CDM

Memorandum

To: *Paul Moore, P.E.*

From: *Danielle Honour, P.E.*

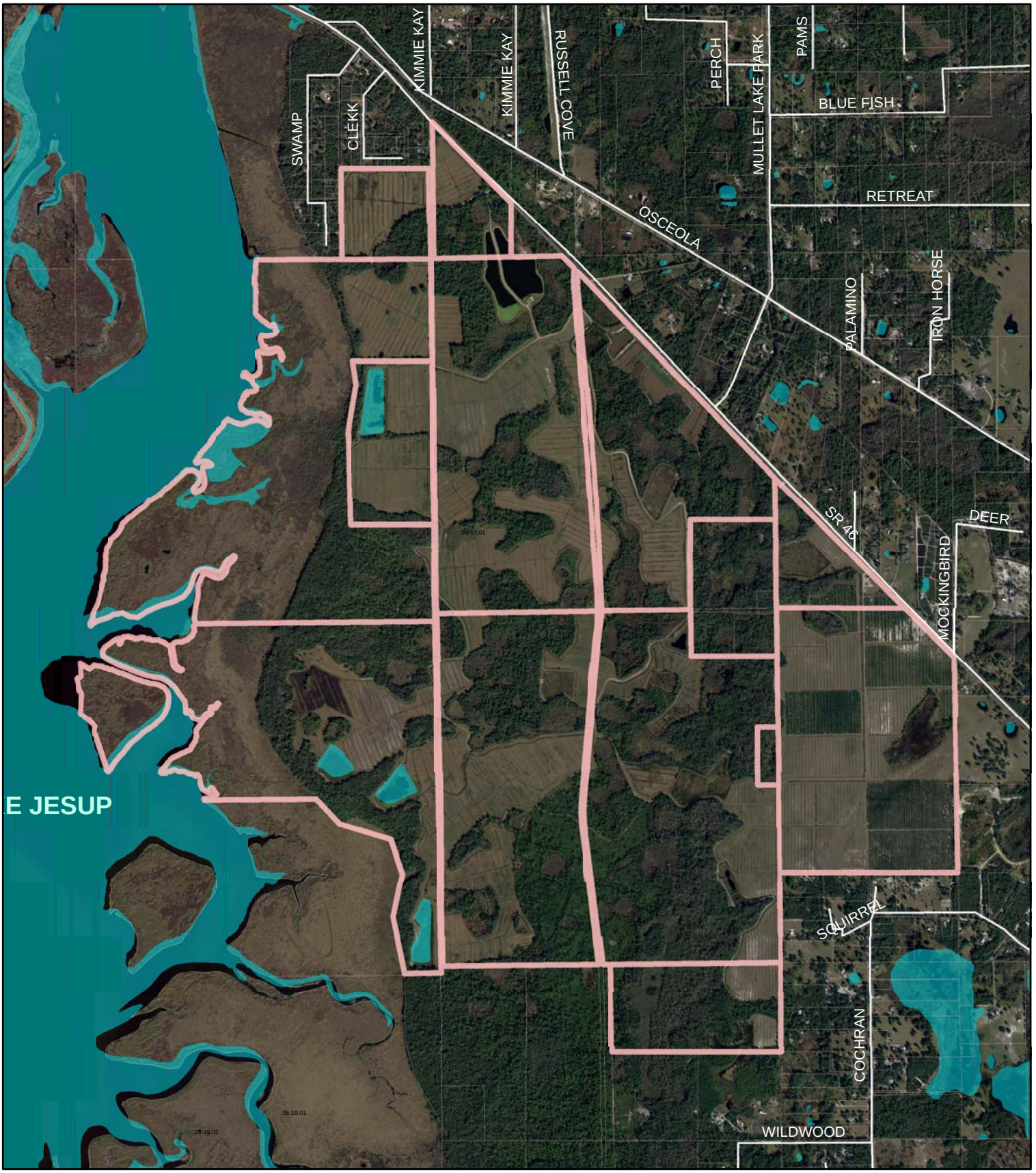
Date: *February 27, 2007*

Subject: *City of Sanford Site 10 Data Evaluation*

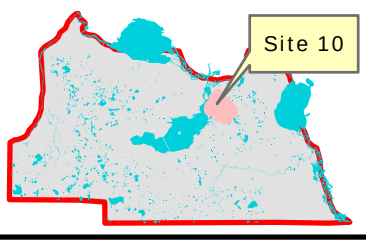
The City of Sanford (the City) requested CDM's assistance with responding to a data request from the Florida Department of Environmental Protection (FDEP) for preparation of the Lake Jesup, Crane Strand and Long Branch Basin Management Action Plan (BMAP). FDEP has requested additional data from the City regarding the Sanford Reuse Land Application Facility (Site 10), as shown in **Figure 1**, located on the northeastern shore of Lake Jesup and it's potential impact on the Total Maximum Daily Load (TMDL) that has been formulated for the lake for both total phosphorus (TP) and total nitrogen (TN). FDEP specifically requested information on the facility itself (i.e., description and operations), on-site nutrient loading due to reclaimed water operations and residuals applications and nutrient transport to the lake via groundwater and surface runoff. This memorandum summarizes the findings of the data evaluation as well as an updated pollutant load model developed specifically for Site 10.

Facility Description

The City owns a number of parcels along the northeast shore of Lake Jesup, which total approximately 2,204 acres. On these parcels resides one of the City's permitted wastewater facilities known as Site 10, which itself is comprised of approximately 1,868 acres. The remaining area is occupied by the marsh fringe associated with Lake Jesup. Site 10 is generally bounded on the west by Lake Jesup, on the north and the east by SR 46, and on the south by the Lake Jesup Conservation Area owned by the St. Johns River Water Management District (SJRWMD). Agriculture (i.e., pastures and citrus groves) and wetlands are the dominating land uses on Site 10 as shown in **Figure 2**. Review of the Seminole County Soil Survey geographic information systems (GIS) layer, developed by the SJRWMD and the National Resource Conservation Service (NRCS), indicates that soils on Site 10 are dominated by B/D and D hydrologic soil groups.



LOCATION MAP



LEGEND

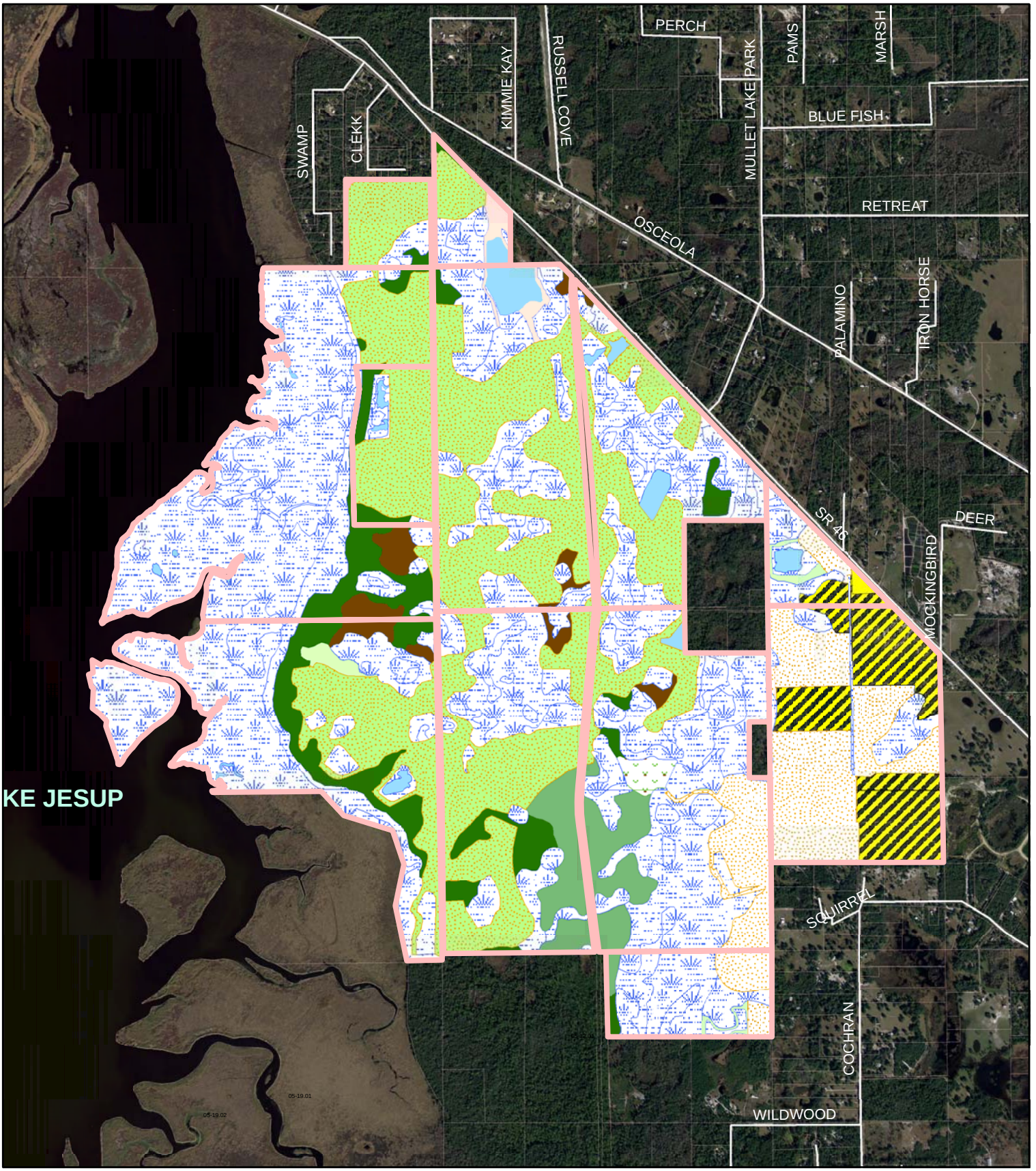
- Sanford Owned Parcels
- Parcels
- Roads
- Water Bodies

0 1,000 Feet

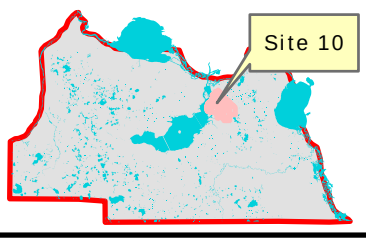
City of Sanford
Wastewater Facility (Site 10) Data Evaluation

CDM

Figure 1
Site 10 Boundaries



LOCATION MAP



LEGEND

- Sanford Owned Parcels
- Parcels
- Roads

SJRWMD Land Use/Land Cover (2004)

- Improved Pastures
- Citrus Groves
- Commercial
- Disturbed Land
- Field Crops
- Herbaceous upland nonforested
- Low Density Residential
- Mixed upland nonforested
- Ornamentals
- Row Crops
- Rural Residential
- Shrub and brushland
- Unimproved Pastures
- Upland Forests
- Water Bodies
- Wetlands

N W E S

0 1,000 2,000 Feet

City of Sanford
Wastewater Facility (Site 10) Data Evaluation

CDM

Figure 2
Site 10 Land Use

Wastewater and Reclaimed Water Operations

The City currently holds a Domestic Wastewater Facility National Pollutant Discharge Elimination System (NPDES) Permit from FDEP (Permit No. FL0020121), which was revised in February 2005. Under the NPDES permit, the City is allowed to discharge 2.84 million gallons per day (MGD) annual average daily flow (AADF) to a permitted capacity slow-rate public access reuse system consisting of 1,868 acres at Site 10. The reuse system also includes an additional 37 MG of reclaimed water storage at Site 10 in the form of two holding ponds located in the northeast area of the site. A pump station is located in the same area as the holding ponds in order to distribute reclaimed water to 620 acres of hay fields by seepage swales and 270 acres of citrus groves by a micro-jet irrigation system as shown in **Figure 3**. A photograph of east holding pond is show in **Figure 4**. The hay fields are permitted to receive up to 1.94 MGD while the citrus groves can receive 0.9 MGD for irrigation purposes. During times of wet-weather and when the storage ponds have reached their capacity (i.e., 5.4 days of wet weather holding capacity), the City is permitted to discharge up to 1.0 MGD AADF to the St. Johns River. The discharge point is near the Interstate 4 bridge where it crosses Lake Monroe. The permit also identifies Site 10 as an area where landspreading of residuals may occur.

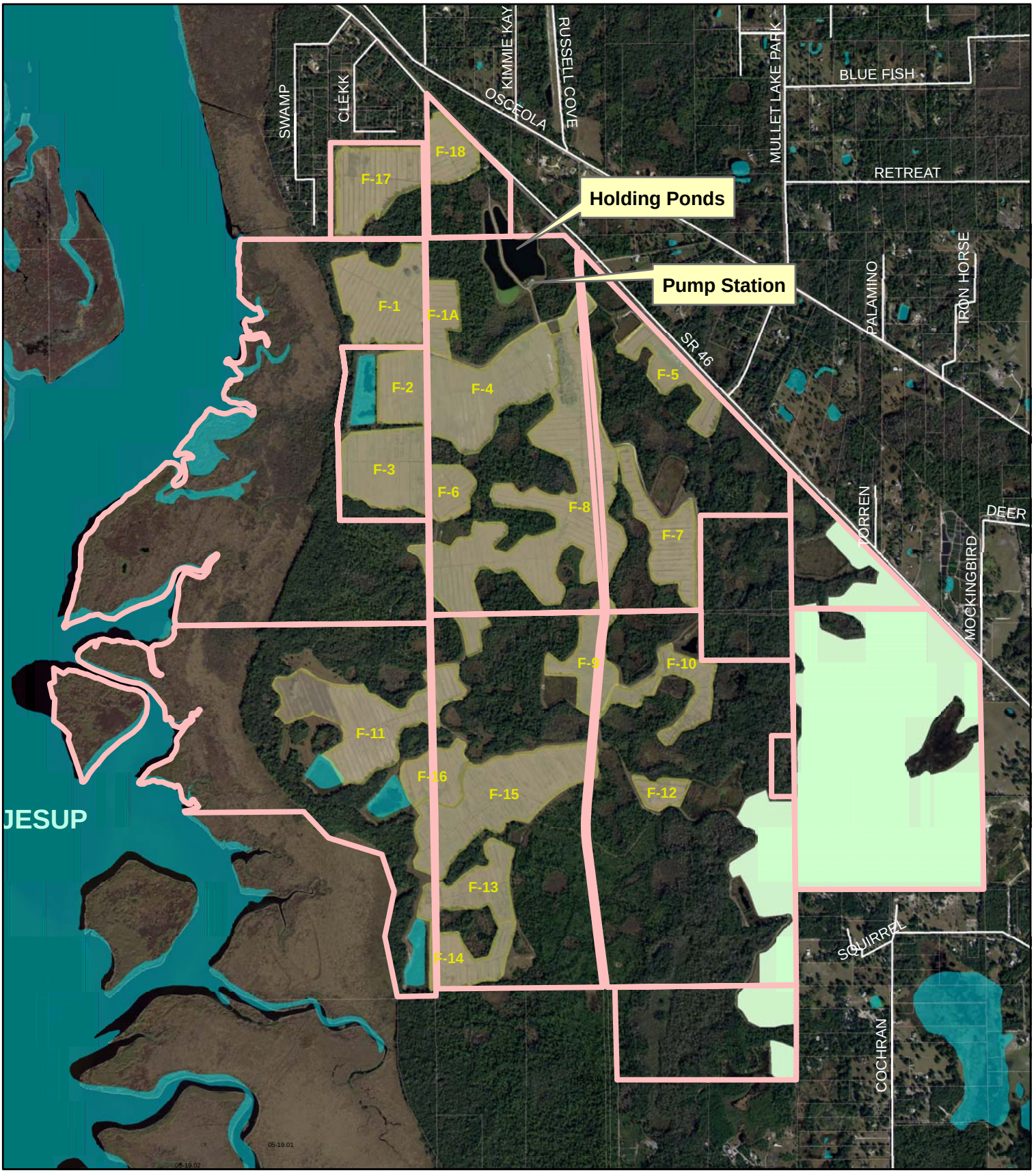
Figure 4 – East Holding Pond

Reclaimed Water Application Points

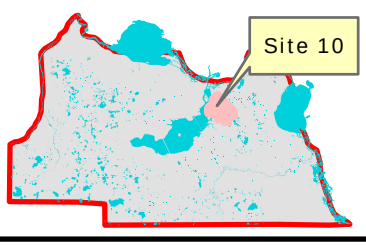
A system of reclaimed water distribution lines emanate from the pump station near the holding ponds and run throughout Site 10 to provide irrigation to the various hay fields and citrus groves on the site. These lines are shown in detail on the *Irrigation and Stormwater Plan at Site 10* plans prepared by Conklin Porter and Holmes Engineers, Inc. (CPH, 1990). The individual fields are then served by subswales that distribute reuse water across the fields. The subswales that distribute reuse water are separate from the subswales that convey stormwater runoff to the stormwater ponds. The reuse swales dead end at each field and do not connect to the stormwater swales.

Residual Application Points

The City currently uses the hay fields for residuals application. Occasionally, the City will land apply to an empty grove field, but this is rare. On average, Seven to 10 loads of residuals are hauled to Site 10 every week and the biosolids are spread within 24 hours of land application. The weight of each load of sludge ranges between 13 to 15 tons per load.



