FILE

GROUNDWATER MONITORING PLAN
Phases I - VI and
Sections 7 and 8

Southeast County Landfill
Hillsborough County, Florida

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SOUTHEAST COUNTY LANFILL
HILLSBOROUGH COUNTY, FLORIDA

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SECTION 1

INTRODUCTION

BACKGROUND

This Groundwater Monitoring Plan (GWMP) update modifies the existing GWMP for the Southeast County Landfill (SCLF). This update includes the addition of monitoring wells for Section 8 of the Capacity Expansion Area. The SCLF is located in Hillsborough County (See Figure 1-1). Two permits were issued to the Hillsborough County Solid Waste Management Department (SWMD) by the Florida Department of Environmental Protection (FDEP) to operate, maintain and monitor Class I disposal areas at the SCLF.

- Permit Number 35435-006-SO, issued on June 25, 2002 includes approximately 200 acres referred to as Phases I-VI (Phases I-VI). The permit expires June 20, 2007.
- Modification 35435-008 to existing Operation Permit Number 35435-007-SO, issued on July 21, 2003 includes approximately 13 acres referred to as Section 7 Capacity Expansion (Capacity Expansion). The permit expires June 20, 2007.

The Groundwater Monitoring Plan (GWMP) addresses the components as noted in Phase I-VI permit, Specific Conditions 29 (as amended), 30, 34 (as amended), 35 (as amended), 36 (as amended), 37 (as amended), 38 (as amended), 39 (as amended), 40 (as amended), 41 (as amended) and 42 (as amended). The GWMP also addresses the components as noted in the Capacity Expansion permit, Specific Conditions 29, 30, 34, 35, 36, 37, 38, 39, 40, 41 and 42.

This GWMP includes groundwater monitoring for Phases I-VI and for the Capacity Expansion, Section 7 as permitted. Additionally groundwater monitoring for the Capacity Expansion, Section 8, which is currently in the operations permit process is included.

REQUIREMENTS OF F.A.C. 62-701.510(9)(b)

The technical report required by F.A.C. 62-701.510(9)(b) which summarized and interpreted water quality and water level measurements collected from January 30, 2004 through February 9, 2004 was submitted to the FDEP on July 21, 2004.

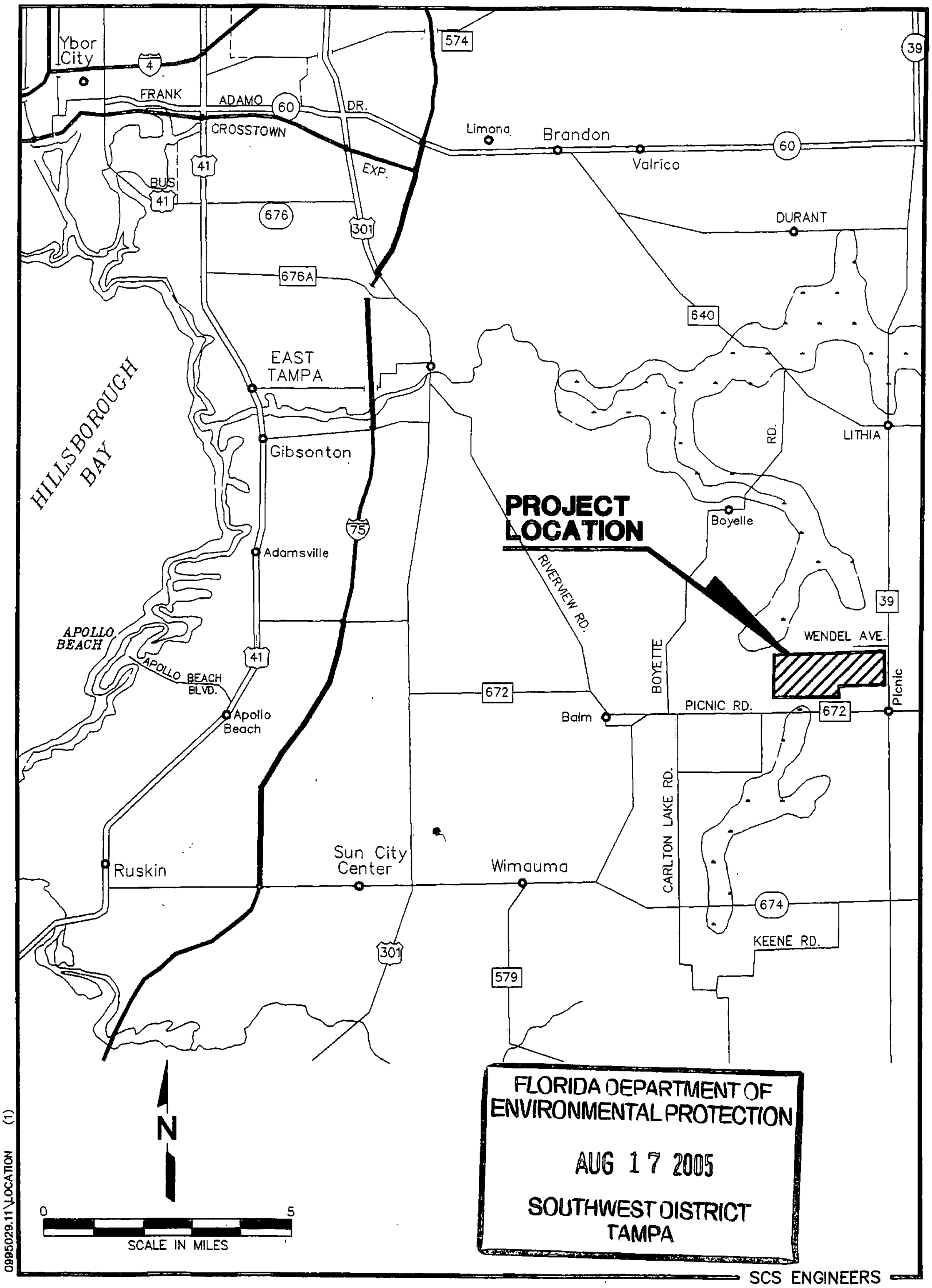

Figure 1-1. Location of the Southeast County Landfill, Hillsborough County, Florida.

SECTION 2

SUMMARY OF THE GROUNDWATER AND SURFACE WATER MONITORING PROGRAM

Water quality monitoring at the SCLF is conducted at several groundwater and surface water sites. The following summarizes the monitoring described in the current operations permits, which address Phases I-VI, as well as the monitoring for the Section 7 of the Capacity Expansion Area. Planned groundwater monitoring for Section 8 of the Capacity Expansion is also addressed.

