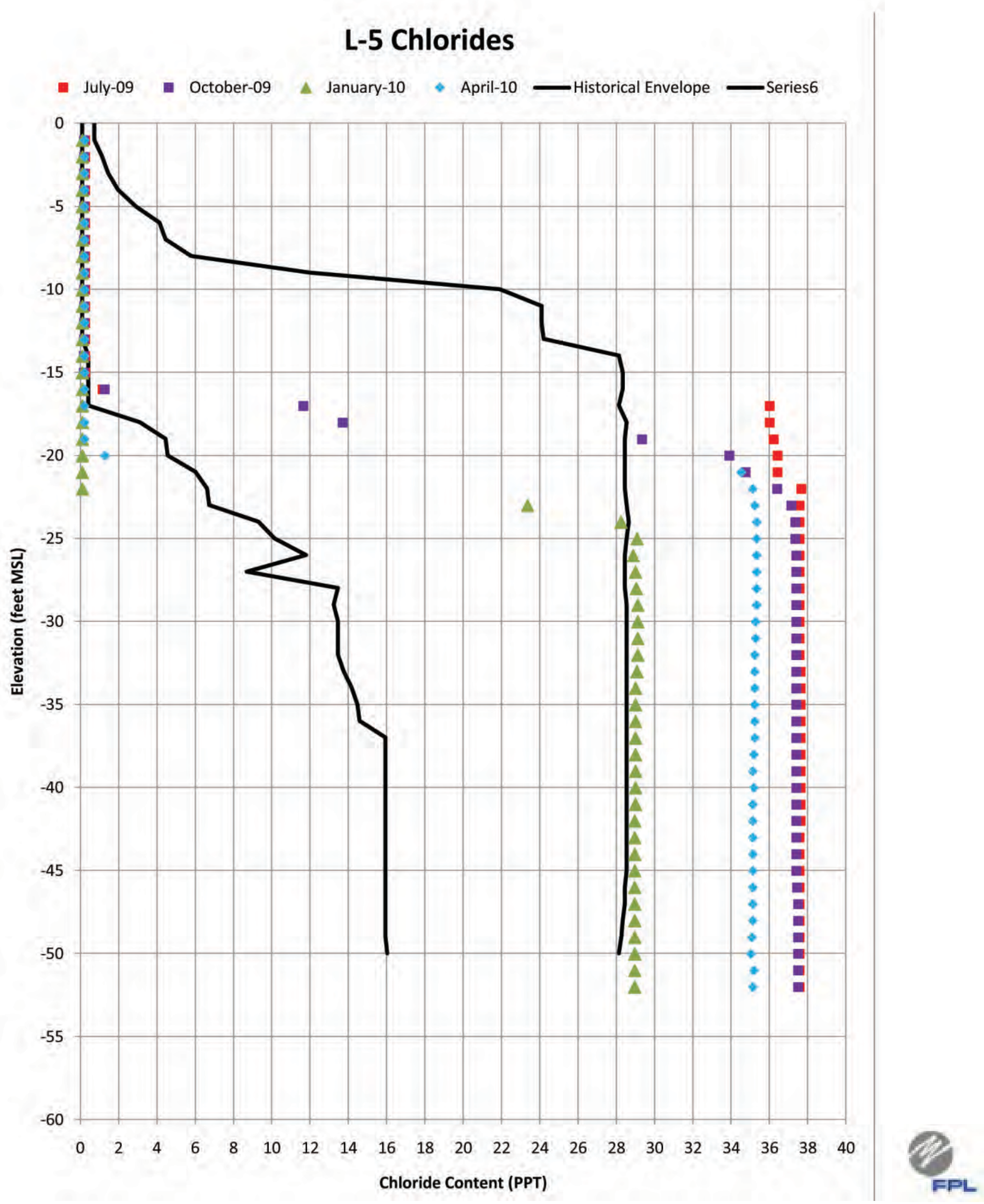
Golder Associates

Atlanta, Georgia

TITLE: L-3 Chloride			
DRAWN: MT	DATE: 8/26/10	JOB NO.: 10390259	
CHECKED: SM	SCALE: NTS	DWG. NO.	REV. NO.
REVIEWED: HF	FILE NO.: 10390259 Figure 12	SUBTITLE	FIGURE NO.: 12

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL



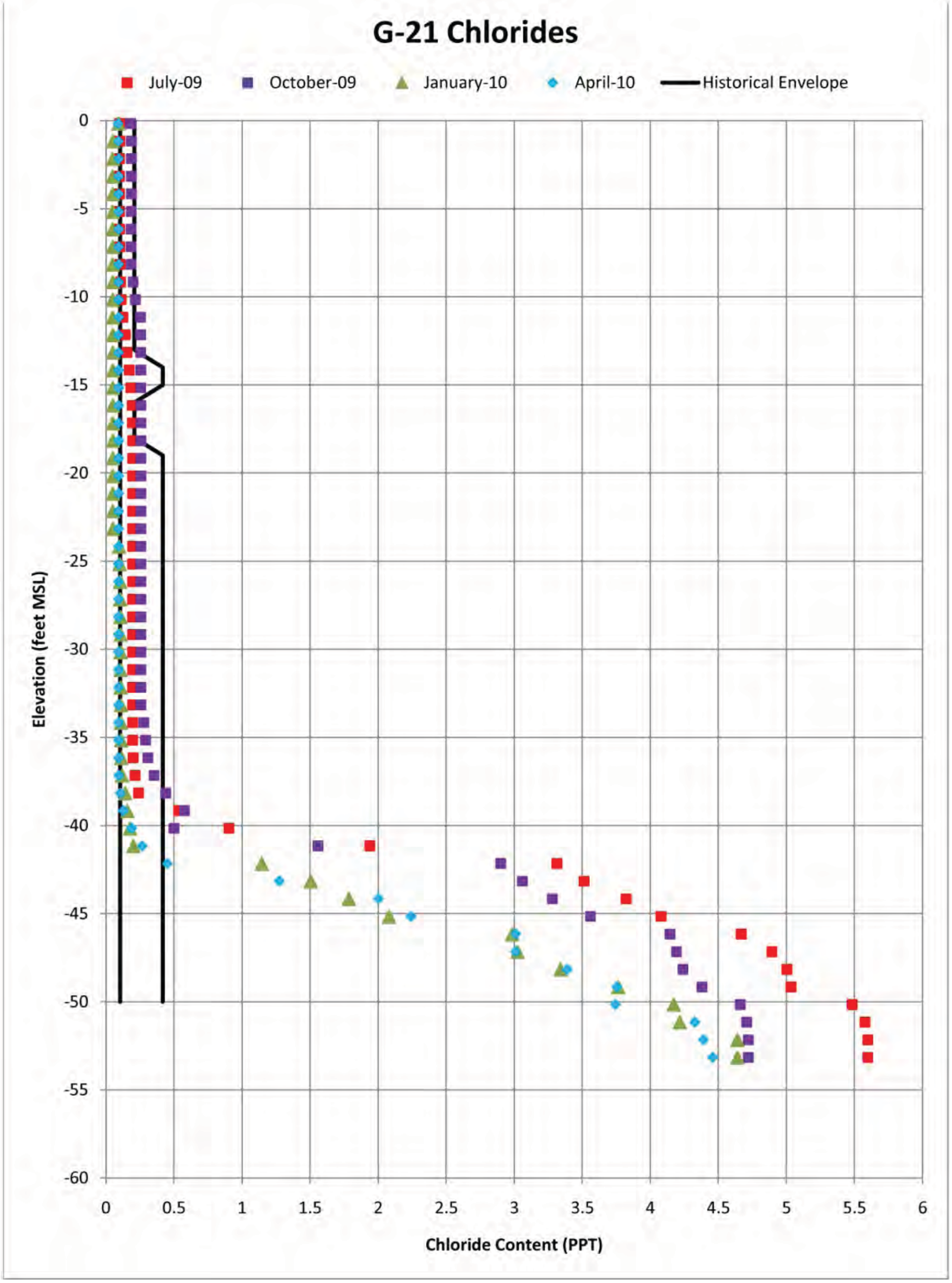
Golder Associates

Atlanta, Georgia

TITLE	L-5 Chloride		
DRAWN: MT	DATE: 8/26/10	JOB NO.: 10390259	
CHECKED: SM	SCALE: NTS	DWG. NO.	REV. NO.
REVIEWED: HF	FILE NO.: 10390259 Figure 13	SUBTITLE	FIGURE NO.: 13

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL



Golder Associates

Atlanta, Georgia

TITLE	G-21 Chloride			
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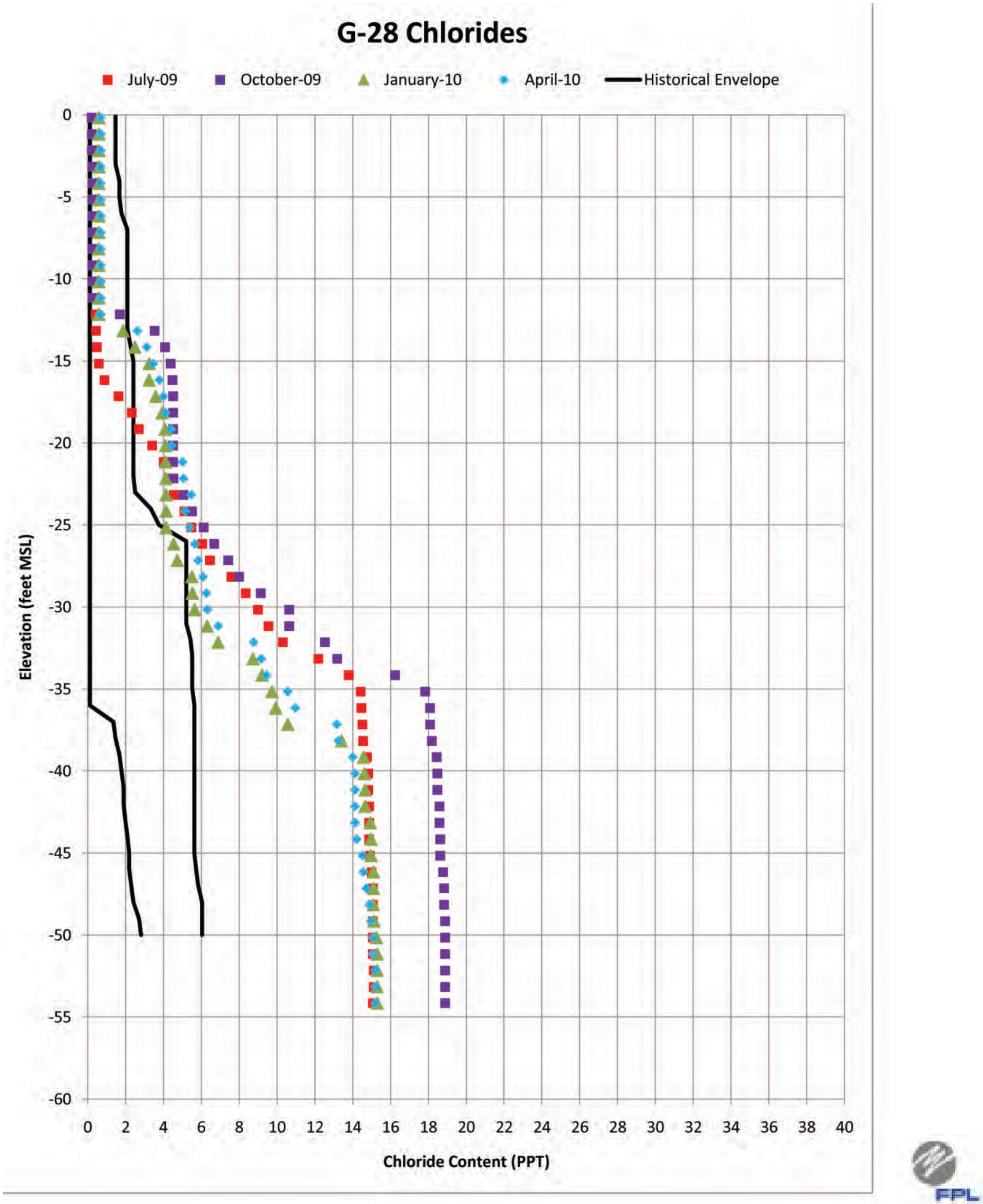
	REVIEWED: HF	FILE NO.: 10390259 Figure 14	SUBTITLE	FIGURE NO.: 14



Golder Associates

Atlanta, Georgia

TITLE: G-28 Chloride				
CLIENT/PROJECT: FPL/2010 Annual Report Groundwater Monitoring Program/FL	DRAWN: MT	DATE: 8/26/10	JOB NO.: 10390259	
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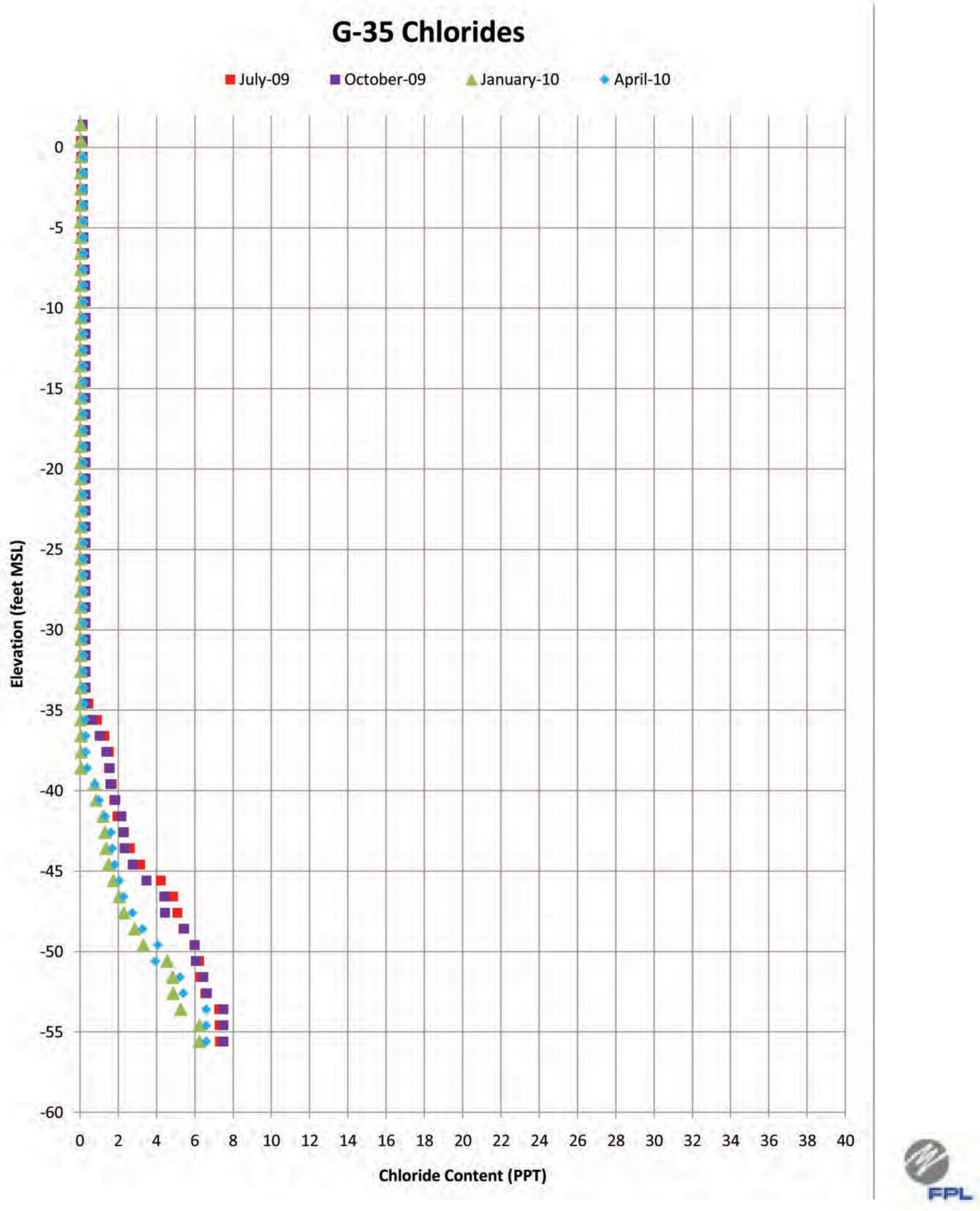