LOCATION MAP



LEGEND

- Sanford Owned Parcels
- Parcels
- Site 10 Groves
- Site 10 Hay Fields
- Water Bodies
- Roads

N
W E
S

0 1,000 2,000 Feet

City of Sanford
Wastewater Facility (Site 10) Data Evaluation

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Figure 3
Site 10 Hay Fields and Citrus Groves

Stormwater

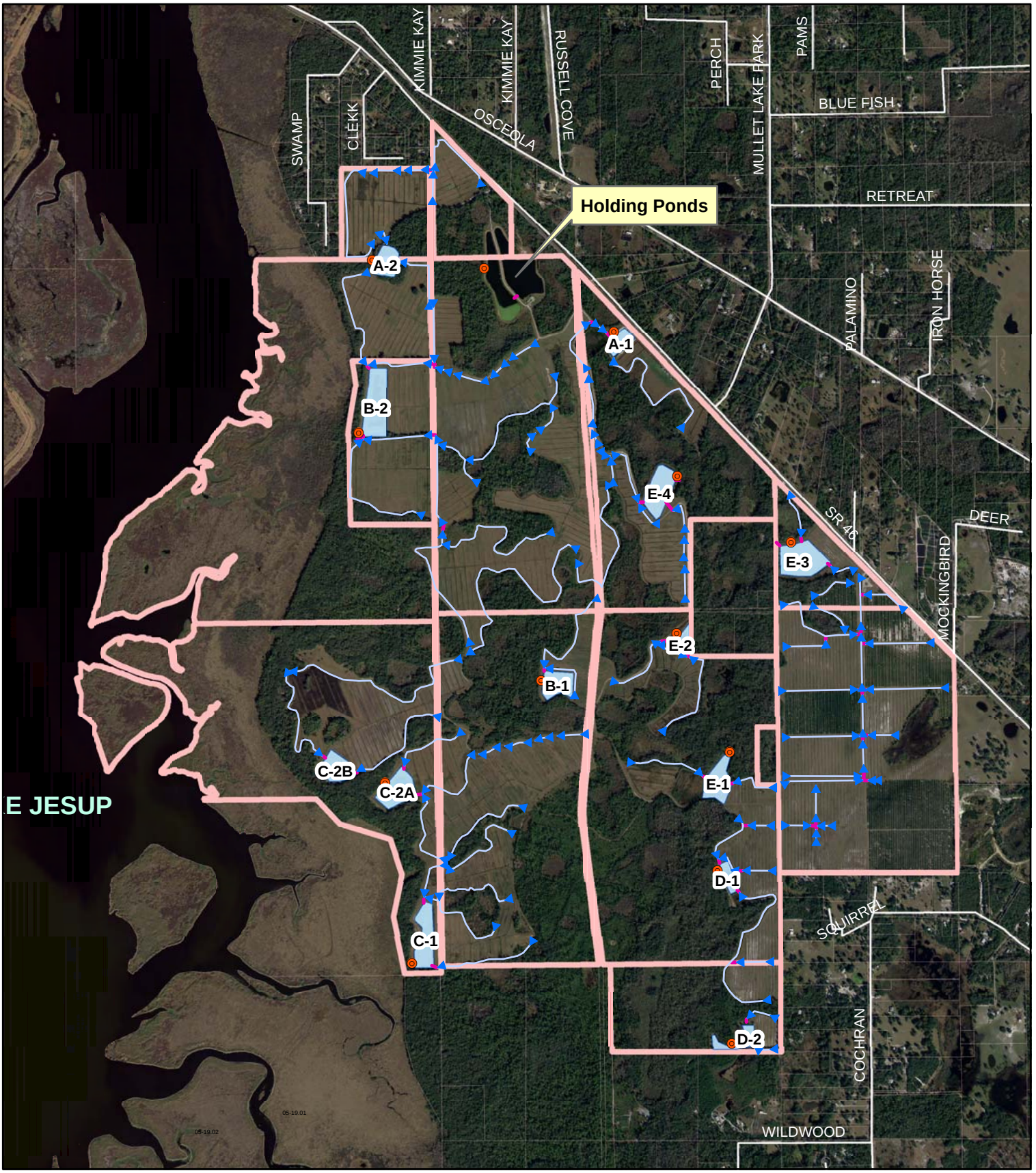
The *Irrigation and Stormwater Plan at Site 10* plans prepared by CPH (1990) were reviewed to determine how stormwater is managed on Site 10. Site 10 is served by a series of wet detention ponds which provide stormwater treatment for the various hay fields and citrus groves on the site. The locations of these ponds were mapped using the GIS software package Arcview® Version 9.0 and are shown in **Figure 5**. The field subswales as well as culvert crossings were also mapped to show the direction of surface water flow into the stormwater ponds and are shown on Figure 5 as well. All of the stormwater ponds are served by overflow structures and bleed-down devices to allow the ponds to discharge into adjacent wetland and forested areas throughout the site, an example of which is shown in **Figure 6**.

Figure 6 – Pond Overflow

CDM and the City conducted a field visit to Site 10 in November 2006 and visited two of the ponds located adjacent to Lake Jesup (Ponds A-2 and B-2). The overflow structures are in the form of concrete slabs that are set at a higher elevation than the pond control elevation. The two ponds visited are also equipped with bleed-down devices in the form of corrugated metal pipes (CMPs). Six 15-inch CMPs were observed at Pond A-2 and are consistent with what is shown on the CPH plans while the plans also indicate there is a 30-inch CMP bleeddown pipe associated with Pond B-2 (which was not visible at the time of the field visit but was confirmed by on the City staff members). Discussions with City staff who work at the site indicated that they have never seen the ponds stage up high enough so that overflow conditions would occur, even during the 2004 hurricane season. At the time of the field inspection, there was a continuous flow of water through the six 15-inch CMP bleed-down pipes from Pond A-2 (as shown in **Figure 7**). At the time of the inspection it was not clear where this water was flowing to, but based on review of the CPH plans, it appears this stormwater pond discharges to a wetland channel which eventually discharges to Lake Jesup. The CPH design engineer believes that this water is coming from a natural spring.

Figure 7 – Bleeddown Pipes from Pond A-2

In addition to the CPH plans provided by the City, CDM also obtained and reviewed a copy of the Mullet Lake Park Road Outfall Study prepared by Inwood Consulting Engineers for Seminole County in 2004. This report provides an evaluation of the existing conditions and problems within the Mullet Lake Park Road drainage basin, which includes



City of Sanford
Wastewater Facility (Site 10) Data Evaluation

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Figure 5
Site 10 Stormwater Management System

portions of Site 10. This drainage basin discharges to the northeast towards Mullet Lake which is outside of the Lake Jesup watershed. The drainage basin delineations presented in Inwood's study were used by CDM to determine the contributing area of Site 10 to the Lake Jesup Watershed which is shown in **Figure 8**. Based on this delineation, the resulting area of Site 10 that is tributary to the Lake Jesup Watershed is 1,252 acres. The marsh fringe along the shore of Lake Jesup was not included in this delineation as the Site 10 operations do not expand into this land area and based on the plans developed by CPH, it does not show Site 10 occupying any of these areas. CDM then delineated this contributing area into 13 smaller subbasins within Site 10 based on the CPH plans as well as available 1-foot topographic contour data. These delineations are also shown on Figure 8.

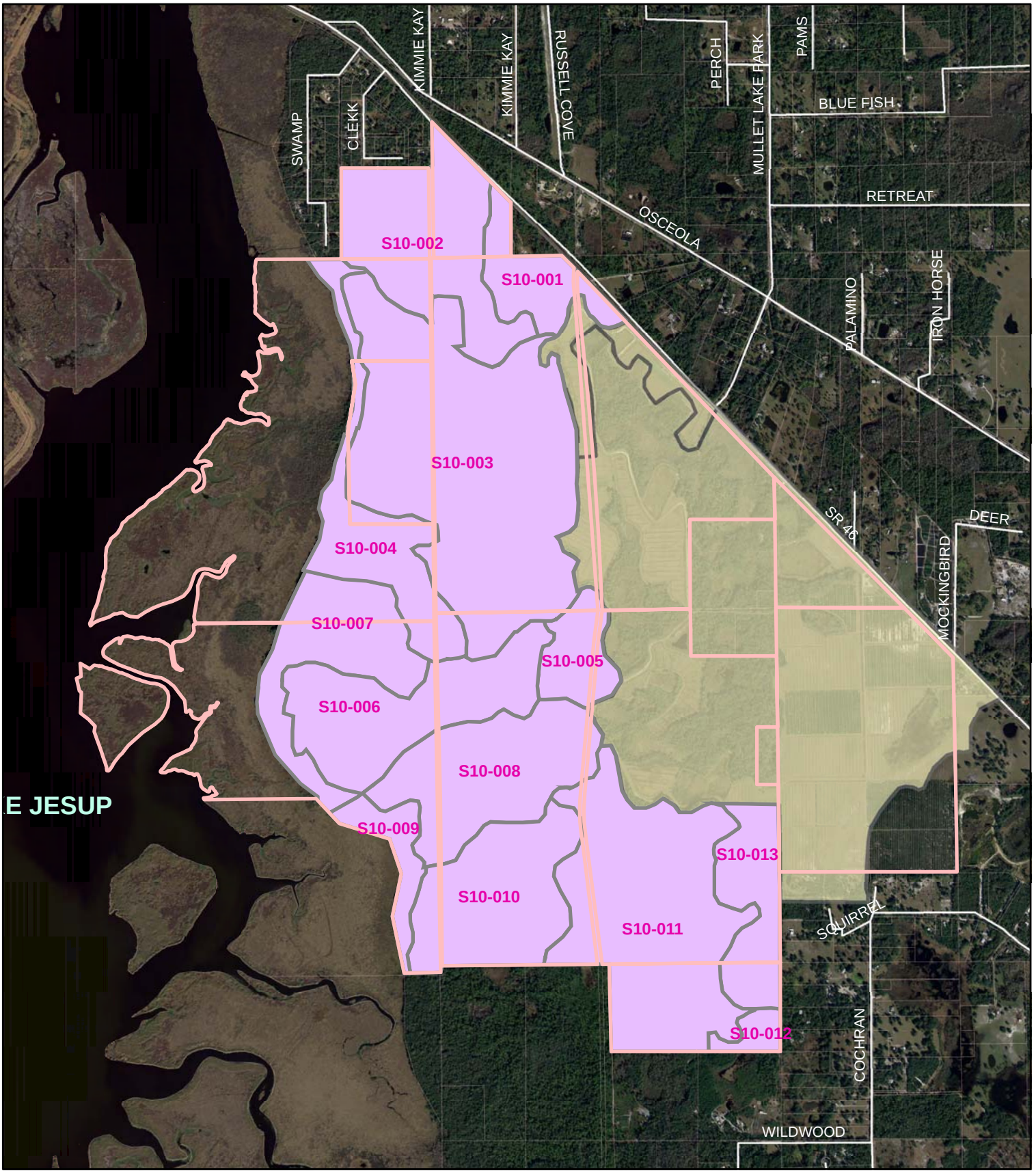
In addition to delineating the subbasins, CDM used available existing 1-foot topographic contour data and the CPH plans to map the overall direction of flow from each of the subbasins to determine which subbasins if any have the potential to discharge stormwater to Lake Jesup. These flow directions are shown in **Figure 9** and also corroborate the subbasin delineations. As can be seen in the figure, Subbasins S10-004, S10-007 and S10-009 have the potential to discharge directly to Lake Jesup. These subbasins however are dominated by forested areas, wetlands and shrub and brushland. With the exception of S10-001 and S10-011, the remaining subbasins are all equipped with wet detention facilities as can be seen on the figure. The holding ponds are located within Subbasin S10-001. The holding ponds are equipped with an emergency discharge structure on the west side of the ponds whose elevation is set at 19.5 ft-NGVD (the normal water level of the ponds is 15.0 ft-NGVD) and the ponds would discharge into the adjacent wetland areas in Subbasin S10-002. Subbasin S10-011 is dominated by wetland and forested areas and it appears that surface runoff would discharge via overland flow towards the south off of Site 10, and then southwest towards the lake. Based on review of the 1-foot topographic contour data, surface runoff would have to be conveyed approximately 1 mile before it reached Lake Jesup.

Nutrient On-Site Loading

An estimate of the on-site nutrient loading due to both reclaimed water as well as residuals land application was made using available data. As FDEP requires a TMDL for TN and total TP for Lake Jesup, these are the only constituents that will be addressed in this analysis. A description of how each was calculated and the results is described in the following paragraphs.

Reclaimed Water Nutrient Loading

As previously mentioned, the hay fields are permitted to receive up to 1.94 MGD of reclaimed water while the citrus groves can receive 0.9 MGD for irrigation purposes. From the City's discharge monitoring reports (DMRs), FDEP provided the average monthly flow to Site 10 and the associated water quality data (TN and TP) measured at the St. Johns River discharge for the years 2001 through 2006. For those months where there was no discharge to the St.



City of Sanford
Wastewater Facility (Site 10) Data Evaluation

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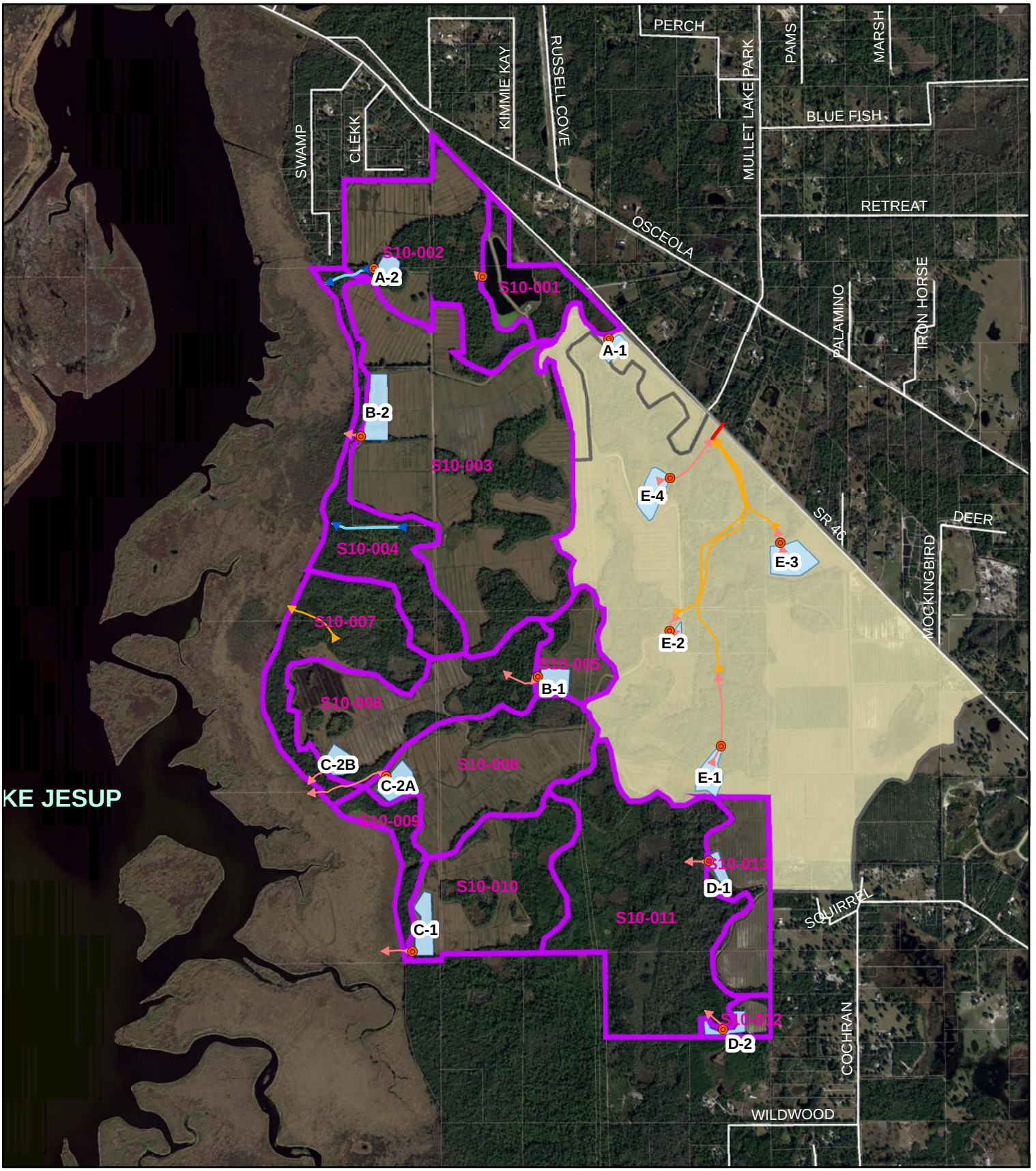
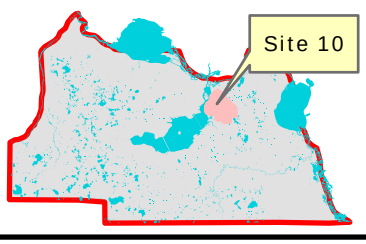
Figure 8
Site 10 Subbasin Boundaries



LOCATION MAP



LEGEND

- Control Structure
- Site 10 Ponds
- Site10 Subbasins
- Mullet Lake Park Road Drainage Basin
- Parcels
- Roads

Outflow

- 2 3'x8' CBCs
- Overland Flow
- Pond Overflow
- Wetland Channel

0 1,000 2,000 Feet

City of Sanford
Wastewater Facility (Site 10) Data Evaluation

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Figure 9
Site 10 Pond Outflow

Johns River, water quality samples were not obtained, however, there was still flow to Site 10. Based on this information, CDM calculated the average TN and TP concentrations to Site 10 (it was assumed that the same concentration that is being discharged to the river during wet weather is also being received at Site 10) for the years 2003 through 2005. In FDEP's original data request that prompted this study, CDM's analysis of Site 10 is supposed to cover the time period of 2003 through 2006. However, since the DMRs were not available after September 2006, only data for the years 2003 through 2005 were used. CDM used these data as well as the permitted flow rates for the hay fields and the citrus groves to estimate an annual loading of TP to Site 10 due to reclaimed water (actual loading values for TN were available from FDEP and the City which are discussed later in this memorandum). From the discussion in the Stormwater subsection of this memorandum, it was determined that only a portion of Site 10 is within the Lake Jesup Watershed (i.e., 1,252 acres), therefore, only the acreages of the hay fields and citrus groves on these 1,252 acres were considered when estimating the loading due to irrigation with reclaimed water. These results are summarized in **Table 1**.

Table 1
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Estimated TP Loading to Site 10 from Reclaimed Water (2003 – 2005)

Average Measured Flow to Site 10 (MGD)	1.5	
	Hay Fields	**Citrus Groves**
% Distribution of Flow based on Permit Limits (1.94 vs. 0.9 MGD)	0.68	0.32
Resulting Flow (MGD) to Hay Fields vs. Citrus Groves	1.02	0.47
Average Measured TP to Site 10 (mg/l)	1.6	1.6
Site 10 TP Loading[1] (lbs/yr)	4,971.2	2,290.6
Total Acreage on Site 10	478.1	277.4
Total Acreage in Lake Jesup Watershed	368.3 (77.0%)	43.8 (16%)
Resulting TP Loading in Lake Jesup Watershed from Site 10 (lbs/yr)	3827.8	366.5
Resulting TP Loading in Lake Jesup Watershed from Site 10 (lbs/ac/yr)	10.4	8.4

1. Hay Fields: (1.6 mg/l X 8.3454lb/MG) X (1.02MG/Day) X (365Days/yr) =4,971.2 lb/yr
Citrus Groves: (1.6 mg/l X 8.3454lb/MG) X (0.47MG/Day) X (365Days/yr) =2,290.6 lb/yr

Residual Land Application Nutrient Loading

The City currently uses the hay fields for residuals application and on a very rare occasion, the citrus groves are used. Therefore the estimated loading from residuals application was only considered for the hay fields. According to the City, seven to 10 loads of residuals are hauled to Site 10 every week and the biosolids are spread within 24 hours of land application. The weight of each load of sludge varies between 13 to 15 tons per load. The FDEP Domestic Wastewater Facility permit requires the City to sample the residuals at least once every three months and report the TN and TP in terms of percent dry weight. The reported percent dry weights of the residuals for the period of 2002 through 2005 were available and are provided below in **Table 2**.

Table 2
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Residual TN and TP Concentrations (% Dry Weight)

Year/Parameter	TN (%)	TP (%)
2002	7.22	3.22
2003	7.32	3.15
2004	6.43	3.02
2005	8.05	3.94

Estimated On-Site Loading

Nitrogen

Some additional information was made available by FDEP on actual nitrogen loading rates due to both biosolids disposal as well as reclaimed water. These data were presented in memorandums from the City to FDEP for the years 2003 through 2005 and are summarized below in **Table 3.** Only the fields that are within the tributary area of Lake Jesup and their associated loading rates are provided in the table.

