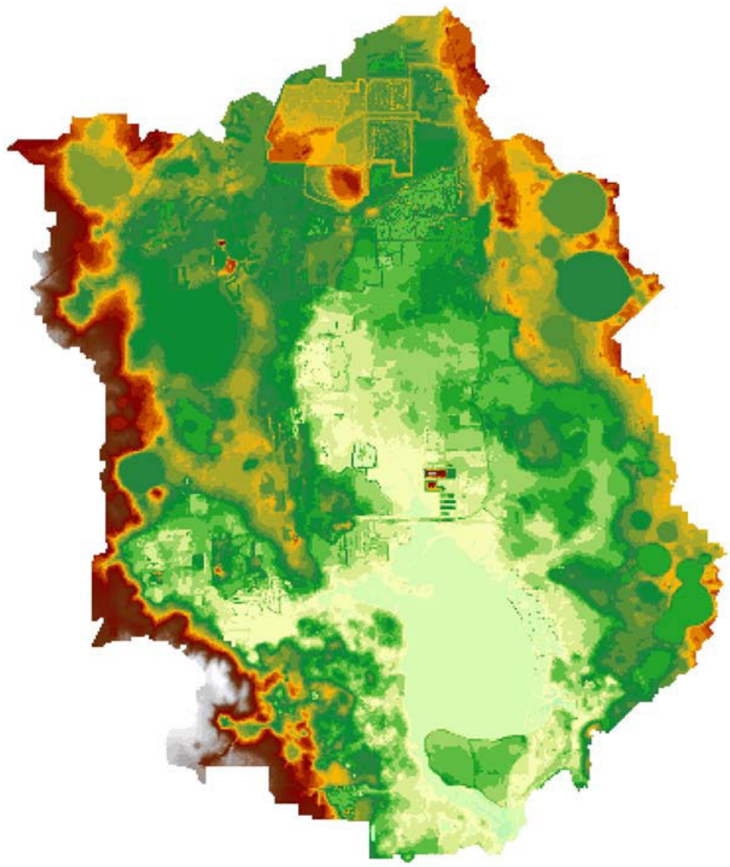
Lake Hancock Lake Level Modification Preliminary Evaluation Final Report



Produced for:

Southwest Florida Water Management District

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EXECUTIVE SUMMARY

BCI Engineers and Scientists, Inc. (BCI) was contracted by the Southwest Florida Water Management District (District) to conduct a preliminary evaluation of benefits and impacts associated with raising Lake Hancock's operating level as part of the upper Peace River's Minimum Flows and Levels (MFLs) recovery. The modifications evaluated include raising the Lake's operating level from 98.5 feet to 99.5, or 100.0 or 100.5 feet. Benefits evaluated include the assessment of the number of MFL days that can potentially be recovered in the River for the three identified MFL sites (Bartow, Fort Meade, and Zolfo Springs), the restoration potential of the historic Lake level, and the restoration potential of adjacent wetland vegetation. Impacts evaluated included areas of inundation for each operating level; the areas of inundation associated with a 100-year rainfall event for each operating level; and the potential effects on structures, septic systems, natural systems, access roads, major highways, the City of Lakeland's Cemetery, and the Polk County's North Central Landfill.

MFLs have been proposed by the District for the upper Peace River as mandated by the State Legislature, through Chapter 373.042, Florida Statutes. The State Legislature also directs, through Chapter 373.0421, when established MFLs are not being met, that the District is to expeditiously implement a recovery strategy. The District's Lake Hancock's Lake Level Modification Project (H008) is one of several strategies proposed in the "*Southern Water Use Caution Area Recovery Strategy*" (March 2004) for MFL recovery for the upper Peace River.

Evaluation results for the number of MFL days that can be recovered vary from 5% to about 70% using the historical record at the Fort Meade Gage as a reference. Between January 1, 1975 and December 31, 2003 (29 years) there were 2,795 days or 7.7 years where flows were below the proposed MFL of 27 cubic feet per second. Factors influencing the percentage of days recovered are: streambed losses, the Peace River Water Supply Authority's Permitted Withdrawals, and Lake storage parameters such as: the operating level, the low operating level, and the percentage of historical Lake outflows stored.

Portions of 41 parcels are routinely inundated by the current operating level for Lake Hancock. For each of the proposed operating levels an additional 22, 24, 45 parcels will be affected. The area of inundation increases from 312.6 acres for the current level to: 1027, 1222.7, and 1950.5 acres for the proposed levels. District owned lands are excluded from the results. One residential home, based on the available topography, may be impacted at the 99.5-foot level, 3 homes at the 100-foot level, and 4 homes at the 100.5-foot level. For each of the proposed levels: 28, 29, and 30 existing residential septic systems may be potentially impacted by water table impacts.

The number of parcels potentially affected by the 100-year rainfall event increases from 160 for the current operating level to: 165, 165, and 167 for each of the proposed levels. Public rights-of-ways and District lands have been excluded. The area of inundation increases by 96.8, 154.6, and 236.9 acres for each level from the 3,625.5 acres currently inundated. These increases in floodplain areas are small; however, the depth, duration, and frequency of inundation in the current floodplain area will also be increased.

The Polk County's North Central Landfill may be potentially affected by increases in the water table. Portions of the landfill are currently within the 100-year floodzone designated by the Federal Emergency Management Agency and could be potentially affected by any increases. The cemetery will not be inundated by the operating level and is only inundated by the 100-year event for the 100.5-foot operating level. Additional site specific analysis will have to be done to determine if there will be a sufficient rise in the water table to affect burial plots.

This study meets the goals for "Step 1" which is to provide sufficient information regarding the benefits and impacts for determining the optimum operating range of the Lake for MFL recovery.

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1.0 OVERVIEW

1.1 Project Authorization

BCI Engineers and Scientists, Inc. (BCI) was contracted by the Southwest Florida Water Management District (District) to conduct a preliminary evaluation of benefits and impacts associated with raising Lake Hancock's operating level as part of the upper Peace River's Minimum Flows and Levels recovery. One of the District's proposed recovery strategies is to provide additional storage of surface waters within Lake Hancock that can be used to maintain Minimum Flows in the River when required. Lake Hancock's water level control Structure P-11 current operation level is 98.5 feet NGVD. The top of structure elevation is 98.7 feet NGVD. BCI, Inc. was contracted specifically to evaluate the incremental benefits and impacts associated with raising the Lake's operating levels to 99.5, 100.0 and 100.5 feet, which is Step 1 of the District's Lake Hancock Lake Level Modification Project (H008).

1.2 Upper Peace River Minimum Flows and Levels

The primary purpose of this project is to reestablish the minimum flows and levels (MFLs) in the upper Peace River. The Florida Legislature, through Chapter 373.042, Florida Statutes, mandates that the five water management districts establish minimum flows and levels for all surface watercourses that include lakes and streams, and the minimum level of the groundwater in an aquifer. In this statute, the minimum flow is defined as **"the minimum flow for a given watercourse shall be the limit at which further withdrawals would be significantly harmful to the water resources or ecology of the area."** Minimum levels are defined as **"the minimum water levels shall be the level of groundwater in an aquifer and the level of surface water at which further withdrawals would be significantly harmful to the water resources of the area."** The establishment of MFLs for flowing watercourses considers minimum stream levels and the flows necessary to maintain those levels.

The basic premise of the legislation is to ensure that the hydrologic requirements of natural systems associated with lakes, streams and rivers are given high priority when evaluating impacts generated from excessive ground water and surface water withdrawals. Establishment and implementation of MFLs through planning and regulatory efforts ensures that the hydrologic requirements of natural systems will be maintained while allowing waters to be available for agricultural, industrial, commercial, and residential uses.

The Peace River has been analyzed for minimum low flows and levels whereby it has been concluded that the upper Peace River is a surface watercourse experiencing a reduction in flows with significant harm. In the draft report entitled, "Upper Peace River an Analysis of Minimum Flows and Levels," District, August 25, 2002, documentation is provided supporting this conclusion. Justification for adoption of minimum flows and levels was based on site specific information. Biological transects, stream cross sections, historical flow data, and other stream morphological indicators were used to make this determination.

The Southwest Florida Water Management District (District) recognizes that multiple minimum flows are necessary to maintain the River's flow regime and the health of the aquatic ecosystem. The maintenance of a particular aquatic system is dependent upon the existence of specific in-stream conditions. Hill et al., (1991) identified four types of flows that should be considered when analyzing river flow requirements for aquatic ecosystems: flood flows, overbank flows, in-channel flows, and critical in-stream flows. However, only minimum low flows (critical in-stream flows) have been established for the upper Peace River at this time. Mid- and high-minimum flows are to be established once their controlling factors and functions are better understood.

Minimum flows have been proposed for the upper Peace River at the United States Geological Survey (USGS) gaging stations located near Bartow, Fort Meade, and Zolfo Springs where the River has been historically monitored. The proposed minimum flows are focused on returning the perennial conditions to the upper Peace river. Specifically, they are based on maintaining the water elevations needed for fish passage (0.6 feet or 7.2 inches) or the lowest wetted perimeter inflection point (maximum stream bed coverage with the least amount of flow). This approach yielded minimum low flows of 17 cubic feet per second (cfs), or 11.0 million gallons per day (mgd) at Bartow. For the Fort Meade and Zolfo Springs USGS gages, minimum flows of 27 cfs (17.5 mgd) and 45 cfs (29.1 mgd) were determined, respectively. It is proposed that these flows are to be met or exceeded 95 percent of the time on an annual basis, which is 348 days per year.

The Upper Peace River Analysis Report indicates that the proposed minimum flow criteria at Bartow (17 cfs) was met twice between the years of 1985 and 2000 while Fort Meade's minimum flow (27 cfs) was not met for any of the years. Zolfo Spring's fares better with its minimum flow (45 cfs) being met for all years except for 3. Kissengen Spring, located along the River Section between Bartow and Fort Meade, ceased flowing on a continual basis around 1950 and completely ceased flowing in 1960 when Floridan aquifer levels dropped below the elevation of the stream bed as a result of ground water withdrawals. Polk County ground water withdrawals grew from 230 mgd in 1960 to a peak of 410 mgd in 1975 (Marella 1992, Duerr and Trommer 1981). The Spring used to flow at a rate of 20-30 cfs or 12-19 million gallons a day providing a majority of the baseflow to the River. The Spring now functions as a sink for surface water with the result that the River section between Bartow and Fort Meade functions as a losing stream where water enters sinks connecting to the aquifer. Trends in rainfall have also been noted to significantly affect Peace River flows, especially in the middle and lower portions. Ground water withdrawal appears to be the most important factor in the reduction of flows in the upper Peace River.

1.3 Upper Peace River Recovery

When it has been determined that a water course is experiencing significant harm due to reduction in low flows, Chapter 373.0421, Florida Statutes, directs the District to expeditiously implement a recovery or prevention strategy. In keeping with these statutes, the District developed a recovery plan for the upper Peace River and surrounding areas (Southern Water Use Caution Area Recovery Strategy, District, Draft March, 2004). The goals of the SWUCA recovery strategy are to accomplish the following in an economically, environmentally and technologically feasible manner: (1) restore minimum levels to priority lakes in the Lake Wales Ridge by 2015; (2) restore minimum flows to the upper Peace River by 2015; (3) reduce the rate of saltwater intrusion in coastal Hillsborough, Manatee and Sarasota counties by achieving the proposed minimum aquifer levels for saltwater intrusion by 2020; and (4) ensure that there are sufficient water supplies for all existing and projected reasonable-beneficial uses. This project addresses goal number (2), restoration of flows in the upper Peace River by modifying the control structure of Lake Hancock to store excess water and operate the structure to slowly release the stored water to meet the minimum flows and levels requirements.

A strategy investigated, but not being pursued at this time, is the immediate reduction of ground water withdrawals to restore aquifer levels. Ground water withdrawals in Polk have decreased by about 135 mgd as a result of water conserving practices in agriculture and mining, since its peak of 410 mgd in 1975. This decrease in withdrawals has resulted in a partial rebound of the Floridan aquifer in the area, but not to the point where MFL flows in the upper River are reestablished.

In a draft report entitled, "Predicted Change in Hydrologic Conditions along the Upper Peace River due to a Reduction in Ground-Water Withdrawals," District, May 2002, the required reduction to return the Spring flows in a 676 square-mile area (26 mi x 26 mi) around Kissengen Springs was presented. Fifty-percent and 100-percent reduction scenarios in ground water withdrawals within the area were analyzed using the Eastern Tampa Bay Regional Ground-Water Flow model. Results indicate that the 50-percent reduction (105 mgd) would not return Kissengen Spring flow while the 100-percent reduction (210 mgd) generates the potential for the return. This 210 mgd reduction represents approximately 76% of Polk County's total ground water use. The ability of businesses dependent upon ground water use to absorb such an economic impact was considered too great to implement this recovery strategy.

Lake Hancock provides a unique opportunity with its limited lakefront development and its location in the headwaters of the Peace River where it can be used to provide the storage necessary to supplement the low flows. Surface waters can be captured and stored in Lake Hancock by modifying the existing outfall Structure P-11. Operating the Structure P-11 to a level of 100.5-feet would provide approximately 10,000 acre-feet of storage (3.26 billion gallons of water). Over a 90-day period, this amount of storage could sustain a flow of 56 cfs or 36 mgd. No other natural surface water body located within the headwaters of the Peace River has the potential to provide this amount of storage.

In addition to Lake Hancock Project, other options or projects are recommended in the SWUCA Recovery Strategy Report for the upper Peace River. These include storing runoff in areas located within previously mined phosphate areas, restoration of the upper Peace Creek Canal area that was ditched and drained for agricultural purposes, and the management of stream flow losses through existing sinks located within the River bed between Bartow and Fort Meade. Preliminary results generated from this study indicate that other similar projects may be required to help meet the minimum flow compliance criteria in the upper Peace River.

2.0 PEACE RIVER WATERSHED

2.1 Description of the Peace River Watershed

The following description of the Peace River is from Canter Brown, Jr.'s, prologue to *"Florida's Peace River Frontier,"* University of Central Florida Press, Orlando, 1991.

"The Peace River originates in Lake Hamilton, one of many beautiful lakes that dot the heart of Interior peninsular Florida in northern Polk County, although some of its waters can be traced as far to the north and northwest as the great reservoir of the Green Swamp ..... Just to the east of the river's source and paralleling its course through Polk County is Florida's natural spine, the chain of high sandy hills known as "The Ridge," which marked in ancient times all of peninsular Florida remaining above the sea.

From Lake Hamilton the narrow stream of the Peace River today is channeled by drainage canals first to the south and then to the west where, just to the north of Polk's county seat of Bartow, it joins Saddle Creek, an outlet of Lake Hancock two miles to the north. From the junction, the river plunges southward again past Bartow and the town of Fort Meade. Three miles below Fort Meade the stream, continuing its southward course, is combined with the waters of Bowlegs Creek, which rises to the east on the Ridge, near Lake Buffum.

At Bowling Green, a little less than 40 miles along its course, the river enters Hardee County as well as beginnings of the low South Florida prairie through which it will pass on most of its remaining journey to the sea. For half of the distance through Hardee's 21-mile width, the river continues it southward flow, edging in its progress the county seat of Wauchula. At Zolfo Springs, however, its course bows to the southwest, then turns to the south before bowing again, this time to the southeast and a junction with Charlie Apopka Creek at a point just to the north of the DeSoto County line. The enlarged river then carries its waters to the southwest and, on an ever more twisting and turning course, passes Arcadia and Fort Odgen, strengthened along the way by the discharges of Joshua and Horse creeks. Three miles below Fort Ogden the widening stream enters Charlotte County and begins a slow turn to the west, which carries it beyond Punta Gorda to its meeting with the sea at Charlotte Harbor on Florida's southwest Gulf of Mexico coast. On a straight line Peace River's length totals only about 110 miles, but its often serpentine course doubles that distance."

2.1.1 Permitted Uses of Surface Waters

There are no known significant existing permitted uses of surface waters from the Peace River between Lake Hancock and Arcadia. Below the Peace River at Arcadia a Water Use Permit (WUP No. 2010420.04-S) has been issued for the Peace River Manasota River Water Supply Authority DeSoto Charlotte Sarasota County et al. The Water Supply Authority's has a permitted average daily withdraw rate of 32,700,000 gallons per day (gpd) or 50 cfs and a peak daily withdraw amount of 90,000,000 gpd or 140 cfs from the Peace River. Permit conditions specify that they can withdraw 10% of the Arcadia flows along as the flows are not lowered below 130 cfs and at their peak withdraw rate is 90 mgd or 140 cfs.

2.1.2 Streambed (Sink) Losses

An important component in the recovery of the upper Peace River includes the addressing of the sink losses within the streambed between the USGS gauging stations at Bartow and Fort Meade. Numerous fractures and openings exist within this reach that allows surface waters to enter into the aquifer. During what is termed the predevelopment period (era of no significant groundwater withdrawals) aquifer water flowed from the streambed and adjacent springs providing significant baseflow to the upper Peace River. As groundwater withdrawals increased, aquifer levels were lowered below the streambed causing the cessation of groundwater discharge.

To obtain estimates of the streambed losses in this reach, the historical surface flow records for the Bartow and Fort Meade gauging stations were evaluated. Twenty-nine years (1975-2003) of concurrent historical data were reviewed for the periods when Fort Meade flows were less than the target minimum flow of 27 cfs. Out of the 10,592 plus days of record, Fort Meade flows were below the minimum flow approximately 2,800 days. During the days when Fort Meade flows were below the MFL, 64% of the time Bartow flows were greater than Fort Meade's providing insight into the streambed loss (recharge) that was occurring. Further analysis indicated that when this condition was occurring, 75% of the time the flow differences were 9 cfs or less, 23% of the time the differences ranged between 9 to 22 cfs, and 2% of the time the flow differences were greater than 22 cfs. This indicates that the most probable range of sink loss within the streambed is between 0 and 25 cfs. Sink losses could be greater during extended drought conditions.

The District also has an ongoing project with the USGS to better estimate the streambed losses by concurrent direct measurement of stream flows along the reach. Preliminary information furnished by the USGS for May 2002 and May 2003 indicated that the maximum losses were approximately 30 and 16 cfs respectively. Higher aquifer levels in 2003 probably reduced the amount of losses within the streambed.

2.2 Upper Peace River

The Peace River has a watershed area of 2,350 square-miles, and is approximately 105 miles long from the confluence of Peace Creek Drainage Canal and South Saddle Creek (outfall for the Lake Hancock Watershed) to Charlotte Harbor. The watershed resides in portions of Polk, Hillsborough, Manatee, Hardee, DeSoto, Highlands, Sarasota, Glades, and Charlotte Counties. The Peace River has been divided into three sections for analysis purposes: the upper, middle, and lower sections. Minimum Flows and Levels have been determined for the upper section only which has been designated the upper Peace River Watershed. The upper Peace River Watershed occupies 826 square-miles above the Zolfo Springs Gage (**Figure 1**). United States Geological Survey (USGS) gaging stations at Bartow, Fort Meade, and Zolfo Springs (located in the upper Peace River Watershed), and Arcadia are referred to in this report. Numbers and IDs of the stations are provided in **Table 1**.

Table 1.
Gaging Stations Identification

Gaging Station	USGS Number	District Site ID
Bartow	02294650	79
Fort Meade	02294898	78
Zolfo Springs	02295637	77
Arcadia	02296750	80

The USGS gaging station at Bartow is located on the downstream side of the Highway 60 bridge just below the confluence of South Saddle Creek which conveys surface runoff from Lake Hancock through Structure P-11 and the Peace Creek Canal which conveys surface runoff from the Lake Alfred and the Winter Haven areas. The Fort Meade gage is located near Fort Meade on the downstream side of the Highway 98 bridge and 5 miles from the Bartow gage. The Zolfo Springs gage is located 23 miles downstream of the Fort Meade gage, on the downstream side of the Highway 17 bridge, about 0.8 miles north of Zolfo Springs, which is located at the southern boundary of the upper Peace River Watershed. Another gage referenced in this report is the Arcadia gage which is located in Arcadia, 33 miles south of the Zolfo Springs gage, and about 500 feet upstream of the Highway 70 bridge. The Arcadia gage is not within the Upper Peace River Watershed. It is used to evaluate predicted flow changes as a result of the Lake Hancock Lake Level Modifications.

Arcadia's gage data covers the longest period of record of the four river gaging stations from April 1, 1931 to present. Zolfo Springs has the next longest record from September 1, 1933 to present. Bartow's record covers a period from October 1, 1939 to present while Fort Meade's record is from June 1, 1974 to present. The Arcadia and Zolfo Spring's gage record contains a significant flood event that occurred in September 1933 as a result of a hurricane.

Recorded flows during this time are about one-third higher than the next largest magnitude storm recorded for these gages. Arcadia had a record peak flow of 36,200 cubic feet per second (cfs), while Zolfo springs had a peak flow of 26,300 cfs. Bartow's recorded maximum of 4,140 cfs occurred in September 1947, while Fort Meade's 2,250 cfs recorded maximum occurred in February 1998 during the recent El Niño.

As previously stated, Minimum Flows and Levels (MFL) have been established for Bartow, Fort Meade, and Zolfo Springs of 17, 27, and 45 cfs respectfully (District, August 2002). The number of below minimum flow days for each of the gaging stations from January 1, 1975 to December 31, 2003 are 2,063, 2,795, and 524 days respectfully. The Lake Hancock Lake Level Modification Project (Project) proposes to reduce the number of below MFL days for each of these gaging stations. **Table 2** provides descriptive flow statistics for each of the gaging stations while **Table 3** provides descriptive level statistics. **Figures 2-5** contain the flow hydrographs for the USGS gaging stations at Bartow, Fort Meade, Zolfo Springs and Arcadia for their period of record. **Figure 6-9** contains the level hydrographs for the respective stations.

Table 2.
Gaging Station Flow Statistics

		Flows in Cubic Feet Per Second (cfs)					
Station	**Years of Record thru Dec 2003**	**Min**	**Mean**	**Median**	**Max**	**MFL Rate**	**MFL-Days**
Bartow	64	0	224	103	4,140	17	2,063
Fort Meade	* 29	0.06	198	80	2,250	27	2,795
Zolfo Springs	70	3.6	630	320	26,300	45	524
Arcadia	72	5.6	1076	458	36,200	Not Det.	---

*** Fort Meade Gaging Station Initiated in June 1974.**

Table 3:
Gaging Station Level Statistics

		Levels in Feet NGVD 1929				
Station	**Years of Record thru Dec 2003**	**Min**	**Mean**	**Median**	**Max**	**Std Dev.**
Bartow	64	88.22	92.88	93.03	98.53	1.47
Fort Meade	* 29	69.59	72.15	71.64	78.93	1.76
Zolfo Springs	70	33.37	37.40	36.59	54.07	2.63
Arcadia	72	6.46	10.30	9.43	25.9	2.82

3.0 LAKE HANCOCK WATERSHED

3.1 Description of Watershed

The Lake Hancock watershed is located within west-central Polk County near the geographic center of peninsular Florida (**Figure 10**). **Figure 11** is an aerial photo of the area. Polk County is part of the highland area that trends along the north-south axis of peninsular Florida. Within the county are three ridges separated by relatively flat lowland areas. The Lake Hancock watershed occupies the area between the Lakeland Ridge on the western boundary and Winter Haven Ridge along the eastern boundary. Land surface elevations typically vary from 265 feet National Geodetic Vertical Datum of 1929 (NGVD 1929) for highs along the ridges and then sloping down into the valleys where elevations gradually decrease to around 98 feet near the outfall on South Saddle Creek. Significant portions of the watershed have been mined creating remnant overburden spoil piles, clay settling area embankments, and water filled depressions. The tributary watershed to Structure P-11, which regulates flow from Lake Hancock, is 135 sq-miles. Lakes within the watershed occupy an area of about 20 square-miles.

Lake Hancock receives inflow from three major tributaries. Saddle Creek originates east of the City of Lakeland generally flowing south through a swampy area before entering into the Lake. Lake Lena Run originates in Auburndale and enters Lake Hancock on the northeast side. Banana Lake, located about 1-mile northwest of Highland City, discharges into the Banana Lake Overflow Canal that enters the west side of the Lake. These three tributaries account for 81% of the Lake Hancock Watershed. The Eagle Lake system located below Lake Lena Run is a minor tributary that originates in the Eagle Lake area and enters Lake Hancock on the southeast side. Remaining areas of the watershed are contiguous to the Lake.

3.2 Climate

The climate is subtropical with humid, rainy summers, and dry mild winters. Average monthly temperatures range from 61°F in January to 82°F in July and August. About half of the annual rainfall occurs during the summer months of June through September. There has been an extended period of below normal rainfall in the Lake Hancock area and in central Florida generally since 1960.

3.3 Watershed Hydrogeology

The Lake Hancock Watershed is underlain by a layer of sand, clay, and limestone, ranging in thickness from about 100 to 400 feet. Under the surficial layer is several thousand feet of limestone and dolomite. The formations comprising the watershed (Hammett, Snell, Joyner; USGS 1981) can be divided into three hydrogeologic units: (1) the surficial aquifer, (2) secondary artesian aquifers and confining beds, and (3) the Floridan aquifer. The surficial aquifer is composed of sand, sandy clay, and pebble phosphate deposits, which in Polk County have been strip mined extensively. The thickness of this unit varies between 20 and 130 feet. The secondary artesian aquifers and confining beds are composed of clay, dolomite, and limestone of the Hawthorn Formation and Tampa Limestone. The thickness of this unit varies between 50 and 150 feet.

Mining for phosphate in the vicinity of Lake Hancock began between 1941 and 1952. No mining in the vicinity of Lake Hancock is evident in a 1941 aerial photograph of the Lake. By 1952, aerial photographs indicate some areas approximately one mile to the northeast of the lake were being mined. Areas to the south of the lake showed mining activity by 1958. These areas were ultimately converted to clay settling areas. The 1968 aerials show active mining along the majority of the east side of the lake. Most of these mined areas have been reclaimed.

The Floridan aquifer consists of limestone and dolomite of the Suwannee Limestone, Ocala Limestone, and Avon Park Limestone. Drilling logs indicate that zones within the limestone and dolomite contain numerous cavities and honeycomb features that have resulted from dissolution of the carbonate rock by circulating ground water. Weaknesses in the geologic structure caused by dissolution are responsible for sinkhole collapses. Ardaman and Associates, Inc. in 1976 reported that between the years 1956 and 1975 more than 20 sinkhole collapses had occurred within two miles of Lake Hancock. Ground water in the surficial and the secondary artesian aquifers typically flow from the ridge areas to the streams and lakes of the lowland areas. However, the lowering of the Florida aquifer due to ground water withdrawals has created a downward movement of the surficial water into the secondary artesian in the area of Lake Hancock and the upper Peace River.

Lake Hancock occupies an approximate area of 4,500 acres with an average lake depth of 5 feet. A muck layer ranging in thickness from 1 to 4 feet covers the bottom of the lake. Underlying the muck are surficial deposits ranging from 9 to 17 feet in thickness which reside on top of the Bone Valley Formation containing phosphatic sands, gravels, and clays (Patton, 1980). Below the Bone Valley formation are Hawthorne limestones which have been dissolutioned by lateral movement of water to form the Lake.

3.4 Water Budget

A water budget was conducted on Lake Hancock by the USGS from the period of 1964 through 1977. During that time, the average annual rainfall was 48.61 inches and average evaporation for the Lake was about 50 inches. Measured net surface inflow into the Lake averaged 132.49 inches per year over the Lake while the outflow averaged 106.30 inches per year generating a net gain of 26.19 inches. Since the Lake stage was fairly constant during this time period, this yielded an average loss to the ground water system from the Lake of about 25 inches per year. The outflow in terms of average annual net runoff depth over the 135 square-mile watershed is about 6 inches per year which is equivalent to the measured average daily discharge of the P-11 structure of 62-63 cfs between the period of 1975 to 2003.

In the report entitled, "Lake Hancock Water and Nutrient Budget and Water Quality Improvement Project," (Harper et al., 1999), it was indicated that stormwater inputs represented 71.1% of the total Lake inflow, rainfall on the Lake 23.6%, and ground water seepage 5.3%, with a total average annual input of 79,217 acre-feet per year for the period between 1969-1998. Of the total stormwater inputs, the Saddle Creek Watershed represented the largest portion at 76.9%, Lake Lena Run 8.2%, Banana Creek 3.1%, and the other tributary basins 11.8%. Ground water seepage into the Lake was estimated based on seepage monitors installed in the Lake bottom.

Losses from Lake Hancock are represented by discharges from Structure P-11 at 54.2%, direct Lake evaporation of 24.8%, and deep ground water losses of 21.0%. Deep ground water losses were calculated as a residual of the inputs minus the known outputs. The deep ground water losses calculated were 2/3 greater than those previously calculated by the USGS, yielding a range from 25 to about 40 inches per year for the Lake area.

3.4.1 Point Source Discharges

A review of available data from the Florida Department of Environmental Protection (FDEP) indicates that several point source discharges contributed or have contributed a significant portion of the inflows into Lake Hancock. One significant source that has been discontinued is the City of Lakeland's Waste Water Treatment Plant which discharged into Stahl Canal, a tributary to Banana Lake until April 1987. Between January 1975 and April 1987, the plant discharged on average 6.4 million gallons per day or 9.9 cfs. This is about 16 percent of the historical outflows through Structure P-11. This point source inflow was accounted for in the simulation model. Lake Hancock inflows were reduced by the point source discharge to better predict the expected recovery, and downstream gaging station flows were also modified to reflect the removal of the point source inflow. The average outflow from Lake Hancock for the time period between January 1975 and December 2003 was reduced from 62.6 cfs to 59 cfs. The predicted number of MFL days at Fort Meade increased from about 2,800 days to 3,024 days as a result of the removal of the point source.

3.5 Water Quality

3.5.1 Water Quality Parameters

Lake Hancock, the primary receiver of all inflows from the Watershed, has been characterized as hypereutrophic and of poor water quality. Nutrient concentrations within the Lake promote the growth of phytoplankton with a predominance of blue-green algae such as Anacystic and Anabaena. Due to the shallow configuration of the Lake, winds can also easily stir up the organic bottom material making the Lake turbid. Mean water quality characteristics of the combined runoff and baseflow from the 3 major tributaries to the Lake between December 1998 and June 1999 are provided in the **Table 4** (Harper, 1999).

Table 4.
Mean Water Quality Characteristics

		MEAN VALUE		
PARAMETER	**UNITS**	**BANANA CREEK**	**LAKE LENA RUN**	**SADDLE CREEK**
Ph	s.u.	7.97	8.14	7.94
Specific Conductivity	µmho/cm	230	398	298
Alkallinity	mg/l	60.1	138	122
NH_3	µg/l	381	60	57
NO_x	µg/l	441	331	280
Dissolved Organic Nitrogen	µg/l	1364	761	586
Particulate Nitrogen	µg/l	2570	326	161
Total Nitrogen	µg/l	4756	1478	1084
Orthophosphorus	µg/l	351	193	327
Particulate Phosphorus	µg/l	657	118	75
Total Phosphorus	µg/l	1059	348	423
Color	Pt-Co	47	107	84
TSS	mg/l	65.3	6.9	6.8
BOD	mg/l	15.8	1.7	1.8

Banana Creek runoff contained the highest concentrations of nutrients (nitrogen and phosphorous especially in the particulate forms. Because of the green coloration of the water columns, the nutrients appear to be associated with algal biomass particulates. The measured mean concentration of total nitrogen for Banana Creek of 4756 µg/l is approximately 2-3 times the concentrations typically observed in urban runoff and baseflow. Lake Lena Run has the second highest concentration of nitrogen and third highest concentration of phosphorus; however, the predominant species is in the dissolved form. Saddle Creek has the third highest concentration of nitrogen in the dissolved form, but has the second highest concentration of phosphorus. Nutrient concentrations found in Saddle Creek and Lake Lena Run are more characteristic of urban runoff. The higher concentration of nutrients in Banana Creek is attributed to the historic discharge of effluent from a waste water treatment plant.

Saddle Creek has the highest loading rate of most constituents due to the volume of runoff generated from this tributary at 76.9%, Lake Lena Run 8.2%, Banana Creek 3.1%, and the other tributary basins 11.8%. Estimated loadings generated from runoff, groundwater seepage and rainfall are summarized in **Table 5**.

Table 5.
Summary of Loadings

SOURCE	ANNUAL MASS LOAD (kg/yr)				PERCENT OF TOTAL (%			
	TN	TP	BOD	TSS	TN	TP	BOD	TSS
Banana Creek	10,009	2,229	33,249	137,415	6	6	14	13
Lake Lena Run	8,240	1,940	9,649	206,989	5	6	4	19
Saddle Creek	56,775	22,218	95,819	355,525	32	63	41	34
Miscellaneous Basins	16,133	2,175	41,577	212,016	9	6	18	20
Tributary Subtotal	91,157	28,562	180,294	911,945	52	81	77	86
Rainfall	18,127	1,878	18,473	143,168	10	6	7	14
Ground water Seepage	66,595	4,646	36,693	0	38	13	16	0
Totals	175,879	35,086	235,460	1,055,113	100	100	100	100

3.5.2 Tropic State Index

Trophic State Index (TSI) values were calculated for Lake Hancock based upon the Florida Trophic State Index proposed by Brezonik (1984). The TSI provides an indication of the biological productivity lake and which biological communities may be favored (plant or fish habitat). TSI values are calculated based on chlorophyll-a concentration, phosphorus concentration, and Secchi disk depth visibility. The averages of the three values are then used to estimate the TSI for the Lake which provides an indication of the Lake's ability to support plant and fish life. Average trophic state values less than 50 indicate oligotrophic conditions (low nutrient concentrations with low support for plant or fish production), values between 50 and 60 indicate mesotrophic conditions (adequate nutrients with conditions favorable for balanced plant and fish production), and values from 61-70 indicate eutrophic conditions (tending toward over nourishment favoring plant production over fish), while values over 70 represent hypereutrophic conditions (highly over nourished with high tendency to favor plant production over fish in the form of algae or phytoplankton). Lake Hancock's average TSI is 91 (Harper, 1999), hypereutrophic.

Results from a study of the Lake sediments performed by the University of Florida (Brenner, Whitmore, et al., 2002) indicated that the trophic state of Lake has always been mesotrophic to eutrophic prior to it becoming hypereutrophic. The diatom assemblages, coupled with the results of the Lead 210 dating, suggests that the shift to a hypertrophic state probably occurred within the last 100 years.

3.5.3 Biological Characterization

The following Lake Hancock's biological characterization is summarized from the report entitled, "Lake Hancock Restoration Management Plan," (Camp Dresser and McKee, January 2002). Lake Hancock and its shoreline sustain a large, highly diverse fauna including one of Central Florida's largest colonial wading bird rookeries and a dense American alligator population. Much of the lake open water is bordered by cypress dominated forested swamps. Red maple and black willow dominate the understory and are the dominant woody species when cypress is absent. Submerged, floating and emergent nuisance species occur throughout the lake. Historical documentation (soils maps and aerial photographs) indicates that the lake and its associated shoreline wetland formerly occupied a larger area than in its current condition.

Sport fishery has been limited in the lake for many years due to poor water quality and lack of quality aquatic habitat. Some fish species have the ability to take advantage of the hypereutrophic conditions dominating the population. Two native fish species, gizzard shad *(Dorosoma cepedianum)* and the threadfin shad *(Dorosoma petenense)* often respond favorably to nutrient enriched lakes because of the high level of algal growth upon which they feed. Many other native fish species will exhibit a decline because the food web is disrupted by the algae which out compete other plants that prey fish need to feed upon. Hypereutrophic conditions result in the frequent occurrence of anoxic conditions, which eliminate many fish and invertebrates that are intolerant of low oxygen conditions. Another non-native species, suckermouth catfish *(Hypostomus plecostomus)* has also become abundant in Lake Hancock and other lakes within the region.

3.6 Commercial and Recreational Uses

Lake Hancock presently supports a commercial fishery for tilapia and catfish. In Lake Hancock and other lakes in Florida, blue tilapia *(Oreochromis aurea),* a non-native species introduced in 1961, has been able to flourish as a result of the hypereutrophic state of the lake. Commercial harvests began in the early 1970s, initially as part of rough fish removal programs in various lakes, with blue tilapia as the economic incentive for fishing. This fish is sold as a menu item by wholesale and retail fish markets.

Recreational use of the Lake by boaters, sport fishermen, and water sport enthusiasts (such as swimmers and water skiers) is limited due to poor quality, shallow depth, and limited access.

3.7 Existing Lake Hancock Levels

3.7.1 Operation History

Lake Hancock's levels are regulated by releases through the Outfall Structure P-11 located approximately 3,500 feet south of the Lake in South Saddle Creek (**Figure 12)**. Structure P-11 was constructed in 1963 to replace a structure that consisted of concrete, timber piles, and removable boards. This current structure is operated and maintained by the Southwest Florida Water Management District (District). Two 7-foot high by 20-foot wide radial gates with an invert of 91.7 feet NGVD are used to regulate the flows until an elevation of 98.7 feet is attained (**Figure 13**). When the level of the Lake attains this elevation, surface water will begin to flow around the structure.

Water levels on Lake Hancock have been monitored by the United States Geological Survey (USGS) and the District on a regular basis since August 1959. Discharges and elevations associated with Structure P-11 structure have been monitored by the USGS since November 1963. **Figure 14** provides a hydrograph of lake levels for the period of 1959 to December 2003, while **Figure 15** provides a hydrograph of the discharges from P-11 for the period of 1963 to December 2003. **Figure 14** indicates that Lake Hancock levels typically vary between 96 to 99.5 feet around a mean of 97.7 feet NGVD.

Statistics for Lake levels and P-11 outflows are provided in **Table 6**. Lake Hancock's maximum level of record (101.88 feet) occurred on September 16, 1960 after Hurricane Donna passed through the area. The low of record occurred on May 23, 1968 as a result of a sink hole that opened up near the center of the Lake. The median elevation of the Lake is 97.87 feet indicating that half the time the Lake is above and half the time the Lake is below that elevation. Maintenance of a specific level is impossible due to the hydrogeologic setting of the Lake and watershed.

Table 6.
Statistics for Lake Hancock Levels and P-11 Flows

Item	No. Obs	Mean	Median	Min	Max	Std. Dev	Range
Lk. Hancock Levels (Feet NGVD 1929)	10814	97.7	97.87	93.98	101.88	0.844	7.9
P-11 Flows (cfs)	14672	63.6	0.86	0	936	118.0	936

3.7.2 Adopted Levels

In September 1980, management levels were adopted for Lake Hancock by the District to provide guidance regarding expected water level fluctuations. The levels adopted include: the Ten (10) Year Flood Guidance Level - 102.4 feet, the High Level - 99.0 feet, the Low Level - 96.0 feet, and the Extreme Low Level - 94.0 feet. A Maximum Desirable Level of 98.5 feet, not an adopted level, is used by District operations as a guide to manage the Lake. Definitions for these levels are as follows:

Ten (10) Year Flood Guidance Level – means that elevation, in feet above mean sea level (same as NGVD 1929), which approximates the level of flooding expected on a frequency of not less that the ten (10) year recurring interval, or on a frequency of not greater than a 10 percent (10%) probability of occurrence in any given year, as determined from analysis of best available data. This is an advisory level provided as a discretionary guideline for lake shore development.

High Level – means the highest level to which a surface water body shall be allowed to fluctuate without interference as approved by the Board for the purpose of conserving the waters in the state so as to realize their full beneficial use. Such level shall be expressed as an elevation, in feet above mean sea level. Drainage works in the lake require District permits to ensure proper design and prevent over drainage, so that the lake's ability to reach the minimum flood level is maintained. For lakes associated with control structures, this is the maximum level which the lake would achieve by operation of the control structure. It is a peaking elevation and not one which is held.

Low Level – The normal yearly low level used as a guide for operation of a lake control structure

Extreme Low Level – This is a drought year low level used to operate a lake control structure. It is not a drawdown level, but merely a normal cyclic low that the lake should reach only periodically for the biological health of the lake. This level is provided as information for consumptive use permitting.

Maximum Desirable Level – is the lake elevation which provides optimum aesthetic and recreational benefits, based on the existing development on the shoreline and floodplain. Established by determining:

1. An elevation historically equaled or exceeds 20% (range 10-30%) of the period of record as determined from a stage-duration curve.
2. An elevation one foot (1') below most dock decks. An elevation one-half (1/2') below most seawall caps (tops).
3. The highest elevation to which most lake residents would <u>like</u> to have the lake come up relative to their property.
4. An elevation that will saturate soil around willow *(Salix sp.)* and Buttonbush *(Cephalanthus sp.)* and approach the elevation of the fern *(Blechnum)*. Also, this elevation should back up water into bordering swamps where interior vegetation is indicative of seasonal flood, e.g. St. John's Wort *(Hypericum fasciculatum).*

3.7.3 Existing Operational Protocol

Typically releases from the Lake Hancock through Structure P-11 occur when a flood is imminent or when the Lake level approaches or exceeds the 98.5 foot Maximum Desirable Level. When levels are rapidly approaching or exceed the Maximum Desirable level, Structure P-11 is opened permitting discharge to the Peace River. As the Lake continues to rise, Structure P-11 will be overtopped at an elevation of 98.7 feet and downstream conditions in the Peace River and South Saddle Creek will control the discharge from the Lake. As the level declines below the Maximum Desirable Level, Structure P-11 is usually closed to minimize further draining of the Lake, which may continue as a result of ground water seepage and evaporation. Below 98.0 feet, the structure remains closed until that elevation is reestablished when an upward cycle of Lake levels reoccurs, then the release protocol will be reinitiated. Based on discussions with District Structure Operations staff, requests have been made by Lake front property owners for the District's to lower the Lake below the Maximum Desirable level to an elevation around 98.2 feet to prevent continued saturation of yards where residential encroachments have occurred. **Figure 16** provides an example of the operation protocol described by comparing the Lake levels and the P-11 releases for a 5-year period between January 1995 to December 2000.

3.8 Evidence of Higher Lake Levels

Geologic and other more recent information indicates that Lake Hancock previously experienced higher water levels prior to the man-made alterations to South Saddle Creek Outfall circa 1930s. Historical shorelines at different Lakes levels are evidence by geologic terraces that were formed. Shorelines of lakes are subject to continuous erosional action by waves which washout and carry away the finer materials from the beach zone, leaving the larger heavier materials behind. This combined action of landward erosion and lakeward deposition of materials will over time create a bench or terrace that marks the shoreline. Several years of stabilized lake levels are required for these benches or terraces to form.

Patton (1980) used three techniques to determine the presence of former shoreline elevations for Lake Hancock: 1) transects were established and oriented perpendicular and away from the Lake to determine the presence or absence of "wave-cut terraces" in sediment elevation profiles, 2) soils were tested along transects perpendicular and away from the Lake to check for wetlands-type soils, and 3) the presence of old growth trees with varying tolerances to inundation frequencies and durations was noted.

Two distinct terraces were encountered, one that clustered at an elevation of 102.5 to 103.3 feet, and one that clustered at an elevation of 100.4 to 100.8 feet. These terraces, which are formed when wind-blown waves erode a shoreline during storm events, are typically higher than the Lake's normal high water level. Patton (1980) concluded that the previously formed terraces indicate Lake levels that were at 103.0 and then 100.5 feet.

Soil profiles showed that a black, highly organic layer was found as a subsurface feature at elevations up to 100.5 feet. There was no evidence of organic-rich soils above the 100.5-foot elevation. This suggests that the 100.5-foot elevation was more recent, and that the higher elevation of 103.0 occurred so long ago that soils no longer are modified by those previously wetter conditions.

Also, Patton (1980) described a condition where live oaks (*Quercus virginianus*) and saw palmettos (*Serenoa repens*) have grown down to approximately 100.5 feet, whereas bald cypress (*Taxodium distichum*) grew to elevations of approximately 100.5 feet. The relatively distinct line between these two types of vegetation (live oaks and saw palmettos cannot withstand as wet a condition as bald cypress) suggest that the Lake's older high water level elevation of 100.5 feet had been sustained for a long period of time.

Other sources of information support the conclusion that Lake Hancock had previously been at a higher water level. The Polk County soils map **(Figure 17)** of this region from 1927 clearly shows areas along the eastern shoreline and in the Banana Creek region were classified as "grass and water", although they are drier regions today. The BCI modeled 100.5 feet Normal Operating Level **(Figure 18)** for the Lake matches up very well with the 1927 soil map in terms of the area of increased water levels. Surveys conducted in the 1850's also suggest that the Lake was higher at that time, as marshy wetlands were encountered in the same locations as is shown in the 1927 soils map.

District staff, using techniques for determining minimum flows and levels (MFL's) for Florida lakes surveyed cypress trees at two locations; those that border the Lake at present, and those that are older and which are found farther from the Lake. Using the same relationship between water level and the buttress inflection point that is used to set MFL's, the older, more distant cypress trees probably established and grew at a time when the Lake's level was at approximately 100.4 feet, a value that matches the observations from Patton (1980). Wetland trees that are currently found at ground elevations between 98.1 and 99.6 feet would have been within the Lake at its previous higher level. Ten trees were carefully evaluated for age within this elevation range with the oldest tree aged at less than 70 years old. This suggests that cypress, maple, elm and laurel oaks that now grow along the waters edge of Lake Hancock probably became established during the time that the Lake's level had dropped from its historical high water level of 100.5 feet, to its current operating level of 98.5 feet, and this change probably occurred sometime between 1927 and 1944.

4.0 ALTERNATIVES EVALUATED

4.1 Alternative Analysis Conditions

Several factors affect the amount of water that can be stored and subsequently released by the Lake Hancock Lake Level Modification Project to meet the MFL requirements for the upper Peace River. Such factors include: 1) the Lake's operating level, 2) the percentage of historical outflows that can be stored, 3) the Lake's lower operating level when releases can no longer be made, and 4) the operational protocol for Structure P-11 regarding existing users of surface waters and downstream MFLs. An extraneous factor that affects the number of MFL days that can be recovered is the streambed losses between the Bartow and the Fort Meade gaging stations. Estimates from the USGS and other sources are being used regarding the magnitude of the losses. The District currently has an ongoing contract with the United States Geological Survey to provide better prediction of those losses.

Specific criteria associated with the alternatives evaluated included the three proposed operating levels of 99.5, 100.0 and 100.5 feet as specified in the contract; and outflow capture rates from 2 to 13% of the historical outflows; a lower operating level of 98.0 feet; and progressive streambed losses of 0, 25 and 50 cfs. Ninety-eight feet was selected as the lower operating level because this level typically represents when Structure P-11 is closed to maintain the Lake level. Other lower operating levels were analyzed under the assumption of 0 streambed losses and 10 - 15% of the outflows captured to evaluate the additional MFL days that could be achieved. **Figure 19** provides a depiction of Lake level ranges evaluated under the various alternatives proposed. The MFL storage area is represented by the area labeled as the “Typical Operating Range for MFL Recovery”.

4.1.1 Lake Hancock Proposed Operation Protocol

The operational protocol proposed for the increased levels is similar to the current Lake's operating protocol already presented in **Section 3**. The proposed operating levels of 99.5, 100.0 and 100.5 feet NGVD will be substituted for the current operating level of 98.5 feet to evaluate the Lake's ability to meet the Peace River MFL recovery under various simulation scenarios. Structure P-11 will have to be altered or replaced to effect changes in the Lake's operating level. The operational assumption for the new outfall structure is that the current discharge capacity of Structure P-11 would be maintained.