The monitoring program update for the SCLF includes three background wells and 14 detection wells. Phases I-VI includes two background wells and seven detection wells. Section 7 of the Capacity Expansion includes one background well and four detection wells. Section 8 will add three new detection wells, using the existing Section 7 background well as background for Section 8.

There is one Floridan aquifer background monitoring well (TH-19) and one Floridan detection well (TH-40) for Phases I-VI. Additionally, Phases I-VI includes one surficial aquifer background well (TH-22A) and six surficial aquifer detection wells (TH-28A, TH-57, TH-58, TH-65, TH-66, and TH-67). The surficial aquifer background well for Section 7 at the Capacity Expansion area is TH-36A. Four surficial aquifer detection wells monitor Section 7: TH-61and TH-64 on the east side, and TH-59 and TH-60 on the west side. The surficial aquifer background well for Section 7 will also be used as background well for Section 8. Three surficial aquifer detection wells will be constructed to monitor Section 8: TH-62 and TH-63 on the west side, and TH-68 east side.

There are no intermediate aquifer (permeable beds of the Hawthorn Group) monitoring wells because the aquifer is not present at the site (Ardaman 1983, p. 4-3).

Figure 2-1 provides the location of these wells along with locations of piezometers and surface water sampling points at the SCLF. Table 2-1 lists construction characteristics of the groundwater monitoring wells, and notes those wells proposed for construction. A typical construction detail is shown on Figure M-2 of the Engineering Report.

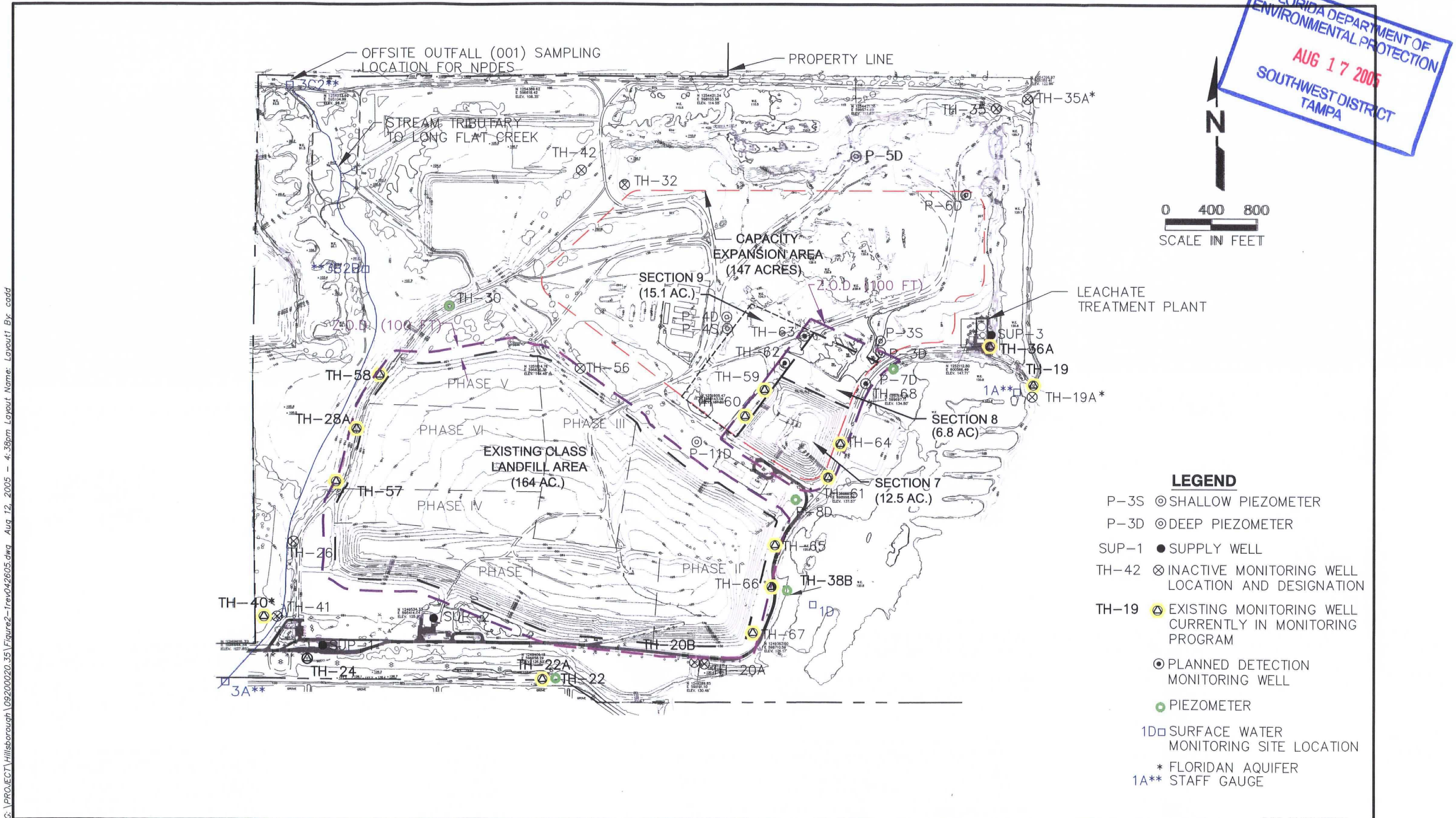

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Figure 2-1. Location of Monitoring Wells, Piezometers, and Surface Water Sampling Points.

