2.0 STATUS AND TRENDS

This section provides a brief history of Lake Seminole, an overview of historical trends in water quality and living resources, and a summary of existing conditions as they relate to the identified priority lake and watershed management issues. This information was derived primarily from work conducted as part of the Lake Seminole Diagnostic Feasibility Study (SWFWMD, 1992), as well as additional diagnostic feasibility studies performed in support of the development of this Plan.

2.1 History of Lake Seminole

Physical Modifications

Lake Seminole, located in west central Pinellas County, Florida, was created in the mid-1940s by the impoundment of an arm of Long Bayou, a brackish water segment of Boca Ciega Bay. On July 3, 1945, the Pinellas County Board of County Commissioners passed a resolution to create a freshwater lake in conjunction with the planned construction of Park Boulevard and a causeway across Long Bayou by the State Public Roads Administration. A secondary purpose for the creation of a freshwater lake was to provide a source of irrigation water for nearby citrus groves as well as to augment potable water supplies provided by the Pinellas County Water System (SWFWMD, 1992). Fresh water was contained in the lake through the construction of a fixed crest weir with an elevation of 6-feet NGVD at the south end of the lake. In the late 1960s, this structure was subsequently replaced with the fixed curvilinear weir that exists today. The fixed elevation of the existing weir is 5-feet NGVD.

Since the single fixed crest weir located at the south end of the lake had the potential to cause significant tailwater flooding upstream of the lake, a second weir was constructed at the north end of the lake in the late 1940s (SWFWMD, 1992). Water was then pumped from a dredged basin at the southern end of Long Creek (the original tributary which flowed to Long Bayou) over the north weir and into the lake via three lift pumps. This modification allowed the water level in Lake Seminole to be permanently maintained at elevation 6-feet NGVD. Between 1957 and 1965, Long Creek was channelized upstream of Lake Seminole to improve drainage conveyance in a rapidly urbanizing portion of Pinellas County.

During the mid to late 1970s, the Seminole Bypass Canal was constructed in response to flooding in the upper Long Creek basin, and to a perceived decrease in lake water quality thought to be caused by the pumping of Long Creek flows into the lake (SWFWMD, 1992). The construction of the Seminole Bypass Canal diverted runoff from approximately eleven square miles of the historic Long Creek basin, around Lake Seminole to the east and directly into Long Bayou. Subsequently, a fixed crest weir with an elevation of 3-feet NGVD was constructed at the southern terminus of the

Seminole Bypass Canal. Although this modification successfully reduced flooding potential in the upper Long Creek watershed, it essentially resulted in the hydrologic isolation of Lake Seminole, and substantially increased the residence time of the lake. Prior to this modification, the lake was discharging at or slightly above the 5-foot NGVD weir crest elevation a majority of the time. However, after the construction of the Seminole Bypass Canal and the dismantling of the pumps, discharge over the weir has been infrequent and of short duration (SWFWMD, 1992).

An additional small outfall was created during the 1960s with the construction of Lake Seminole Park. An 18-inch diameter outfall pipe with an invert elevation of 3.5-feet NGVD was constructed from the lake through a series of three interconnected ponds in the park. Water flows from the lake through this series of interconnected ponds and eventually discharges into the Seminole Bypass Canal over a weir slightly below elevation 5-feet NGVD. The purpose of this outfall was to provide relatively constant flow through the ponds to prevent stagnation and water quality problems.

Land Use

Since the construction of the Park Boulevard causeway and the impoundment of Long Bayou, land uses in the Lake Seminole watershed have changed from predominantly low density rural residential and agriculture (e.g., improved pasture and citrus) to high density urban residential and commercial. A review of historic aerial photography indicates that urbanization in the basin began in the 1950s, and was first evident along the western side of the lake where numerous waterfront residential developments were initiated. Many of these developments involved major dredge and fill activities to create canals and bulkheads.

From the early 1950s through the mid-1960s, urbanization continued to occur predominantly in the western portion of the watershed, along the Seminole Boulevard corridor. In the mid-1960s, land use changes in the eastern portion of the watershed began to occur. In 1967, Lake Seminole Park was constructed, and the park was subsequently expanded in 1976. Rapid infilling of urban land uses occurred throughout the watershed during the 1970s and 1980s, however, no new major dredge and fill activities in the lake were permitted during this time period. In the mid-1990s the 102nd Avenue Bridge was constructed over the central "narrows" portion of Lake Seminole. Figure 2-1 shows the boundaries of the Lake Seminole watershed and existing (1995) land use in the basin.

Causes of Current Problems

It should be emphasized at the outset that many of the problems facing Lake Seminole today were essentially predetermined by the physical origins of the lake, as well as the subsequent hydrologic modifications and land use changes that later occurred in the watershed. Long Bayou was historically a shallow tidal embayment which likely had been accumulating fine organic muck sediments in the poorly flushed backwaters for several centuries. When the lake was created by impounding Long Bayou, these sediments along with the riparian mangrove swamps were simply flooded by detained freshwater discharges from Long Creek. Today, these deposits of organic sediments constitute a lake

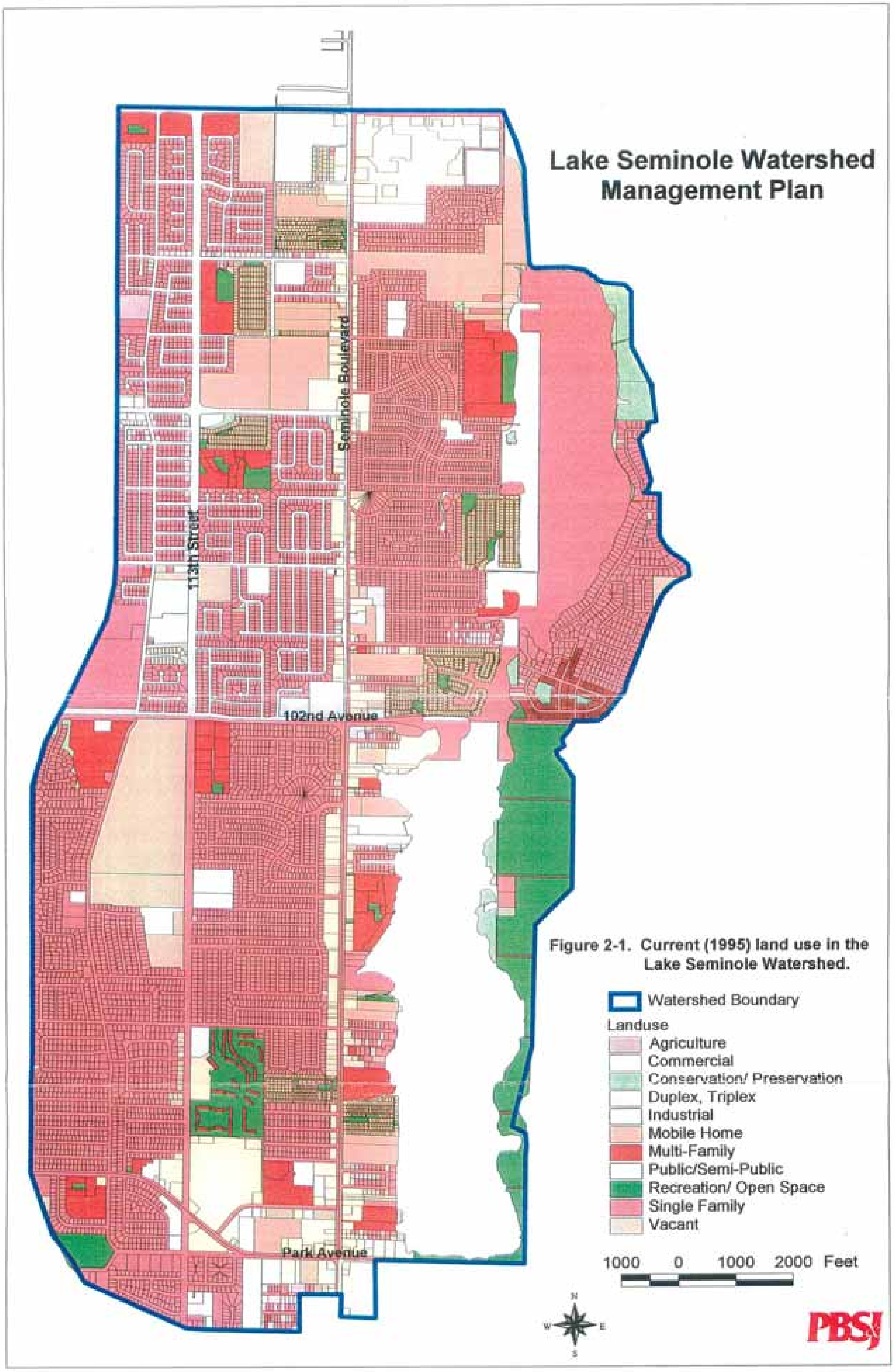

Figure 2-1. Current (1995) land use in the Lake Seminole Watershed.

management problem that now, more than ever, needs to be addressed. In addition, the subsequent isolation of Long Creek flows from the lake via the construction of the Lake Seminole Bypass Canal substantially reduced lake circulation and flushing and increased the residence time of nutrients entering the lake. Combined with rapid urbanization with little or no stormwater treatment in the surrounding watershed, this hydrologic modification has likely significantly contributed to the persistent algae blooms and rapidly increasing cultural eutrophication observed in Lake Seminole.

When the original decision was made by the Pinellas County Board of County Commissioners to create Lake Seminole, these problems could scarcely have been anticipated. However, with the commitment to create the lake comes the obligation to manage the lake and its watershed in a manner consistent with the goals, objectives, and policies of the Pinellas County Comprehensive Plan. The Plan set forth herein provides the framework for remediating the historic problems described above, as well as for creating a new future for Lake Seminole.

2.2 Water Quality

This section discusses water quality status and trends in Lake Seminole in terms of: 1) trophic state; 2) water and nutrient budgets; and 3) pollutant loads.

2.2.1 Trophic State

The primary concern with regard to water quality in Lake Seminole is excessive cultural (human-induced) eutrophication. Other types of water quality problems can occur in lakes, such as high concentrations of toxics (e.g., heavy metals, pesticides, etc.) and pathogens (e.g., coliform bacteria), but these types of public health problems have not been observed in Lake Seminole to any significant degree. Rather, the major water quality concerns are: 1) the control of excessive nutrients entering the lake; and 2) the fate of the nutrients that do reach the lake (e.g., internal nutrient recycling).

The term *trophic state* can be loosely defined as the nutritional status of a lake (Huber et al, 1982). Like other plants, microscopic, single-celled algae, also referred to as phytoplankton, require nitrogen and phosphorus and other primary nutrients to grow and reproduce. However, if nutrients are available in the water column of lakes in concentrations that are too high, nuisance algae blooms occur. If these conditions persist for a prolonged period of time, many ecological changes begin to take place in the lake. First, the excessive algae concentrations increase turbidity in the water column and shade out the light that supports rooted plants, eventually resulting in the die-off of submerged aquatic vegetation. Second, the bacterial breakdown of the excessive amount of dead algal cells raining down on the lake bottom results in a depletion of oxygen in the water column which can result in fish kills. Third, when algae becomes the dominant source of primary production (photosynthesis) in the lake, this can result in a shift in the fish population structure from a predominance of carnivorous sport fish (e.g., largemouth bass) to a predominance of herbivorous rough fish (e.g., gizzard shad). This process is called *eutrophication*.

Lake eutrophication is a natural process resulting from the gradual accumulation of nutrients, increased productivity, and a slow filling in of the basin with accumulated sediments, silt and organic matter from the watershed. The classical lake succession sequence is usually depicted as a unidirectional progression through the following series of phases or trophic states including:

- *Oligotrophy* - nutrient-poor, biologically unproductive, low turbidity;
- *Mesotrophy* - intermediate nutrients and biological productivity, moderate turbidity;
- *Eutrophy* - nutrient-rich, high biological productivity, high turbidity;
- *Hypereutrophy* - pea soup conditions, the extreme end of the trophic continuum.

Although natural eutrophication could take tens of thousands of years to occur, a lake's lifespan can be drastically shortened by human-induced cultural eutrophication. Activities in the watershed such as forest clearing, road building, agricultural cultivation, residential and commercial development, stormwater runoff and wastewater discharges can all result in substantial increases in the discharge of nutrients, organic matter and sediments to the lake. Figure 2-2 illustrates the differences between natural and cultural, or human-induced, eutrophication.