Golder Associates

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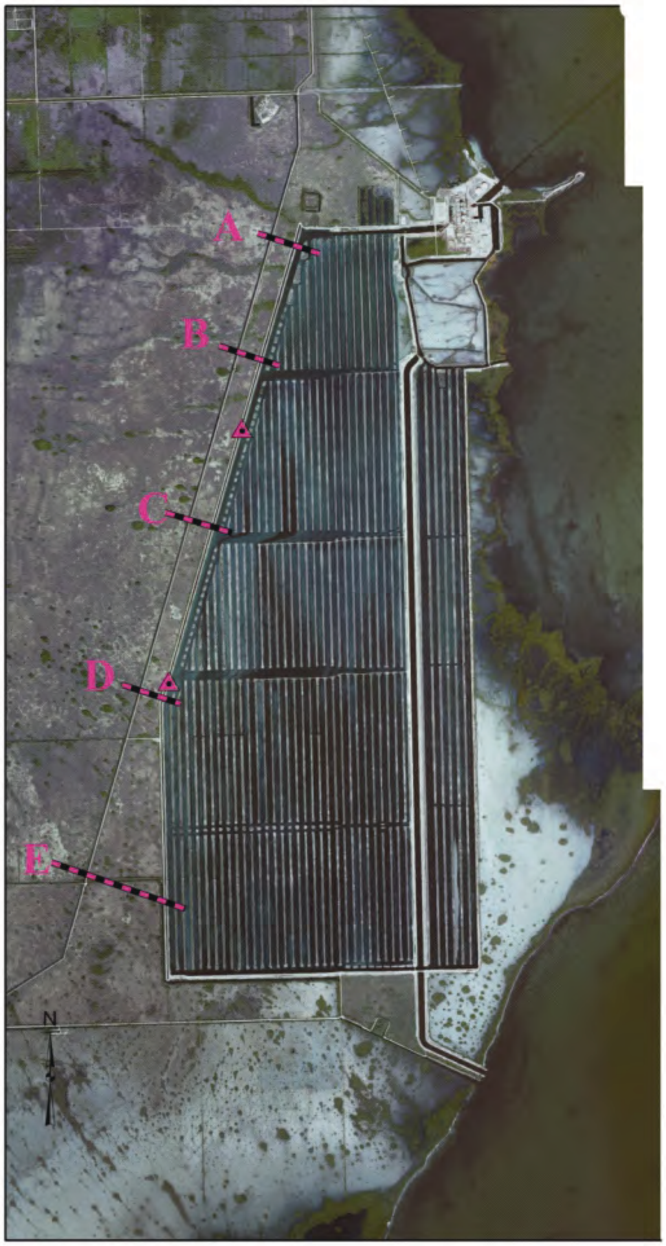
TITLE

G-35 Chloride

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN	DATE	JOB NO.	
MT	8/26/10	10390259	
CHECKED	SCALE	DWG. NO.	REV. NO.
SM	NTS		
REVIEWED	FILE NO.	SUBTITLE	FIGURE NO.
HF	10390259 Figure 16		16



LEGEND

0 37.5 75 150 Mile

FPL

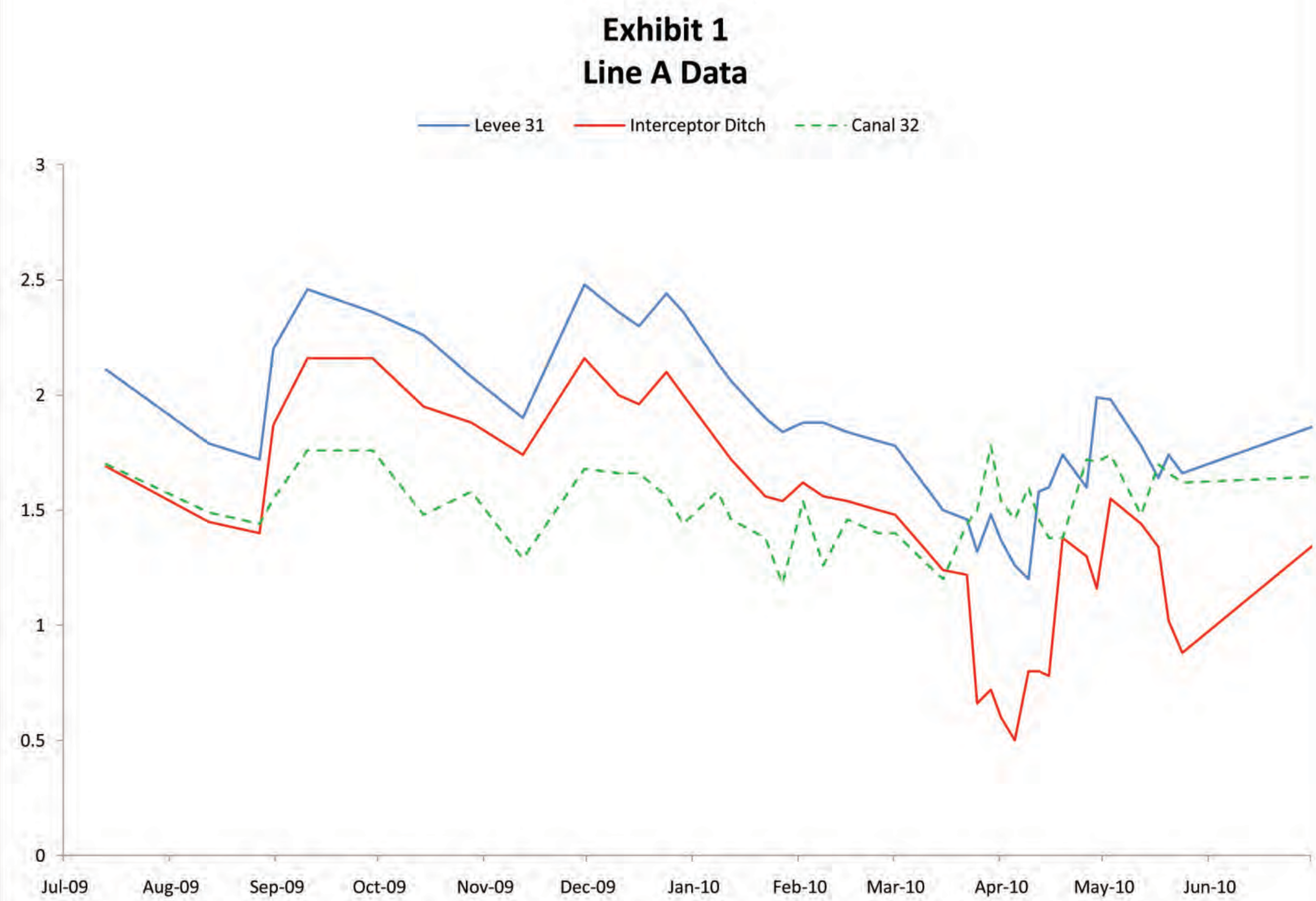
Golder Associates

Atlanta, Georgia

TITLE

Interceptor Ditch Surface Water Monitoring Lines

CLIENT/PROJECT	DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
FPL/2010 Annual Report Groundwater Monitoring Program/FL	CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
	REVIEWED HF	FILE NO. 10390259 Figure 17	SUBTITLE	FIGURE NO. 17



Atlanta, Georgia

TITLE Line A Water Level Data				
DRAWN MAT	DATE 8/26/10	JOB NO. 10390259		
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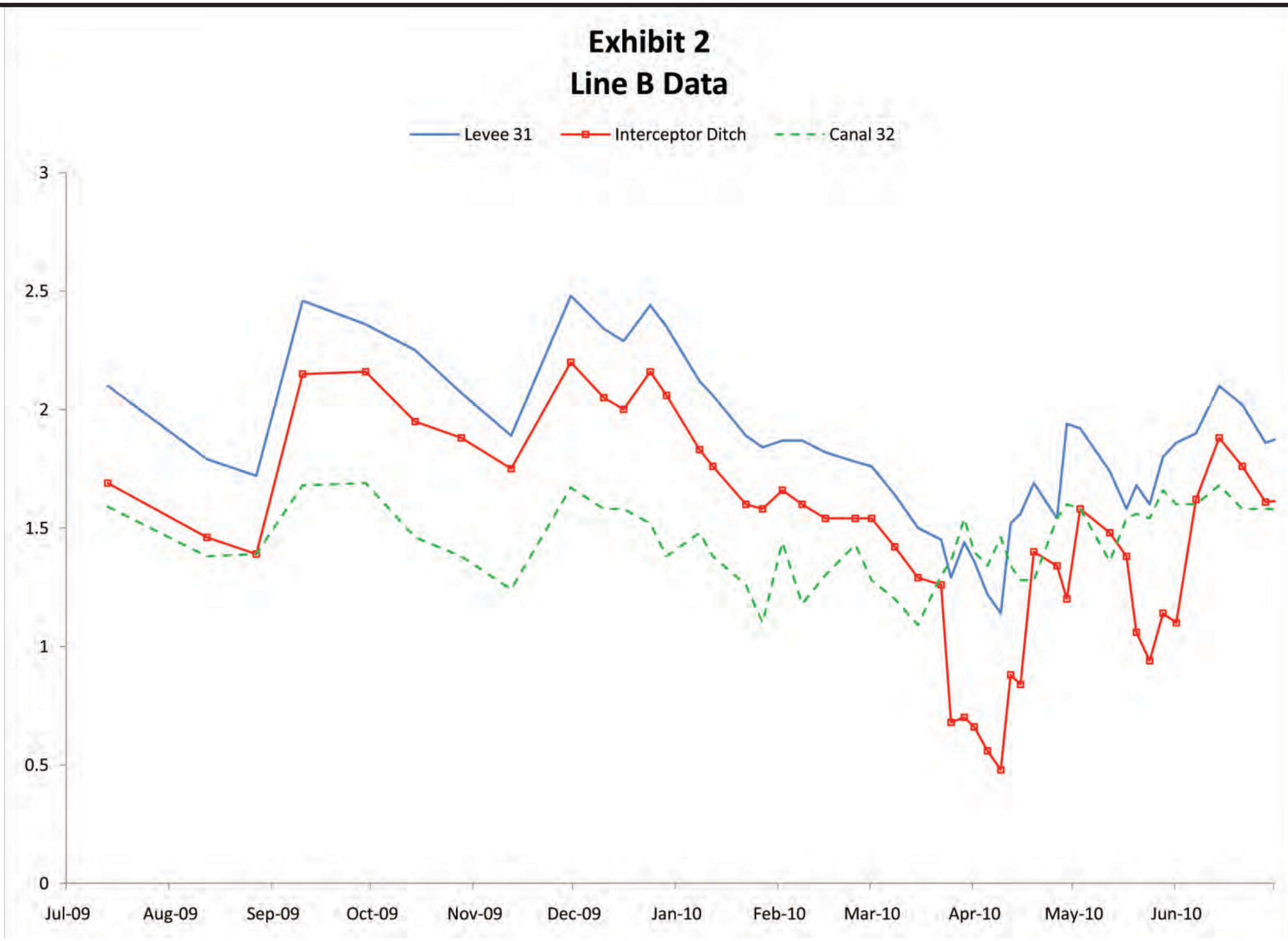
REVIEWED HF	FILE NO. 10390259 Figure 16	SUBTITLE	FIGURE NO. 18	

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL



Golder Associates

Atlanta, Georgia

TITLE: Line B Water Level Data				
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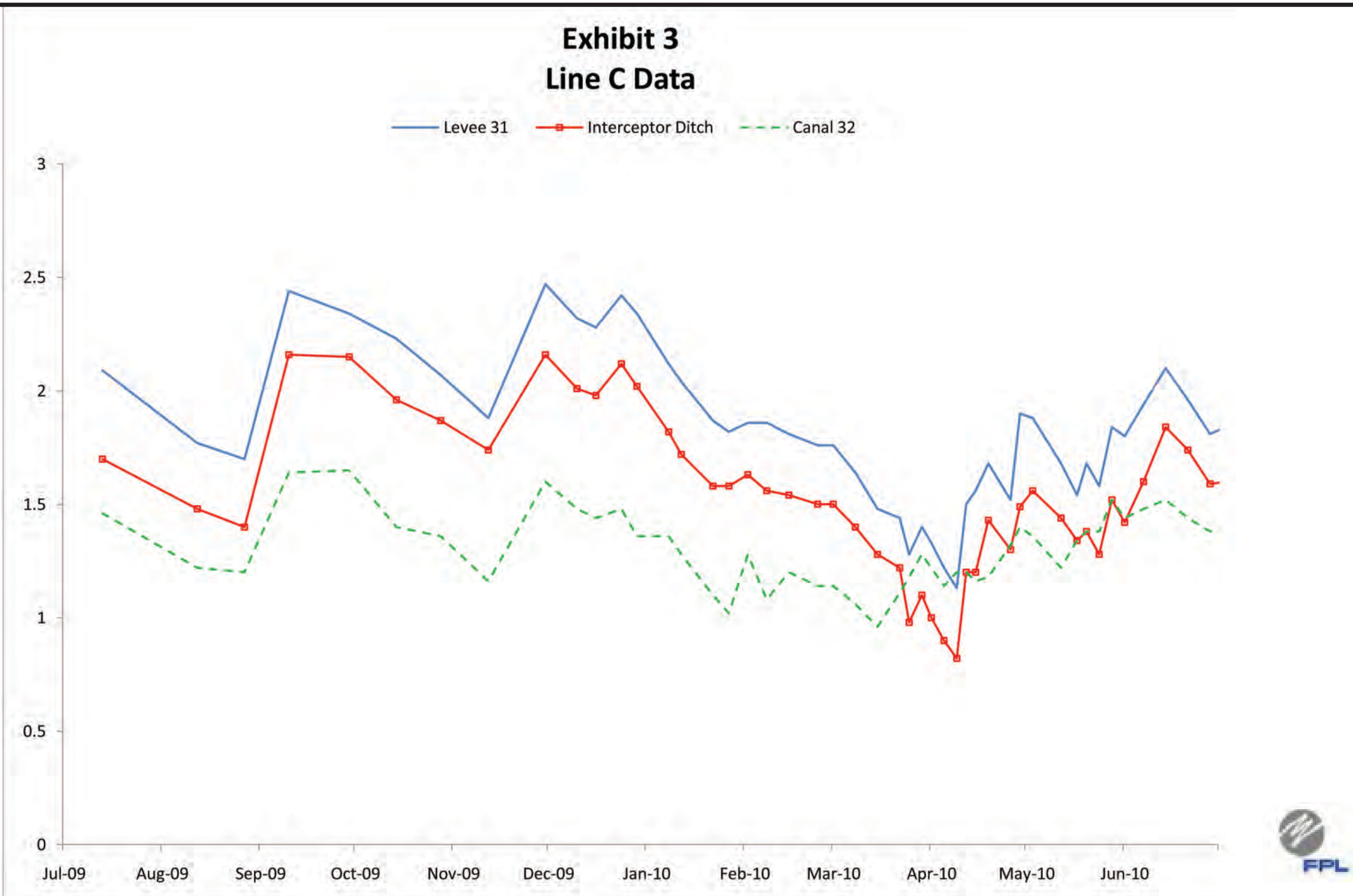
REVIEWED: HF	FILE NO.: 10390259 Figure 19	SUBTITLE	FIGURE NO.: 19	