Table 3
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Field Nitrogen Loading Rates due to Biosolids and Reclaimed Water Application

Field No.[1]	Field Acreage[2]	Field Acreage In Watershed	2003 Measured N Loading (lb/ac)	2004 Measured N Loading (lb/ac)	2005 Measured N Loading (lb/ac)	Average TN Loading Rate (lb/ac/yr)	TN Loading in Watershed (lb/yr)
F1	32.2	32.1	162.3	91.8	92.5	115.5	3,707.6
F2	15.3	15.3	371.0	91.8	92.5	185.1	2,832.0
F3	29.3	29.3	365.5	152.7	282.3	266.8	7,817.4
F4	42.5	41.6	398.7	91.8	373.7	288.1	11,985.0

Table 3
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Field Nitrogen Loading Rates due to Biosolids and Reclaimed Water Application

Field No.[1]	Field Acreage[2]	Field Acreage In Watershed	2003 Measured N Loading (lb/ac)	2004 Measured N Loading (lb/ac)	2005 Measured N Loading (lb/ac)	Average TN Loading Rate (lb/ac/yr)	TN Loading in Watershed (lb/yr)
F6	9.5	9.5	162.3	91.8	365.2	206.4	1,960.8
F8	97.1	58.8	343.9	91.8	168.6	201.4	11,842.3
F9	16.8	16.3	363.9	361.3	247.8	324.3	5,286.1
F11	42.3	42.3	162.3	374.1	92.5	209.6	8,866.1
F13	17.0	17.0	314.9	317.9	307.45	313.4	5,327.8
F14	15.2	15.2	390.7	335.7	388.4	371.6	5,648.3
F15	47.8	47.8	389.3	347.1	370.3	368.9	17,633.4
F16	13.7	13.7	289.5	396.1	92.5	259.4	3,553.8
F17	24.7	24.7	162.3	91.8	92.5	115.5	2,852.9
F18	11.6	4.7	162.3	91.8	92.5	115.5	542.9
	Total:	**368.3**					**89,856.4**

1. Field 1A, although shown on Figure 3, was not included in the City memorandums that summarized TN loading rates by field.

2. Field acreages were obtained from a GIS layer originally provided by the City showing the field locations. These were then subsequently edited to match the extents shown on the CPH plans and verified using the 2004 aerial digital orthophoto quads available from the SJRWMD. Acreages were then calculated using GIS capabilities.

Phosphorus

As the same type of data shown in Table 3 were not available for actual TP loading, CDM used the values shown in Table 1 for reclaimed water application and the percent dry weight values shown in Table 2 to estimate the overall TP loading to Site 10. According to the City, seven to 10 loads of residuals are hauled to Site 10 every week and the biosolids are spread within 24 hours of land application. The weight of each load of sludge varies between 13 to 15 tons per load. It was assumed that the sludge has approximately 85 percent moisture content and therefore 15 percent solids content. Municipal biosolids available for land application in Florida can vary widely in moisture content and solids in de-watered materials is typically 15 percent. Based on this information, the following calculations were made and are summarized in **Table 4**. It was assumed, however that the residuals were applied to the same fields shown above in Table 3.

Table 4
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Estimated Phosphorus Loading due to Biosolids Application

Average number of loads delivered per week (average of 7 to 10 loads per week)	8.5 loads/week
Average number of loads delivered per day	1.2 loads/day
Average ton of residuals per load (average of 13 to 15 tons per load)	14 tons/load
Total tons of residuals delivered per year[1]	6,132 tons/yr
Dry Weight of Solids Delivered per year[2]	920 tons/yr
Average of 2003-2005 Percent Dry Weight Values of TP	3.33%
Average TP Loading[3]	60,707 lb/yr
Average Loading Rate of TP applied to hayfields in watershed (lb/ac/yr)[4]	164.8 lb/ac/yr

1. 14 tons/load X 1.2 loads/day X 365days/yr=6,132 tons/yr
2. 6,132 tons/yr X 15% solids content = 920 tons/yr
3. 920 tons/yr X 0.033 X 2000lb/ton = 60,707 lb/yr
4. (60,707 lb/yr) / (368.3 ac) = 164.8 lb/ac/yr

CDM used the same combination of biosolids and reclaimed application for each of the fields shown in Table 3 (i.e., in some years, certain fields received only biosolids, reclaimed water and/or both) as documented in the memorandums sent from the City to FDEP. Using this information and the estimated average loading TP rate shown in Tables 1 and 4 for reclaimed water and biosolids application, respectively, CDM calculated the average TP loading in the watershed as shown in **Table 5**. Based on Table 5, the total loading of TP in the Lake Jesup Watershed due to both biosolids and reclaimed water application is estimated to be 39,948 lb/yr.

Groundwater Nutrient Transport

This section provides a discussion of the potential nutrient loading to Lake Jesup through groundwater seepage. This discussion also provides some background on the geology and hydrogeology of the site as well as soil properties.

Table 5
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Field Phosphorus Loading Rates due to Biosolids and Reclaimed Water Application

Resulting TP Loading in Lake Jesup Watershed from Reclaimed Water (from Table 1): **10.4** lbs/ac/yr
Average Loading Rate of TP from Residuals applied to hayfields in watershed (Table 4): **164.8** lbs/ac/yr

Field No.	Total Acreage[1]	Acreage in Watershed	Estimated 2003 Loading Rate (lb/ac)	Estimated 2004 Loading Rate (lb/ac)	Estimated 2005 Loading Rate (lb/ac)	Average TP Loading Rate 2003-2005 (lb/ac/yr)	TP Loading in Watershed[2] (lb/yr)
F1			R	R	R		
	32.2	32.1	10.4	10.4	10.4	10.4	333.8
F2			B&R	R	R		
	15.3	15.3	175.2	10.4	10.4	65.3	999.6
F3			B&R	B&R	B&R		
	29.3	29.3	175.2	175.2	175.2	175.2	5,133.4
F4			B&R	R	B		
	42.5	41.6	175.2	10.4	164.8	116.8	4,858.9
F6			R	R	B&R		
	9.5	9.5	10.4	10.4	175.2	65.3	620.7
F8			B&R	R	B&R		
	97.1	58.8	175.2	10.4	175.2	120.3	7,071.7
F9			B&R	B	B&R		
	16.8	16.3	175.2	164.8	175.2	171.7	2,799.3
F11			R	B&R	R		
	42.3	42.3	10.4	175.2	10.4	65.3	2,763.6
F13			B&R	B	B		
	17	17	175.2	164.8	164.8	168.3	2,860.5
F14			B	B&R	B		
	15.2	15.2	164.8	175.2	164.8	168.3	2,557.7
F15			B&R	B	B		
	47.8	47.8	175.2	164.8	164.8	168.3	8,043.1
F16			B&R	B	R		
	13.7	13.7	175.2	164.8	10.4	116.8	1,600.2
F17			R	R	R		
	24.7	24.7	10.4	10.4	10.4	10.4	256.9
F18			R	R	R		
	11.6	4.7	10.4	10.4	10.4	10.4	48.9
Total Acres in Watershed:		**368.3**			**Total Loading in Watershed:**		**39,948.1**

R - Reclaimed Only
B - Biosolids Only
B&R - Biosolids and Reclaimed

1. Field acreages were obtained from a GIS layer originally provided by the City showing the field locations. These were then subsequently edited to match the extents shown on the CP&H plans and verified using the 2004 aerial digital orthophoto quads available from the SJRWMD. Acreages were then calculated using GIS capabilities.
2. Product of loading rate (lb/yr/ac) x area

Hydrogeology

Based on published data, the surficial aquifer system (SAS) and the Floridan aquifer system (FAS) are the principal water-bearing units in Central Florida including Site 10. The two aquifer systems are separated by the Intermediate Confining Unit (ICU) of the Hawthorn Group Formation. The Floridan aquifer system has two major water-bearing zones, the Upper Floridan aquifer (UFA) and the Lower Floridan aquifer (LFA) which is separated by a less-permeable semiconfining unit known as the Middle semiconfining Unit. **Figure 10** illustrates the location of a north-south and an east-west cross section in Seminole County. The cross-sections are shown on **Figure 11**, and the geologic and hydrogeologic units are shown in **Figure 12**. The boring locations are soil illustrated in **Figure 13** while the boring profiles of Site 10, reported by Ardaman and Associates (1988) are shown in **Figures 14** and **15**.

Surficial Aquifer System

The (SAS) in Seminole County is unconfined and consists mainly of lenses of fine-to-medium quartz sand and varying amounts of shell and clay. The geologic units probably range between Pliocene and Holocene in age and consist of undifferentiated deposits.

In the swampy lowlands and flatlands, the water table generally is at or near land surface. The slope of the water table varies depending on the hydrologic conditions, such as antecedent rainfall and evapotranspiration. Thickness of the surficial aquifer system is variable. In the low-lying areas around Lake Jesup, and along the Econlockhatchee and St. Johns Rivers in Seminole County, the thickness of the SAS is about 10-20 ft (Murray and Halford, 1996). The surficial aquifer at Site 10 is composed primarily of 10 to 20 feet of surficial sand (Ardaman and Associates, 1988). The altitude of the water table in the SAS varies seasonally and responds to changes in rates of recharge and discharge. Water levels are generally highest in October and lowest in May. Recharge to the SAS is chiefly by the infiltration of the rainfall.

The water-bearing properties are dependent largely upon aquifer thickness, lithology, grain-size distribution, sorting, packing, and cementation of the sediments. Horizontal hydraulic conductivity values at Site 10 ranged from 3.58×10^{-3} cm/sec (10.07 ft/day) to 1.57×10^{-4} cm/sec (0.44 ft/day), determined from eight in-situ permeability tests (Ardaman and Associates, 1988). The average horizontal hydraulic conductivity is 3.5 ft/day.

Intermediate Confining Unit

The Intermediate Confining Unit (ICU), which forms the base of the SAS, consists primarily of the Hawthorn Group of late-to-middle Miocene age and, locally, low permeability beds of early Pliocene age. Thickness of the ICU is generally less than 25 ft around north of Lake Jesup (Murray and Halford, 1996). The confining units at the site consisted of a nine-foot thick silty fine sand to sandy clay 53 to 82 feet below land surface and a 2.5- to 5- foot thick mottled clay layer 8 to 25 feet below land surface in the southeastern part of the site

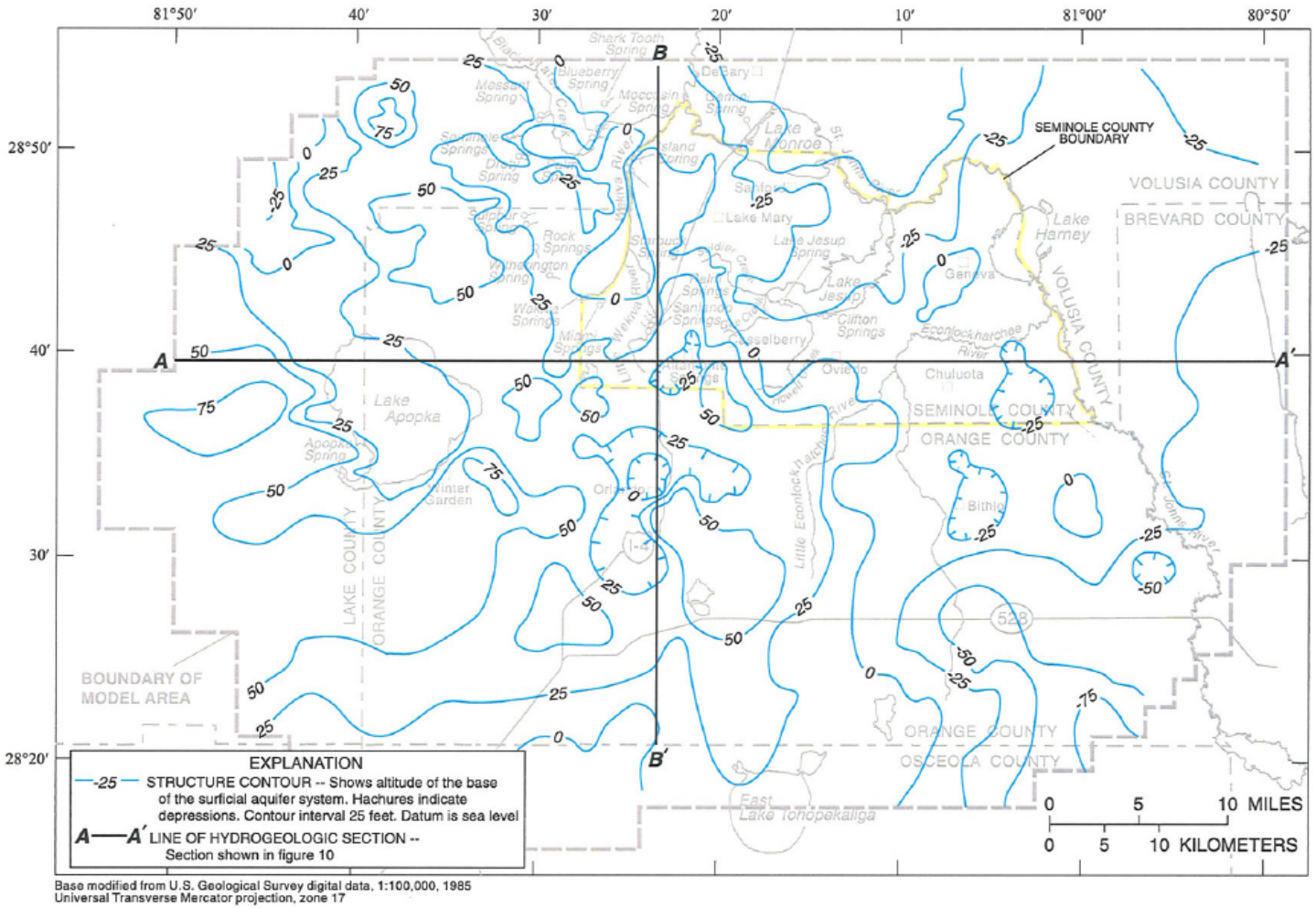


Figure 10 Altitude of the base of the surficial aquifer system

Source: Spechler, 2001.

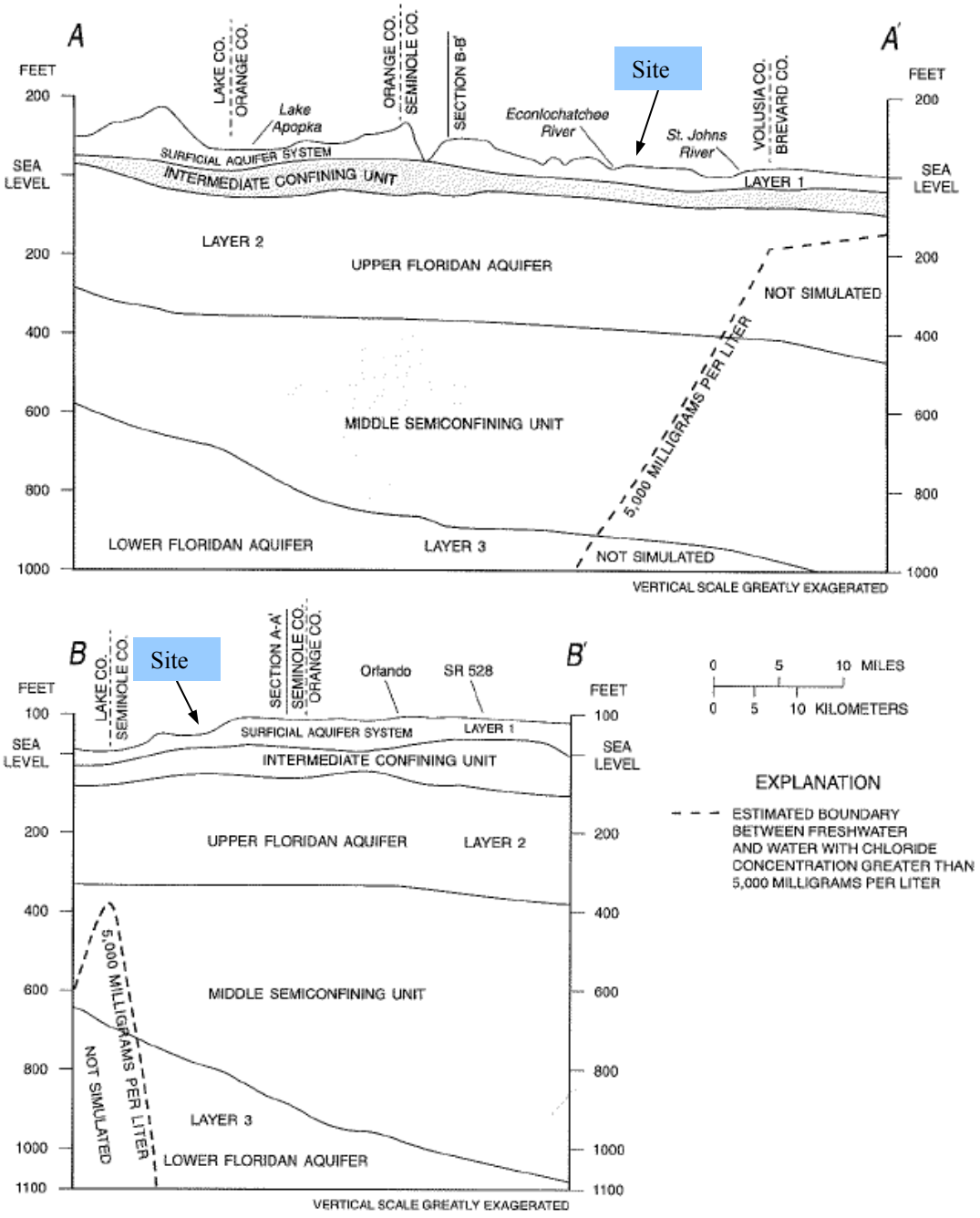


Figure 11 Generalized hydrogeologic sections A-A′ and B-B′

Sources: Spechler, 2001; Miller, 1986.