The primary measure of the degree of eutrophication in a lake is the concentration of *chlorophyll-a* in the water column. Chlorophyll-a is an estimate of algal cell biomass, and may be directly related to the trophic state of the lake. In addition, the primary nutrients of concern with respect to controlling eutrophication are total nitrogen (TN) and total phosphorus (TP). Finally, the most commonly used measure of water transparency is the Secchi disk depth, or the maximum depth at which a disk suspended on a weighted line can be visually detected below the water surface.

The following summaries of the status and trends in water quality and pollutant loading sources focus on the parameters related to the trophic state of the lake, including chlorophyll-a, TN, TP, and Secchi disk depth. With respect to indicators of eutrophication, water quality in Lake Seminole has generally declined over the past decade. Figures 2-3 through 2-7 show plots of annual averages of monthly water quality data collected in Lake Seminole from 1991 through 1999.

Figure 2-3 shows trends in annual average chlorophyll-a concentrations. Chlorophyll-a is the most commonly used measure of lake trophic state, and is an indicator of algal biomass. Chlorophyll-a concentrations in Lake Seminole were generally stable from 1991 through 1998, but increased substantially in 1999. The mean annual chlorophyll-a concentration from 1991 through 1998 was 65 ug/l. In 1999, however, the mean monthly chlorophyll-a concentration increased to 118 ug/l, almost double the mean annual concentration over the previous eight years. This increase is alarming in light of the fact that rainfall in Pinellas County during 1999 was close to average for the 1990s (see Figure 2-7). In addition, no substantial changes in the lake or watershed that could significantly affect external pollutant loads or internal nutrient recycling were known to have occurred.

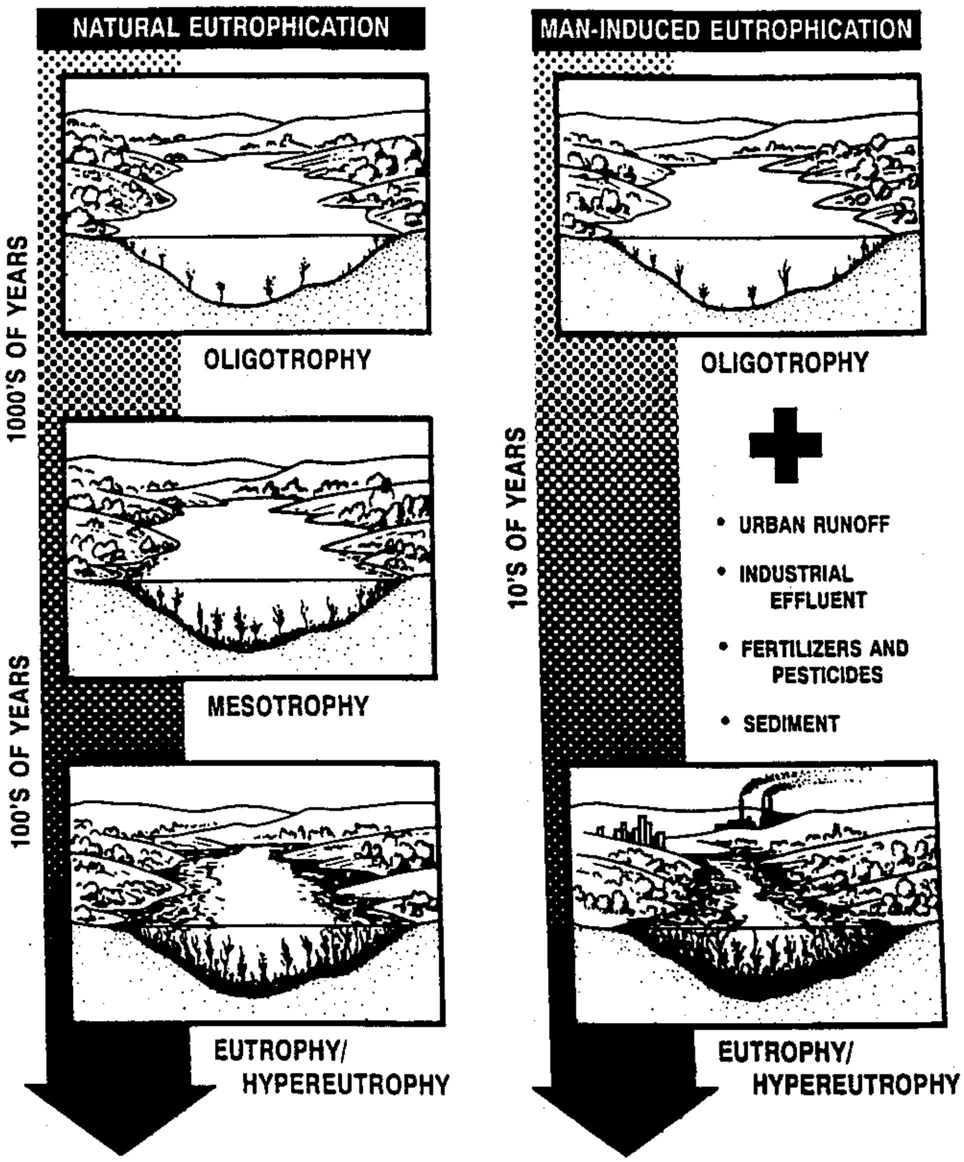

Figure 2-2. Natural vs. cultural (human-induced) eutrophication.

Figure 2-3. Trend in Lake Seminole annual average Chlorophyll-a concentrations.

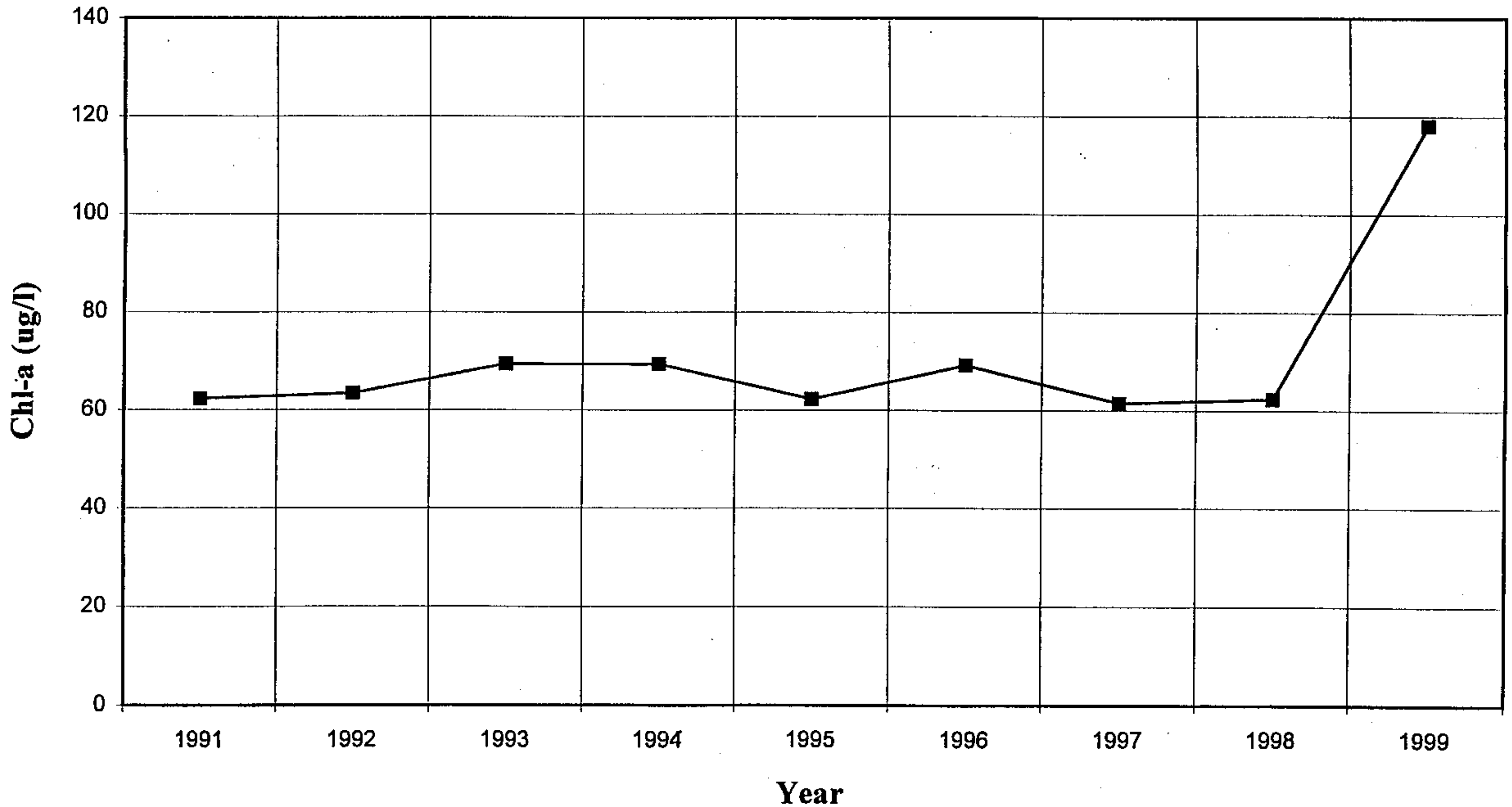

Figure 2-4. Trend in Lake Seminole annual average Total Nitrogen concentrations.

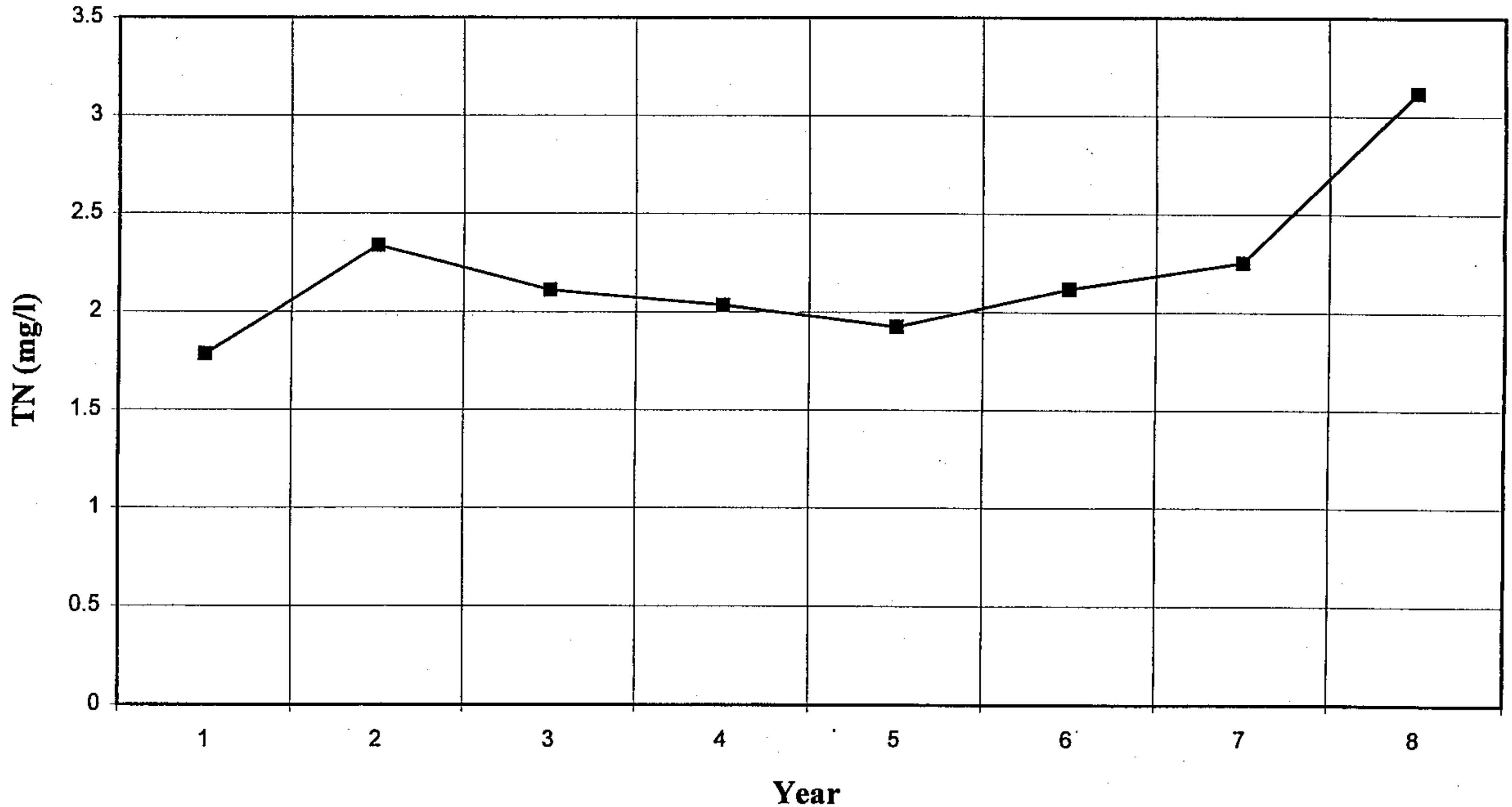

Figure 2-5. Trend in Lake Seminole annual average Total Phosphorus concentrations.