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL



Golder Associates

Atlanta, Georgia

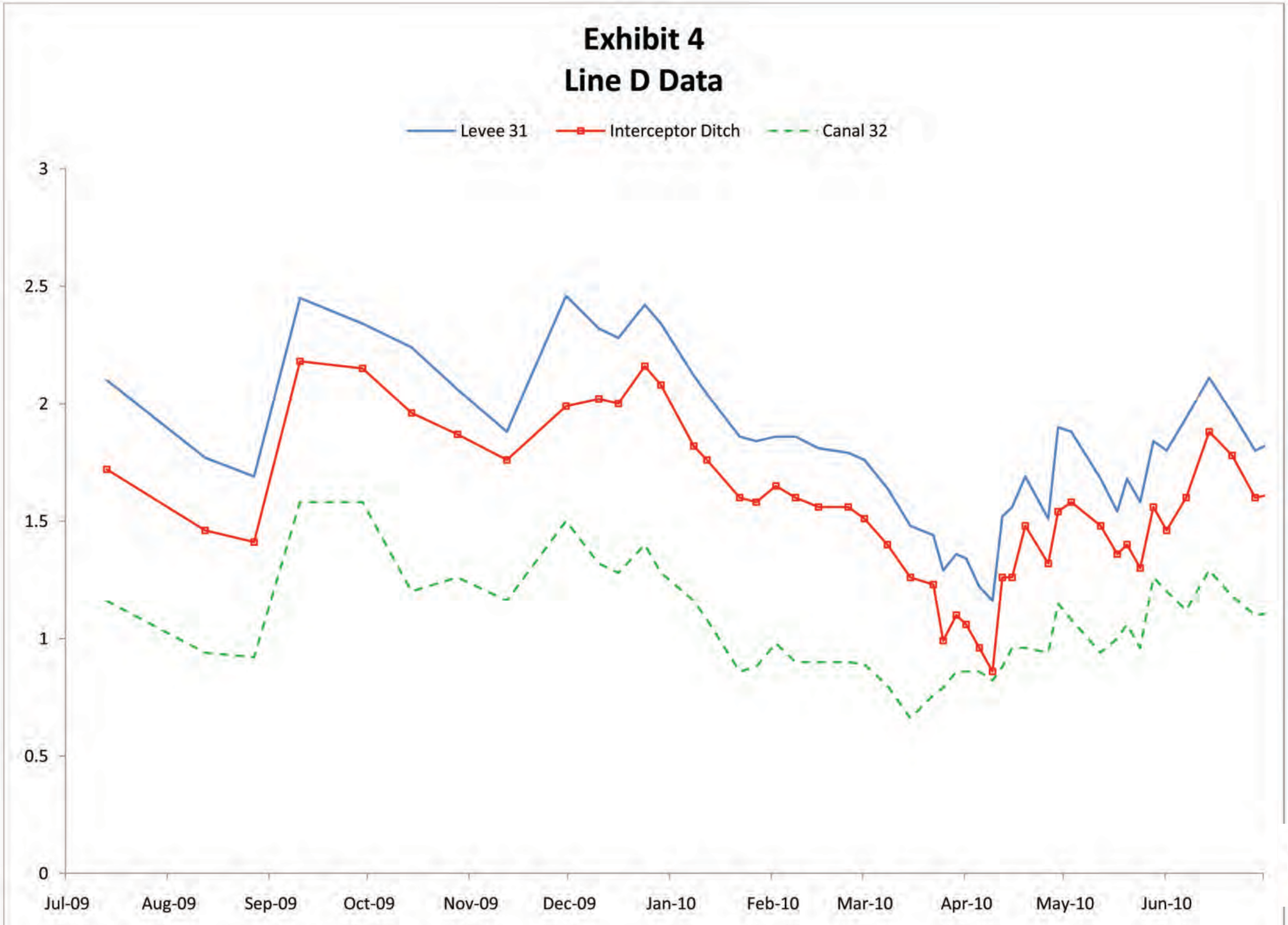
TITLE

Line C Water Level Data

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MAT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 20	SUBTITLE	FIGURE NO. 20



Golder Associates

Atlanta, Georgia

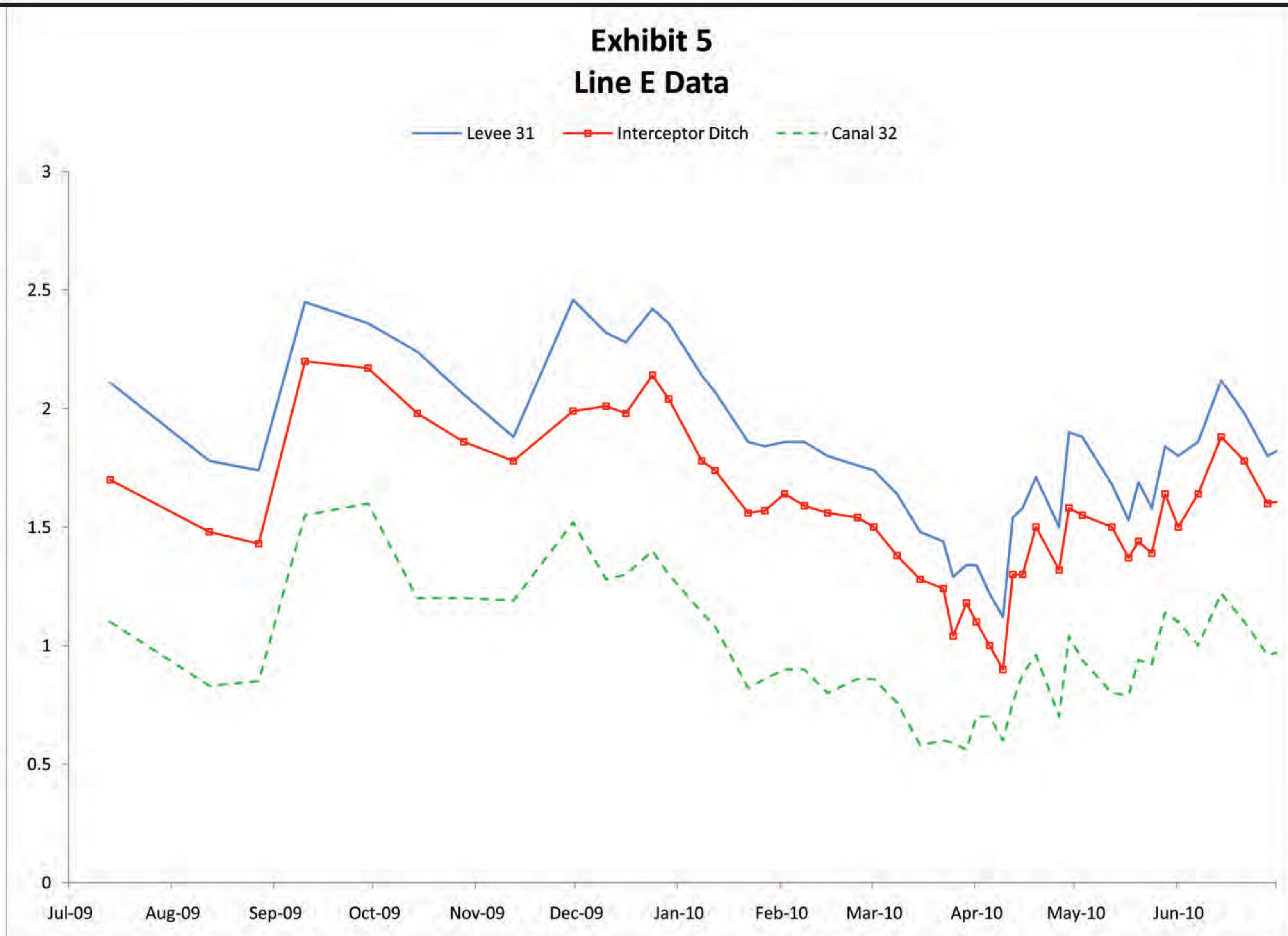
TITLE

Line D Water Level Data

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MAT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 21	SUBTITLE	FIGURE NO. 21

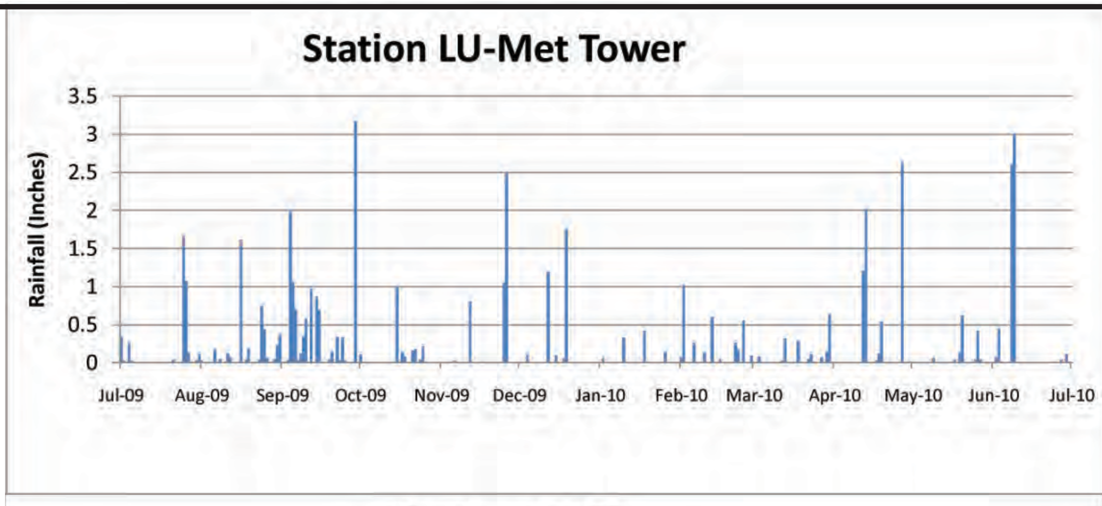


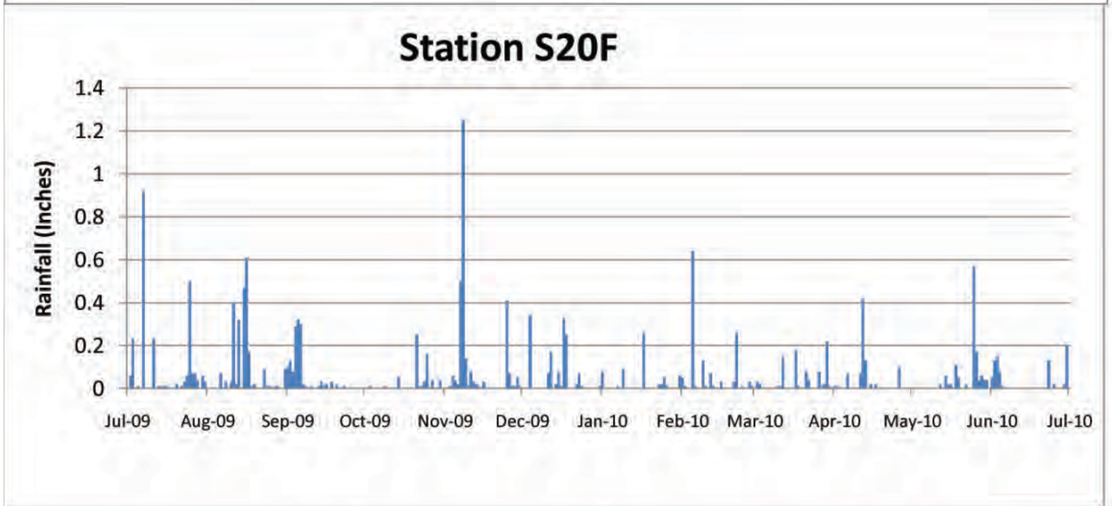
FPL

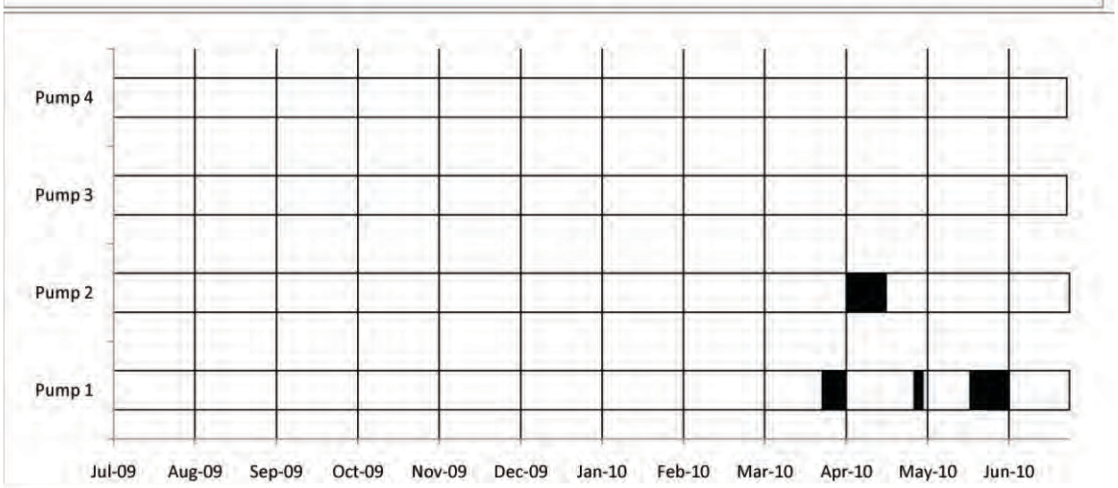
Golder Associates

Atlanta, Georgia

TITLE	Line E Data
CLIENT/PROJECT	FPL/2010 Annual Report Groundwater Monitoring Program/FL
DRAWN	MAT
CHECKED	SM
REVIEWED	HF
DATE	8/26/10
SCALE	NTS
FILE NO.	09390244 Figure 22
JOB NO.	10390259
DWG. NO.	
REV. NO.	
SUBTITLE	
FIGURE NO.	22







Note:
Rainfall data reported as S-20 from March 2008 onward is actually from FPL's Meteorological Tower near the Land Use Building.