TABLE 2-1. MONITORING WELL CHARACTERISTICS SUMMARY SOUTHEAST COUNTY LANDFILL

Well No.	Purpose	Aquifer Monitored[1]	Approximate Ground Elevation at Well[2] (Ft. NGVD)	Top of Screen or Open Hole (Ft, BLS[2])	Top of Screen or Open Hole (Ft, NGVD[3])	Length Of Screen (Ft)	Total Depth (Ft, BLS)	Total Depth (Ft, NGVD)	Measuring Point (MP) Location	MP Elevation (Ft, NGVD)	Construction Date	Last Survey Date	Historical Water Levels High Ft. NGVD	Date	Low Ft. NGVD	Date
TH-19	Background	Floridan	127.50	146.0	-18.68	5	151.0	-23.68	TPVC[5]	130.05	12/82	3/97	47.21	2/16/98	-9.53	5/19/00
TH-22A	Background	Surficial	126	2	124	10	12	114[5]	TPVC	Data unavailable	10/02	Data unavailable	124.37	8/13/03	123.35	2/9/04
TH-28A	Detection	Surficial	128	18	110	10	28	100[5]	TPVC	Data unavailable	9/02	Data unavailable	105.38	2/16/98	102.72	1/30/01
TH-38B	Inactive	Surficial	128	2	126	10	12	116[5]	TPVC	Data unavailable	9/02	Data unavailable	123.43	9/17/04	120.51	6/4/04
TH-36A	Background	Surficial	150.08	26	124.08	10	36	114.08	TPVC	152.70	7/97	Data unavailable	121.81	2/16/98	118.50	5/11/01
TH-40	Detection	Floridan	122.05	158.0	-35.70	5	163.0	-40.7	TPVC	124.77	12/82	3/97	45.65	2/16/98	-14.07	5/19/00
TH-57	Detection	Surficial	Data unavailable	14	111.09	10	24	101.09	TPVC	128.09	12/82	3/97	109.64	2/16/98	107.35	5/19/00
TH-58	Detection	Surficial	Data unavailable	18	109.67	10	28	99.67	TPVC	127.67	12/82	3/97	100.26	8/13/03	99.12	2/19/01
TH-59	Detection	Surficial	139.38	13.00	126.38	10	23	116.38	TPVC	141.93	8/03	11/03	123.07	11/10/03	121.67	2/21/05
TH-60	Detection	Surficial	139.37	12.00	127.37	10	22	117.37	TPVC	142.73	8/03	11/03	125.73	11/10/03	122.80	2/21/05
TH-61[5]	Detection	Surficial	135.78	13.00	122.78	10	23	112.78	TPVC	138.73	2/01	11/03	124.25	1/9/03	117.75	6/15/01
TH-62[7]	Detection	Surficial	139[8]	13[8]	126[8]	10[8]	23[8]	116[8]	TPVC	To be determined	To be constructed	To be surveyed	126[9]		122[9]	
TH-63[7]	Detection	Surficial	139[8]	13[8]	126[8]	10[8]	23[8]	116[8]	TPVC	To be determined	To be constructed	To be surveyed	126[9]		122[9]	
TH-64	Detection	Surficial	136.03	10	126.03	10	20	116.03	TPVC	139.64	8/03	11/03	124.43	2/21/05	124.39	11/10/03
TH-65	Detection	Surficial	132.39	10	122.39	10	20	112.39	TPVC	135.40	8/03	11/03	122.72	11/10/03	122.61	2/21/05
TH-66[10]	Detection	Surficial	127.53	9	118.53	10	19	108.53	TPVC	130.58	2/01	11/03	124.59	8/13/03	118.78	6/15/01
TH-67	Detection	Surficial	126.46	2	124.46	10	12	114.46	TPVC	129.51	8/03	11/03	123.09	2/21/05	122.85	11/10/03
TH-68[7]	Detection	Surficial	136.5[8]	10[8]	126[8]	10[8]	20[8]	116.5[8]	TPVC	To be determined	To be constructed	To be surveyed	125.5[9]		120[9]	

Data from Hillsborough County Solid Waste Management Department

Notes:
1 Aquifer from which the well is deriving its water.
2. Below land surface
3. National Geodetic Vertical Datum of 1929.
4. Top of PVC Casing
5. TH-61 was formerly designated as P-9D
6. More precise elevations will be listed when survey data is available
7. Section 8 Groundwater Monitoring Wells
8. Construction characteristics are estimated.
9. Water level data are estimated from nearby monitoring wells.
10. TH-66 was formerly designated as P-10D

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GROUNDWATER MONITORING

Groundwater Monitoring Wells, Phases I-VI

The current operations permit established the groundwater-monitoring program for Phases I-VI. The program consists of the monitoring wells and the indicated purpose as shown on Table 2-2 (see Figure 2-1 for locations of the wells).

TABLE 2-2. GROUNDWATER MONITORING WELLS AT SOUTHEAST COUNTY LANDFILL (PHASES I-VI) AND AQUIFER MONITORED

Well Number	Aquifer Monitored	Purpose
TH-19	Floridan	Background
TH-40	Floridan	Detection/ Compliance
TH-22A	Surficial	Background
TH-38B	Surficial	Inactive
TH-28A	Surficial	Detection
TH-57	Surficial	Detection
TH-58	Surficial	Detection
TH-65	Surficial	Detection
TH-66	Surficial	Detection
TH-67	Surficial	Detection

Notes:
See Table 2-2 for well construction characteristics.
TH-66 was formerly designated as piezometer P-10D.

Groundwater Monitoring Wells, Capacity Expansion Area

Section 7

The operations permit for Section 7 established the groundwater-monitoring program for Section 7 and activated the program for the Capacity Expansion Area. The program for Section 7 consists of the monitoring wells as noted in Table 2-3 (see Figure 2-1 for locations of the wells) with the indicated purpose.

Section 8

The planned groundwater monitoring program for Section 8 will consist of the monitoring wells with the indicated purpose as noted in Table 2-3. Three surficial aquifer detection wells are planned, one upgradient and two down gradient. As shown on Figure 2-1, TH-62 and TH-63 will be placed approximately 300 feet apart and 50 feet down the hydraulic gradient westward from the planned edge of waste of Section 8. TH-68 will be placed ~~upgradient~~downgradient, approximately 50 feet east of the planned edge of waste. The current background well, TH-36A will be used as the background monitoring well for Section 8.

TABLE 2-3. GROUNDWATER MONITORING WELLS FOR THE CAPACITY EXPANSION AREA

Well Number	Aquifer Monitored	Purpose
Capacity Expansion, Sections 7 and 8		
TH-36A	Surficial	Background
Section 7		
TH-61	Surficial	East Detection
TH-64	Surficial	East Detection
TH-59	Surficial	West Detection
TH-60	Surficial	West Detection

Well Number	Aquifer Monitored	Purpose
Section 8		
TH-62	Surficial	West Detection
TH-63	Surficial	West Detection
TH-68	Surficial	East Detection

Notes:
See Table 2-3 for construction characteristics.
TH-61 was formerly designated as piezometer P-9D.

Groundwater Quality Parameters

The current permit requires semi-annual sampling of the background and detection wells for the field and laboratory parameters listed below.