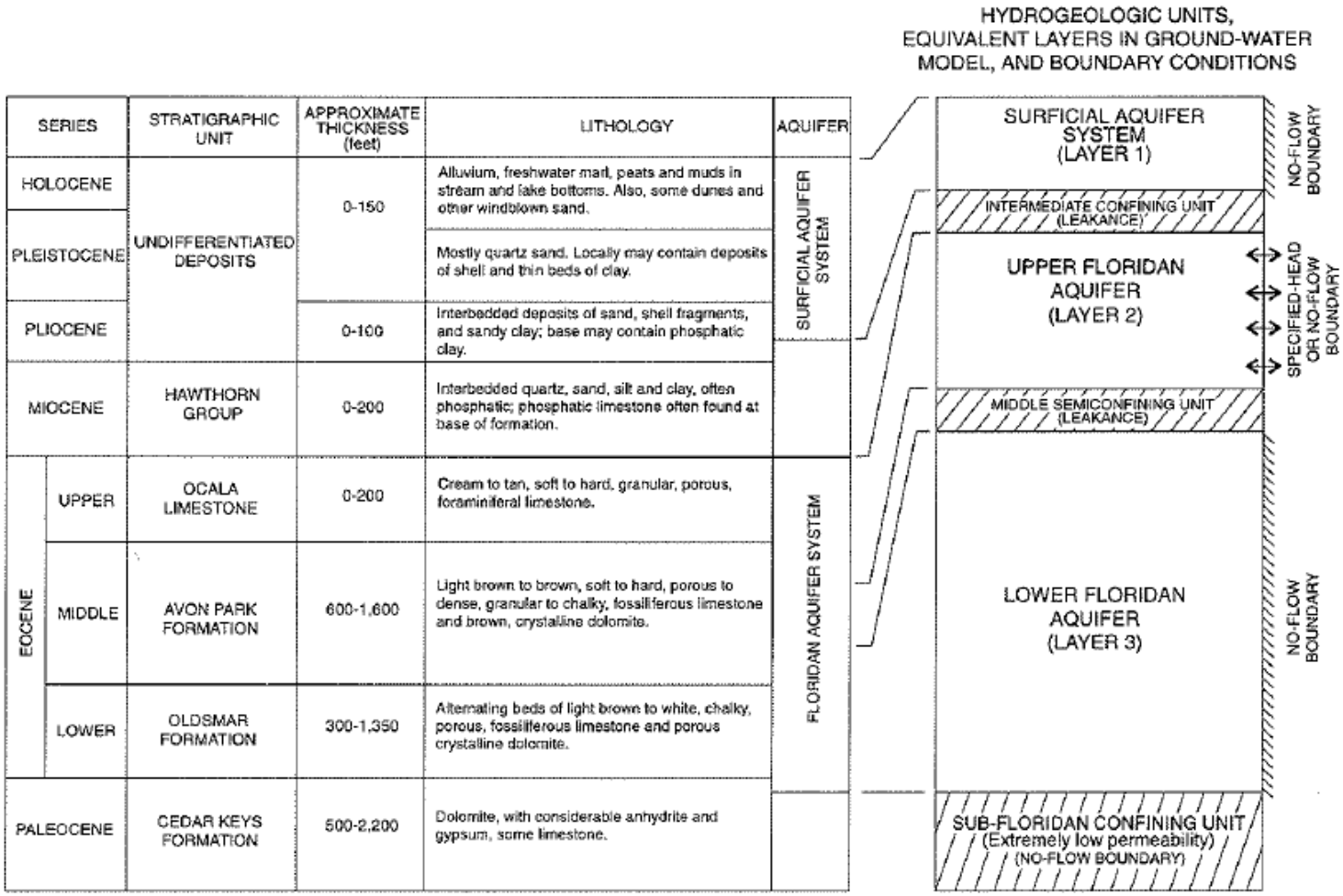
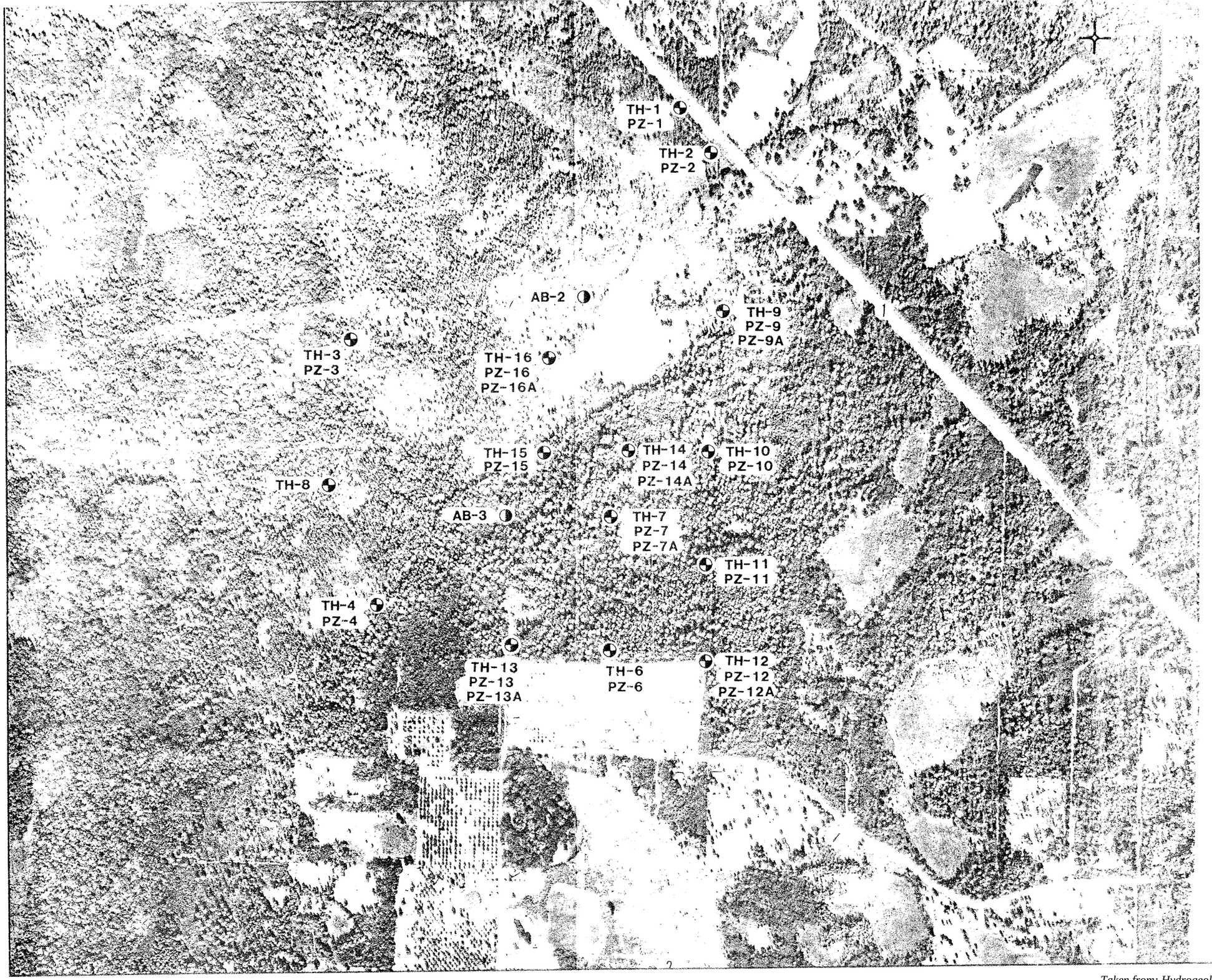


Figure 12 Geologic unit, hydrogeologic units, and equivalent layers
Sources: Spechler, 2001 ; Murray and Halford, 1996.



0 600

SCALE FEET

LEGEND

TH-1 STANDARD PENETRATION TEST (SPT) BORING LOCATION

AB-2 AUGER BORING LOCATION

PZ-1 PIEZOMETER LOCATION

FIGURE 13

BORING LOCATION PLAN

Ardaman & Associates, Inc.
Consulting Engineers in Soils, Hydrogeology, Foundations, and Materials Testing

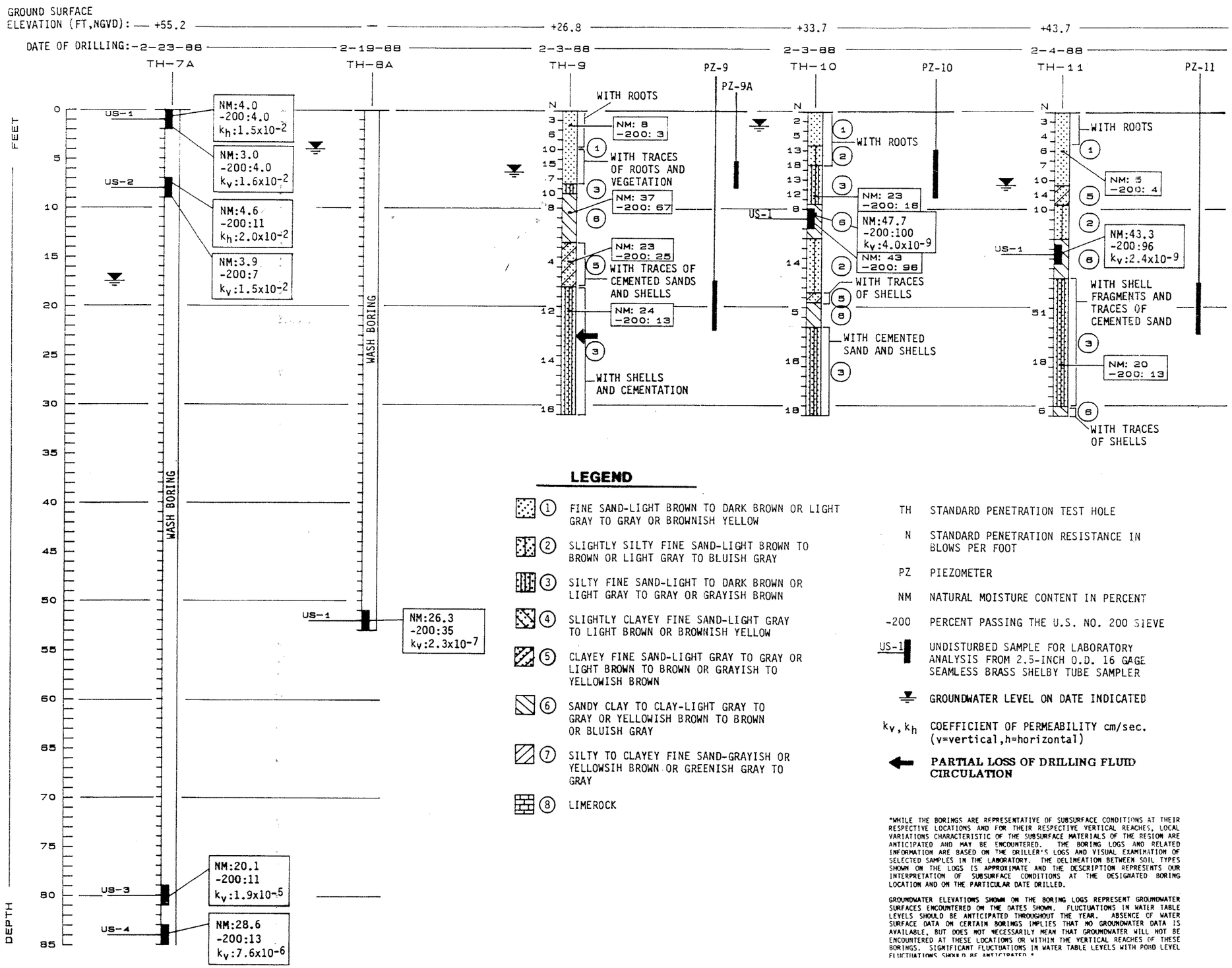
HYDROGEOLOGICAL SURVEY
SITE NO. 10
SEMINOLE COUNTY, FLORIDA

R.B.E. 5/5/88

87-149

N05842

Taken from: Hydrogeological Survey, Land Application System Evaluation and Groundwater Monitoring Plan, Site No. 10, Seminole County, Florida, Ardaman and Associates, Inc.(1988)



LEGEND

1. FINE SAND-LIGHT BROWN TO DARK BROWN OR LIGHT GRAY TO GRAY OR BROWNISH YELLOW
2. SLIGHTLY SILTY FINE SAND-LIGHT BROWN TO BROWN OR LIGHT GRAY TO BLUISH GRAY
3. SILTY FINE SAND-LIGHT TO DARK BROWN OR LIGHT GRAY TO GRAY OR GRAYISH BROWN
4. SLIGHTLY CLAYEY FINE SAND-LIGHT GRAY TO LIGHT BROWN OR BROWNISH YELLOW
5. CLAYEY FINE SAND-LIGHT GRAY TO GRAY OR LIGHT BROWN TO BROWN OR GRAYISH TO YELLOWISH BROWN
6. SANDY CLAY TO CLAY-LIGHT GRAY TO GRAY OR YELLOWISH BROWN TO BROWN OR BLUISH GRAY
7. SILTY TO CLAYEY FINE SAND-GRAYISH OR YELLOWSIH BROWN OR GREENISH GRAY TO GRAY
8. LIMEROCK

TH STANDARD PENETRATION TEST HOLE

N STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT

PZ PIEZOMETER

NM NATURAL MOISTURE CONTENT IN PERCENT

-200 PERCENT PASSING THE U.S. NO. 200 SIEVE

US-1 UNDISTURBED SAMPLE FOR LABORATORY ANALYSIS FROM 2.5-INCH O.D. 16 GAGE SEAMLESS BRASS SHELBY TUBE SAMPLER

GROUNDWATER LEVEL ON DATE INDICATED

k_v, k_h COEFFICIENT OF PERMEABILITY cm/sec. (v=vertical,h=horizontal)

PARTIAL LOSS OF DRILLING FLUID CIRCULATION

"WHILE THE BORINGS ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THEIR RESPECTIVE LOCATIONS AND FOR THEIR RESPECTIVE VERTICAL REACHES, LOCAL VARIATIONS CHARACTERISTIC OF THE SUBSURFACE MATERIALS OF THE REGION ARE ANTICIPATED AND MAY BE ENCOUNTERED. THE BORING LOGS AND RELATED INFORMATION ARE BASED ON THE DRILLER'S LOGS AND VISUAL EXAMINATION OF SELECTED SAMPLES IN THE LABORATORY. THE DELINEATION BETWEEN SOIL TYPES SHOWN ON THE LOGS IS APPROXIMATE AND THE DESCRIPTION REPRESENTS OUR INTERPRETATION OF SUBSURFACE CONDITIONS AT THE DESIGNATED BORING LOCATION AND ON THE PARTICULAR DATE DRILLED.

GROUNDWATER ELEVATIONS SHOWN ON THE BORING LOGS REPRESENT GROUNDWATER SURFACES ENCOUNTERED ON THE DATES SHOWN. FLUCTUATIONS IN WATER TABLE LEVELS SHOULD BE ANTICIPATED THROUGHOUT THE YEAR. ABSENCE OF WATER SURFACE DATA ON CERTAIN BORINGS IMPLIES THAT NO GROUNDWATER DATA IS AVAILABLE, BUT DOES NOT NECESSARILY MEAN THAT GROUNDWATER WILL NOT BE ENCOUNTERED AT THESE LOCATIONS OR WITHIN THE VERTICAL REACHES OF THESE BORINGS. SIGNIFICANT FLUCTUATIONS IN WATER TABLE LEVELS WITH POND LEVEL FLUCTUATIONS SHOULD BE ANTICIPATED."

ENGINEERING CLASSIFICATION

COHESIONLESS SOILS

DESCRIPTION	BLOW COUNT 'N'
VERY LOOSE	0 TO 4
LOOSE	4 TO 10
MEDIUM DENSE	10 TO 30
DENSE	30 TO 50
VERY DENSE	ABOVE 50

COHESIVE SOILS

DESCRIPTION	UNCONFINED COMPRESSIVE STRENGTH, TSF	BLOW COUNT 'N'
VERY SOFT	BELOW .25	0 TO 2
SOFT	.25 TO .50	2 TO 4
MEDIUM STIFF	.50 TO 1.0	4 TO 8
STIFF	1 TO 2	8 TO 15
VERY STIFF	2 TO 4	15 TO 30
HARD	ABOVE 4	ABOVE 30

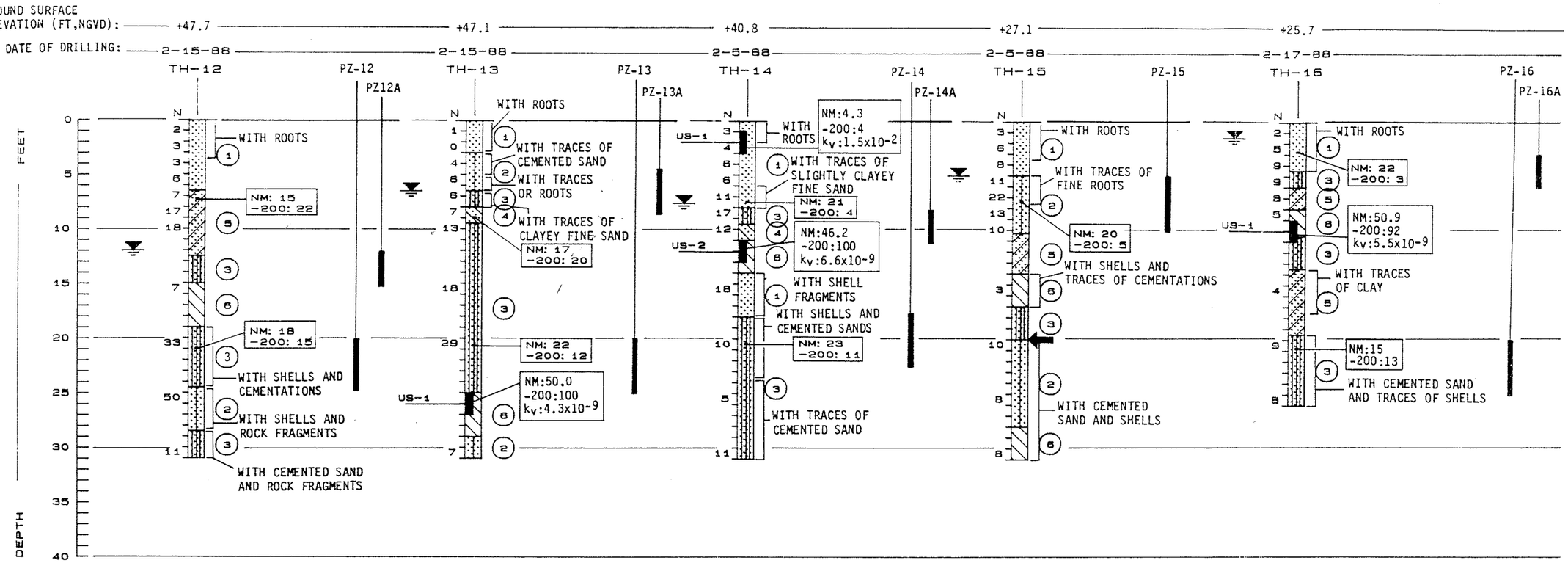
FIGURE 14

BORING PROFILES

Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing

HYDROGEOLOGICAL SURVEY
SITE NO. 10
SEMINOLE COUNTY, FLORIDA

Taken from: Hydrogeological Survey, Land Application System Evaluation and Groundwater Monitoring Plan, Site No. 10, Seminole County, Florida, Ardaman and Associates, Inc.(1988)



LEGEND

1. FINE SAND-LIGHT BROWN TO DARK BROWN OR LIGHT GRAY TO GRAY OR BROWNISH YELLOW
2. SLIGHTLY SILTY FINE SAND-LIGHT BROWN TO BROWN OR LIGHT GRAY TO BLUISH GRAY
3. SILTY FINE SAND-LIGHT TO DARK BROWN OR LIGHT GRAY TO GRAY OR GRAYISH BROWN
4. SLIGHTLY CLAYEY FINE SAND-LIGHT GRAY TO LIGHT BROWN OR BROWNISH YELLOW
5. CLAYEY FINE SAND-LIGHT GRAY TO GRAY OR LIGHT BROWN TO BROWN OR GRAYISH TO YELLOWISH BROWN
6. SANDY CLAY TO CLAY-LIGHT GRAY TO GRAY OR YELLOWISH BROWN TO BROWN OR BLUISH GRAY
7. SILTY TO CLAYEY FINE SAND-GRAYISH OR YELLOWSIH BROWN OR GREENISH GRAY TO GRAY
8. LIMEROCK

TH	STANDARD PENETRATION TEST HOLE
N	STANDARD PENETRATION RESISTANCE IN BLOWS PER FOOT
PZ	PIEZOMETER
NM	NATURAL MOISTURE CONTENT IN PERCENT
-200	PERCENT PASSING THE U.S. NO. 200 SIEVE
US-1	UNDISTURBED SAMPLE FOR LABORATORY ANALYSIS FROM 2.5-INCH O.D. 16 GAGE SEAMLESS BRASS SHELBY TUBE SAMPLER
▽	GROUNDWATER LEVEL ON DATE INDICATE:
k_h, k_v	COEFFICIENT OF PERMEABILITY cm/sec. (v=vertical,h=horizontal)
◀	PARTIAL LOSS OF DRILLING FLUID CIRCULATION

ENGINEERING CLASSIFICATION

COHESIONLESS SOILS

DESCRIPTION	BLOW COUNT 'N'
VERY LOOSE	0 TO 4
LOOSE	4 TO 10
MEDIUM DENSE	10 TO 30
DENSE	30 TO 50
VERY DENSE	ABOVE 50

COHESIVE SOILS

DESCRIPTION	UNCONFINED COMPRESSIVE STRENGTH, TSF	BLOW COUNT 'N'
VERY SOFT	BELOW .25	0 TO 2
SOFT	.25 TO .50	2 TO 4
MEDIUM STIFF	.50 TO 1.0	4 TO 8
STIFF	1 TO 2	8 TO 15
VERY STIFF	2 TO 4	15 TO 30
HARD	ABOVE 4	ABOVE 30

"WHILE THE BORINGS ARE REPRESENTATIVE OF SUBSURFACE CONDITIONS AT THEIR RESPECTIVE LOCATIONS AND FOR THEIR RESPECTIVE VERTICAL REACHES, LOCAL VARIATIONS CHARACTERISTIC OF THE SUBSURFACE MATERIALS OF THE REGION ARE ANTICIPATED AND MAY BE ENCOUNTERED. THE BORING LOGS AND RELATED INFORMATION ARE BASED ON THE DRILLER'S LOGS AND VISUAL EXAMINATION OF SELECTED SAMPLES IN THE LABORATORY. THE DELINEATION BETWEEN SOIL TYPES SHOWN ON THE LOGS IS APPROXIMATE AND THE DESCRIPTION REPRESENTS OUR INTERPRETATION OF SUBSURFACE CONDITIONS AT THE DESIGNATED BORING LOCATION AND ON THE PARTICULAR DATE DRILLED.