The following is a description of the expected operation protocol for MFL recovery for various simulated Lake scenarios. If the Lake level is between the operating level and the low operating level (when releases can no longer be made), stored water can be released to meet the MFLs in the River or a portion of the Lake inflow can be stored to meet future MFL requirements. Typically, when conditions are dry, water will be released to meet the River MFLs. If conditions are wet, a portion of the Lake inflows could be stored to meet future MFL requirements. Water will be stored as long as the USGS gages in the upper Peace River are above their MFL flows and the Arcadia flows are in excess of 1400 cfs. The 1400 cfs limit at the Arcadia gaging station was included as a result of a permitted withdrawal below Arcadia.

If the Lake is lowered below the low operating level, then no more releases will be made to the River to protect the ecology of the Lake. In addition, all Lake inflows will be used to restore the Lake to the low operating level (i.e., no releases will occur until the low operating level is restored). If the Lake is at or quickly approaching the selected operating level, inflows will be released in a similar fashion to the historical releases. As levels increase above the alternative operating level, Structure P-11 flows will also increase.

4.2 Lake Simulation Model

The time period simulated was from January 1, 1975 to December 31, 2003 due to limitations of the data record for Fort Meade, June 1974. SAS Institute's, Inc., SAS Version 8.02 personal computer software was used to conduct the simulations and produce the graphical output. A continuous mass balance simulation model was assembled to predict the MFL days that could be recovered by the modification of Lake Hancock's operating levels and operational protocol. Historical gaging station data was used to predict the inflow to the Lake by solving the following equation:

Net Lake Inflows = Change in Lake Storage + Outflows

The volume of water associated with the change in Lake Storage was developed through the use of the daily historical Lake Level record and the stage volume relationship developed for the Lake. Outflows were based on the USGS record at Structure P-11. Solving of the above equation using these relations allowed the generation of the Lake's net inflows. It was decided that the use of the historical record in the model would generate the best estimate of the MFL days that could be recovered. Embedded within the recorded data are the watershed and Lake responses to rainfall, evaporation, point source discharges, and seepage.

After the Lake inflows were generated, the operating protocol was converted to computer code for simulation. As indicated the protocol is similar to the current operation of Structure P-11 with modifications for MFL recovery. Simulations were conducted for the various alternative conditions previously discussed.

4.3 Simulation Input Data

To accurately predict the MFLs that can be recovered from the modification of Lake Hancock's Lake levels required the use of the historical records from the Peace River USGS gaging stations and Lake Hancock. In addition, historical point source flow data, permitted withdrawal information for the River, and information concerning streambed or sink losses within the River between Bartow and Fort Meade was assembled. To account for sink losses, losses were simulated in 0, 25 and 50 cfs progressions (i.e., the simulated sink losses were proportionally increased as flows at Fort Meade dropped below the 27 cfs MFL). For example, for the 25 cfs progression, at a historical gaged flow of 27 cfs there would be no sink losses to overcome, at a gage flow of 10 cfs a sink loss of 5.7 cfs would be generated, and at 0 cfs the sink loss would be 25 cfs. For the projected sink loss of 25 cfs, the release from Lake Hancock would be 52 cfs, the 25 cfs sink loss plus the 27 cfs to restore the MFL. A similar progression was generated for the 50 cfs loss. This progressive sink loss generates a release from Hancock greater than the difference between the actual gage discharge and the MFL rate. Justification for this simulation is that part of the stream between Bartow and Fort Meade can become dry even though Fort Meade has measured flow. This happens because the upper portion of the streambed between Bartow and Fort Meade will become dry as a result of the sink losses while the lower part of the streambed will have flow due to other watershed inflows or discharges.

5.0 BENEFITS

5.1 The Projected MFL Recovery at Fort Meade

Due to the variability of levels and conditions simulated for Lake Hancock and the resultant Peace River MFL recovery, a family of results is generated for each of the proposed operating levels of 99.5, 100.0, and 100.5 feet. Variability in storage rates, streambed losses, the low water level, and operational protocol generates a range of expected MFL recoveries. Consequently, graphical representation of the information is used to portray the volume of information generated.

The USGS gage at Fort Meade is used as a reference indicator for meeting the MFLs in the upper Peace River, because Fort Meade exhibited the most number of below MFL days of the 3 stations. Also, if Fort Meade's MFLs are being met, Bartow's MFLs are automatically being met because it is upstream and has a lower MFL requirement.

5.1.1 Results for the Operating Level of 99.5 Feet NGVD

Figure 20 represents the expected MFL recoveries at Fort Meade using the operating level of 99.5 feet; a Low Level of 98.0 feet; 0, 25 and 50 cfs sink loss progression; and outflow storage rates varying between 3 and 11% of the historic Structure P-11 outflows on an average annual basis. The simulations indicate that the MFLs recovered, ranges between a maximum of 52% to a low of about 5% depending on simulated sink losses and storage rates. It is apparent from the graphs that the sink losses within the River can have a significant impact on the number of MFL days recovered.

5.1.2 Results for the Operating Level of 100.0 Feet NGVD

Figure 21 represents the expected MFL recoveries at Fort Meade using the Maximum Desirable Level of 100.0 feet; a Minimum Water Level (Low) of 98.0 feet; 0, 25 and 50 cfs sink loss progression; and outflow storage rates varying between 3 and 12% of the historic Structure P-11 outflows on an average annual basis. The simulations indicate that the MFLs recovered, ranges between a maximum of 64% to a low of 6% depending on simulated sink losses and storage detention rates.

5.1.3 Results for the Operating Level of 100.5 Feet NGVD

Figure 22 represents the expected MFL recoveries at Fort Meade using the Maximum Desirable Level of 100.5 feet; a Minimum Water Level (Low) of 98.0 feet; 0, 25 and 50 cfs sink loss progression; and outflow storage rates varying between 3 and 13% of the outflows on an average annual basis. The simulations indicate that the MFLs recovered range between maximum of 71% to a low of 6% depending on simulated sink losses and storage rates.

5.1.4 Results from Lowering the Low Water Level

It is apparent that by increasing the operating level of the Lake and by increasing the percentage of historical outflows that are stored on any given day, there is an increase in the number of MFL days recovered. An increase in the MFLs recovered can also be realized by a concurrent lowering of the low water level. Lowering the low water level of the Lake from 98.0 to 97.0 feet will provide an additional 8-30% of the MFL days recovered depending on the operating level **(Figure 23)**. Preliminary analysis indicates that lowering of the low water level could be implemented without having the Lake go below its current Extreme Low Level. This level will be further evaluated during the Environmental Resource Permitting process.

5.1.5 Other Simulation Results

Other simulations conducted, but results not presented, indicate that if the historical Lake outflows were allowed to be stored when Arcadia flows are less than the 1400 cfs, significantly more MFL days could be recovered. It is projected that the impact on the annual withdrawal capacity of the Peace River Manasota River Water Supply Authority below Arcadia would be minimal. During Step 2 of the Lake Hancock Level Modification Project, this option can be further explored with the Water Supply Authority.

5.2 Graphical Representation of Fort Meade MFLs Recovered

Figures 24 through **26** provide comparative graphs of the existing below MFL days to the recovery for 0 and 50 cfs sink losses for the 99.5, 100.0, and 100.5 foot Maximum Desirable Levels. The horizontal axis of the graphs represents time in days while the vertical axis represents the amount of flow in cfs required to meet the MFL. The vertical axis is expressed in negative values. The areas where the vertical density of the graphs is increased is indicative of extended dry periods that have occurred in the past. It is during these periods that the stored water in Lake Hancock will be depleted and levels will recede to the Minimum Water Level (low) whereby no releases can be made. If Lake Hancock is also required to meet the sink losses, there will be an increase in the number of MFL days to be recovered.

5.3 Lake Hancock Lake Level Response

Comparisons between existing and simulated stage hydrographs for Lake Hancock are provided for the 100.0 foot Maximum Desirable Level scenario for 0, 25, and 50 cfs sink losses, **Figures 27** through **29.** The increase in Lake levels is readily apparent for the proposed 100.0 foot level. As more of the sink losses are furnished by the Lake releases, Lake levels tend to decrease while the amount of outflows stored increase. The average annual storage values are provided in the Figure titles.

5.4 Other Expected Benefits

There are a number of water quality benefits that should result from the project. The lake will have an expanded littoral zone that will provide increased wetland area for added uptake of nutrients and other constituents. Due to the increase in storage volume, water passing through Lake Hancock will have an increased mean residence time. Increased residence time is typically beneficial for allowing natural treatment processes such as nutrient uptake and settling of suspended solids to take place.

Along with the increased storage volume, typical lake depth will also increase. Resuspension of lake bottom sediments has been identified in previous studies as a likely major contributing factor to Lake Hancock's water quality problems. Increased lake depth should reduce sediment resuspension resulting from wind-driven wave action and boat operation.

The expanded littoral zone around the lake will provide increased habitat for numerous species. The proposed additional vegetation plantings and management of nuisance species will increase the diversity and wildlife habitat value of these areas.

The proposed increase in water levels at Lake Hancock should have an overall positive effect on the existing vegetation. Development by property owners around Lake Hancock has altered the typical lake regime. This is evidenced by the cypress trees found up to one hundred yards away from the lake edge. These trees have been left by property owners but the accompanying vegetation typically found with cypress trees has been cleared completely. By raising water levels the wetland vegetation will increase in these areas and slowly restore the lake to a typical lake regime. Existing pasture areas with scattered cypress trees will develop into cypress swamps that will be flanked landward by transitional wetland forests. The existing transitional/hardwood hummocks among the existing cypress forests will continue to develop, increasing diversity within the Lake Hancock system.

The increased lake depth and expanded littoral zone is also expected to improve conditions for game fish by providing additional nursery area and more access to cover.

6.0 IMPACTS

6.1 Evaluation of Impacts at the Proposed Operating Levels

Inundation impacts at the three proposed operating levels of 99.5, 100.0, and 100.5 feet and the resultant impacts generated from a 100-year, 5-day Rainfall Event on the Lake Hancock watershed starting from each of the levels are provided in this section. The impacts for these two conditions are presented due to the differences in the depths, durations, and frequencies of inundation. One condition represents the areas that will be routinely inundated when the Lake is at the operating level. The operating level will be achieved and maintained for several weeks every year. The second condition represents the projected maximum area inundated based on a 100-year, 5-day Rainfall Event. This rainfall event is used to predict 100-year flood levels for the watershed. The frequency and duration of inundation will be less, but the depth of inundation is significantly greater than in the first condition.

Areas of inundations and potential impacts will be presented for each condition. Acreages of properties (parcels) impacted along with discussions of the potential impacts to structures, infrastructure, roadways, and the environment will be provided. Other specific areas of impact include: the City of Lakeland's Cemetery, the North Central Landfill, and major access roads.

6.2 Impacts at the Existing and Proposed Operating Level

6.2.1 Existing Operating Level of 98.7 feet NGVD

Figure 30 represents the area inundated when the Lake Level is at an elevation of 98.7 feet. The area of inundation which includes the Lake covers approximately 4,950 acres.

6.2.2 Operating Level of 99.5 feet NGVD

Figure 31 represents the area inundated when the Lake Level is at an elevation of 99.5 feet. The area of inundation expands to approximately 5,700 acres. This is an increase of 750 acres from the existing level of 98.7 feet. There is significant inundation in the wetlands north and south of County Road 540 along Saddle Creek. The inundation also reaches into the relatively flat wet prairie area around Banana Lake Canal and into the Circle B Bar Ranch. The residential area to the west of Saddle Creek and north of County Road 540 also shows inundation. It is believed that this is partially the result of topographic voids in the area (i.e., the available topographic data does not reflect current land surface conditions) and may not represent what is actually inundated. Further surveys will be needed.

6.2.3 Operating Level of 100.0 feet NGVD

Figure 32 represents the area inundated when Lake is at a level of 100.0 feet. The area of inundation covers approximately 5,930 acres. This shows an increase of 980 acres from the existing 98.7-foot level and an increase of 200 acres from the 99.5 foot level. The only significant increase is in the wet prairie around Banana Lake Canal. There are also some smaller increases north of the Polk County Parkway in the wetlands along Saddle Creek.

6.2.4 Operating Level of 100.5 feet NGVD

Figure 33 represents the area inundated when the Lake is at a level of 100.5 feet. The area of inundation covers approximately 6,960 acres. This is an increase of 2,010 acres from the 98.7 level and an increase of 1,030 acres from the 100.0 foot level. The dramatic increase is primarily shown in the wetlands and lakes of the previously mined area along the east side of Lake Hancock. There are also significant increases in the wet prairie along Banana Lake Canal and in the wetlands around Saddle Creek north of the Polk County Parkway. This level represents the historical Lake level according to Patton, 1980.

6.2.5 Summary of Impacts

6.2.5.1 Property Owners/Residents

Table 7 summarizes the impact to parcels resulting from the three proposed operating levels. A GIS map overlay of the inundated boundary (**Figures 30–33**) with the parcel map obtained from the Polk County Property Appraiser was used to determine the total parcel area inundated at each of the proposed levels. Lands owned by the District were excluded to assess the private properties affected. For example, the total increase in the inundation area for a lake level change from 98.7 to 99.5 feet was approximately 750 acres as previously indicated above. However, in **Table 7**, only 714 acres are indicated because 36 acres are owned by the District.

From this overlay analysis, it was determined that at a Lake level of 98.7 feet there are 41 parcels affected excluding District parcels. The total acreage of the affected parcels is 3,137.8 acres. Of the total parcel acres, 312.6 acres are inundated while 2,825.2 acres are not inundated. Increasing the Lake level to 100.5 feet NGVD includes a total of 86 parcels with a total acreage of 5,669.1 acres having 1,950 acres within the boundary and 3,719.1 acres outside. Increasing the Lake operating level from 98.7 feet to 100.5 feet would increase the parcels affected by 45 parcels (41 to 86) and increase the area of private parcels routinely inundated by 1,637.9 acres in comparison to the existing conditions.

Table 7.
Summary of Parcels Impacted by Current and Proposed Operating Levels at Lake Hancock

Lake Hancock Operating Level (ft NGVD)	Portion of Parcel Areas Inundated (acres)		Incremental Parcel Area (acres)	Number of Parcels Impacted
Current 98.7	Not Inundated	2,825.2		41
	Inundated	312.6	0	
99.5	Not Inundated	3,221.5	396.3	63
	Inundated	1,027.0	714.4	
100	Not Inundated	3,397.7	572.4	65
	Inundated	1,222.7	910.1	
100.5	Not Inundated	3,719.1	893.9	86
	Inundated	1,950.5	1,637.9	

Impacts that might be experienced by the proposed levels include direct inundation of structures. The term "structures" as used in this report includes homes, out buildings such as sheds, barns and separate garages, in-ground pools, and docks. Based on a topographic delineation at a contour elevation of 105 feet NGVD, a total of 59 potentially impacted structures were initially identified for more detailed review. Identified structures consisted of 24 main buildings (i.e. houses), 4 docks, 21 out buildings and 10 residential lots ready-for-construction. The residential lots ready-for-construction were treated as though they already contained a main building. **Table 8** summarizes the number of structures that are within the impact area based on current topographic elevations near the structures or building sites. A survey of all structure elevations has not been completed. Survey information or nearby ground elevations derived from the available topographic information were used to assess whether a structure was likely to be impacted.

Table 8.
Estimated Number of Structures within Impact Area

Structure Type within Inundated Area	Lake Hancock Operating Level (feet NGVD)		
	99.5	**100.0**	**100.5**
Main Building	1	3	4
Out Building	4	4	5
Dock	4	4	4

6.2.5.2 Infrastructure

In addition to damage to structures, an increase in the operating level can result in ground water table impacts. Increased yard flooding and difficulty accesses properties are examples of these impacts from changes in the water table elevations.

Sanitary/wastewater Impacts - A typical cross section of a septic tank and drain field is shown in **Figure 34**. Ground cover above the tank may vary but is typically about 6 inches. Proper hydraulic function of a septic tank drain field requires 2.5 feet of separation from the bottom of the perforated pipe to the seasonal high water table. In total, approximately 4 feet of separation between land surface and the seasonal high water table is required for a septic field to be considered functional.

As noted in Section 6.2.5.1, 24 existing main building structures and 10 residential lots ready-for-construction were initially identified for detailed review based on the 105 foot contour elevation. **Table 9** summarizes the estimated number of septic tanks potentially impacted for each operating level. For example, 30 main building structures were considered to have septic systems that could potentially be impacted by the proposed operating level of 100.5 feet. These structures were located within the 104.5 foot contour which provides the 4 feet of separation between the new expected seasonal high and the land surface for proper drain field function.

Table 9.
Estimated Number of Structures with Septic System Impacts

Potential Impact	Lake Hancock Operating Level (feet NGVD)		
	99.5	**100.0**	**100.5**
Main Building	28	29	30

Local Roadways - **Figures 31 – 33** show the area of inundation expected for Lake Hancock at operating levels of 99.5, 100.0 and 100.5 feet NGVD. GIS overlays of the area of inundation resulting from the three operating levels were reviewed against aerial photography and topographic information to identify any potential impacts to local roadways. Based on typical local road base construction, an impact was determined to exist if the highway elevation was below 102.5 feet. No impacts to local roadways were identified for any of the proposed changes in the proposed operating levels.

Limited Access & Primary Highways - GIS overlays of the area of inundation resulting from the three operating levels were reviewed against aerial photography and topographic information to identify any potential impacts to limited access and primary highways. Based on typical highway road base construction, an impact was determined to exist if the highway elevation was below 103.25 feet. No impacts to limited access or primary highways were identified for any of the proposed changes in the operating levels.

6.2.5.3 Polk County North Central Landfill

The Polk County North Central Landfill would not be directly inundated by a change in the operating level of Lake Hancock. However, the landfill may be impacted by expected changes in the water table. Potential impacts to the Polk County North Central Landfill resulting from possible changes in the water table elevation include:

- Increased leachate production resulting from water table fluctuation.
- Uplifting and interference with existing facilities such as liners, piping, and leachate collection systems.
- Reduced capacity in existing stormwater systems due to higher ground water levels.
- Loss of solid waste volume and increased construction costs resulting from raising the new facilities to higher base elevations.
- Possible permit issues with a proposed vertical expansion construction on top of existing unlined cells.

Several meetings have been held with Polk County Solid Waste personnel and others to discuss these concerns. Information provided by the Solid Waste personnel includes topographic data described earlier and a recently completed draft of the final facility build-out plan. Additional information and evaluation data will be required to determine the likely impacts in greater detail. It is recommended that a joint meeting with FDEP permitting personnel be held to discuss permit issues.

6.2.5.4 City of Lakeland Oak Hill Cemetery

The City of Lakeland Oak Hill Cemetery would not be directly inundated by an increase in the operating levels of Lake Hancock. Potential impacts to the City of Lakeland Oak Hill Cemetery resulting from possible changes in the water table elevation include:

- Loss use of planned burial plots.
- Impacts to existing burials plots, including uplifting of vaults and caskets due to increased buoyancy.

A limited site survey was conducted on March 9 & 11, 2004. The purpose of the site visit was to generally confirm the existing topographic information and assess possible impacts from the impoundment of water in a depression located east of the cemetery or from high water levels in Banana Creek to the north. The Lake Hancock water level on these dates was approximately 98.3 feet NGVD. Nearby sites in Banana Creek canal have channel bottom elevations in the range of 99 to 101 feet. Water was flowing in the Creek at rate of about 3 to 5 cfs. The eastern end of the cemetery has the lowest topographic elevations of approximately 104 feet NGVD. The bottom elevation of the depression is approximately 99 feet NGVD.

Surface water from Lake Hancock cannot directly flow into the depression until the lake reaches a level of approximately 100 feet based on the available topographic data. The depression has a partial constructed channel that approaches but is not connected to the Banana Creek Canal.

Interviews with cemetery staff and the superintendent indicated that burials are typically 4–5 feet in depth. The recollection was that water had not been encountered at any plot site during preparation for a burial during the past 20 years. The wettest historical time period recalled by cemetery staff occurred during the 1997-1998 El Niño. The recollection is that the depression was inundated from spring through summer of 1998, but that no problems were encountered with any burial. Some of the outlying portions of the cemetery property, including a tree nursery area, were saturated and unusable during that time. Review of aerial photographs collected by the District during March of 1998, indicates that the water level in the depression was between 100–101 feet NGVD at that time.

BCI personnel performed two hand auger borings during the March visit to determine the current water table elevation. One boring was conducted in a wooded area approximately 200 feet east of the lowest burial plots. The ground elevation was approximately 103 to 103.5 feet NGVD at this location. The water table was not found to a depth of slightly over 7 feet at this location.

A second boring was conducted on the edge of the depression in the bottom of the connected channel. The nearby ground elevation was approximately 101 feet NGVD. The channel was approximately 5 feet deep. The channel bottom was dry during the site visit. The water table was encountered approximately 1.5 feet below the channel bottom indicating that the water table was around 94 to 95 feet.

These preliminary results show that the water table in this area was below the Lake elevation and below the water surface elevation in Banana Creek at the time of the field visit. Previous dredging work on Banana Lake in 1989 and 1990 encountered a similar phenomenon in that the water table dropped to lower elevations than Banana Lake while moving south into higher topography. This information combined with the historical anecdotal evidence may indicate that a more complex geologic situation in the area influences the water table.

It is not known at this time whether the apparent depressed water table is evident at all times or would remain in the same relative position if Lake Hancock levels were increased and higher water levels became more frequent.

6.2.6 Environmental Impacts

6.2.6.1 Vegetation Impact Assessment Analysis

BCI Engineers & Scientists, Inc. (BCI) conducted a site visit to assess the current vegetation communities and probable impacts to these communities related to increased water levels in Lake Hancock. BCI staff conducted the field work on January 16, 2004. The Lake water level on that day was approximately 98.2 feet NGVD.

6.2.6.2 Methodology

BCI identified the current vegetative communities associated with Lake Hancock and mapped them on a one inch equals 200 feet aerial photograph. Communities were identified in the field and marked with a handheld Geographic Positioning System (GPS) unit (Garmin 76). GPS data was downloaded and converted to an ArcInfo coverage and a current landuse map (**Figure 35**) was produced using the Florida Land Use, Cover and Forms Classification System (FLUCCS).

Each community was observed for vegetation type, diversity, stain lines, lichen lines, age of stand, health and other biological factors that could be used to predict impacts caused from increase water levels. Tree species were then evaluated and applied to a percent inundation table to assess predicted impacts to increased inundation, (Rhodes).

6.2.6.3 Results

Three distinctive wetland communities and three upland communities were observed around the limits of Lake Hancock. Freshwater marshes (FLUCCS code 641), cypress (FLUCCS code 621) and wetland forest mixed (FLUCCS code 630) were the wetland classifications identified at Lake Hancock. Upland communities surrounding Lake Hancock included improved pasture (FLUCCS code 211), citrus groves (FLUCCS code 221), and various residential areas. **Table 10** lists the vegetation communities to an elevation of 105 feet NGVD and provides approximate acreages within the floodplain surrounding Lake Hancock. The following is a description of the communities identified during the field reconnaissance:

Table 10.
Lake Hancock Vegetation Mapping Summary Table

FLUCCS Code and Description	Area (acres)
1100 - RESIDENTIAL LOW DENSTIY	13.7
1900 - OPEN LAND	15.8
1920 - INACTIVE LAND WITH STREET PATTERN NO STRUCTURES	0.4
1940 - OTHER OPEN LAND	42.4
2100 - CROPLAND AND PASTURELAND	163.6
2110 - IMPROVED PASTURES	118.3
2120 - UNIMPROVED PASTURES	42.5
2140 - ROW CROPS	0.2
3100 - HERBACEOUS (DRY PRAIRIE)	0.1
3200 - SHRUB AND BRUSHLAND	72.3
4000 - UPLAND FORESTS	0.9
4200 - UPLAND HARDWOOD FORESTS	15.9
4340 - HARDWOOD CONIFER MIXED	32.2
5000 - WATER	7.0
5200 - LAKES	4,070.9
5300 - RESERVOIRS	91.8
6100 - WETLAND HARDWOOD FORESTS	7.9
6150 - STREAMS AND LAKE SWAMPS (BOTTOMLAND)	102.4
6210 - CYPRESS	351.4
6300 - WETLAND FORESTED MIXED	345.5
6410 - FRESHWATER MARSHES	566.3
6412 - CATTAIL	474.6
6430 - WET PRAIRIES	343.9
6440 - EMERGENT AQUATIC VEGETATION	62.3
6500 - NON-VEGETATED WETLAND	2.8
7430 - SPOIL AREAS	11.2
8100 - ROAD	3.5
8142 - DIVIDED ROAD (POLK PARKWAY)	0.5

Freshwater Marshes (FLUCCS code 641) - Most of the freshwater marsh communities consisted of high amounts of cattail (*Typha spp*.), duck potato (*Sagittaria lancifolia*), pickerelweed (*Pontederia cordata*), duck weed (*Lemna minor*), and pennywort (*Hydrocotle umbellata*). Lesser amounts of water primrose (*Ludwigia spp*.), maidencane (*Panicum hemitomon*), and smartweed (*Polygonum punctatum*) were observed. Water depths within these communities ranged from two to four feet.

Wetland Forest Mixed (FLUCCS code 630) -Several hummocks of decaying vegetation have built up over time within the freshwater marshes. These masses have begun to support transitional tree species that include buttonbush (*Cephalanthus occidentalis*) and red maple (*Acer rubrum*). Hardwood tree species diversity is limited within this community. This community is interspersed with bald cypress (*Taxodium distichum*) and pond cypress (*Taxodium ascendens*) trees growing in the deeper portions where the decaying matter has not accumulated. Most of the cypress trees in these areas are larger, older trees.

Brazilian pepper trees (*Schinus terebinthifolius*) have also begun to grow on the hummocks located within this community. The understory of this community is comprised of cattail, pickerelweed, duck potato and various other herbaceous species. Water depths in these systems ranged from two to three feet.

Cypress Forest (FLUCCS code 621) - The cypress community is dominated by bald cypress and pond cypress. The secondary overstory species include red maple and buttonbush. Most of the cypress trees are large, older trees like those found in the mixed forested wetlands. The cypress trees have buttressing up to five feet above the water surface. Cypress knees extended one to one and a half feet above the water surface as well. Most of the cypress trees contain seeds; however, there does not appear to be much regeneration within the community. This is most likely due to the relatively stable water levels over the last few years. Water depths within these areas ranged from three to five feet.

Upland Communities - The improved pastures consisted primarily of bahia grass (*Paspalum notatum*) with stands of various oaks and pines throughout the pasture areas. The pasture areas were within one foot of the water surface in certain locations and several feet as distance is traveled away from the lake. Several full grown cypress trees were observed growing at elevations greater than five feet above the current water surface inside the pasture designation. Orange groves were located more than six feet above the current water level of Lake Hancock. The lowest residential areas ranged from approximately one foot to several feet above the current water level.

6.2.6.4 Impact Assessment and Conclusions

Figures 36 and **37** shows the typical zones for wetland communities and the associated wetland plants. Most natural lake cross sections transition from upland to transitional wetland species to deeper wetland trees to herbaceous wetlands to open water. Due to the hummocks of decaying matter and development around Lake Hancock, the typical cross section for this lake is much different. It appears that development around Lake Hancock has removed the transitional wetlands that would typically be found along the lake edge. Traveling lakeward, an abrupt change from upland to cypress forest is found. Beyond the cypress forest, a transitional area that contains hummocks of decaying vegetation and muck supporting several transitional trees was observed. After the transitional areas, herbaceous vegetation and ultimately open water is found.

According to Rhodes, the species present in Lake Hancock can support increased inundation time periods from 36 to 50 percent of the time. Buttressing of the cypress trees to four feet and above the current water level of 98.2 feet, suggests that this system may have contained a water level several feet higher than the suggested increased water level of 100.5 feet. Because of these factors, it is expected that increased water levels within this system will have little to no impact on the system as a whole. At most, it is expected that transitional wetlands will begin to develop in more natural locations around the current cypress stands. Several acres of pasture will also become herbaceous wetlands and transitional areas as well. This impact will most likely return the lake system to a typical lake ecosystem.

Most of the trees observed were producing seeds which will aid in the shift of wetland species to different locations. Species diversity was low at the site. Several nuisance species were observed during the field visit including cattail, Brazilian pepper, water primrose, water lettuce (*Pistia stratiotes*), and water hyacinth (*Eichhornia crassipes*).

Based on the results of the field investigation, impacts to the existing plant communities will be minimal. At most, it is expected that the transitional zones located around Lake Hancock will become deeper cypress zones and the adjacent areas will develop into transitional forested wetlands. Current, cypress zones have been established for many years and it is unlikely that there will be any impact to these areas with the additional water depths. Ultimately it is predicted that Lake Hancock will develop into a lake that represents a more diverse habitat with a transitional forested wetland fringe followed by cypress and herbaceous plants traveling lakeward.

6.3 Flooding Potential from Lake Level Modifications

6.3.1 Watershed Model Description

Lake Hancock watershed modeling was completed using the Interconnected Pond Routing (ICPR) hydrodynamic model. Assembly of the watershed model relied heavily on data available from existing models. The core of the watershed model was based primarily on information obtained from the recently completed Saddle Creek Model produced by Keith and Schnars, P. A. for the District and Polk County. Model development details are provided in **Appendix A**. Flood elevations associated with the surface water modeling are not furnished in this section of the report. **Appendix B** contains tabulated elevations for the various model conditions, along with maps containing the location of the specified elevations at the model junctions.

6.3.2 Existing and Potential Flood Levels

6.3.2.1 100-Year Flood Level - 98.7 feet NGVD (Existing)

The areas of inundation projected from the 100-Year, 5-Day Rainfall Event of 16 inches with a Lake Hancock starting elevation of 98.7 feet NGVD is outlined in **Figure 38.** This Rainfall Event will generate a 100-year return frequency flood event for the watershed. **Figure 31** represents the area inundated from the 100-year event when the Lake is at a starting level of 98.7 feet. Structure P-11 was assumed to remain closed for the duration of the simulated event. Comparative simulations were conducted with various gate openings that resulted in only a nominal change (approximately –0.1 feet) in the peak stage attained in the lake. Therefore, the structure was simulated as being closed to provide a conservative estimate of the flood levels that would be attained in Lake Hancock and adjacent areas.

The resultant area of inundation from the 98.7-foot starting level, and 100-Year, 5-Day Rainfall Event covers approximately 10,720 acres. The limits of the area of impact were defined as the inundation area that had projected changes in water surface levels, between the existing level starting condition of 98.7 feet and the maximum starting level condition of 100.5 feet.

Model information was reviewed to determine where the changes in water surfaces were essentially zero. Where the zero changes were first observed defined the impact area. Areas beyond the first observed zero change in the model-projected levels were excluded from the maps.

Areas of interest in the existing 98.7 foot starting level and Rainfall Event includes the northern stormwater pond of the Polk County Landfill and SR 540. In the existing conditions simulation, the resulting water surface levels were overtop the berm and around the stormwater pond. SR 540 is nearly overtopped and actually becomes overtopped in the 99.5 foot simulation. It is believed that SR 540 road surface elevations may be slightly higher than what is represented in the current topography.

6.3.2.2 100-Year Flood Level - 99.5 feet NGVD

The resultant area of inundation for the 99.5-foot starting level and the Rainfall Event is outlined in **Figure 39** and covers approximately 10,840 acres. This shows an increase of 120 acres inundated from the 98.7-foot starting level. The increase is minor throughout the floodplain with only the wetlands on the northeast side of Lake Hancock showing significant change in the area inundated. The northern stormwater pond in the landfill shows more of the berm overtopped. SR 540 is shown as overtopped in this simulation.

6.3.2.3 100-Year Flood Level - 100.0 feet NGVD

The resultant area of inundation for the 100.0-foot start level and Rainfall Event is outlined in **Figure 40** and covers approximately 10,920 acres. This shows an increase of 200 acres inundated from the 98.7-foot starting level and an increase of 80 acres from the 99.5-foot level. The major increase is at the Polk County Landfill. In this simulation, the predicted flood elevations indicate that both the northern and southern stormwater ponds would be overtopped.

6.3.2.4 100-Year Flood Level - 100.5 feet NGVD

The resultant area of inundation for the 100.5-foot start level and Rainfall Event is outlined in **Figure 41** and covers approximately 11,010 acres. This shows an increase of 290 acres inundated from the 98.7-foot level and an increase of 90 acres from the 100.0-foot level. The two major increases for this simulation is at the Polk County Landfill and at the City of Lakeland Oak Hill Cemetery. The Polk County Landfill shows inundation well into the surface water collection system adjacent to the landfill cells. The cemetery shows encroachment into the easternmost burial plots.

6.3.3 Impacts from Potential Changes in Flood Level

6.3.3.1 Property Owners/Residents

Table 11 provides a summary of the areas inundated as a result of the 100-Year, 5-day Rainfall Event simulations for the proposed lake operating levels.

Table 11.
Summary of Parcels Impacted by a 100-year, 5-day Rainfall Event at Current and Proposed Operating Levels at Lake Hancock

Lake Hancock Operating Level (ft NGVD)	Portion of Parcel Areas Inundated (acres)		Incremental Parcel Area (acres)	Number of Parcels
98.7	Not Inundated	3,988.7		160
	Inundated	3,625.5	0	
99.5	Not Inundated	4,078.6		165
	Inundated	3,722.3	96.8	
100	Not Inundated	4,020.8		165
	Inundated	3,780.2	154.6	
100.5	Not Inundated	3,938.7		167
	Inundated	3,862.4	236.9	

The 100.5 simulation predicts that 3,862.4 acres are within the floodplain. This is 236.9 acres greater than the area within the floodplain under current conditions.

Incremental impacts to public right-of-ways and lands belonging to the Southwest Florida Water Management District are not included in **Table 11**. For example, the increase in floodplain acreage from the 98.7 to the 99.5 flood level results was approximately 120 acres, but only 96.8 acres of that change impacts landowners other than the District.

6.3.3.2 Infrastructure

Sanitary/wastewater Impacts -The primary impacts to sanitary facilities such as septic tanks would be their impaired function due to increased water levels and direct overtopping. Septic tank impacts during flooding would be approximately equivalent to the number identified in **Table 9**. The same structures that are likely subject to water table impacts identified in the previous **Section 6.2** are also subject to flooding impacts.

Local Roadways - **Table 12** provides a summary of the impacts to local roadways resulting from the increase in flood levels and extent as a result of the 100-Year, 5-Day Rainfall simulations for the proposed lake levels.

Table 12.
Estimated Impacts on Local Roadway Flooding

	Lake Hancock Operating Level (feet NGVD)		
Potential Impact	**99.5**	**100**	**100.5**
Linear Feet of Roadway	2,110	3,081	5,245

Limited Access & Primary Highways -The current 2000, Polk County, Federal Emergency Management Agency (FEMA), Federal Insurance Rate Map (FIRM) indicates, that SR 540 is overtopped by the 100-year flood. The analysis completed during the current study indicates that SR 540 would be nearly overtopped by the Rainfall Event with the existing condition starting level of 98.7 feet for Lake Hancock, and clearly overtopped for the three simulations at higher lake starting levels. The linear feet of SR 540 affected is unknown due to insufficient elevation data.

Polk County North Central Landfill - The current 2000, Polk County, FIRM indicates that the majority of the landfill area is within a flood zone. Water surface levels shown on the FIRM for Saddle Creek, adjacent to the landfill, range from 105 to 106 feet NGVD. The analysis completed during the current study indicates, that various portions of the landfill facilities would be inundated during the base simulation with the existing conditions starting level of 98.7 feet NGVD for Lake Hancock and any of the incremental lake starting levels. The northern stormwater pond is overtopped during all simulations. The southern stormwater pond is overtopped during the 100.0-foot and 100.5-foot simulations. Stormwater channels within the facility are inundated during the 100.5-foot simulation.

City of Lakeland Oak Hill Cemetery -The current 2000, Polk County, FIRM indicates that approximately 2,900 burial plots are located within the 100-year flood zone. The water surface levels predicted by the 98.7, 99.5 and 100.0-foot simulations conducted during this study show no inundation of any burial plots. The water surface levels predicted for the 100.5-foot simulation indicates approximately 460 burial plots would be inundated.

6.3.4 Environmental Impacts

Environmental impacts due to flood level increases are expected to be minimal. Wetland systems are well-adapted to occasional flooding. Pastures and forested areas typically experience few impacts from short-term inundation. The 5-Day, 100-Year Rainfall Event analysis indicates a duration of approximately 16 - 20 days of significantly elevated levels within the floodplain areas immediately connected to Lake Hancock.

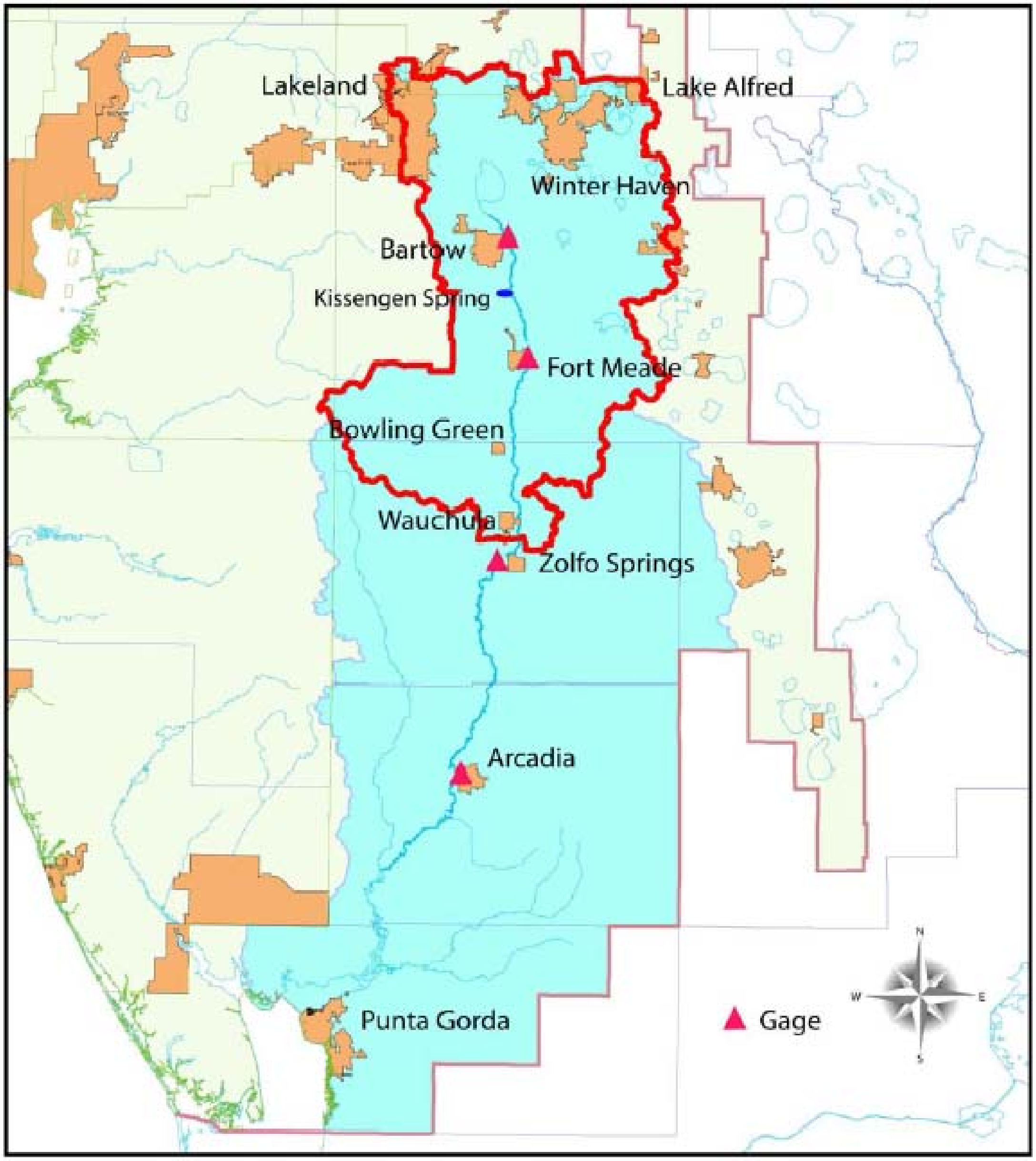

Figure 1 Peace River watershed showing locations of USGS gage sites. The Upper Peace River is the portion of the watershed above the USGS Zolfo Springs gage and is outlined in red.