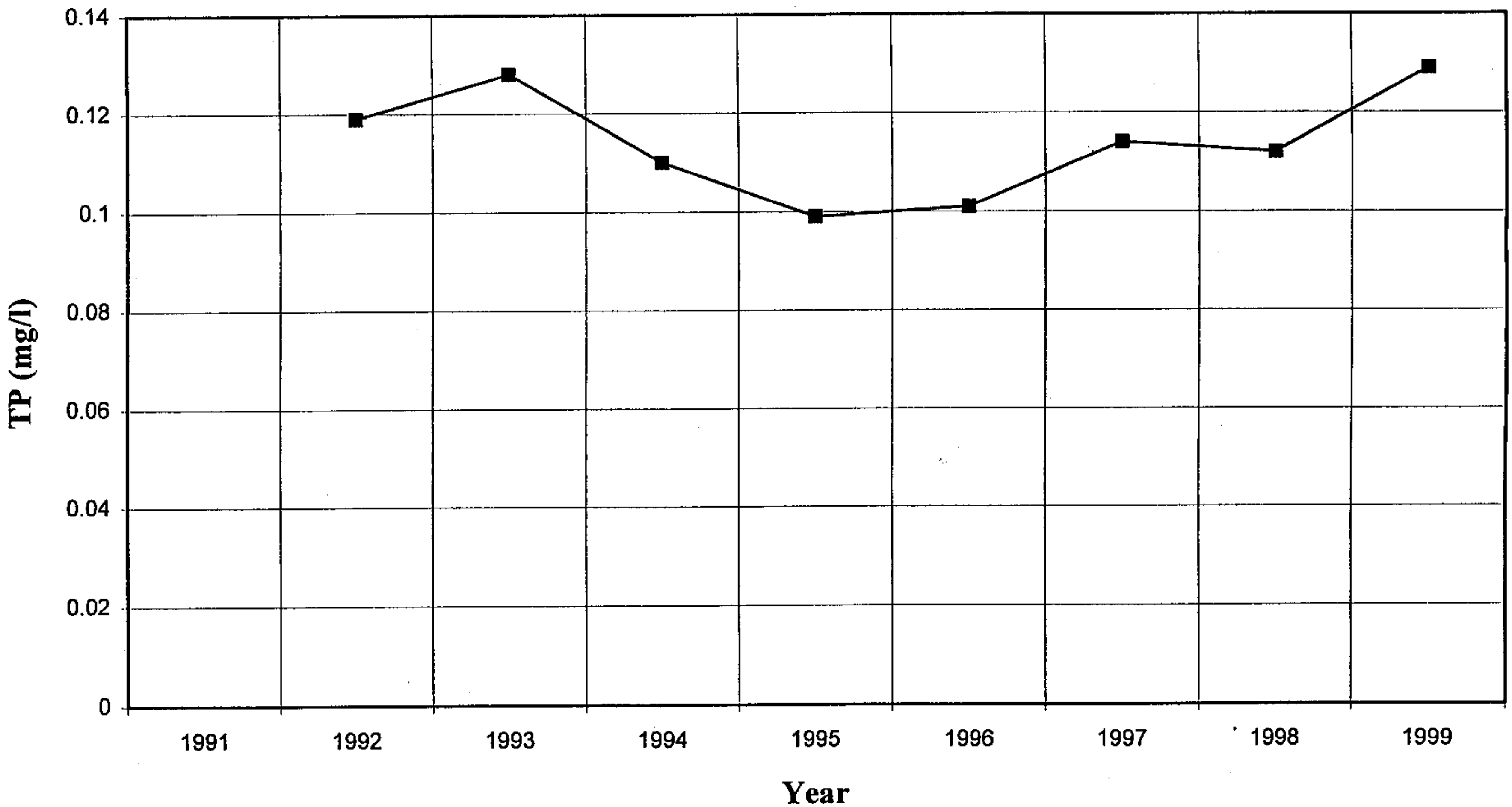

Figure 2-6. Trend in Lake Seminole annual average Secchi disk depths.

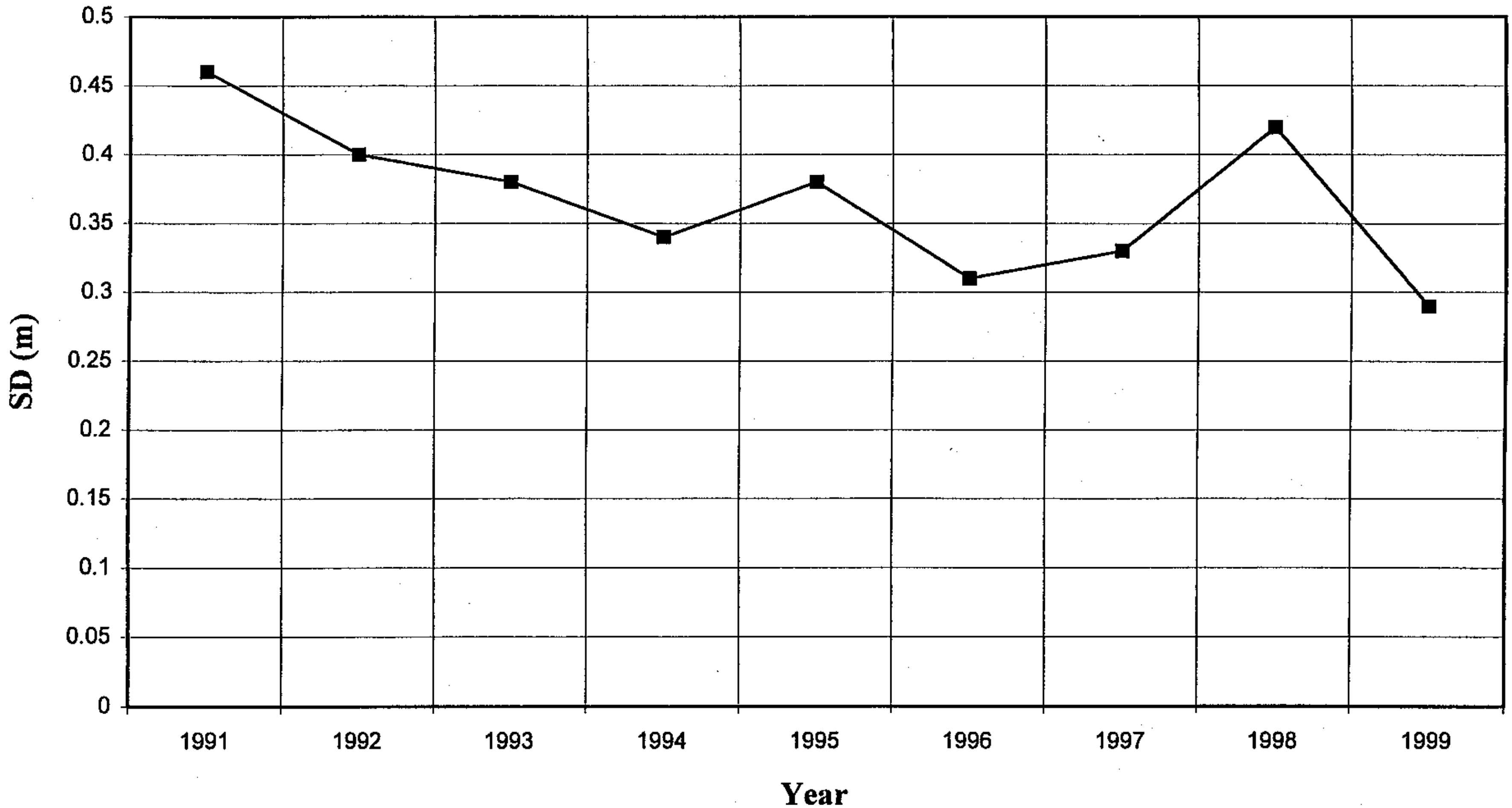

Figure 2-7. Trend in annual rainfall totals in the Lake Seminole watershed (Largo).

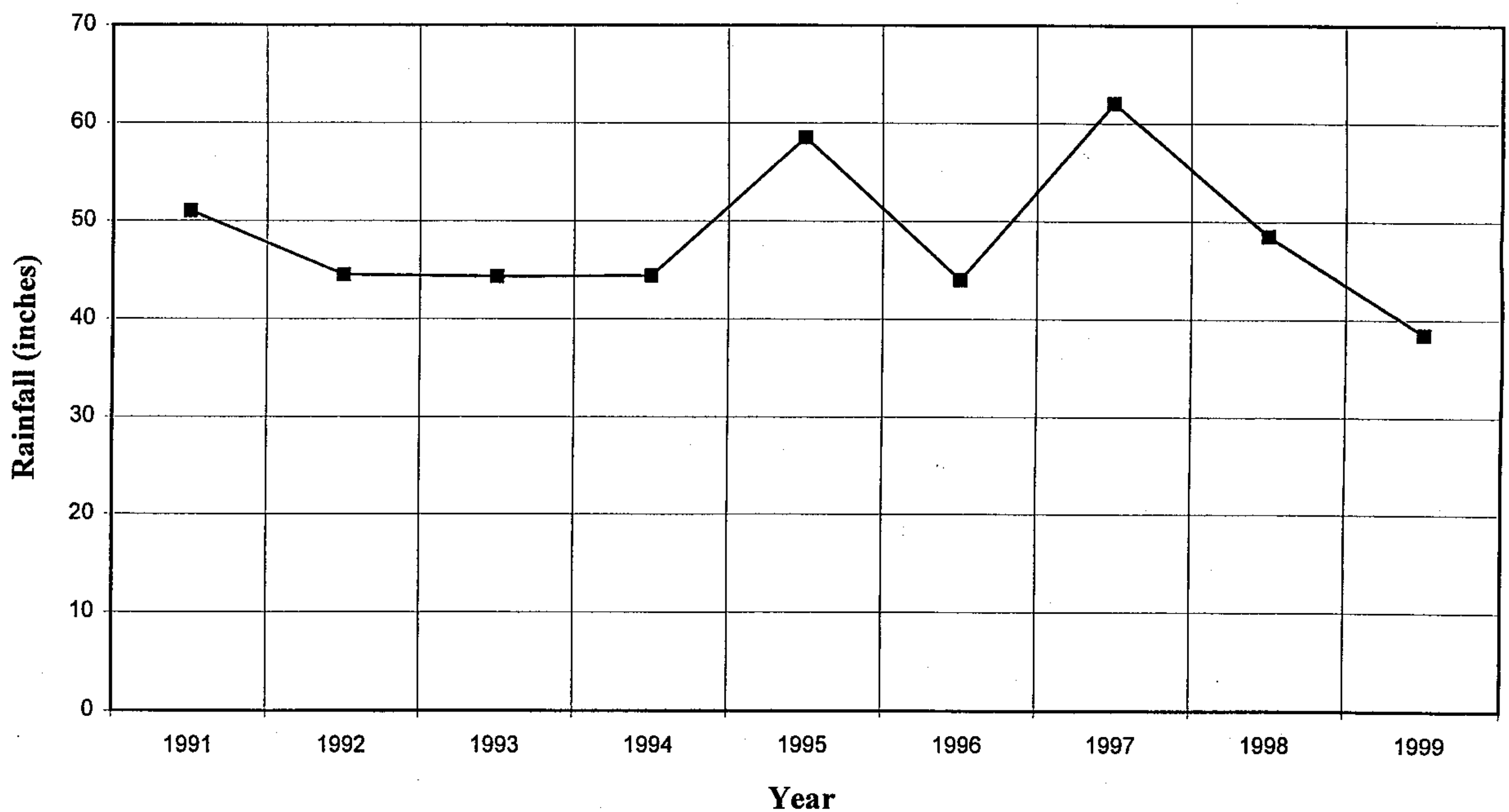

Figure 2-4 shows trends in annual average total nitrogen concentrations. Like chlorophyll-a, total nitrogen concentrations in Lake Seminole were relatively stable from 1991 through 1998, but increased substantially in 1999. As shown in Figure 2-5, total phosphorus concentrations decreased somewhat between 1993 and 1995, but have been on the increase since 1995.