GROUNDWATER ELEVATIONS SHOWN ON THE BORING LOGS REPRESENT GROUNDWATER SURFACES ENCOUNTERED ON THE DATES SHOWN. FLUCTUATIONS IN WATER TABLE LEVELS SHOULD BE ANTICIPATED THROUGHOUT THE YEAR. ABSENCE OF WATER SURFACE DATA ON CERTAIN BORINGS IMPLIES THAT NO GROUNDWATER DATA IS AVAILABLE, BUT DOES NOT NECESSARILY MEAN THAT GROUNDWATER WILL NOT BE ENCOUNTERED AT THESE LOCATIONS OR WITHIN THE VERTICAL REACHES OF THESE BORINGS. SIGNIFICANT FLUCTUATIONS IN WATER TABLE LEVELS WITH POND LEVEL FLUCTUATIONS SHOULD BE ANTICIPATED."

FIGURE 15

BORING PROFILES

Ardaman & Associates, Inc.
Consulting Engineers in Soil Mechanics, Foundations, and Materials Testing

HYDROGEOLOGICAL SURVEY
SITE NO. 10
SEMINOLE COUNTY, FLORIDA

Taken from: Hydrogeological Survey, Land Application System Evaluation and Groundwater Monitoring Plan, Site No. 10, Seminole County, Florida, Ardaman and Associates, Inc.(1988)

(Ardaman and Associates, 1988). From the calibrated groundwater model of Seminole County (Spechler and Halford, 2001), leakance across the ICU, ranged from 1×10^{-4} to 1×10^{-3} day $^{-1}$ across most of Seminole County.

Floridan Aquifer System

The FAS, the principal source of groundwater in east-central Florida includes the following stratigraphic units in descending order: the Ocala Limestone, the Avon Park Formation, the Oldsmar Formation, and the upper part of the Cedar Keys Formation. The FAS ranges from about 2,000 to 2,600 ft in thickness in the county.

The Upper Floridan aquifer (UFA) consists of the Ocala Limestone and the dolomitic limestones of the upper one-third of the Avon Park Formation. In Seminole County, the altitude of the top of the Upper Floridan aquifer is less than 50 ft below see level in much of the eastern, western and southern part of the county. Transmissivity for the UFA around the site was about 10,000 to 50,000 ft^2/day in Seminole County (Murray and Halford, 1996). In 2005, the potentiometric surface of the UFA ranged from 13 ft to 20 ft NGVD (Kinnaman, 2005) in the vicinity of Site 10.

The middle semiconfining unit separates the UFA and Lower Floridan aquifers (LFA), and is composed of beds of relatively less permeable limestone and dolomitic limestone. In Seminole County, the unit ranges in thickness from about 400 to 550 ft (Miller, 1986). Reported leakance ranges from 1.2×10^{-5} to 1×10^{-3} day $^{-1}$ (Szell, 1993; Murray and Halford, 1996; and Barnes, Ferland and Associates, 1997).

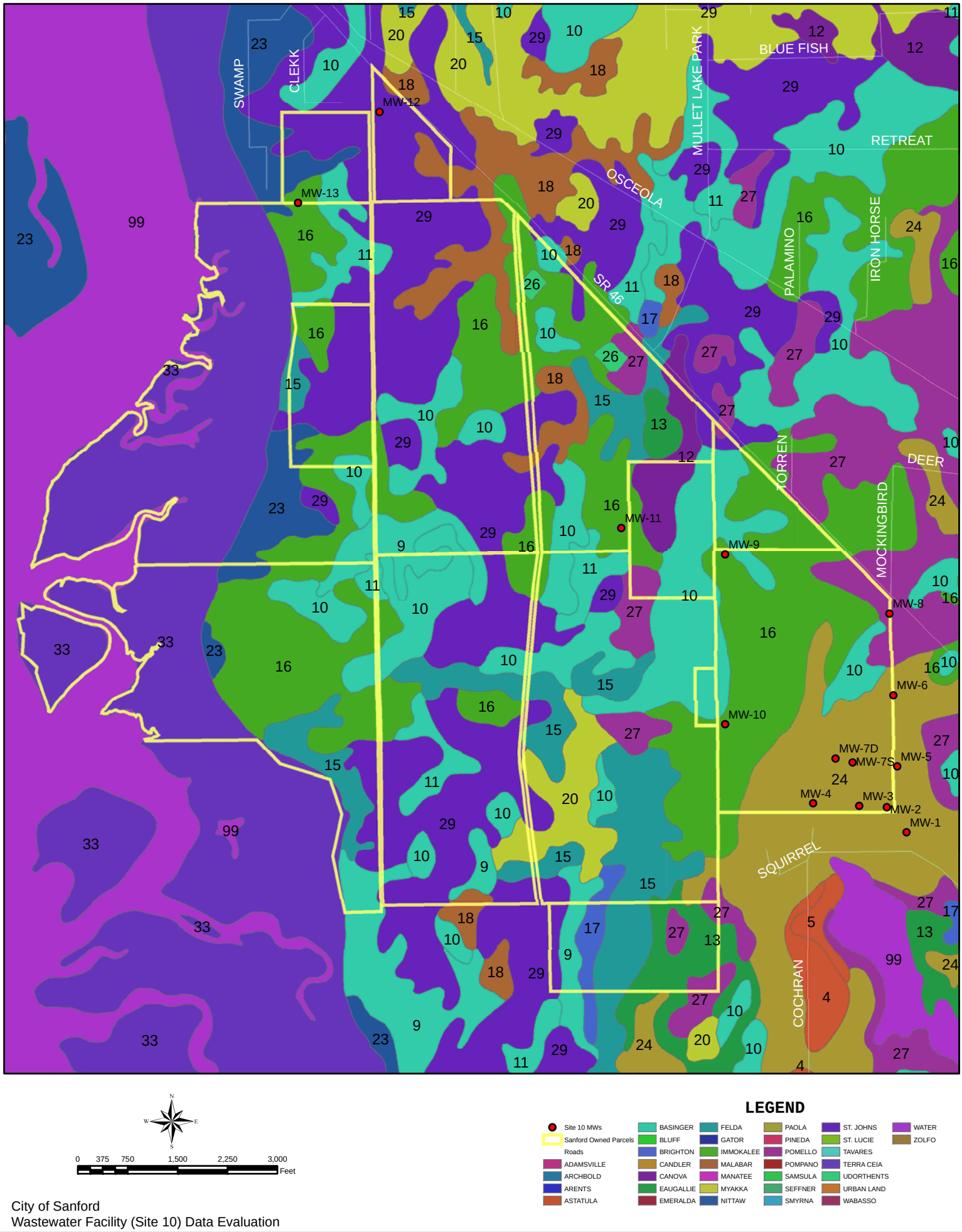
The LFA includes about the lower one-third of the Avon Park Formation and all of the Oldsmar Formation. This portion of the aquifer is highly productive. The unit ranges in thickness from about 1,300 to 1,500 ft in Seminole County (Miller, 1986). The model calibrated transmissivity of LFA ranged from 5,000 to 10,000 around the study site. The potentiometric surface of LFA was between 20 ft and 30 ft. Storage coefficient values from aquifer tests in both UFA and LFA range from 1×10^{-4} to 1×10^{-3} (Murray and Halford, 1996).

Soil Types and Characteristics

The Natural Resources Conservation Service (NRCS) soil types in the study area are illustrated on **Figure 16.** The data source is Soil Survey Geographic (SSURGO) database of Florida. As shown in the map, Site 10 is covered by numerous surficial soil types. The descriptions of detailed soil units are attached. The summary of the soil characteristics is shown in **Table 6.**

SAS Groundwater Levels and Flow Rates

From topography, the natural groundwater flow direction is from Site 10 towards Lake Jesup and its tributaries. The following data also support this conceptual model;



City of Sanford
Wastewater Facility (Site 10) Data Evaluation

CDM

Figure 16
Soil Types and Monitoring Well Locations

Table 6
Sanford Wastewater Facility (Site 10) Data Evaluation
Soil Characteristics Summary

Soil Name	Map Symbol	Depth (in)	USDA Texture	Classification Unified	Percentage Passing Sieve Number				Liquid Limit (pct)	Plasticity Index	Clay (pct)	Permeability (in/hr)	Available Water Capacity (in/in)	Organic Matter [1] (pct)	Hydrologic Group	Flooding			High Water Table		
					4	10	40	200								Frequency	Duration [2]	Months [2]	Depth (ft) [3]	Kind [4]	Months
St.Johns	29	0-12	Fine sand	SP,SP-SM	100	100	75-95	3-10	---	NP	1-4	6.0-20	0.10-0.15	2-4	B/D	None	---	---	0-1.0	Apparent	Jun-Apr
		12-22	Sand, fine sand	SP, SP-SM	100	100	85-95	3-10	---	NP	1-3	6.0-20	0.03-0.08								
		22-54	Sand, fine sand, loamy fine sand	SP-SM, SM	100	100	85-95	5-20	---	NP	2-6	0.2-2.0	0.10-0.30								
		54-80	Sand, fine sand	SP, SP-SM	100	100	80-90	2-10	---	NP	1-4	6.0-20	0.03-0.08								
EauGallie		0-16	Fine sand, sand	SP, SP-SM	100	100	80-98	2-5	---	NP	<5	6.0-20	0.02-0.07	2-8	B/D	None	---	---	0-1.0	Apparent	Jun-Oct
		16-35	Sand, fine sand	SP-SM, SM	100	100	80-98	5-20	---	NP	1-8	0.6-6.0	0.15-0.25								
		35-38	Sand, fine sand	SP, SP-SM	100	100	80-98	2-12	---	NP	1-5	6.0-20.0	0.02-0.05								
		38-72	Sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, SC	100	100	80-98	20-35	<40	NP-20	13-31	0.06-2.0	0.10-0.20								
		72-80	Sand, loamy sand, loamy fine sand	SP-SM, SM	100	100	80-98	5-25	---	NP	1-13	0.6-6.0	0.05-0.15								
Immokalee	16	0-6	Fine sand	SP,SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.05-0.10	1-2	B/D	None	---	---	0-1.0	Apparent	Jun-Oct
		6-36	Fine sand, sand	SP, SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.02-0.05								
		36-56	Fine sand, sand	SP-SM, SM	100	100	70-100	5-21	---	NP	2-7	0.6-2.0	0.10-0.25								
		56-80	Fine sand, sand	SP, SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.02-0.05								
Basinger	10	0-6	Mucky fine sand	SP, SP-SM	100	100	85-100	1-12	---	NP	1-6	6.0-20	0.15-0.20	8-20	D	None	---	---	+2-0	Apparent	Jun-Feb
		6-18	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	0-4	6.0-20	0.05-0.10								
		18-35	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.10-0.15								
		35-80	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.05-0.10								
Samsula		0-26	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.25	>20	B/D				+2-0		Jan-Dec
		26-80	Sand, fine sand, loamy sand	SP-SM, SM, SP	100	100	80-100	2-20	---	NP	1-14	6.0-20	0.02-0.05								
Hontoon		0-80	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.30-0.50	75-85	B/D				+2-0		Jan-Dec
Basinger	11	0-5	Mucky fine sand	SP, SP-SM	100	100	85-100	1-12	---	NP	1-6	6.0-20	0.15-0.20	8-20	D	None	---	---	+2-0	Apparent	Jun-Feb
		5-15	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	0-4	6.0-20	0.05-0.10								
		15-25	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.10-0.15								
		25-80	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.05-0.10								
Smyrna		0-2	Fine sand	SP, SP-SM	100	100	80-100	2-12	---	NP	1-6	6.0-20	0.05-0.10	1-5	D				+2-0		Jun-Feb
		2-15	Sand, fine sand	SP, SP-SM	100	100	80-100	2-10	---	NP	0-3	6.0-20	0.02-0.05								
		15-25	Sand, fine sand, loamy fine sand	SM, SP-SM	100	100	80-100	5-20	---	NP	3-8	0.6-6.0	0.10-0.20								
		25-80	Sand, fine sand	SP, SP-SM	100	100	80-100	2-10	---	NP	1-6	6.0-20	0.03-0.07								
Basinger	9	0-5	Fine sand	SP	100	100	85-100	1-4	---	NP	0-4	6.0-20	0.03-0.07	0.5-2	B/D	None	---	---	0-1.0	Apparent	Jun-Feb
		5-30	Sand, fine sand	SP,SP-SM	100	100	85-100	2-12	---	NP	0-4	6.0-20	0.05-0.10								
		30-50	Sand, fine sand	SP,SP-SM	100	100	85-100	2-12	---	NP	1-6	6.0-20	0.10-0.15								
		50-80	Sand, fine sand	SP,SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.05-0.10								
Delray		0-12	Fine sand	SP-SM, SM, SM-SC	100	100	95-100	5-20	<20	NP-5	3-13	6.0-20	0.10-0.15	2-5	B/D				0-1.0		Jun-Mar
		12-50	Fine sand, sand	SP-SM	100	100	95-100	5-12	---	NP	1-7	6.0-20	0.05-0.08								
		50-80	Sandy loam, fine sandy loam, sandy clay loam	SM,SM-SC, SC	100	100	95-100	20-35	<40	NP-15	13-30	0.6-6.0	0.10-0.15								
Pomello	27	0-31	Fine sand	SP, SP-SM	100	100	60-100	1-8	---	NP	<2	>20	0.02-0.05	<1	C	None	---	---	2.0-3.5	Apparent	Jun-Nov
		31-40	Coarse sand, fand, fine sand	SP-SM, SM	100	100	60-100	6-15	---	NP	<2	2.0-6.0	0.10-0.30								
		40-80	Coarse sand, fand, fine sand	SP,SP-SM	100	100	60-100	4-10	---	NP	<2	6.0-20	0.02-0.05								
Terra Ceia	33	0-80	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.30-0.50	>60	D	Frequent	Long	Jun-Nov	0-1.0	Apparent	Jan-Dec

Table 6
Sanford Wastewater Facility (Site 10) Data Evaluation
Soil Characteristics Summary

Soil Name	Map Symbol	Depth (in)	USDA Texture	Classification Unified	Percentage Passing Sieve Number				Liquid Limit (pct)	Plasticity Index	Clay (pct)	Permeability (in/hr)	Available Water Capacity (in/in)	Organic Matter [1] (pct)	Hydrologic Group	Flooding			High Water Table		
					4	10	40	200								Frequency	Duration [2]	Months [2]	Depth (ft) [3]	Kind [4]	Months
Felda	15	0-4	Mucky fine sand	SP, SP-SM	100	100	90-100	2-12	---	NP	1-6	6.0-20	0.15-0.20	10-20	D	None	---	---	+2-0	Apparent	Jun-Dec
		4-28	Sand, fine sand	SP, SP-SM	100	100	90-100	2-5	---	NP	1-3	6.0-20	0.02-0.05								
		28-36	Sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, SC	100	100	90-100	15-35	<40	NP-15	13-30	0.6-6.0	0.10-0.15								
		36-80	Sand, fine sand, loamy sand	SP, SP-SM	100	100	80-100	2-12	---	NP	1-10	6.0-20	0.02-0.05								
Manatee		0-19	Mucky fine sand, fine sand, loamy sand	SP-SM, SM	100	100	85-100	8-15	---	NP	2-8	2.0-6.0	0.15-0.25	15-30	D				+2-0		Jun-Feb
		19-50	Fine sandy loam, sandy loam	SM-SC, SC,SM	100	100	90-100	18-30	<30	NP-10	10-20	0.6-2.0	0.10-0.15								
		50-80	Fine sandy loam, sandy loam, loamy fine sand	SM,SM-SC, SC, GM	60-100	50-100	50-100	13-30	<30	NP-10	6-20	0.6-2.0	0.08-0.15								
Malabar	18	0-10	Fine sand	SP, SP-SM	100	100	80-100	2-10	---	NP	0-4	6.0-20	0.03-0.08	1-2	B/D	None	---	---	0-1.0	Apparent	Jun-Nov
		10-35	Sand, fine sand	SP, SP-SM	100	100	80-100	3-12	---	NP	1-5	6.0-20	0.05-0.10								
		35-48	Sand, fine sand	SP, SP-SM	100	100	80-100	2-10	---	NP	1-5	6.0-20	0.02-0.05								
		48-70	Sandy clay loam, fine sandy loam, sandy loam	SC, SM-SC, SM	100	100	80-100	20-40	<35	NP-20	12-25	<0.2	0.10-0.15								
		70-80	Sand, fine sand, loamy fine sand	SP-SM, SM	100	100	80-100	5-20	---	NP	1-8	6.0-20	0.03-0.08								
Paola	24	0-3	Fine sand	SP	100	100	85-100	1-2	---	NP	0-2	>20	0.02-0.05	0-1	A	None	---	---	>6.0	---	---
		3-25	Sand, fine sand	SP	100	100	85-100	1-2	---	NP	0-2	>20	0.02-0.05								
		25-80	Sand, fine sand	SP	100	100	80-100	1-4	---	NP	0-3	>20	0.02-0.05								
St. Lucie		0-2	Sand	SP	100	90-100	80-99	1-4	---	NP	0-1	>20	0.02-0.05		A				>6.0	---	---
		2-80	Sand, fine sand	SP	100	90-100	80-99	1-4	---	NP	0-1	>20	0.02-0.03								
Myakka	20	0-5	Fine sand, sand	SP, SP-SM	100	100	85-100	2-10	---	NP	1-3	6.0-20	0.05-0.15	2-5	B/D	None	---	---	0-1.0	Apparent	Jun-Oct
		5-28	Fine sand, sand	SP, SP-SM	100	100	85-100	2-10	---	NP	0-2	6.0-20	0.02-0.05								
		28-45	Sand, fine sand, loamy fine sand	SM, SP-SM	100	100	85-100	5-20	---	NP	1-8	0.6-6.0	0.10-0.20								
		45-80	Sand, fine sand	SP, SP-SM	100	100	85-100	2-8	---	NP	0-2	6.0-20	0.02-0.10								
EauGallie		0-18	Fine sand	SP, SP-SM	100	100	80-98	2-5	---	NP	<5	6.0-20	0.02-0.07	2-8	B/D				0-1.0		Jun-Oct
		18-30	Sand, fine sand	SP-SM, SM	100	100	80-98	5-20	---	NP	1-8	0.6-6.0	0.15-0.25								
		30-41	Sand, fine sand	SP, SP-SM	100	100	80-98	2-12	---	NP	1-5	6.0-20	0.02-0.05								
		41-60	Sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, SC	100	100	80-98	20-35	<40	NP-20	13-31	0.06-2.0	0.10-0.20								
		60-80	Sand, loamy sand, loamy fine sand	SP-SM, SM	100	100	80-98	5-25	20-32	NP	1-13	0.6-6.0	0.05-0.15								
EauGallie	13	0-18	Fine sand	SP, SP-SM	100	100	80-98	2-5	---	NP	<5	6.0-20	0.02-0.07	2-8	B/D	None	---	---	0-1.0	Appatrent	Jun-Oct
		18-30	Sand, fine sand	SP-SM, SM	100	100	80-98	5-20	---	NP	1-8	0.6-6.0	0.15-0.25								
		30-45	Sand, fine sand	SP, SP-SM	100	100	80-98	2-12	---	NP	1-5	6.0-20	0.02-0.05								
		45-64	Sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, SC	100	100	80-98	20-35	<40	NP-20	13-31	0.06-2.0	0.10-0.20								
		64-80	Sand, loamy sand, loamy fine sand	SP-SM, SM	100	100	80-98	5-25	20-32	NP	1-13	6.0-20	0.05-0.15								
Immokalee		0-4	Fine sand	SP,SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.05-0.10	1-2	B/D	None	---	---	0-1.0	Apparent	Jun-Oct
		4-42	Fine sand, sand	SP, SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.02-0.05								
		42-62	Fine sand, sand	SP-SM, SM	100	100	70-100	5-21	---	NP	2-7	0.6-2.0	0.10-0.25								
		62-80	Fine sand, sand	SP, SP-SM	100	100	70-100	2-10	---	NP	1-5	6.0-20	0.02-0.05								