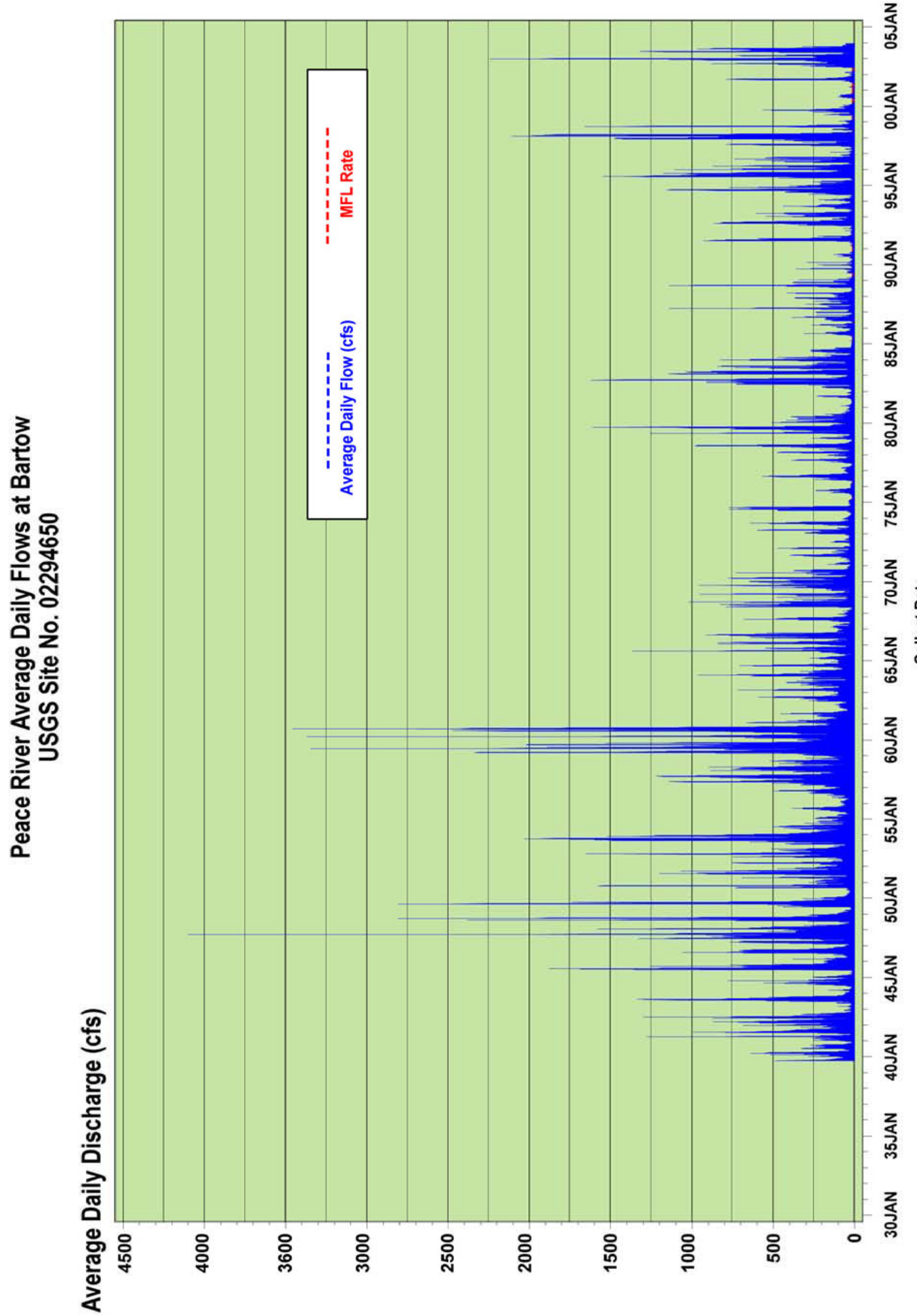

Figure 2. Average Daily Flows at Bartow

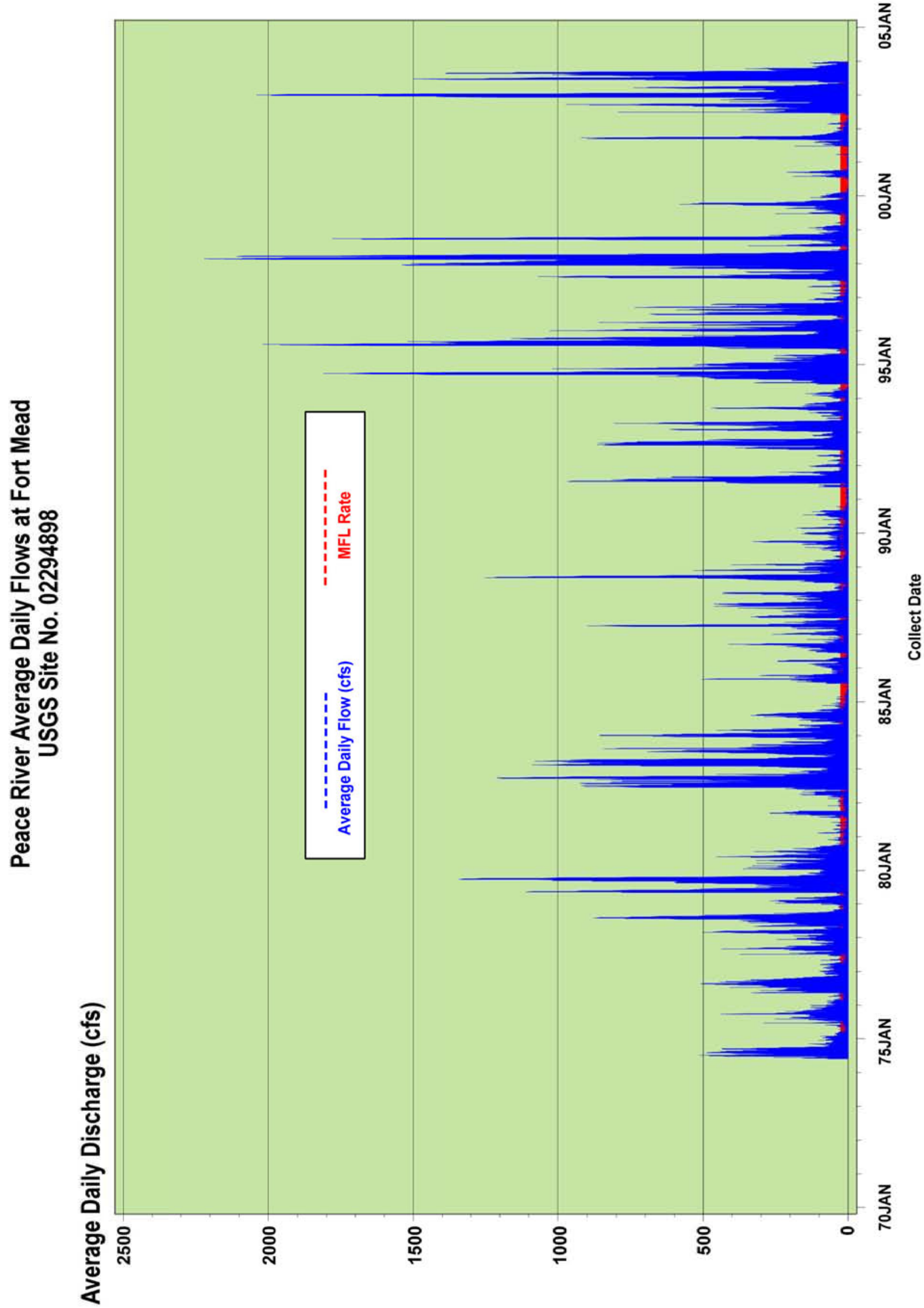

Figure 3. Average Daily Flows at Ft. Meade

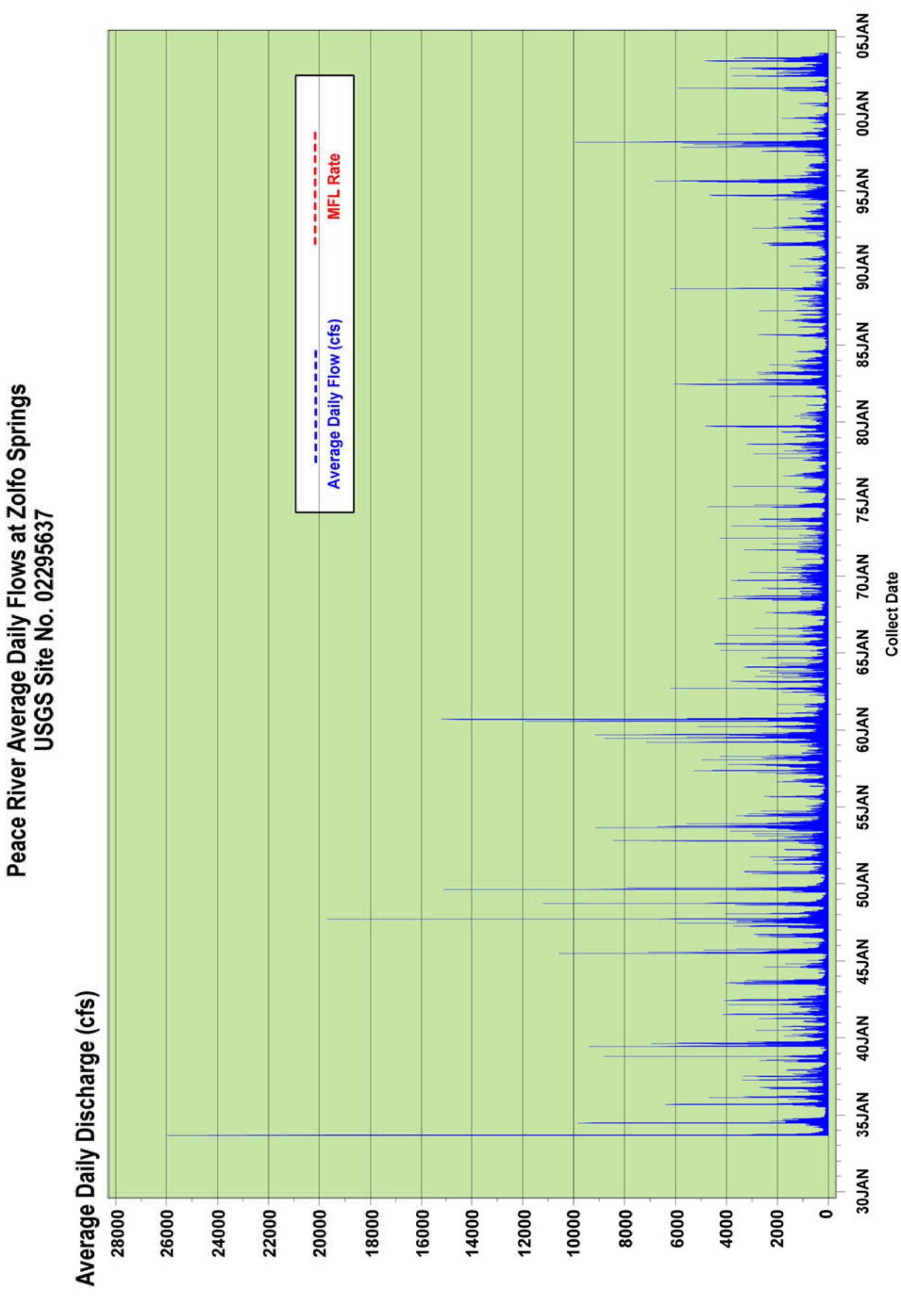

Figure 4. Average Daily Flows at Zolfo Springs

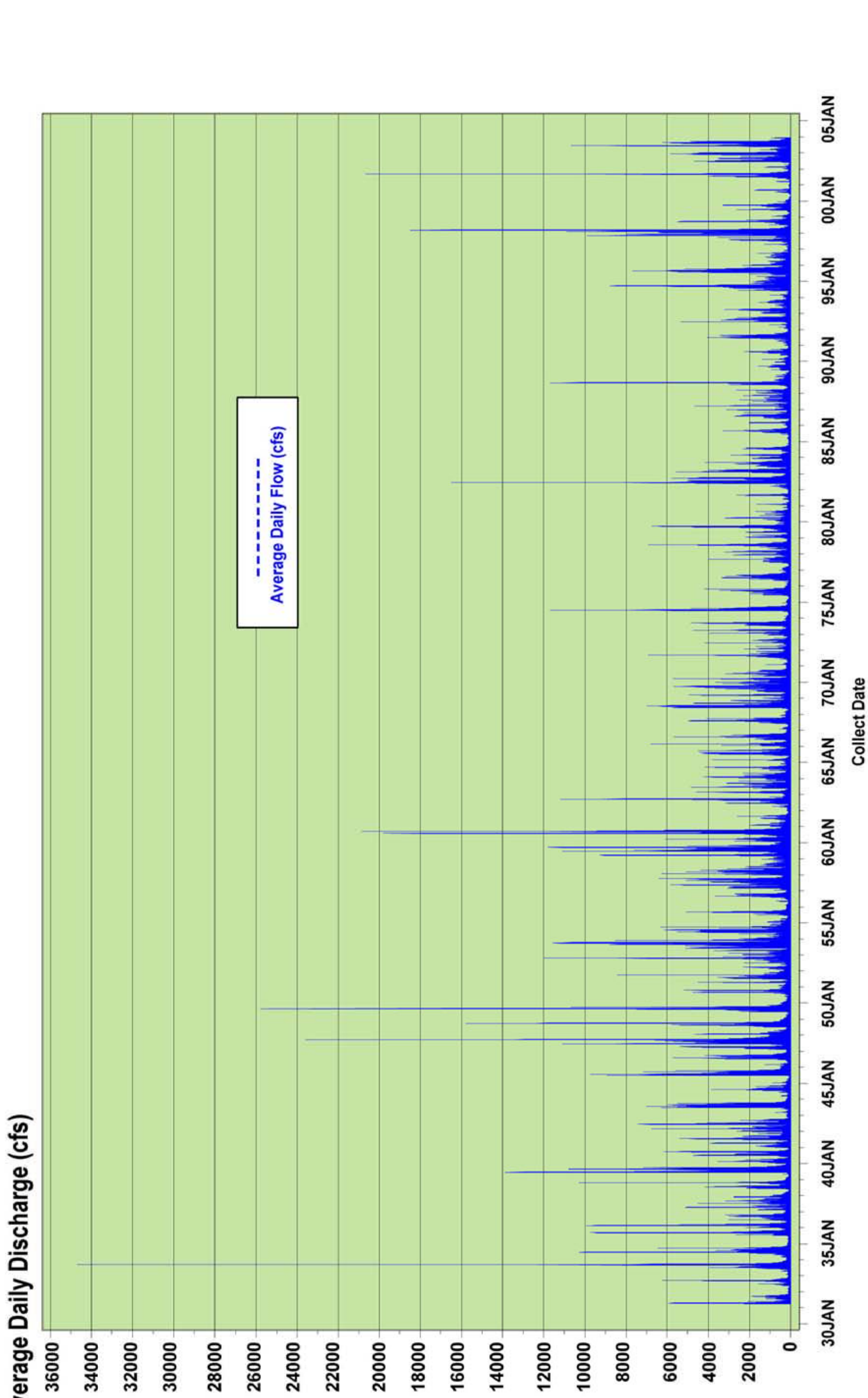

Figure 5. Average Daily Flows at Arcadia

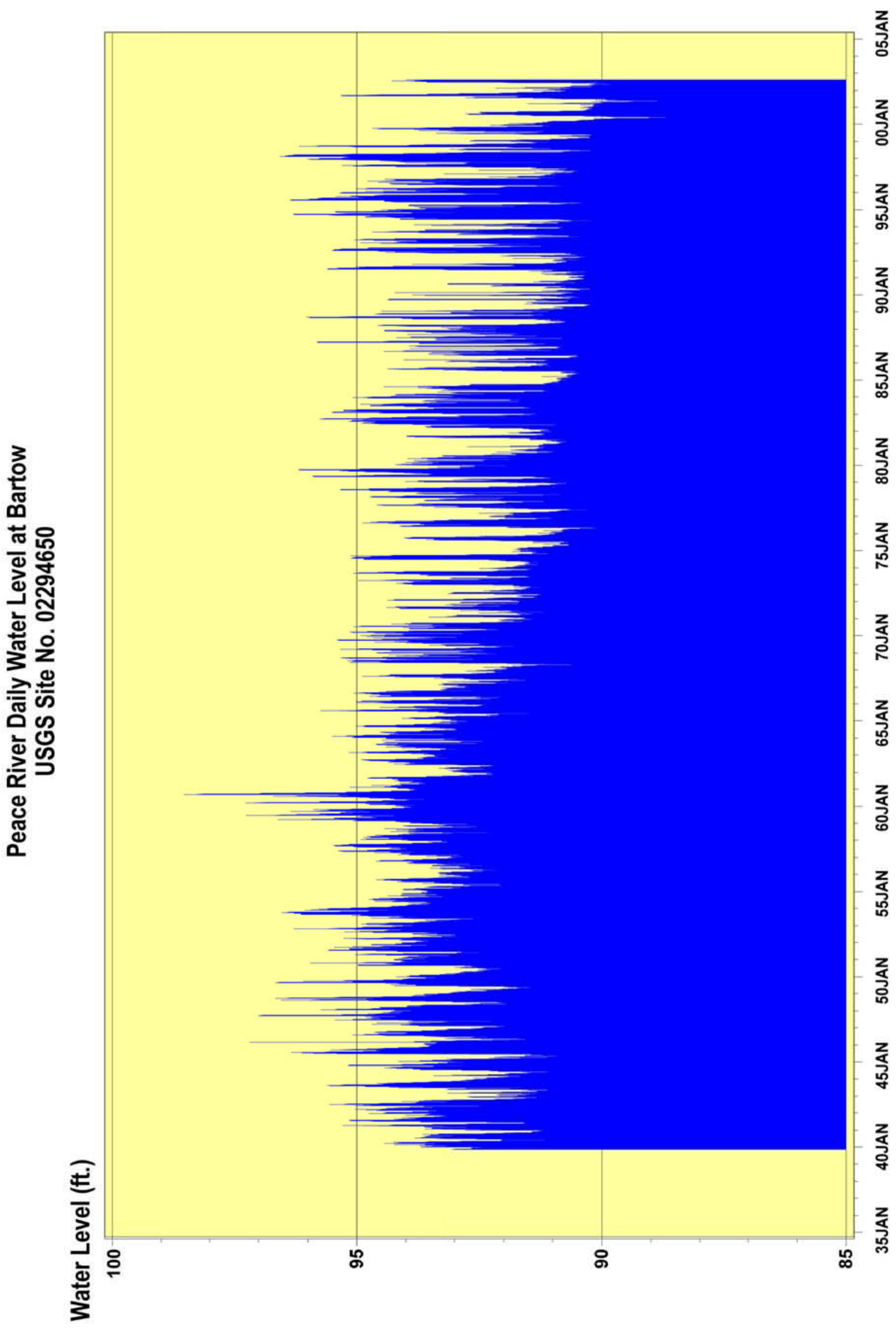

Figure 6. Average Daily Levels at Bartow

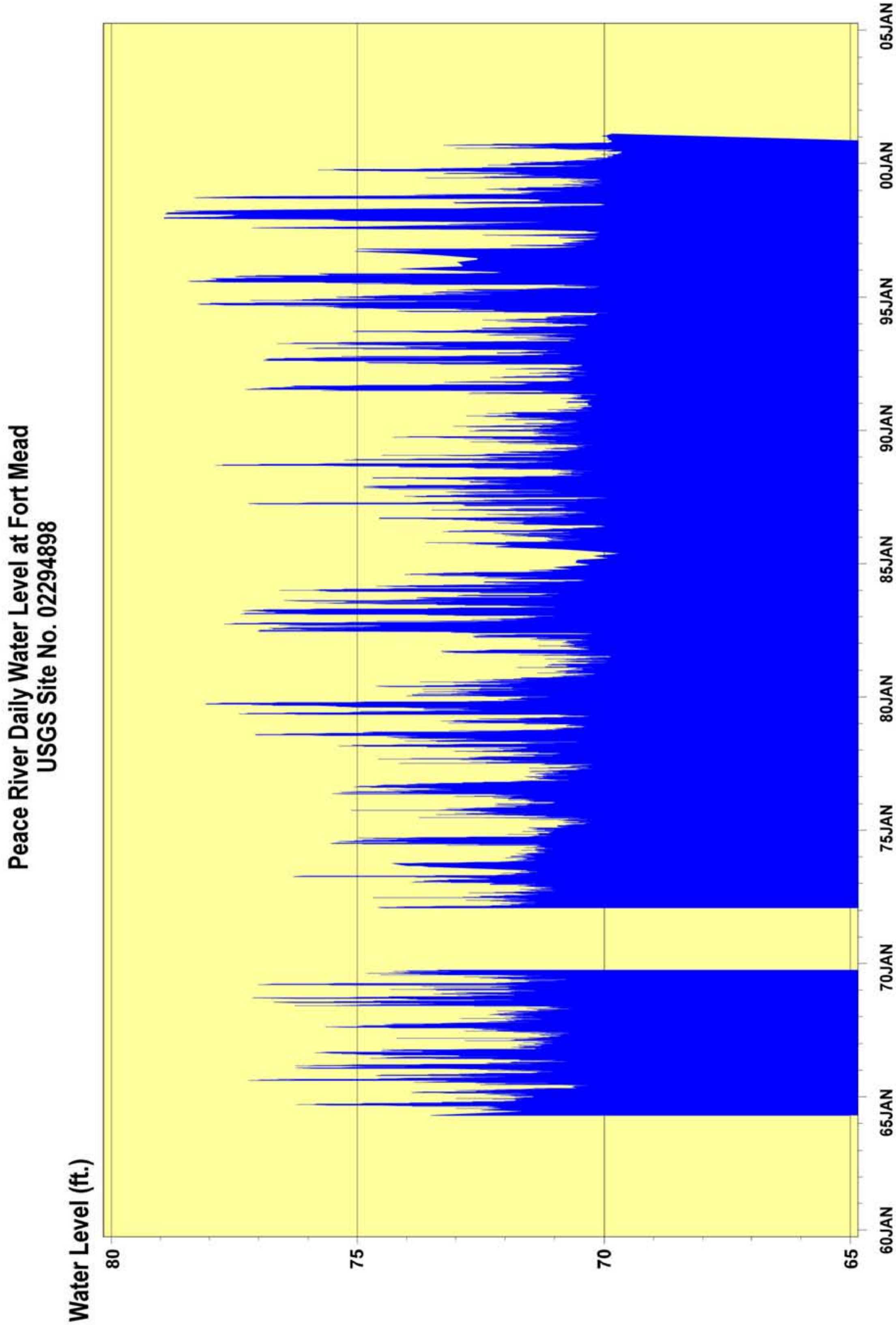

Figure 7. Average Daily Levels at Ft. Meade

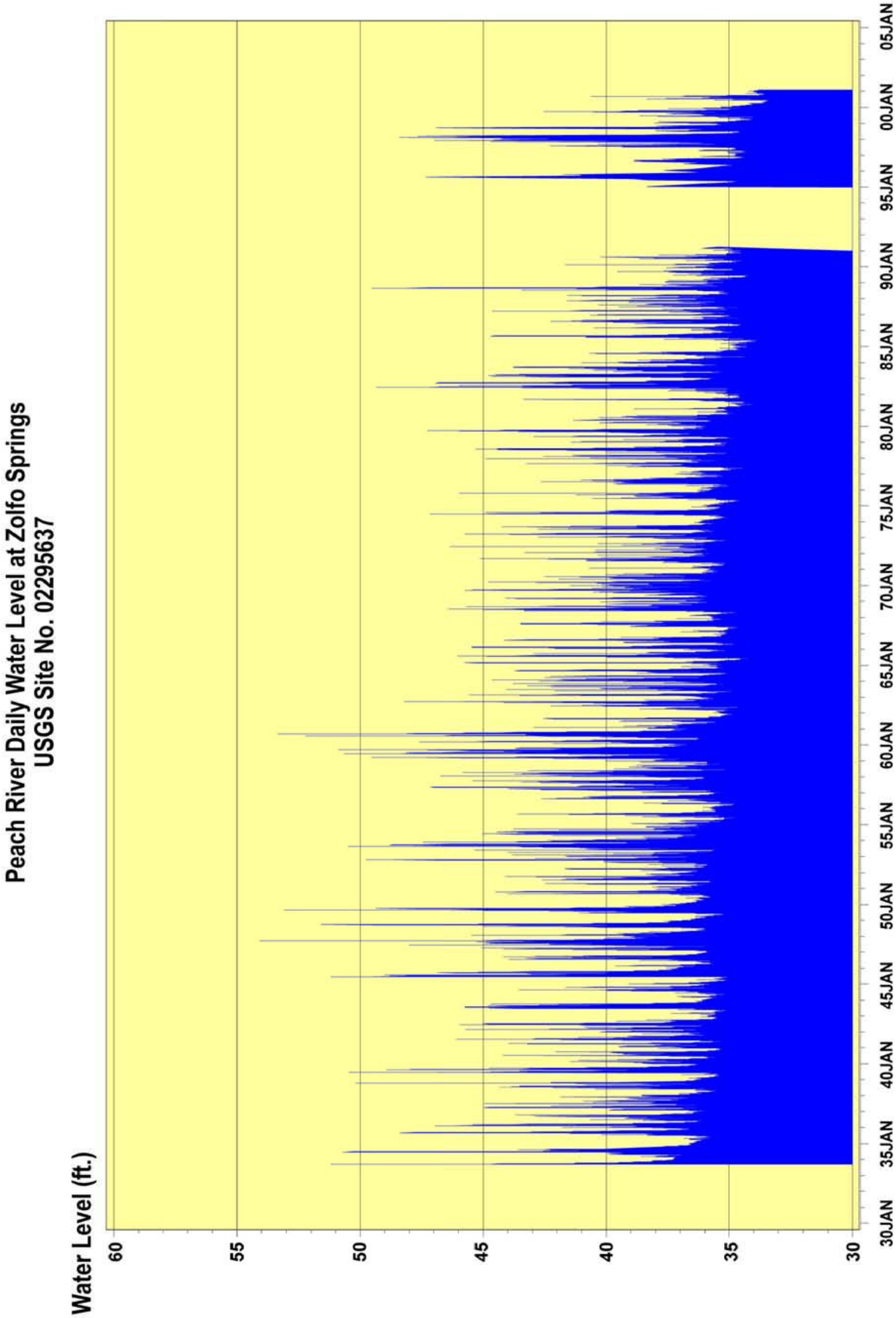

Figure 8. Average Daily Levels at Zolfo Springs

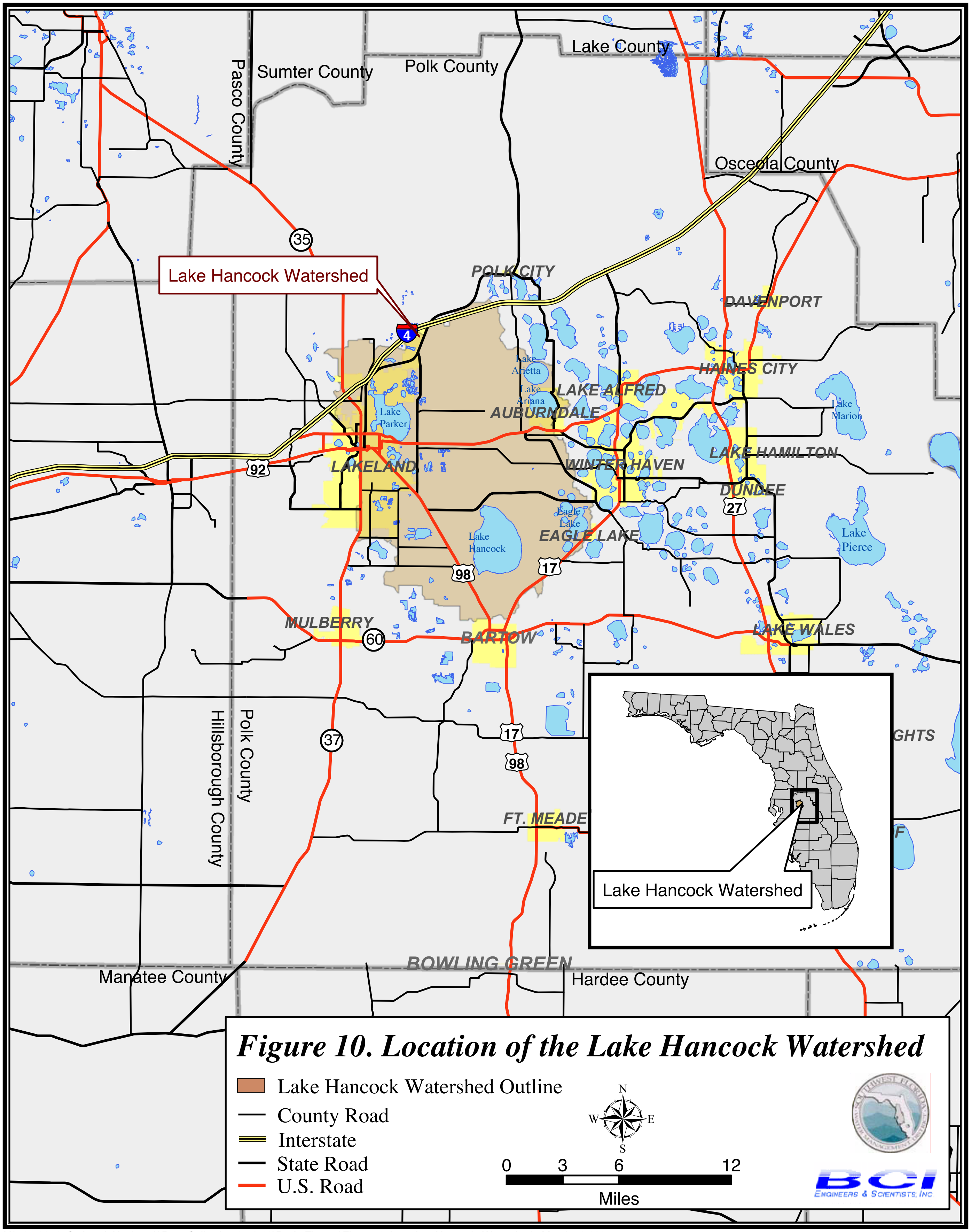

Figure 10. Location of the Lake Hancock Watershed

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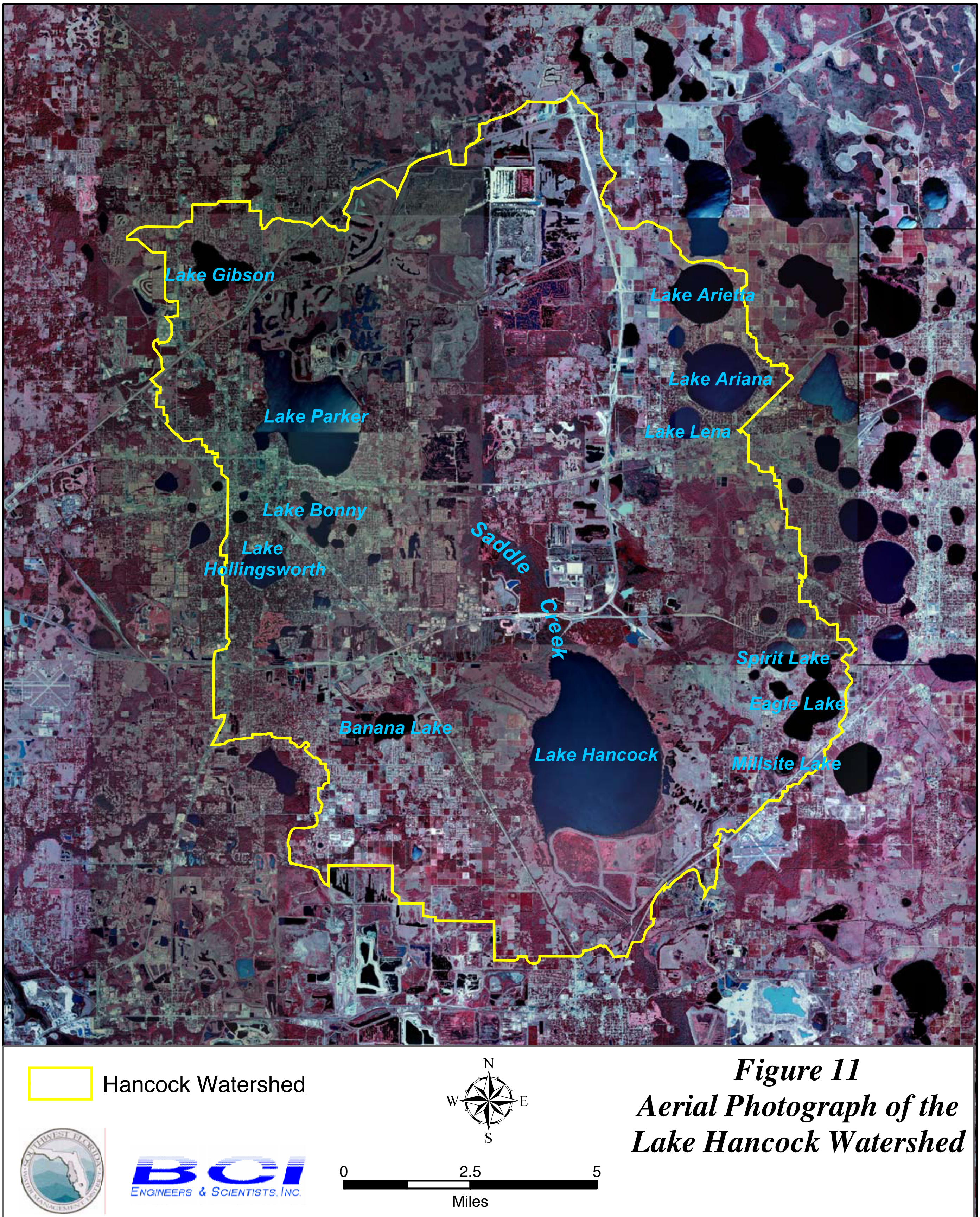

Figure 11
Aerial Photograph of the Lake Hancock Watershed

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Figure 12
Aerial of Lake Hancock
SWFWMD Control Structure