Field Parameters

- Static water level before purging
- Specific conductivity
- pH
- Dissolved oxygen
- Turbidity
- Temperature
- Color and sheens by observation

Laboratory Parameters (Unfiltered)

- Total ammonia-nitrogen
- Chlorides
- Iron
- Mercury
- Nitrate
- Sodium
- Total dissolved solids (TDS)
- Parameters listed in 40 CFR (Code of Federal Regulations) Part 258, Appendix I

SURFACE WATER MONITORING SITES AND PARAMETERS

The surface water monitoring sites include one site in Smith Lake (1D) along the eastern boundary of the landfill and three sites in or contributing to Long Flat Creek (3A, 3B2B, and 3C2) along the western boundary of the landfill. Surface water sampling sites are listed in Table 2-4 and shown on Figure 2-1.

TABLE 2-4. SURFACE WATER MONITORING SITE CHARACTERISTICS SUMMARY, SOUTHEAST COUNTY LANDFILL

Site No.	Site Description	Date Established	Date Staff Gauge Installed	Elevation Correlation[1]	Last Survey Date
3A	Long Flat Creek South	12/82	10/93	3.00 ft = 125.00 ft NGVD[2]	10/96
3B2B	Long Flat Creek Central	12/82	10/93	3.00 ft = 97.63 ft NGVD	10/96
3C2	Long Flat Creek North	12/82	10/93	3.00 ft = 91.99 ft NGVD	10/96
1A	Smith Lake Elevation	12/82	10/93	6.00 ft = 124.73 ft NGVD	10/96
S.L. 1-D	Smith Lake, Sample only	12/82	NA[3]	NA	NA

Notes:
1. Elevation Correlation = Staff gage reading minus surveyed elevation in feet NGVD at the indicated gage value.
2. National Geodetic Vertical Datum of 1929
3. Not Applicable

Surface water sites are sampled every six months for the following parameters:

<u>Field Parameters</u>

- Specific Conductivity
- pH
- Dissolved Oxygen
- Turbidity
- Temperature
- Colors and Sheens (by observation)

Laboratory Parameters

- Unionized Ammonia
- Total Hardness
- Biochemical Oxygen Demand (BOD_5)
- Copper
- Iron
- Mercury
- Nitrate
- Zinc
- Total Dissolved Solids (TDS)
- Total Organic Carbon (TOC)
- Fecal Coliform
- Total Phosphates
- Chlorophyll A
- Total Nitrogen
- Chemical Oxygen Demand (COD)
- Total Suspended Solids (TSS)
- Parameters listed in 40 CFR Part 258

~~The following describes the methods used at each Smith Lake sampling location for collecting composite and individual samples.~~

~~Staff Gage~~
~~Staff gages are located at sites 3A, 3B2B, 3C2 (Long Flat Creek), and site 1A (Smith Lake). Lake and creek levels are read and recorded at each staff gage during each sampling event.~~

~~Conductivity~~
~~Measurements are made at each site and the values averaged.~~

~~pH~~
~~Measurements are made at each site and the values averaged.~~

~~TDS~~
~~Samples are composited in the field.~~

~~TSS~~
~~Samples are composited in the field.~~

~~☐**Temperature**~~
~~Measurements are made at each site and the values averaged.~~

~~☐**Turbidity**~~
~~Measurements are made at each site and the values averaged.~~

~~☐**Nitrate**~~
~~Samples are composited in the field.~~

~~☐**Dissolved Oxygen**~~
~~Measurement are made at each site and values averaged.~~

~~☐**Total Phosphorus**~~
~~Samples are composited in the field.~~

~~☐**Biochemical Oxygen Demand**~~
~~Samples are composited in the field.~~

~~☐**Chemical Oxygen Demand**~~
~~Samples are composited in the field.~~

~~☐**Chlorophyll A**~~
~~Samples are composited in the field.~~

~~☐**Total Hardness**~~
~~Samples are composited in the field.~~

~~☐**Fecal Coliform**~~
~~Samples are collected at each site and analyzed individually.~~

~~☐**40 CFR Part 258 Appendix I**~~
~~Samples are collected at each site and analyzed individually.~~

SECTION 3

GROUNDWATER LEVELS AND FLOW

The following summary includes a brief description of the primary hydrogeologic units at the site. Hydraulic characteristics are provided for use in Section 4 of this GWMP update. These include hydraulic conductivity and permeability values, unit thickness, and effective porosity along with related hydraulic characteristics.

HYDROGEOLOGY AND HYDRAULICS CHARACTERISTICS

Southeast County Landfill (SCLF) Site

Four geologic cross sections were prepared previously (March 2001) to show the hydrogeologic system and relationship of the monitoring wells at the SCLF. The cross sections included Phases I-VI and the Capacity Expansion Area. Locations of the cross sections are shown on Figure 3-1. The geologic cross sections with groundwater elevations are shown on Figure 3-2. Background and detection wells are highlighted on both figures.

The Phases I-VI area is constructed on existing phosphatic clays that are used as a bottom liner. These clays have permeabilities that range from 6.0×10^{-7} to 3.0×10^{-10} centimeters per second (cm/sec)(Ardaman, 1983, p. 5-2). These values are approximately equal to 1.7×10^{-3} to 8.5×10^{-7} feet per day (ft/d). Following compaction that occurs 5 to 10 years after placement of the final landfill cover, the permeability of these clays is calculated to decrease to 1.3×10^{-8} cm/sec (Ardaman, 1983, p. 6-7) (approximately 3.7×10^{-5} ft/d). The effective porosity of the phosphatic clay liner is assumed to be 20 percent following compaction.

Based on mapping of the surficial aquifer and the top and bottom of the phosphatic clay liner, it appears that the potentiometric surface of the aquifer slopes across the clay liner of Phases I-VI. It is above the top of the liner on the east side of the landfill, and slightly below the bottom of the liner on the west side (SCS Engineers, 1994 Permit Renewal Application, Exhibit L, Figures 2 and 3). Once the clays consolidate, the differential pore pressure that occurs during consolidation will be dissipated. The clays will remain saturated and the potential for vertical movement of fluid through the clays will be related to the leachate head overlying the clay and the surficial aquifer potentiometric surface. It was assumed that the surficial aquifer potentiometric surface would, on average, lie approximately at the bottom of the clay. The resulting hydraulic gradient across the clay would then be approximately 1 ft/ft since the leachate head over the clay would be small.