Golder Associates
Atlanta, Georgia

TITLE
Interceptor Ditch Pump Operation and Rainfall

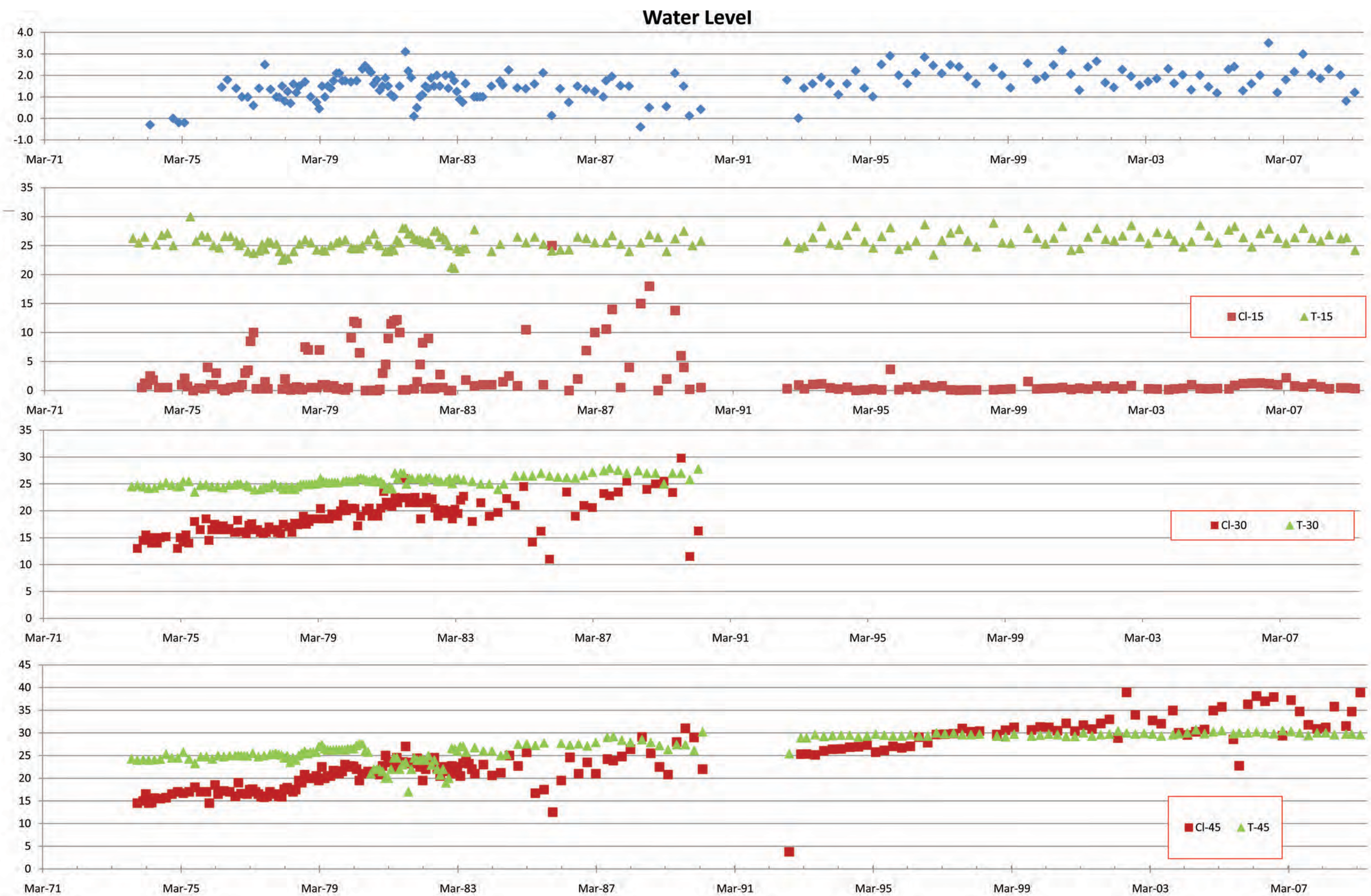
CLIENT/PROJECT
FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure 23	SUBTITLE	FIGURE NO. 23

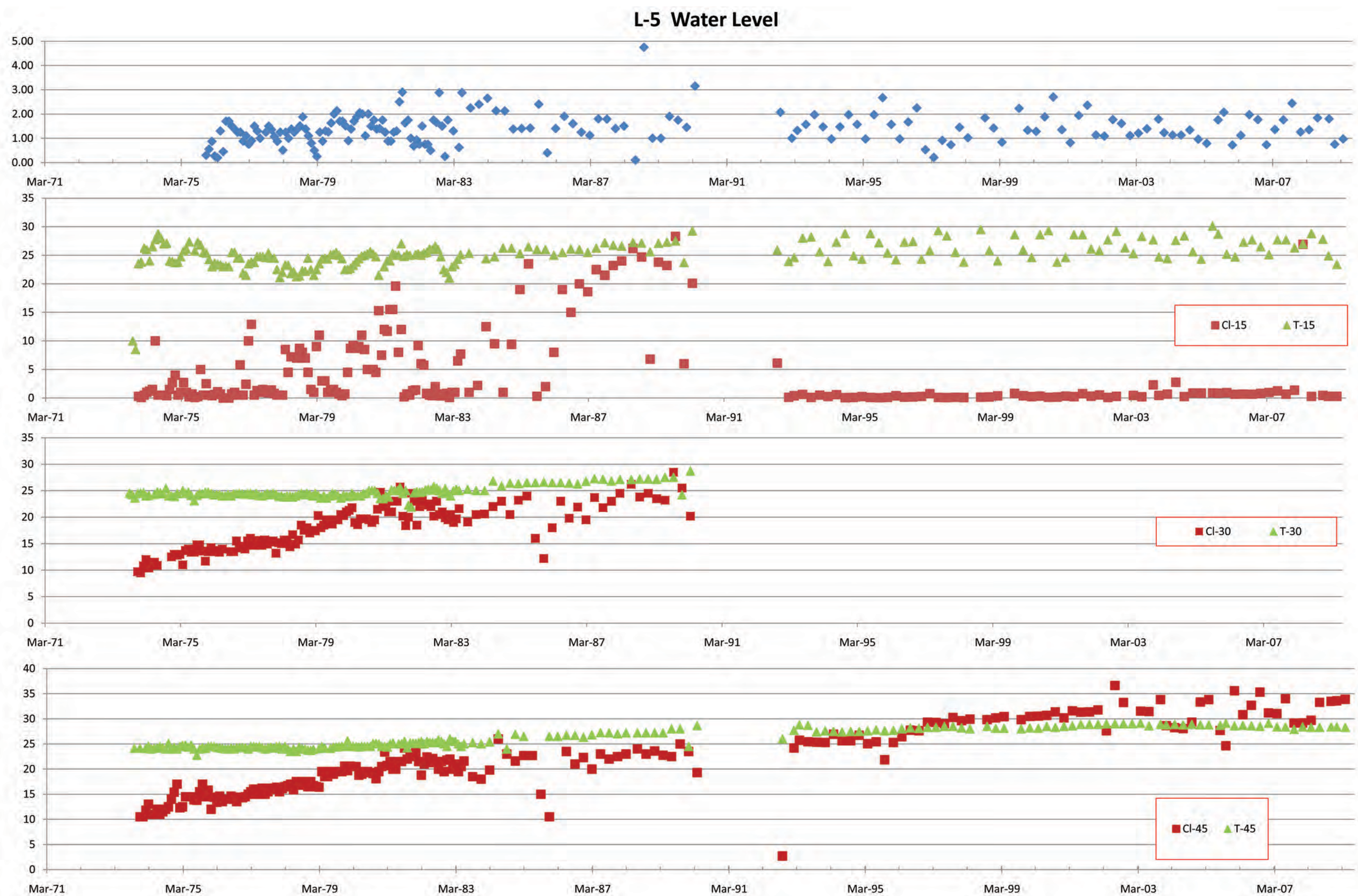
APPENDIX A
TIME-HISTORY PLOTS

APPENDIX A
TIME-HISTORY PLOT

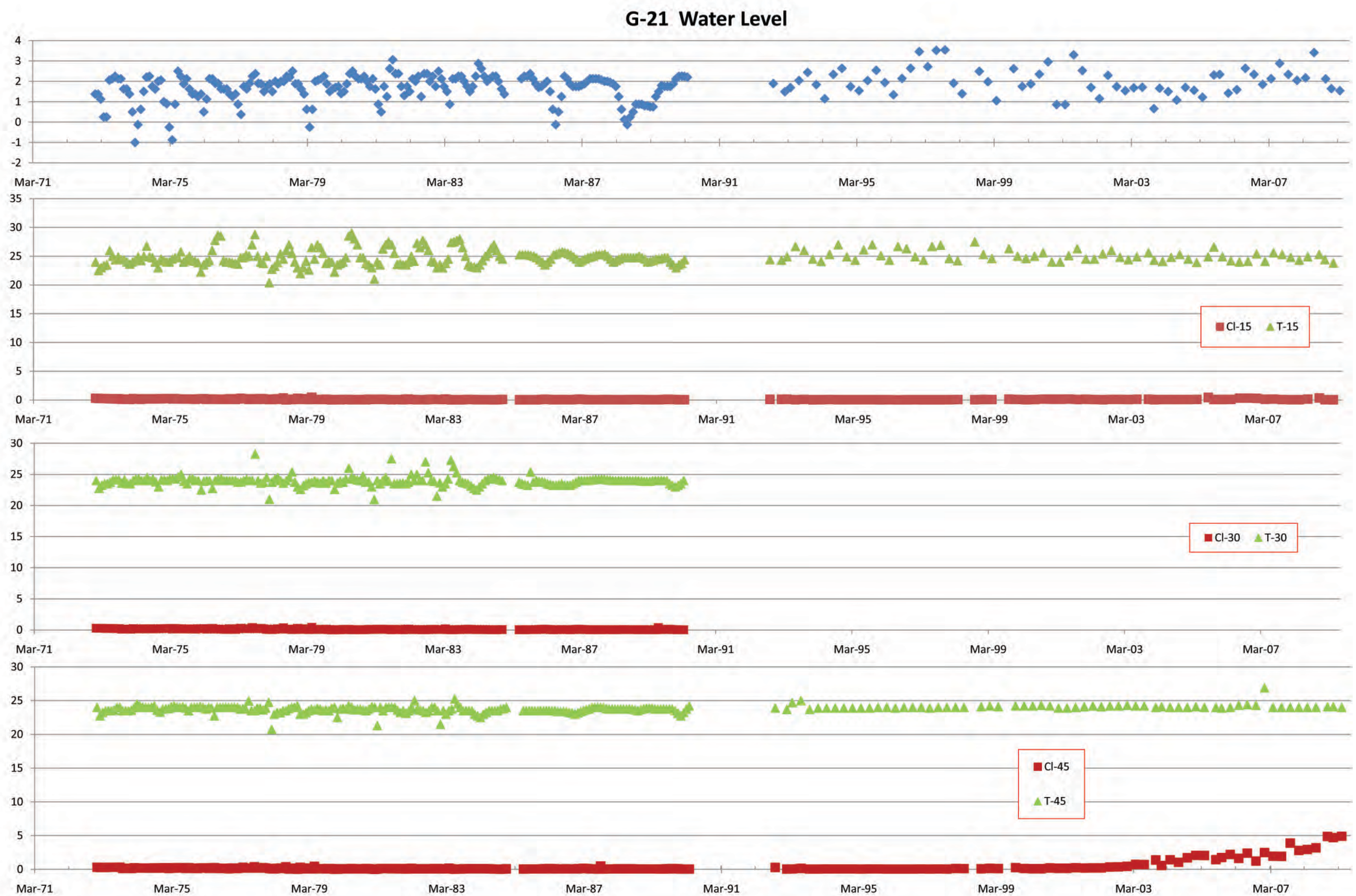
The following figures A-1 through A-5 present the time-history plots of water levels, temperatures, and estimated chloride content (chlorinity) for wells L-3, L-5, G-21, G-28, and G-35, respectively. Figure A-6 presents rainfall and selected water levels, and ground-water temperatures and chlorinities.



Golder Associates, Atlanta, GA	
DWG NO. 10390259 Figure A-1	CLIENT/PROJECT: FPL/2010 Annual Report Groundwater Monitoring Program/FL
REV. NO.	JOB NO. 10390259
DATE 8/26/10	DRAWN MAT
SCALE NTS	CHECKED SM
FILE NO.	REVIEWED HAF
TITLE	TIME-HISTORY PLOTS WELL NUMBER L-3
FIGURE NO.	A-1



Golder Associates, Atlanta, GA	DWG NO. 10390259 Figure A-2		CLIENT/PROJECT: FPL/2010 Annual Report Groundwater Monitoring Program/FL
	REV. NO.	JOB NO. 10390259	
	DATE 8/26/10	DRAWN MAT	TITLE: TIME-HISTORY PLOTS WELL NUMBER L-5
	SCALE NTS	CHECKED SM	
	FILE NO.	REVIEWED HAF	FIGURE NO. A-2



DWG NO. 10390259 Figure A-3		CLIENT/PROJECT FPL/2010 Annual Report Groundwater Monitoring Program/FL
REV. NO.	JOB NO. 10390259	
DATE 8/26/10	DRAWN MAT	TITLE TIME-HISTORY PLOTS WELL NUMBER G-21
SCALE NTS	CHECKED SM	
FILE NO.	REVIEWED HAF	FIGURE NO. A-3

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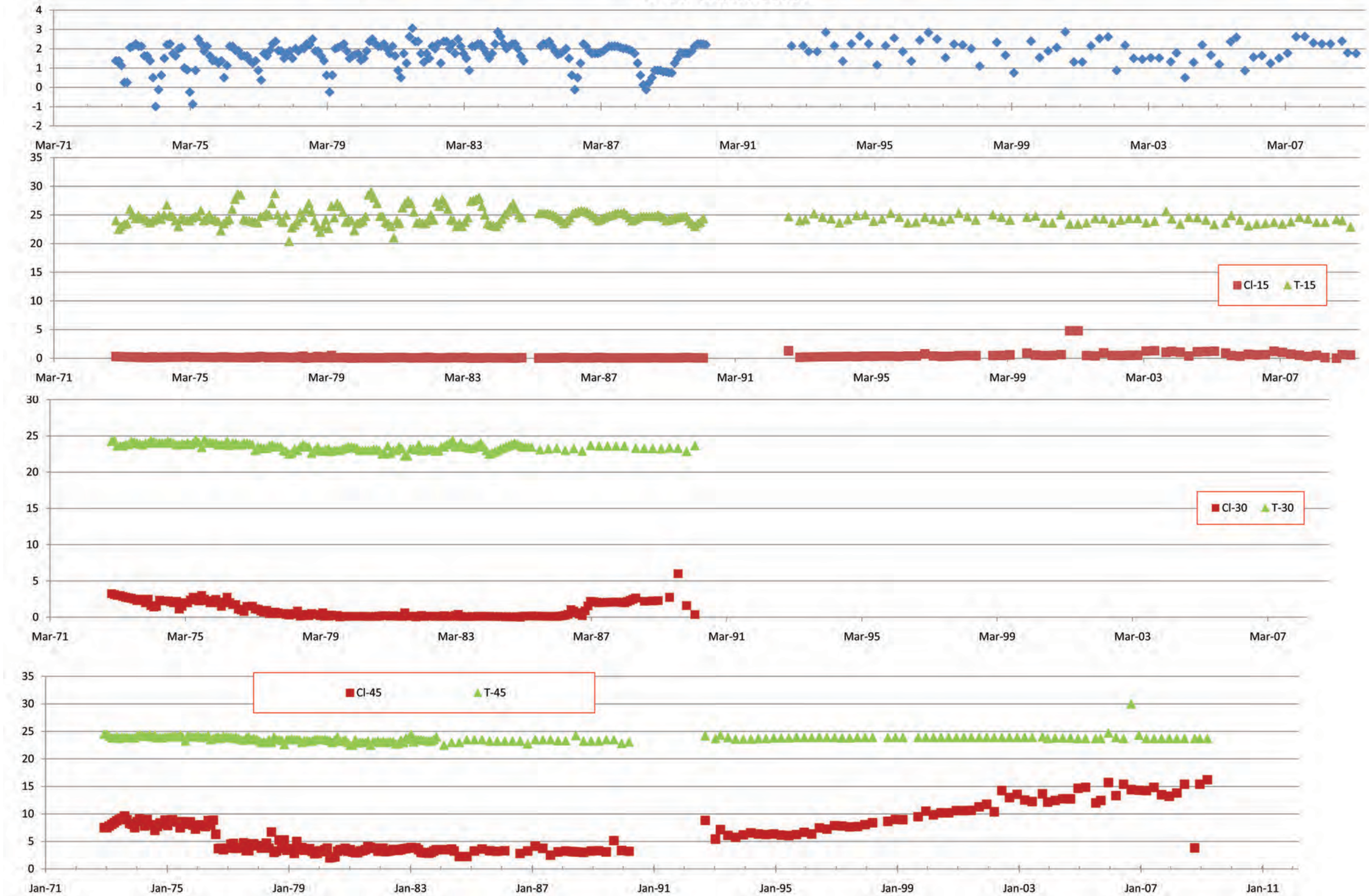
FPL