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Figure 13 Structure P-11

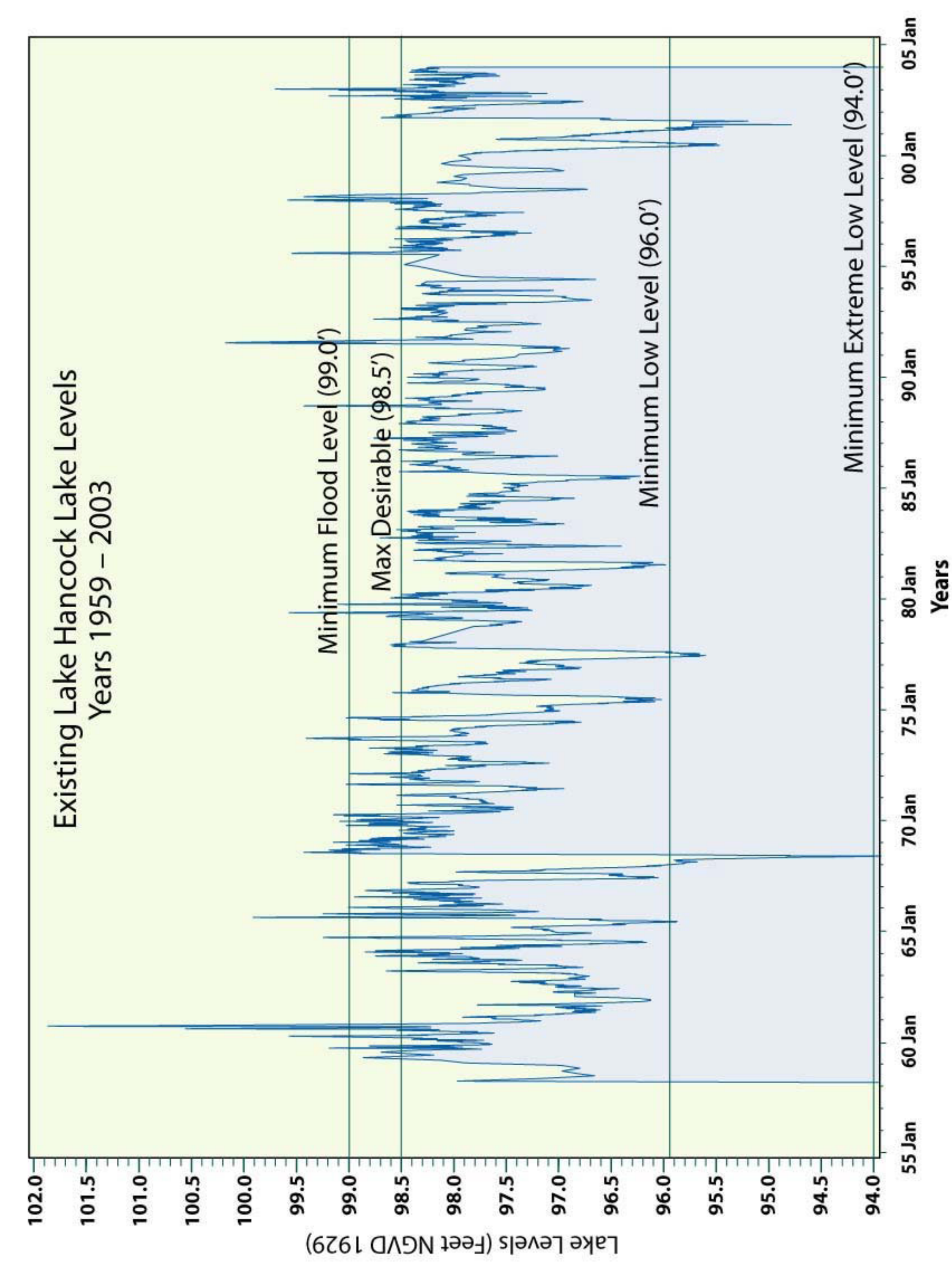


Figure 14. Existing Lake Hancock Levels

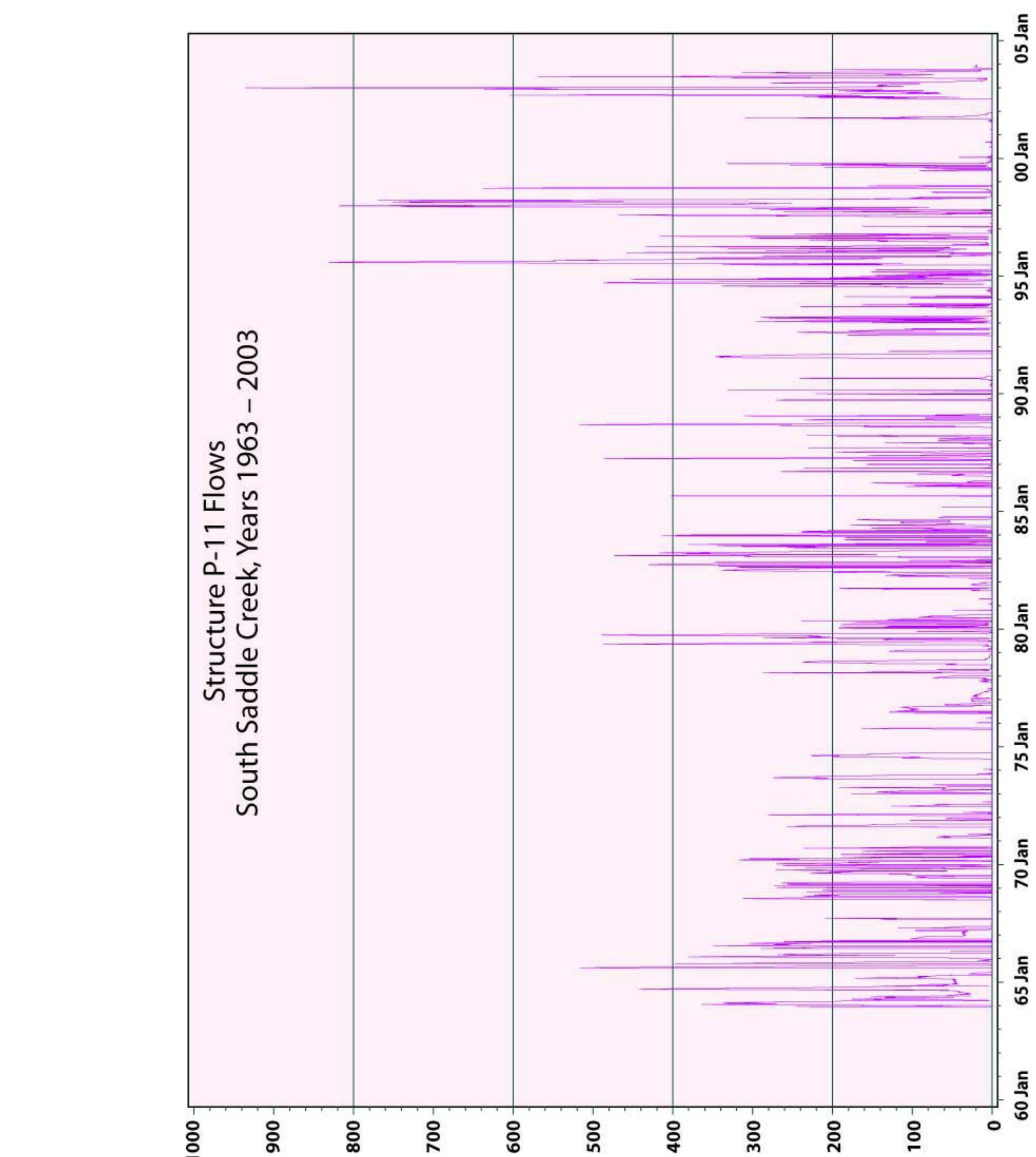


Figure 15. Structure P-11 Flows

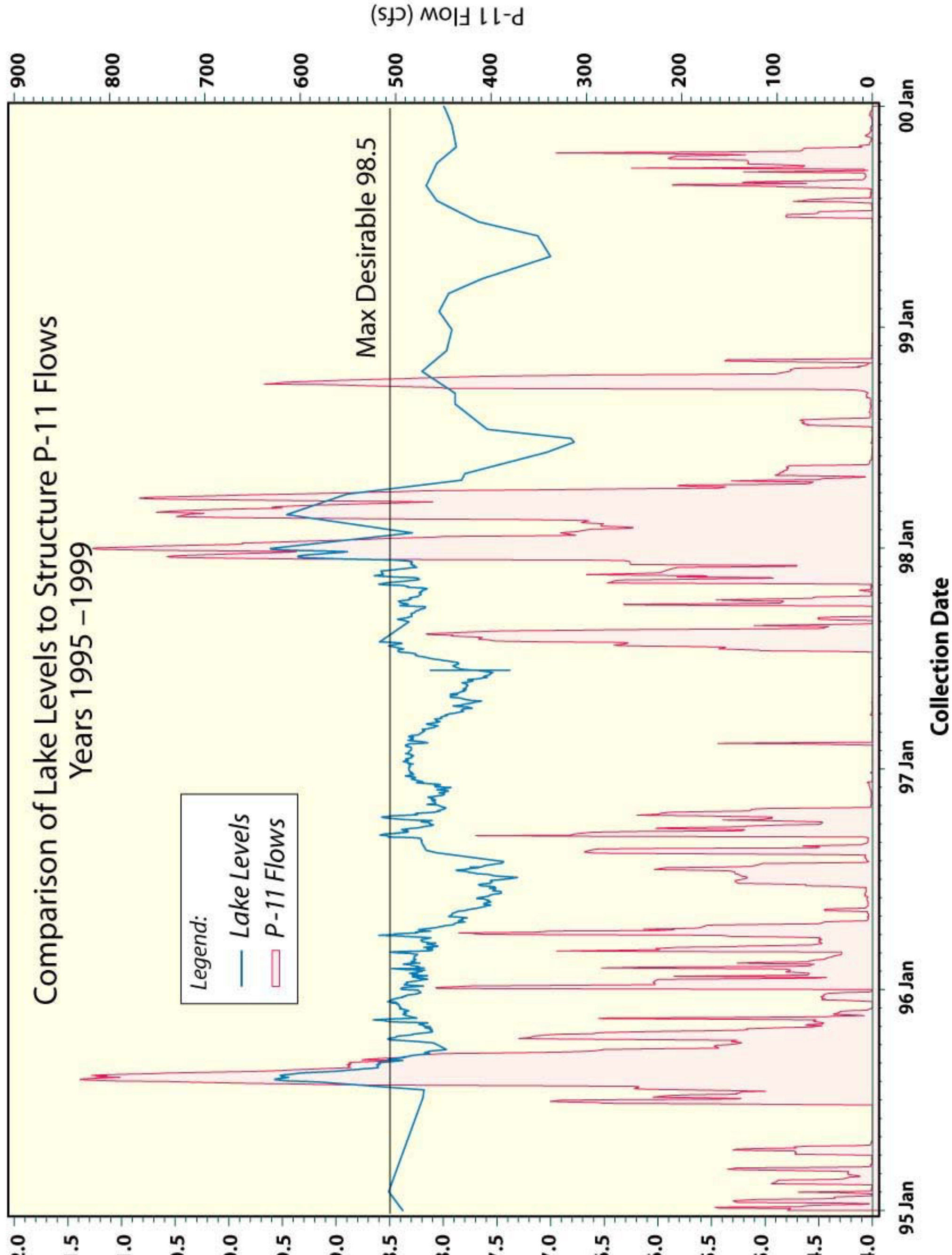


Figure 16. Comparison of Lake Levels to Structure P-11 Flows

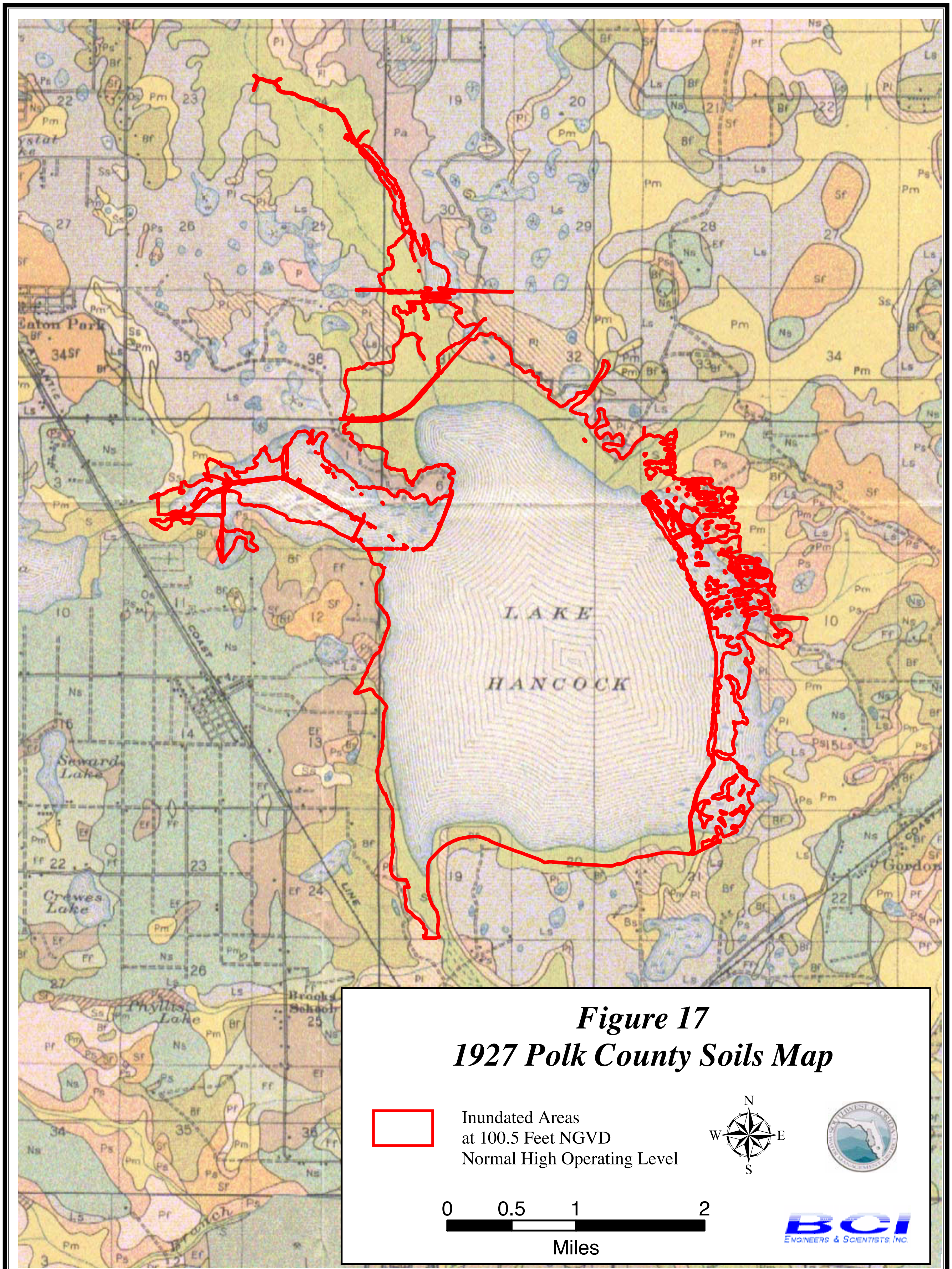


Figure 17
1927 Polk County Soils Map

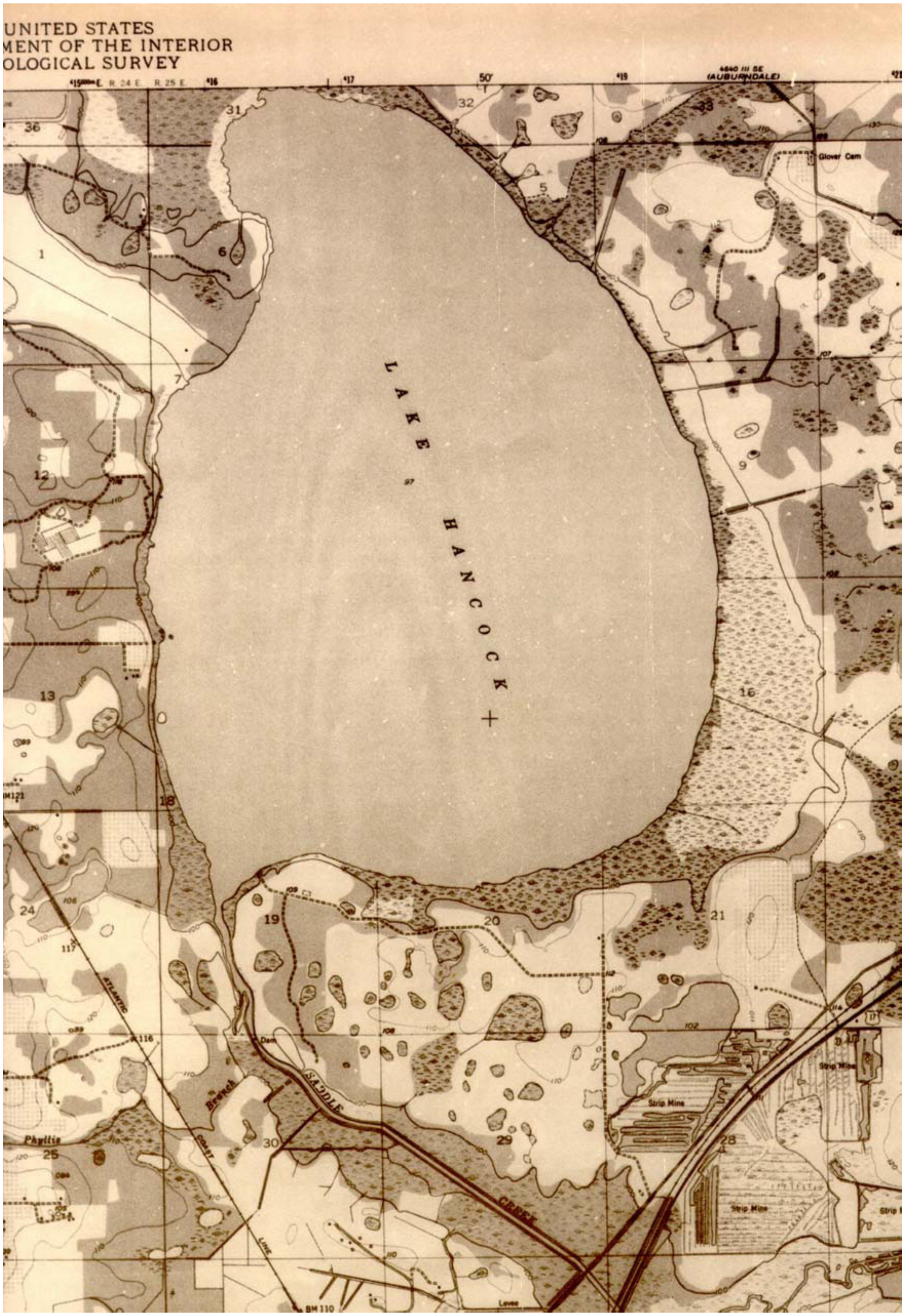


Figure 18 USGS 1949 Bartow Quadrangle Map

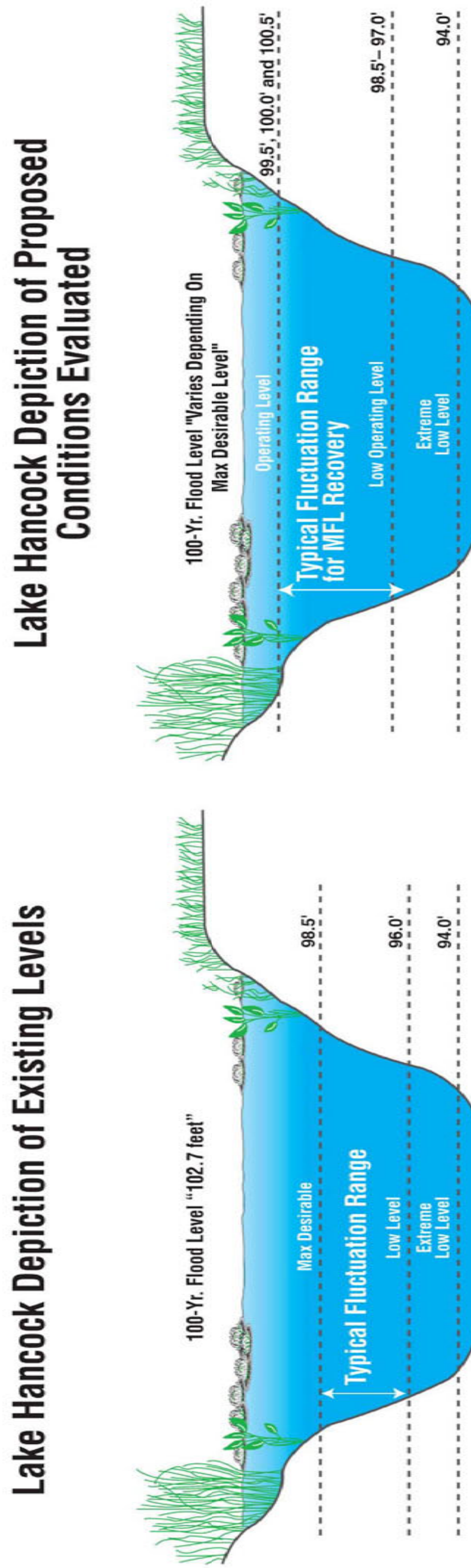
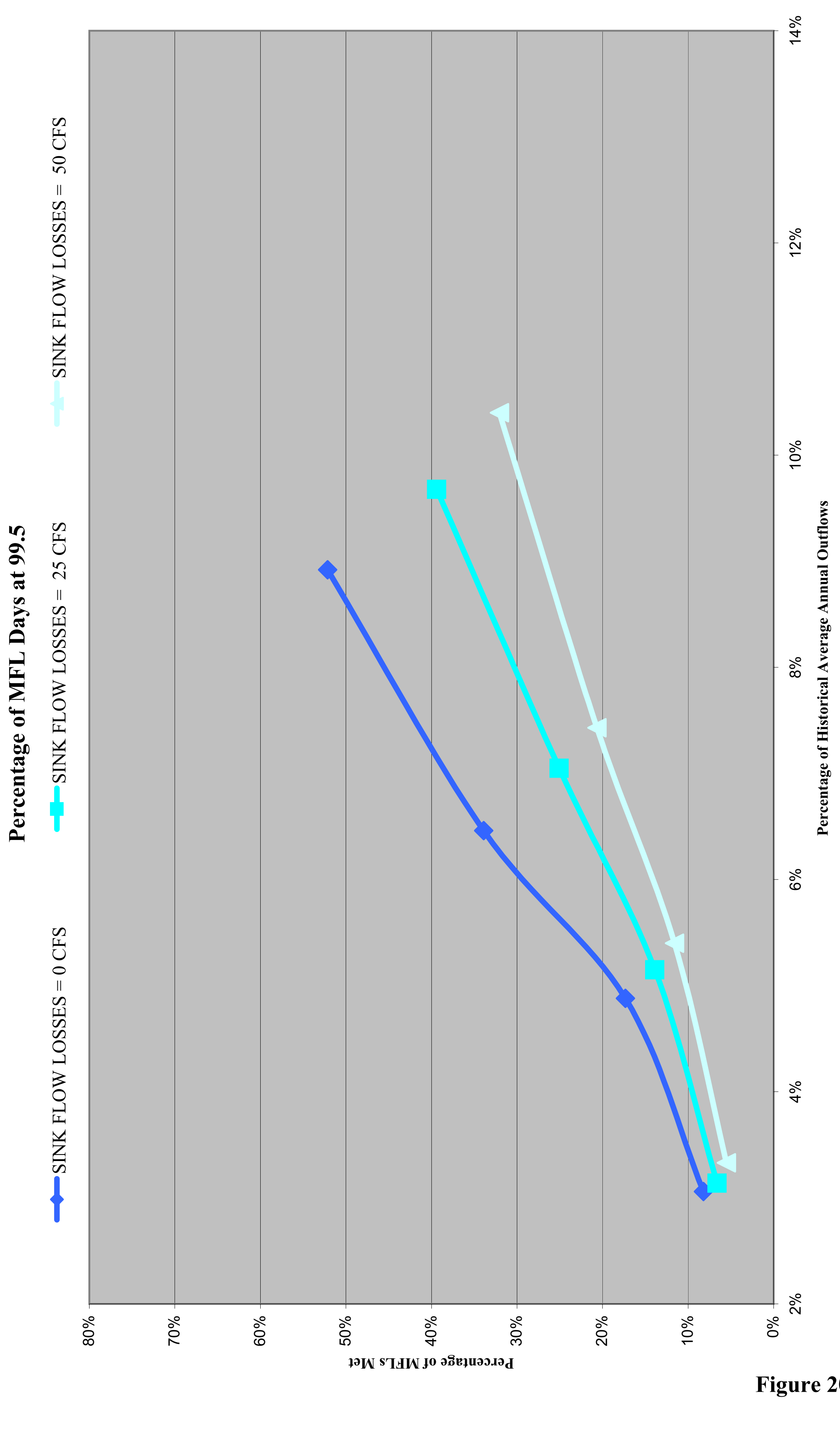
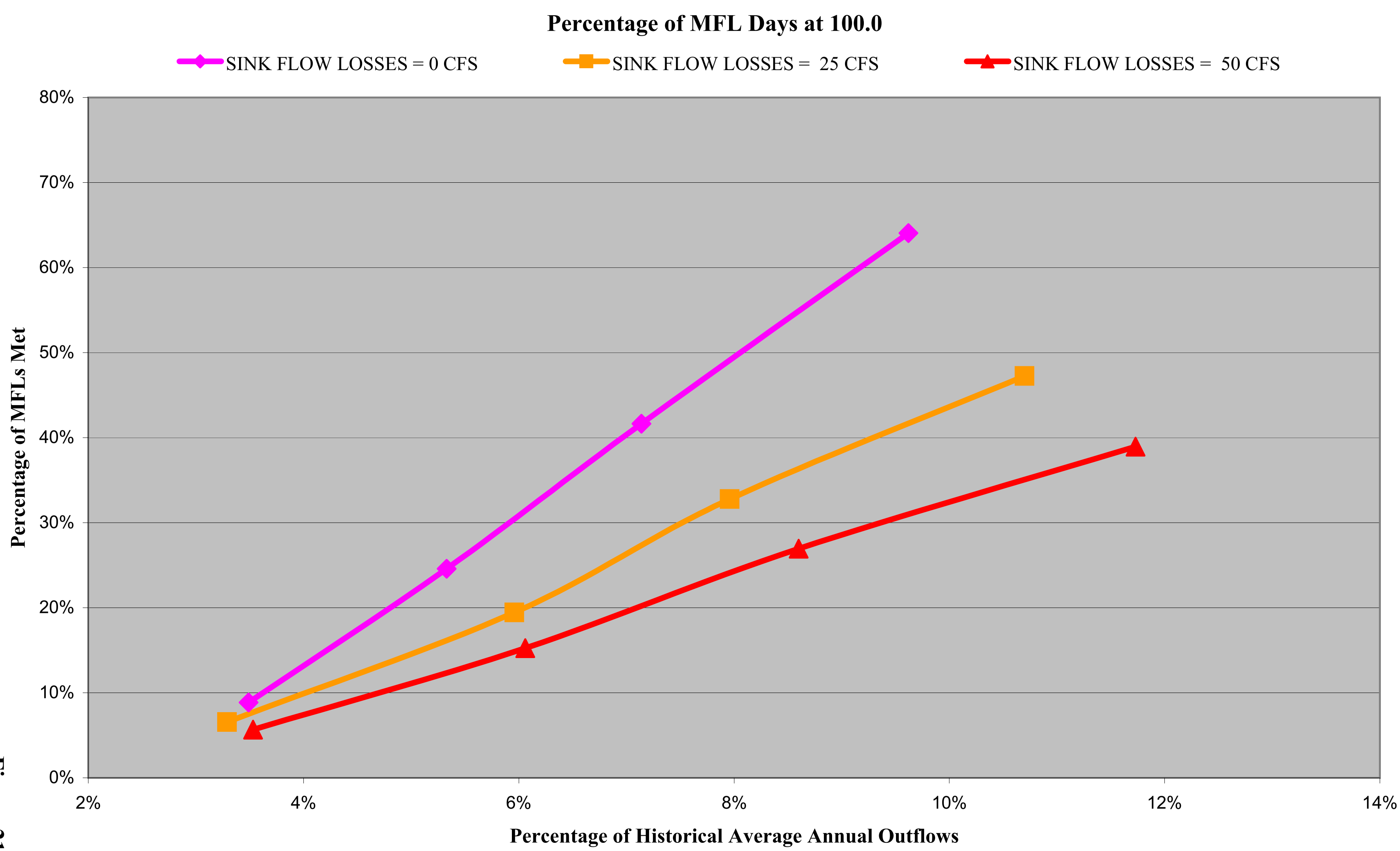

Lake Hancock Depiction of Existing Levels
100-Yr. Flood Level "102.7 feet"
Max Desirable
Typical Fluctuation Range
Low Level
Extreme
Low Level
98.5'
96.0'
94.0'
Lake Hancock Depiction of Proposed
Conditions Evaluated
100-Yr. Flood Level "Varies Depending On
Max Desirable Level"
Operating Level
Typical Fluctuation Range
for MFL Recovery
Low Operating Level
Extreme
Low Level
99.5', 100.0' and 100.5'
98.5'– 97.0'
94.0'

Figure 19.



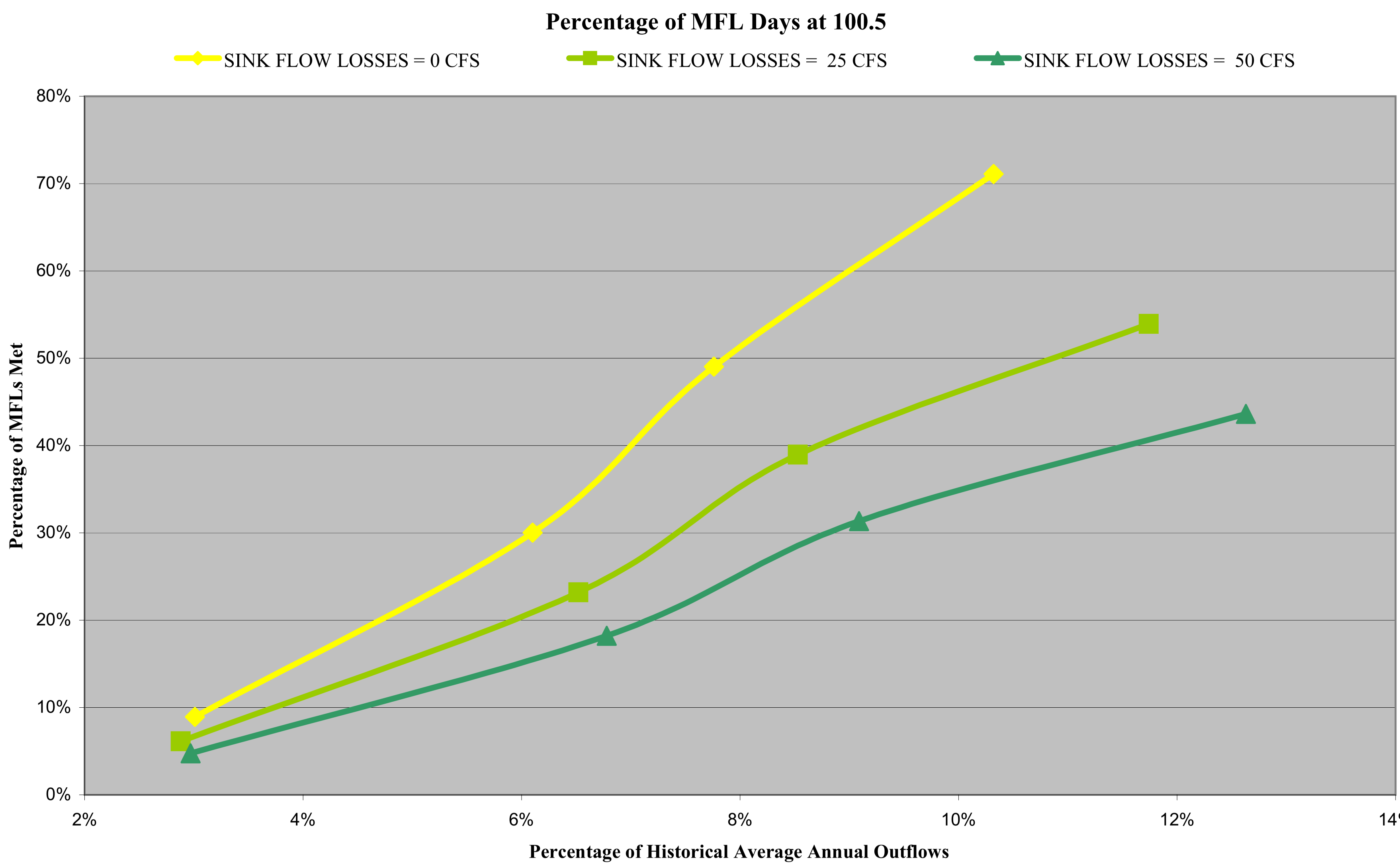
Percentage of MFL Days at 99.5
SINK FLOW LOSSES = 0 CFS
SINK FLOW LOSSES = 25 CFS
SINK FLOW LOSSES = 50 CFS
Percentage of MFLs Met
Percentage of Historical Average Annual Outflows
0%
10%
20%
30%
40%
50%
60%
70%
80%
2%
4%
6%
8%
10%
12%
14%

Figure 20.



Percentage of MFL Days at 100.0
SINK FLOW LOSSES = 0 CFS
SINK FLOW LOSSES = 25 CFS
SINK FLOW LOSSES = 50 CFS
Percentage of MFLs Met
80%
70%
60%
50%
40%
30%
20%
10%
0%
2%
4%
6%
8%
10%
12%
14%
Percentage of Historical Average Annual Outflows

Figure 21.



Percentage of MFL Days at 100.5
SINK FLOW LOSSES = 0 CFS
SINK FLOW LOSSES = 25 CFS
SINK FLOW LOSSES = 50 CFS
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percentage of MFLs Met
2%
4%
6%
8%
10%
12%
14%
Percentage of Historical Average Annual Outflows

Figure 22.

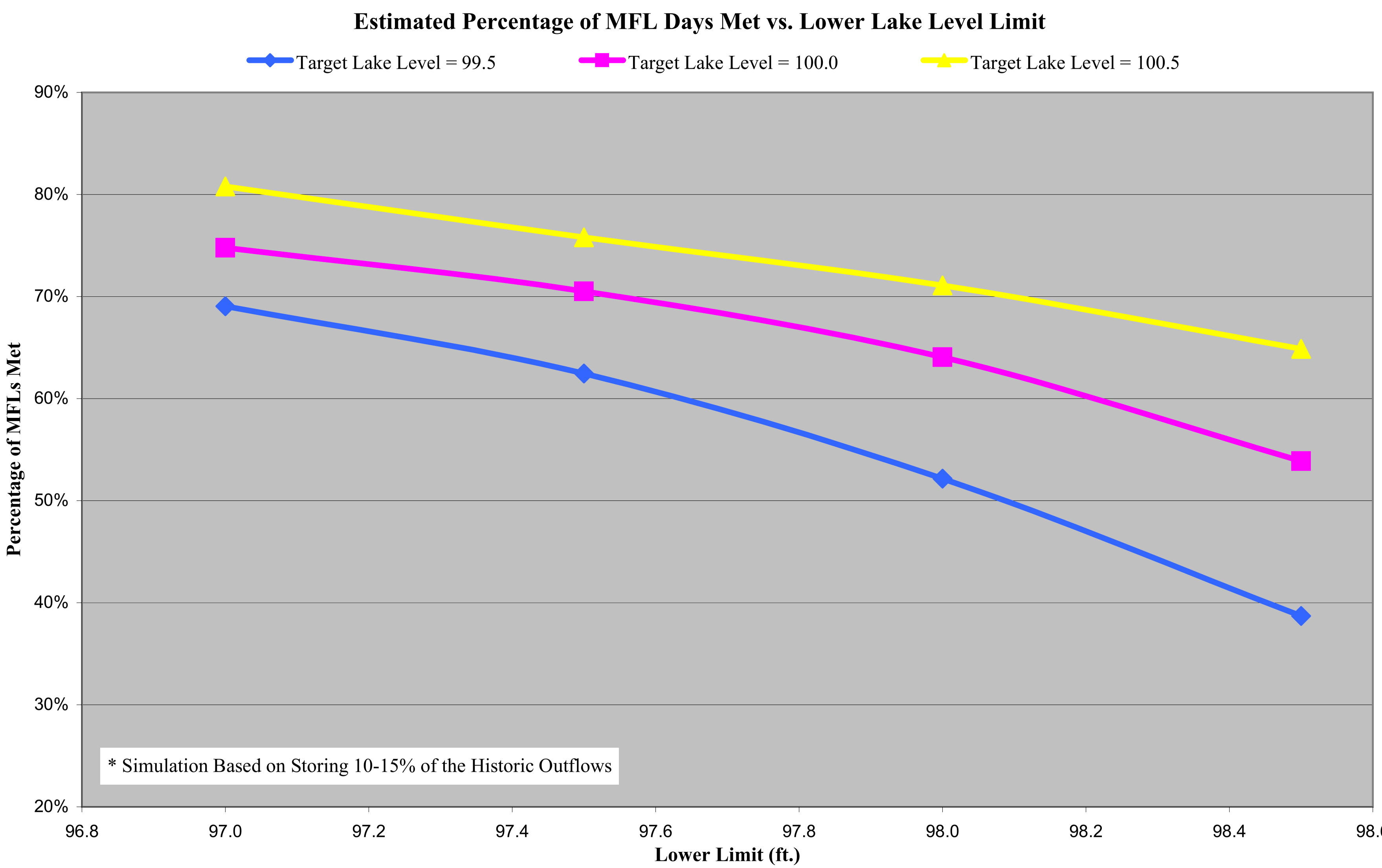

Estimated Percentage of MFL Days Met vs. Lower Lake Level Limit
Target Lake Level = 99.5
Target Lake Level = 100.0
Target Lake Level = 100.5
Percentage of MFLs Met
90%
80%
70%
60%
50%
40%
30%
20%
96.8
97.0
97.2
97.4
97.6
97.8
98.0
98.2
98.4
98.6
Lower Limit (ft.)
* Simulation Based on Storing 10-15% of the Historic Outflows

Figure 23.

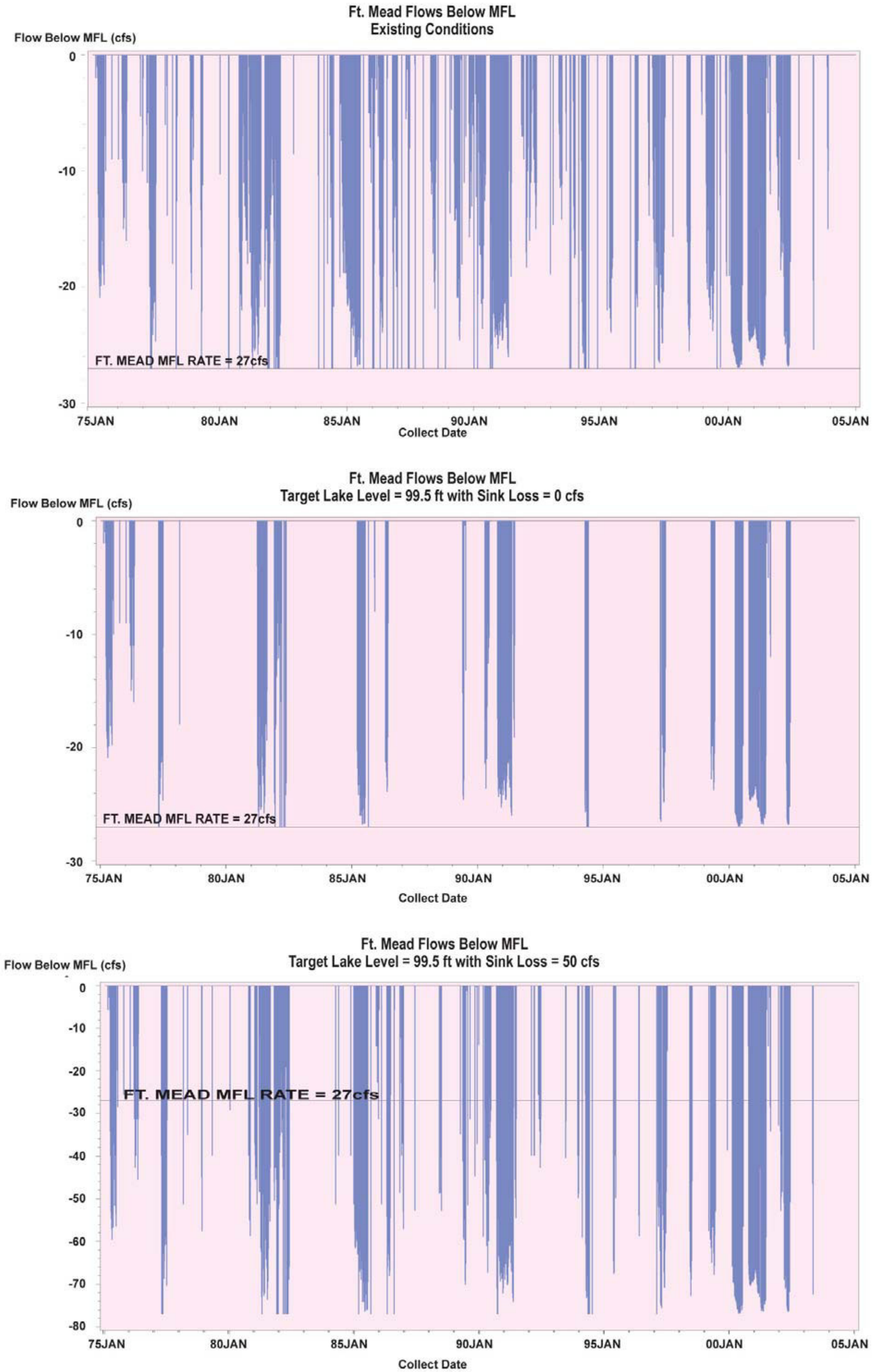


Figure 24. MFLs for Existing, 0, and 50 cfs Sink Losses at 99.5

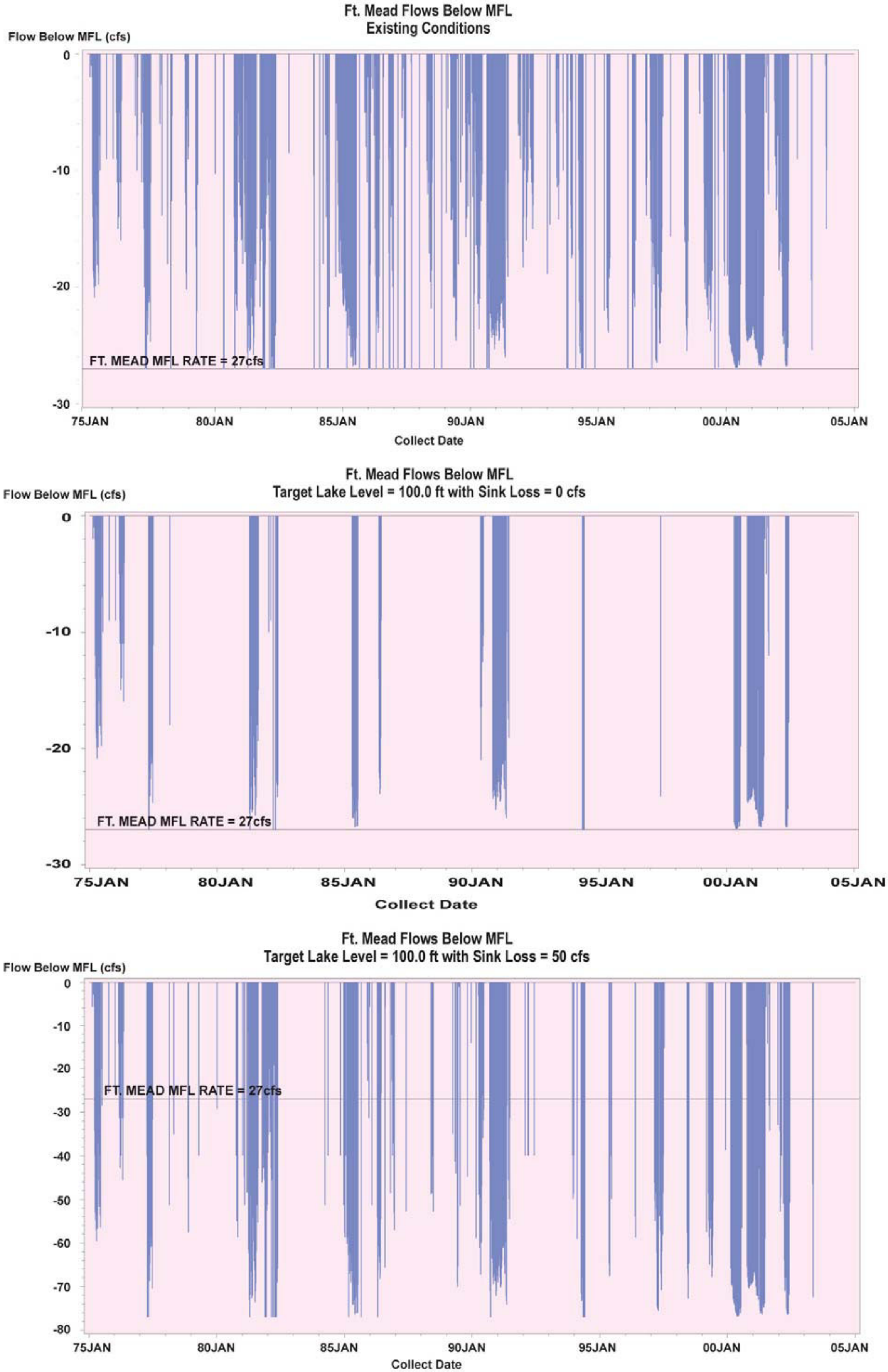


Figure 25. MFLs for Existing, 0, and 50 cfs Sink Losses at 100.0

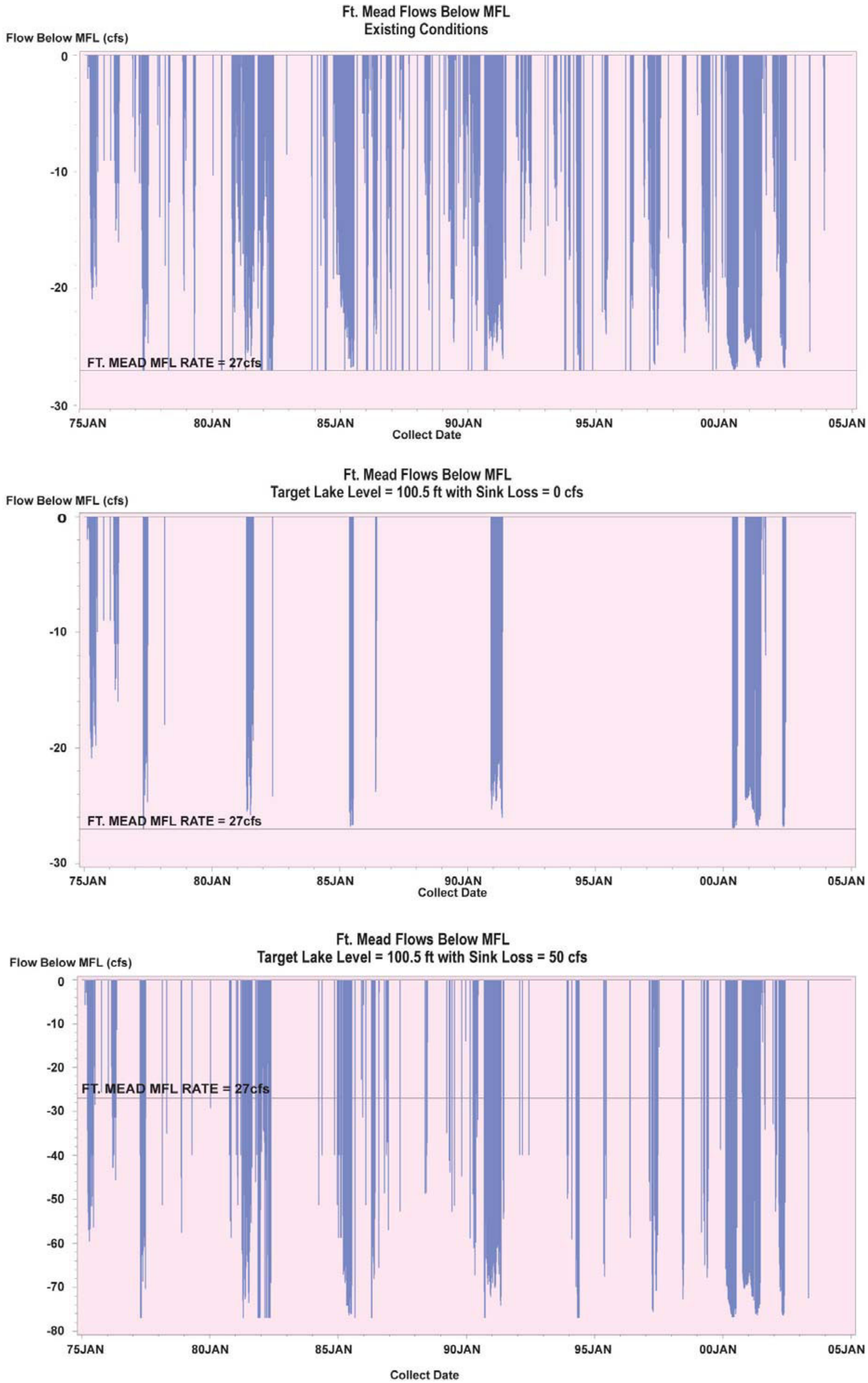
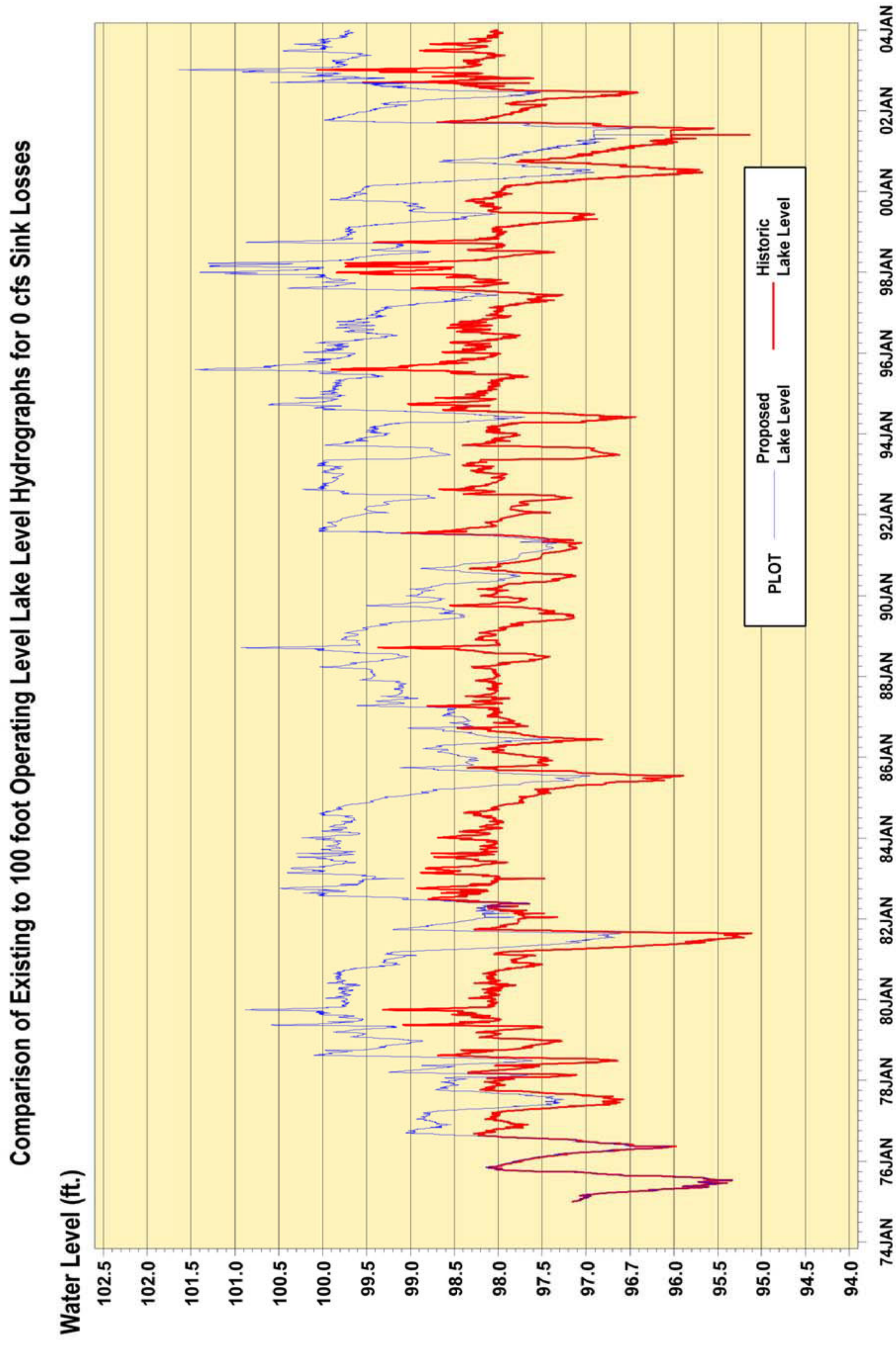


Figure 26. MFLs for Existing, 0, and 50 cfs Sink Losses at 100.5



Comparison of Existing to 100 foot Operating Level Lake Level Hydrographs for 0 cfs Sink Losses
Water Level (ft.)
102.5
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.7
96.0
95.5
95.0
94.5
94.0
74JAN
76JAN
78JAN
80JAN
82JAN
84JAN
86JAN
88JAN
90JAN
92JAN
94JAN
96JAN
98JAN
00JAN
02JAN
04JAN
Collect Date
PLOT
Proposed Lake Level
Historic Lake Level

Figure 27.

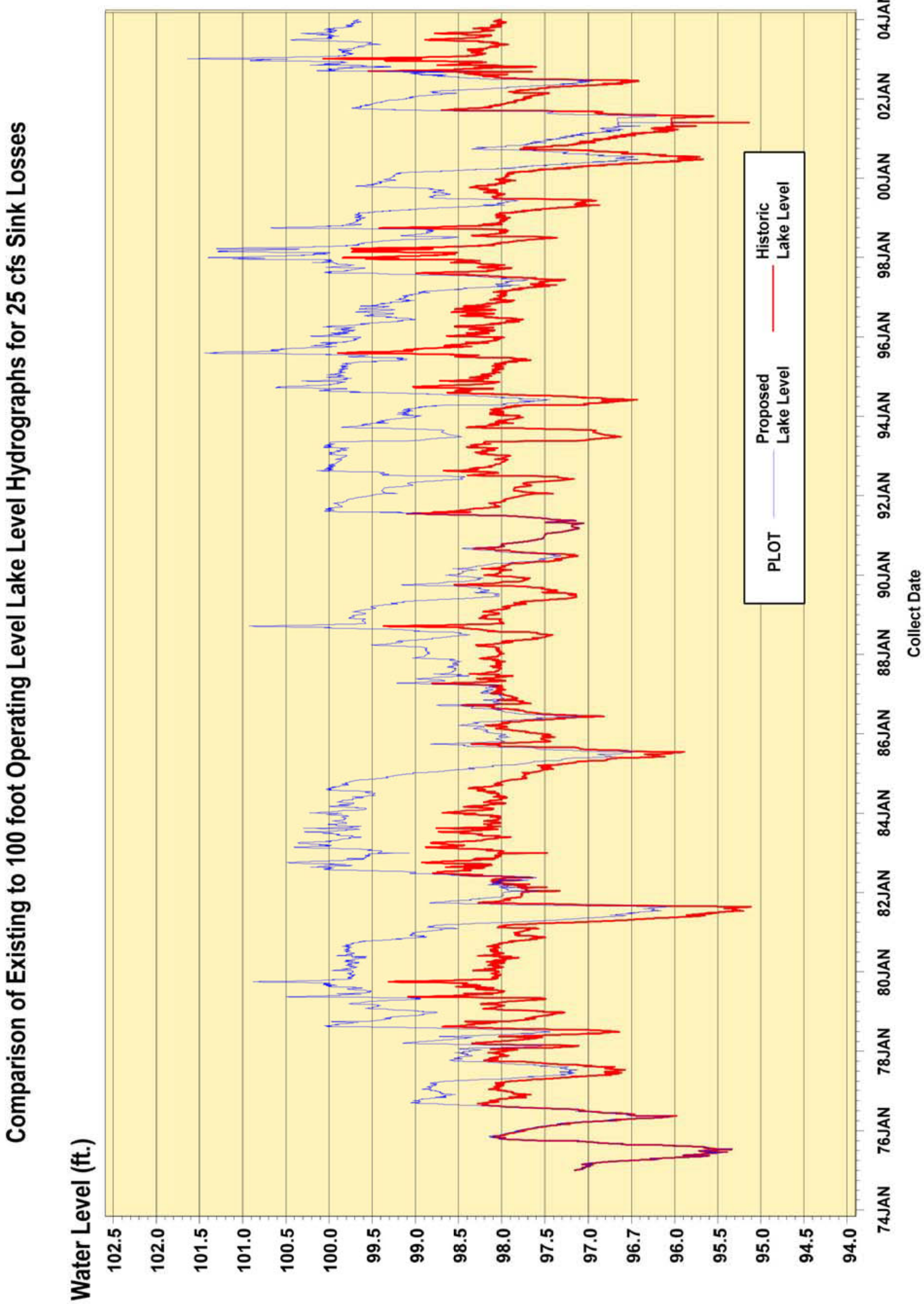
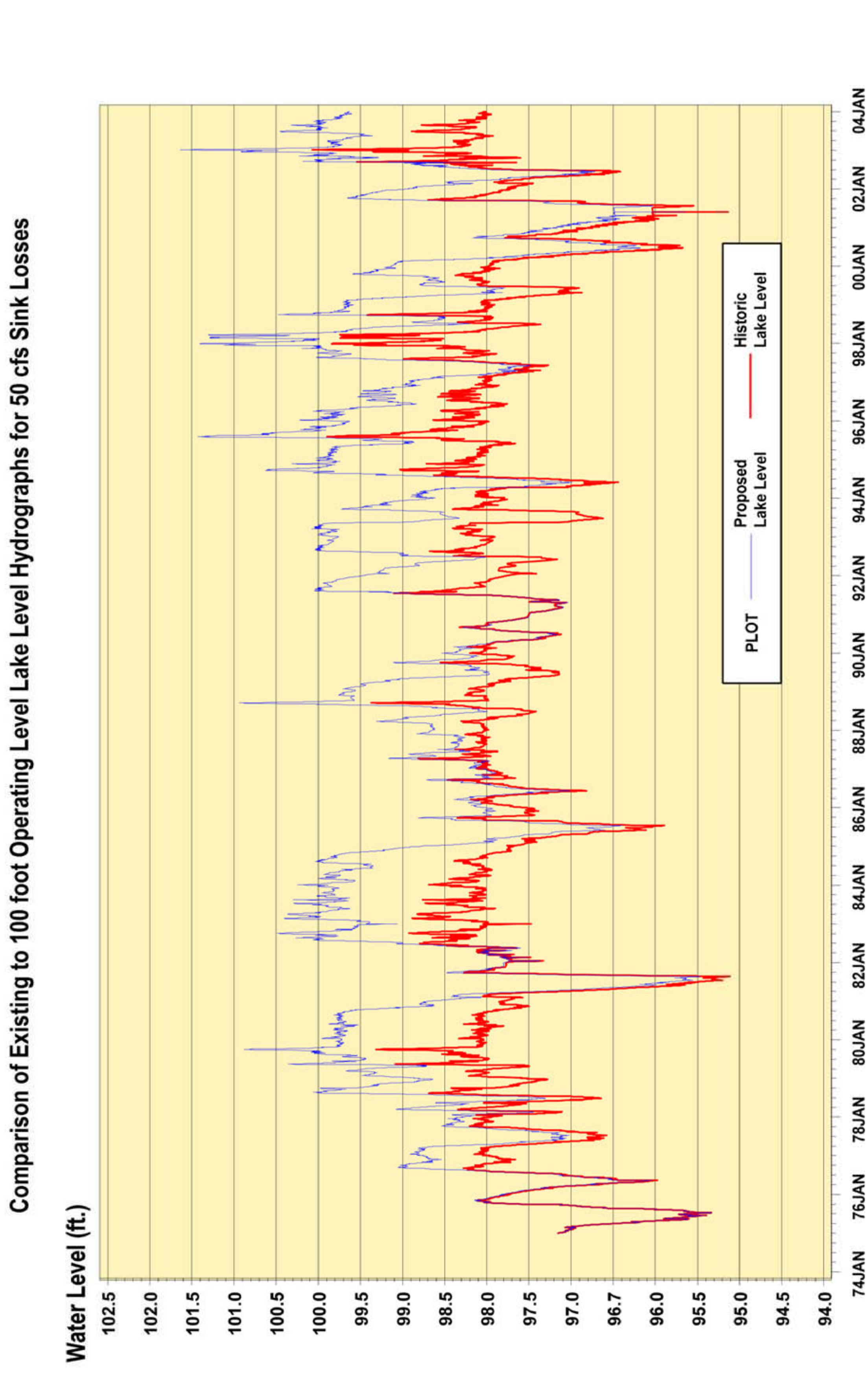
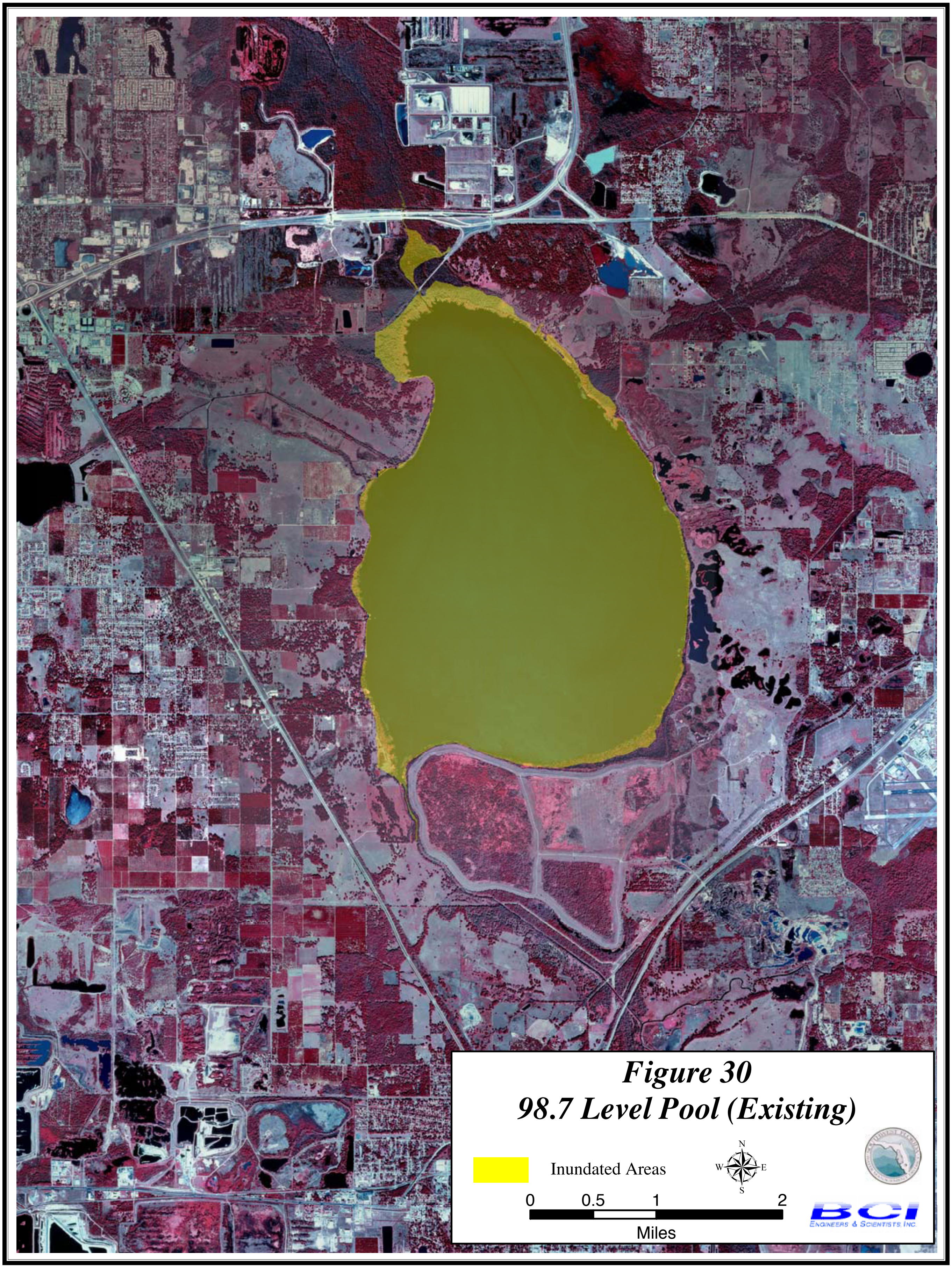

Comparison of Existing to 100 foot Operating Level Lake Level Hydrographs for 25 cfs Sink Losses
Water Level (ft.)
102.5
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.7
96.0
95.5
95.0
94.5
94.0
74JAN
76JAN
78JAN
80JAN
82JAN
84JAN
86JAN
88JAN
90JAN
92JAN
94JAN
96JAN
98JAN
00JAN
02JAN
04JAN
Collect Date
PLOT
Proposed Lake Level
Historic Lake Level

Figure 28.



Comparison of Existing to 100 foot Operating Level Lake Level Hydrographs for 50 cfs Sink Losses
Water Level (ft.)
102.5
102.0
101.5
101.0
100.5
100.0
99.5
99.0
98.5
98.0
97.5
97.0
96.7
96.0
95.5
95.0
94.5
94.0
74JAN
76JAN
78JAN
80JAN
82JAN
84JAN
86JAN
88JAN
90JAN
92JAN
94JAN
96JAN
98JAN
00JAN
02JAN
04JAN
Collect Date
PLOT
Proposed Lake Level
Historic Lake Level

Figure 29.



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V:\19-12376_Swfwmd_Hancock\Data-Collection-9-10-03\Draft_Figures\Figure31_99.5_Level.mxd May 7, 2004


Figure 32
100.0 Level Pool
Inundated Areas
N
W
E
S
0
0.5
1
2
Miles
BCI
Engineers & Scientists Inc.