Figure 2-6 shows trends in the annual average Secchi depth. Secchi depth in Lake Seminole has generally decreased since 1991. In 1999, the mean monthly Secchi depth was 0.29 meters, the lowest during the nine year reporting period. As an indicator of water transparency, Secchi depth values are generally inversely related to chlorophyll-a concentrations. Secchi depth values less than about 0.5 meters generally represent conditions that are severely light limiting for aquatic macrophytes, including desirable species such as eel grass.

Figure 2-7 shows trends in annual rainfall totals in the Lake Seminole area (Largo) for the period 1990-1999. As shown, 1995 and 1997 were the wettest years during this period of record, with 1997 being a documented "El-Nino" year during which most of the rainfall occurred during the winter months. Conversely, 1990 and 1999 were the driest years during this period. Given the lesser 1999 rainfall total, the observed increase in chlorophyll-a concentrations in 1999 cannot be readily explained in terms of increased external nutrient loads from stormwater runoff.

Although trophic state concepts have been in existence for some time, much controversy has existed over the terminology, the precise definition of various trophic state classes, and the development of an ecologically meaningful and widely accepted quantitative procedure for determining trophic state. In general, the most widely accepted trophic state index for Florida lakes is that developed by Huber et al. (1982). This index is unique in that it was developed specifically for Florida lakes, and thus recognizes and assimilates various characteristics (e.g. well-mixed, nitrogen limiting conditions) generally not accommodated in trophic state indices developed for temperate lakes. The Florida lakes index is calculated differently for nitrogen limited, phosphorus limited, and nutrient balanced lakes, and involves the calculation of separate sub-indices for total nitrogen, total phosphorus, chlorophyll-a, and Secchi depth. The overall trophic state index (TSI) for a lake is determined by combining the appropriate sub-indices to obtain an average for the physical, chemical, and biological features of the trophic state.

To determine the current trophic state of Lake Seminole, the most recent monitoring data available from Pinellas County, covering the period January through December 1999, were used. These most recent data corrected previous laboratory problems related to the lower detection limit which resulted in the skewing of monthly and annual TP means. The mean monthly concentrations of chlorophyll-a, TN, TP, and the mean monthly Secchi depth, for this time period are as follows:

- Chlorophyll-a (Chl-a) = 118.08 ug/l
- Total Nitrogen (TN) = 3.116 mg/l
- Total Phosphorus (TP) = 129.0 ug/l
- Secchi Depth (SD) = 0.29 m

As discussed by Huber et al. (1982), three classes of lakes can be described pursuant to the total nitrogen to total phosphorus ratio. They are as follows:

- Nitrogen-limited lakes = TN/TP < 10
- Nutrient-balanced lakes = 10 < TN/TP < 30
- Phosphorus-limited lakes = TN/TP > 30

Using the mean values shown above, the TN:TP ratio in Lake Seminole is **24.16**, making it a nutrient-balanced lake, at least under current conditions. Therefore, the TSI for nutrient balanced lakes is appropriate, and is defined as:

TSI(AVE) = 1/3 [TSI(Chl-a) + TSI(SD) + 0.5[TSI(TPB) + TSI(TNB)]]

Where TSI(Chl-a), TSI(SD), TSI(TPB), and TSI(TNB) are sub-indices for chlorophyll-a, Secchi depth, TN nutrient-balanced, and TP nutrient-balanced, respectively. These sub-indices are given and solved as follows:

- TSI(Chl-a) = 16.8 + (14.4 ln Chl-a) = **85.51**
- TSI(SD) = 10 [6.0 - (3.0 ln SD)] = **97.14**
- TSI(TNB) = 10 [5.6 + (1.98 ln TN)] = **78.50**
- TSI(TPB) = 10 [(1.89 ln TP) - 1.84] = **73.45**

With the values of all sub-indices known, TSI(AVE) for Lake Seminole can be solved as follows:

- TSI(AVE) = 1/3 [62.47 + 59.70 + 0.5 (57.15 + 52.24) = **86.21**

Therefore, the calculated current trophic state index for Lake Seminole for the period January through December 1999 is **86.21**. It should be noted that in other lakes where tannin colored waters are typical, investigators use modified versions of the above described trophic state index whereby water transparency (e.g., Secchi disk depth) is not considered. The integration of Secchi disk depth into the Lake Seminole TSI is appropriate, however, given the lack of tannin colored waters in the basin. The use of modified versions of the above described trophic state index, or other indices altogether, will yield different calculated TSI values which may lead to confusion with regard to the establishment of defensible resource management and pollutant load reduction goals. Therefore, it is recommended that the above described form of the Florida lakes TSI, as derived by Huber et al. (1982), be used for all comparative TSI calculations for Lake Seminole.

A primary issue regarding the application of the TSI to the classification of Florida lakes for management purposes is the selection of a critical TSI value, or a value above which the lake is considered to have trophic related problems. Based upon a review of data from 573 Florida lakes, and the subsequent classification of each, Huber et al. (1982) determined the TSI value of 60 to be a generally applicable critical value defining eutrophic conditions. Therefore, in consideration of the

Plan goals and objectives adopted by the Lake Seminole Advisory Committee, as well as a realistic understanding of the lake's urban setting, a TSI goal of 65 is considered appropriate for Lake Seminole.

Previous monitoring data from Lake Seminole collected during the 1990s have indicated that the lake has been consistently eutrophic, and has exhibited numerous trophic related problems, during the past decade. However, using the above described criteria with a calculated current TSI of 86.21, Lake Seminole can now be classified as severely hypereutrophic. Although it remains to be seen whether the recently observed hypereutrophic conditions will be maintained in the lake, it is likely that an aggressive program of both external and internal nutrient load reduction will be needed to meet a reasonable TSI target of 65.

2.2.2 Water and Nutrient Budgets

The first step in determining the pollutant loads to any lake is the establishment of a water budget. Flows carry pollutants into and out of lakes, and a meaningful analysis of lake eutrophication and most other water quality problems cannot be conducted without a quantitative understanding of lake hydrology. The basic water balance equation considers the following terms, typically expressed in units of acre-feet per year:

INFLOW + PRECIPITATION =
OUTFLOW + EVAPORATION + CHANGE IN STORAGE

For Lake Seminole, a storage volume of 3,420 acre-feet was calculated using an average depth of 5.0 feet and a surface area of 684 acres. Because the lake water level is currently managed within a relatively narrow range, this volume was assumed to be static for the purposes of this water budget analysis. Because the annual change in storage volume is considered to be zero, the water budget equation must be solved as follows:

INFLOWS + PRECIPITATION = OUTFLOWS + EVAPORATION

Figure 2-8 below graphically illustrates the water budget concept. The water budget calculated for Lake Seminole using 1997 data is summarized in Table 2-1.

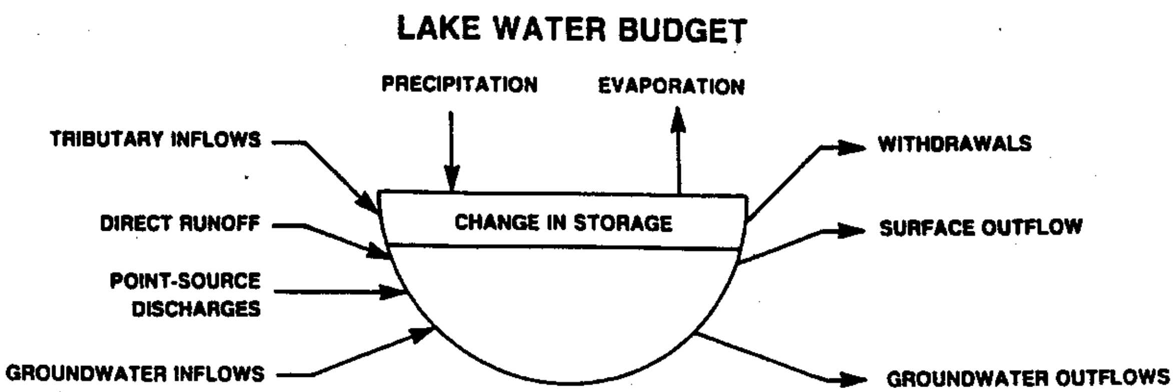

Figure 2-8. Graphical depiction of the lake water budget.

Table 2-1. Water budget for Lake Seminole calculated using 1997 data.

Inflows	cf	cfs	m^3	%
Direct Runoff (SWMM)	323,610,000	10.26	9,164,635	65.4%
Precipitation	168,013,404	5.33	4,758,140	33.9%
Surficial Aquifer	3,560,758	0.11	100,841	0.7%
TOTALS	**495,184,161**	**15.70**	**14,023,615**	**100.0%**
Outflows	**cf**	**cfs**	**m3**	**%**
Weir & Pipe Outflows	403,315,200	12.79	11,421,886	81.4%
Evapotranspiration	88,106,568	2.79	2,495,178	17.8%
Storage Loss	3,762,393	0.12	106,551	0.8%
TOTALS	**495,184,161**	**15.70**	**14,023,615**	**100%**
Lake Residence Time = 72 days				

Using the information developed in the water budget, lake nutrient budgets provide the cornerstone for evaluating lake eutrophication problems. The following terms are evaluated and are typically expressed in terms of tons or kilograms per year:

INFLOW LOADINGS =
OUTFLOW LOADING + NET SEDIMENTATION + CHANGE IN STORAGE

Nutrient budgets can be prepared for both nitrogen and phosphorus, although there are differences in some of the minor terms of the equation. The major components of inflow and outflow nutrient loads are essentially determined by multiplying appropriate nutrient concentration data with the respective inflow and outflow water volumes determined in the lake water budget.

The **net sedimentation** term defines the amount of nitrogen and phosphorus accumulated or retained in lake bottom sediments and/or the macrophyte standing crop. It reflects the net result of all physical, chemical, and biological processes causing vertical transfer of nutrients between the water column and the lake bottom.

For a given loading, lake water quality will generally improve as the magnitude of sedimentation increases because higher sedimentation leaves less available nutrients behind in the water column to stimulate algal growth. Because several complex processes are involved that vary spatially and seasonally within a given lake, it is generally infeasible to measure net sedimentation directly. Accordingly, this term is usually calculated by obtaining the difference from the other terms, or estimated using empirical models; however, site specific data have been collected in Lake Seminole to enable a more direct estimate of net sedimentation of TN and TP (SWFWMD, 1992; PBS&J, 2000).

The **change in storage** term accounts for changes in the total mass of nitrogen and phosphorus stored in the lake water column between the beginning and end of the study period. Such changes would reflect changes in lake volume, average nutrient concentrations, or both.

As discussed above, there is no significant change in the volume of Lake Seminole on an annual average basis, and water quality monitoring has indicated relatively stable nutrient concentrations prior to 1999. Therefore, for the purposes of this analysis, the change in nutrient storage is considered to be close to zero allowing that the equation be solved as follows:

INFLOW LOADINGS = OUTFLOW LOADINGS + NET SEDIMENTATION

Figure 2-9 below graphically illustrates the nutrient budget concept with respect to phosphorus. The nutrient budgets calculated for Lake Seminole using 1997 data are summarized in Tables 2-2 and 2-3 for total nitrogen and total phosphorus, respectively.

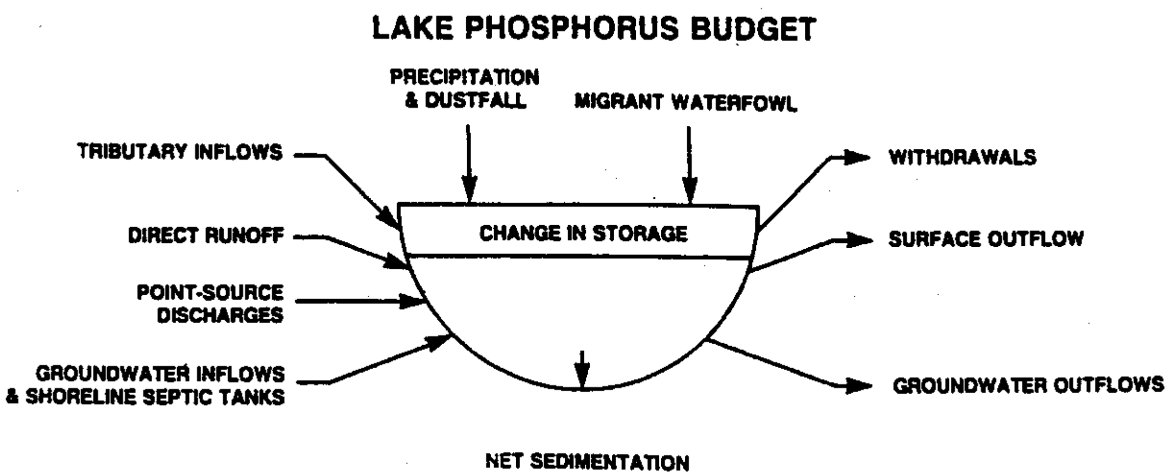

Figure 2-9. Graphical depiction of the lake phosphorus budget.