Table 6
Sanford Wastewater Facility (Site 10) Data Evaluation
Soil Characteristics Summary

Soil Name	Map Symbol	Depth (in)	USDA Texture	Classification Unified	Percentage Passing Sieve Number				Liquid Limit (pct)	Plasticity Index	Clay (pct)	Permeability (in/hr)	Available Water Capacity (in/in)	Organic Matter [1] (pct)	Hydrologic Group	Flooding			High Water Table		
					4	10	40	200								Frequency	Duration [2]	Months [2]	Depth (ft) [3]	Kind [4]	Months
Brighton	17	0-8	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.50	60-90	B/D	None	---	---	+2-0	Apparent	Jan-Dec
		8-80	Mucky peat	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.40								
Samsula		0-26	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.25	>20	B/D				+2-0		Jan-Dec
		26-80	Sand, fine sand,loamy sand	SP-SM, SM,SP	100	100					1-14	6.0-20	0.02-0.05								
Sanibel		0-6	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.50	20-50	B/D				+2-0		Jun-Feb
		6-8	Sand, fine sand, mucky fine sand	SP, SP-SM	100	100	85-95	5-12	---	NP	2-6	6.0-20	0.10-0.15								
		8-80	Sand, fine sand	SP, SP-SM	100	100	85-95	5-12	---	NP	2-6	6.0-20	0.03-0.10								
Canova	12	0-10	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.10-0.20	35-75	B/D	None	---	---	+2-0	Apparent	Jan-Dec
		10-27	Sand, fine sand	SP, SP-SM	100	100	70-100	3-10	---	NP	1-6	6.0-20	0.02-0.05								
		27-30	Sandy loam, fine sandy loam, sandy clay loam	SM, SM-SC, SC	100	100	75-95	15-38	<40	NP-20	15-34	0.6-6.0	0.10-0.15								
		30-38	Sandy clay loam	SC	100	100	75-95	18-35	20-40	9-26	18-34	0.6-2.0	0.10-0.15								
		38-80	Sandy clay loam, fine sandy loam, sandy loam	SM, SM-SC, SC	100	80-100	65-95	15-35	<40	NP-20	15-25	0.6-6.0	0.10-0.15								
Terra Ceia		0-80	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.30-0.50	60-90	B/D				+2-0		Jan-Dec
Udorthents	26																				
Nittaw	23	0-4	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.25	20-90	D	Frequent	Very long	Jun-Sep	0-1.0		Jun-Nov
		4-9	Sand, fine sand, mucky fine sand	SP-SM, SM	100	100	85-100	5-20	---	NP	1-10	6.0-20	0.05-0.15								
		9-80	Sandy clay, clay	CH, CL	100	100	85-100	51-70	40-80	21-50	35-60	0.06-0.2	0.15-0.18								
Okeelanta		0-42	Muck	PT	---	---	---	---	---	---	---	6.0-20	0.20-0.45	60-85	D	Frequent	Very long	Mar-Sep	0-1.0	Apparent	Jan-Dec
		42-80	Fine sand, sand, loamy sand	SP, SP-SM, SM	100	85-100	80-95	2-15	---	NP	1-5	6.0-20	0.05-0.10								
Rasinger		0-22	Fine sand	SP	100	100	100	1-4	---	NP	0-4	6.0-20	0.03-0.07	0.2-1.0	D	Frequent	Long	Jul-Sep	0-1.0		Jun-Nov
		22-38	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-6	6.0-20	0.10-0.15								
		38-80	Sand, fine sand	SP, SP-SM	100	100	85-100	2-12	---	NP	1-3	6.0-20	0.05-0.10								

NOTES:
--- Absence of an entry indicates that data were not available or were not estimated
[1] Organic Matter applies only to the surface layer
[2] Absence of an entry indicates that the feature is not a concern.
[3] The plus sign under "High water table -- Depth" indicates ponding.
[4] Kind is defined as: (1) Apparent Water Table - a thick zone of free water in the soil. It is indicated by the level at which water stands in an encased borehole after adequate time time is allowed for adjustement in the surrounding soil.
(2) Perched Water Table - is water standing above an unsaturated water zone. In places an upper, or perched, water table is separate from a lower one by a dry zone.

Soil Site Characteristics are based on the following tables taken from the Soil Survey of Seminole County Area, Florida (Issued March 1990):
(1) Table 13 - Engineering Index Properties; (2) Table 14 - Physical and Chemical Properties of the Soil; and (3) Table 15 - Soil and Water Features.

- Water table elevations from 13 monitoring wells at site 10 (in the study area) (Figure 16) range from 6.9 ft to 45.8 ft NGVD during the monitoring period from March 2003 to September 2006 (**Table 7**).

- The water level in Lake Jesup fluctuated from 0.39 ft (May, 2004) to 7.36 ft (October 2004) NGVD between January 2003 to December 2006.

- The average water level at SEMCO_PWHYDRO station and SJRWMD_HYDRO station in Lake Jesup during 2003 -2006 was 2.51 ft-NGVD (**Table 8**).

The monitoring well closest the Lake Jesup is MW-13, which is located about 1,471 ft from the lake. The average groundwater level of well MW-13 was 8.6 ft NGVD. The altitude of the base of the SAS is about -25 ft NGVD (Murray and Halford, 1996). Therefore, the saturated thickness of the surficial aquifer is approximately 33.6 feet at MW-13.

The Dupuit equation can be used to estimate the groundwater flow rate in an unconfined aquifer, as follows:

$$q = \frac{K_h}{2x}\left(h_1^2 - h_2^2\right) = \frac{Q}{w}$$

Where:

q	=	flow per unit width of aquifer or specific discharge (ft2/day);
K_h	=	horizontal hydraulic conductivity of the aquifer (feet/day);
x	=	the horizontal distance between two points h1 and h2 (feet);
h1	=	head at location 1 above the impermeable unit (feet); and
h2	=	head at location 1 above the impermeable unit (feet).

If the specific discharge (q) is multiplied by the cross sectional flow width (w) the volumetric groundwater flow rate (Q) between Site 10 and Lake Jesup can be estimated. The input data was taken from both published and site specific data. The input assumptions and calculated SAS groundwater flow rates between Site 10 and Lake Jesup are presented in **Table 9** and **Table 10**. The average flow per unit width calculated from the data of 13 monitoring wells is 0.43 ft^2/day.

Table 7
Sanford Wastewater Facility (Site 10) Data Evaluation
Monitoring Well Data

				31-Mar-03		30-Jun-03		30-Sep-03		31-Dec-03		31-Mar-04		30-Jun-04		30-Sep-04		31-Dec-04	
Facility MW Name	Permit Builder MW ID	MWAFR ID/#	Total Phosphorus mg/L (Average 1992-97)*	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l
SITE 10																			
MW-1	MWB-1 Site 10	6778	0.29	24.99	<0.02	24.1	<0.02	25.45	<0.02	24.57	<0.02	23.63	<0.003	22.6	0.08	22.48	<0.003	24.63	<0.003
MW-2	MWC-2 Site 10	6777	0.05	41.83	0.02	41.02	<0.02	41.42	<0.02	40.16	<0.02	38.87	<0.003	37.97	0.01	41.3	<0.003	40.66	0.006
MW-3	MWC-3 Site 10	6776	0.04	44.22	0.11	43.4	0.04	43.78	0.34	42.43	0.05	41.11	9.7	40.24	6.4	43.86	1.48	43.28	2.82
MW-4	MWC-4 Site 10	6775	0.17	42.64	<0.02	43.89	<0.02	44.29	<0.02	43.11	<0.02	42.01	<0.003	41.83	0.004	45.77	<0.003	44.69	0.014
MW-5	MWC-5 Site 10	6774	0.22	30.07	10	28.99	8.42	29.54	0.49	27.63	1.36	26.19	0.21	25.59	0.22	29.87	1.78	29.11	0.008
MW-6	MWC-6 Site 10	6773	0.04	33.72	6.56	33.66	4.29	33.48	2.24	32.76	<0.02	32.14	<0.003	31.22	<0.003	33.87	<0.003	33.26	5.34
MW-7s	MWC-7 Site 10	6772	0.04	39.5	8.94	39.08	14.8	39.76	8.2	38.35	7.9	37.27	9.6	38.17	9.8	46.67	11.2	39.53	13.2
MW-8	MWC-8 Site 10	6771	0.04	27.53	0.02	27.79	0.27	27.63	0.04	26.94	<0.02	26.33	<0.003	25.65	<0.003	28.25	<0.003	29.08	<0.003
MW-9	MWC-9 Site 10	6770	0.45	18.65	<0.02	18.16	0.26	17.03	0.05	16.6	<0.02	15.89	<0.003	14.87	<0.003	14.52	<0.003	17.22	<0.003
MW-10	MWC-10 Site 10	6769	0.19	20.99	<0.02	20.23	0.04	0.05	20.51	19.6	<0.02	20.22	0.03	18.31	<0.003	21.04	<0.003	20.15	<0.003
MW-11	MWC-11 Site 10	6768	2.97	16.53	0.04	15.8	<0.02	16.02	0.09	15.02	<0.02	14.87	<0.003	13.79	<0.003	16.53	<0.003	15.41	<0.003
MW-12	MWC-12 Site 10	6767	0.24	13.87	0.02	12.6	0.05	13.25	0.05	12.86	<0.02	12.12	<0.003	11.44	<0.003	13.92	<0.003	12.53	0.006
MW-13	MWC-13 Site 10	6766	0.16	8.89	<0.02	8.08	0.05	8.89	0.07	7.85	<0.02	7.87	<0.003	6.93	<0.003	9.11	<0.003	7.34	<0.003

			31-Mar-05		30-Jun-05		30-Sep-05		31-Dec-05		31-Mar-06		30-Jun-06		30-Sep-06	
Facility MW Name	Permit Builder MW ID	MWAFR ID/#	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l	Water Level Relative to ft-NGVD	Nitrogen, Nitrate Total (as N) mg/l
SITE 10																
MW-1	MWB-1 Site 10	6778	24.24	<0.005	23.82	<0.019	24.83	<0.019	25.62	0.019	24.43	<0.003	23.28	0.008	21.68	0.021
MW-2	MWC-2 Site 10	6777	39.36	0.023	39.17	0.019	39.88	<0.019	41.06	<0.019	38.65	0.01	37.62	<0.0075	36.45	0.005
MW-3	MWC-3 Site 10	6776	41.67	1.94	41.2	<0.019	42.92	0.019	43.33	9.8	41.17	11	40.41	7.1	39.1	6.3
MW-4	MWC-4 Site 10	6775	43.13	<0.003	42.94	<0.019	43.94	0.021	44.53	<0.019	42.78	0.005	41.62	0.051	40.6	<0.003
MW-5	MWC-5 Site 10	6774	26.63	0.041	26.67	0.689	27.58	3.98	29.21	2.5	26.37	0.66	25.67	0.3	24.84	0.14
MW-6	MWC-6 Site 10	6773	32.49	4.05	31.96	4.98	32.26	2.46	33.36	0.86	32.07	2.9	30.84	2.8	30.46	5.1
MW-7s	MWC-7 Site 10	6772	37.7	11.5	37.92	9.32	38.42	9.47	39.33	7.5	37.19	9.7	37.09	9.3	37.15	7.9
MW-8	MWC-8 Site 10	6771	26.29	0.09	26.5	<0.019	27.36	<0.019	27.76	<0.019	26.67	0.015	25.42	<0.0075	24.58	<0.003
MW-9	MWC-9 Site 10	6770	16.82	<0.003	16.6	<0.019	17.65	0.033	17.94	<0.019	17.12	<0.0030	14.97	0.01	13.35	<0.003
MW-10	MWC-10 Site 10	6769	19.47	<0.003	19.01	<0.019	20.26	0.02	20.4	<0.019	20.2	0.047	18.02	0.051	17.29	0.064
MW-11	MWC-11 Site 10	6768	15.51	0.021	16.03	<0.019	16.76	<0.019	15.91	<0.019	15.38	0.0042	13.34	0.023	12.18	<0.003
MW-12	MWC-12 Site 10	6767	11.64	<0.003	13.74	<0.019	13.14	<0.019	13.28	<0.019	12.59	<0.0030	10.97	0.008	10.82	<0.003
MW-13	MWC-13 Site 10	6766	7.9	0.033	9.21	<0.019	8.64	<0.019	8.39	<0.019	7.97	<0.0030	7.11	0.086	7.22	<0.003

MWB = Background; MWI = Intermediate; MWC = Compliance
* Phosphorus sampling was removed from Permit requirements post 1997.

Table 8
Sanford Wastewater Facility (Site 10) Data Evaluation
Lake Jesup Water Levels

Source	Station	Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	*Average*
			Water Level Feet												
SJRWMD_HYDRO	1410650	2003	4.35	2.57	2.63	2.18	0.98	0.90	1.51	3.26	3.92	3.87	2.92	1.53	*2.55*
SJRWMD_HYDRO	1410650	2004	0.93	1.25	1.40	0.72	0.39	0.47	0.90	2.47	6.42	7.36	5.57	3.11	*2.58*
SJRWMD_HYDRO	1410650	2005	2.01	1.87	1.43	2.28	1.59	2.47	4.46	4.24	3.87	4.80	6.06	4.68	*3.31*
SJRWMD_HYDRO	1410650	2006	2.74	1.53	0.93	0.60	0.75	0.46	0.60	0.50	1.91	1.92	1.37	1.23	*1.21*
SJRWMD_HYDRO	1410650	*Average*	*2.51*	*1.81*	*1.60*	*1.44*	*0.93*	*1.08*	*1.87*	*2.62*	*4.03*	*4.49*	*3.98*	*2.64*	*2.42*
USGS_NWIS	2234435	2003	4.47	2.82	2.86	2.44	1.22	0.85	1.88	3.55	4.19	4.15	3.19	1.79	*2.78*
USGS_NWIS	2234435	2004	1.18	1.51	1.67	0.75	0.48	0.60	1.23	1.44	NV	NV	NV	NV	*1.11*
USGS_NWIS	2234435	2005	2.18	1.88	1.47	2.25	1.58	2.50	4.49	4.27	3.88	4.83	6.13	4.76	*2.58*
USGS_NWIS	2234435	2006	2.79	1.55	0.92	0.58	0.77	0.49	0.62	0.49	1.93	1.93	1.41	1.24	*1.23*
USGS_NWIS	2234435	*Average*	*2.66*	*1.94*	*1.73*	*1.51*	*1.01*	*1.11*	*2.06*	*2.44*	*3.34*	*3.64*	*3.58*	*2.59*	*2.30*
SEMCO_PWHYDRO	SCPW-L-jes2	2003	3.19	2.80	2.97	2.88	1.00	1.80	1.75	2.20	3.95	3.62	1.50	1.17	*2.40*
SEMCO_PWHYDRO	SCPW-L-jes2	2004	0.85	2.21	2.10	NV	0.43	0.43	1.05	3.80	6.65	6.50	4.55	2.60	*2.83*
SEMCO_PWHYDRO	SCPW-L-jes2	2005	2.30	1.34	1.53	2.52	1.44	4.77	4.55	3.97	3.99	5.29	5.56	4.26	*3.46*
SEMCO_PWHYDRO	SCPW-L-jes2	2006	2.28	1.34	1.06	0.57	0.64	NV	0.60	0.95	2.26	2.75	NV	NV	*1.38*
SEMCO_PWHYDRO	SCPW-L-jes2	*Average*	*2.16*	*1.92*	*1.92*	*1.99*	*0.88*	*2.33*	*1.99*	*2.73*	*4.21*	*4.54*	*3.87*	*2.68*	*2.60*

Table 9
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Groundwater Flow Rate Parameters

Parameter	Description	Units	Average Value
K_h	Horizontal hydraulic conductivity	ft/day	3.5
x	Horizontal distance between MW-13 and Lake Jesup	feet	1,471
h_1	Head in MW-13	feet	33.6
h_2	Head in Lake Jesup	feet	27.51
q	Flow per unit width to Lake	ft^2/day	0.44
w	Cross-section width	feet	12,000
Q	Volumetric GW flow rate	ft^3/day	5173

Table 10
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Mass Loading of Nitrate to Lake Jesup

Well	**Water Level** (ft)	**x** (ft)	**h1** (ft)	**h2** (ft)	**q** (ft^2/d)	**w** (ft)	**Q** (ft^3/day)	**C** (mg/l)	**M** (lb/day)
MW-1	23.3	10514.4	48.3	27.5	0.26	12000	3145.9	0.02	0.003
MW-2	41.2	10269.2	66.2	27.5	0.62	12000	7419.7	0.01	0.006
MW-3	42.5	9840.0	67.5	27.5	0.67	12000	8097.8	3.81	1.925
MW-4	45.2	9196.3	70.2	27.5	0.79	12000	9534.8	0.01	0.009
MW-5	29.3	10483.7	54.3	27.5	0.37	12000	4382.6	2.05	0.562
MW-6	32.4	10667.7	57.4	27.5	0.42	12000	5005.2	2.77	0.867
MW-7s	39.3	9778.7	64.3	27.5	0.60	12000	7250.9	9.89	4.476
MW-8	27.6	10851.6	52.6	27.5	0.32	12000	3887.1	0.04	0.009
MW-9	18.2	9012.3	43.2	27.5	0.21	12000	2577.1	0.03	0.005
MW-10	14.9	8062.2	39.9	27.5	0.18	12000	2174.5	1.39	0.189
MW-11	15.8	5119.3	40.8	27.5	0.31	12000	3724.1	0.02	0.004
MW-12	13.3	3126.7	38.3	27.5	0.40	12000	4743.5	0.02	0.005
MW-13	8.6	1471.4	33.6	27.5	0.44	12000	5306.7	0.02	0.008
				Average	***0.43***	***12000***	***5173.07***	***1.54***	***0.50***

Nutrient Transport in SAS

Nutrient transport in groundwater occurs primarily through advection. Advection is defined as traveling with the average groundwater flow velocity. Also, the nutrient mass is assumed to travel as a conservative element that does react with the aquifer matrix. The mass loading to Lake Jesup is calculated by multiplying volumetric groundwater flow rate by the groundwater nitrate concentration. The average nitrate concentration in the monitoring wells is 1.54 mg/l, and average nitrate mass loading to Lake Jesup is 0.50 lb/day or 182 lbs/year (Table 10).