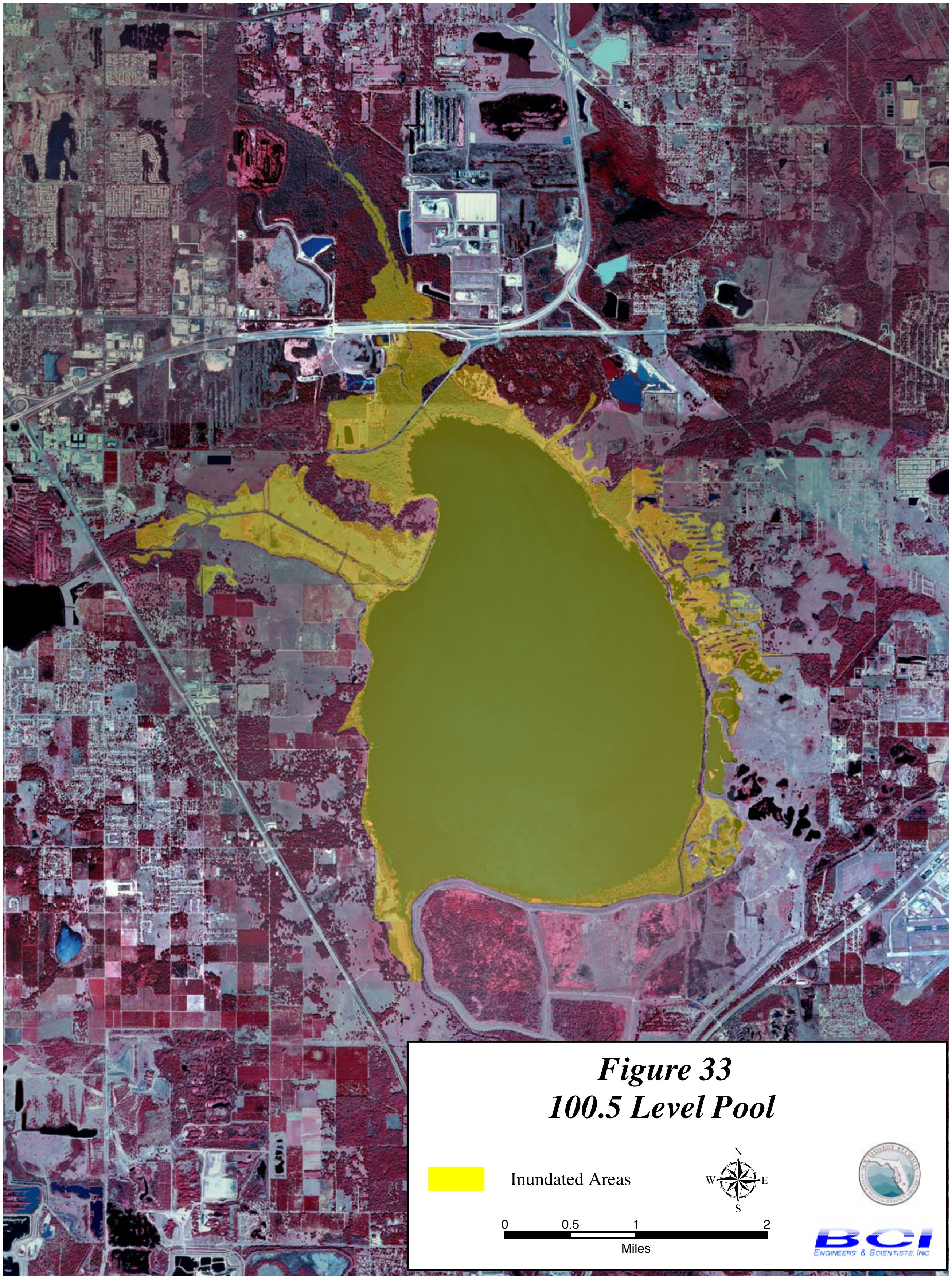
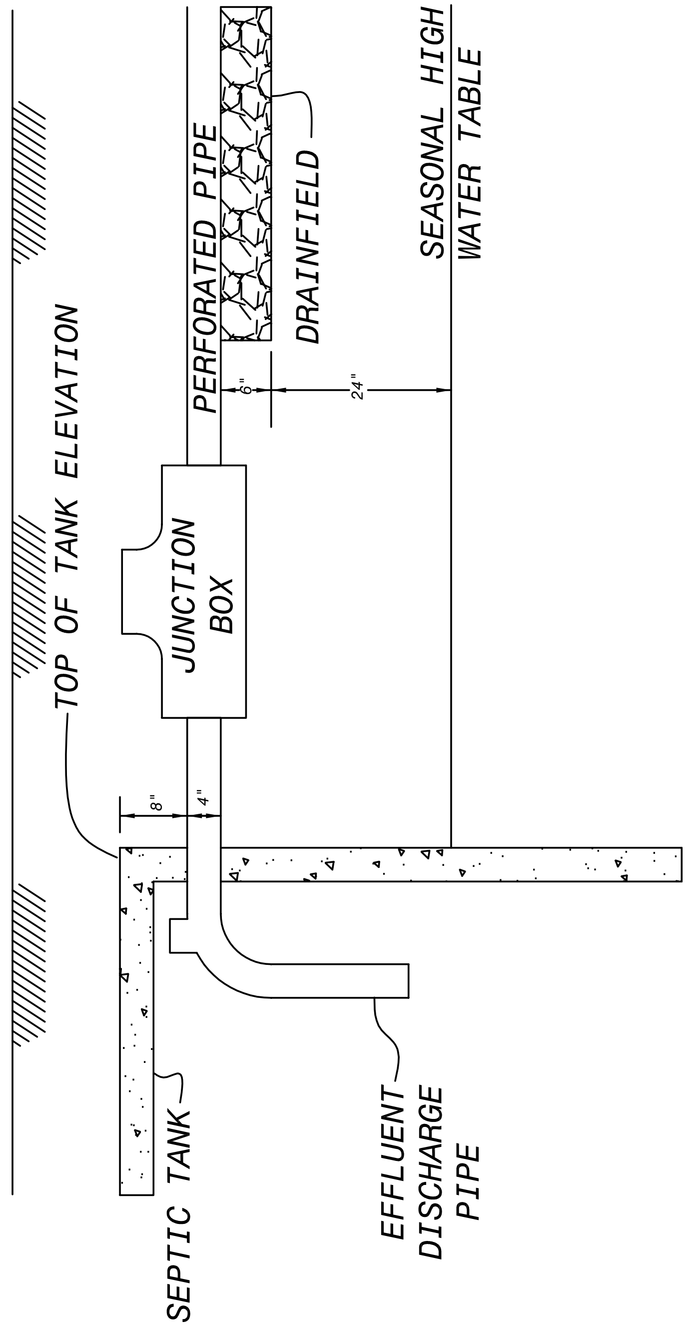


Figure 33
100.5 Level Pool



BCI FILE: P:\PROJECTS\19-12376.9\dwg\19-12376.9 SEPTIC TANK.dwg - Wed, May 5 2004 - 11:48 AM

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ENGINEERS & SCIENTISTS, INC.
2000 E. EDGEWOOD DRIVE, LAKELAND, FL 33803
PHONE: (863) 667-2345
WEB SITE: www.BCIENG.com
EB-0007867

FIGURE 34

TYPICAL CROSS SECTION
OF
SEPTIC TANK/DRAINFIELD

DATE: 03-31-04	REVISED:	DRAWN BY: CHR	SCALE: NTS	PROJECT NO.: 19-12376.9

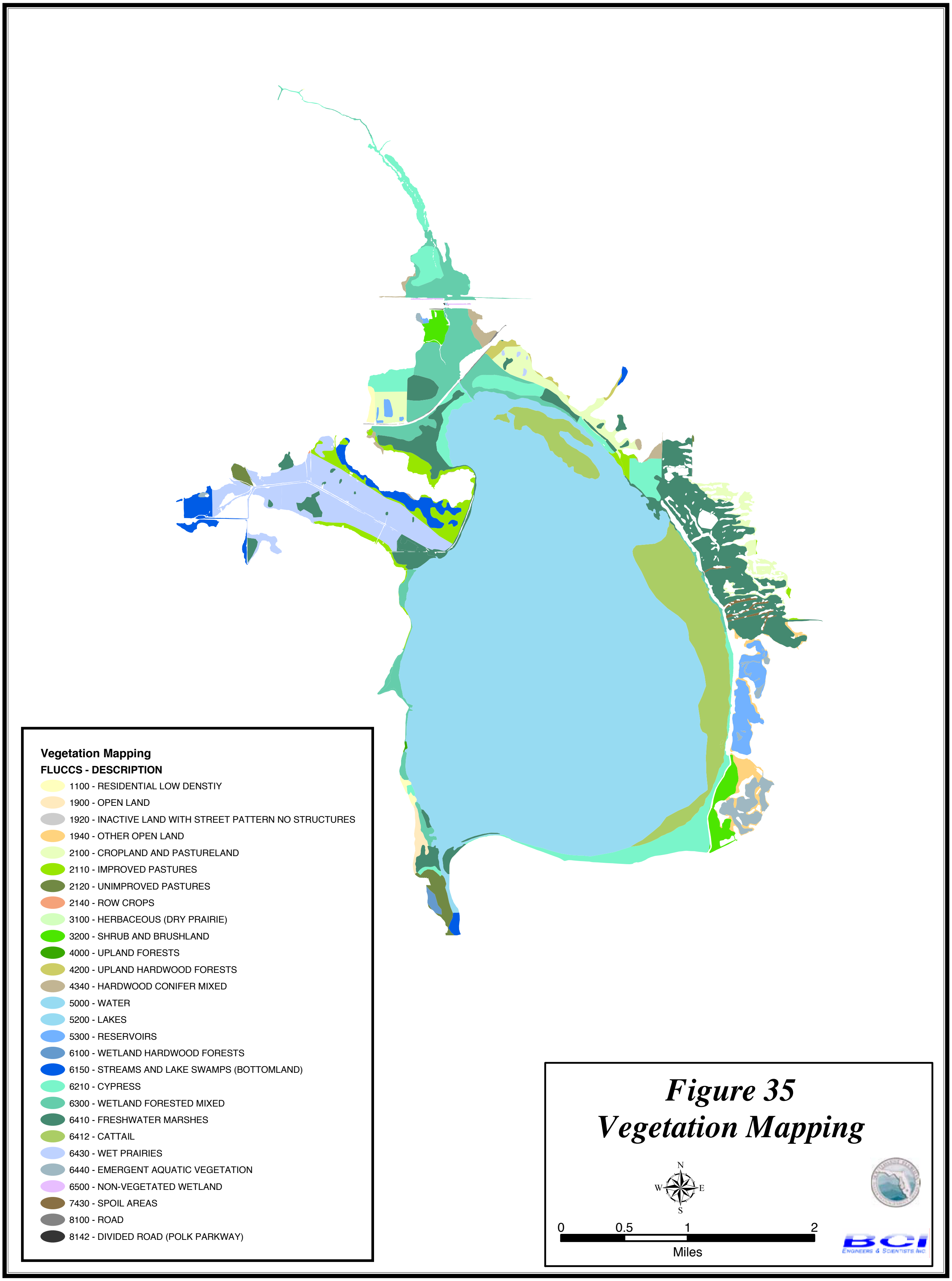

Figure 35
Vegetation Mapping

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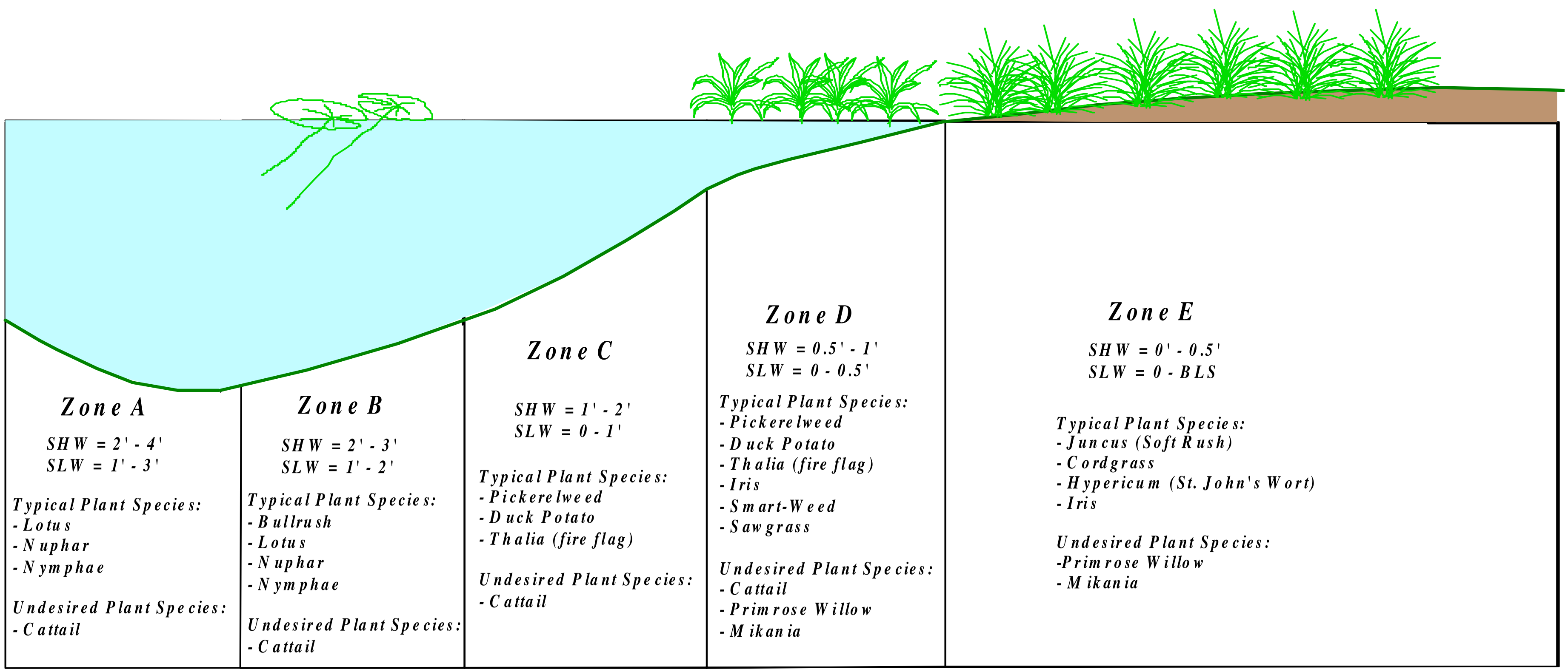
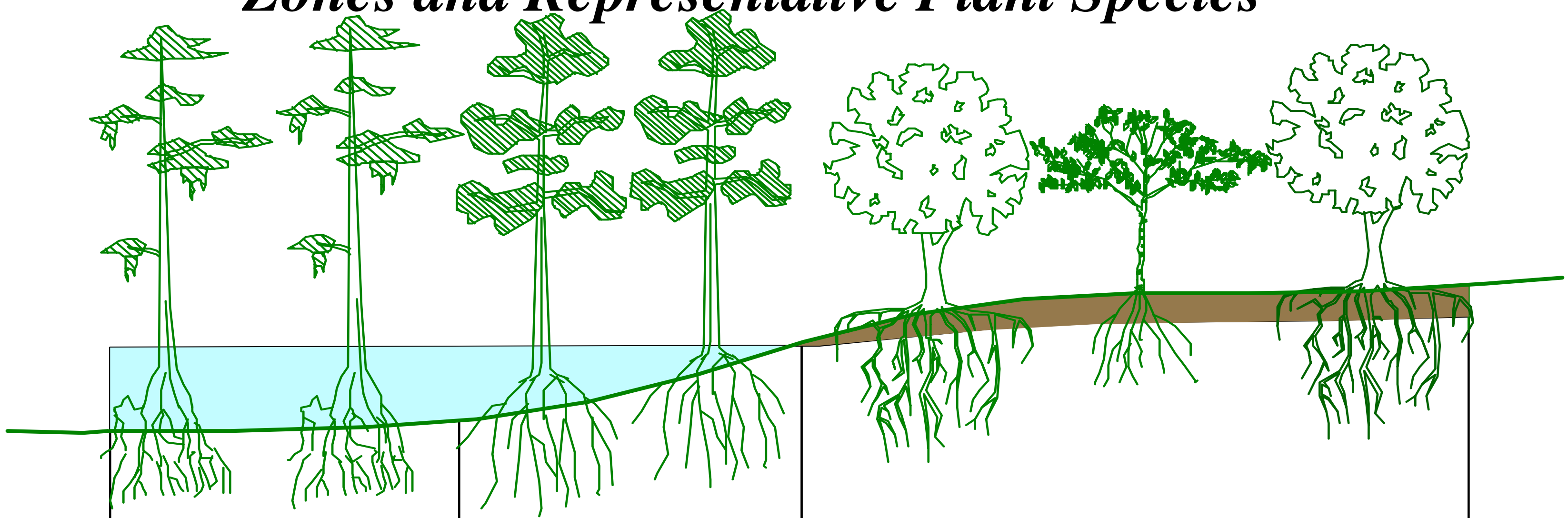
*Figure 36 Herbaceous Wetlands, Hydrologic Zones and Representative Plant Species**



* Increase in water depth may cause transition to adjacent zone.

Figure 37 Forested Wetlands, Hydrologic Zones and Representative Plant Species



Zone A	Zone B	Zone C
SHW = 1' - 2.5' SLW = 0 - 1'	SHW = 0.5' - 1' SLW = 0 - 0.5'	SHW = 0 - 0.5' SLW = Saturated in BLS
Typical Plant Species: - Cypress - Black Gum - Pop Ash	Typical Plant Species: - Water Hickory - Bay Trees (Loblloly, Red Bay, Sweet Bay) - Maple - Black Gum - Pop-Ash	Typical Plant Species: - Water Oaks - Laurel Oaks - Maples - Sweetgum - Slash Pine - Dahoon Holly
Undesired Plant Species: - Cattail - Primrose Willow	Undesired Plant Species: - Cattail - Primrose Willow - Mikania	Undesired Plant Species: -Primrose Willow - Mikania
Increases in water depth may cause transition to wetland herbaceous	Increases in water depth may cause transition to Zone A	Increases in water depth may cause transition to Zone B

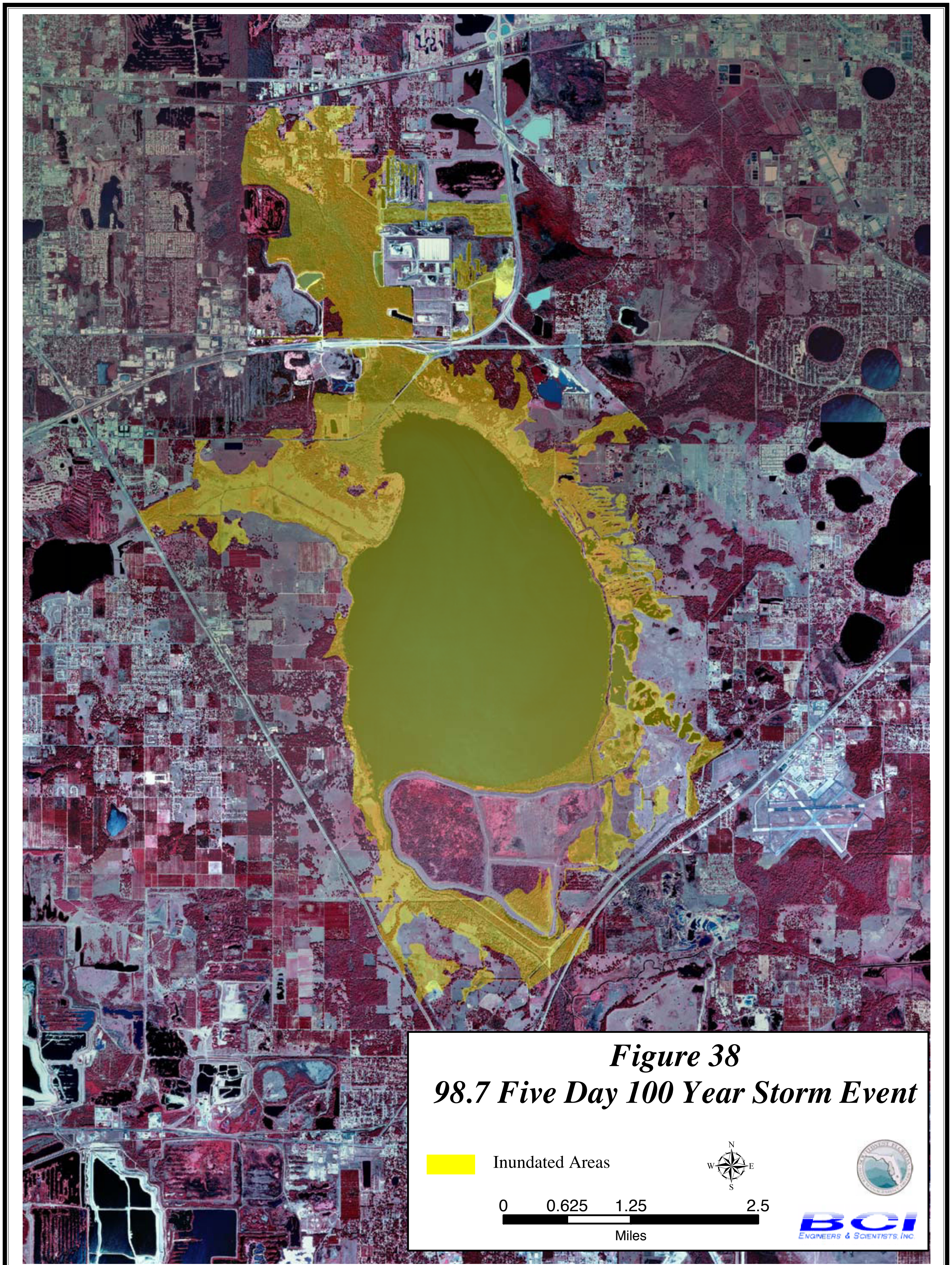


Figure 38
98.7 Five Day 100 Year Storm Event

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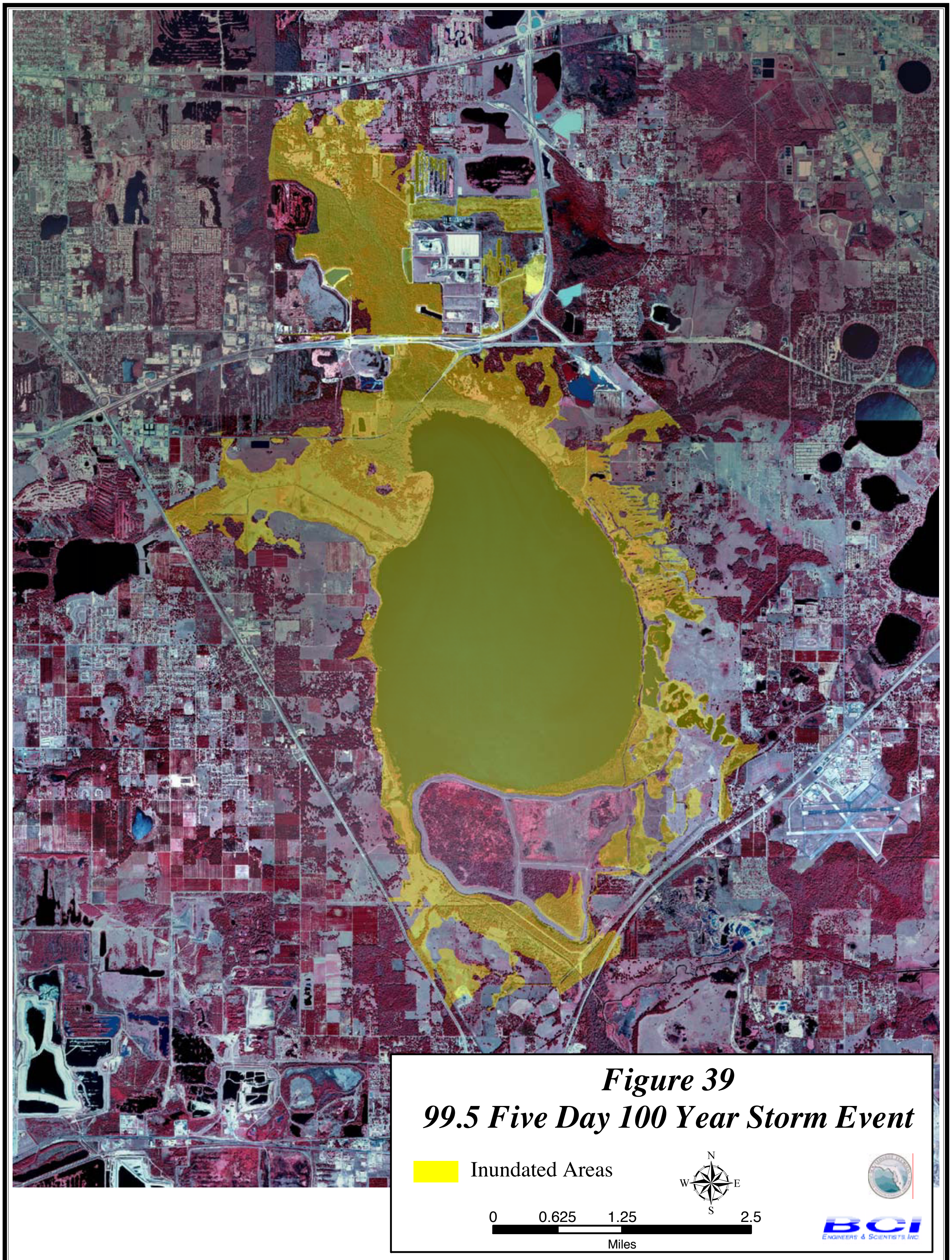

Figure 39
99.5 Five Day 100 Year Storm Event

Figure 40

100.0 Five Day 100 Year Storm Event

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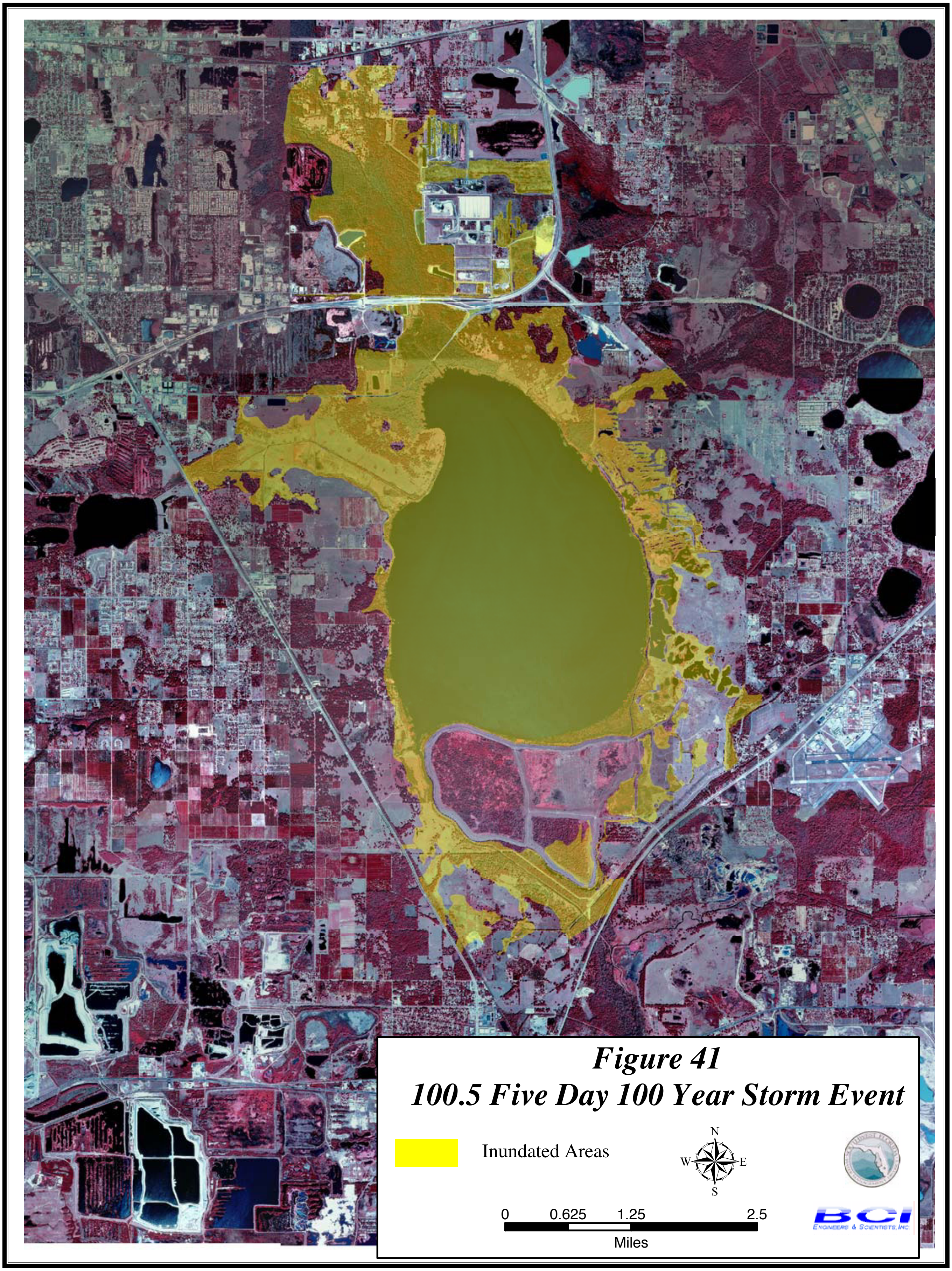

Figure 41

100.5 Five Day 100 Year Storm Event

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APPENDIX A

FLOODPLAIN SIMULATION MODEL

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

FLOODPLAIN SIMULATION MODEL

DESCRIPTION OF THE WATERSHED

Figure A1 shows the location of the Lake Hancock Watershed within Polk County Florida. The Lake Hancock Watershed is part of the Upper Saddle Creek watershed of the Upper Peace River watershed and includes parts of the cities of Lakeland, Auburndale, Highland City, and Eagle Lake. The watershed extends north of Interstate-4 and south to U.S. Highway-17.

Figure A2 provides an aerial photograph of the Lake Hancock watershed. The Lake Hancock Watershed has an area of approximately 157 square miles. The watershed contains a number of lakes that make up over 20 square miles of the watershed.

Figure A3 shows the Lake Hancock Watershed divided into nine hydrologic basins. Topographic surface elevations within the area range between 75 and 265 feet National Vertical Geodetic Datum (ft. NGVD) and are shown in **Figure A4**.

The northern-most basin, encompassing the Tenoroc Fish Management Area (TFMA), is upstream of C.R. 546 (Saddle Creek Road), has an area of 23.8 square miles, and includes the previously phosphate-mined lands of Coronet, Bridgewater and Williams. Discharge from the Upper Saddle Creek Tenoroc Basin enters Saddle Creek and flows to Lake Hancock. Within the Tenoroc basin are numerous lakes, wetlands, and clay settling areas (CSA) that provide significant retention and detention of runoff. A major restoration project designed to create significant wetland acreage and improve surface water discharge is currently underway in this area.

The Lake Parker basin encompasses an area of approximately 23.6 square miles, draining most of the central and eastern portions of the City of Lakeland. Other lakes within this system include Lake Gibson, Lake Deeson, Lake Crago, Lake Bonny, Lake Mirror and Lake Holloway. Lake Parker discharges along the eastern side of the lake through Lake Parker Outfall Canal. Discharge from the lake is controlled by a 26’ x 3’ weir gate in a single bay operated by tandem Armco lifts. The gate crest is adjustable and generally maintains water levels within the lake between 129.75 and 131.60 ft National Geodetic Vertical Datum (NGVD).

The Cabbage Branch basin has an area of approximately 6.8 square miles just south of the Tenoroc basin. Cabbage Branch is generally a shallow channel that meanders through large natural wetland systems. The eastern portion of the basin is characterized by remnant lakes of borrow mining operations. Cabbage Branch basin discharges to Saddle Creek downstream approximately midway between S.R. 546 (Saddle Creek Road) south of the Tenoroc basin and S.R. 540 north of Lake Hancock. Under high flow or flood conditions, discharge from Cabbage Branch may enter K-Ville Ditch.

The K-Ville Ditch drainage basin has an area of approximately 2.7 square miles just south of Cabbage Branch basin. The K-Ville ditch is a relatively straight and shallow ditch that flows through wooded areas and older residential developments. At the downstream extent, the ditch flows are routed into remnant mine ponds before discharging to Saddle Creek approximately 2 miles downstream of the Cabbage Branch confluence with Saddle Creek.

The Middle Saddle Creek Basin has an area of 17.0 square miles and extends from the southern extent of the Tenoroc Basin at S.R. 546 downstream to S.R. 540 just north of Lake Hancock. The basin contains numerous natural and man-made lakes and large natural wetlands providing storage and runoff detention. The Middle Saddle Creek basin receives inflows from the Lake Parker, Cabbage Branch, and K-Ville basins.

The Lena Run drainage basin has an area of approximately 20.5 square miles and lies east of the Tenoroc, Cabbage Branch, and K-Ville Basins. The Lena Run basin includes the interconnected Lakes Arietta, Ariana, Whistler, and Lena. Lake Lena discharge is controlled by SWFWMD Structure P-1. The basin also includes Lake Thomas and the interconnected lakes of Sears, Spirit, Grassy, and Dinner. Lake Thomas is a ‘closed basin’ with no outfall structure. Grassy Lake was formerly a ‘closed basin’, but was recently modified with a pumping station and piping to discharge under near-flood conditions to Dinner Lake, which discharges over a weir and through a channel to wetlands that drain into Lena Run. Spirit Lake was similarly a part of a ‘closed basin’ that included Sears Lake, until the system was recently modified to discharge through underground pipes to the wetlands north and downstream of Dinner Lake.

The Eagle/Millsite Lakes Basin is just south of the Lena Run Drainage Basin, and has an area of approximately 7.3 square miles. Discharge from Eagle Lake passes through a canal to Millsite Lake. Discharge from Millsite Lake passes through a series of ditches, wetlands, and culverts until it reaches the former Old Florida Plantation (OFP) property. Flow through the OFP property passes through a series of lakes, which are remnants of old phosphate mining and reclamation activities, before passing over a weir and entering Lake Hancock.

The Banana Lake Basin east of Lake Hancock has an area of approximately 21.4 square miles and includes portions of south Lakeland and the City of Highlands. Discharge from Banana Lake was historically controlled by four 24-inch diameter culverts and a 28-foot wide concrete overflow weir with a 9-foot deep steel sheet pile cut-off wall. An erosion channel bypassing the structure formed more than ten years ago that typically passes low flow discharges. The District currently has no plans to repair or modify the Banana Lake outfall. Discharge from Banana Lake drains into the Banana Lake Outfall Canal which passes through the Circle B Bar Ranch and into Lake Hancock.

The Lower Saddle Creek Basin has an area of approximately 34.2 square miles and includes Lake Hancock and its directly contributing areas. Discharge from Lake Hancock is controlled by Structure P-11 which has two 20’x7’ radial gates with a concrete spillway and steel sheet pile weir. Lower Saddle Creek joins with the Peace Creek Drainage Canal about 2.3 miles downstream of P-11.

GEOLOGIC SETTING

The Lake Hancock Watershed is located within the Polk Uplands physiographic province between the Lakeland Ridge and the Winter Haven Ridge (**Ref. 1**). The topographic relief of the watershed (**Figure A4**) is variable, ranging from relatively flat to gently undulating on some of the unmined areas, reclaimed mine sites and old clay settling areas (CSAs), to steeply sloping in the Lakeland Ridge and areas of remnant overburden spoil piles and CSA embankments. The highest elevations (approximately 260+ feet, referenced to the National Geodetic Vertical Datum [NGVD] of 1929) lie on some of the unmined areas in the wesstern portion of the watershed, and the lowest elevations (approximately 75 feet NGVD) are found in the south central portion of the watershed, below the southern end of Lake Hancock.

Peninsular Florida is underlain by a thick sequence of carbonate rocks capped by a thin series of siliciclastic rocks that range from mid-Mesozoic to Recent in age (**Ref. 2**). The aquifer systems of Florida are found within the rocks deposited in the earliest Tertiary (55 million years ago) to Recent Ages (<100,000 years ago). In west-central Florida, the most prominent structural feature is the Ocala Platform. The Ocala Platform was a positive feature during the Miocene Age. The Ocala limestone comprises the youngest geologic unit present on the crest of the Ocala Platform (east of the project area), and is of Late Eocene Age. It is believed that the Hawthorn Group sediments (of Miocene Age) have been removed from the crest of the platform through erosion. In west central Florida, rocks of Eocene Age generally dip to the south, away from the Ocala Platform. Miocene Age rocks follow this trend and thicken appreciably to the south, toward the Okeechobee basin. Rocks of the Late Eocene (40 million years old) to Recent Ages outcrop in Polk County. The significant stratigraphic and hydrogeologic units of west-central Florida are summarized in **Table A1**.

Table A1
Stratigraphic and Hydrogeologic Units
Underlying the Lake Hancock Watershed

Age	Stratigraphic Nomenclature	Hydrogeologic Unit (Aquifer)	Approximate Thickness (feet)
Recent to Pleistocene	Undifferentiated Recent to Pleistocene Deposits and the upper portion of the Peace River Formation (Bone Valley Member)	Surficial	60
Miocene	Hawthorn Group (includes the Bone Valley Member of the Peace River Formation, and the Arcadia Formation, including the Tampa Member)	Intermediate	75
Oligocene	Suwannee Limestone	Floridan	75 - 150
Eocene	Ocala Limestone		>200

A description of these units can be found in (**Refs. 2, 3, 4, and 5**).

Three principal hydrogeologic units present in west-central Florida (**Table A1**) are: the Surficial Aquifer system; the Intermediate Aquifer System, and the Floridan aquifer system. The Surficial Aquifer is found primarily in permeable sand units of the undifferentiated surficial sediments, and in upper portions of the Peace River Formation (the Bone Valley Member). The Intermediate Aquifer System is present in the dolomite and limestone units of the lower portion of the Bone Valley Member and the Arcadia Formation. The Intermediate Aquifer System is equivalent to the secondary artesian aquifer, per Stewart (**Ref. 6**). A lower clay-confining unit (the Tampa Member) occurs at the base of the Arcadia Formation. The Floridan Aquifer is encountered in the underlying Suwannee and Ocala Limestones.

USE OF EXISTING SURVEYS

The watershed evaluation performed during this study relied primarily on the use of existing information obtained from previous hydrologic and hydraulic modeling efforts conducted jointly and separately for Polk County and SWFWMD. The preparation of watershed-wide topographic information is described in the Digital Terrain Model Development section. The use of previously collected survey information is described in the Hydraulics section.

Watershed data needs to update or supplement existing information were identified during this preliminary evaluation and will be addressed during future project efforts.

DIGITAL TERRAIN MODEL DEVELOPMENT

Lake Hancock is located within the 157 square mile Saddle Creek Watershed in Polk County, Florida. The focus of the current study is to evaluate the impacts of water level modification within Lake Hancock. Therefore, detailed evaluation of available topographic data was limited to a core watershed area of approximately 49 square miles centered on Lake Hancock and portions of its major tributaries that would potentially experience increased inundation resulting from the proposed lake level modification and during flooding events.

Topographic maps available from the District were used as the primary base map information to generate the digital terrain model (DTM). Base topographic information for the watershed was developed from historical SWFWMD topographic maps that were produced at various times during the 1970's and 1980's. This topographic information was used as the best available information for most of the core project area. Additional topographic information obtained from various other sources during the course of the project was incorporated into the dataset as needed.

Topographic Data Resources

The District's 1"= 200' aerial topographic maps were the primary source of hardcopy information for generating a DTM of the watershed surface. The District provided digitized one foot contours derived from the aerial topographic maps for the entire Saddle Creek Watershed. The District also provided scanned and geo-referenced images of the aerial topographic maps for 34 sections within the core project area surrounding the lake to be used for evaluation of the existing topography. Project tasks included QA/QC review of the digitized contours against the digital scans of the original hardcopy topographic sheets and identification of topographic voids.

Detailed topographic contours were available for the Tenoroc Fish Management Area in the northern portion of the Lake Hancock watershed due to ongoing restoration efforts at that site. This dataset was incorporated into the overall watershed DTM. A limited edge-matching effort was conducted but not all differences could be readily resolved. For example, the recently constructed Polk Parkway is reflected in the Tenoroc dataset but does not appear in the historical base topographic data for the adjacent areas.

In addition, updated topographic information was provided in AutoCad drawing format for the Circle B Bar ranch property along the northwestern portion of the lake. Information in the CAD file covered approximately 3 sections. This supplemental topographic data was edge matched and incorporated into the DTM of the core area in the Lake Hancock Watershed. Recent topographic information developed for the Old Florida Plantation (OFP) site and the Polk County North Central Landfill area was obtained following construction and review of the initial watershed DTM.

Old Florida Plantation topography was provided by CCL Consultants, Inc. in AutoCad drawing format. The topographic information provided was not georeferenced and had to be spatially adjusted to match with the existing Old Florida Plantation property boundary. The updated information was merged into the existing topography for DTM creation.

Polk County Landfill topographic information produced by Pickett & Associates, Inc., I.F. Rooks & Associates, Inc., and Jones, Edmunds & Associates, Inc. was provided by the Polk County Solid Waste Division. The Pickett & Associates October 2003 photogrammetry-derived contour information encompassed the north central part of the Landfill. I.F. Rooks & Associates April 2003 photogrammetry-derived contour information covered the remaining area of the landfill. Jones, Edmunds & Associates provided 2002 LIDAR-derived contour information that covered the landfill and surrounding area. The three updated topography files were merged together and then merged with the existing Lake Hancock watershed topography to create the contour file used for final DTM development.

Detailed edge matching of these topographic datasets with the historical contour information was not performed because updated LIDAR topography for the entire watershed is expected to be available soon. The merged datasets generally match with the historical topographic information within a one-foot range in areas where major construction, borrow, or mining activities have not taken place.

Vertical Datum for DTM

Modification of Lake Hancock lake levels will potentially redefine flood elevations in portions of the watershed. Although the Federal Emergency Management Agency (FEMA) specifies that the North American Vertical Datum of 1988 (NAVD88) shall be used for all new flood studies, the project team decided to defer conversion of all topographic, water level, channel, structure, and survey information to a future date. In order to stay consistent with available data sources, all project work during the current investigation was completed using the National Geodetic Vertical Datum of 1929 (NGVD29).

A limited investigation using the United States Army Corps of Engineers (USACE) CORPSCON software was conducted to determine the effort that might be required during future datum conversion. Information for locations at the northern end of the Saddle Creek watershed will require an adjustment of approximately –0.84 feet to convert from NGVD29 to NAVD88. Information for locations at Lake Hancock and the southern end of the Saddle Creek watershed will require an adjustment of approximately –0.88 feet to convert from NGVD29 to NAVD88. Under FEMA's guidelines for vertical datum adjustment, a single conversion factor could be used for the entire watershed.

Horizontal Datum for DTM

Horizontal location data provided for use during this project are primarily based on the North American Datum of 1983 (NAD83). Under the District's Watershed Management Program Guidelines and Specifications (G&S), current work should be referenced to the High Accuracy Reference Network (HARN). As also noted in the watershed management plan guidelines, the horizontal difference between the NAD83 datum and HARN datum is less than the standards required for horizontal map accuracy; therefore no horizontal datum adjustments are necessary for maps in NAD83. New mapping produced during the course of the project is referenced to the HARN datum.

<u>DTM/TIN Generation</u>

A Digital Terrain Model (DTM) consists of the available spot elevation, contour and breakline data available for a given area. This information can be collectively transformed to other formats useful for graphical representation and calculations in computer software. One such format is known as the Triangulated Irregular Network (TIN). The following classes of data were used to develop the TIN illustrated on **Figure A4**.

<u>Contours.</u> Updated contours from the District's scanned 1:200 aerial topographic maps, the Circle B Bar ranch property, Tenoroc Fish Management Area, Polk County North Central Landfill area, and the Old Florida Plantation property were combined to form the contours for the entire Lake Hancock Watershed. These were included in the final DTM as HARDBREAK lines.

<u>Spots.</u> Spot elevations were not available from the District's previous efforts in digitizing the aerial topographic maps. Reproduction of the original spot elevation data from the historical aerial topographic maps was not expected to provide significant additional useful information beyond the contour data and was not performed.

<u>Water Bodies.</u> The shorelines of all lakes within the Lake Hancock Watershed were entered into the TIN as HARDREPLACE Polygons.

<u>Bounding Polygon.</u> A bounding polygon defining the Lake Hancock Watershed was used as a HARDCLIP feature during the TIN creation.

<u>Topographic Voids</u>

Topographic Voids are areas where the available topographic information does not represent the actual ground terrain due to new development or other land use changes. Limitations in airborne topographic collections, such as heavy tree cover, can also affect the accuracy of the available topographic data.

The topographic void areas were located by comparing contours derived from the SWFWMD 1970's and 1980's 1:200 aerial topographic maps with USGS 1999 Digital Orthophoto Quads and Polk County 2000 and 2002 Orthophotos. Environmental Resource Permit coverages, obtained from SWFWMD, were also used to locate areas of new development or land use changes. A GIS polygon coverage was created outlining the most critical void areas in the area immediately surrounding Lake Hancock. An attribute table was produced with the GIS coverage identifying areas requiring updated topographic information. Options for updates included ground survey or production of new aerial photogrammetric or LIDAR topographic information.

LIDAR information for the entire Lake Hancock watershed will be used to update topographic information. Contributing factors in the decision to update the entire topographic dataset included the extensive area of topographic voids throughout the watershed as well as in the core area of concern identified during this assessment and the usefulness of the new data to other District projects in the Lake Hancock and Upper Peace River watersheds. The LIDAR data has been collected and is currently being processed.

Quality Control

The contour mapping within the bounding polygon for the Lake Hancock watershed was checked against the available geo-referenced scans of the historical aerial topographic maps and updated as necessary. All sections were also checked against the recent (non-topographic) aerials to determine consistency with the apparent terrain and to locate topographic voids.

A TIN was generated from the available DTM information within the bounding polygon and reviewed for quality assurance. The TIN surface was reviewed for obvious errors or poor representation of the contours and adjustments made as necessary.

WATERSHED MODEL DEVELOPMENT

Use of Existing Models

The basis for conducting the preliminary assessment of the potential impacts within the Lake Hancock watershed resulting from the proposed lake level change was to use existing models as much as possible. Existing model data was obtained from a variety of sources, including:

- K&S Saddle Creek Watershed Management Project (2003) (Reference 23)
- BCI Tenoroc Fish Management Area Restoration Project (2003) (Reference 16)
- BCI Dinner and Spirit Lake model (1998) (Reference 26)
- BCI Eagle Lake Model (including CCL model of Old Florida Plantation property) (2002) (Reference 25)
- BCI Lake Seward Model (1996) (Reference 30)
- BCI North Lake Parker Wetlands Model (2004) (Reference 31)
- BCI Regional Drainage Model (1990) (Reference 28)
- Reynolds Road and Maine Avenue Flood Study (1992) (Reference 32)
- BCI Lake Deeson Drainage Improvements (1997) (Reference 31)
- USF Tenoroc – Upper Saddle Creek Model (2001) (References 15, 24)
- City of Lakeland – Dames and Moore model (1990-1992) (Reference 27)
- Current City of Lakeland drainage information (2003)

The existing models were constructed before the development of the Southwest Florida Water Management District's current Watershed Management Program Guidelines and Specifications (G&S). Models constructed under the current guidelines would include greater detail in watershed segmentation so that detailed flood elevations could be uniformly determined throughout the watershed. Sufficient detail was incorporated in the existing models to support the preliminary determination of probable impacts within the lake floodplain area likely to be impacted.