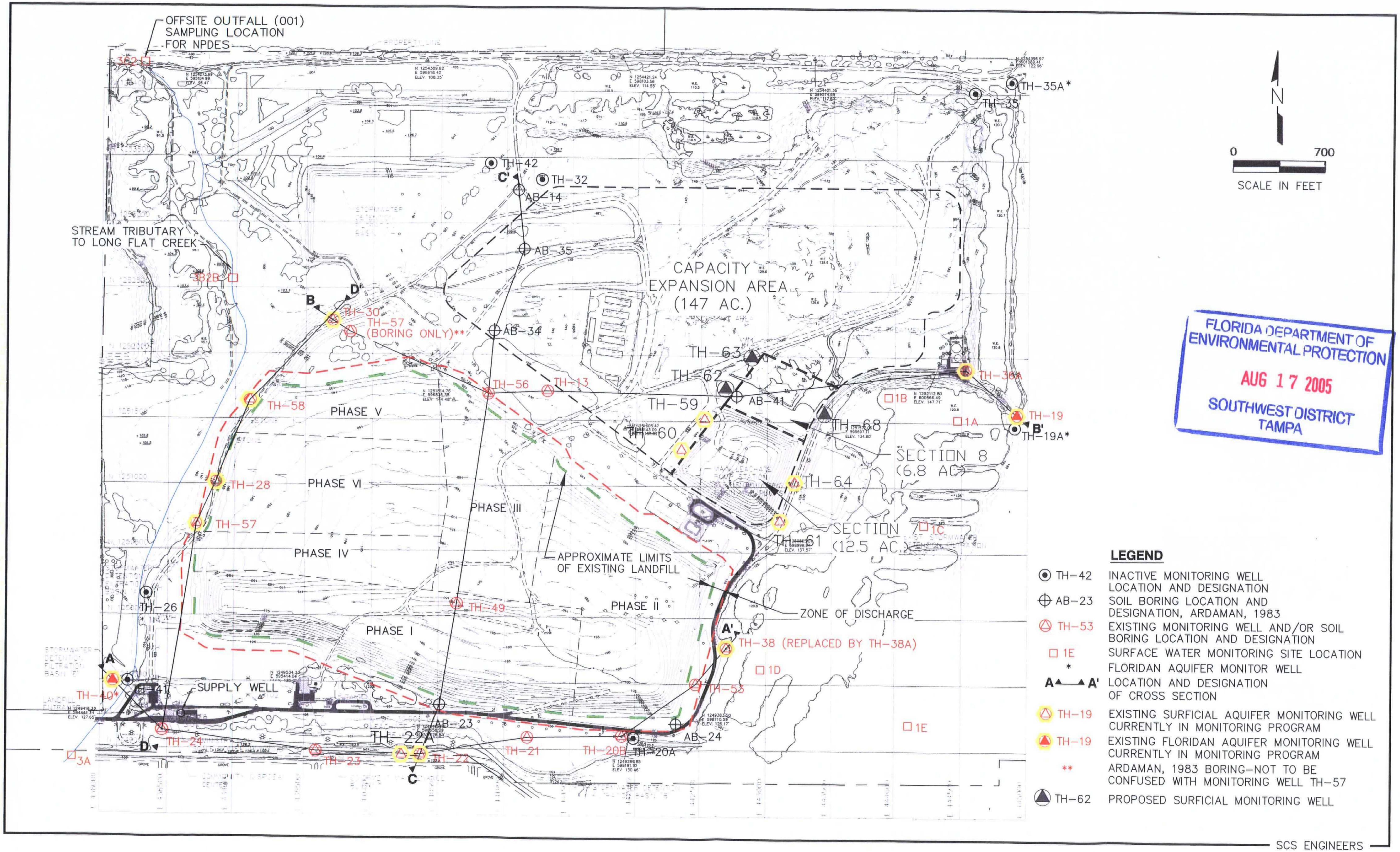

Figure 3–1. Locations of Monitoring Wells and Geologic Cross Sections

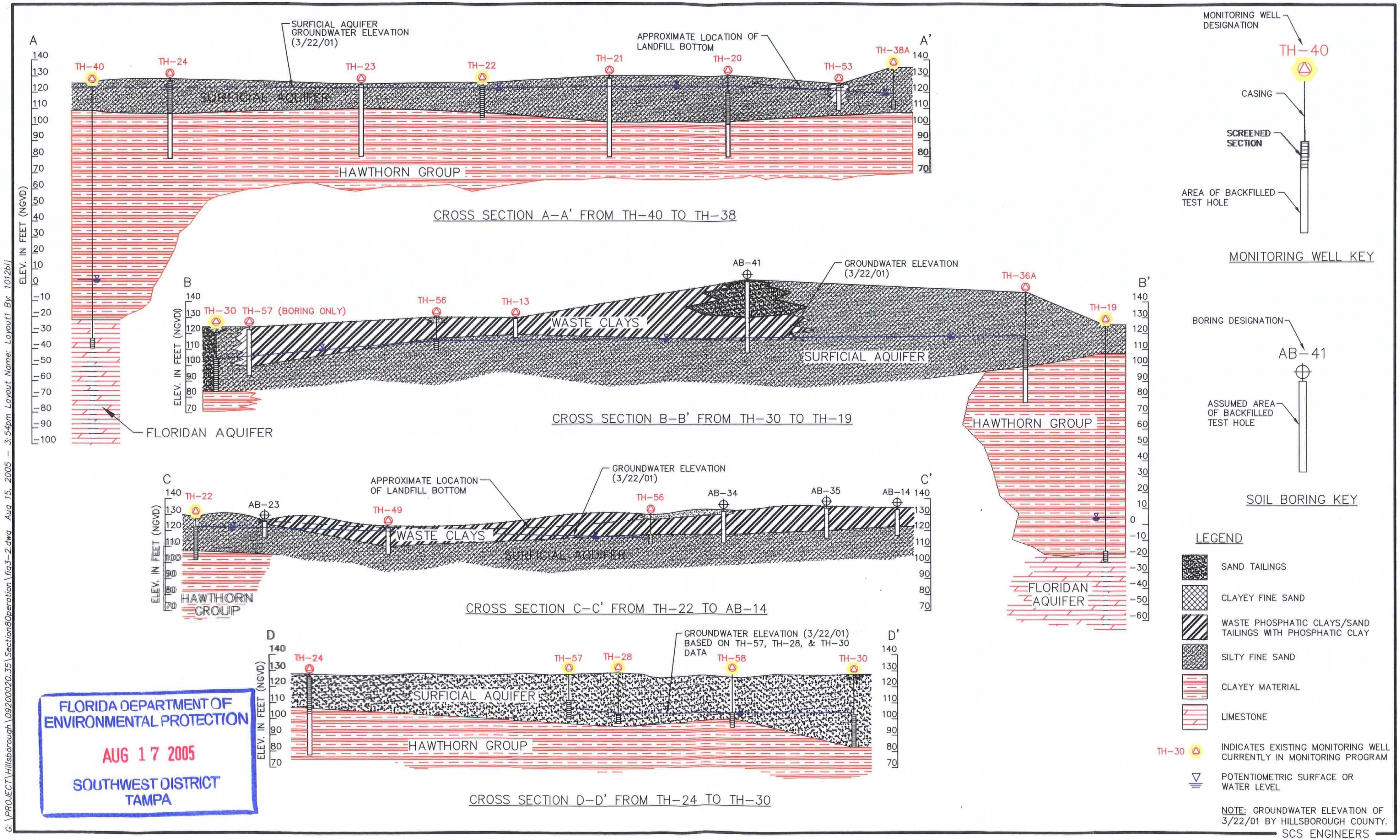

Figure 3–2. Geologic Cross–Sections, Southeast County Landfill, Hillsborough County, Florida.