Surface Nutrient Loading

Pollutant Load Analysis

CDM estimated the relative annual pollutant loads for Site 10 for existing conditions as of 2004 based on the most recent aerial photography and land use data. Nonpoint source (NPS) pollutant loads were estimated using the CDM Watershed Management Model (WMM), Version 4.24. The WMM was used to conceptually evaluate the TP and TN for each of the subbasins that are within the Lake Jesup Watershed as shown on Figure 8. The purpose of the evaluation was to update the pollutant load analysis that had been previously done by CDM for the *Lake Jesup Basin Engineering Study and Drainage Inventory* (2001) for Seminole County. In this previous analysis as well as the analysis used by FDEP to develop the TMDL, industrial land use had been assigned to a large portion of Site 10 as it was identified as a utility in Seminole County's existing land use coverage. Based on recent discussions with FDEP at the BMAP meetings, field visits, review of the 2004 aerial photography and the Land Use and Land Cover (2004) GIS layer available from the SJRWMD, Site 10 is dominated by agriculture (i.e., pastures and citrus groves) and wetlands as previously shown in Figure 2. The WMM also accounts for BMPs present on the site as previously discussed in this memorandum.

Watershed Management Model (WMM) Background

WMM uses a database platform to estimate annual or seasonal pollutant nonpoint surface loads within a basin. Data required for the WMM include stormwater event mean concentrations (EMCs) for each pollutant type, land use, and average annual precipitation. In addition, impacts due to failing septic systems, annual baseflow and average baseflow concentrations, point source flows and pollutant concentrations, and average number of combined sewer overflows (CSOs) and concentrations can also be taken into account in the WMM if applicable. The model is a "stand alone" application that runs in Microsoft Windows 95® or greater.

Within a given watershed, multiple subbasins can be evaluated. Subbasins are typically subdivided by tributary areas, outfalls, or other receiving water body within a basin. However, subbasins can be delineated based on non-hydrologic boundaries such as

jurisdictional limits. This provides decision makers with information regarding the relative contribution of pollution loadings from various areas within a basin which can be used for targeting control measures to those areas which are responsible for generating the majority of the pollutant load.

The WMM consists of three major computational modules, the import utility, and numerous related database records. WMM was developed using Visual Basic® and Microsoft Access®.

Rainfall/Runoff Relationships

NPS pollution loading factors (lbs/acre/year) for different land use categories are based upon annual runoff volumes and event mean concentrations (EMCs) for different pollutants. The EMC is defined as the average of individual measurements of storm pollutant mass loading divided by the storm runoff volume. One of the keys to effective transfer of literature values for nonpoint pollution loading factors to a particular study area is to make adjustments for actual runoff volumes in the basin under study. In order to calculate annual runoff volumes for each subbasin, the pervious and impervious fractions of each land use category are used as the basis for determining rainfall/runoff relationships. For rural/agricultural (nonurban) land uses, the pervious fraction represents the major source of runoff or stream flow, while impervious areas are the predominant contributors for most urban land uses.

Rainfall

The average annual rainfall data from 1995 through 2005 for the Sanford Weather Station (COOP ID: 087982) were used for the WMM analysis. Total rainfall from 1995 through 2002 was used in the analysis for the *Nutrient and Unionized Ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A* (FDEP, 2005). CDM obtained annual rainfall totals for 2003 through 2005 and averaged the values from 1995 through 2005 resulting in an annual rainfall of 54.98 inches that was used in the WMM analysis.

Annual Runoff Volume

WMM calculates annual runoff volumes for the pervious/impervious areas in each land use category by multiplying the average annual rainfall volume by a runoff coefficient. A runoff coefficient of 0.95 is typically used for impervious areas (i.e., 95% of the rainfall is assumed to be converted to runoff from the impervious fraction of each land use). A pervious area runoff coefficient of 0.15 is typically used. The total average annual surface runoff from land use "L" is calculated by weighting the impervious and pervious area runoff factors for each land use category as follows:

$$R_L = [C_P + (C_I - C_P)\, IMP_L] * I; \qquad \textit{(Equation 1)}$$

where:

R_L = total average annual surface runoff from land use L (in/yr);

IMP_L = fractional imperviousness of land use L;

I = long-term average annual precipitation (in/yr);

C_P = pervious area runoff coefficient; and

C_I = impervious area runoff coefficient.

Total runoff in a basin is the area-weighted sum of R_L for all land uses.

Nonpoint Pollution Event Mean Concentrations

The WMM estimates loads from pollutants which are most frequently associated with nonpoint pollution sources. For the purposes of the WMM updated by CDM, only TP and TN were evaluated as these are the parameters that the TMDL is set for.

The event mean concentration (EMC) is a flow-weighted average concentration for a storm event and is defined as the sum of individual measurements of stormwater pollution loads divided by the storm runoff volume. The EMC is widely used as the primary statistic for evaluations of stormwater quality data and as the stormwater pollutant loading factor in analyses of pollutant loadings to receiving waters.

Nonpoint pollution loading analyses typically consist of applying land use specific stormwater pollution loading factors to land use scenarios in the basin under study. Runoff volumes are computed for each land use category based on the percent impervious of the land use and the annual rainfall. These runoff volumes are multiplied by land use specific mean EMC load factors (mg/L) to obtain nonpoint pollution loads by land use category. Selection of nonpoint pollution loading factors depends upon the availability and accuracy of local monitoring data as well as the effective transfer of literature values for nonpoint pollution loading factors to a particular study area.

To be consistent with the work that FDEP used to develop the TMDL for Lake Jesup, CDM used the same EMC values as identified in the *Nutrient and Unionized Ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A* (FDEP, 2005). These are shown below in **Table 11**. Much of the area previously assigned industrial land use is comprised mainly of agricultural, wetland, forested and open areas.

Table 11
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Event Mean Concentrations

SJRWMD Land Use Land Cover (2004)	Consolidated WMM Land Use	TP (mg/l)	TN (mg/l)
Improved Pastures	Agriculture – Pasture[1]	0.48	2.48
Row Crops	Agriculture – Row Crops[1]	0.56	2.68
Herbaceous upland nonforested; Shrub and brushland; Mixed upland nonforested; Pine flatwoods; Upland mixed coniferous/hardwood	Forest/Rural Open	0.05	1.25
	Industrial	0.31	1.79
Low Density Residential	Low Density Residential	0.44	1.97
Reservoirs	Water	0.11	1.28
Bay swamp; Mixed wetland hardwoods; Cabbage palm hammock; Cypress; Hydric pine flatwoods; Wetland forested mixed; Freshwater marshes; Emergent aquatic vegetation; Mixed scrub-shrub wetland – these areas represent impacted wetlands based (FDEP 2005)	Wetlands	0.19	1.60
Unimpacted wetlands (taken from FDEP 2005)	Wetlands 2	0.06	1.25

1. Taken from *Stormwater Loading Rate Parameters for Central and South Florida* (Harper, 1994).

To estimate annual pollutant loads discharged to receiving waters from a municipality, median EMCs are converted to mean values (USEPA, 1983b; Novotny, 1992) by the following relationship:

$$M = T * ((1 + CV^2))^{1/2}; \qquad \textit{(Equation 2)}$$

where:

M = arithmetic mean;

T = median; and

CV= coefficient of variation = standard deviation/mean.

Nonpoint Pollution Loading Factors

WMM estimates pollutant loadings based upon nonpoint pollution loading factors (expressed as lbs/ac/yr) that vary by land use and the percent imperviousness associated with each land use. The pollution loading factor M_L is computed for each land use L by the following equation:

$$M_L = EMC_L * R_L * K; \qquad \textit{(Equation 3)}$$

where:

M_L = loading factor for land use L (lbs/ac/yr);

EMC_L = event mean concentration of runoff from land use L (mg/l); EMC_L varies by land use and by pollutant;

R_L = total average annual surface runoff from land use L computed from Equation 1 (in/yr); and

K = 0.2266, a unit conversion constant.

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual pollution load from a subbasin can be computed. The EMC coverage is typically not changed for various land use scenarios within a given study basin, but any number of land use data sets can be created to examine and compare different land use scenarios (e.g., existing versus future) or land use management scenarios.

BMP Pollutant Removal Efficiencies

The WMM applies a constant removal efficiency for each pollutant to all land use types to simulate treatment BMPs. The BMPs used on Site 10 consist of wet detention ponds and the removal efficiencies used for this type of BMP are shown in **Table 12**.

Table 12
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
BMP Removal Efficiencies

BMP Type/Parameter	TP (%)	TN (%)
Wet Detention[1]	65	25

1. Literature Values from "Pollutant Removal Efficiencies for Typical Stormwater Management Systems in Florida", Harper, 1999

Calculation of Pollutant Loading Reduction from BMPs

The effectiveness of BMPs in reducing nonpoint source loads is computed for each land use in each subbasin. Up to five BMPs per land use can be specified. The percent reduction in nonpoint pollution per pollutant type in each subbasin of the basin is calculated as:

$$P_{L,SB} = (AC_{1,SB}(REM_1) + (AC_{2,SB}(REM_2) + (AC_{3,SB}(REM_3) + (AC_{4,SB}(REM_4) + (AC_{5,SB}(REM_5)$$ (*Equation 4*)

where:

$P_{L,SB}$ = percent of annual nonpoint pollution load captured in subbasin SB by application of the five BMP types on land use L;

$AC_{1,SB}$; $AC_{2,SB}$;
$AC_{3,SB}$; $AC_{4,SB}$; = fractional area coverage of BMP types 1 through 5 on subbasin SB; $AC_{5,SB}$

REM_1; REM_2 = removal efficiency of BMP types 1 through 5 respectively; REM;
REM_3; REM_4; varies by pollutant type but not by land use or subbasin.
REM_5

Equation 4 enables the user to examine the effectiveness of various BMPs and the degree of BMP coverage within a basin. Coverage might vary depending upon whether the BMP is applied to new development only, existing plus new development, etc. Also, topography may limit the areal coverage of some BMPs.

The nonpoint pollution load from a basin is thus computed by combining Equations 3 and 4 and summing over all land uses and all subbasins; i.e.,

$$MASS = \sum_{SB=1}^{N} \sum_{L=1}^{15} M_{L,SB}(1 - P_{L,SB}); \qquad \textit{(Equation 5)}$$

where:

MASS = annual nonpoint pollution load washed off the basin in lbs/yr with BMPs taken into account.

N = number of subbasins

The resultant model is a very versatile yet simple algorithm for examining and comparing nonpoint pollution management alternatives for effectiveness in reducing nonpoint pollution.

Model Limitations

The WMM was developed to estimate the relative changes in nonpoint source pollutant loads (average annual or seasonal) due to changes in land use or from the cumulative effects of alternative basin management decisions (e.g. treatment BMPs). The models should be applied to appropriate spatial (basin-wide) and temporal (average annual or seasonal) scales. It is not appropriate to use these input/output models for analysis of short-term (i.e., daily, weekly) water quality impacts. It is also not appropriate to use WMM to estimate absolute loads for a given outfall system without specific monitoring data for that system.

WMM Results

The WMM was used to evaluate the delineated subbasins previously shown in Figure 8 under existing land use conditions (i.e., 2004) to estimate annual pollutant loads. The results of the WMM analysis for existing land use conditions with and without BMPs considered under annual rainfall are included in **Table 13**. Pollutant loading estimates are calculated in units of lbs/yr. However, when comparing subbasins using these units, the size of the subbasin has a large effect on the estimated load (i.e., one will typically see larger pollutant loads associated with larger subbasins). Therefore, in an effort to normalize the estimates, the loading rate was calculated using the subbasin tributary area (i.e., lb/ac/yr). This provides a better basis for comparison to determine where the generated loads are more concentrated. As can be seen from the table, the amount of loading (in terms of lbs/ac/yr) are comparable across all subbasins and range from 4 to 7 lbs/ac/yr for TN and 0.2 to 0.7 lbs/ac/yr for TP, with Subbasin S10-001 generating the highest estimated load of TN and TP.

Stormwater Sampling

The City currently collects water quality samples at 6 locations every other month throughout Site 10. The approximate locations of the sampling sites are shown in **Figure 17**. Water quality sampling data for nitrogen and phosphorus are provided in **Table 14** for 2003 through 2006. Based on Figure 17, Sites 2, 3, 4 and 6 are all located within the area of Site 10 that is tributary to Lake Jesup. Samples for Sites 2, 3 and 6 appear to be taken from the stormwater sub-swales that eventually discharge into a stormwater treatment pond. Flows from ponds discharge via bleeddown pipes. The sampling location at Site 4 is associated with Pond B-2. The average TN and TP values for each of the sites are also shown in Table 14. These average concentrations are much higher than the target TN and TP concentrations for Lake Jesup of 1.32 and 0.094 mg/l, respectively as identified in the *Nutrient and Unionized Ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A* (FDEP, 2005) to achieve the TMDL for Lake Jesup.

Flow is not measured in the subswale systems on Site 10, therefore no flow data were available for the site. There are no known flooding problems on the site (i.e., areas that are inundated). Based on inspection of the 1-foot topographic contours, there are some depressional areas associated with wetlands on the site that may have the potential to become inundated. There are areas located in Subbasin S10-004, S10-006 and S10-011.

Summary and Conclusions

The results of the various loading analyses that were performed and conclusions that can be drawn from this evaluation are summarized in the following paragraphs.

Table 13
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Pollutant Load Analysis Results

Annual Pollutant Load Estimate w/o BMPs

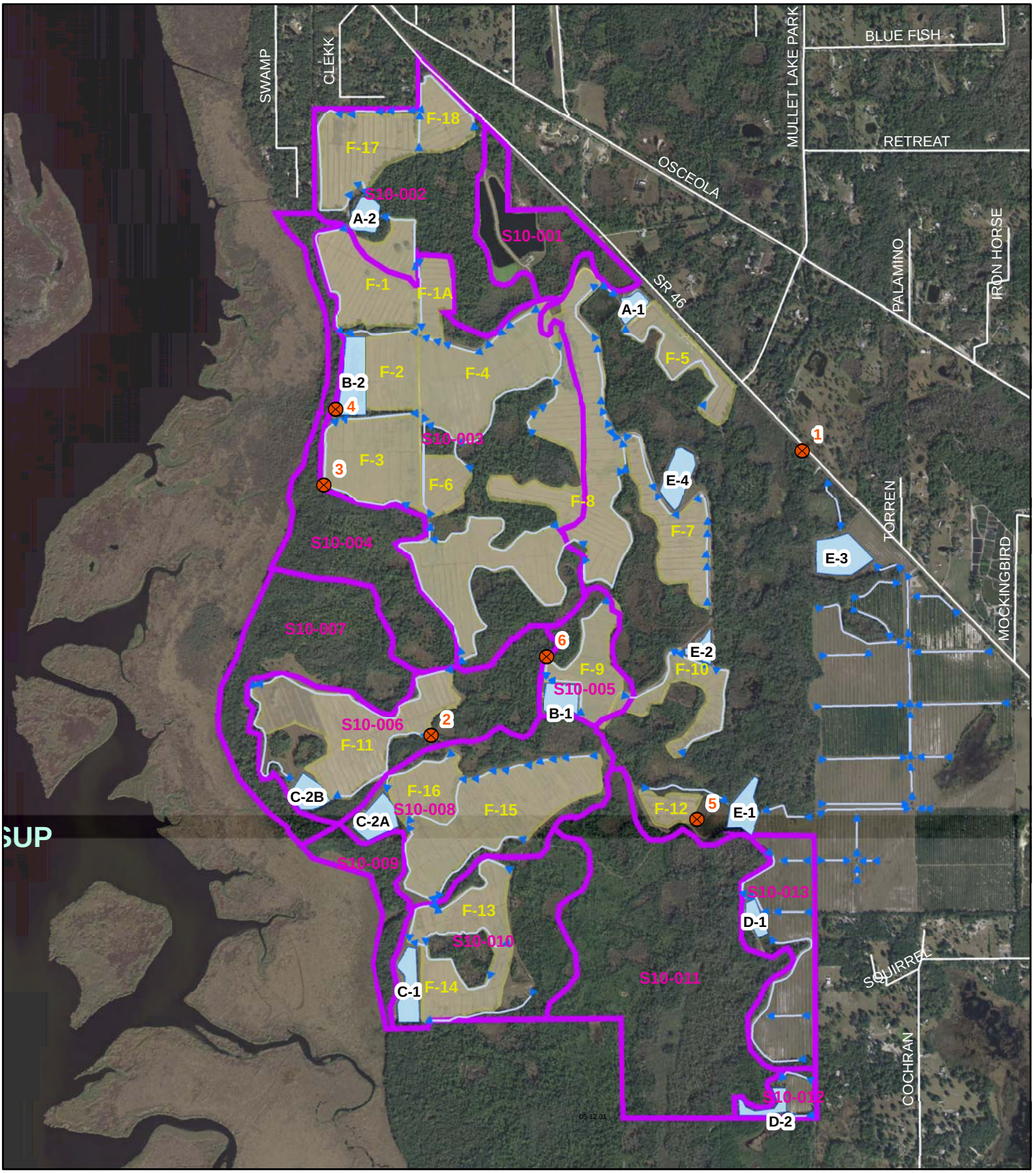
Basin Name	Drainage Area (acres)	DCIA Drainage Area (acres)	%DCIA	Flow (ac-ft/yr)	TN (lbs/yr)	TN (lbs/ac/yr)	TP (lbs/yr)	TP (lbs/ac/yr)
S10-001	39	10	26.0	64	257	7	29	0.7
S10-002	114	15	12.9	132	663	6	97	0.9
S10-003	292	23	7.9	286	1605	5	267	0.9
S10-004	80	14	18.0	107	455	6	51	0.6
S10-005	34	3	7.8	33	179	5	29	0.9
S10-006	108	13	11.6	120	615	6	92	0.9
S10-007	84	15	17.9	113	468	6	49	0.6
S10-008	110	8	7.5	106	580	5	94	0.9
S10-009	25	7	26.3	42	145	6	8	0.3
S10-010	102	8	8.1	100	454	4	54	0.5
S10-011	195	38	19.6	274	933	5	44	0.2
S10-012	15	2	12.6	17	80	5	11	0.7
S10-013	55	2	4.4	47	298	5	57	1.0