Table 2-2. Total nitrogen (TN) budget for Lake Seminole calculated using 1997 data.

Inflows	lbs.	tons	kg	%
Direct Runoff (SWMM)	31,168	15.58	14,135	36.8%
Precipitation	4,487	2.24	2,035	5.3%
Surficial Aquifer	131	0.07	60	0.2%
Undetermined Sources*	48,805	24.40	22,138	57.7%
TOTALS	**84,591**	**42.30**	**38,366**	**100.0%**
Outflows	**lbs.**	**tons**	**kg**	**%**
Weir & Pipe Outflows	55,820	27.91	25,315	66.0%
Sedimentation**	28,772	14.39	13,051	34.0%
TOTALS	**84,591**	**42.30**	**38,366**	**100.0%**

* Calculated undetermined N sources = (sum of N outflows) - (sum of N inflows from direct runoff, precipitation and surficial aquifer).

** Calculated N sedimentation = (calculated P sedimentation) x (measured sediment TN:TP ratio of 7.09).

Table 2-3. Total phosphorus (TP) budget for Lake Seminole calculated using 1997 data.

Inflows	lbs.	tons	kg	%
Direct Runoff (SWMM)	6,467	3.23	2,933	96.2%
Precipitation	248	0.12	112	3.7%
Surficial Aquifer	9	0.00	4	0.1%
TOTALS	**6,724**	**3.36**	**3,049**	**100.0%**
Outflows	**lbs.**	**tons**	**kg**	**%**
Weir & Pipe Outflows	2,666	1.33	1,209	39.6%
Sedimentation*	4,058	2.03	1,840	60.4%
TOTALS	**6,724**	**3.36**	**3,049**	**100%**

* Calculated P sedimentation = (sum of the P inflows) - (weir & pipe P outflows).

Based on the water and nutrient budgets summarized in Tables 2-1 through 2-3, the following conclusions can be made regarding the inflow and outflow of both water and the nutrients TN and TP in Lake Seminole.

- Direct runoff from the watershed land surface accounts for about 65.4% of the total annual hydrologic inflows. Direct precipitation on the lake water surface accounts for about 33.9% of the total annual hydrologic inflows. Groundwater seepage from the surficial aquifer accounts for the remaining 0.7%.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 81.4% of the total annual hydrologic outflows. Evapotranspiration accounts for about 17.8% of the total annual hydrologic outflows. Storage loss due to sedimentation accounts for the remaining 0.8%.

- Direct runoff from the watershed land surface and direct precipitation on the lake water surface account for about 36.8% and 5.3% of the total annual TN inflows, respectively. Groundwater seepage from the surficial aquifer only accounts for about 0.2% of the total annual TN inflows.

- Approximately 57.7% of the total annual TN inflows are derived from undetermined sources. Internal nutrient recycling processes (e.g., sediment fluxes) could account for a substantial fraction of this TN mass. In addition, analyses of Lake Seminole phytoplankton populations conducted during the summer and fall of 2000 have revealed high concentrations of the nitrogen fixing blue-green alga *Cylindrospermopsis cuspis* (PCDEM, 2000). The observed dominance of nitrogen-fixing cyanobacteria indicates that the biological fixation of atmospheric nitrogen may be a major source of TN inflows to Lake Seminole.

- Other potential undetermined sources of nitrogen inflows could include illicit discharges to lake surface waters or the municipal drainage system, and sanitary sewer overflows or leaks. To date, however, no direct evidence of such nitrogen sources has been discovered in Lake Seminole.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 66.0% of the total annual TN outflows. Sedimentation accounts for the remaining 34.0% of the total annual TN outflows.

- Direct runoff from the watershed land surface accounts for about 96.2% of the total annual TP inflows. Direct precipitation on the lake water surface accounts for about 3.7% of the total annual TP inflows. Groundwater seepage from the surficial aquifer accounts for the remaining 0.1%.

- Hydrologic discharges from the Lake Seminole weir structure and diversion pipe in the south lobe of the lake account for about 39.6% of the total annual TP outflows. Sedimentation accounts for the remaining 60.4% of the total annual TP outflows.

2.2.3 Pollutant Loads

It should be noted that there are no permitted point source discharges in the basin, and the entire Lake Seminole watershed is served by central sanitary sewer facilities. Therefore, the water and nutrient budgets presented above underscore two very important points with respect to potential pollutant load reduction strategies for Lake Seminole:

- **stormwater runoff** represents the single most important source of external phosphorus loads to Lake Seminole; and

- **internal nutrient recycling** - including nitrogen fixation by blue-green algae and sediment fluxes - constitutes a substantial cumulative nitrogen load to Lake Seminole surface waters.

Stormwater Runoff

As part of the planning process, modeling of stormwater runoff using the SWMM model was conducted to determine those major sub-basins contributing the highest nonpoint source pollutant loads. The location of the major sub-basins in the Lake Seminole watershed are shown in Figure 2-10, whereas the modeled annual nonpoint source loads of TN, TP and total suspended solids (TSS) for each of the major sub-basins are summarized in Figure 2-11.

Using a ranking procedure which integrates modeled TN, TP, and TSS loads, the five priority major sub-basins, or those with the highest integrated nonpoint source pollutant loads, are listed below in Table 2-4 in order of decreasing priority.

Table 2-4. Major sub-basins with the highest integrated nonpoint source pollutant loads listed in order of decreasing priority.

Major Sub-basin	Drainage Area	%Total NPS Load	Priority Rank
3	654 acres	15%	1st
1	461 acres	14%	2nd
7	548 acres	12%	3rd
6	391 acres	12%	4th
2	478 acres	11%	5th

Lake Seminole Watershed Management Plan

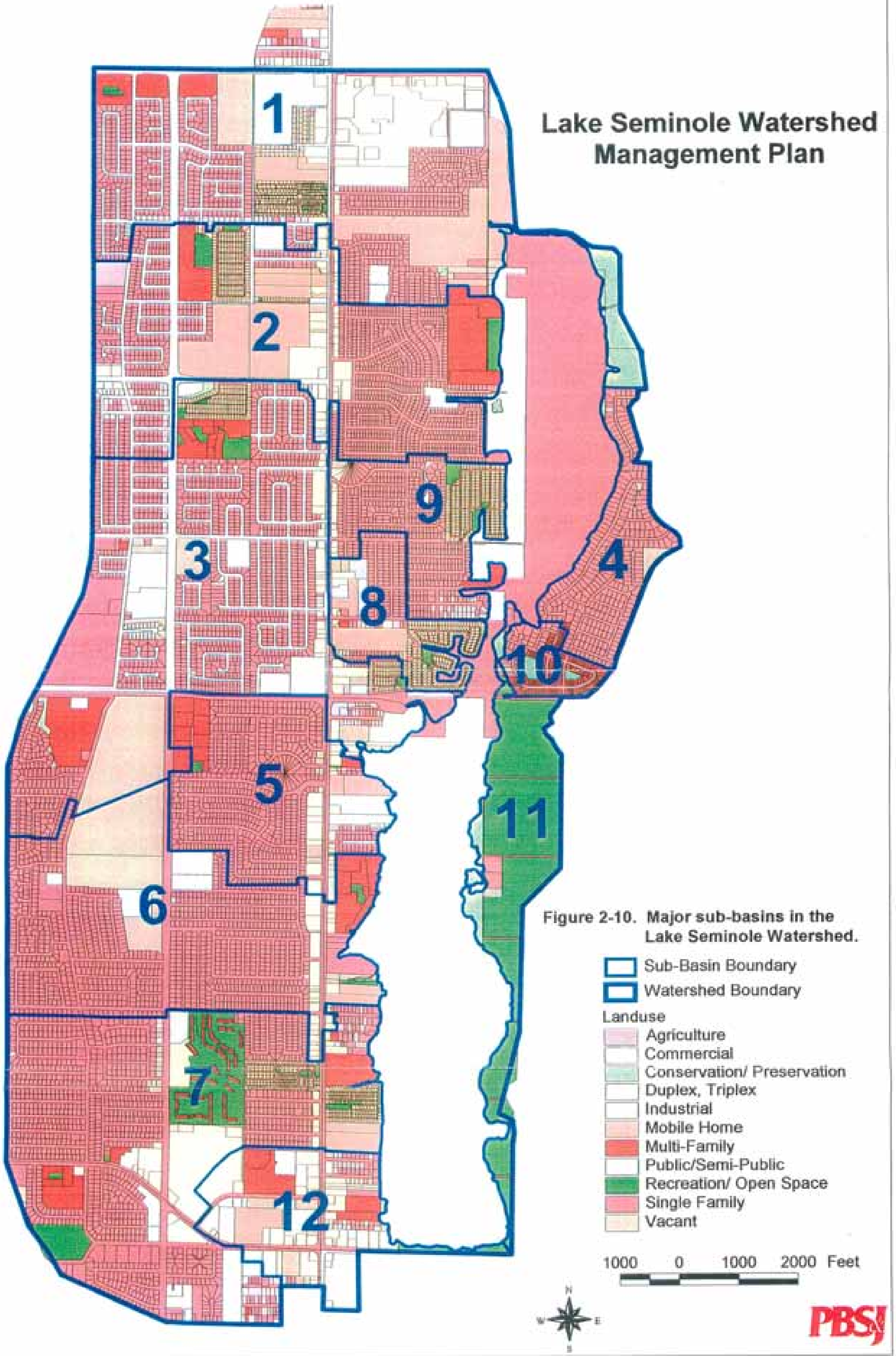

Figure 2-10. Major sub-basins in the Lake Seminole Watershed.

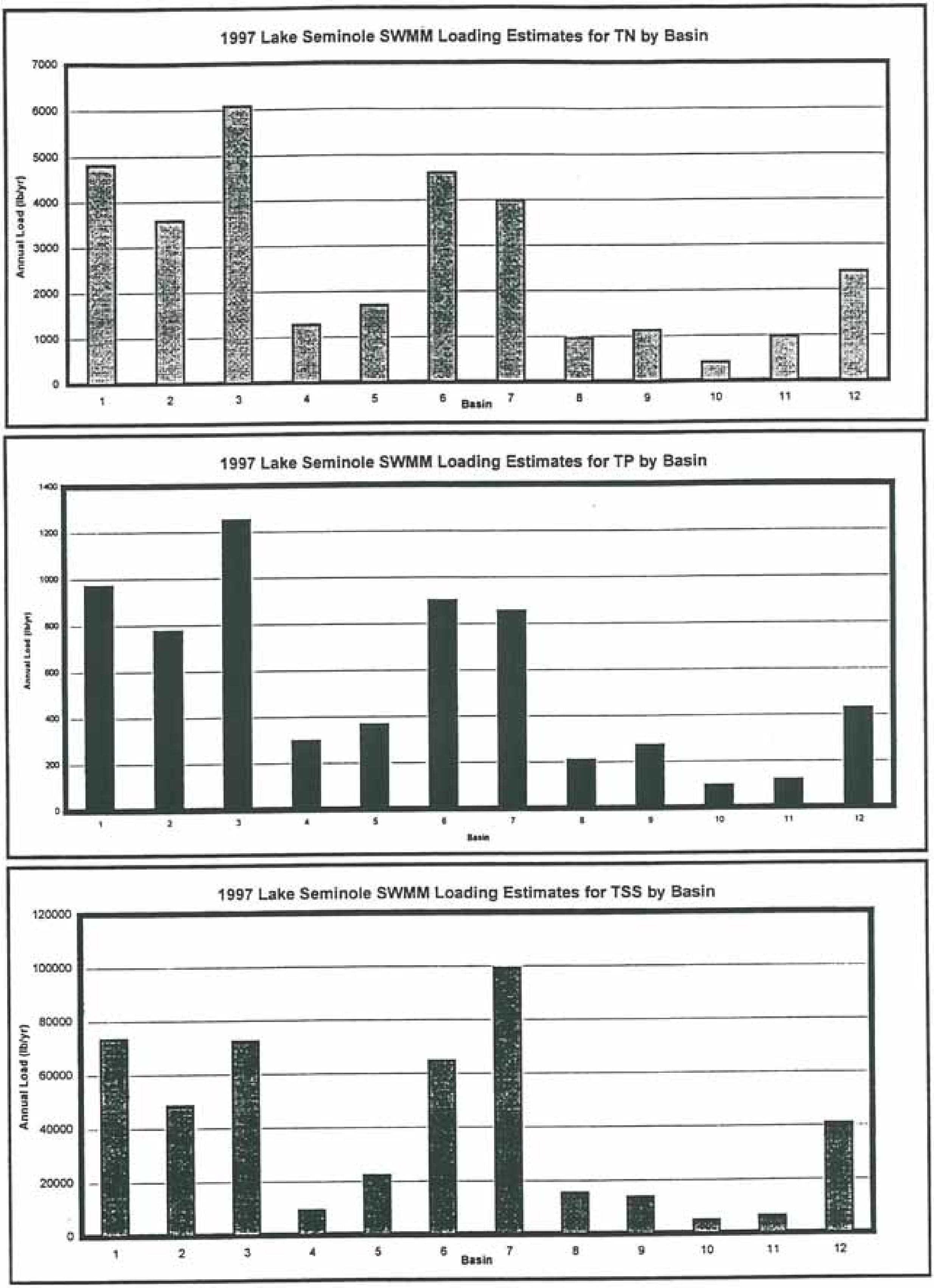

Figure 2-11. Pollutant load rankings of the major sub-basins.