The K&S Saddle Creek SWMM model contained significant detail on the major channel systems in the watershed and was used as the basis for constructing a more complete watershed-wide model of the Lake Hancock system. Watershed parameter assignments for various model elements were used directly from previous modeling efforts or recalculated for the entire watershed in a consistent manner.

SUBBASIN HYDROLOGY

The hydrologic feature inventory consists of assembling all available base mapping for the watershed and producing a delineation and characterization of individual hydrologic subbasins. Subbasin delineation is typically guided by the location of known features in the landscape such as lakes, wetlands, streams and ponded areas and structural flow controls such as bridges, pipe culverts at road crossings, discharge structures from lakes and ponded areas and natural and man-made channels.

Subbasin Hydrology (Runoff)

Landuse coverage, updated as of 1999, was provided by SWFWMD. **Figure A5** shows the general level one breakdown of landforms across the watershed. The level one classification is shown by both the residential, commercial, industrial groupings and extractive (mined) lands. This figure clearly indicates the highly urbanized nature of significant portions of the watershed along with the mined lands and those remaining in agriculture. **Figure A6** shows the detailed level three breakdown of landuse. This detailed breakdown was used in conjunction with soils information to calculate runoff parameters for the watershed model.

Soils coverage, updated between 1989 and 1992, was also provided by SWFWMD. The soils coverage represents a digital copy of the National Resource Conservation Service soil survey map of Polk County. **Figure A7** shows the watershed soils breakdown classified by hydrologic group. The hydrologic group classification is used to determine the overall runoff response from the land due to properties of the soils. 'A' type soils are typically well-drained sandy soils while 'D' type soils can vary in texture but are generally located lower in the topography and have a high hydrologic response (i.e. higher runoff). The multi-classed 'B/D' soils vary in their hydrologic response depending primarily on whether man-made drainage improvements are in place. **Figure A8** shows the soils breakdown by soil texture. The sandy clayey loam and muck areas show the remnants of natural wetland and stream systems. The clay areas shown are primarily the clay deposition areas remaining after phosphate mining.

Runoff Generation

The model selected for this project is a version of Interconnected Pond Routing, ICPR (Ref. 9), which uses SCS unit hydrograph methods to transform rainfall into basin runoff. ICPR is a FEMA accepted model for use in floodplain delineation (Ref. 10). However, model calibration is strongly recommended by FEMA when ICPR is used (Ref. 10).

The runoff estimated using the SCS method is the combined overland and ground water flow that reaches the outfall from a basin whose perimeter is described by a surface water divide.

ICPR Model - Runoff Calculations

The Interconnected Channel and Pond Routing model (ICPR), is a Streamline Technologies, Inc. product. ICPR is a single event model, which computes direct runoff resulting from any synthetic or natural rainstorm. ICPR can be used to develop flood hydrographs and simulate the routing of the flow through stream channels and reservoirs. This program uses the procedures described in the SCS National Engineering Handbook, Section 4, Hydrology (NEH-4).

The runoff volume calculated by ICPR uses the SCS runoff equation outlined in Chapter 10, NEH-4. This method is based on observed large storms over small areas. When double-mass curves of accumulated runoff versus accumulated rainfall for a storm are made the curves become asymptotic to a straight line. That is, the rate accumulative runoff increases approaches the rate accumulated rainfall increases so that on arithmetic graph paper the curve approaches a 45-degree slope. The relation between rainfall, runoff, and retention at any point on the mass curve after initial abstraction can be expressed as:

$$F/S = Q/(P-I) \qquad \text{EQ. 1}$$

Where F = the retention after runoff begins
S = the potential maximum retention
Q = the accumulative runoff
P = the accumulative rainfall
I = the initial abstraction

Initial abstraction is the rainfall that accumulates prior to that start of runoff. This includes the rainfall that initially gets caught in the leaves and branches, the rainfall that accumulated in puddles and depressions, and infiltrates prior to the start of runoff. Retention is the rainfall that is not converted to runoff. This would include the rainfall that infiltrates into the soil, but does not appear as subsurface or base flow. Since $F = (P – I – Q)$, the above equation can be solved for Q to get

$$Q = (P – I)^2/(P – I + S), \qquad \text{EQ. 2}$$

which is the rainfall-runoff relation with the initial abstraction taken into account. To solve this equation, an empirically derived relationship between I and S for large storms on small watersheds is used.

$I = 0.2\ S$ EQ. 3

S is a function of the curve number (CN), which is related to soil and vegetative characteristics

$S = -10 + 1000/CN$ EQ. 4

There is considerable scatter in the plot between 'I' and S used to derive equation 3. For small rainfall events, 'I' could be a much larger portion of the total retention. In this case and using equation 2 above, a larger value of S would be necessary to get the same value of Q. Since S is a function of the curve number (EQ. 4), a smaller curve number would be needed in those cases were the initial abstraction is larger than twenty percent of the maximum retention.

S is not a function of the storm duration or its distribution as calculated in equation 4. So, it could be misleading to calibrate to a curve number for a storm or a particular size and distribution and use that curve number for a design storm (of some other size and distribution). This method of estimating runoff is probably best applied when used to compare the runoff estimated for storms of the same size and distribution. That is, the application of ICPR is most useful if applied (as it generally is) for a 25 or 100 year storm event of fixed duration, comparing the runoff estimates for the land area.

Equation 2 and the subbasin area are used in ICPR to estimate the total discharge volume from a subbasin. The runoff hydrograph for a subbasin is an incremental unit hydrograph, which requires an estimate of the time of concentration, T_c.

ICPR also includes for each basin, directly connected impervious areas (DCIA). This may be important, especially for small storms over areas, which show almost immediate discharge after the rainfall begins. ICPR assumes that the first 0.1 inches of rainfall over the DCIA is lost to initial abstraction. The combined rainfall excess for each drainage basin is computed by adding the rainfall excess from the DCIA's to the runoff excess calculated using Equation 2.

ICPR using the unit hydrograph method can calculate the runoff hydrograph. In this method, the peak discharge, q_p, is calculated using the following equation:

$q_p = K'AQ/t_p$ EQ. 11

where q_p = the peak discharge (cubic feet per second)
K' = the peak rate factor
A = the drainage area (square miles)
Q = the direct runoff (inches)
t_p = is the time to peak discharge (hours)
t_p = 0.6666 t_c
t_c = the time of concentration (hours)

In this project, a stage-area table was entered to represent some areas of potential water storage in the basin. ICPR uses linear interpolation to estimate values between the user-specified values of the rating curves.

ICPR is a single event model, which computes direct runoff resulting from a synthetic or natural rainstorm using procedures described in the National Engineering Handbook (Soil Conservation Service, March 1985). This method is based on observed large storms over small areas. That is, when double-mass curves of accumulated runoff versus accumulated rainfall for a storm are made, the curves become asymptotic to a straight line. That means that the rate of increasing accumulative runoff approaches the rate of increasing accumulated rainfall. On arithmetic graph paper the curve approaches a 45-degree slope.

Curve Number Assignment

Model parameters were selected for use in the model through the GIS, with parameters assigned to specific soils (**Figure A7**) and landuse (**Figure A6**). **Table A2** lists the curve numbers assigned to various landuse and soils combinations, and **Table A3** lists the Manning's n and % Directly Connected Impervious Area (DCIA) parameters assigned in association with landuse. Source data for the soils and landform/landuse GIS maps used in this investigation were downloaded from the SWFWMD internet site (Ref. 20)

For the SCS unit hydrograph method, a hydrologic classification is assigned to each soil. A soil of class A will generally accept greater infiltration and at higher rates than a soil of class D. The GIS data listing the hydrologic classification of the soils within the Lake Hancock Watershed and used in model setup were downloaded from the SWFWMD internet site (Ref. 20). Soil hydrologic groups included in the area of the Lake Hancock Watershed include: A, B, B/D, C, D, UND, and W. Soils classified as UND were assigned a classification based on the soils name. 'UDORTHENTS/EXCAVATED' generally refers to overburden at previously mined sites and were assigned a hydrologic classification of B, and 'URBAN LAND' soils were also assigned a hydrologic classification of B. Soils classified as W (i.e., water) were assigned a curve number of 99.8, which reflects very low retention at these areas.

Table A2 Watershed Parameter Assignments - Base Curve Number (CN) Assignment

FLUCCS	Generalized Landuse Description	Hydrologic Soils Group					
		A	B	B/D	C	D	W
1100	Residential-Low Density	39	61	80	74	80	99.8
1200	Residential-Med Density	39	61	80	74	80	99.8
1300	Residential-High Density	39	61	80	74	80	99.8
1400	Commercial / Institutional	39	61	80	74	80	99.8
1500	Industrial	39	61	80	74	80	99.8
1600	Recreation / Open Space	37	52	66	62	66	99.8
1700	Commercial / Institutional	39	61	80	74	80	99.8
1800	Recreation / Open Space	37	52	66	62	66	99.8
1900	Recreation / Open Space	37	52	66	62	66	99.8
2100	Agriculture - Pasture / General	39	61	80	74	80	99.8
2140	Agriculture - Row & Field Crops	67	78	89	85	89	99.8
2200	Agriculture - Citrus	32	58	79	72	79	99.8
2300	Agriculture - Feeding	67	78	89	85	89	99.8
2400	Agriculture	67	78	89	85	89	99.8
2500	Agriculture	67	78	89	85	89	99.8
2550	Agriculture	67	78	89	85	89	99.8
2600	Agriculture Open Space	37	52	66	62	66	99.8
3100	Herbaceous Rangeland	39	61	80	74	80	99.8
3200	Shrub Rangeland	30	48	73	65	73	99.8
3300	Mixed Rangeland	35	55	77	70	77	99.8
4100	Forest	32	58	79	72	79	99.8
4110	Forest	32	58	79	72	79	99.8
4200	Forest	32	58	79	72	79	99.8
4340	Forest	32	58	79	72	79	99.8
4400	Forest	32	58	79	72	79	99.8
5100	Water	99.8	99.8	99.8	99.8	99.8	99.8
5200	Water	99.8	99.8	99.8	99.8	99.8	99.8
5300	Water	99.8	99.8	99.8	99.8	99.8	99.8
6100	Wetland	98	98	98	98	98	99.8
6150	Wetland	98	98	98	98	98	99.8
6200	Wetland	98	98	98	98	98	99.8
6210	Wetland	98	98	98	98	98	99.8
6300	Wetland	98	98	98	98	98	99.8
6410	Wetland	98	98	98	98	98	99.8
6430	Wetland	98	98	98	98	98	99.8
6440	Wetland	98	98	98	98	98	99.8
6530	Wetland	98	98	98	98	98	99.8
7400	Mining	36	51	64	60	64	99.8
8100	Transportation / Utilities	83	89	89	92	93	99.8
8200	Transportation / Utilities	83	89	89	92	93	99.8
8300	Transportation / Utilities	83	89	89	92	93	99.8

Table A3. Watershed Parameter Assignments - Manning's n and % DCIA

FLUCCS	Generalized Landuse Description	Manning's n	DCIA%
1100	Residential-Low Density	0.16	20
1200	Residential-Med Density	0.13	25
1300	Residential-High Density	0.08	50
1400	Commercial / Institutional	0.05	85
1500	Industrial	0.07	72
1600	Recreation / Open Space	0.3	0
1700	Commercial / Institutional	0.13	65
1800	Recreation / Open Space	0.13	10
1900	Recreation / Open Space	0.3	0
2100	Agriculture - Pasture / General	0.15	0
2140	Agriculture - Row & Field Crops	0.15	0
2200	Agriculture - Citrus	0.3	0
2300	Agriculture - Feeding	0.2	10
2400	Agriculture	0.2	10
2500	Agriculture	0.2	5
2550	Agriculture	0.2	5
2600	Agriculture Open Space	0.15	0
3100	Herbaceous Rangeland	0.3	0
3200	Shrub Rangeland	0.3	0
3300	Mixed Rangeland	0.3	0
4100	Forest	0.45	0
4110	Forest	0.45	0
4200	Forest	0.45	0
4340	Forest	0.45	0
4400	Forest	0.45	0
5100	Water	0	100
5200	Water	0	100
5300	Water	0	100
6100	Wetland	0.45	100
6150	Wetland	0.3	100
6200	Wetland	0.35	100
6210	Wetland	0.35	100
6300	Wetland	0.3	100
6410	Wetland	0.06	100
6430	Wetland	0.06	100
6440	Wetland	0.06	100
6530	Wetland	0.06	100
7400	Mining	0.3	0
8100	Transportation / Utilities	0.2	25
8200	Transportation / Utilities	0.2	25
8300	Transportation / Utilities	0.2	25

Soils of Special Consideration

Some soils of special consideration are those listed as Arents and Hoqlaquents. Arents are soils that were reworked during phosphate mining. These areas occur within the soils classified as 'VAR' texture on **Figure A8**. They can be generally identified as sand tailings, overburden and clays. Areas of overburden and sand tailings may also include areas identified as 'Arents/organic substratum'. These are areas of reclaimed or created wetlands in which organic soils were placed on top of the re-contoured overburden or sand tailing soils.

Overburden soils are soils removed in order to gain access to the underlying phosphatic clays during mining. These soils are ultimately left in place after mining. The overburden soils generally have the same or slightly lower permeabilities than the natural soils before mining.

Sand Tailings are produced during froth flotation recovery of phosphate particles in the beneficiation process. The grain size of the tailings fraction generally ranges between 1mm and 0.1 mm in diameters, since both larger and smaller diameter particles are removed by screening and hydrocycloning prior to flotation. The hydrocycloning operation generally removes all clay-sized particles and generally leaves no more than 1 to 4 percent silt sized particles. Typical reported values of permeability for sand tailing are in the range of 28 ft/day ±50 percent. However, in-situ measures of permeability within sand tailing areas can be much lower than estimates from the laboratory (**Ref. 12 and 13**).

The clays and silts removed during the beneficiation process are pumped as a slurry back to holding ponds to settle out. These areas are also identified as Haplaquents if the clays have not consolidated and dried out sufficiently to support the weight of a cattle and Hydroquaents if the soils have dried out and consolidated. These clays have very low permeabilities (0.00003 to 0.0003 feet/day) at about 40 to 50 percent solids content (Ref. 14). These soils occur in the areas identified as 'Clay' on **Figure A8**.

The CN listed in **Table A2** were extrapolated based on published CN assignments (Ref. 19 and 21). The CN listed in these tables were adjusted to allow specific inclusion of a directly connected impervious area (DCIA), which is described below.

DCIA

ICPR also includes for each basin, directly connected impervious areas (DCIA). These areas may be important, especially for small storms. ICPR assumes that the first 0.1 inches of rainfall over the DCIA is lost to initial abstraction and adjusts the curve number relative to the value of DCIA. The higher the DCIA is, the higher the calculated curve number. The equations used in this adjustment are included in **Appendix B**. The part of a basin that is used in estimating the DCIA is based on the percent impervious area listed for Urban and Residential districts in Table 2-2a of Technical Release 55 (Ref. 19). Since DCIA is explicitly represented in the model, it is necessary to adjust the CN assignments (as listed in Table 2-2a of Technical Release 55) to represent conditions without the impervious areas. Based on the description provide in **Appendix B**, 0.1 inches of discharge are 'abstracted' from the runoff in the DCIAs.

Since the total abstraction from these areas is 0.1 inches, the effective curve number for the DCIAs is

S = -10 + 1000/CN. That is,
0.1 = -10 + 1000/CN, and CN = 99.

This estimate of the CN within the DCIA can be used to adjust the CN within areas that a DCIA is specified. For example, a high density residential area with soils of hydrologic group A would receive a CN of 77. If a DCIA of approximately 50 percent is specified for this area, the resulting estimate of the CN is

99*0.55 + 0.45*CN = 77, and CN = 50.

Calculations in this manner were used to adjust CN with DCIA assigned in association with the land form identification. DCIA assigments used during this modeling effort are shown in **Table A3**. These assignments are reasonably consistent with assignments made by others during the other modeling efforts referred to in this study.

Time of Concentration

Topographic surface elevations and hydraulic lengths were estimated for each of the basins included in the model simulations. The hydraulic length is the longest path or streamline within the basin and is used to estimate the time of concentration (TOC) for each basin. Conceptually, TOC is the longest time it takes runoff from somewhere in the basin (generally, the most distant location) to reach the outfall from the basin. In addition to the length of the path, the slope along the path is used in calculating TOC. TOC was divided into two components: a component of sheet flow with a maximum length of 300 feet, and a component of concentrated flow that extents past 300 feet until a significant stream or channel is reached. The significant streams and channels within the basins were represented explicitly within the hydraulic section of the model and the time to travel along these conveyances is not included in the calculation of TOC.

The time to travel along a path under conditions of sheet flow was calculated using the following equation.

T = 0.007(nL)0.8/(P20.5s0.4) Equation 3-3 of Ref. 19

where T is the travel time in hours
n is the Manning's roughness coefficient
L is the flow length (ft)
P2 is the 2-year, 24-hour rainfall depth (inches), and
s is the slope along the hydraulic grade line (ft/ft).

Using this equation requires an estimate of the roughness coefficient; which were assigned based on landuse descriptions, as shown in **Table A3**.

The TOCs for concentrated flow conditions were estimated using equations provided in Appendix F-1 of Technical release 55 (Ref. 19).

For unpaved areas: V = 16.1345 (s)0.5
For paved areas: V = 20.3282 (s)0.5

where V is the average velocity (ft/s) and s is the slope of the hydraulic grade line (ft/ft).

Subbasin Delineation

The subbasin delineations produced by Keith and Schnars, Inc. during a previous study of the Upper Saddle Creek Watershed were the primary data source used in developing the hydrologic inventory. Subbasin boundaries from the K&S study were primarily based on the historical SWFWMD topography with some updates to account for major watershed changes such as the construction of the Polk Parkway. In addition, subbasin delineations from two previous BCI studies, Tenoroc Fish Management Area and Eagle Lake, were directly incorporated into the final subbasin coverage. The previous K&S modeling effort had included the inflow contributions from these two sub-watersheds as inflow hydrographs to Lake Hancock. Discharges from the Tenoroc area developed by BCI since the K&S work were found to be significantly different from the information used previously by K&S. The lower portions of the Eagle Lake Basin primarily within the Old Florida Plantation property were anticipated to perform differently in light of the proposed lake level changes. Consequently, it was decided to incorporate these areas directly into the revised watershed model.

The final model representation during the current project effort includes 366 separate subbasin contributing areas. In most cases, the direct catchment areas of lakes and large wetlands were modeled as separate subbasins. The average subbasin size used in the model is approximately 274 acres. It should be noted that several large lakes over 1000 acres and the Lake Hancock direct catchment at over 4500 acres are included in this calculation.

In this project, the detailed topography, hydraulic control structures, and determinations made for previous modeling efforts were used to delineate basins within the watersheds. Subbasin boundaries throughout the Lake Hancock watershed were reviewed and updated as needed using the available topographic information. Automated terrain processing tools that used the available digital topographic information were also employed to assist with the subbasin delineation and review process. The resultant subbasin divides used for each of the major subwatersheds are shown in **Figures A9a-A9h**.

HYDRAULICS

The hydraulic feature inventory is a detailed compilation of the elevations, lengths and characteristics of water control features in the watershed. This includes discharge structures, bridges, natural and man-made channels and pipes. Also included are characterizations of locations where flow might pass overland from a ponded area or over a road at a channel crossing, for example. An important element of the hydraulic feature inventory is compilation of stage-area or stage-volume information for all watershed locations that might temporarily or continuously store water. These areas include lakes, ponded areas, wetlands, and portions of stream floodplains that are outside of the main flowpath and not otherwise represented within the channel cross-sections.

The Junction/Reach (or Node/Link) network primarily incorporated elements from the Keith & Schnars Saddle Creek model, BCI Tenoroc Fish Management Area model, BCI Eagle Lake model, Dames and Moore City of Lakeland model, BCI Spirit & Grassy Lake model, City of Lakeland Drainage Information, Reynolds Road and Maine Ave Drainage Study, and the BCI Lake Deeson Drainage Study. Limited field reconnaissance was conducted to generally verify elements incorporated in the existing models and identify additional elements that should be included in the model. The major additions were in portions of the Old Florida Plantation property not previously modeled and the large channel north of SR540 connecting Reynolds Road drainage to Lake Hancock.

Characterization of Channels and Structures

The primary source of information for the core area of the watershed was obtained in GIS shapefile format from the K&S Saddle Creek Model. The backup information provided for the SWMM Extran portion of the model was geographically located included survey data to verify locations and elevations of structures and channel cross sections. In typical practice, limited actual survey within a couple of hundred feet of the channel was conducted for channel cross-sections, with the remaining data extracted from the floodplain topography. In some instances the junction and reach network needed updating to better locate watershed features and add additional elements. Survey data and information in the model was used to correctly identify proper orientation of flow. These revisions were conducted in general accordance with the SWFWMD G&S. The project specification was that all structures and cross-sections must be located within 20 feet of actual.

Information for much of the contributing area outside of the core channelized area was primarily obtained from the SWMM Runoff block of the K&S model. This information was provided as a conceptual line schematic of the hydrologic system. All structure and channel information had to be adjusted to the correct location to conform with the District's G&S. Limited survey information was available for some elements to help verify actual locations. The remainder were located by careful review of aerial photography and field reconnaissance.

Model parameter assignments for structures and channels contained in the previous models were reviewed and updated as needed. The majority of the updates included minor changes for consistency where slightly varying roughness (friction) factors had been assigned to similar channel segments and pipes. Additional parameter updates completed following the mapping update included review and adjustment of assigned channel lengths.

Depression Storage

Extensive effort was devoted to updating storage area characterizations as these are crucial to determining accurate pool and flood elevations at locations throughout the watershed. The watershed topographic information developed previously was processed by computer to develop revised stage-area tables for all water storage nodes represented in the watershed model. It should be noted that the topographic information obtained from either standard photogrammetry or LIDAR provides only the water surface elevation or near shoreline information for water bodies. In many instances, the controlling structural outflow elevation is located below the water surface and additional bathymetric information for lower elevations for water storage areas must be developed or estimated. This effort resulted in the update of all existing stage-area tables via production of approximately 230 new stage-area tables for various model elements.

Initial Conditions and Model Starting Elevations

Starting elevations for the model simulations assumed that all waterbodies were brim-full and ready to discharge. In other words, all water storage areas defined in the model were assumed to contain water up to the invert elevation of the downstream controlling structure or overflow. The channel and floodplain areas immediately connected to Lake Hancock were assumed to be full to the elevation of the lake. The modeling starting elevation assumptions are approximately equivalent to late summer / wet season conditions following normal rainfall during preceding months.

An extensive library of supporting watershed information was compiled during this project, including stage records for 37 lakes in or near the watershed, rainfall data from 13 active and historical rainfall gages, and flow records at several locations throughout the watershed. **Figure A10** shows the location of stream gages, rainfall gages and pan evaporation sites in or near the watershed. Information from these records was used to establish initial conditions.

Flood Events of Record

Limited information is available concerning large floods on Saddle Creek, Lake Hancock and the upper Peace River. Flow records at Arcadia date back to 1931, while records for the Bartow gaging station are available back to 1939. Lake Hancock water levels have been recorded since 1958 and discharge flows from Structure P-11 since 1963.

The largest event on record occurred in September 1933 as a result of intense rainfall associated with a tropical hurricane. This information is shown in **Figure A11**. Unfortunately, corresponding Lake Hancock levels and corresponding flows at Bartow are not available for this event.

Rainfall associated with a hurricane in September 1947 resulted in the largest recorded flows at Bartow, as shown in **Figure A12**. **Figures A13** and **A14** illustrate significant flows at Bartow and Arcadia associated with hurricanes in September 1948 and late August 1949.

The summer of 1960 was one of the wettest on record, with over 48 inches recorded at Bartow from May through October 1. **Figure A15** shows rainfall and flows from an event occurring in late July and early August of 1960. This was followed in early September (**Figure A16**) by the passage of Hurricane Donna. Undoubtedly, the wet antecedent conditions contributed significantly to the severity of the flooding experienced during this event.

The Peace River experienced a significant event in June of 1982, but the rainfall and flows in the upper part of the basin were not particularly severe, as shown in **Figure A17**.

Extended wet periods resulting from El Nino conditions can also result in high lake levels and high flows. **Figure A18** shows an extremely wet period experienced in 1959. Bartow flows averaged nearly 1000 cfs for the time period shown in the figure. Another wet period occurred in early 1998, as shown in **Figure A19**. Wet conditions at the end of 2002 and into early 2003 are shown in **Figure A20**. A rainfall sequence exceeding 18 inches in December resulted in flows at Bartow comparable to past hurricane events.

Outfall Controls and Boundary Conditions for Structure P-11

The flow and stage records available for large events for the Lake Hancock outfall at Structure P-11 and the Peace River at Bartow USGS Gage 02294650 were used to develop the downstream boundary condition ratings for the modeled events. The Bartow gage is approximately 16,400 feet downstream from Structure P-11. The model terminates at the confluence of Saddle Creek with Peace Creek Canal. This location is approximately 10,300 feet downstream from Structure P-11.

Figure A21 shows the July and September 1960 lake stage and stages observed at the Bartow gage in September. Additional events were also analyzed to develop the curve labeled BCI Hancock as representative of lake stage performance during a large event. Most large events exhibited similar broadened peaks and extended discharge on the declining limb of the hydrograph. Using the representative lake stage curve in conjunction with Bartow gage stages, channel elevations and slopes, and downstream distance, the composite curve labeled BCI Downstream Boundary was developed and used for the modeling.

In examining the records, it was determined that Lake Hancock typically experiences peak stages approximately 3 – 8 days following the peak rainfall in the watershed.

FLOODPLAIN ANALYSIS AND DELINEATION

Rainfall Frequencies and Durations

The modeling conducted during this study was limited to determining the 100 year flood elevations for existing conditions and each of the three proposed lake level alternatives. Previous studies had identified that the Lake Hancock watershed was likely to display the greatest flood elevations in response to either the 24 hour design storm event or the 5-day storm event. Using SWFWMD's Environmental Resource Permitting Information Manual Part D Project Design Aids, the rainfall total for the 24 Hour, 100 Year Design Storm Event was assigned as 9.5 inches. The SCS Type II Modified unit hydrograph distribution was used for this event. The District's G&S (Table 3 in that document) defines the appropriate total for the 5-Day, 100 Year Storm Event for Polk County as 16.0 inches total rainfall depth. The G&S also prescribes the rainfall distribution to be used for the 5-Day event in Table 4 of that document.

Typically, watershed areas that are 'rate-sensitive' respond with higher flooding elevations to the 24 hour storm, while areas that are 'volume-sensitive' respond with higher flooding elevations to multi-day events.

Based on previous experience with the watershed, it was initially determined to limit the current investigation to the use of the 24 hour, 100 year return interval design storm and the 5-day, 100 year return interval storm as one of these was expected to provide the most critical flooding. The 5-day, 100 year return interval storm event with a total of 16.0 inches and distributed according to the specifications in the District's G&S was used for the simulations summarized in this report.

Floodplain Delineation Methodology

In the past, floodplain boundaries have been created manually using topography, cross sections, and aerial photography. Some hydrologic models have developed tools to automate the delineation process. For example, The Army Corps of Engineers has developed an extension for ArcView that automatically creates the Floodplain Inundation files directly from HEC-RAS model results. In the Lake Hancock project, Streamline Technologies, Inc. ICPR model was used to model the watershed. ICPR model results must be manually exported to ArcGIS or other GIS software.

Watershed Concepts has developed a method using ArcGIS 8.3 / ArcView 3.x to limit the amount of manual work for the floodplain delineation from models that have no automatic mapping export tools.

The general procedure used for creating the floodplain inundation mapping requires extensive setup of mapping cross sections and polygons for each node where water surface elevations were calculated from the model. Cross-section mapping is suitable for flow-ways such as channel systems while polygon mapping is needed for lakes, wetlands, and other ponded areas.

The model result tables providing peak stage elevations for each node are then joined to the mapping cross-sections and polygons. Results from different model runs can then be imported to the mapping elements to assign elevations for automatic floodplain creation.

A new Triangulated Irregular Network (TIN) combining the model-predicted water surface elevations and topography above water is then created from the model elevations using ESRI's 3D Analyst and ArcGIS 8.3 software. Via conversion to grid format, the resulting TIN can be subtracted from the existing topographic grid to produce the inundation boundary. This floodplain grid is then converted to a shapefile and cleaned to generate the final inundation polygon. Due to the nature of the software interpolation involved in calculating the TIN, careful placement of the mapping elements is critical to ensure that model results are accurately and correctly depicted. Several iterations may be required.

Model Results

As noted above, analyses were completed for both the 24 hour, 100 year return interval design storm and the 5-Day, 100 year return interval storm The 5-Day event proved to be the more critical event for Lake Hancock and all associated floodplain areas during this study. Appendix B provides summary tables tabulating results from the 5-Day, 100 Year Storm Event simulations completed during this study (**Tables B1 – B8**). Appendix B also provides large maps (**Figures B1, B2**) identifying model node locations and labeling.

The predicted peak stage obtained for Lake Hancock (Node ID N2100) for the 5-Day storm event simulation with a lake starting level of 98.7 feet (existing conditions) is 102.74 feet NGVD. Similarly, the predicted peak stages for Lake Hancock (Node ID N2100) for the 5-Day storm event simulations with lake starting levels of 99.5, 100.0, and 100.5 feet (proposed alternative conditions) are 103.01, 103.24, and 103.52 feet NGVD, respectively.

Storm Event Flood Level - 98.7 feet NGVD (Existing)

The flood levels attained from the 5-Day, 100 Year Storm Event of 16 inches total rainfall with a Lake Hancock starting elevation of 98.7 feet NGVD is outlined in **Figure A22.** This figure represents the area inundated when the P-11 Structure is set at an elevation of 98.7. The structure was assumed to remain closed for the duration of the event simulation. Comparative simulations were conducted with various structure operation procedures that resulted in only a nominal change (approximately –0.1 feet) in the peak stage attained in the lake. Therefore, the structure was simulated as being closed to provide a conservative estimate of the flood elevations that would be attained in Lake Hancock and adjacent floodplain areas.

The 98.7, 5-Day 100 Year Storm Event covers approximately 10,720 acres within the area of impact. The area of impact is defined as any floodplain area predicted to experience a flood elevation change for the three alternative lake operating level simulations in comparison to the existing conditions simulation with the lake operating level at 98.7 feet NGVD.

Areas that showed no change in the model-predicted floodplain elevations for the different lake operating level simulations were not included in this analysis and have not been mapped.

Areas of interest in the 98.7 (Existing) 5-day storm event include the northern stromwater pond of the Polk County Landfill and SR 540. In the existing conditions simulation the storm event overtops the berm around the stormwater pond. SR 540 is in danger of being overtopped as well and actually becomes overtopped in the 99.5 simulation. It is believed that SR 540 elevations may be slightly higher than what is represented in the current topography.

Storm Event Flood Level - 99.5 feet NGVD

The 99.5, 5-Day 100 Year Storm Event is outlined in **Figure A23.** This figure represents the area inundated when the P-11 structure is set at an elevation of 99.5. The 99.5, 5-Day 100 Year Storm Event covers approximately 10,840 acres. This shows an increase of 120 acres under water from the 98.7 elevation. The increase is minor throughout the floodplain with only the wetlands on the northeast side of Lake Hancock showing significant change in area inundated. The northern stormwater pond in the landfill shows more of the berm overtopped. SR 540 is shown as overtopped in this simulation.

Storm Event Flood Level - 100.0 feet NGVD

The 100.0, 5-Day 100 Year Storm Event is outlined in **Figure A24**. This figure represents the area inundated when the P-11 structure is set at an elevation of 100.0. The 100.0, 5-Day 100 Year Storm Event boundary covers approximately 10,920 acres. This shows an increase of 200 acres under water from the 98.7 elevation and an increase of 80 acres from the 99.5 elevation. The major increase is at the Polk County Landfill. In this simulation, the predicted flood elevations indicate that both the northern and southern stormwater ponds would be overtopped.

Storm Event Flood Level - 100.5 feet NGVD

The 100.5, 5-Day 100 Year Storm Event is outlined in **Figure A25**. This figure represents the area inundated when the P-11 structure is set at an elevation of 100.5. The 100.5, 5-Day 100 Year Storm Event boundary covers approximately 11,010 acres. This shows an increase of 290 acres under water from the 98.7 elevation and an increase of 90 acres from the 100.0 elevation. The two major increases for this simulation is at the Polk County Landfill and at the City of Lakeland Oak Hill Cemetery. In this scenario, the Polk County Landfill shows inundation well into the surface water collection system adjacent to the landfill cells. The cemetery shows encroachment into the easternmost burial area.

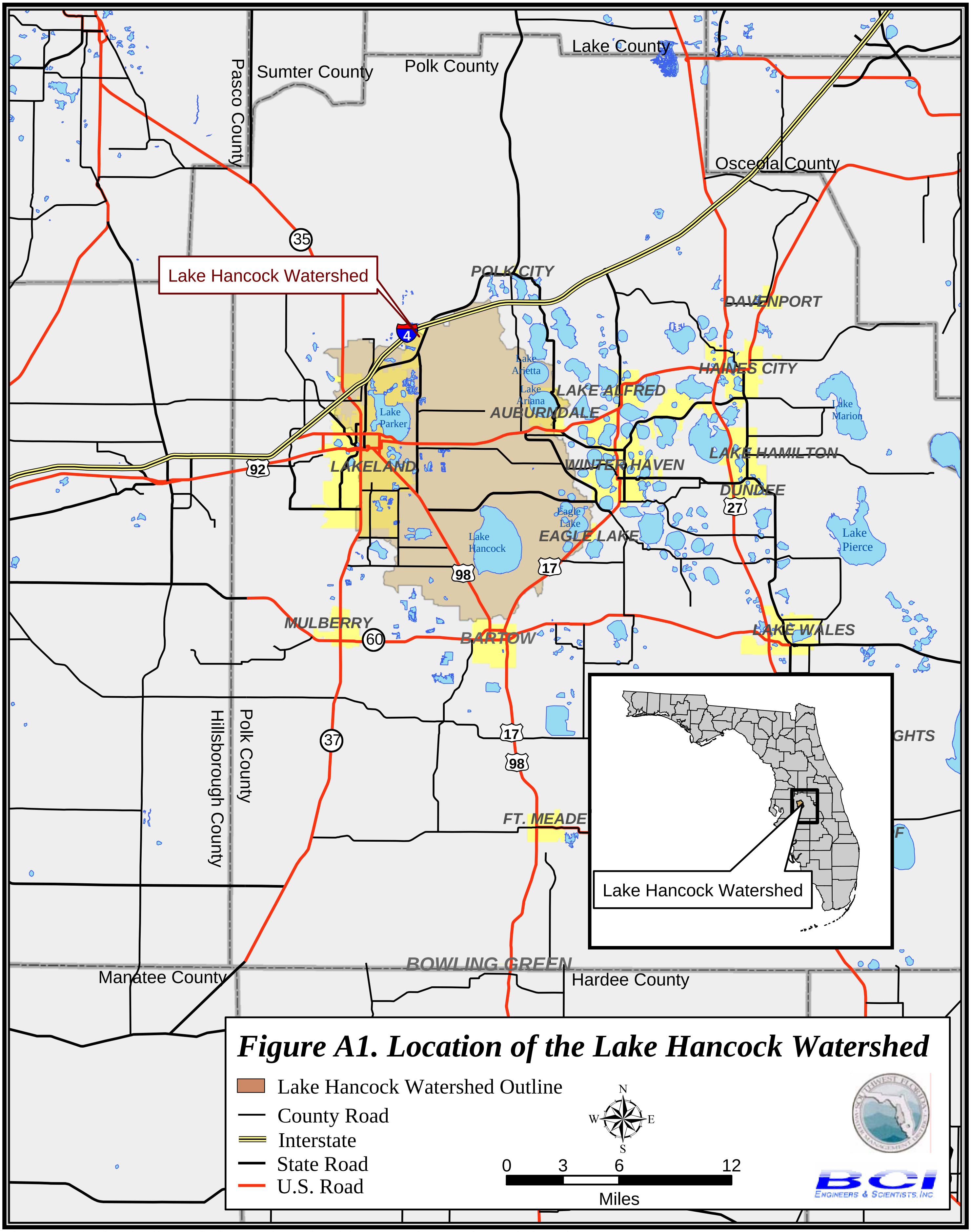

Figure A1. Location of the Lake Hancock Watershed

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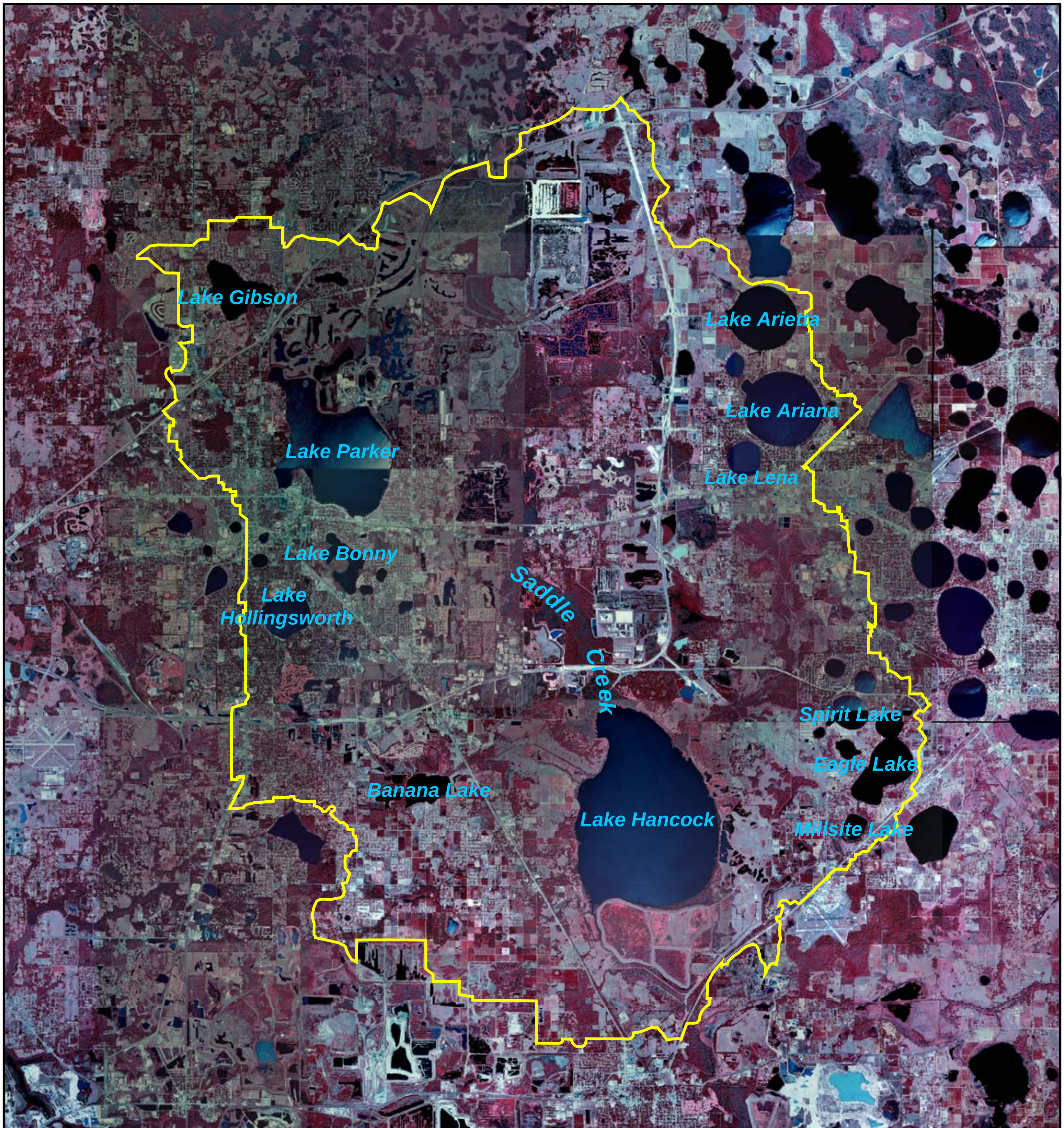

Hancock Watershed

N
W
E
S

0 2.5 5
Miles

ENGINEERS & SCIENTISTS, INC.

Figure A2
Aerial Photograph of the Lake Hancock Watershed

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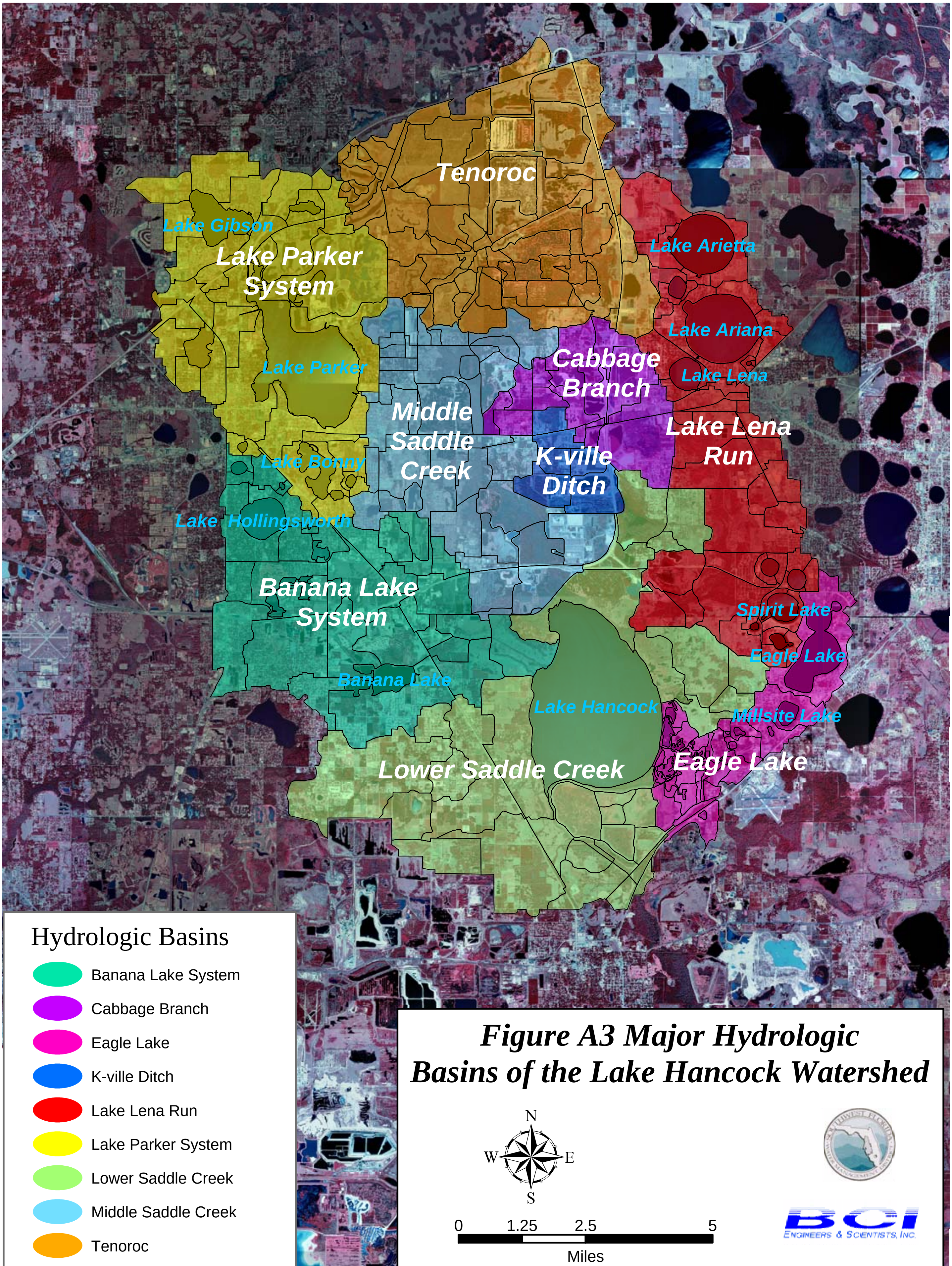

Figure A3 Major Hydrologic Basins of the Lake Hancock Watershed

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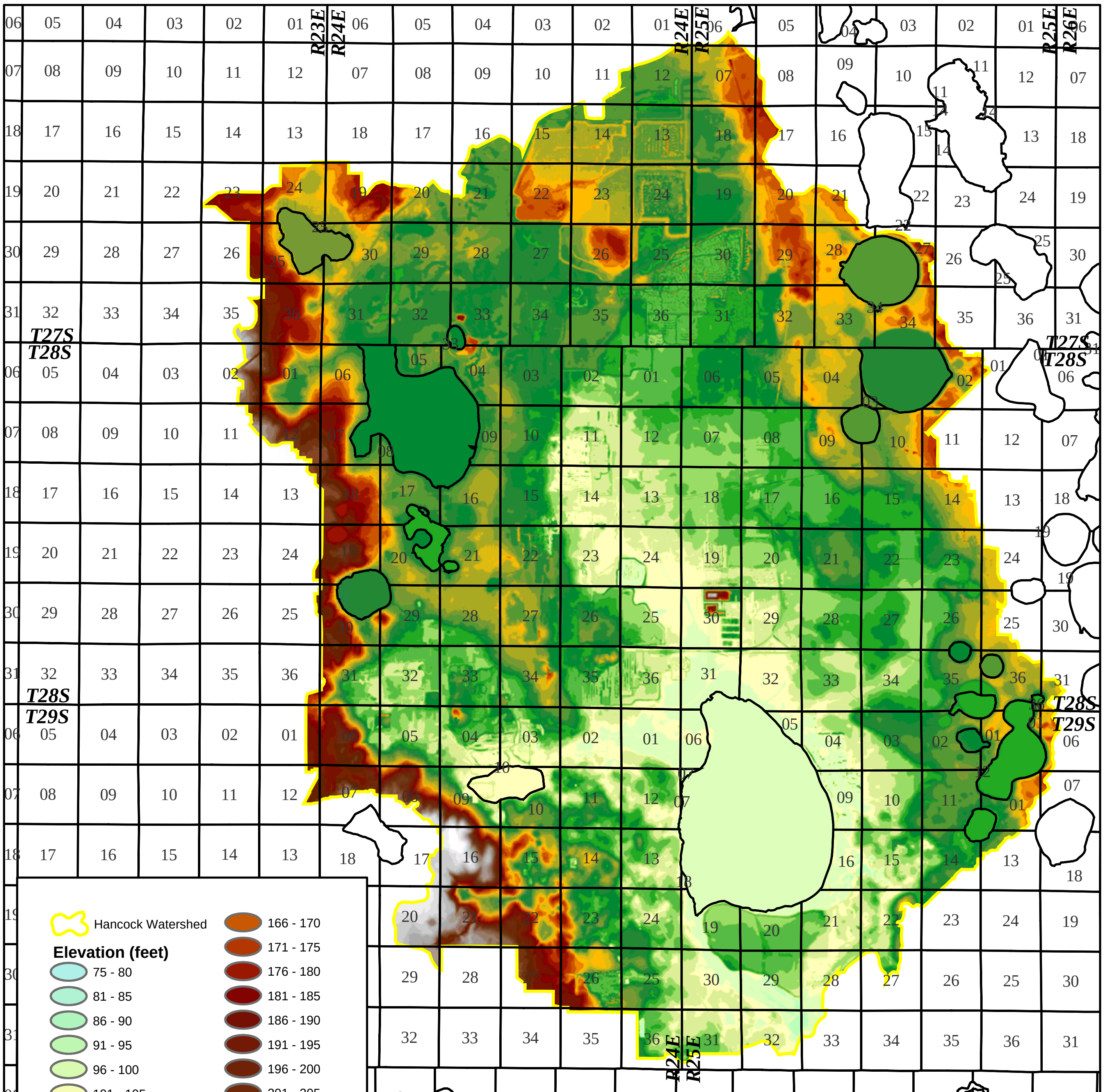


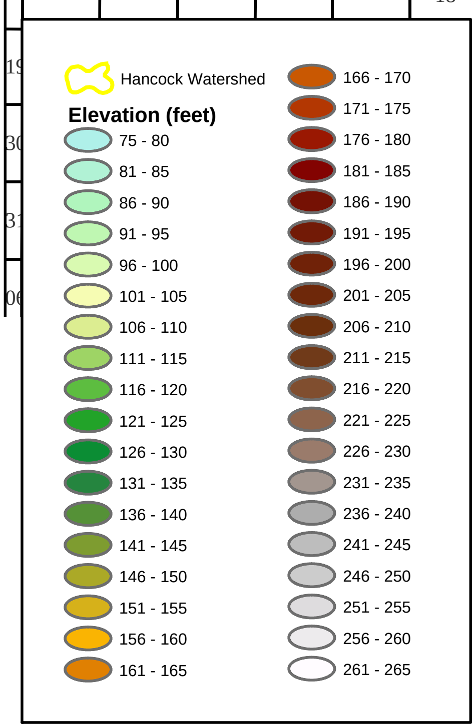


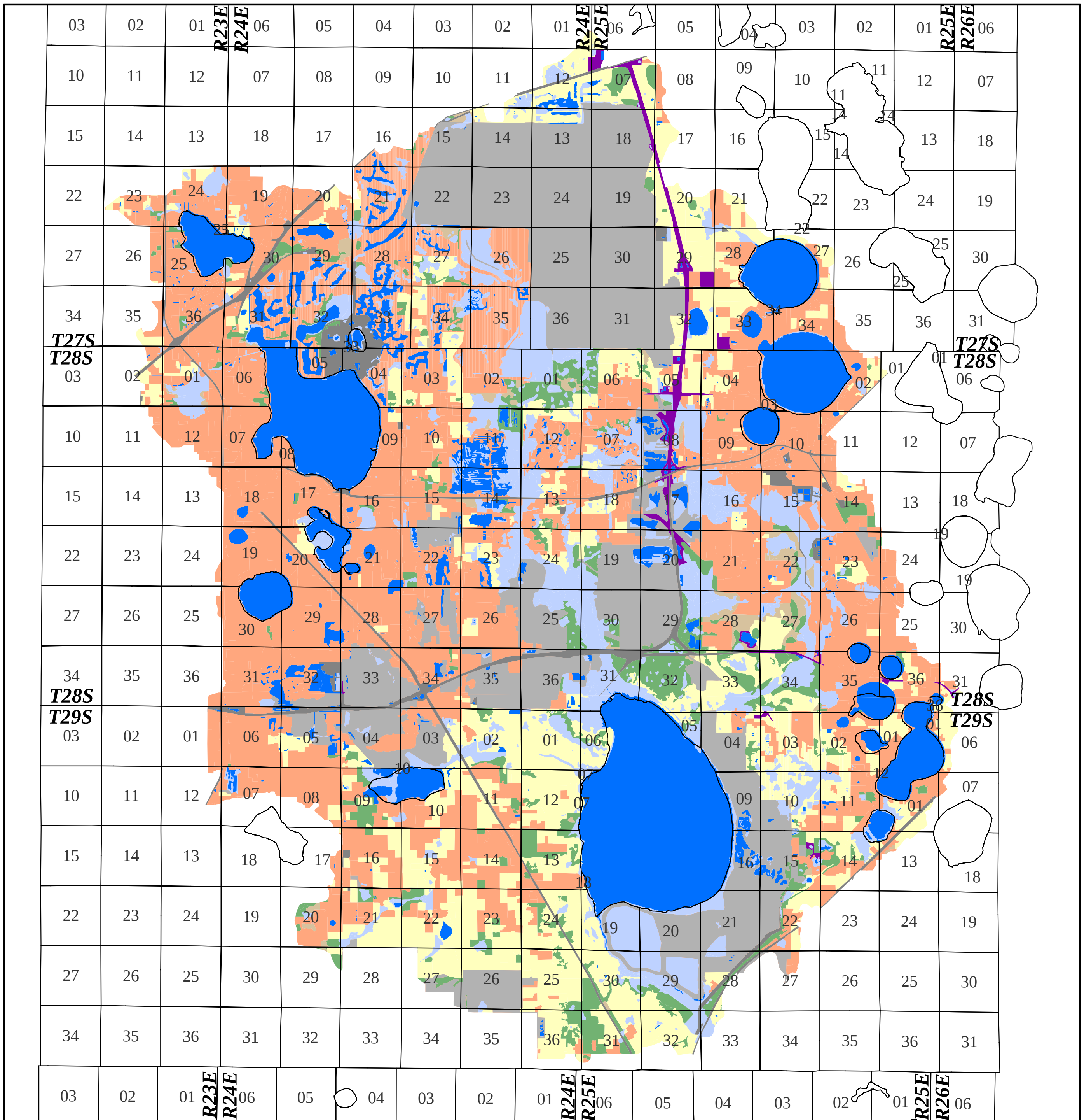
Figure A4
Topographic Surface Elevations[a] within the Lake Hancock Watershed

[a] Topographic surface elevations derived from TIN

N
W E
S

0 2.5 5 Miles

ENGINEERS & SCIENTISTS, INC.