Annual Pollutant Loads w/ BMPs

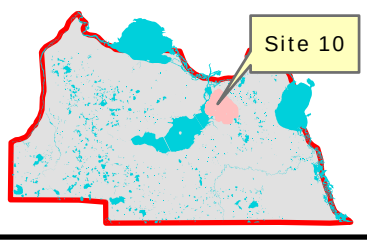
Basin Name	Drainage Area (acres)	DCIA Drainage Area (acres)	%DCIA	Flow (ac-ft/yr)	TN (lbs/yr)	TN (lbs/ac/yr)	TP (lbs/yr)	TP (lbs/ac/yr)
S10-001	39	10	26.0	64	257	7	29	0.7
S10-002	114	15	12.9	132	599	5	65	0.6
S10-003	292	23	7.9	286	1355	5	142	0.5
S10-004	80	14	18.0	107	455	6	50	0.6
S10-005	34	3	7.8	33	154	5	17	0.5
S10-006	108	13	11.6	120	546	5	59	0.5
S10-007	84	15	17.9	113	468	6	49	0.6
S10-008	110	8	7.5	106	491	4	50	0.5
S10-009	25	7	26.3	42	145	6	8	0.3
S10-010	102	8	8.1	100	389	4	27	0.3
S10-011	195	38	19.6	274	933	5	44	0.2
S10-012	15	2	12.6	17	75	5	8	0.5
S10-013	55	2	4.4	47	240	4	25	0.5

Annual Pollutant Loads - Percent Reduction Due to BMPs

Basin Name	Drainage Area (acres)	DCIA Drainage Area (acres)	%DCIA	Flow (ac-ft/yr)	BOD (%)	COD (%)
S10-001	39	10	26.0	64	0.0	0.0
S10-002	114	15	12.9	132	9.7	33.1
S10-003	292	23	7.9	286	15.6	46.7
S10-004	80	14	18.0	107	0.0	0.1
S10-005	34	3	7.8	33	13.7	42.5
S10-006	108	13	11.6	120	11.3	36.3
S10-007	84	15	17.9	113	0.0	0.0
S10-008	110	8	7.5	106	15.4	47.0
S10-009	25	7	26.3	42	0.0	0.1
S10-010	102	8	8.1	100	14.4	50.8
S10-011	195	38	19.6	274	0.0	0.0
S10-012	15	2	12.6	17	6.7	24.3
S10-013	55	2	4.4	47	19.6	55.7



LOCATION MAP



LEGEND

- Surface Water Sampling Sites
- Site 10 Ponds
- Pond Inflow Direction
- Roads
- Site10 Subbasins
- Site 10 Hay Fields

N
W E
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0 875 1,750
Feet

City of Sanford
Wastewater Facility (Site 10) Data Evaluation

CDM

Figure 17
Surface Water Sampling Locations

Table 14
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Surface Water Sampling Results

Station	Year	JAN		MAR		MAY		JUL		SEP		NOV	
		TP	TN	TP	TN	TP	TN	TP	TN	TP	TN	TP	TN
		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
#2	2003	0.070	2.340	0.200	5.450	*Dry*		0.020	1.450	0.130	2.370	*Dry*	
#3		1.100	2.430	0.240	3.110	0.240	1.370	0.310	2.270	0.340	3.680	0.955	0.458
#4		0.860	4.000	0.500	1.430	0.190	0.176	1.140	3.090	1.050	3.050	1.730	3.740
#6		0.130	1.610	0.150	1.840	*Dry*		0.450	1.750	0.190	1.850	0.772	1.480
#2	2004	*Dry*		*Dry*		*Dry*		0.050	2.522	0.508	2.120	*Dry*	
#3		1.750	7.260	0.680	1.950	1.930	5.960	0.203	3.017	1.450	2.740	0.264	2.347
#4		1.620	2.570	0.341	0.119	0.462	1.170	1.130	1.869	1.390	2.677	1.560	5.420
#6		0.354	3.430	5.140	11.900	*Dry*		0.248	1.589	0.218	1.630	0.104	1.660
#2	2005	*Dry*		*Dry*		*Dry*		0.132	2.460	0.097	1.510	0.098	2.360
#3		0.180	0.851	0.140	1.900	N/A	N/A	0.214	2.620	0.384	1.840	0.090	2.084
#4		0.670	0.938	1.490	4.200	N/A	N/A	0.854	3.304	1.510	4.340	1.240	1.650
#6		0.150	1.775	0.560	2.200	N/A	N/A	0.096	1.620	0.076	1.660	0.094	1.120
#2	2006	N/A	N/A	*Dry*		*Dry*		*Dry*		*Dry*		N/A	N/A
#3		N/A	N/A	1.200	1.900	*Dry*		*Dry*		1.200	5.111	N/A	N/A
#4		N/A	N/A	1.700	3.070	0.980	2.012	0.490	2.209	*Dry*		N/A	N/A
#6		N/A	N/A	*Dry*		*Dry*		2.500	1.900	*Dry*		N/A	N/A

N/A = Not Available

Station	Average	
	TP	TN
	mg/L	
#1	0.21	1.58
#2	0.15	2.51
#3	0.68	2.78
#4	1.05	2.55
#5	0.08	1.59
#6	0.70	2.44
Average Concentration of Stations 2,3,4 & 6	**0.64**	**2.57**
Median Concentration for Stations 2,3,4 & 6	**0.35**	**2.10**

Those stations within the Lake Jesup watershed.

Nutrient On-Site Loading

Based on actual data made available from the City and FDEP, the total average loading of TN at Site 10 due to both biosolids and reclaimed water application is 89,856 lb/yr. As actual data were not available for phosphorus, several assumptions were made to estimate the loading of this parameter as previously discussed. The total average loading of TP in the Lake Jesup Watershed due to both biosolids and reclaimed water application is estimated to be 39,948 lb/yr. It should be noted that these values do not account for plant uptake or soil absorption and those should be considered when determining the overall potential net loading to the watershed.

Groundwater Loading

The average nitrate concentration in the monitoring wells on Site 10 is 1.54 mg/l, and average nitrate mass loading to Lake Jesup is estimated to be 0.50 lb/day or 182 lbs/year. Monitoring data for phosphorus were not available as this parameter is not required to be monitored over the period of interest (i.e., 2003 through 2006).

In the *TMDL Report, Nutrient and Unionized Ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A* (FDEP, 2005), a baseflow analysis was used to separate surface runoff from the ground water contribution. FDEP found that baseflow in the Lake Jesup Watershed is primarily from the surficial aquifer. Based on the baseflow separation analysis, about 17 percent of the total stream flow in the Lake Jesup watershed comes from baseflow. In their analysis, FDEP estimated that the annual loading of TN to the Lake Jesup watershed due to baseflow is 8.4 tons/year or 16,800 lbs/yr. Nitrate loadings were not estimated as part of FDEP's analysis. As only nitrate levels are measured in the Site 10 wells, a comparison between the nitrate loadings estimated by CDM and the TN loadings estimated by FDEP was not made.

Background concentration data for nitrate levels were available from the *1993 Annual Report for Groundwater Monitoring at Site 10 Land Application System Site, FDEP Permit Number DC59-186526, City of Sanford, Florida* (Ardaman & Associates, Inc., 1993) and are presented in **Table 15**. CDM then compared average readings for each well from 2003 through 2006 to these background concentrations, which is also shown in Table 15. Background concentration data for TP levels were also available from the 1993 report and included in the table. The City was not required to monitor the groundwater wells for TP after 1997, so there is limited information available for this parameter.

Table 15
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Groundwater Monitoring Data Comparison

Well	Average Nitrate Background Concentration (mg/l) From May 1992 through June 1993	Average Nitrate Background Concentration (mg/l) From March 2003 through September 2006	Difference (mg/l)	Average TP Background Concentration (mg/l) From May 1992 through June 1993	Average TP Background Concentration (mg/l) From 1992 through 1997	Difference (mg/l)
MW-1	0.10	0.02	-0.08	0.33	0.29	-0.04
MW-2	1.60	0.01	-1.59	0.03	0.05	0.02
MW-3	0.60	3.81	3.21	0.03	0.04	0.01
MW-4	0.14	0.01	-0.13	0.22	0.17	-0.05
MW-5	1.52	2.05	0.53	0.13	0.22	0.09
MW-6	0.17	2.77	2.60	0.03	0.04	0.01
MW-7s	4.28	9.89	5.61	0.05	0.04	-0.01
MW-8	0.07	0.04	-0.03	0.03	0.04	0.01
MW-9	0.29	0.03	-0.26	0.57	0.45	-0.12
MW-10	0.20	1.39	1.19	0.39	0.19	-0.20
MW-11	0.32	0.02	-0.30	6.54	2.97	-3.57
MW-12	0.33	0.02	-0.31	0.22	0.24	0.02
MW-13	0.38	0.02	-0.36	0.24	0.16	-0.08

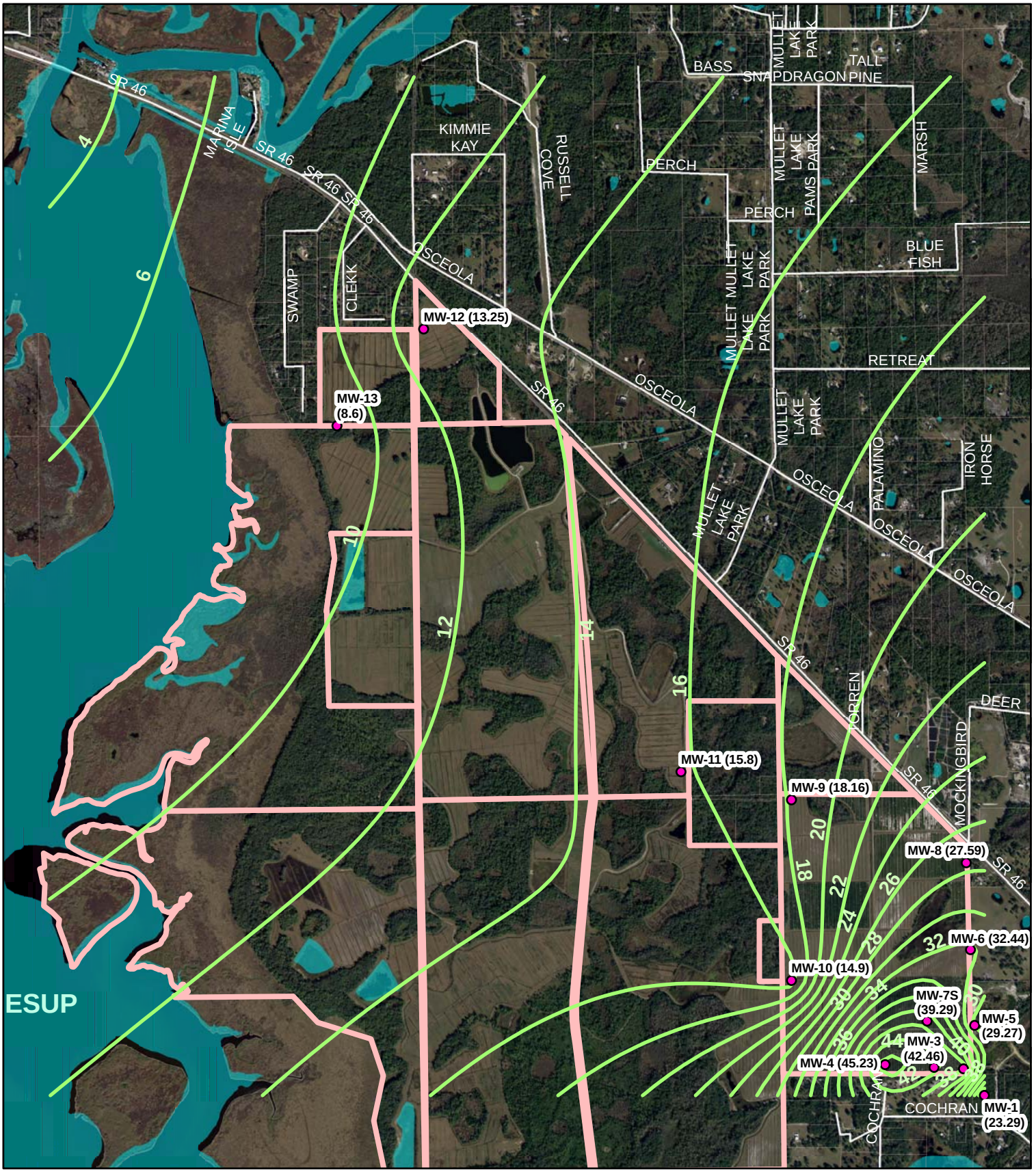
Compared to the background conditions, nitrate concentrations in several of the wells have decreased over time while levels have increased in others. Nitrate levels measured in wells MW-5 and MW-7s have consistently been significantly higher under both background as well as current conditions. Intermittent irrigation occurred in the latter half of 1993 along with fertilization of the citrus groves. Reclaimed water was applied on a regular basis starting in January 1994, which may explain the higher background concentration in these wells. Under current conditions (i.e., 2003 through 2006), wells, MW-3, MW-5, MW-6, MW-7s and MW-10 have exhibited levels significantly higher than those of other wells. For wells, MW-3, MW-5, MW-6 and MW-7s, this may be explained by the fact that in addition to reclaimed water application, the City continues to apply fertilizer to the citrus groves, which could result in higher nitrate readings. The wells closest to the lake (MW-12 and MW-13) have consistently had relatively low levels of nitrate (i.e., 0.02 mg/l) over the last few years.

As CDM has documented throughout this evaluation, a portion of the surface flow from Site 10 discharges to the northeast towards Mullet Lake and not entirely to Lake Jesup as originally thought in previous studies. CDM explored the same possibility as it relates to groundwater. Although surface water basins and groundwater basins typically do not coincide, the question was raised if all or only a portion of the groundwater encompassed by Site 10 is discharged as baseflow to Lake Jesup. In order to make this determination, a potentiometric map of the surficial aquifer contour elevations would be needed to determine if this groundwater divide exists. A detailed map showing these elevations was not available for Site 10, so CDM used the average water levels from each well to estimate the potentiometric contours for Site 10 using the contour mapping software package Surfer®. The resulting contour lines are shown in **Figure 18**. From the limited monitoring well data available, it appears that there may be a peak in groundwater levels in the southeast corner of Site 10. This is also the same area where the highest average of nitrate concentrations was reported. Based on the estimated contours, there could be a possible divide in this area where groundwater is flowing in a radial direction (i.e., a portion of it may be flowing to the west and northwest towards Lake Jesup, but it may also be flowing in other directions away from the lake). Again, this is a suggestion and additional data within and surrounding Site 10 would be needed to draw definitive conclusions regarding the groundwater flow patterns on the site.

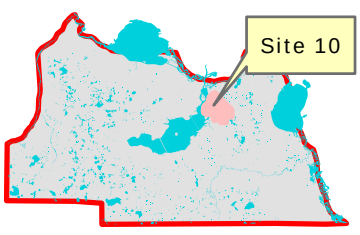
Stormwater Loading

CDM updated the pollutant load analysis for Site 10 so that the analysis was more reflective of actual land cover and not land uses previously assigned to the site for the purposes of developing the TMDL (i.e., industrial land uses). The estimated amount of loading (in terms of lbs/ac/yr) due to stormwater runoff was comparable across all subbasins and ranged from 4 to 7 lbs/ac/yr for TN and 0.2 to 0.7 lbs/ac/yr for TP, with Subbasin S10-001 generating the highest estimated load of TN and TP. The total estimated loading for the portion of Site 10 tributary to Lake Jesup was 6,107 and 573 lbs/yr for TN and TP, respectively.

The City also performs surface water sampling at 6 locations on Site 10. Of these 6 stations, four stations are located in the Lake Jesup Watershed. As shown in Table 14, average measured TP concentrations at these 4 stations range from 0.15 to 1.05 mg/l while average TN concentrations range from 2.4 to 2.8 mg/l. These particular stations are located in either stormwater ponds or the subswales that receive runoff from agricultural areas, primarily pasture lands (i.e., hay fields). CDM compared the measured values to the typical EMC values for agricultural pasture lands. This comparison is shown below in **Table 16**.



LOCATION MAP



LEGEND

- Site 10 Monitoring Wells
- Estimated Potentiometric Contours (SAS)
- Sanford Owned Parcels
- Parcels
- Water Bodies
- Roads

* Average water level is shown in parentheses

0 950 1,900 Feet

City of Sanford
Wastewater Facility (Site 10) Data Evaluation

CDM

Figure 18
Estimated Potentiometric Contours for the Surficial Aquifer

Table 16
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Surface Water Concentration Comparisons

	TP	TN
EMC (mg/l)	0.48	2.48
Range of Measured Concentration (mg/l)	0.15 to 1.05	2.4 to 2.8
Median Concentration (mg/l)	0.35	2.10
Mean Concentration (mg/l)	0.64	2.57

As shown in Table 16, the measured TN concentrations for Site 10, where both reclaimed water and biosolids are applied on a routine basis, are fairly consistent with the EMCs reported for unaffected pasture (i.e., where such activities are not occurring). The measured TP concentrations have a wider range and the EMC falls within that measured range of concentrations. The mean TP concentration is somewhat higher than the EMC, while the median concentration is lower.

Site 10 is located within the Lake Jesup sub-watershed that was identified in the *TMDL Report, Nutrient and Unionized Ammonia TMDLs for Lake Jesup, WBIDs 2981 and 2981A* (FDEP, 2005). The estimated loadings for the Lake Jesup sub-watershed presented in that report are summarized in **Table 17.** These loading were compared to the Site 10 loadings to who relative comparisons between Site 10 and the sub-watershed. CDM also contacted FDEP to request additional information regarding the original loading estimates done as part of the Lake Jesup TMDL for Site 10, which is shown in **Table 18**. This original loading estimate done by FDEP was compared to the Site 10 loadings done by CDM as part of this effort to show the difference in loadings using different methodologies.

Table 17
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Surface Loading Comparisons to the Lake Jesup Subwatershed

	Lake Jesup Subwatershed (FDEP)	Site 10 (CDM)	Percent of Total Estimated Loading
Simulated Mean TN loading[1] (tons/yr)	61.3	3.05	5.0%
Simulated Mean TP loading[1] (tons/yr)	5.1	0.29	5.7%

1. Lake Jesup Subwatershed loadings are mean loadings from 1995 – 2002.

Table 18
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Surface Loading Comparisons FDEP Predicted Loadings for Site 10

	Site 10 (FDEP)	Site 10 (CDM)	Percent of Total Estimated Loading
Simulated Mean TN loading[1] (tons/yr)	9.5	3.05	32.1%
Simulated Mean TP loading[1] (tons/yr)	0.62	0.29	47%

1. Site 10 FDEP loadings were estimated by FDEP using the Lake Jesup TMDL model. For this analysis, Site 10 loadings were not simulated for every year from 1995 through 2002. Instead, the 2001 rainfall, which was 52.7 inches and close to the long-term average 53 inches for the period from 1995 through 2002, was used to simulate the loadings.

As shown in Table 17, the current Site 10 loadings for TN and TP are estimated to be 5.0 and 5.7 percent, respectively of the total surface loadings estimated for the Lake Jesup sub-watershed. According to Table 18, the current Site 10 loading estimates are predicted to be almost one third and one half for TN and TP, respectively of the original predictions for Site 10 made by FDEP as part of the Lake Jesup TMDL.

cc: Migdalia Hernandez, P.E., City of Sanford