Because high density urban land uses in the Lake Seminole basin are relatively ubiquitous, there are not significant differences in the unit area loads generated from each of the major sub-basins. Although there are minor differences in the age of the urban land uses in the various sub-basins, and whether or not on-site stormwater treatment is provided, these differences are generally not significant. Consequently, the major sub-basins with greatest contributing drainage area were generally the ones that ranked highest in terms of nonpoint source pollutant loads, as they deliver the greatest hydrologic and pollutant loads per unit rainfall.

Internal Nutrient Recycling

As shown in Table 2-2, it is estimated that undetermined sources accounted for approximately 24.40 tons, or about 57.7%, of the annual TN inflows to Lake Seminole in 1997. It should, however, be noted that the *undetermined sources* term was not measured but rather derived as the balancing term after accounting for modeled and measured inflows and outflows, and after accounting for an estimated sedimentation rate based on a measured sediment N:P ratio of 7.09. The estimated 24.40 tons of nitrogen from undetermined sources in Lake Seminole during 1997 equates to a rate of approximately 7.9 g $N/m^2/yr$. Under nitrogen limiting conditions, certain blue-green algae species (cyanobacteria) are capable of fixing atmospheric nitrogen to support their growth and reproduction. Measured nitrogen fixation rates in other hypereutrophic Florida lakes have ranged as high as 5.7 g $N/m^2/yr$, accounting for about 44% of the annual TN inflows, in Lake Tohopekaliga (Dierberg and Scheinkman, 1987). Therefore, based on the fact that nitrogen-fixing cyanobacteria are the dominant alga in Lake Seminole (SWFWMD, 1992; PCDEM, 2000), it is reasonable to assume that nitrogen fixation accounts for the majority of the undetermined sources of nitrogen inflows to Lake Seminole.

Upon a closer inspection of Tables 2-2 and 2-3 it can be seen that the TN:TP ratio of the measured and modeled inflows to Lake Seminole (excluding the calculated *undetermined sources* term in the nitrogen budget) is 5.32, whereas the TN:TP ratio for the measured outflows is 20.98. These findings indicate that the nutrient inflows should establish nitrogen limiting conditions, however, the outflows reflect nutrient balanced conditions. Since very little dissolved inorganic nitrogen (ammonia and nitrate/nitrite) or phosphorus (orthophosphate) is present in Lake Seminole surface waters, the measured TN:TP ratio in lake outflows represents that which has been assimilated in phytoplankton biomass. Therefore, the additional nitrogen assimilated by lake phytoplankton must be derived from internal sources which likely include both nitrogen fixation and sediment nitrogen fluxes.

It is also possible that some portion of the internally derived mass of nitrogen revealed in the lake nitrogen budget may actually represent an undocumented point source discharge to Lake Seminole. Such a discharge could include sanitary sewer leaks or overflows, or an illicit discharge(s) to lake surface waters or municipal storm sewer systems. It should be noted, however, that no direct evidence of an undocumented or illicit point source discharge has been discovered to date, and the presence of such an external pollutant source is not needed to explain the observed conditions and nutrient budgets. Nonetheless, Pinellas County should continue to investigate the possible existence of an undocumented point source discharge to Lake Seminole.

If subsequent investigations further confirm that the majority of the undetermined nitrogen inflows to Lake Seminole are attributable to internal nitrogen fixation, then the most effective approach to improving water quality and reducing the dominance of cyanobacteria will involve management actions that drive the lake towards phosphorus limitation and away from nitrogen limitation. Examples of such management actions include reduction of external phosphorus loads (e.g., enhanced stormwater treatment), and the removal or inactivation of sediment phosphorus stores (e.g., lake dredging). Other effective means of reducing the dominance of cyanobacteria include improving internal circulation and reducing residence time of lake surface waters.

It should also be noted that the nutrient budgets presented above indicate that a substantial mass of nitrogen, estimated at 27.91 tons per year for 1997, is discharged from Lake Seminole downstream to Boca Ciega Bay. Restoring the assimilative capacity of Lake Seminole would not only improve trophic conditions in the lake, but also in the downstream estuarine receiving waters of Boca Ciega Bay, a management segment of Tampa Bay.

2.3 Lake Sediments

As part of the planning process, a characterization study of Lake Seminole sediments was conducted (BCI, 1997). The final report from this effort is contained in Appendix 1 of this document.

Based on a bathymetric survey and laboratory analyses of sediment physical characteristics conducted as part of the planning process, Lake Seminole is estimated to contain a total of about 4.9 million cubic yards of unconsolidated sediments (PBS&J, 2000). Of this total, approximately 800,000 cubic yards is considered to be low density, organic silt (e.g., muck) which is located primarily in the north lobe and the "narrows" area, and in deeper isolated pockets of the south lobe, of the lake (PBS&J, 2000). These sediments are probably less than 100-150 years old (Schelske et al., 1991; in SWFWMD, 1992), and are composed predominantly of organic silts derived from the deposition of dead phytoplankton cells accumulated since the creation of Lake Seminole in the mid-1940s.

In addition to these low density flocculent muck sediments, this work also confirmed the presence of another approximate 130,000 cubic yards of highly organic, fibrous sediments located along the periphery of the lake (PBS&J, 2000). The majority of this material is on the east shore of the lake, but several large isolated pockets also occur along the west shore. These sediments are also relatively young in origin, and were originally derived from the accumulation of organic detritus in the historic mangrove swamps that were flooded with the construction of the lake. Since the lake was constructed, additional fibrous organic sediments have developed along the same shoreline areas through the accumulation of organic detritus from the decomposition of nuisance aquatic vegetation, predominantly cattails and primrose willow. The remaining unconsolidated sediment mass is primarily fine grained sands. Clays make up a very small fraction of the sediment mass in Lake Seminole (PBS&J, 2000). Chemical testing has indicated that Lake Seminole sediments do not contain toxic concentrations of heavy metals or anthropogenically derived organic compounds (PBS&J, 2000).

Figure 2-12 shows a bathymetric map of Lake Seminole indicating the depth of the water column. Figure 2-13 shows a map of the sediment thickness contours, or the difference between the sediment surface and the lake hard bottom. Figure 2-14 shows the muck thickness contours, or the difference between the sediment surface and the bottom of the muck layer, as well as the deposits of highly organic fibrous sediments along the shoreline of the lake. This latter figure essentially indicates the location of the problematic sediments potentially targeted for removal from Lake Seminole.

Both the low density flocculent sediments and the highly organic fibrous sediments are potentially problematic in Lake Seminole. Due to the shallowness of Lake Seminole, the low density flocculent sediments are easily resuspended by turbulent wave energy, especially those located in the "narrows" between the north and south lobes. This is demonstrated by a lack of reliable stratigraphy in sediment cores taken from this area (Schelske, 1991; in SWFWMD, 1992). Organic deposits in the north and south lobes show more reliable stratigraphy and are probably less prone to resuspension (Schelske et al., 1991; in SWFWMD, 1992).

The resuspension of low density flocculent sediments due to turbulent wave energy (e.g., generated by wind or powerboat wakes) has the potential to cause reduced water transparency and compromised recreational experiences, at least in localized areas. Although the direct contribution of sediment resuspension to reduced water clarity has not been quantified, there is strong anecdotal evidence that it contributes significantly to the very poor transparency observed in Lake Seminole during and following periods of high wind.

The low density flocculent sediments are also likely to be a major periodic source of water column nutrient enrichment, especially during the summer months when high bacterial respiration and high water temperatures can lead to low dissolved oxygen or hypoxia at the sediment/water column interface. Hypoxia at the sediment/water column interface, in turn, can cause chemical changes in the surface layer of the sediments which may facilitate the release of elemental phosphorus into the overlaying water column.

Schelske et al. (1991; in SWFWMD, 1992) concluded that nutrient release rates from Lake Seminole sediments may be a significant factor in the nutrient budgets of the lake. They measured nitrogen and phosphorus release rates from *in-vitro* sediment cores and found that N release rates ranged from 0.117 to 7.698 g/m2/yr ($\bar{x} = 3.705$), and P release rates ranged from 0.360 to 2.218 g/m2/yr ($\bar{x} = 0.824$). They compared these experimentally derived rates to "dangerous external loading rates" published by Vollenweider (1968) for lakes with a <5m mean depth and found the N release rate to be up to 6 times higher, and the P release rate to be up to 17 times higher, than the "safe" release rates for shallow lakes. The authors caution that the experimentally derived sediment nutrient release rates may represent maximum release rates caused in part by the removal of the sediment column from the lake bottom, and recommend that these rates be verified using alternative methods such as a nutrient loading model.

Lake Seminole Watershed Management Plan

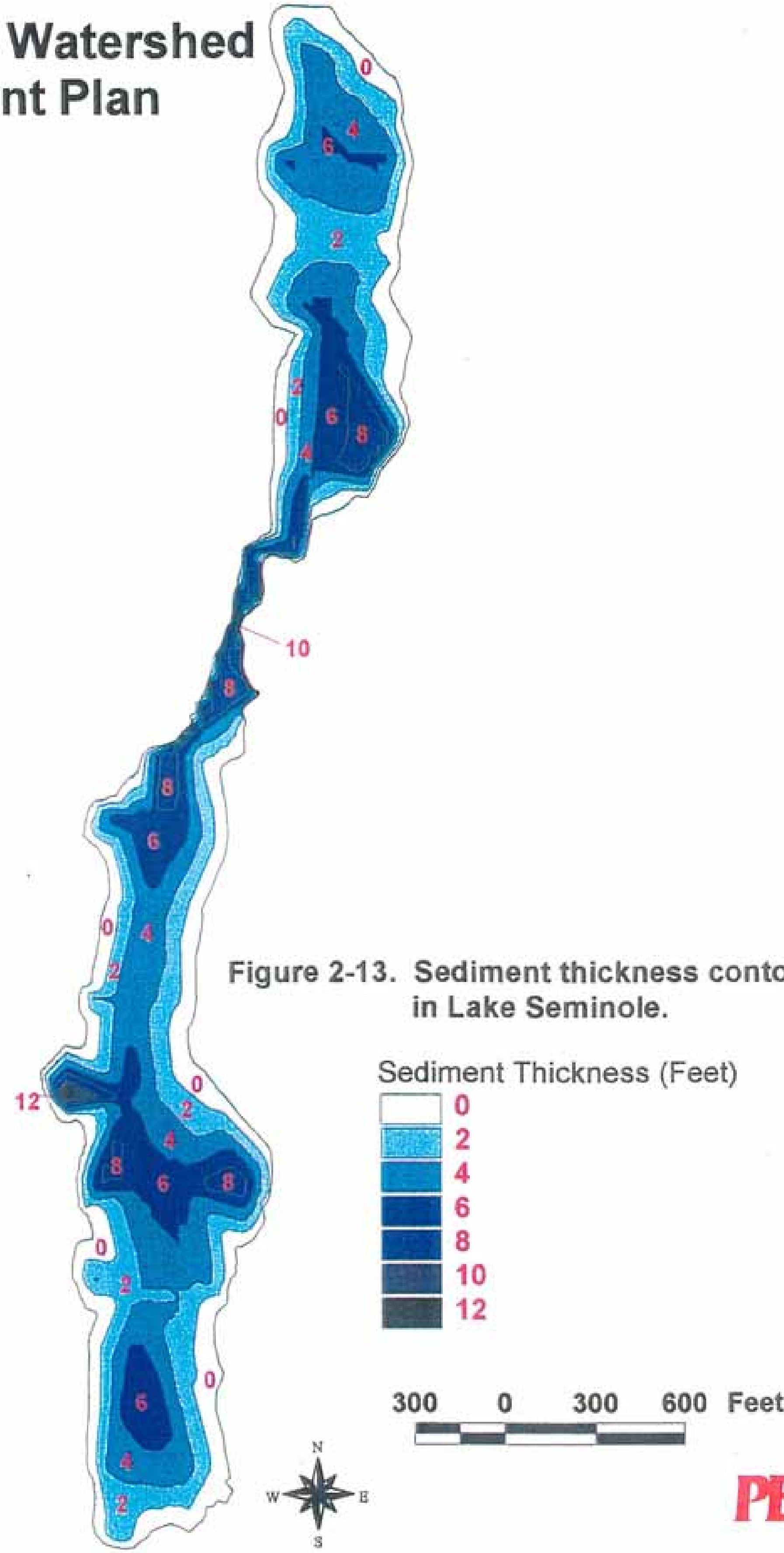

Figure 2-13. Sediment thickness contours in Lake Seminole.