FLUCCS Definitions Level I

- 100 Urban and Built-Up
- 1600 Extractive
- 200 Agriculture
- 300 Rangeland
- 400 Upland Forests
- 500 Water
- 600 Wetlands
- 700 Barren Land
- 800 Transportation, Communications and Utilities

Figure A5 Landforms within The Lake Hancock Watershed

N
W E
S

0 1.25 2.5 5
Miles

BCI
ENGINEERS & SCIENTISTS, INC.

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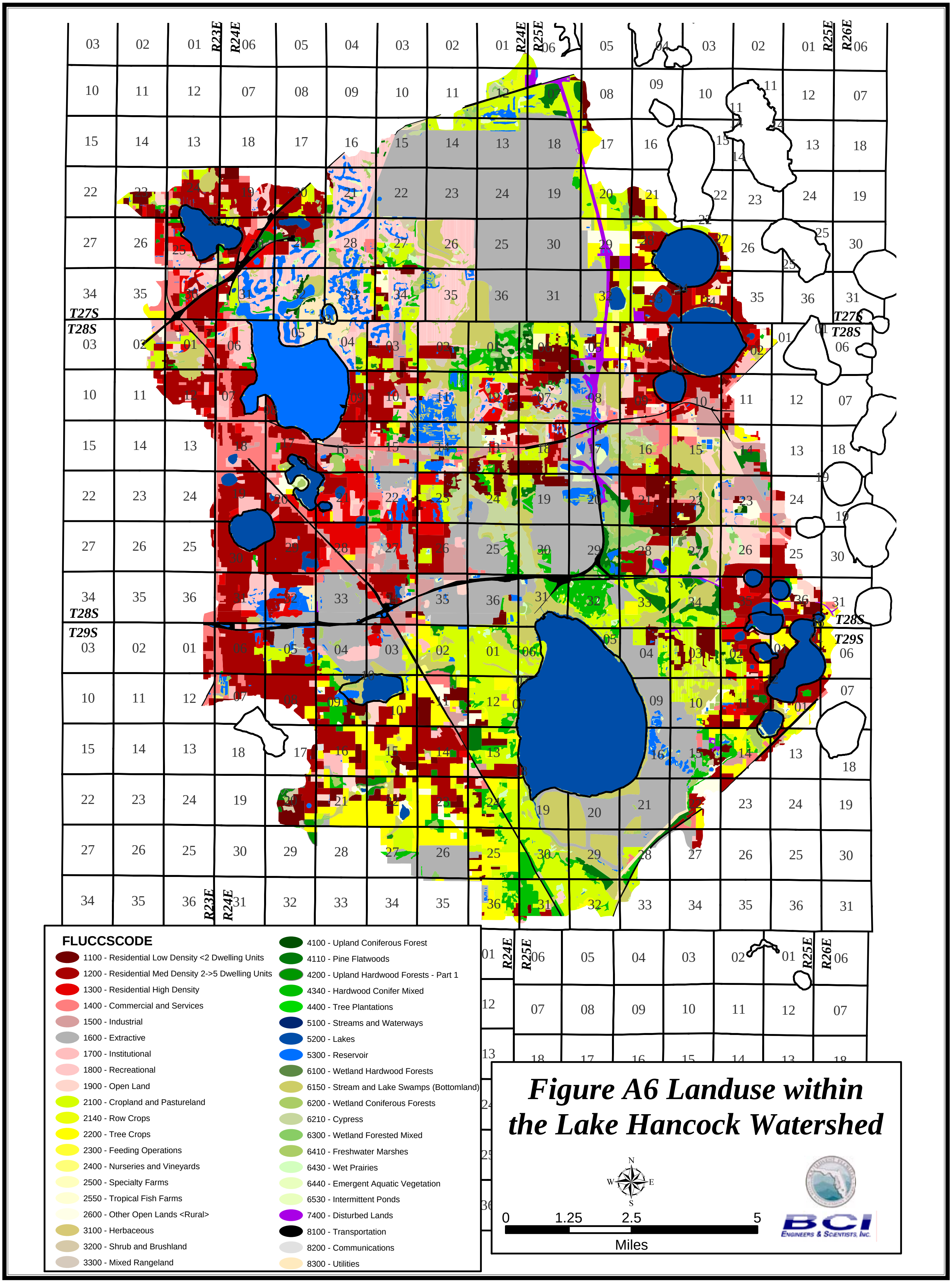

Figure A6 Landuse within the Lake Hancock Watershed

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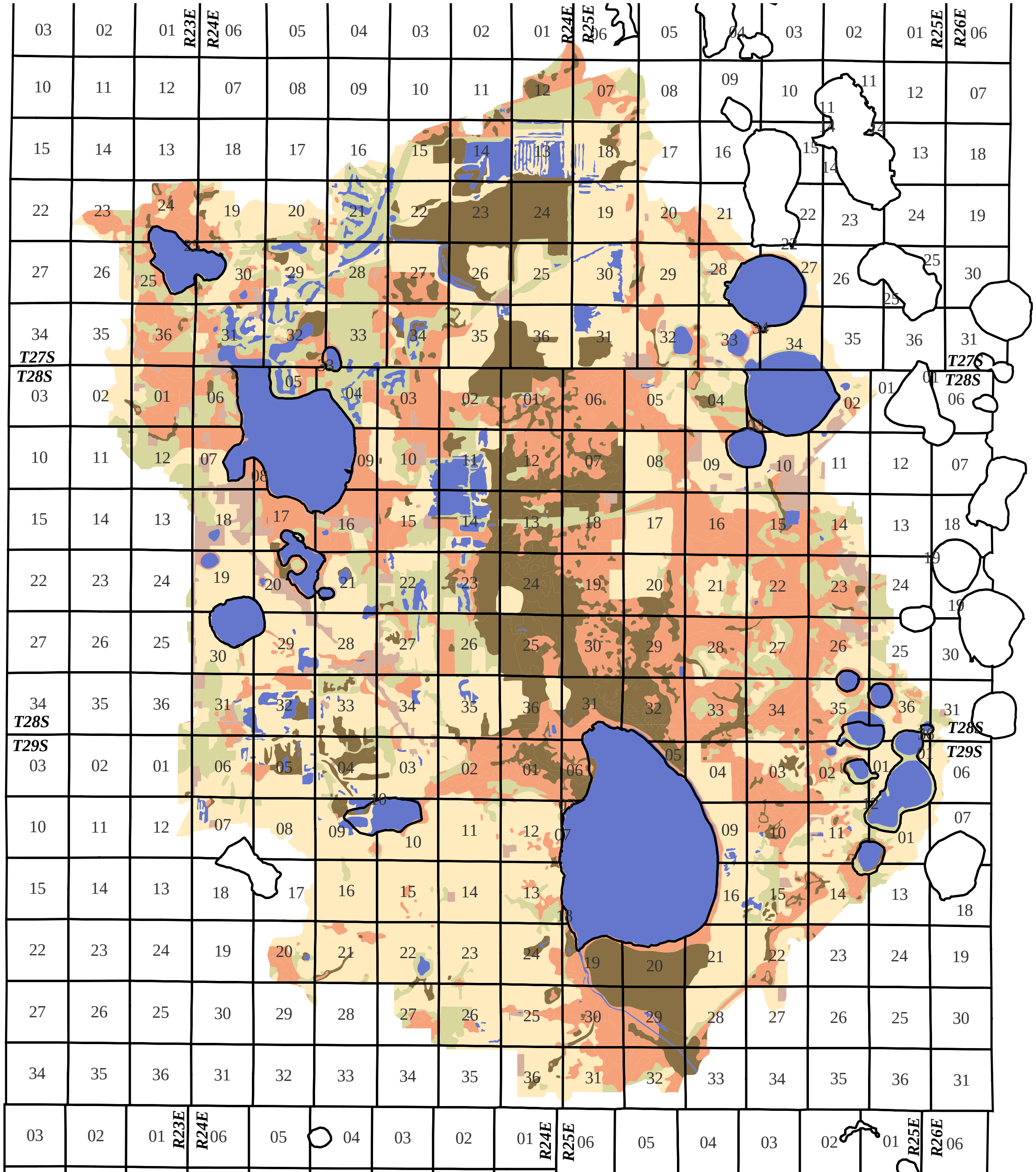

Soils Classified by Hydrologic Group

- A
- B
- B/D
- C
- D
- W

Figure A7. Soils Classified by Hydrologic Group within the Lake Hancock Watershed

N
W E
S

0 2.5 5
Miles

BCI ENGINEERS & SCIENTISTS, INC.

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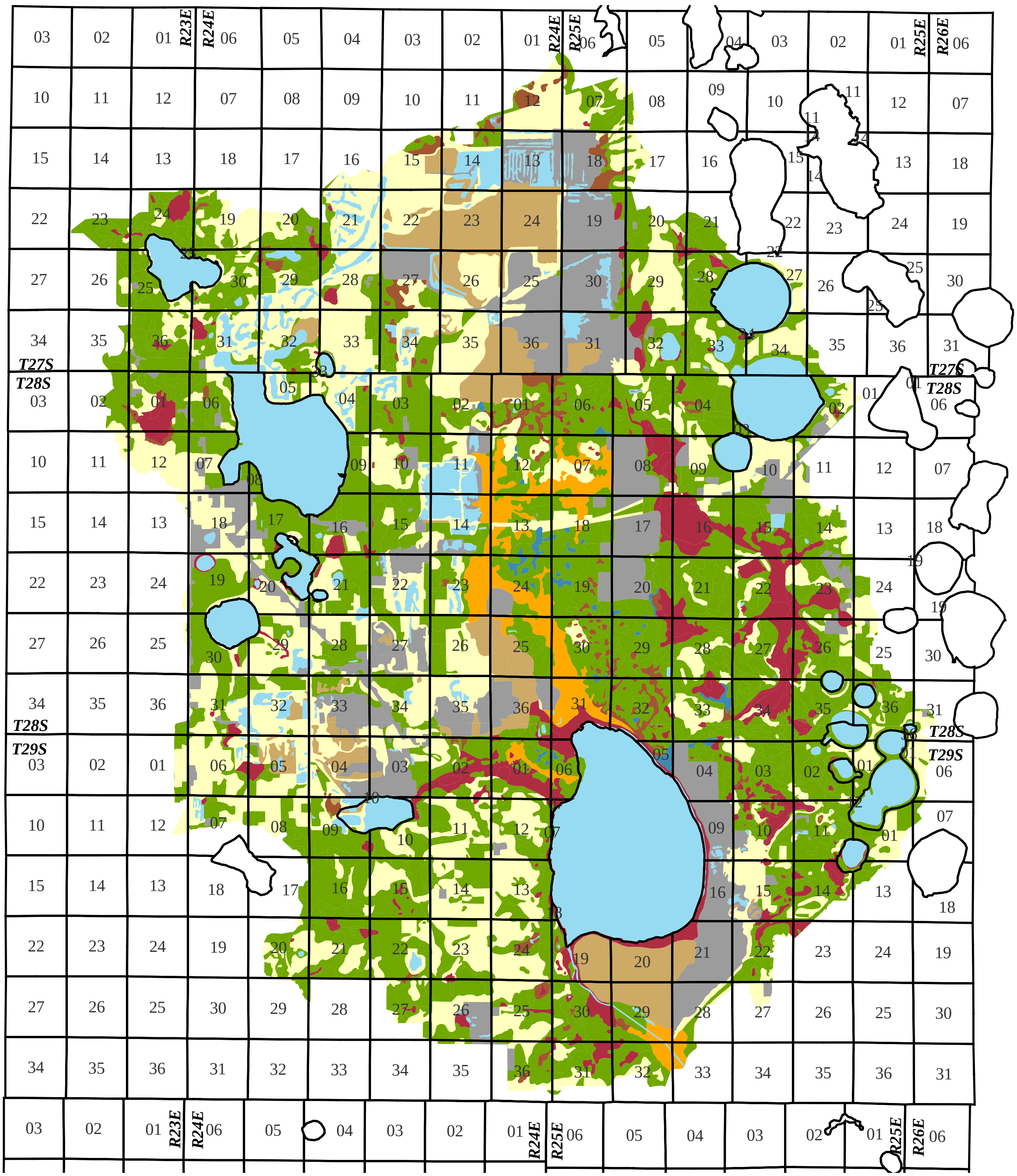

Soils Classified by Texture

- Water
- C, Clay
- FS, Fine Sand
- FSL, Fine Sandy Loam
- MK-FS, Mucky Fine Sand
- MUCK
- S, Sand
- SCL, Sandy Clayey Loam
- VAR, Reclaimed Mined Lands and other

Figure A8
Soils Classified by Texture within the Lake Hancock Watershed

0 2.5 5
Miles

V:\19-12376_Swfwmd_Hancock\Data-Collection-9-10-03\Draft_Figures\FigureA8_Soils_Lake_Hancock_Watershed.mxd

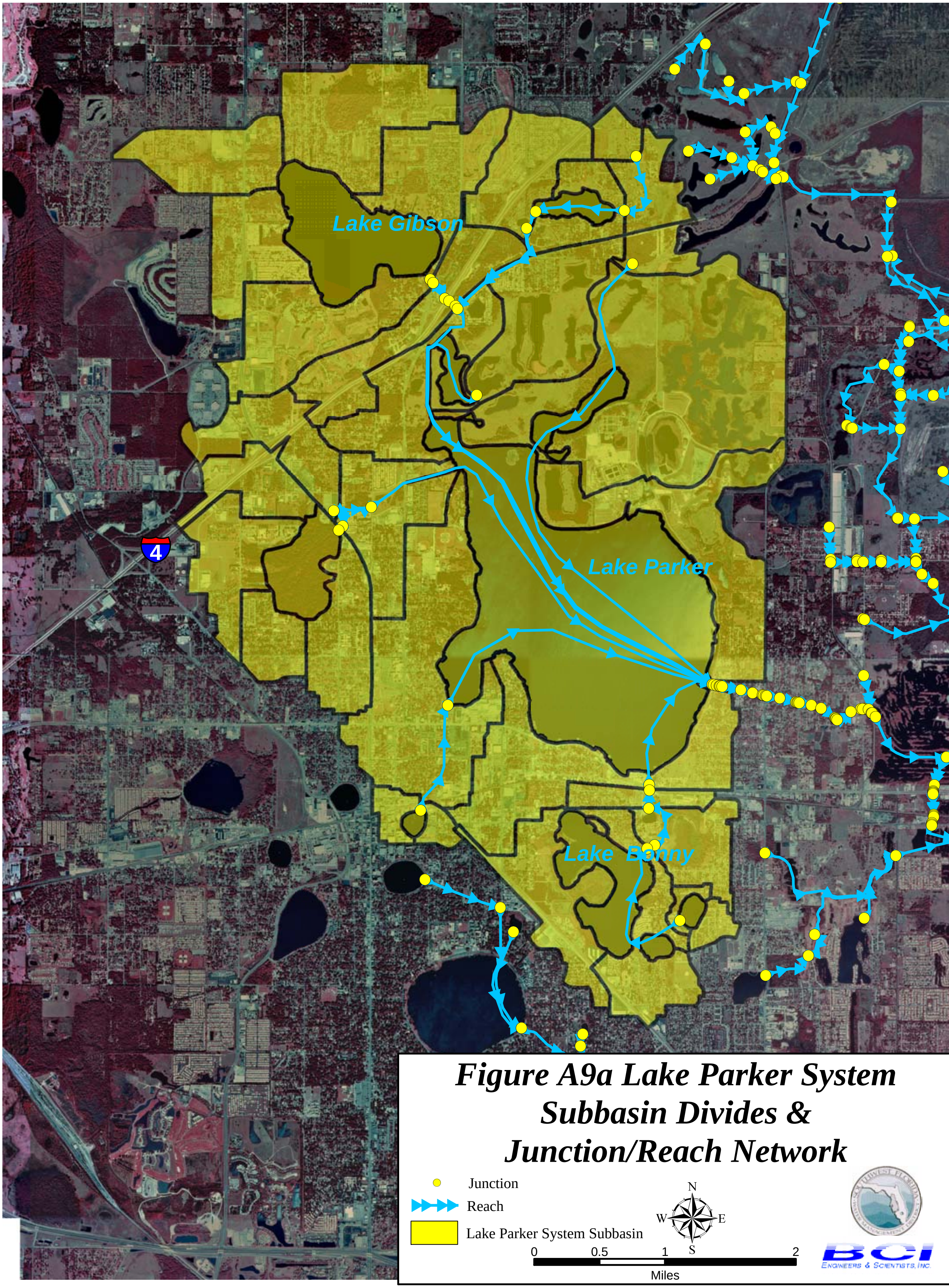

Figure A9a Lake Parker System Subbasin Divides & Junction/Reach Network

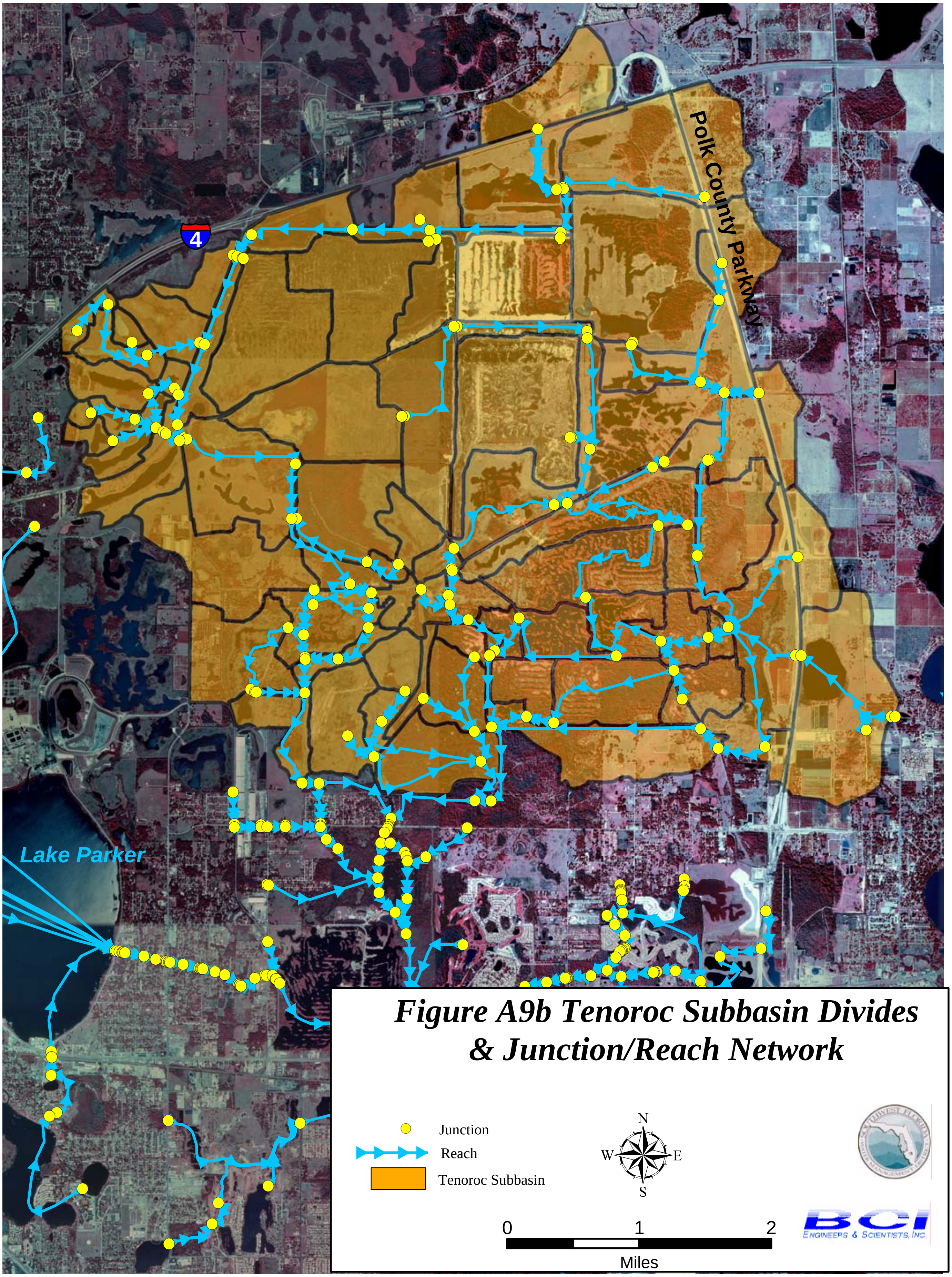

Figure A9b Tenoroc Subbasin Divides & Junction/Reach Network

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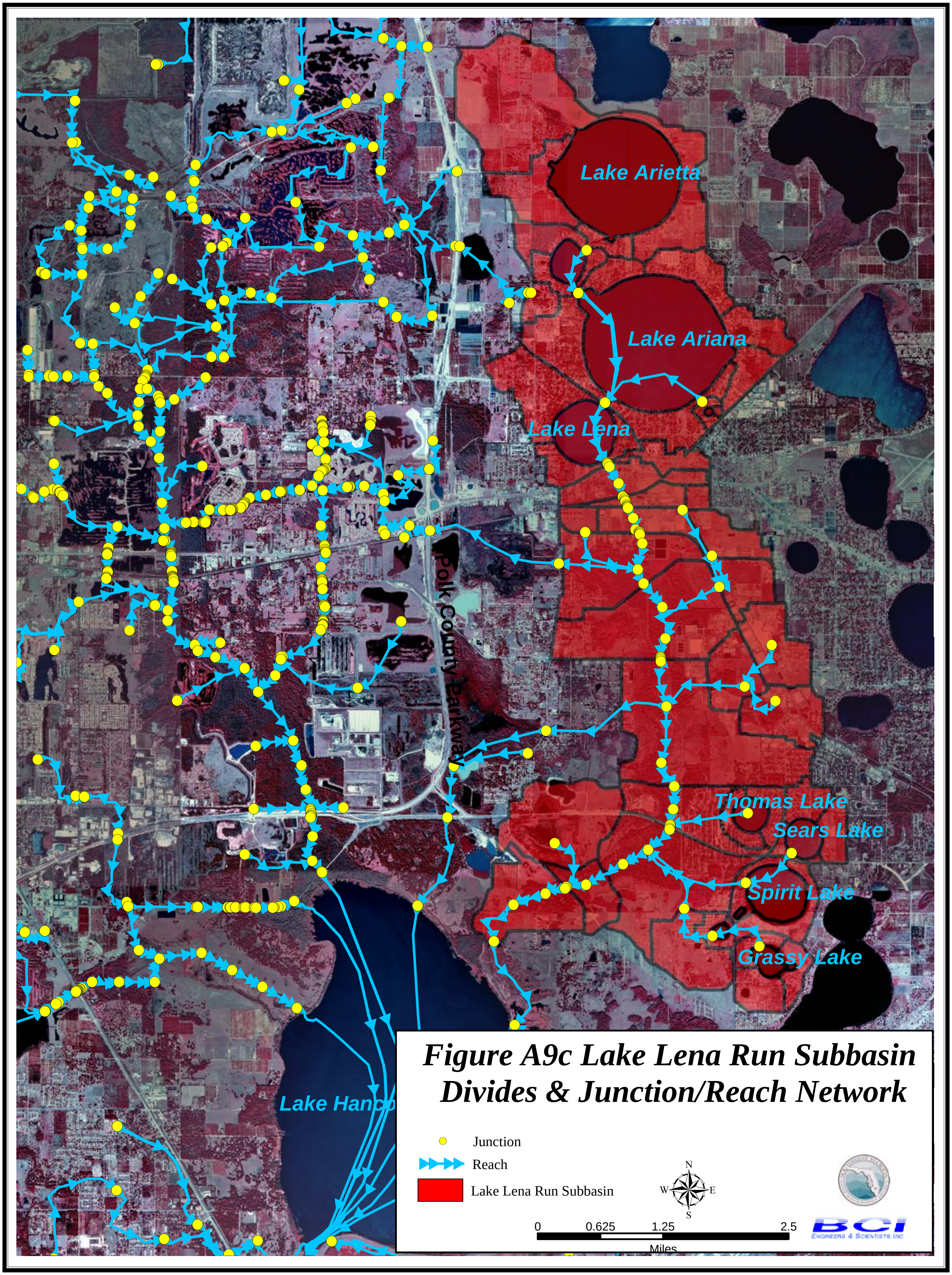

Figure A9c Lake Lena Run Subbasin Divides & Junction/Reach Network

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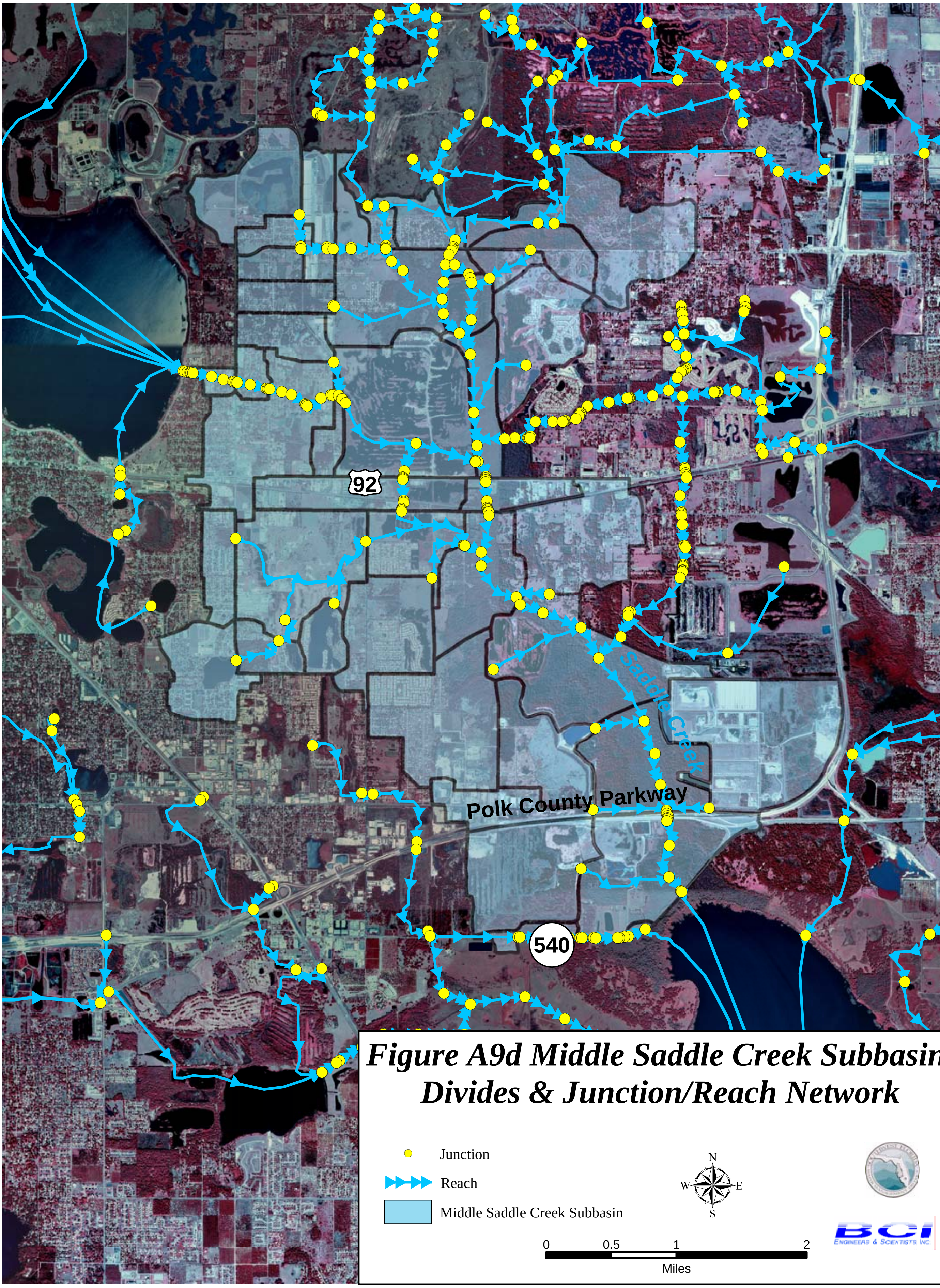

Figure A9d Middle Saddle Creek Subbasin Divides & Junction/Reach Network

Junction

Reach

Middle Saddle Creek Subbasin

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Miles

BCI Engineers & Scientists Inc.

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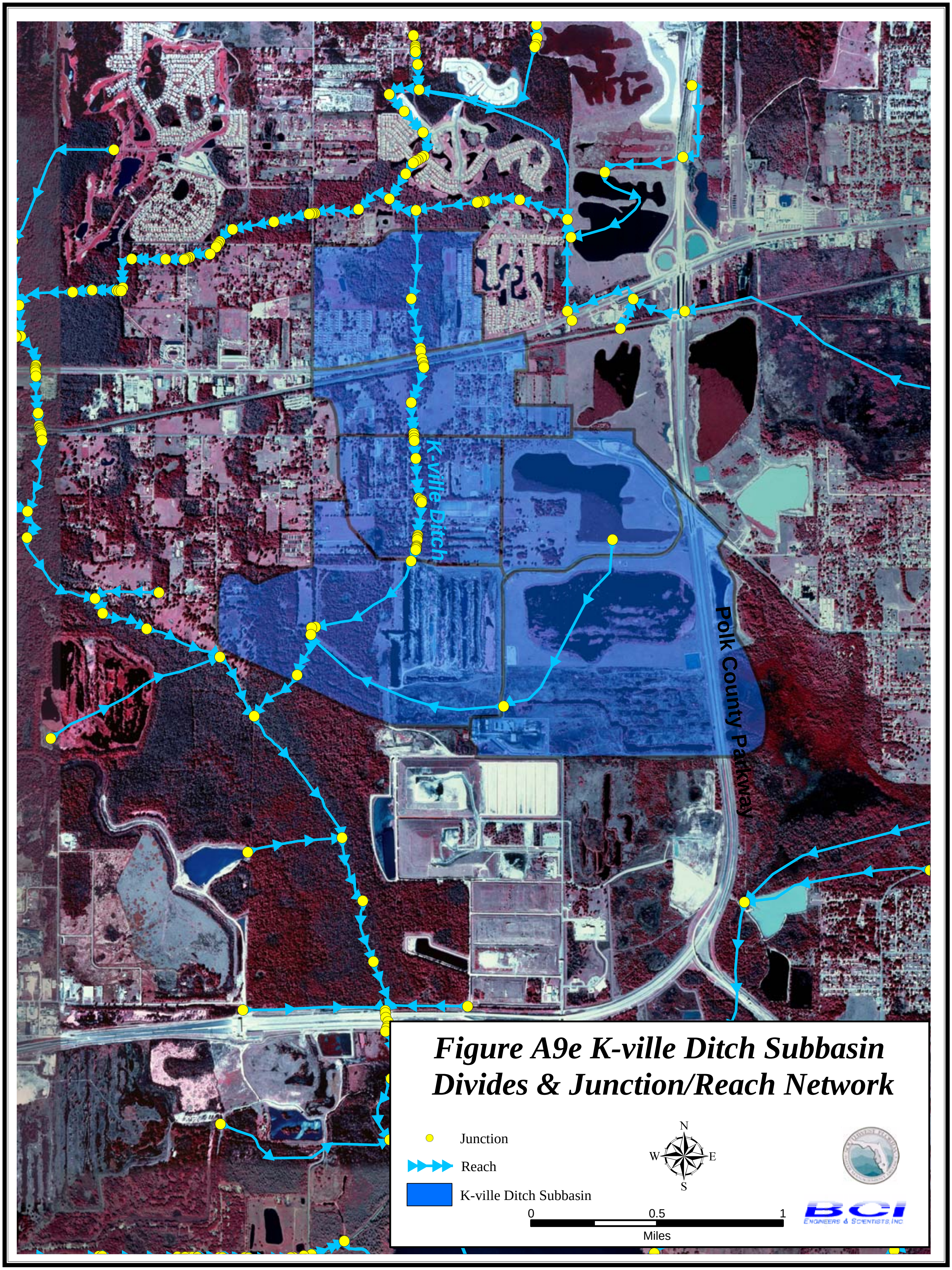

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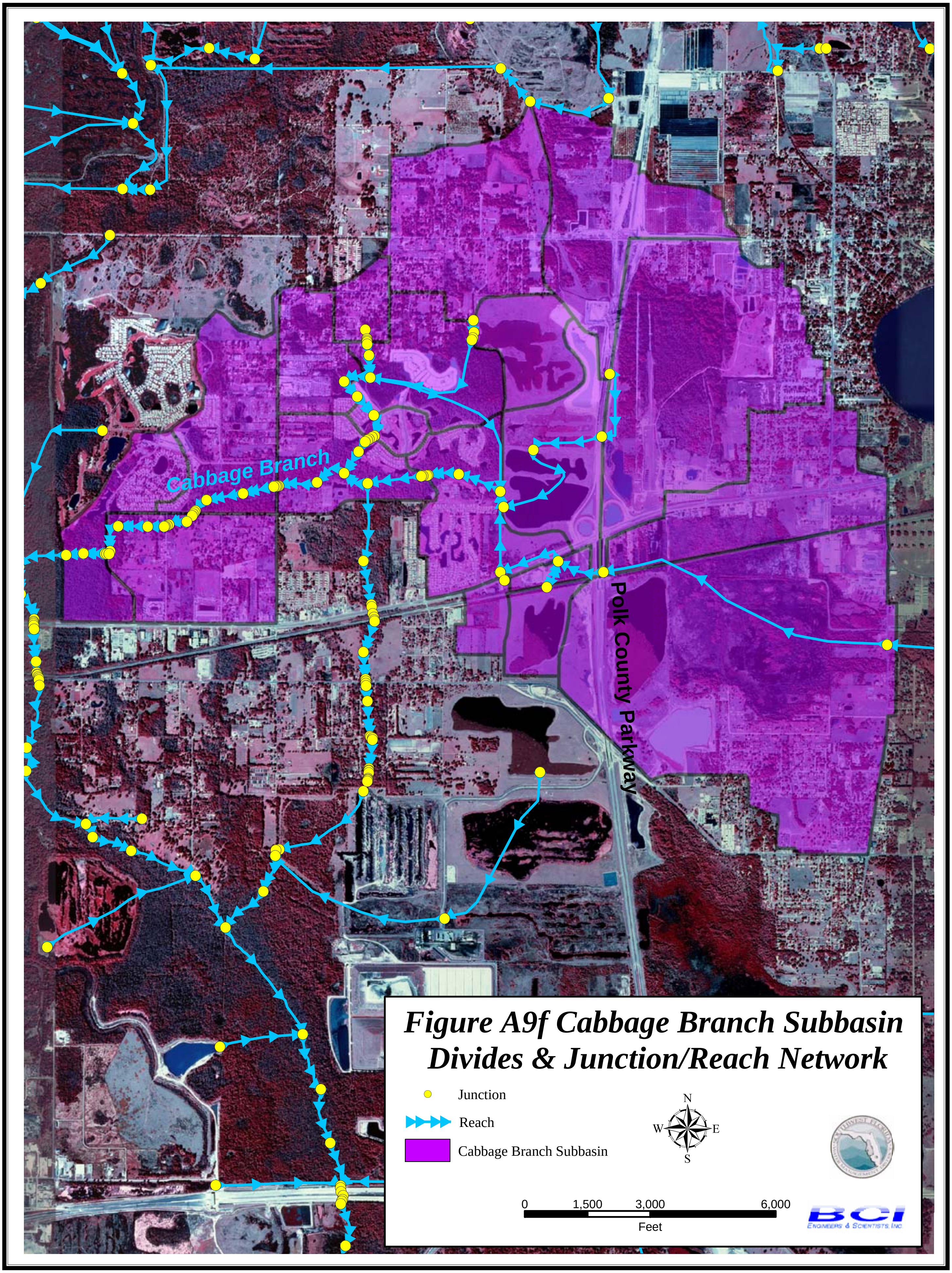

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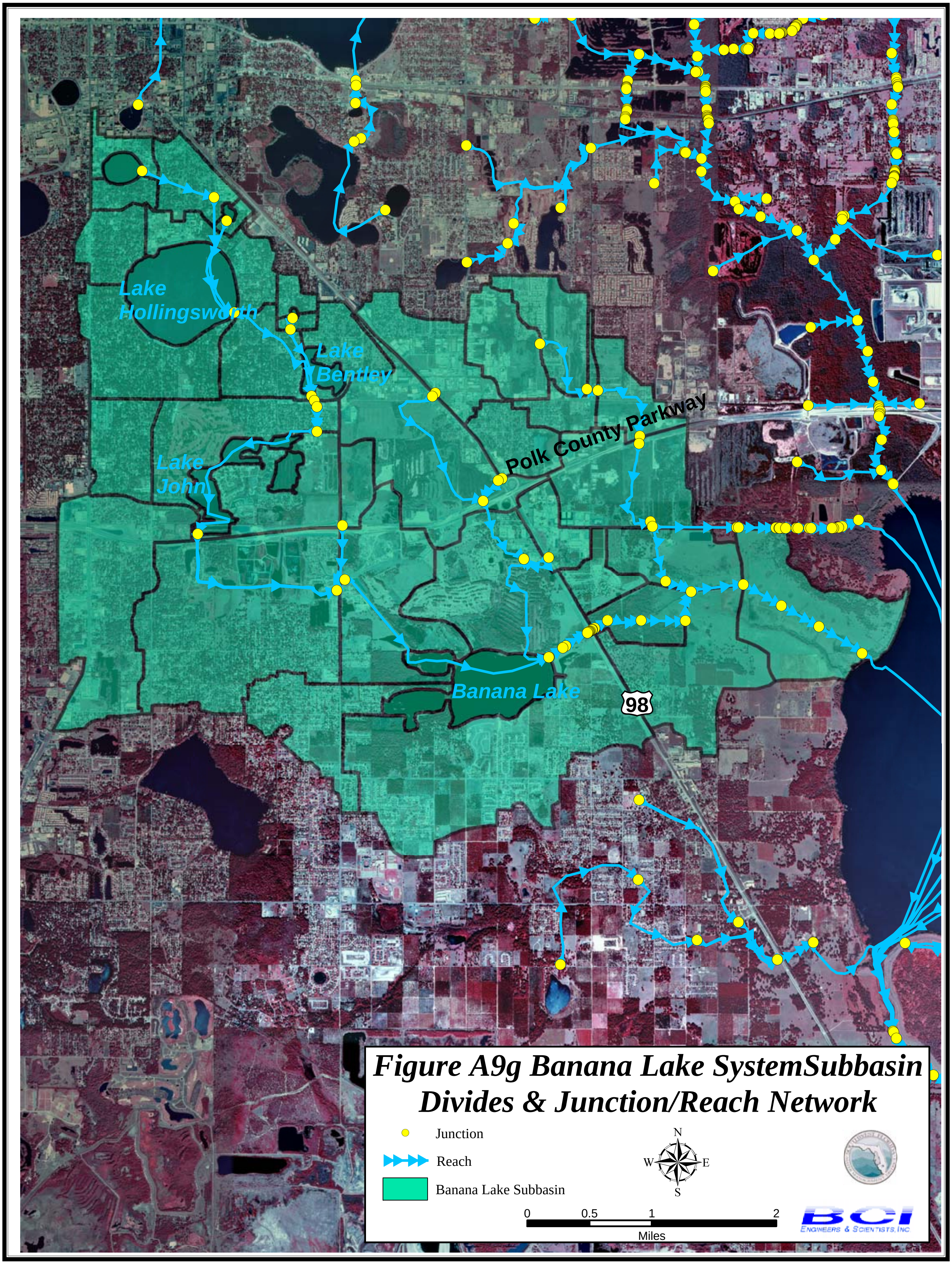

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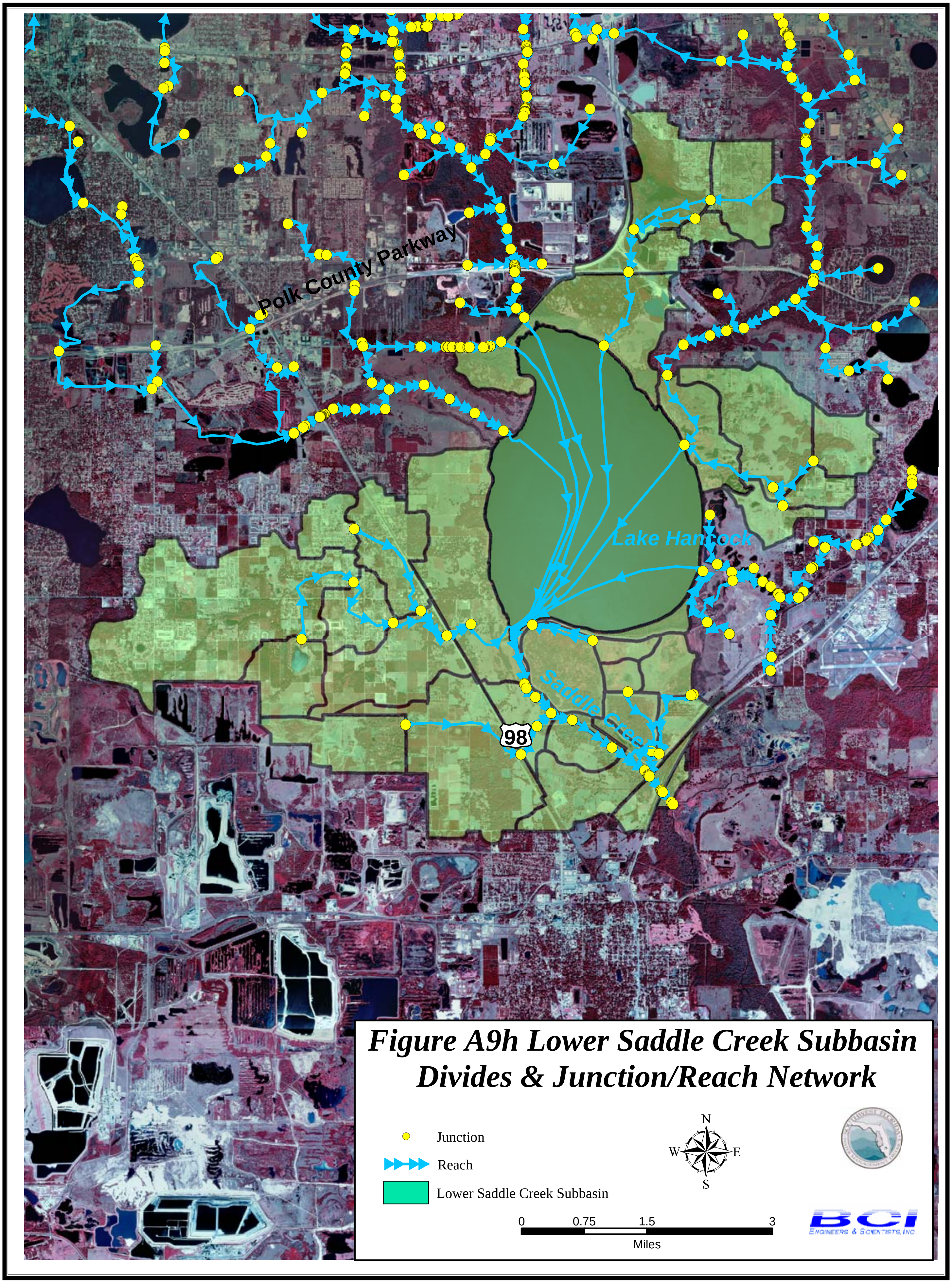
Polk County Parkway
Lake Hancock
Saddle Creek
98
Figure A9h Lower Saddle Creek Subbasin
Divides & Junction/Reach Network
Junction
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Lower Saddle Creek Subbasin
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Engineers & Scientists, Inc.