G-28 Water Level



Golder Associates
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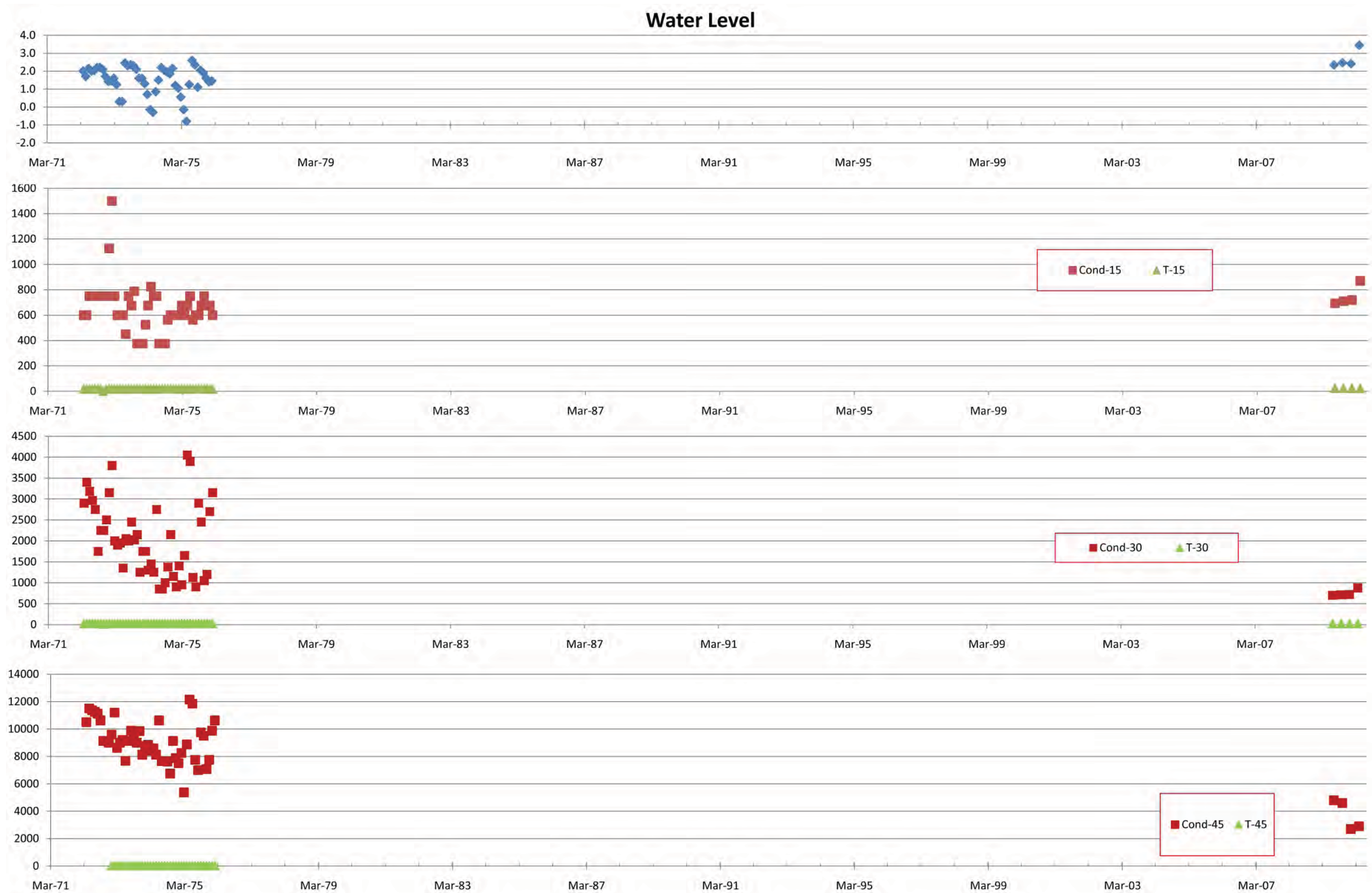
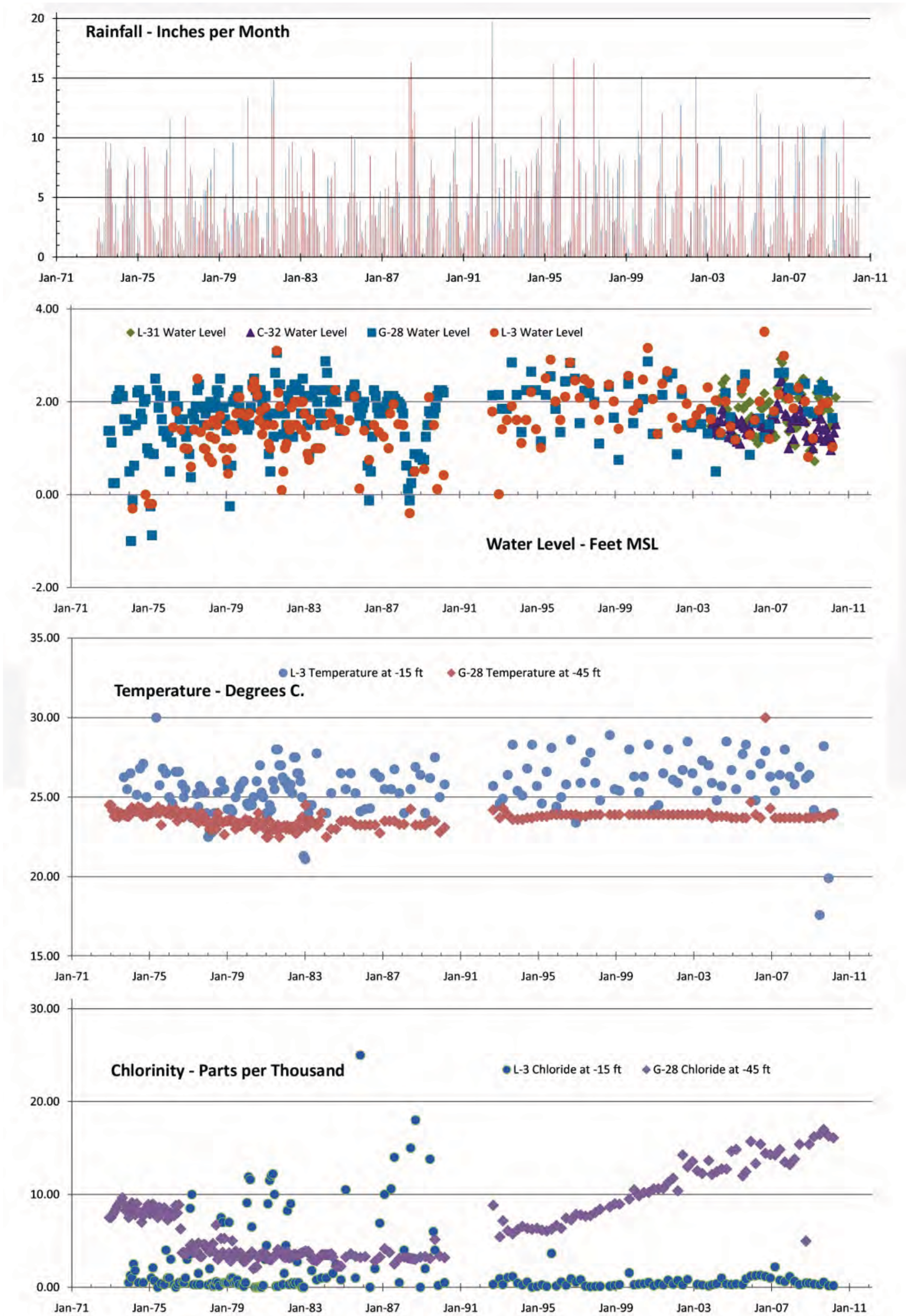
DWG NO. 10390259 Figure A-4		CLIENT/PROJECT FPL/2010 Annual Report Groundwater Monitoring Program/FL	
REV. NO.	JOB NO. 10390259		
DATE 8/26/10	DRAWN MAT	TITLE TIME-HISTORY PLOTS WELL NUMBER G-28	
SCALE NTS	CHECKED SH		
FILE NO.	REVIEWED HAF		FIGURE NO. A-4



Golder Associates, Atlanta, GA	DWG NO. 10390259 Figure A-5		CLIENT/PROJECT: FPL/2010 Annual Report Groundwater Monitoring Program/FL
	REV. NO.	JOB NO. 10390259	
	DATE 8/26/10	DRAWN MAT	TITLE: TIME-HISTORY PLOTS WELL NUMBER G-35
	SCALE NTS	CHECKED SH	
	FILE NO.	REVIEWED HAF	FIGURE NO. A-5



Note:
Rainfall data reported as S-20 from March 2008 onward is actually from FPL's Meteorological Tower near the Land Use Building.

FPL

Golder Associates

Atlanta, Georgia

TITLE

Rainfall, Water Level, Water Temperatures and Chlorinites

CLIENT/PROJECT

FPL/2010 Annual Report Groundwater Monitoring Program/FL

DRAWN MT	DATE 8/26/10	JOB NO. 10390259	
CHECKED SM	SCALE NTS	DWG. NO.	REV. NO.
REVIEWED HF	FILE NO. 10390259 Figure A-6	SUBTITLE	FIGURE NO. A-6

APPENDIX B

INTERCEPTOR DITCH OPERATION

APPENDIX B
INTERCEPTOR DITCH OPERATION

INTRODUCTION

The purpose of the Interceptor Ditch is to restrict inland movement of cooling canal water by maintaining a seaward ground-water gradient during times when a natural seaward gradient does not exist. During the wet season and the early part of the dry season, a natural seaward gradient usually does exist. During the rest of the year, however, it may be necessary to artificially generate a seaward gradient east of the levee 31 Borrow Canal by pumping water out of the Interceptor Ditch. The procedure for monitoring the ground-water gradient and operation of the Interceptor Ditch is presented in the following sections.

MONITORING LOCATIONS

Surface water elevations shall be monitored at staff gauges located in the West Feeder Canal 32 of the Cooling Canal System, Levee 31 Borrow Canal and the Interceptor Ditch at five locations relative to Lines A, B, C, D and E, as show on the inset, Figure 1 in the main text. When pumping of the Interceptor Ditch commences, additional data shall be obtained at each of the two ID pump stations. Locations of the pump stations are also shown Figure 1.

MONITORING FREQUENCY

Water elevation data shall be collected at the five monitoring locations twice a month during non-pumping periods. These elevations will be measured on or about the first of each month and again near the middle of the month. Non-pumping periods typically reflect the wet season high water levels, i.e., June through November.

During the dry period, December through May, water elevation data will be collected once a week except during periods when pumping is necessary to create a seaward gradient. When pumping is required, water surface elevation data will be collected at least twice weekly. Adequate surveillance shall be set up to assure proper Interceptor Ditch operation. Data on pump run time and segments of the Interceptor Ditch being pumped will be recorded in the Interceptor Ditch Pump Operation Log.

PUMPING CRITERIA

As long as a natural seaward ground-water gradient exists, pumping of the Interceptor Ditch is not required. The following criteria define when a natural seaward gradient exists and when the Interceptor Ditch must be pumped to create an artificial gradient east of Levee 31 Borrow Canal.

Natural Seaward Gradient – a natural seaward gradient exists when the Levee 31 Borrow Canal water surface elevation (feet MSL) minus the West Feeder Canal, Number 32 water surface elevation (feet MSL) is greater than 0.20 feet.

If this criterion is not met, a natural seaward gradient still exists if the Levee 31 Borrow Canal water surface elevation (feet MSL) minus the Interceptor Ditch water surface elevation (feet MSL) is greater than 0.30 feet.

Artificial Seaward Gradient – If a natural seaward gradient does not exist, pumping of the Interceptor Ditch must be initiated to artificially create a seaward gradient. Pumping shall be adjusted so that the water surface elevation (feet MSL) in the Interceptor Ditch is maintained greater than 0.30 feet lower than the water surface elevation (feet MSL) in Levee 31. Pumping can be terminated when the criteria for a natural seaward gradient is met.

The flow chart on the subsequent page depicts the requirement for pump operations. This chart should be used each time water elevation data are obtained in order to more easily determine when pumping is or is not required.

The pump stations show on Figure 1, divide the Interceptor Ditch into three segments. Each segment is evaluated separately with respect to the seaward gradient operating criteria. One segment, therefore, might require pumping while another might not. Pumping shall be initiated when any of the lines of staff gauges governing that segment fails to meet the specified criteria for a natural seaward gradient. Adjustable intake gates (stoplogs) in each pump intake basin allow for various pump combinations to drawdown specific Interceptor Ditch segments.

APPENDIX C

INTERIM REPORT ON

SALTWATER ENCROACHMENT IN DADE COUNTY, FL

STATE OF FLORIDA
STATE BOARD OF CONSERVATION
Ernest Mitts, Director

FLORIDA GEOLOGICAL SURVEY
Herman Gunter, Director

INFORMATION CIRCULAR NO. 9

INTERIM REPORT

ON

SALT-WATER ENCROACHMENT

IN

DADE COUNTY, FLORIDA

By

HOWARD KLEIN

PREPARED BY U. S. GEOLOGICAL SURVEY
IN COOPERATION WITH DADE COUNTY, THE CITIES OF MIAMI
AND MIAMI BEACH, THE CENTRAL AND SOUTHERN FLORIDA
FLOOD CONTROL DISTRICT, AND THE FLORIDA GEOLOGICAL SURVEY

Tallahassee, Florida
1957

ILLUSTRATIONS

SALT-WATER ENCROACHMENT IN

DADE COUNTY, FLORIDA

By

HOWARD KLEIN

Recently there has been much activity in reclaiming the low-lying coastal areas of Dade County for residential use, by the addition of fill. The fill is obtained by digging canals both normal to and parallel to Biscayne Bay. The canals serve the additional purpose of providing an access to the Bay for boats. A problem needing to be considered is the effect that these canals will have on the ground-water resources. It is expected that the canals will have little effect on ground water in parts of the county distant from the coast, but their effect in coastal areas is a matter of concern. In order to predict what may happen in the vicinity of these new canals if they are not equipped with adequate control structures, it is instructive to review what has happened in the vicinity of similar canals in the past.

The U. S. Geological Survey, in cooperation with Dade County, the cities of Miami and Miami Beach, the Central and Southern Florida Flood Control District, and the Florida Geological Survey has collected water-level and salinity data on wells and canals in Dade County since 1939. Some of the agencies named, and others, collected similar data before 1939. Analysis of all the data shows that sea water in the Atlantic Ocean and Biscayne Bay is the sole source of salt-water contamination in the Biscayne aquifer of the Dade County area.

According to the Ghyben-Herzberg principle, a head of fresh water one foot above mean sea level indicates that fresh water extends to a depth of about 40 feet below mean sea level. Present studies in the Miami area indicate that this principle is valid but is modified (greatly in certain areas) by field conditions, particularly the movement of ground water.

A report by Parker and others 1/ presents a fairly com-

1/ Parker, G. G., Ferguson, G. E., Love, S. K., and others, 1955, Water resources of southeastern Florida: U. S. Geol. Survey Water-Supply Paper 1255.

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plete history of salt-water encroachment in the Miami area. Figure 1, adapted from figure 169 of that report, shows successive stages of salt-water encroachment in the Miami area from 1904 through 1953. The stippled areas in the figure represent the zones in which wells 80 to 100 feet deep would have tapped ground water having a chloride concentration of 1,000 ppm (parts per million) or more. Figure 2 shows the extent of salt-water encroachment in Dade County in 1951.