Surficial Aquifer

Generally, the phosphatic clays of Phases I-VI are underlain and surrounded by fine sands that contain the surficial aquifer (Figures 3-1 and 3-2). The surficial aquifer is approximately 20 feet thick based on water level data and the depth to the base of the aquifer. The average hydraulic conductivity of the aquifer is 2.0×10^{-4} to 7.1×10^{-3} cm/sec (Ardaman, Inc., 1983, p. 4-6). These values are approximately equivalent to 0.6 to 20 (ft/d). Barnes, Ferland, and Associates, Inc., (1997) estimated the hydraulic conductivity at the surficial aquifer as 1.34 (ft/d).

The effective (interconnected) porosity of the surficial aquifer is assumed to be approximately equal to the aquifer's pore space, expressed as a percent of total volume. A porosity of 30 percent was used for the surficial aquifer groundwater flow, based on averaging the 20 percent value estimated in the Barnes, Ferland, and Associates, Inc., (1997) with the typical value for fine to medium sands, such as those encountered at the site, of 39 percent (Todd, 1980, p. 28).

Hawthorn Group

The surficial aquifer is immediately underlain by the thin remnants of the Bone Valley formation which are the weathered and reworked sediments in the upper portion of the Hawthorn Group (Scott and McGill, 1981). The Bone Valley is composed of phosphatic sands and clays and may be on the order of 25 to 50 feet thick at the site (Barnes, Ferland, and Associates, Inc., (1997), p. 3-1).

Clastic and carbonate sediments of the Hawthorn Group underlie the Bone Valley formation at the base of the surficial aquifer. The Hawthorn Group typically includes limestone and other sediments that can be sufficiently permeable to supply water to small wells. In areas where these permeable units exist in the Hawthorn, they compose the "intermediate aquifer." The Hawthorn Group as a whole acts as an aquitard to restrict movement between the surficial aquifer and Floridan aquifer. The Hawthorn Group is estimated to be approximately 130 feet thick at the site. There are no vertical permeability data available for the Hawthorn group at the SCLF. However, Barnes, Ferland, and Associates, Inc., researched this issue for their work on the adjacent expansion area. They report that regional Floridan aquifer hydraulic tests' leakance values range from 1.0×10^{-7} to 4×10^{-4} ft/d/ft. If the leakance values are assumed to represent the Hawthorn group at the SCLF, the values indicate that the vertical hydraulic conductivity of the Hawthorn Group ranges between approximately 1.3×10^{-5} to 5.2×10^{-2} ft/d (leakance times the Hawthorn Group thickness).

The effective porosity of the Hawthorn Group is on the order of 35 percent (estimated from values presented by Todd, 1980, Table 2-1, for limestone and clay). Based on comparison of water levels in surficial and Floridan aquifer monitoring wells for 1997 and 1998 in data on file supplied by Hillsborough County, the hydraulic head change across the Hawthorn Group is approximately 80 feet and is directed downward.

Floridan Aquifer

The upper part of the Floridan aquifer is approximately 1,200 feet thick (Barnes, Ferland, and Associates, Inc., 1997, p. 3-2). This represents that portion of the aquifer for which potentiometric maps are prepared semi-annually by the Southwest Florida Water Management District (SWFWMD). Barnes, Ferland, and Associates, Inc., (1997, p. 3-2) reports the transmissivity of the upper Floridan aquifer in the vicinity of the site is 100,000 square-feet per day (ft^2/d). Based on a thickness of 1,200 feet, this indicates the upper Floridan aquifer at the site has a hydraulic conductivity of approximately 83 ft/d. The effective porosity of the Floridan aquifer is estimated to be approximately 30 percent based on the typical value reported by Todd 1980, p. 28, Table 2.1.

GROUNDWATER LEVELS AND FLOW DIRECTION

Surficial Aquifer

Water level data is collected by Hillsborough County monthly. Hydrographs and surficial aquifer potentiometric maps of the data available through November 2002 were previously prepared and submitted with the SCLF Groundwater Monitoring Plan dated April 15, 2003. The historical potentiometric maps indicated surficial aquifer groundwater flow across Phases I-VI generally as toward the northwest with a hydraulic gradient of approximately 0.005 feet per foot (ft/ft). Data collection and preparation of potentiometric maps indicated the presence of a groundwater divide occurring over the Phase II area. Along the east side of the divide groundwater appears to flow toward Smith Lake.

Potentiometric maps prepared for the Capacity Expansion area indicated that surficial aquifer groundwater flow is generally toward the northwest across the Capacity Expansion Area. However, there also appeared to be a groundwater divide near the eastern portion of Section 7. Along the east side of the divide, groundwater appeared to flow toward Smith Lake. It is projected that groundwater will move a maximum distance of approximately 88 feet per year from Section 7 toward the east and west. Since Section 8 is adjacent to Section 7, and slightly to the northwest, a similar groundwater flow pattern may be expected. However, since the groundwater divide was in the eastern portion of Section 7, it is possible a groundwater divide does not exist in Section 8. Upon completion of monitoring wells for Section 8, data will be collected and maps prepared to characterize the groundwater flow direction.

Floridan Aquifer

Water level data are collected monthly from the two Floridan aquifer-monitoring wells. Hydrographs for Floridan aquifer water level data were prepared and submitted with the site Groundwater Monitoring Plan dated April 15, 2003.

Portions of the May and September 1999 SWFWMD regional maps of the potentiometric surface of the aquifer, were also submitted with the April 15, 2003 Groundwater Monitoring Plan. The maps indicated the direction of groundwater flow in the aquifer beneath the site was generally west-southwest.

The SWFWMD maps indicated the hydraulic gradient across the site is on the order of 0.0003 ft/ft. This is consistent with water level measurements taken previously from wells TH-19 and TH-40 (assumed to lie along the direction of groundwater flow), which indicate a gradient of 0.0002 ft/ft.