PBSJ

Lake Seminole Watershed Management Plan

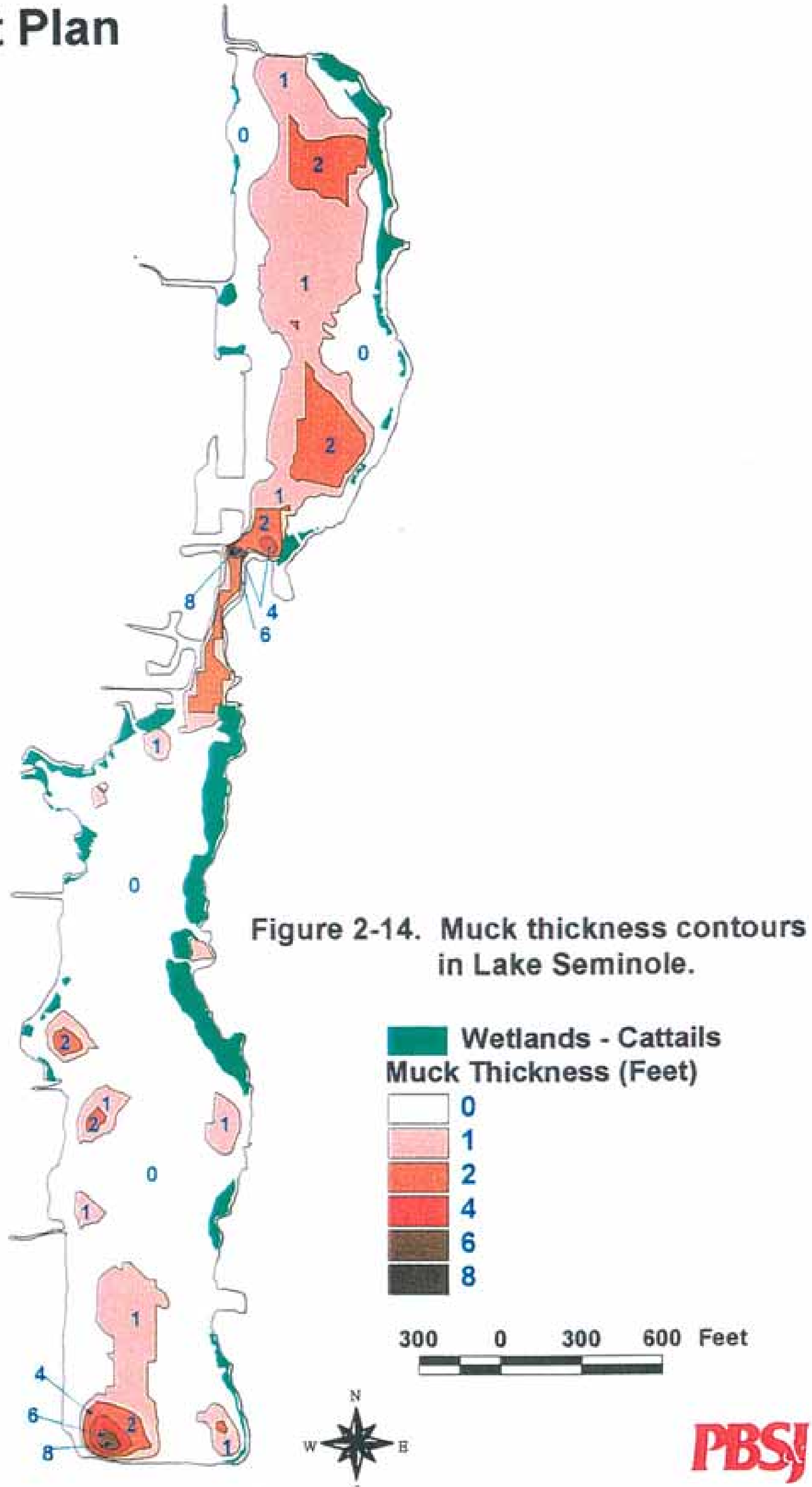

Figure 2-14. Muck thickness contours in Lake Seminole.

PBSJ

Using the mean N and P sediment release rates published by Schelske et al. (1991; in SWFWMD, 1992), the annual N and P fluxes to the lake surface waters are calculated to be 10,374 kg N/yr, and 2,307 kg P/yr, respectively. Compared to the nutrient budgets summarized in Tables 2-2 and 2-3, it can be seen that the measured sediment N flux of 10,374 kg N/yr could account for as much as 47% of the calculated N load attributed to the *undetermined sources* balancing term in the Lake Seminole nitrogen budget. Similarly, the measured sediment P flux of 2,307 kg P/yr could account for as much as 75% of total calculated P load. In addition, waterbody modeling using WASP5 conducted as part of the planning process (see Chapter 3) indicated that sediment N and P fluxes in these orders of magnitude are needed to calibrate the model so that the observed water quality conditions in Lake Seminole are accurately simulated.

Schelske et al. (1991; in SWFWMD, 1992) point out that their measured sediment nutrient release rates were highly variable depending upon the sediment type, and that lakewide estimates of sediment nutrient fluxes should be based on an assessment of proportional areal coverages of organic versus sandy sediments. Nonetheless, these findings clearly suggest that sediment nutrient fluxes potentially constitute a very significant component in the lake nutrient budgets.

In addition to contributing to water quality problems, the substrate provided by these low density flocculent sediments is generally not conducive to the establishment and proliferation of desirable submerged aquatic vegetation. Similarly, the highly organic fibrous shoreline sediments preclude the establishment and proliferation of desirable emergent aquatic vegetation. More importantly, thick accumulations of these sediments in the lake littoral zone severely limit the shallow bottom area available for sport fish spawning. Although there is no evidence that the highly organic fibrous shoreline sediments contribute to water quality problems in the lake, they do compromise shoreline recreational uses and aesthetics through the combined effect of sustaining extensive stands of nuisance aquatic vegetation as well as limiting sport fish spawning.

In summary, the sediments in Lake Seminole constitute both a water quality problem and a habitat problem. At least a partial removal of the more problematic sediment types in the lake is indicated by the available data to meet the defined lake and watershed management goals.

2.4 Aquatic Vegetation

As discussed in Section 2.1, the mangrove and tidal marsh vegetation that originally existed in Long Bayou was flooded with the creation of Lake Seminole. Therefore, the aquatic vegetation communities of Lake Seminole began with conversion of tidal wetlands to freshwater emergent and submerged aquatic vegetation.

The earliest documented survey of aquatic vegetation in Lake Seminole was conducted in 1988 by the Florida Department of Environmental Protection (FDEP). The FDEP conducted follow-up surveys in 1990, 1992, 1993, 1994, and 1995. These surveys were semi-quantitative in nature, and were conducted to estimate the relative cover of major desirable and nuisance species in the lake. The results of these surveys are summarized in Tables 2-5 and 2-6. The FDEP has not conducted any additional aquatic plant surveys on Lake Seminole since 1995.

As part of the planning process, an assessment of in-lake and watershed habitats was conducted. Figure 2-15 below shows the current distribution of major plant communities in Lake Seminole and its watershed.

Table 2-5. Estimated coverages of major nuisance and desirable species in Lake Seminole, as reported by FDEP for the years 1988-1995.

Year	Cattails acres	*Hydrilla* acres	*Vallisneria* acres
1988	68	86	28.0
1990	107	277	4.1
1992	110	0.5	13.2
1993	85	0.0	No Survey
1994	76	0.1	7.1
1995	61	0.0	4.2

The coverage and density of the exotic *Hydrilla* was a major concern in Lake Seminole during the late 1980s. As shown in Table 2-5, the coverage of *Hydrilla* rapidly expanded from 86 acres in 1988 to 277 acres in 1990. In response to this concern, the Florida Game and Freshwater Fish Commission released approximately 7,800 triploid grass carp into the lake between 1988 and 1991 with the objective of controlling the continued expansion of *Hydrilla*. Since then, the coverage and density of *Hydrilla* has declined to the point where its presence has been almost completely eradicated.

The subsequent harvesting of the *Hydrilla* crop by grass carp in the early 1990s clearly had a significant impact on the trophic state of Lake Seminole. This can be seen in the elevated TN, TP, and Chlorophyll-a concentrations that occurred in the lake during 1993, and the declining Secchi disk depths beginning in 1991 (see Figures 2-3 through 2-6). It can be assumed that a significant portion of the nutrient mass contained in approximate 277 acres of *Hydrilla* present when the carp were introduced was converted to carp waste, and subsequently to inorganic forms of N and P available for algal uptake. Huber et al. (1982) note that in many Florida lakes an inverse relationship generally exists between macrophyte coverage and phytoplankton (expressed as chlorophyll-a). Although phytoplankton were certainly a major source of primary production in Lake Seminole prior to 1991, the introduction of carp likely precipitated a major trophic shift from a macrophyte dominated system towards the algal dominated system that is present today.

Table 2-6. Results of the 1995 FDEP aquatic plant survey of Lake Seminole.

Scientific Name	Common Name	Acres
Alternanthera philoxeroides	alligator weed	0.1
Bacopa monnieri	smooth water-hyssop	0.1
Brachiaria mutica	para grass	0.6
Colocasia esculenta	wild taro	1.1
Cyperus spp.	sedge	0.1
Echinochloa spp.	barnyard grass	0.1
Eichornia crassipes	water hyacinth	0.2
Eleocharis interstincta	giant spikerush	0.1
Hibiscus spp.	hibiscus	0.2
Hydrocotyle spp.	pennywort	0.3
Lemna spp.	duckweed	0.1
Ludwigia peruviana	primrose willow	5.4
Nuphar luteum	spatterdock	0.1
Nymphaea odorata	fragrant water-lilly	0.6
Panicum repens	torpedo grass	1.2
Polygonum hydropiperoides	smartweed	0.2
Pontederia cordata	pickerelweed	0.3
Sagittaria lancifolia	lanceleaf arrowhead	0.4
Sagittaria latifolia	common arrowhead	0.1
Salix caroliniana	willow	3.5
Salvinia minima	water fern	0.1
Scirpus cubensis	burhead sedge	0.1
Scirpus californicus	giant bulrush	0.2
Typha spp.	cattail	61.4
Vallisneria americana	eel grass	4.2