Uncontrolled or inadequately controlled tidal canals have been the chief cause of salt-water contamination in the Biscayne aquifer, the principal aquifer of southeastern Florida. Such canals cause salt-water encroachment in two ways:

1. They drain off fresh ground water, thereby reducing the fresh-water head that opposes the inland movement of salt water; and,

2. They provide a path for sea water to move readily inland during dry periods. A tongue of salty ground water extends several miles inland along each principal tidal canal.

A comparison of the maps in figure 1 shows that the greatest inland movement of salt water occurred between 1943 and 1946, as a result of the severe drought during 1944 and 1945. Much of the aquifer near the Miami, Little River, and Biscayne canals, and also a large part of the aquifer underlying Coral Gables, became contaminated. The map for 1950 indicates the effectiveness of temporary control structures in the several canals in retarding overdrainage of ground water from storage and in retarding inland movement of salt water in open canals. In the vicinities of Biscayne, Little River, and Miami canals, the salt-water front

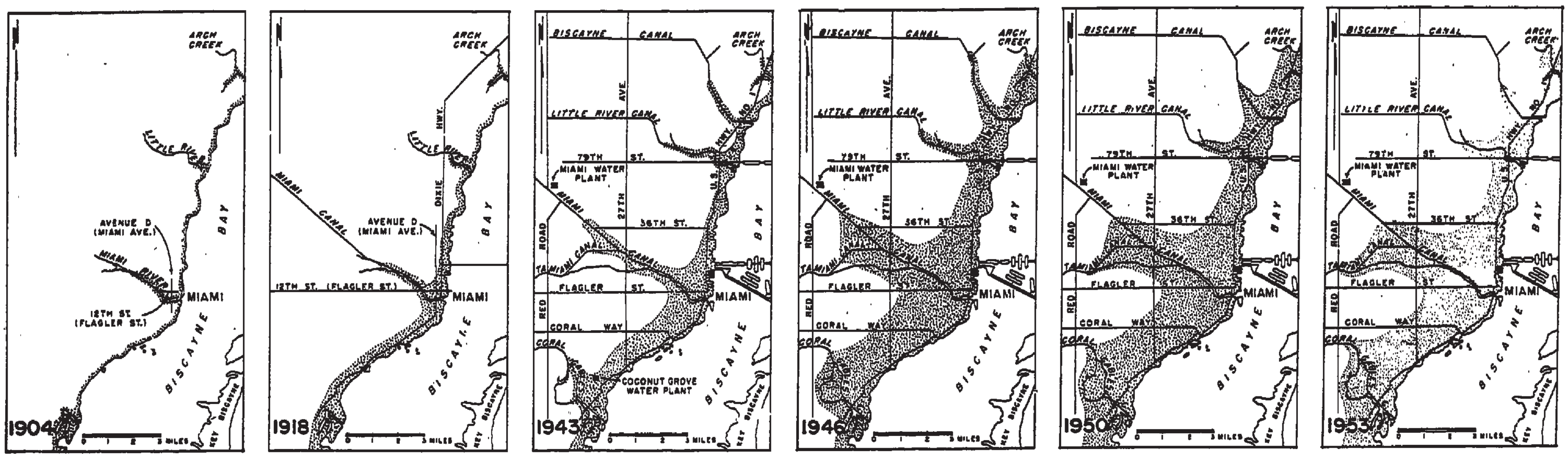

Figure 1. Maps showing progressive salt-water encroachment in the Miami area, 1904-53.

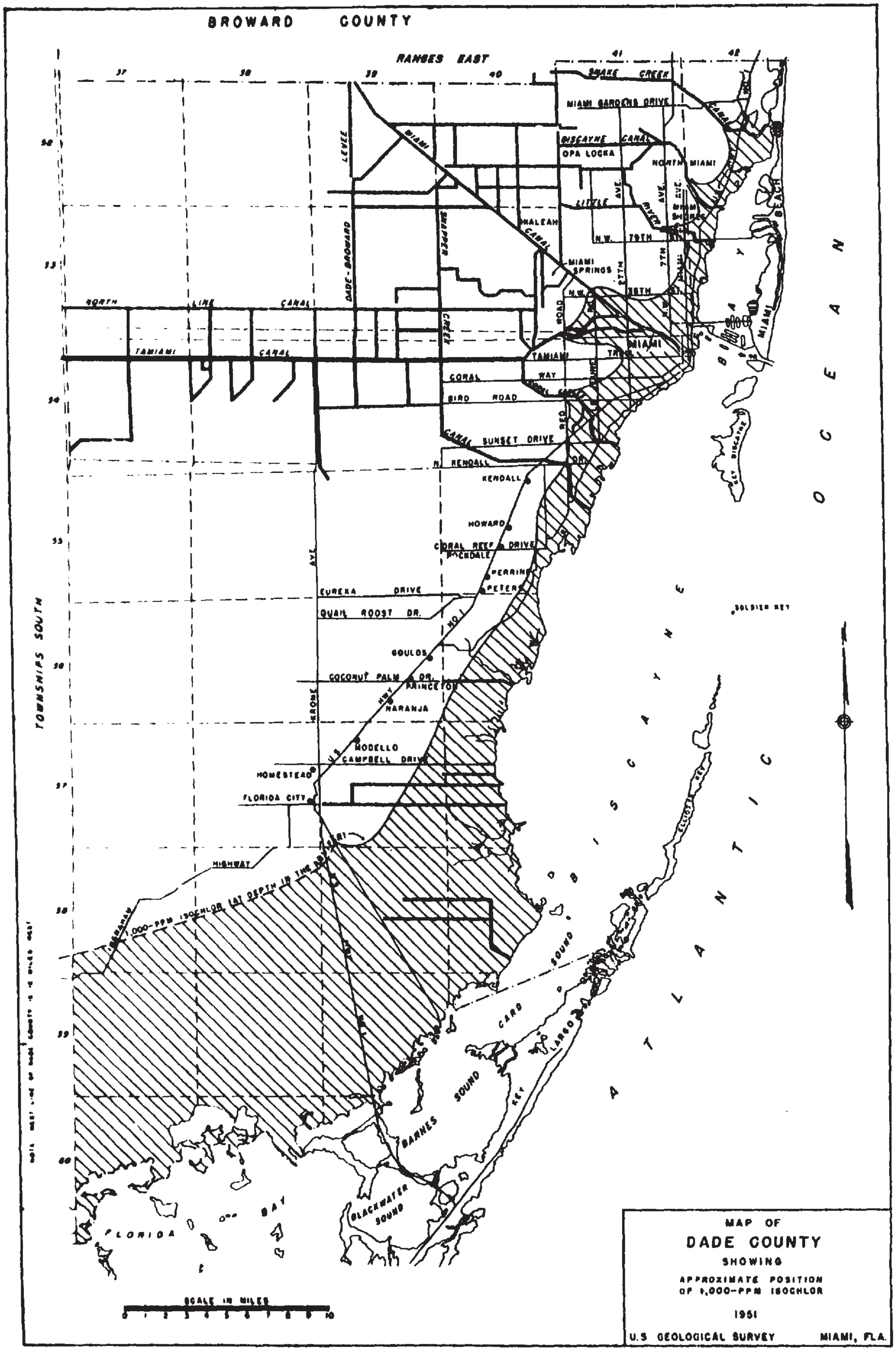

Figure 2. Map of Dade County showing approximate position of the 1,000-ppm isochlor.

retreated seaward approximately to the control structures, but along the Coral Gables and Tamiami canals it migrated farther inland, almost to Red Road. The continued encroachment in the vicinities of the Coral Gables and Tamiami canals can be attributed to the fact that the control structures were placed too far upstream to be effective in retarding the inland movement of salt water.

One of the most intensively studied areas in Dade County is the Silver Bluff area, where Garald G. Parker, during early years of the cooperative study, and Nevin D. Hoy and Francis A. Kohout, in recent years, have correlated the movements of salt water with ground-water levels. An opportunity to expand these studies came in August 1954 when the State Road Department began excavation of an open-trench storm sewer beneath 27th Avenue. This excavation, in reality, was an uncontrolled tidal drainage ditch, because the altitude of its bottom ranged from three feet below mean sea level at the Bay to sea level at a distance of about 9,000 feet from the outlet. On June 17, 1954, prior to the ditching operations, measurements of water levels were made in various wells in the Silver Bluff area and these were used to draw the water-level contours in figure 3. On November 29, 1955, something like a year after the completion of the ditching operations, the water levels in the wells were measured again, and these measurements were used to draw the water-level contours in figure 4. The most prominent change in the patterns shown by figures 3 and 4 is the realignment of the contours along 27th Avenue. This realignment indicates that ground water drains continuously into the storm sewer and thence to Biscayne Bay. Figure 4 shows that by November 1955 the effects of this drainage had extended over a considerable area on both sides of 27th Avenue and to a point north of 16th Street.

In addition to the water-level measurements, water samples from many wells in the Silver Bluff area were analyzed for chloride content. Figure 5 is a contour map of the surface below which the chloride content exceeded 1,000 ppm on July 20, 1953, prior to the excavation of the trench. This is to be compared with figure 6, a contour map of this surface on April 4, 1956. In the 1956 map the contours curve northward along 27th Avenue, indicating that

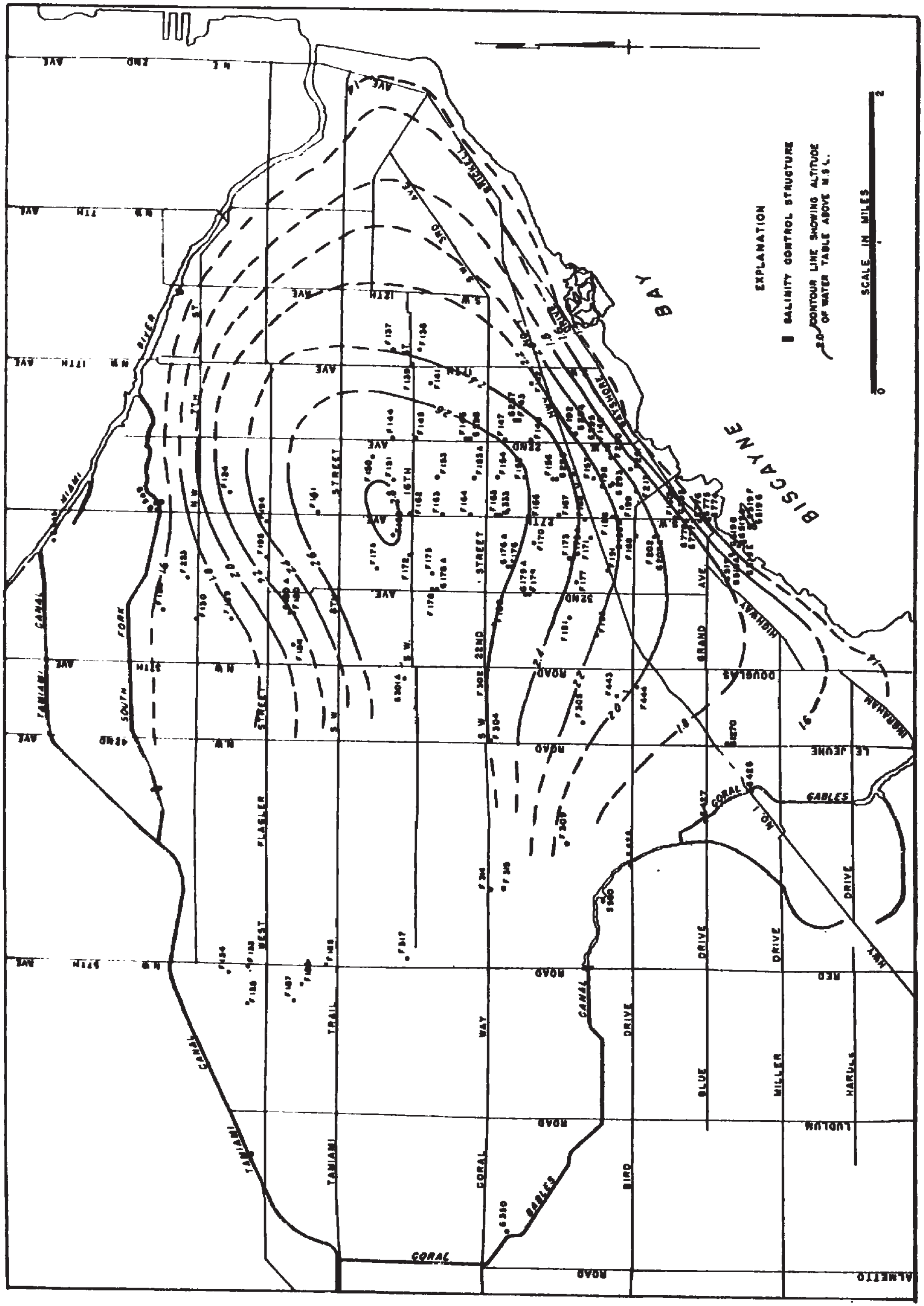

Figure 3. Contour map showing the altitude of the water table in the Silver Bluff area, June 17, 1954.

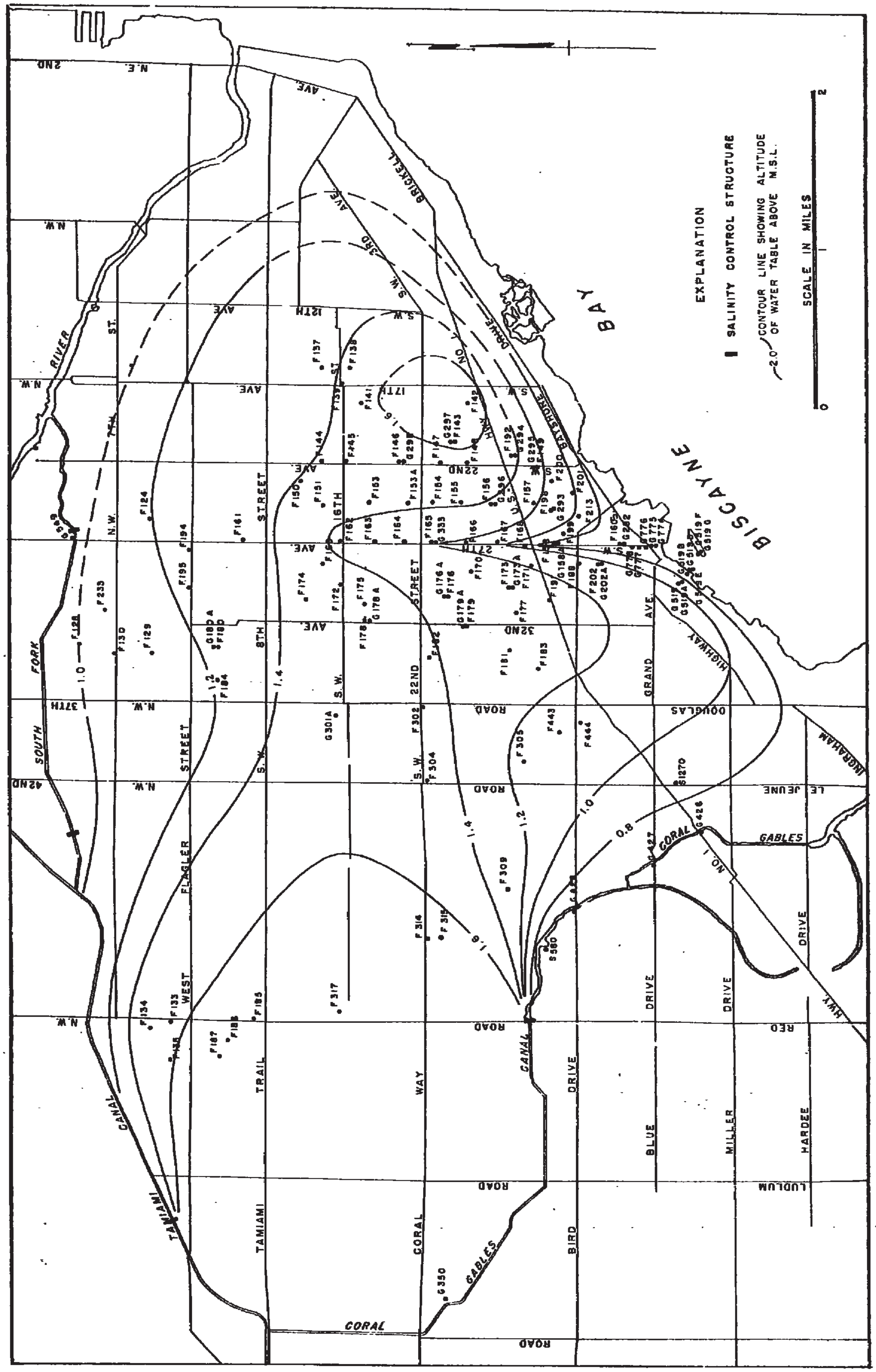

Figure 4. Contour map showing the altitude of the water table in the Silver Bluff area, November 29, 1955.