GROUNDWATER FLOW RATE

The apparent horizontal groundwater flow rate was calculated for both the surficial and Floridan aquifers and the vertical flow rate across the phosphatic clay liner and the Hawthorn group also was calculated. Flow rates were calculated using a modification of the Darcy equation as described in Lohman (1972), p.10. Hydraulic values used in the calculations are those presented in the previous section.

Phosphatic Clay Liner Vertical Flow

When the phosphatic clay liner beneath Phases I-VI reaches full consolidation, internal pore pressures will reach equilibrium with hydraulic heads associated with the overlying leachate and underlying surficial aquifer. Once this occurs, the potential for leachate to move through the liner develops. The values discussed above were used to calculate the travel time through the liner after consolidation:

- Vertical hydraulic conductivity: 3.7×10^{-5} ft/day.
- Hydraulic gradient: 1 ft/ft.
- Effective porosity: 0.20

Based on these values and the Darcy equation, the leachate flow rate through the clay liner of Phases I-VI will be approximately 2×10^{-4} ft/d. Consequently, based on an 8-foot thickness, leachate would require approximately 118 years to move through the liner and into the surficial aquifer.

The calculations of leachate travel time through the liner were based on an assumed approximate location of the surficial aquifer water table at the bottom of the liner of Phases I-VI. This is a conservative assumption indicating the potential for leachate to migrate out of the landfill via seepage downward through the liner. The assumed approximate location of the water table was based on its presence above the liner on the east and crossing the liner to a point where it is below the liner on the west. The actual potential flow of water through the liner is somewhat more complex than the assumption of a general downward flow. On the east side, where the groundwater elevations may exceed the elevation of the leachate inside the landfill, groundwater flow potentially is upward and into the landfill. On the west side where groundwater elevation is lower than the leachate elevation inside the landfill, leachate will potentially move downward and out of the landfill. Toward the center of the landfill, the groundwater level will be similar to the leachate level and there will be no potential for vertical movement through the liner.

Surficial Aquifer Horizontal Flow at Phases I-VI

The following values were used for the horizontal groundwater flow calculation for the surficial aquifer:

- Horizontal hydraulic conductivity: 20 ft/day (most conservative value).
- Hydraulic gradient: 0.005 ft/ft.
- Effective porosity: 0.3.

Based on these values and the Darcy equation, the groundwater flow rate in the surficial aquifer is approximately 0.3 ft/d. From the edge of the waste of Phases I-VI, surficial aquifer groundwater requires approximately 330 days to travel laterally to the edge of the zone of discharge (ZOD), located 100 feet from the edge of waste.

Review of the surficial aquifer potentiometric maps as described indicated surficial aquifer flow lines beneath Phases I-VI may be as long as approximately 3,000 to 4,000 feet before reaching a detection monitoring well. This indicates that potential contaminants entering the surficial aquifer could take as long as approximately 15 to 20 years to reach the closest detection monitoring well.

The steepest observed hydraulic gradient east of the divide in Phase II was calculated as approximately 0.006 ft/ft, which was determined to be similar to the gradient west of the divide in Phase II. Based on a maximum hydraulic conductivity of 20 ft/day and a estimated porosity of 0.3, the groundwater velocity in Phase II was calculated as approximately 0.4 ft/day. Consequently surficial aquifer groundwater requires approximately 250 days to travel laterally to the edge of the ZOD on the east side of Phase II.

Surficial Aquifer Horizontal Flow at Section 7

The average observed hydraulic gradients east and west of the groundwater divide in Section 7 was determined previously to be approximately 0.0036 ft/ft. Based on a maximum hydraulic conductivity of 20 ft/day and an estimated porosity of 0.3, the groundwater velocity is approximately 0.24 ft/day or 88 ft/yr. Consequently, surficial aquifer groundwater requires approximately 417 days to travel laterally to the closest edge of the ZOD on the east side of Section 7.

Surficial Aquifer Horizontal Flow at Section 8

Section 8 is adjacent to Section 7 and to the northwest; therefore, the average hydraulic gradient is expected to be similar to the observed gradient at Section 7. Based on an assumed maximum hydraulic conductivity of 20 ft/day and an estimated porosity of 0.3, the groundwater velocity would also be approximately 0.24 ft/day or 88 ft/yr. Since the groundwater divide is in the eastern portion of Section 7, the divide may not be present in Section 8. It is planned to continue monthly groundwater data collection at the proposed monitor wells for Section 8 and similarly monitor groundwater data.

Hawthorn Group Vertical Flow

A range of vertical hydraulic conductivity values was presented above for the Hawthorn group. The highest value was used in the following calculations to obtain conservative results.

- Vertical hydraulic conductivity: 5×10^{-2} ft/day.
- Hydraulic gradient: 0.61 ft/ft.
- Effective porosity: 0.35

Based on these values and the Darcy equation, the groundwater flow rate across the Hawthorn group was estimated as 0.09 ft/d. This vertical flow rate probably is not representative of flow rates across the Hawthorn at the SCLF because the rate appears to be too high to allow development of the surficial aquifer at SCLF. However, since no data are available for the SCLF, the value is used in following discussions to provide conservative results (i.e., high rates of groundwater flow).

Floridan Aquifer Horizontal Flow

The following values were used for the horizontal groundwater flow rate calculation for the Floridan aquifer:

- Horizontal hydraulic conductivity: 83 ft/day.

- Hydraulic gradient: 0.0003 ft/ft.
- Effective porosity: 0.3.

Based on these values and Darcy equation, the groundwater flow rate in the Floridan aquifer was estimated as approximately 0.08 ft/day.

SECTION 4

ADEQUACY OF GROUNDWATER QUALITY MONITORING LOCATIONS AND SAMPLING FREQUENCY

The adequacy of the monitoring well locations and sampling frequency is based primarily on characterization of groundwater flow direction and rate of flow. The following discussion assumes that groundwater flow is perpendicular to potentiometric contours. Further, travel time calculations for estimating groundwater flow rates do not consider the time for potential contaminants to move through the phosphatic clay liner of Phases I-VI (calculated above to be on the order of 200 years). The following discussion assumes that contaminants can potentially enter the surficial aquifer instantaneously from the landfill.

SURFICIAL AQUIFER

Monitoring Well Locations, Phases I-VI

Monitoring locations in the surficial aquifer were reviewed against the measured direction of groundwater flow. Surficial aquifer groundwater apparently enters the site from the south in the vicinity of background monitoring well TH-22A. The groundwater exits the site toward the northwest where the detection wells are located. Three of the four detection wells are located within 100 feet of the edge of liner and, consequently, within the zone of discharge. Well TH-30 is located approximately 400 feet beyond the edge of the zone of discharge.