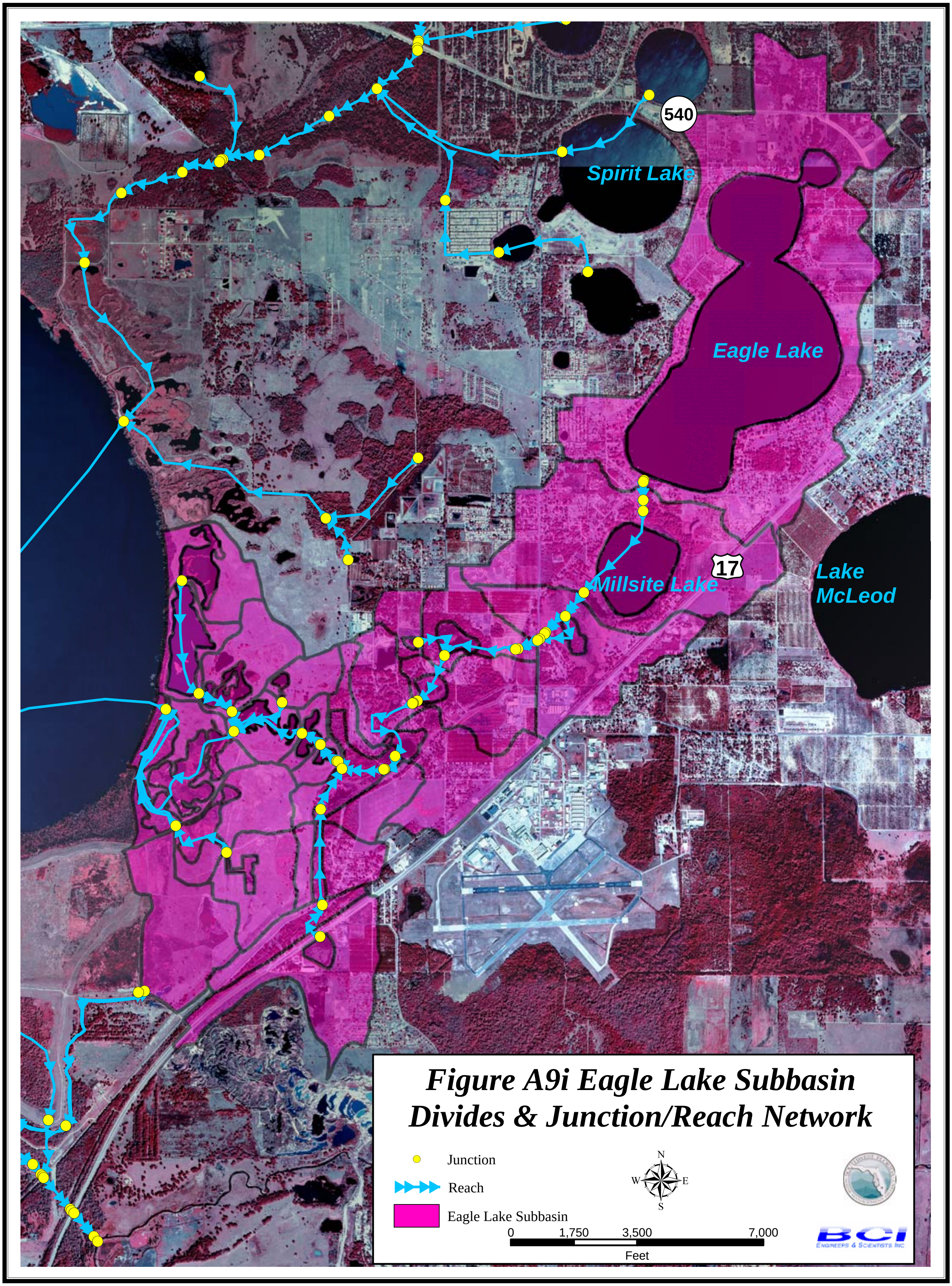

Figure A9i Eagle Lake Subbasin Divides & Junction/Reach Network

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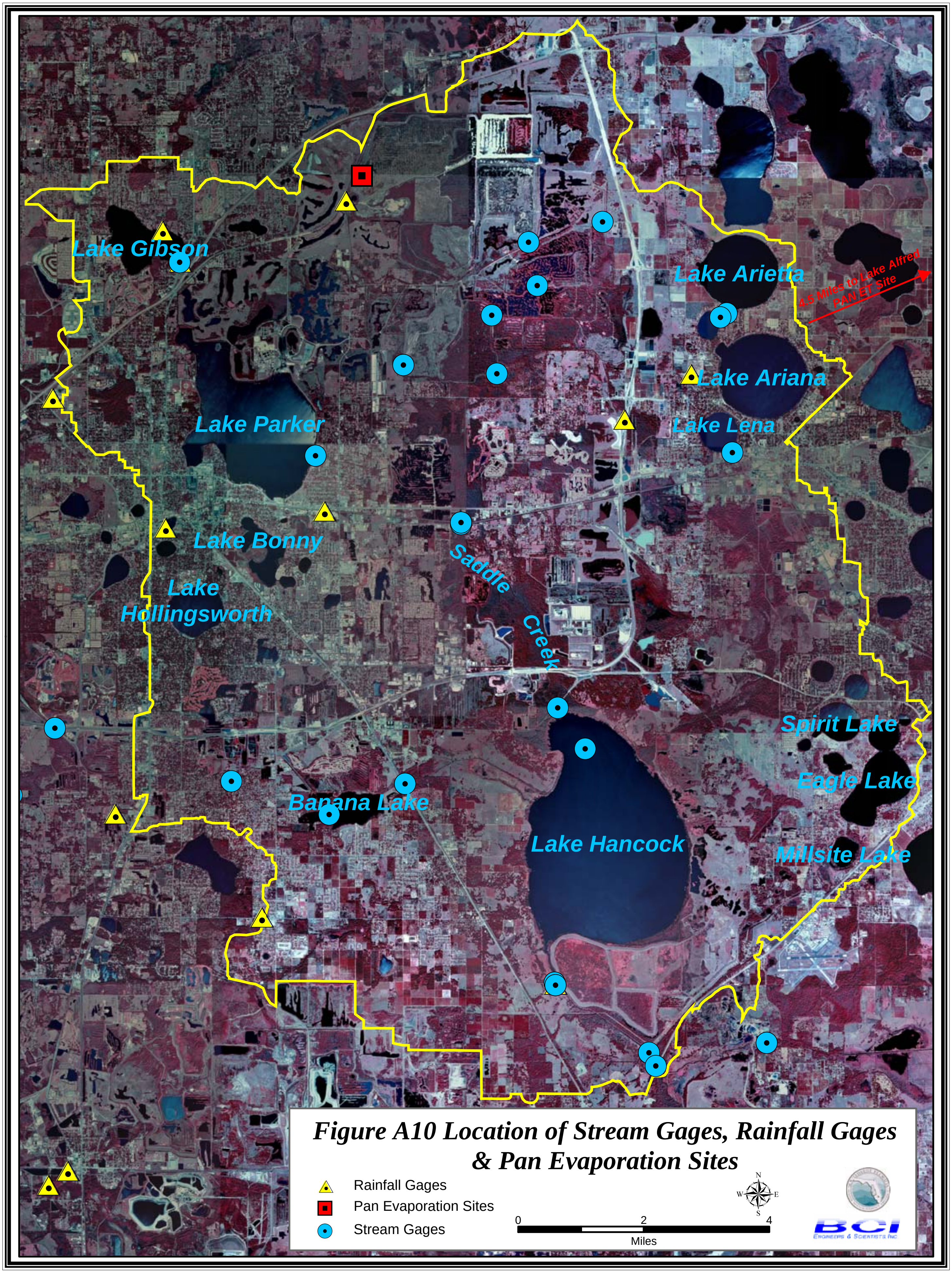

Figure A10 Location of Stream Gages, Rainfall Gages & Pan Evaporation Sites

APPENDIX B

LAKE HANCOCK FLOODPLAIN SIMULATION MODEL

MODEL RESULTS

LIST OF TABLES

LIST OF FIGURES

Table B1. Flood Elevations: 5 Day, 100 Year Storm Event - Lake Parker System

		5 Day - 98.7	5 Day - 99.5	5 Day - 100.0	5 Day - 100.5
Node ID	Description	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)
N4620	Upstream East Lake Parker Dr. bridge	134.20	134.20	134.20	134.20
N3530	Downstream East Lake Parker Dr. Bridge	133.93	133.93	133.93	133.93
N3529	Mainstream	133.79	133.79	133.79	133.79
N3528	Upstream Lake Parker control structure	133.66	133.66	133.66	133.66
N3525	Downstream Lake Parker control structure	133.31	133.31	133.19	133.31
N3522	Mainstream	133.22	133.22	133.23	133.22
N3520	Mainstream	132.39	132.39	132.39	132.39
N3517	Mainstream	131.67	131.67	131.67	131.67
N3515	Mainstream	130.85	130.85	130.85	130.85
N3514	Upstream Combee Road (CR 659)	130.66	130.66	130.66	130.66
N3511	Downstream Combee Road (CR 659)	130.26	130.26	130.26	130.26
N3510	Mainstream	130.03	130.03	130.03	130.03
N3505	Mainstream	127.86	127.86	127.86	127.86
N3500	Mainstream	126.34	126.34	126.34	126.34
N3499	Upstream Woodland Avenue bridge	126.44	126.44	126.44	126.44
N3496	Downstream Woodland Avenue bridge	126.21	126.21	126.21	126.21
N3495	Mainstream	124.42	124.42	124.42	124.42
N3490	Mainstream	122.79	122.79	122.79	122.79
N3485	Mainstream	121.28	121.28	121.28	121.28
N3480	Mainstream	120.28	120.28	120.28	120.28
N3479	Upstream timber pedestrian bridge	119.86	119.86	119.86	119.86
N3476	Downstream timber pedestrian bridge	119.49	119.49	119.49	119.49
N3475	Mainstream	117.91	117.91	117.91	117.91
N3473	Mainstream	114.45	114.45	114.45	114.45
N3470	Mainstream	113.82	113.82	113.82	113.82
N3469	Upstream Fish Hatchery Rd bridge	113.84	113.84	113.85	113.84
N3466	Downstream Fish Hatchery Rd bridge	113.62	113.62	113.62	113.62
N3465	Mainstream	112.91	112.91	112.91	112.91
N3460	Mainstream	112.43	112.43	112.43	112.43
N3455	Mainstream	112.40	112.41	112.41	112.40
N3454	Upstream CSX Railroad bridge	112.41	112.31	112.31	112.41
N3450	Downstream CSX Railroad bridge	111.01	111.01	111.01	111.01
N3448	Mainstream	110.99	110.99	110.99	110.98
N3447	Saddle Creek Lake, junction from Lake Park	110.98	110.98	110.97	110.97

Table B2. Flood Elevations: 5 Day, 100 Year Storm Event - Lake Lena Run

Node ID	Description	5 Day - 98.7 Max Stage (ft)	5 Day - 99.5 Max Stage (ft)	5 Day - 100.0 Max Stage (ft)	5 Day - 100.5 Max Stage (ft)
N1450	Lake Arieatta	144.36	144.36	144.36	144.36
N1440	P-1 Control Structure	144.06	144.06	144.06	144.06
N1430	Lake Whistler	139.12	139.12	139.12	139.12
N1420	Lake Arianna	138.88	138.88	138.88	138.88
N1410	Lake Lena	138.83	138.83	138.83	138.83
N1405	Upstream of Bridgers Ave.	138.93	138.93	138.93	138.93
N1400	Downstream of Bridgers Ave.	138.44	138.44	138.44	138.44
N1390	Upstream of US 92	138.55	138.55	138.55	138.55
N1380	Downstream of US 92	138.46	138.46	138.46	138.46
N1370	Main Stream	138.46	138.46	138.46	138.46
N1360	Upstream CSX Railroad	138.17	138.17	138.17	138.17
N1350	Downstream of CSX~tailroad	138.13	138.13	138.13	138.13
N1348	Main Stream	137.92	137.92	137.92	137.92
N1346	Upstream of CSX Spur	137.91	137.91	137.91	137.91
N1340	Downstream of CSX Spur	135.19	135.14	135.19	135.19
N1330	Main Stream	135.13	135.14	135.13	135.13
N1320	Main Stream	134.96	134.96	134.96	134.96
N1318	Upstream Derby Ave. (CR 544A)	134.90	134.90	134.90	134.90
N1316	Downstream Derby Ave. (CR 544A)	133.77	133.77	133.77	133.77
N1310	Main Stream, small wetland	133.73	133.73	133.73	133.73
N1300	Main Stream, small wetland	133.34	133.34	133.34	133.34
N1295	Main Stream	133.06	133.06	133.06	133.06
N1290	Main Stream	133.05	133.05	133.05	133.05
N1288	Upstream Recker HWY	133.04	133.04	133.04	133.04
N1284	Downstream Recker HWY	130.58	130.58	130.58	130.58
N1280	Main Stream	129.71	129.71	129.71	129.71
N1278	Main Stream	126.75	126.75	126.75	126.75
N1270	Main Stream, Weir to Cabbage Branch	126.27	126.27	126.27	126.27
N1260	Main Stream, large wetland	124.28	124.28	124.28	124.28
N1250	Main Stream, large wetland	122.00	122.00	122.00	122.00
N1240	Main Stream, large wetland	121.93	121.93	121.93	121.93
N1230	Main Stream, large wetland	121.91	121.91	121.91	121.91
N1228	Upstream K-Ville Ave. (CR 542)	121.91	121.91	121.92	121.92
N1222	Downstream K-Ville Ave. (CR 542)	119.74	119.74	119.74	119.74
N1220	Main Stream, large wetland	119.70	119.70	119.70	119.70
N1210	Main Stream, Weir to K-ville Ditch	118.13	118.13	118.13	118.13
N1200	Main Stream	117.51	117.50	117.50	117.50
N1190	Main Stream	117.45	117.45	117.45	117.45
N1180	Main Stream	117.42	117.42	117.42	117.42
N1170	Main Stream	117.36	117.36	117.36	117.36
N1168	Upstream SR 540	117.35	117.35	117.35	117.35
N1164	Downstream SR 540	113.73	113.73	113.73	113.73
N1160	Main Stream	113.71	113.71	113.71	113.71
N1150	Main Stream, large wetland	113.50	113.50	113.50	113.50
N1140	Main Stream, large wetland	112.96	112.96	112.96	112.96
N1130	Main Stream, large wetland	112.21	112.21	112.21	112.21
N1120	Main Stream, large wetland	112.02	112.02	112.02	112.01

Table B2.(cont) Flood Elevations: 5 Day, 100 Year Storm Event - Lake Lena Run

		5 Day - 98.7	5 Day - 99.5	5 Day - 100.0	5 Day - 100.5
Node ID	Description	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)
N1118	Upstream Thornhill Rd Bridge	111.98	111.98	111.98	111.98
N1110	Downstream Thornhill Rd Bridge	110.69	110.69	110.69	110.69
N1100	Main Stream, large wetland	107.73	107.73	107.74	107.74
N1080	Main Stream, large wetland	104.90	104.89	104.88	104.88
N1070	Upstream Wetland	102.90	103.16	103.38	103.65
N2186	Wetland	118.59	118.67	118.65	118.65
N2180	Adj. to Lk. Hancock	108.83	108.62	108.55	108.47
N2174	Ditch	102.78	103.06	103.29	103.57
N2184	wetland	112.26	112.31	112.30	112.30
N2180	Adj. to Lk. Hancock	108.83	108.62	108.55	108.47
N2174	Ditch	102.78	103.06	103.29	103.57

Table B3. Flood Elevations: 5 Day, 100 Year Storm Event - Middle Saddle Creek

Node ID	Description	5 Day - 98.7 Max Stage (ft)	5 Day - 99.5 Max Stage (ft)	5 Day - 100.0 Max Stage (ft)	5 Day - 100.5 Max Stage (ft)
N3369	Tributary	115.67	115.66	115.67	115.66
N3368	Upstream Saddle Creek Road (CR 546)	115.66	115.64	115.65	115.64
N3367	Downstream Saddle Creek Road (CR 546)	114.26	114.24	114.26	114.24
N3366	Tributary, large wetland	112.31	112.32	112.31	112.32
N3365	Tributary, large wetland	112.05	112.06	112.05	112.06
N3364	Tributary, large wetland	110.78	110.78	110.78	110.77
N3362	Tributary, large wetland	110.71	110.71	110.71	110.71
N3361	Tributary, large wetland	110.66	110.66	110.66	110.65
N3360	Tributary, large wetland	110.64	110.63	110.63	110.63
N3359	Tributary, large wetland	110.63	110.63	110.63	110.63
N3358	Tributary, large wetland	110.63	110.63	110.63	110.63
N3380	Tributary, large wetlqpd	118.42	118.42	118.42	118.42
N3379	Upstream Saddle Creek Road (CR 546)	118.38	118.38	118.38	118.38
N3378	Downstream Saddle Creek Road (CR 546)	115.15	115.15	115.15	115.15
N3377	Tributary, large wetland	114.93	114.93	114.93	114.93
N3376	Tributary, large wetland	110.72	110.72	110.72	110.71
N3375	Tributary, large wetland	110.72	110.71	110.71	110.71
N3357	Tributary, large wetland	110.72	110.72	110.72	110.71
N3356	Tributary, large wetland	110.70	110.70	110.70	110.70
N3355	Tributary, large wetland	110.64	110.64	110.64	110.64
N3354	Tributary, large wetland	110.64	110.64	110.64	110.64
N3353	Mainstream, large wetland	110.63	110.63	110.63	110.63
N3352	Mainstream, large wetland	110.58	110.58	110.58	110.57
N3351	Mainstream, junction from Cabbage Branch	110.56	110.56	110.56	110.56
N3447	Saddle Creek Lake, junction from Lake Park	110.98	110.98	110.97	110.97
N3411	Weir from Saddle Creek Lake	110.92	110.92	110.92	110.92
N3410	Weir from Saddle Creek Lake	110.92	110.92	110.92	110.92
N3409	Weir from Saddle Creek Lake	110.92	110.92	110.92	110.92
N3408	Weir from Saddle Creek Lake	110.92	110.92	110.92	110.92
N3350	Mainstream, junction from Saddle Creek Lake	110.55	110.55	110.55	110.55
N3349	Mainstream, large wetland	110.50	110.50	110.49	110.49
N3348	Upstream US 92 Bridge Westbound	110.29	110.29	110.64	110.63
N3347	Downstream US 92 Bridge Westbound	110.44	110.44	110.12	110.11
N3346	Upstream US 92 Bridge Eastbound	109.98	109.98	110.18	110.18
N3345	Downstream US 92 Bridge Eastbound	109.99	109.98	109.98	109.97
N3344	Mainstream, large wetland	109.79	109.79	109.79	109.79
N3343	Mainstream, large wetland	109.77	109.77	109.77	109.77
N3342	Mainstream, large wetland	109.74	109.73	109.74	109.74
N3341	Upstream CSX Railroad	109.77	109.77	109.68	109.67
N3340	Downstream CSX Railroad	109.49	109.49	109.54	109.54
N3339	Mainstream	109.49	109.49	109.40	109.40
N3338	Upstream East Main St. (CR 542)	109.34	109.35	109.43	109.42
N3337	Downstream East Main St. (CR 542)	109.23	109.22	109.21	109.20
N3336	Mainstream, large wetland	109.20	109.20	109.20	109.20
N3446	Downstream of Private Driveway	109.68	109.67	109.67	109.67
N3445	Upstream US 92 Bridge Westbound	109.65	109.67	109.67	109.67
N3444	Downstream US 92 Bridge Westbound	109.71	109.54	109.54	109.54
N3443	Upstream US 92 Bridge Eastbound	109.53	109.68	109.68	109.67
N3442	Downstream US 92 Bridge Eastbound	109.58	109.57	109.57	109.57

Table B3.(cont) Flood Elevations: 5 Day, 100 Year Storm Event - Middle Saddle Creek

Node ID	Description	5 Day - 98.7 Max Stage (ft)	5 Day - 99.5 Max Stage (ft)	5 Day - 100.0 Max Stage (ft)	5 Day - 100.5 Max Stage (ft)
N3441	Upstream CSX Railroad Bridge	109.56	109.56	109.56	109.56
N3440	Downstream CSX Railroad Bridge	109.56	109.56	109.56	109.56
N3439	Tributary, large wetland	109.51	109.51	109.51	109.51
N3438	Tributary, large wetland	109.51	109.51	109.51	109.50
N3437	Upstream East Main St. (CR 542)	109.50	109.50	109.51	109.51
N3436	Downstream East Main St. (CR 542)	109.54	109.54	109.48	109.48
N3435	Small lake junction from trib towards Saddle Creek	109.48	109.48	109.48	109.48
N3430	Downstream Farmer Brown Road	109.46	109.46	109.46	109.45
N3429	Tributary, large wetland	109.10	109.09	109.09	109.09
N3335	Junction, tributary and Saddle Creek	109.03	109.02	109.02	109.01
N3334	Mainstream, large wetland	108.99	108.99	108.98	108.98
N3333	Mainstream, large wetland	108.89	108.89	108.88	108.88
N3332	Mainstream, large wetland	108.73	108.73	108.72	108.71
N3331	Mainstream, large wetland	108.19	108.19	108.18	108.17
N3330	Mainstream, large wetland -	105.76	105.79	105.85	105.92
N3329	Mainstream, junction from K-ville Ditch	105.63	105.64	105.65	105.72
N3328	Mainstream, large wetland	105.13	105.16	105.26	105.39
N3327	Mainstream, large wetland	104.93	104.99	105.11	105.26
N3326	Mainstream, large wetland	104.81	104.90	105.03	105.18
N3325	Mainstream, large wetland	104.38	104.56	104.71	104.90
N3321	Upstream Polk Parkway Bridge Westbound Lane	104.29	104.47	104.63	104.83
N3320	Downstream Polk Parkway Bridge Westbound	104.26	104.45	104.61	104.81
N3319	Upstream Polk Parkway Bridge Eastbound Lane	104.18	104.37	104.53	104.75
N3318	Downstream Polk Parkway Bridge Eastbound	104.12	104.32	104.49	104.70
N3317	Mainstream, large wetland	103.87	104.08	104.25	104.48
N3316	Mainstream, large wetland	103.68	103.89	104.07	104.30
N3315	Mainstream, large wetland	103.38	103.63	103.86	104.13
N3314	Mainstream, large wetland	103.25	103.53	103.76	104.05
N3313	Mainstream, large wetland	103.22	103.50	103.74	104.04
N3312	Upstream State Road 540	103.21	103.50	103.74	104.04
N2100	Lake Hancock	102.74	103.01	103.24	103.52

Table B4. Flood Elevations: 5 Day, 100 Year Storm Event - Cabbage Branch

Node ID	Description	5 Day - 98.7 Max Stage (ft)	5 Day - 99.5 Max Stage (ft)	5 Day - 100.0 Max Stage (ft)	5 Day - 100.5 Max Stage (ft)
N3785	Natural Swale	117.54	117.54	117.54	117.54
N3780	Natural Swale	117.54	117.54	117.54	117.54
N3779	Upstream Taylor Rd	117.54	117.54	117.54	117.54
N3776	Downstream Taylor Rd	116.85	116.85	116.85	116.85
N3775	Tributary, small wetland	116.85	116.85	116.85	116.85
N3770	Tributary, small wetland	116.85	116.85	116.85	116.85
N3765	Tributary, large wetland	116.85	116.85	116.85	116.85
N3760	Tributary, north of the Hamptons	116.84	116.84	116.84	116.84
N3755	Tributary, north of the Hamptons	116.79	116.79	116.79	116.79
N3750	Tributary, north of the Hamptons	116.77	116.77	116.77	116.77
N3745	Tributary, north of the Hamptons	116.68	116.68	116.68	116.68
N3744	Upstream Southhampton Blvd.	116.52	116.52	116.52	116.52
N3741	Downstream Southhampton Blvd.	116.23	116.23	116.23	116.23
N3740	Tributary, through the Hamptons	115.94	115.94	115.94	115.94
N3736	Tributary, through the Hamptons	115.53	115.53	115.53	115.53
N3735	Tributary, leaving the Hamptons	115.21	115.21	115.21	115.21
N3815	Tributary, large wetland	116.10	116.10	116.10	116.10
N3810	Tributary, large wetland	115.83	115.83	115.83	115.83
N3805	Tributary, large wetland	115.64	115.64	115.64	115.64
N3804	Upstream Southhampton Blvd.	115.63	115.63	115.63	115.63
N3801	Downstream Southhampton Blvd.	115.28	115.28	115.28	115.28
N3800	Tributary, large wetland	115.27	115.27	115.27	115.27
N3790	Tributary, large wetland	115.23	115.23	115.23	115.23
N3730	Junction to form Cabbage Branch	115.21	115.21	115.21	115.21
N3725	Mainstream, large wetland	115.11	115.11	115.11	115.11
N3720	Mainstream, large wetland	114.63	114.63	114.63	114.63
N3719	Upstream Old Dixie Hwy (CR 542)	114.46	114.46	114.46	114.46
N3716	Downstream Old Dixie Hwy (CR 542)	113.98	113.98	113.98	113.98
N3715	Mainstream, large wetland	113.31	113.31	113.31	113.31
N3710	Mainstream, large wetland	112.71	112.71	112.71	112.71
N3705	Mainstream, large wetland	112.40	112.40	112.40	112.40
N3700	Mainstream, large wetland	112.37	112.37	112.37	112.37
N3699	Upstream East Carroll Road	112.37	112.37	112.37	112.37
N3696	Downstream East Carroll Road	111.28	111.28	111.28	111.28
N3695	Mainstream	110.68	110.68	110.68	110.68
N3690	Mainstream	110.63	110.63	110.62	110.62
N3685	Mainstream	110.60	110.60	110.60	110.59
N3684	Upstream Palmer Road	110.59	110.59	110.59	110.58
N3682	Downstream Palmer Road	110.59	110.58	110.58	110.58
N3680	Mainstream	110.58	110.58	110.58	110.57
N3675	Mainstream	110.58	110.58	110.58	110.57
N3670	Mainstream	110.57	110.57	110.57	110.57
N3665	Mainstream, small wetland	110.57	110.57	110.57	110.57
N3664	Upstream Schalamar Creek Dr	110.58	110.58	110.58	110.56
N3661	Downstream Schalamar Creek Dr	110.55	110.55	110.55	110.57
N3660	Mainstream, large wetland	110.57	110.56	110.56	110.56
N3655	Mainstream, large wetland	110.56	110.56	110.56	110.56
N3650	Mainstream, large wetland	110.56	110.56	110.56	110.56

Table B5. Flood Elevations: 5 Day, 100 Year Storm Event - Banana Lake System

Node ID	Description	5 Day - 98.7 Max Stage (ft)	5 Day - 99.5 Max Stage (ft)	5 Day - 100.0 Max Stage (ft)	5 Day - 100.5 Max Stage (ft)
N5460	Upstream Banana Lake culverts	109.10	109.10	109.10	109.10
N5455	Downstream Banana Lake culverts	109.10	109.10	109.10	109.10
N5454	Mainstream	108.82	108.82	108.82	108.82
N5453	Mainstream	108.80	108.80	108.80	108.80
N5451	Mainstream	108.55	108.55	108.55	108.55
N5450	Upstream US 98 Southbound lanes bridge	108.54	108.54	108.54	108.53
N5449	Downstream US 98 Southbound lanes bridge	108.11	108.11	108.09	108.10
N5448	Upstream US 98 Northbound lanes bridge	108.10	108.10	108.10	108.10
N5447	Downstream US 98 Northbound lanes bridge	107.59	107.59	107.59	107.59
N5446	Upstream CSX Railroad bridge	107.37	107.37	107.37	107.37
N5445	Downstream CSX Railroad bridge	106.71	106.71	106.71	106.70
N5440	Mainstream, small wetland	105.54	105.54	105.54	105.53
N5435	Mainstream, small wetland	105.31	105.31	105.31	105.30
N5430	Mainstream, small wetland	103.69	103.70	103.72	103.87
N5425	Mainstream	103.01	103.21	103.40	103.65
N5420	Mainstream	102.88	103.12	103.34	103.60
N5415	Mainstream	102.81	103.07	103.29	103.57
N5410	Mainstream	102.79	103.05	103.27	103.55
N5405	Mainstream	102.77	103.03	103.26	103.54
N5400	Mainstream	102.75	103.01	103.24	103.53
N5022	Ditch	119.29	119.29	119.29	119.29
N5021	Rd. Side Ditch	106.32	106.99	107.64	108.15
N5014	Ditch	105.87	105.87	105.85	105.80
N5420	Ditch	102.88	103.12	103.34	103.60
N5022	Ditch	119.29	119.29	119.29	119.29
N5021	Rd. Side Ditch	106.32	106.99	107.64	108.15
N5200	Rd. Side Ditch	105.96	106.77	107.52	108.07
N5210	Rd. Side Ditch	105.70	106.11	106.89	107.47
N5220	Rd. Side Ditch	105.37	105.86	106.79	107.41
N5230	Rd. Side Ditch	104.61	105.14	105.81	106.66
N5240	Rd. Side Ditch	104.59	105.15	105.92	106.29
N5250	Rd. Side Ditch	104.40	104.81	105.23	105.85
N5260	Rd. Side Ditch	104.38	104.79	105.22	105.81
N5270	Rd. Side Ditch	104.05	104.29	104.67	105.12
N5280	Rd. Side Ditch	103.79	104.15	104.61	105.08
N5290	Rd. Side Ditch	103.48	103.90	104.25	104.59
N5300	Rd. Side Ditch	103.34	103.86	104.22	104.56
N5310	Rd. Side Ditch	103.23	103.74	104.06	104.28
N5320	Rd. Side Ditch	103.15	103.68	104.01	104.24
N5330	Rd. Side Ditch	103.05	103.42	103.75	103.98
N5340	Rd. Side Ditch	103.03	103.41	103.74	103.97
N5350	Rd. Side Ditch	102.84	103.11	103.34	103.61
N5360	Rd. Side Ditch	102.80	103.08	103.32	103.59

Table B6. Flood Elevations: 5 Day, 100 Year Storm Event - Lower Saddle Creek

Node ID	Description	5 Day - 98.7	5 Day - 99.5	5 Day - 100.0	5 Day - 100.5
		Max Stage (ft)	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)
N2174	Wetland staging area	102.78	103.06	103.29	103.57
N2100	Lake Hancock	102.74	103.01	103.24	103.52
N2365	Downstream Lake Hancock control structure	102.48	102.63	102.74	102.85
N2360	Mainstream, large wetland	102.38	102.52	102.63	102.74
N2355	Mainstream, large wetland	102.11	102.25	102.36	102.47
N2350	Mainstream, large wetland	101.77	101.89	102.00	102.10
N2345	Mainstream, large wetland	101.61	101.73	101.83	101.94
N2340	Mainstream, small wetland	101.47	101.59	101.69	101.79
N2338	Mainstream, small wetland	101.42	101.54	101.63	101.73
N2337	Mainstream	101.42	101.53	101.63	101.73
N2336	Upstream Old Bartow/Eagle Lake Rd	101.42	101.54	101.63	101.71
N2325	Downstream Lake Hancock control structure	100.26	100.27	100.27	100.28
N2320	Mainstream	100.18	100.18	100.19	100.19
N2315	Upstream US 17 bridge	100.17	100.18	100.18	100.19
N2310	Downstream US 17 bridge	100.12	100.12	100.12	100.12
N2305	Mainstream	100.11	100.11	100.11	100.11

Table B7. Flood Elevations: 5 Day, 100 Year Storm Event - K-Ville Ditch

		5 Day - 98.7	5 Day - 99.5	5 Day - 100.0	5 Day - 100.5
Node ID	Description	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)
N3620	Mainstream, large wetland	115.23	115.23	115.23	115.23
N3615	Mainstream, large wetland	115.23	115.23	115.23	115.23
N3614	Upstream US 92	115.24	115.23	115.23	115.23
N3610	Downstream US 92	114.04	114.04	114.04	114.04
N3605	Upstream CSX Railroad	114.04	114.04	114.03	114.04
N3603	Downstream CSX Railroad	113.85	113.85	113.85	113.85
N3600	Mainstream, small wetland	113.81	113.81	113.81	113.81
N3590	Mainstream	113.80	113.80	113.80	113.80
N3587	Mainstream	113.77	113.77	113.77	113.77
N3585	Upstream E. Main St. (CR 542)	113.77	113.77	113.77	113.77
N3581	Downstream E. Main St. (CR 542)	112.67	112.67	112.66	112.67
N3580	Mainstream	112.62	112.62	112.62	112.62
N3575	Mainstream	112.49	112.49	112.49	112.49
N3574	Mainstream	111.96	111.96	111.95	111.96
N3573	Mainstream	111.91	111.92	111.91	111.91
N3572	Mainstream	111.86	111.87	111.86	111.86
N3571	Mainstream	111.85	111.85	111.84	111.85
N3570	Mainstream	111.72	111.73	111.72	111.72
N3569	Upstream timber pedestrian bridge	111.69	111.72	111.68	111.69
N3567	Downstream timber pedestrian bridge	111.69	111.67	111.69	111.69
N3566	Mainstream	111.63	111.63	111.62	111.63
N3565	Mainstream, small wetland	111.39	111.40	111.39	111.39
N3564	Upstream concrete Pedestrian bridge	111.44	111.44	111.35	111.44
N3562	Downstream concrete Pedestrian bridge	111.35	111.35	111.36	111.35
N3561	Mainstream, small wetland	111.31	111.31	111.30	111.31
N3560	Mainstream, reclaimed mining area	111.02	111.02	111.01	111.02
N3557	Mainstream, large wetland	107.81	107.81	107.81	107.81
N3556	Mainstream, large wetland	107.79	107.79	107.79	107.79
N3555	mainstream, large wetland	107.78	107.78	107.78	107.78
N3550	Mainstream, large wetland	105.65	105.66	105.67	105.73

Table B8. Flood Elevations: 5 Day, 100 Year Storm Event - Eagle Lake

		5 Day - 98.7	5 Day - 99.5	5 Day - 100.0	5 Day - 100.5
Node ID	Description	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)	Max Stage (ft)
N7310	Reclaimed Wetland	106.02	106.02	106.02	106.02
N7320	Reclaimed Wetland	105.90	105.90	105.90	105.90
N7300	Wetland Adjacent to Lk. Hancock	102.74	103.01	103.24	103.52
N7270	Reclaimed Lake	102.78	103.06	103.29	103.57
N7280	Reclaimed Lake	105.39	105.66	105.85	106.09
N7290	Reclaimed Lake	105.39	105.66	105.85	106.09
N7250	Reclaimed Lake	105.39	105.66	105.85	106.09
N7300	Wetland Adjacent to Lk. Hancock	102.74	103.01	103.24	103.52
N7260	Reclaimed Wetland	105.39	105.66	105.85	106.09
N7250	Reclaimed Lake	105.39	105.66	105.85	106.09
N7300	Wetland Adjacent to Lk. Hancock	102.74	103.01	103.24	103.52
N7190	Wetalnd S. of Hwy 17	109.93	109.93	109.93	109.93
N7200	Wetland N. of Hwy 17	109.12	109.12	109.12	109.12
N7210	Wetland East of OFP	106.14	106.14	106.17	106.40
N7180	Mainstream	106.14	106.14	106.17	106.40
N7220	Reclaimed Lake	105.54	105.79	106.08	106.24
N7222	Reclaimed Lake	105.26	105.89	105.60	106.40
N7230	Reclaimed Lake	105.39	105.66	105.86	106.09
N7240	Reclaimed Lake	105.39	105.66	105.86	106.09
N7250	Reclaimed Lake	105.39	105.66	105.85	106.09
N7300	Ealgle Lake	102.74	103.01	103.24	103.52
N7000	Ditch/Channel	131.46	131.46	131.46	131.46
N7010	Ditch/Channel	131.41	131.41	131.41	131.41
N7020	Ditch/Channel	131.31	131.31	131.31	131.31
N7030	Millsite Lake	126.68	126.68	126.68	126.68
N7040	Wetland	126.00	126.00	126.00	126.00
N7050	Ditch/Channel	125.84	125.84	125.84	125.84
N7060	Ditch/Channel	125.83	125.83	125.83	125.83
N7070	Ditch/Channel	125.75	125.75	125.75	125.75
N7080	Ditch/Channel	125.74	125.74	125.74	125.74
N7090	Ditch/Channel	124.89	124.89	124.89	124.89
N7100	Ditch/Channel	124.55	124.55	124.55	124.55
N7110	Ditch/Channel	121.22	121.22	121.22	121.22
N7120	Wetland	112.37	112.37	112.37	112.37
N7140	Wetland	112.16	112.16	112.16	112.16
N7150	Ditch/Channel	111.49	111.49	111.49	111.49
N7152	Ditch/Channel	110.24	110.24	110.24	110.24
N7160	Wetland	110.06	110.06	110.06	110.07
N7170	Ditch/Channel	110.01	110.01	110.01	110.01
N7172	Ditch/Channel	107.01	107.01	107.01	107.01

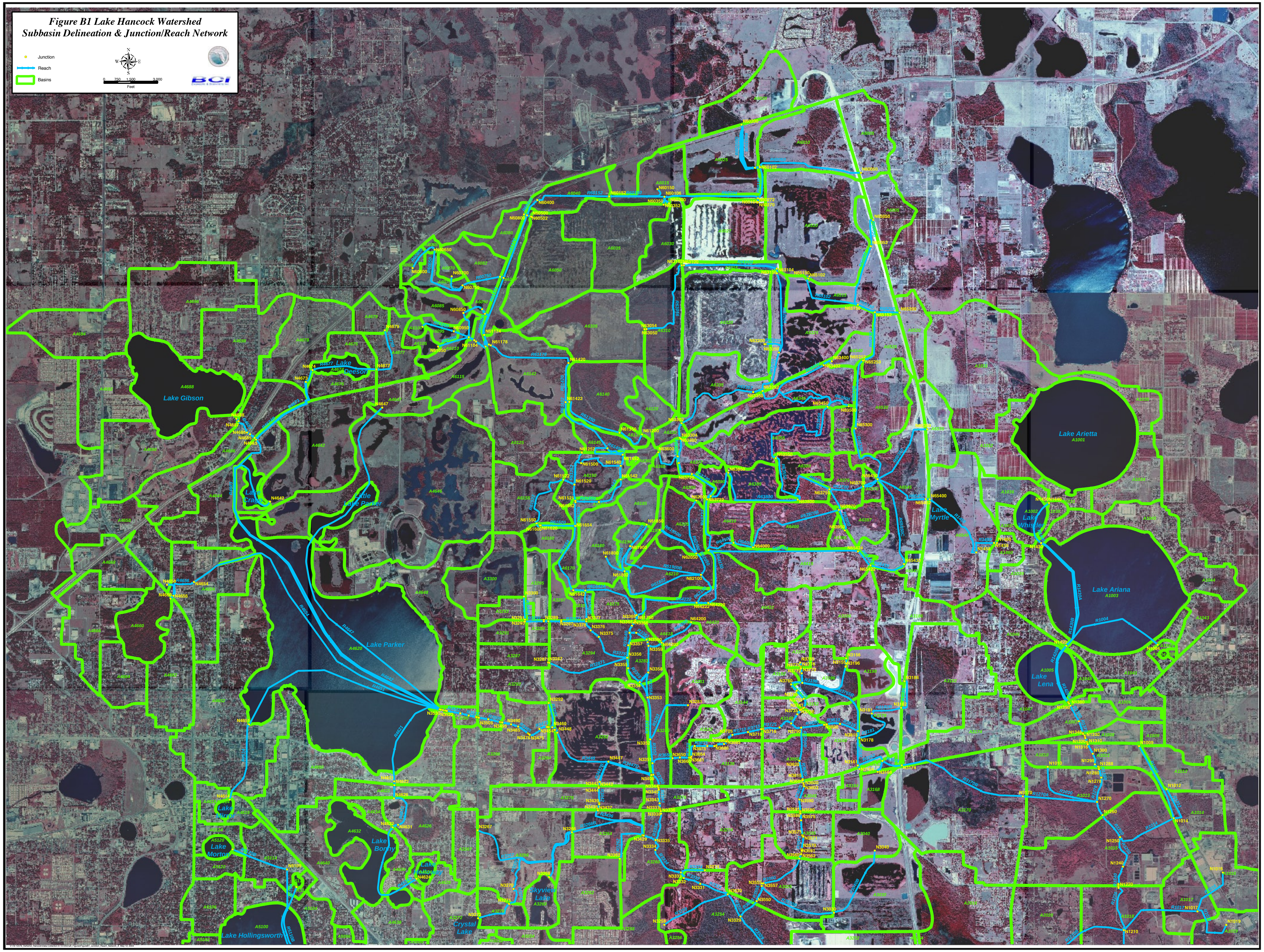
Figure B1 Lake Hancock Watershed
Subbasin Delineation & Junction/Reach Network
Junction
Reach
Basins
N
S
E
W
0
750
1,500
3,000
Feet
BCI
Lake Gibson
Lake Parker
Lake Arietta
Lake Ariana
Lake Lena
Lake Myrtle
Lake Bonny
Lake Morton
Lake Hollingsworth
Crystal Lake

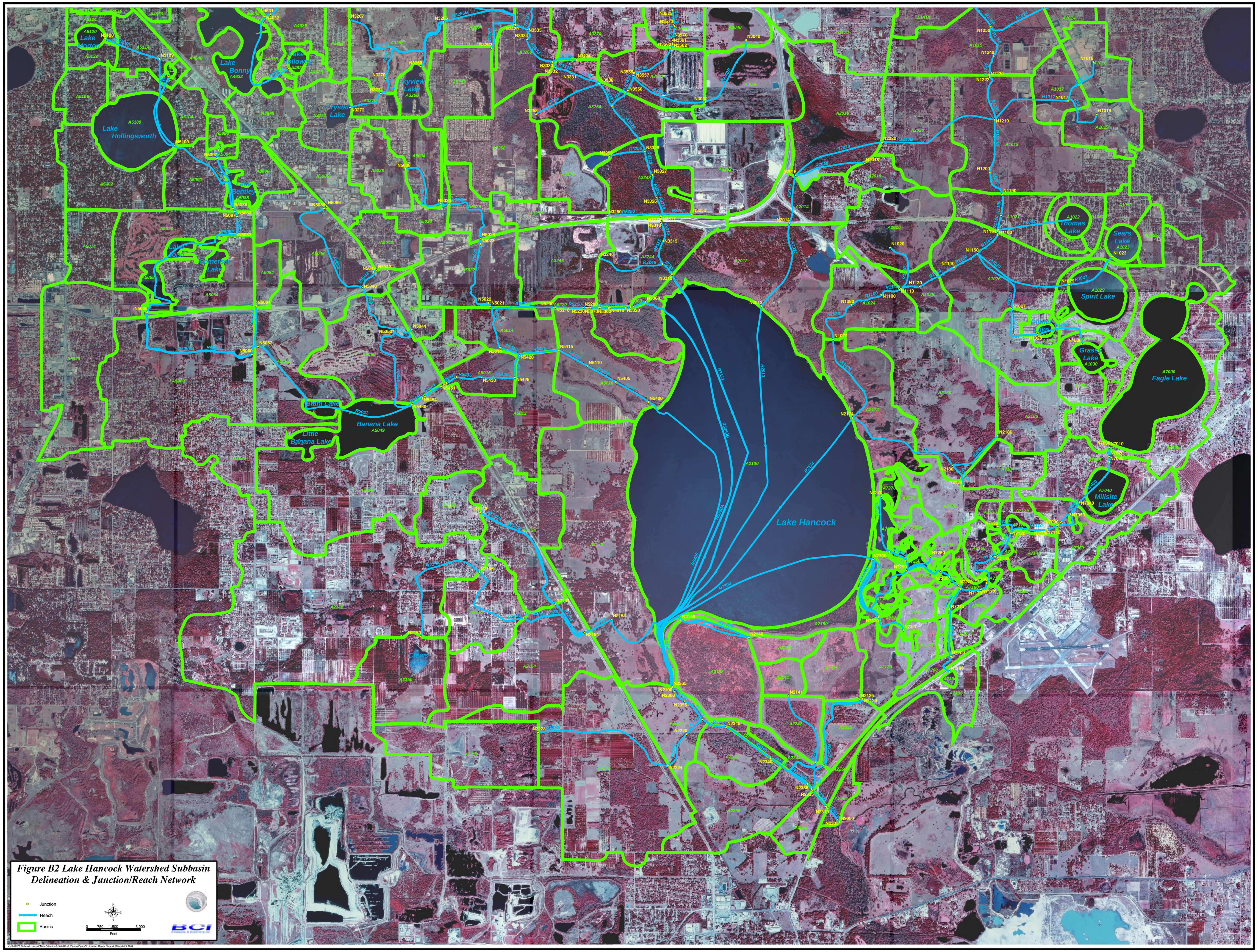

Figure B2 Lake Hancock Watershed Subbasin Delineation & Junction/Reach Network

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