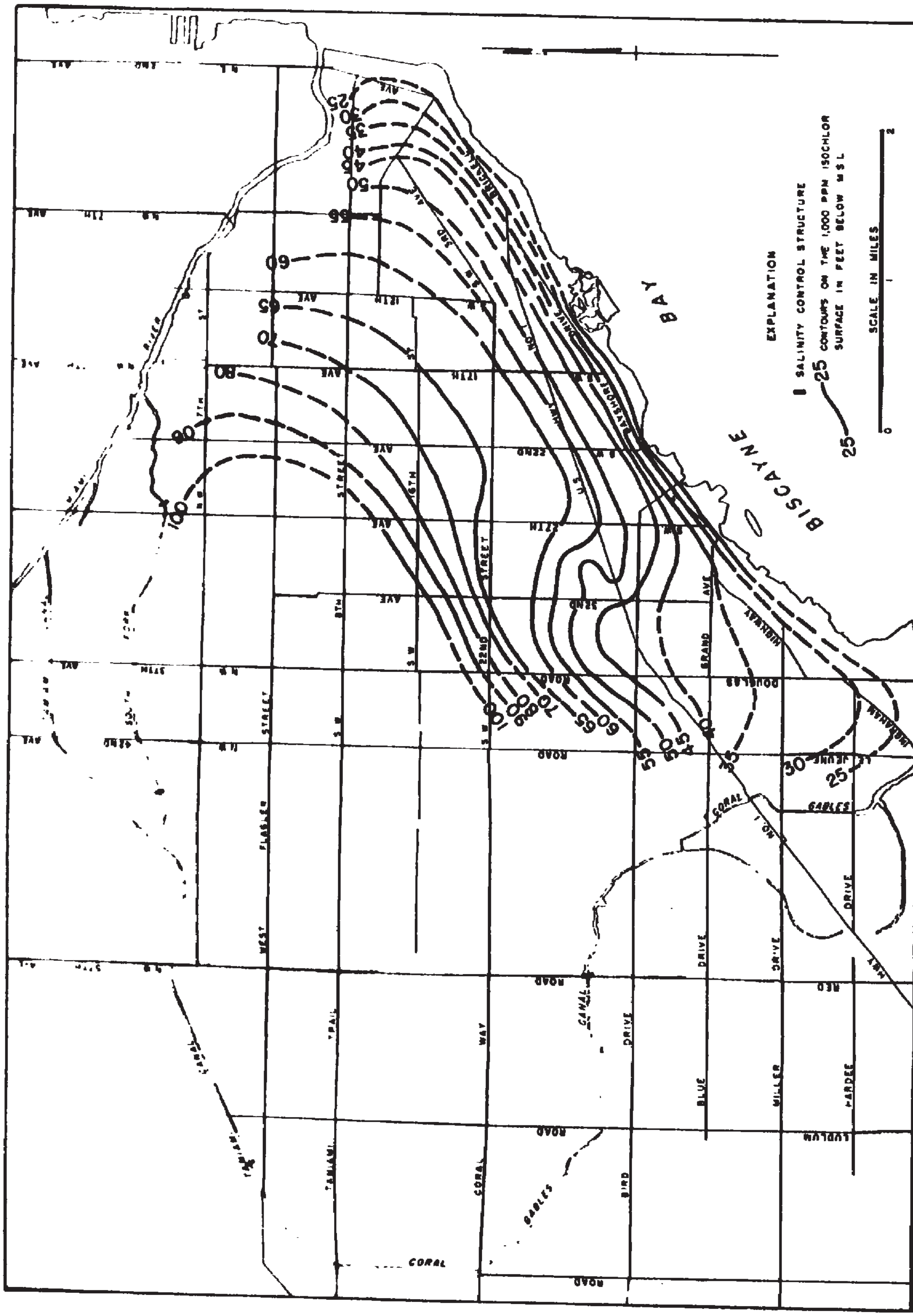

Figure 5. Contour map showing the depth of the 1,000-ppm isochlor surface in the Silver Bluff area, July 20, 1953.

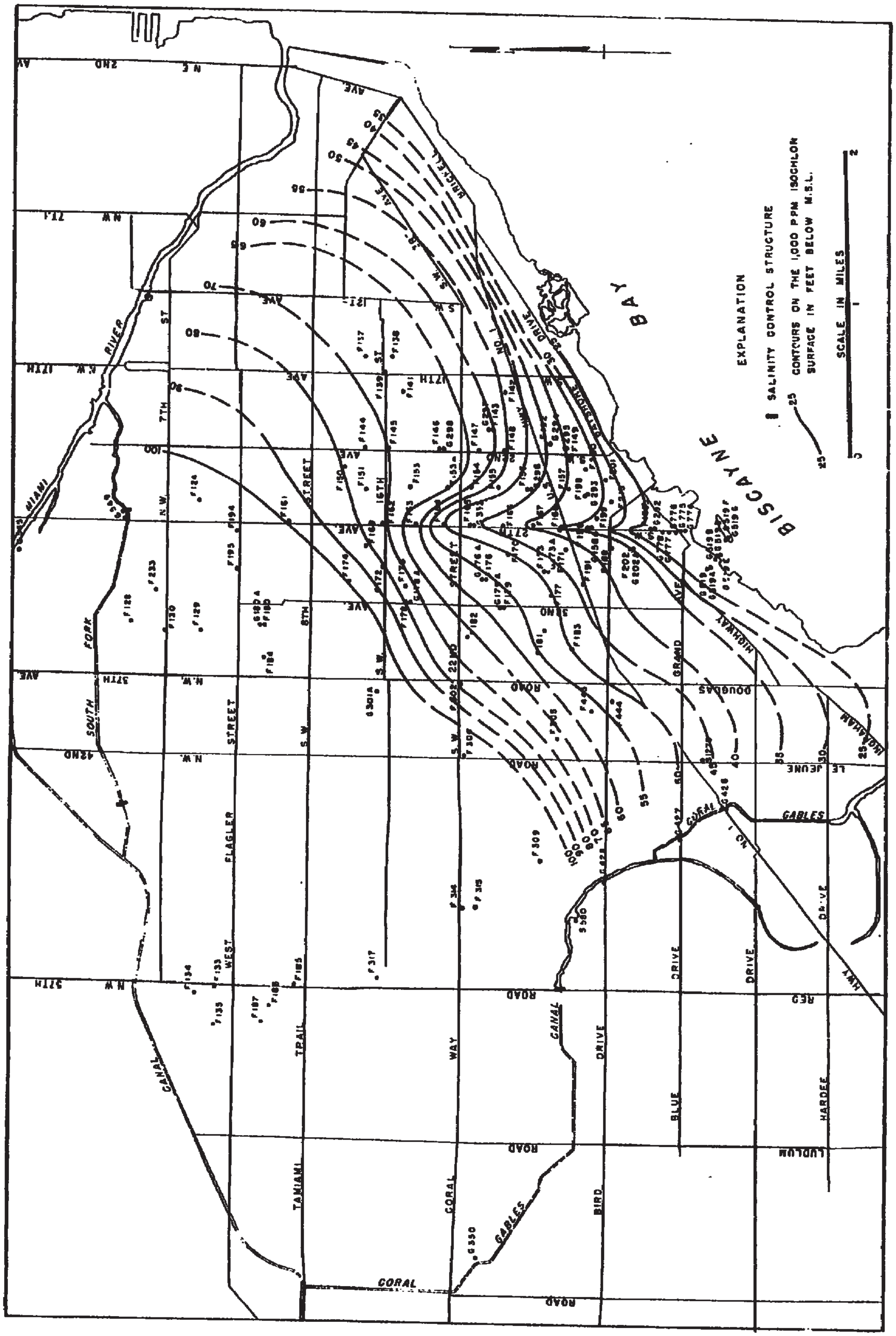

Figure 6. Contour map showing the depth of the 1,000-ppm isochlor surface in the Silver Bluff area, April 4, 1956.

the chloride content in the ground water in that area had increased as a result of the drainage of ground water. However, the encroachment had occurred only in a relatively narrow area parallel to the trench.

Figures 7 to 10 show the water level and the chloride content of the water in wells in the immediate vicinity of 27th Avenue. The graphs show that the chloride content decreases when the water level is high and increases when the water level is low. The increase in chloride content that began in December 1954 can be attributed chiefly to the lowering of the water table as a result of the drainage of ground water into the trench and out to the Bay.

As shown in figure 2, salt-water encroachment has occurred throughout coastal Dade County and farther inland along tidal canals. This does not mean, however, that fresh water is not available in these areas. Moderate quantities of fresh water can be obtained at shallow depths throughout the area affected by encroachment, except in areas immediately adjacent to the Bay or tidal canals and in low-lying coastal marshes that are periodically covered by tidal water.

Data on the salinity of water in wells in the coastal areas indicate that the interface between the fresh water and salt water moves fairly rapidly in response to changes in ground-water levels. Figure 11-A shows, in profile, the position that the interface would assume according to the Ghyben-Herzberg principle. It rises and moves inland whenever the water table is low, and falls and moves seaward when the water table is high. Also shown in figure 11-A are two supply wells, each of which will yield fresh water under the stated conditions.

Figure 11-B assumes the same conditions as those in figure 11-A, except that a network of uncontrolled tidal canals has been added. The position of the interface in the immediate area of the canals is shown to have shifted inland by a distance approximately equal to the maximum inland extension of the canals. As a result of this shift, well 1 would yield salty water at all times and well 2 would do so during low-water conditions.

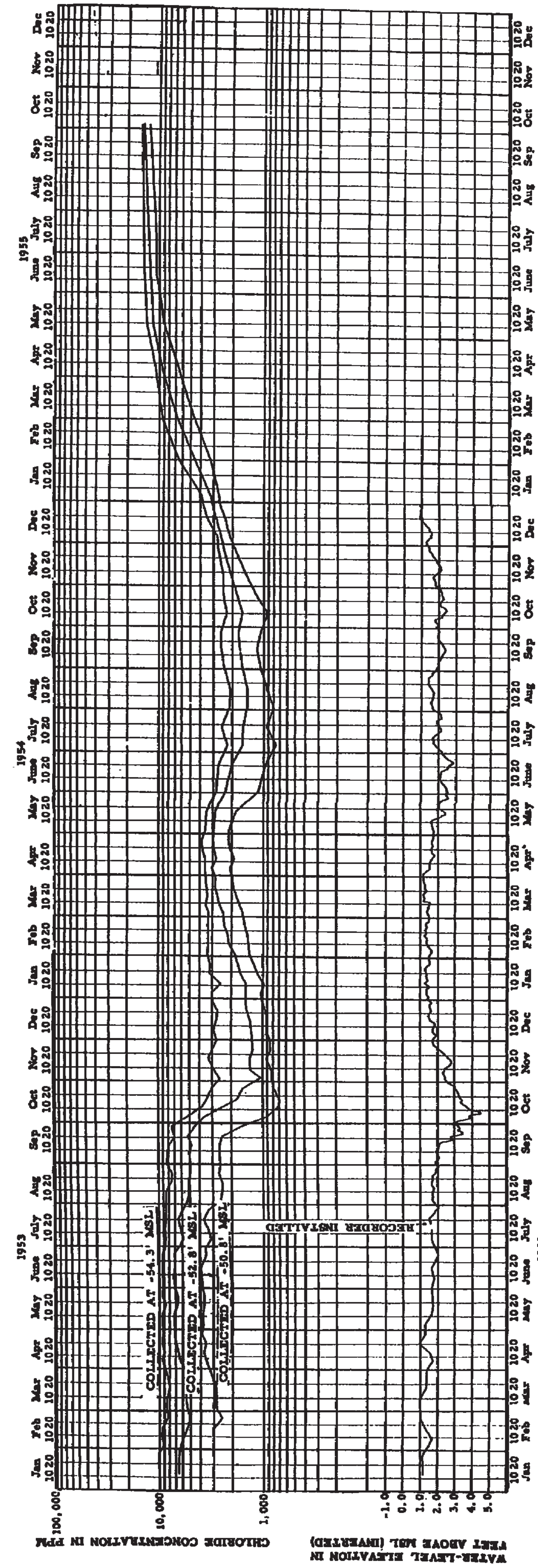

Figure 7. Graph showing fluctuations of chloride content in the open-hole part of well F-198, compared with water-level fluctuations.

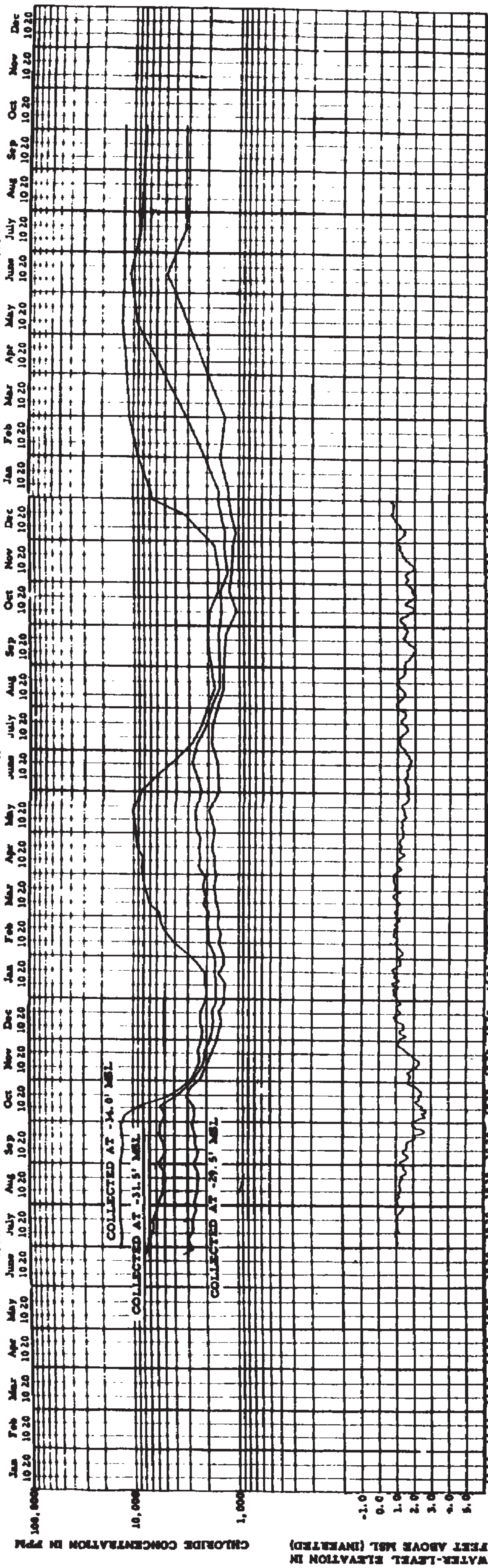

Figure 8. Graph showing fluctuations of chloride content in the open-hole part of well G-519A, compared with water-level fluctuations.