Based on the groundwater flow direction indicated by the potentiometric lines on the figures previously submitted, it is concluded that the locations of the three surficial aquifer monitoring detection wells (TH-57, TH-28, and TH-58) are adequate to monitor potential landfill effects in the surficial aquifer on the west side of the SCLF.

TH-38B was previously identified as a background monitoring well but currently is used for water level measurements only. Surficial aquifer potentiometric maps indicated the presence of a groundwater divide immediately west of Smith Lake at various times. The maps indicated groundwater flows east toward Smith Lake from Phase II. Subsequently, detection monitoring wells TH-65, TH-66, and TH-67 were constructed along the east side of Phase II (see Figure 2-1) to confirm the divide. Water levels are collected monthly. TH-22A was identified as a background well for Phases I-VI.

Monitoring Well Locations, Sections 7 and 8

Four surficial aquifer detection wells were constructed for monitoring Section 7. These wells were placed approximately 300 feet apart and 50 feet down the hydraulic gradient from the planned edge of waste of Section 7 (see Figure 2-1). On the east side, TH-61 (formerly piezometer P-9D) was designated as one of the eastern detection wells. In addition TH-64 was constructed approximately 300 feet north of TH-61 as the second detection well on the east side. Two detection wells (TH-59 and TH-60) were constructed on the west side within 50 feet of Section 7.

Three surficial aquifer detection wells are proposed for monitoring Section 8. TH-62 and TH-63 will be placed approximately 300 feet apart and 50 feet down the hydraulic gradient from the planned edge of waste of Section 8 (see Figure 2-1). TH-68 will be placed within 50 feet of the planned edge of waste, hydraulically ~~upgradient~~downgradient. ~~The groundwater divide is not expected in Section 8 because the cell is located to the northwest of Section 7.~~

Proposed Well Screen Locations

Well screen locations will be determined in the field as the planned groundwater monitoring wells are constructed.

Monitoring Frequency for Phases I-VI

Based on the maximum groundwater velocity calculation of 0.3 ft/day, at the SCLF groundwater will move 50 feet in 167 days. Therefore, continued semi-annual monitoring is appropriate. If contaminants reach the detection wells immediately following a sampling event, sufficient time is available to assess the groundwater quality at the edge of the zone of discharge beyond the wells.

Monitoring Frequency for Sections 7 and 8

As estimated from the groundwater data, the estimated maximum groundwater velocity at Section 7 is approximately 88 feet per year. Therefore, semi-annual monitoring is appropriate. If contaminants reach the detection wells immediately following a sampling event, sufficient time is available to assess the groundwater quality at the edge of the zone of discharge beyond the wells.
The maximum groundwater velocity at Section 8 is expected to be similar to the velocity at Section 7.

FLORIDAN AQUIFER

Monitoring of groundwater in the Floridan aquifer is intended to observe impacts on the aquifer from potential leakage from the landfill. Consequently, the major concern is the potential rate of movement of contaminants to the aquifer from the overlying landfill. Potential contaminants from the landfill would have to move downward through the phosphatic clay liner (time required for this movement is ignored); across a small interval of the surficial aquifer (time for this movement is considered negligible); and then across approximately 130 feet of the Hawthorn group to reach the Floridan aquifer.

Based on the estimated (conservative) velocity of groundwater flow downward through the Hawthorn (0.09 ft/d), if contaminants leak through the phosphatic clays, they could, theoretically, reach the Floridan aquifer in approximately four years. Once a potential contaminant reaches the aquifer, it would move laterally toward the Floridan aquifer monitoring well, TH-40, at a rate of approximately 0.08 ft/d. TH-40 is located approximately 800 feet downgradient from the landfill. Based on the flow rate of 0.08 ft/d, the contaminant would require 27 years to reach the monitoring well if it entered the Floridan aquifer at the edge of waste. Travel time would be longer if the contaminant entered the aquifer farther from the edge of waste. Based on the above finding, the semi-annual frequency of sampling should be maintained.

INTERMEDIATE AQUIFER

As indicated in Section 2 of this report, apparently the intermediate aquifer is not present at the site (Ardaman, 1983, p. 4-3) due to the absence of significant permeable units within the Hawthorn Group. Consequently, no groundwater monitoring is performed between the surficial and Floridan aquifers.

SURFACE WATER

Surface water is monitored semiannually for the parameters listed in Section 2 at the locations noted on Table 2-4. No modifications to the water quality parameters or frequency of sampling are recommended at this time.

SECTION 5

REFERENCES

Ardaman & Associates, Inc. "Hydrogeological Investigation Southeast County Landfill Hillsborough County, Florida," prepared for Camp Dresser & McKee, Inc., February 22, 1983.

Barnes, Ferland and Associates, Inc. "Results of Hillsborough County Southeast County Landfill Capacity Expansion Area Hydrogeological/Geotechnical Investigation," prepared for SCS Engineers, Tampa, Florida, 1997

Florida Geological Survey, Florida's Ground Water Quality Monitoring Program Background Hydrogeochemistry, Florida Geological Survey Bulletin, 1992, No. 34, 364 pp.

Golden Software, Inc. SURFER ® Version 6 software, 1994. Golden, Colorado.

Lohman, S. W.,. "Ground-Water Hydraulics," Geological Survey Professional Paper 708, United States Government Printing Office, 1972, 80 pp.

Metz, P.A., Mattie, J.A., Corral, M.A.. Potentiometric Surface of the Upper Floridan Aquifer, West-Central Florida, September 1996. U.S. Geological Survey Open File Report 97-179.

Metz, P.A., Mattie, J.A., Corral, M.A. Potentiometric, Surface of the Upper Floridan Aquifer, West-Central Florida, May 1997, U.S. Geological Survey Open File Report 97-643.

Scott, Thomas M., and MacGill, Peter L. The Hawthorn Group of Central Florida. State of Florida Department of Natural Resources, 1981, Report of Investigation No. 91, p. 24.

SCS Engineers. Operation Permit Renewal Application, Southeast Landfill, Hillsborough County, Florida – Responses to the Florida Department of Environmental Protection, 1994.

Southwest Florida Water Management District. "Ground-Water Resource Availability Inventory: Hillsborough County, Florida, prepared by the Resource Management and Planning Departments of the Southwest Florida Water Management District, 1988, 203 pp.

Todd, David Keith. Groundwater Hydrology. John Wiley & Sons, New York, 1980, pp.535.