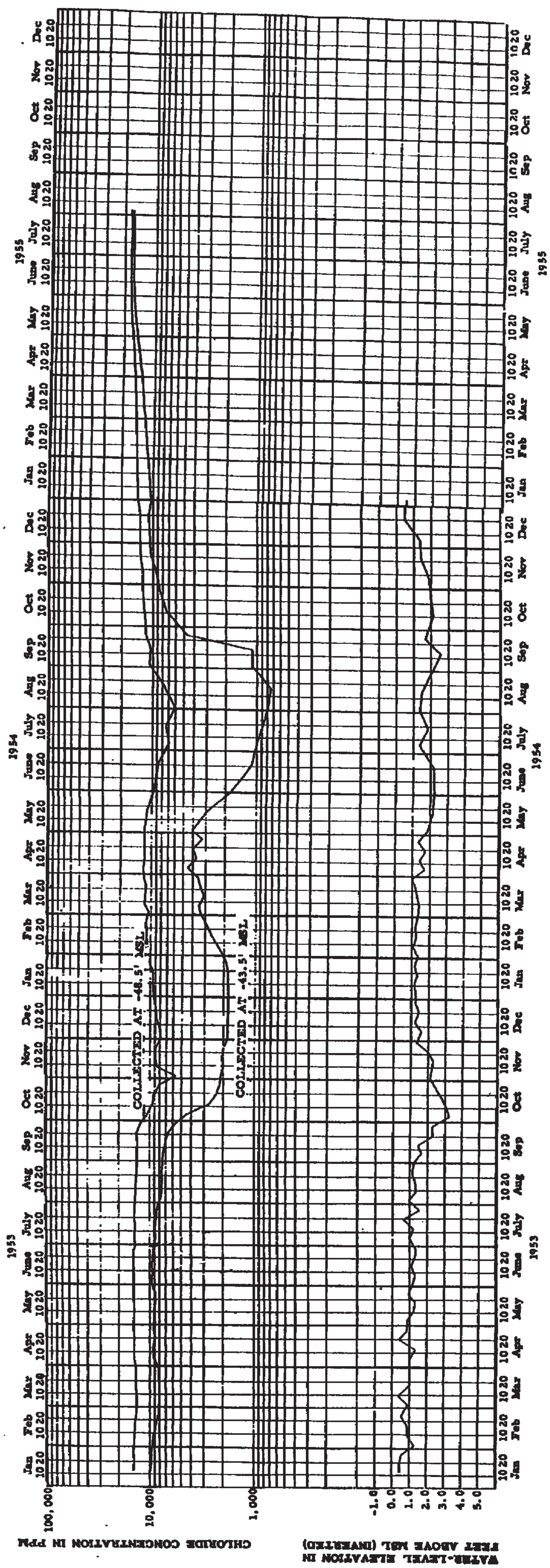

Figure 9. Graph showing fluctuations of chloride content in the open-hole part of well F-160, compared with water-level fluctuations.

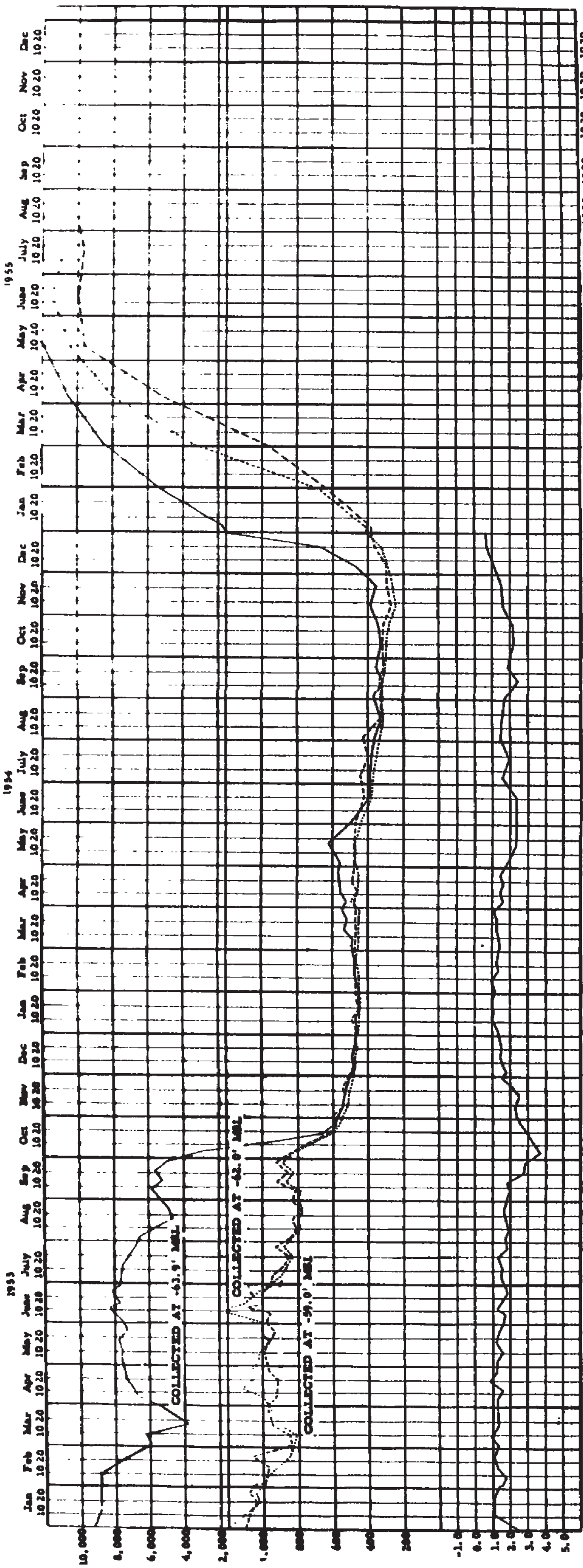

Figure 10. Graph showing fluctuations of chloride content in the open-hole part of well F-202, compared with water-level fluctuations.

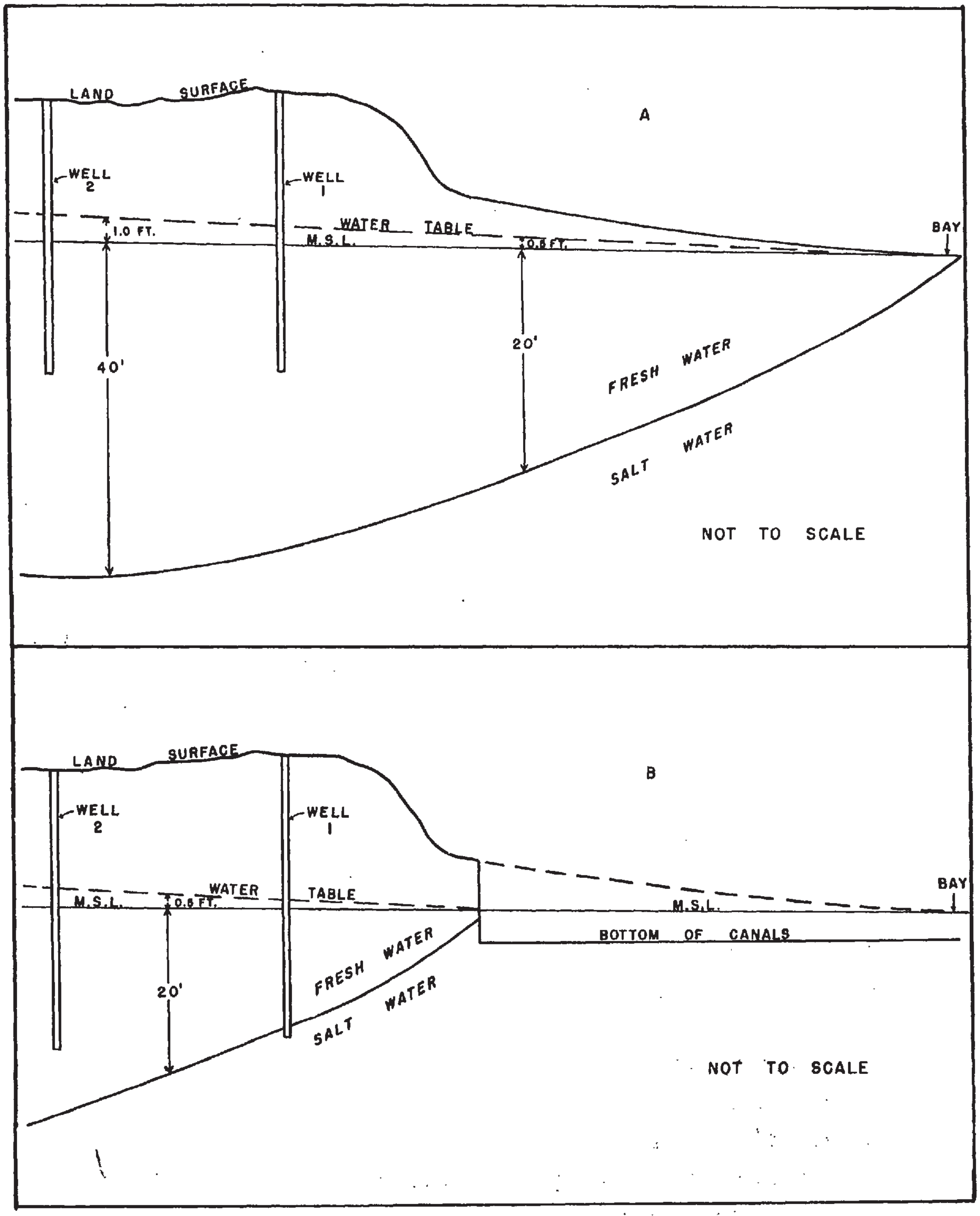

Figure 11. Diagrammatic cross section of coastal area, showing theoretical positions of the fresh-water salt-water interface.

Where a series of closely spaced, uncontrolled tidal canals has been excavated, the ultimate position of the interface would be nearly the same as if an arm of Biscayne Bay extended as far inland as the canals. A network of canals, all connected with the Bay, would cause salt water to move inland over a broad front. The intercanal areas might be underlain to shallow depth by fresh water, but during droughts some or all of the wells in these areas would yield salty water.

The sole source of fresh ground water in the Biscayne aquifer is the rainfall in the area. However, only a part of the water that falls as rain becomes ground water. Much of it runs off or is evaporated and transpired before it reaches the water table. Of that which reaches the water table some is also evaporated and transpired, and the rest flows into Biscayne Bay and the tidal canals or is pumped from wells. Obviously, if a series of uncontrolled tidal canals were dug to the bay, the rate of ground-water outflow would increase, and the water table would fall. A lowering of the water table along the coast will inevitably be accompanied by an advance of the salt-water interface.

Figure 2 indicates that there has been little encroachment in the vicinity of Cutler (south of Snapper Creek), near the center of a coastal reach that has not yet been dissected by canals. The reason that the salt water has not moved inland is probably that the water table is high locally (fig. 12). The nearest drainage canal (Snapper Creek) has little effect on ground-water levels in the Cutler area.

In summary, it is to be stressed that one of the chief causes of the encroachment of salt water in the underlying rocks in the Miami area is the system of uncontrolled or inadequately controlled tidal drainage canals. It has been shown that water-control structures, properly placed, have retarded encroachment and, in some places, have caused the salt water to retreat seaward. In some canals, however, the controls have been placed too far upstream to be effective in retarding or preventing encroachment. The effects of uncontrolled tidal canals between Biscayne Bay and the coastal ridge would be the same as if arms of the Bay extended to the ridge; the salty ground water would occur farther inland over a broad front.

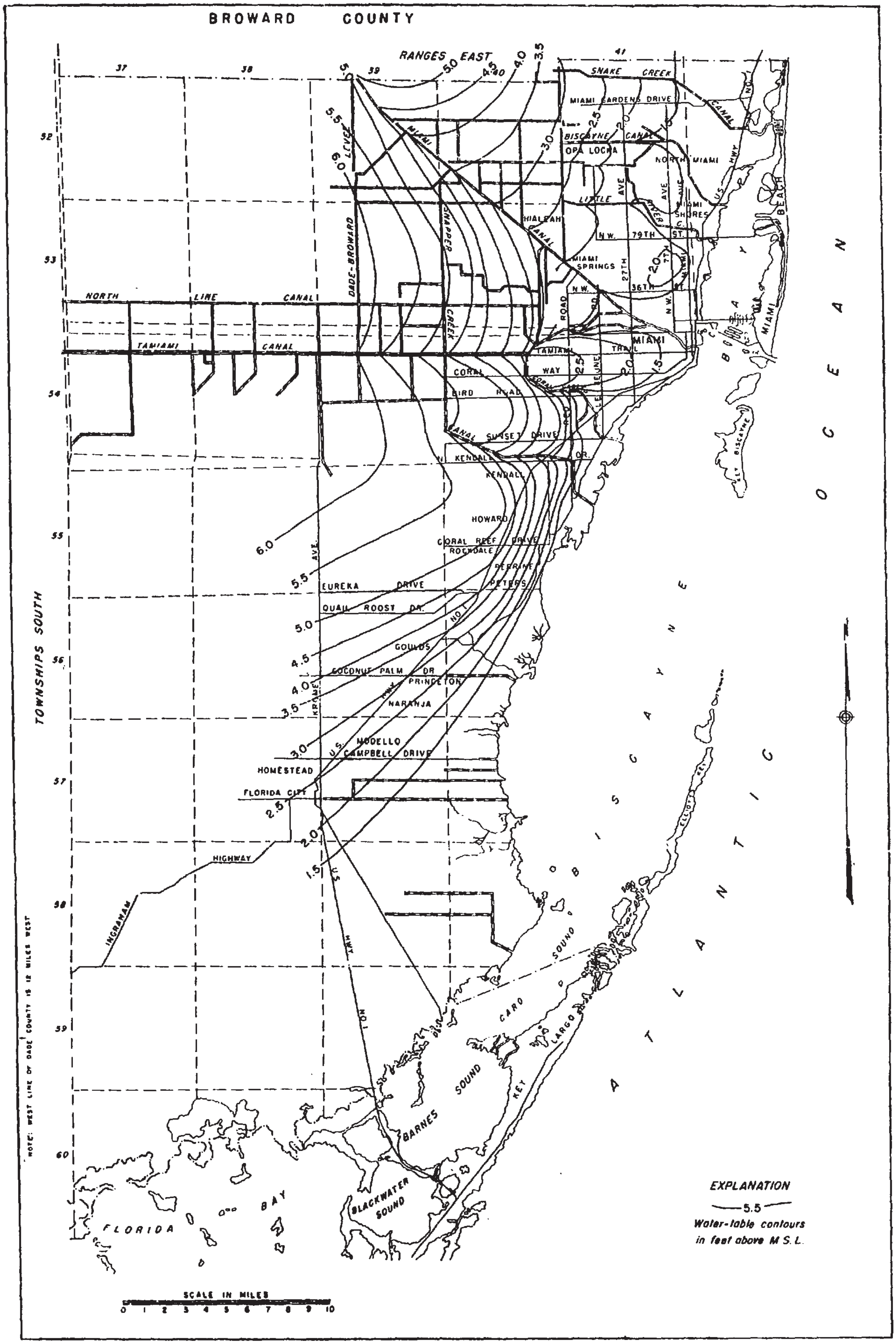

Figure 12. Contour map showing the average altitude of the water table in Dade County, 1940-50.