Lake Seminole Watershed Management Plan

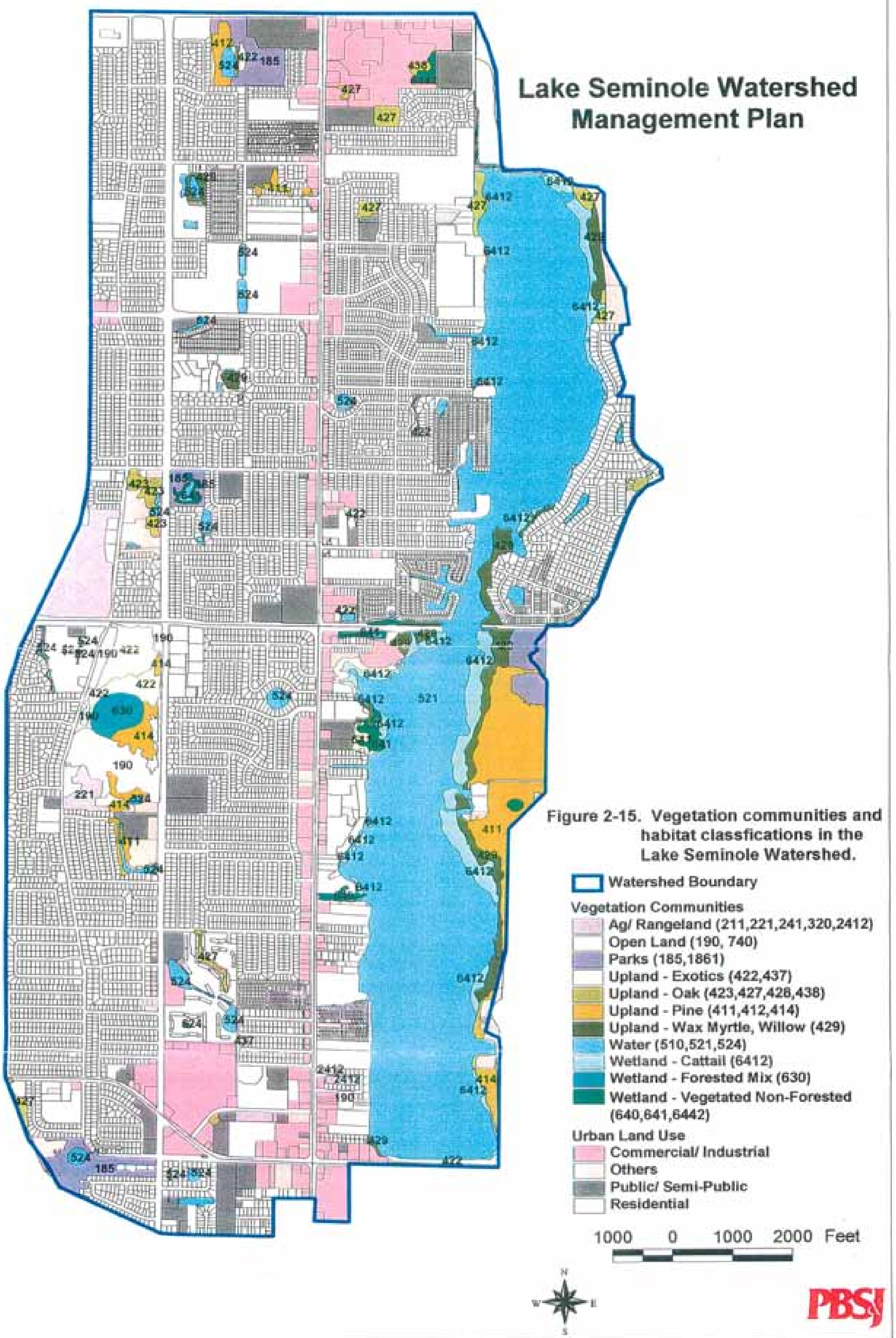

Figure 2-15. Vegetation communities and habitat classfications in the Lake Seminole Watershed.

During the mid-1990s, Pinellas County launched an ongoing mechanical harvesting program to remove cattails (*Typha spp.*) from the lake shoreline. The density of cattails had been determined to be excessive to the extent that waterfront views and shoreline recreational opportunities were being precluded. The harvesting program has been effective at removing dense problematic cattail stands in certain strategic locations around the lake.

Today, diverse populations of desirable native aquatic vegetation, both emergent and submergent, are essentially lacking in Lake Seminole, largely as a result of grass carp and mechanical harvesting of macrophytes, shoreline hardening, and the light limiting environment caused by excessive algal growth in the water column. In addition to these stressors, the maintenance of static water elevations in the lake by the existing weir outfall structure has contributed substantially to the proliferation of monotypic stands of cattails, primrose willow, and carolina willow; and has led to substantially reduced plant diversity in the lake littoral zone. Furthermore, accumulated flocculent sediments in many portions of the lake preclude the establishment of rooted macrophytes due to substrate limitations.

2.5 Fisheries

The freshwater sport fisheries in Lake Seminole developed slowly following the creation of the lake in the mid-1940s. In 1963 Lake Seminole was designated by the Florida Game and Freshwater Fish Commission (FGFWFC) as an official Fish Management Area which obligated this agency to conduct periodic monitoring of the sport fisheries as well as perform various fisheries management activities.

The main source of information about the early biological record of Lake Seminole is from the files and reports prepared by the FGFWFC. Records date back to the 1960s and concentrate mainly on the health of the lake fishery, although recommendations were made regarding the general improvement of the lake ecosystem.

During the late summer and early fall of 1960 through 1963, Lake Seminole was treated with rotenone for species control of threadfin shad, whose numbers were considered too high for healthy sport fish community balance. In 1965, the primary catches by commercial fisherman were brown bullhead and channel catfish (Phillipy, 1965). In addition, the largemouth bass population was rated as excellent and Lake Seminole had one of the highest standing crops per acre in west central Florida (Ware, 1965). By 1968, however, bass fishing success had declined, coinciding with another increase in the shad population (FGFWFC, 1968).

The FGFWFC (1968) also discussed the probability of Lake Seminole becoming highly eutrophic and degraded, and comparisons with nearby Lake Maggiore were made. Recommendations were made for remedial measures to prevent further water quality degradation including the elimination of domestic sewage discharges to the lake, and the preservation of existing aquatic vegetation to help retard the eutrophication process. The sewage effluent involved was from a secondary treatment plant operated by the City of Largo which discharged into a drainage ditch and flowed into the channelized portion of Long Creek north of the lake. From there, effluent was pumped into the lake along with Long Creek flows. The plant is believed to have been shut down and replaced with a new treatment plant outside the watershed in 1971 (SWFWMD, 1992).

A few years later, the FGFWFC (1970) recommended that an extreme drawdown be conducted on the lake to reduce the organic muck on the lake bottom and to control shad populations. Control of the shad population using drawdowns appeared to have merit since the environment, rather than just the fish population, would be manipulated. However, the recommended extreme drawdown was never performed (SWFWMD, 1992). In 1982, in another attempt to further control shad populations, the FGFWFC stocked Lake Seminole with sunshine bass at a density of 10 fish per acre. (SWFWMD, 1992).

As discussed in Section 2.4 above, the proliferation of *Hydrilla* became an issue in Lake Seminole in the late 1980s. To control rapidly spreading *Hydrilla*, the FGFWFC stocked the lake with 350 triploid (reproductively sterile) grass carp (*Ctenopharyngodon idella*) in May 1987. An additional 350 carp were stocked in November 1988, and 2,100 more carp were added in October of 1989. In the spring of 1991, a second series of carp stockings were initiated with 2,000 fish added to the lake in February, and 3,000 more in March. By the summer of 1991, a total 7,800 grass carp had been introduced into Lake Seminole.

Later in 1991, the FGFWFC concluded that poor habitat seriously limits largemouth bass recruitment and sport fish quality in that it creates insufficient production of forage food items required by young bass, and reduces recruitment. In 1991, the total fish biomass averaged 306 kg/ha; however, largemouth bass standing crop was well below the carrying capacity of 23 kg/ha for this species (Champeau et al., 1991). In response to these findings, the FGFWFC recommended that a habitat restoration plan be implemented which included: 1) redesign of the outfall structure; 2) an extended lake drawdown to expose 50% of the bottom; 3) removal of organic sediments that cover the littoral shelf; and, 4) revegetation of the cleared areas with desirable macrophytes. In the early 1990s, Pinellas County initiated a redesign of the outfall structure.

Although the FGFWFC continued to assert that habitat restoration was the best long term solution to improving sport fishing in Lake Seminole, an innovative technique was attempted in 1995 to improve fishery quality. This technique involved the stocking of hatchery-produced adult sized bass that could immediately prey on the existing forage base. In September 1995 the FGFWFC first determined the relative abundance and species composition of the forage base using seines and gill nets. The abundance of forage of required size appeared sufficient to support stocked adult largemouth bass. The forage species collected included:

- gizzard shad;
- seminole killifish;
- small bluegill;

- threadfin shad;
- golden shiner;
- rio grande cichlid;
- black crappie; and
- brook silverside.

In November 1995, a total of 12,430 largemouth bass were stocked in Lake Seminole at a density of 43 fish/ha. Three months after stocking, the stocked bass density was only 0.11 fish/ha. The native bass population was also determined to be low at 8 fish/ha. It was concluded that handling stress accounted for most of the mortality of stocked largemouth bass; however, predatory birds and the inability of stocked bass to effectively forage probably claimed most of the surviving bass. Again, structural habitat in the form of emergent and submerged aquatic vegetation was considered to be critical to improving fishery quality in Lake Seminole.

In summary, the sport fishery in Lake Seminole has declined substantially since the mid-1960s when it was considered one of the most productive bass fishing lakes in west central Florida. The fish population structure has shifted from a dominance of carnivorous sport fish (e.g., largemouth bass, bluegill) to a dominance of planktivorous rough fish (e.g., gizzard and threadfin shad) in response to advancing eutrophication that has occurred over the past three decades. During the past decade, the decline of the sport fishery has been further exacerbated by the loss of submerged aquatic vegetation, and the structural habitat that it provides, due to the introduction of grass carp in Lake Seminole. In addition, the conversion by grass carp of the nutrient mass contained in macrophytes into inorganic forms available to phytoplankton has significantly contributed to the recent hypereutrophication of Lake Seminole.

2.6 Wildlife and Associated Habitat

This section provides an overview of the physical and geological features of the Lake Seminole watershed, and a discussion of the remaining vegetation communities and wildlife habitats that still exist within the basin.

2.6.1 Geology and Soils

Pinellas County is a peninsula, situated between the Gulf of Mexico and Tampa Bay. The peninsula lies within the larger physiographic province called the Gulf Coast Lowlands, an extensive coastal formation that includes much of the west coast of Florida (SWFWMD, 1988). Within Pinellas County these lowlands are generally characterized by relatively flat, often swampy lowlands along the coastal areas. Elevations generally range from sea level to 97 feet (Pinellas County Soil Survey, 1972). The Gulf Coast Lowlands typically have coastal barrier islands separated from the mainlands by bays and lagoons. These barrier islands were formed by erosion of headlands and sediment transport by longshore drift at the current sea level elevations. Pinellas County also exhibits gently sloping marine terraces which were developed during periods of higher sea levels of the Pleistocene epoch. These marine terraces are generally referred to by the corresponding interglacial episodes and the respective sea level elevations above NGVD. Within Pinellas County these terraces are the Wicomico (100 feet), Penholoway (70 feet), and the Pamlico (25 feet). The Pinellas Ridge is one such marine terrace that extends from Seminole to Palm Harbor and reaches a maximum elevation of 97 feet (SWFWMD, 1988).

The geology of the Gulf Coast Lowlands is characterized by marine deposited sands and shelly sands of variable thickness overlaying Cretaceous and Tertiary carbonates, clays and evaporites deposited during times of higher sea level. The underlying geology of the Pinellas peninsula is sandy clays and marls of the Hawthorn Formation and the Tampa Limestone of the middle to early Miocene. These sandy clays and marls comprise the upper confining layers of the Floridan aquifer system and vary in depths from less than 25 feet in the north to areas with depths greater than 150 feet in southern Pinellas. These thick deposits in the south effectively restrict vertical movement of water between the surficial sands and the Floridan aquifer system (SWFWMD, 1988). The northern portion of the Pinellas Ridge exhibits Karst characteristics with sinkholes and a lack of surface drainage features. Karst features are largely absent from the southern extent of the Pinellas Ridge in the vicinity of the Lake Seminole watershed due to the underlying geology.

The western portion of the Lake Seminole watershed is defined by the Pinellas Ridge, an undulating, gently sloping, well drained sandy ridge of marine origin with poorly defined surface drainage features, which reaches an elevation of 55 to 70 feet. The eastern watershed is low, nearly level, poorly drained sandy soils of marine origin with a range of topographic elevation of between 5 and 15 feet. Topographic contours in the Lake Seminole watershed are shown in Figure 2-16.

Two dominant soil associations exist within the Lake Seminole watershed. These include the Astatula-Adamsville Associations in the western ridge area, and the Myakka-Immokalee-Pomello Associations predominantly in the eastern watershed areas. The distributions of major soil types in the Lake Seminole watershed are also shown in Figure 2-16.

Astatula soils are excessively well drained sandy soils that occur mostly on upland ridges within the western portion of the watershed. These soils have very rapid permeability, very low available water capacity, low organic content, and low natural fertility. The water table in this soil series is generally at a depth of more than 60 inches. The natural vegetative communities occurring in these soils typically are: sand and slash pine, scrub oak, saw palmetto, and various scrubs and grasses. These soils are favored for citrus and improved pasture and are less suitable for more intense agriculture because of the low availability of water and low fertility. These soils can produce crops, ornamentals and grasses with adequate amounts of fertilizer and irrigation. Urbanization of these areas began in the 1920s and continues today, partly because of the well drained soils and lack of flooding. Also, these areas were prime for development because they were relatively large tracts of land that had been consolidated into citrus and improved pastures and were readily available for development.

Lake Seminole Watershed Management Plan

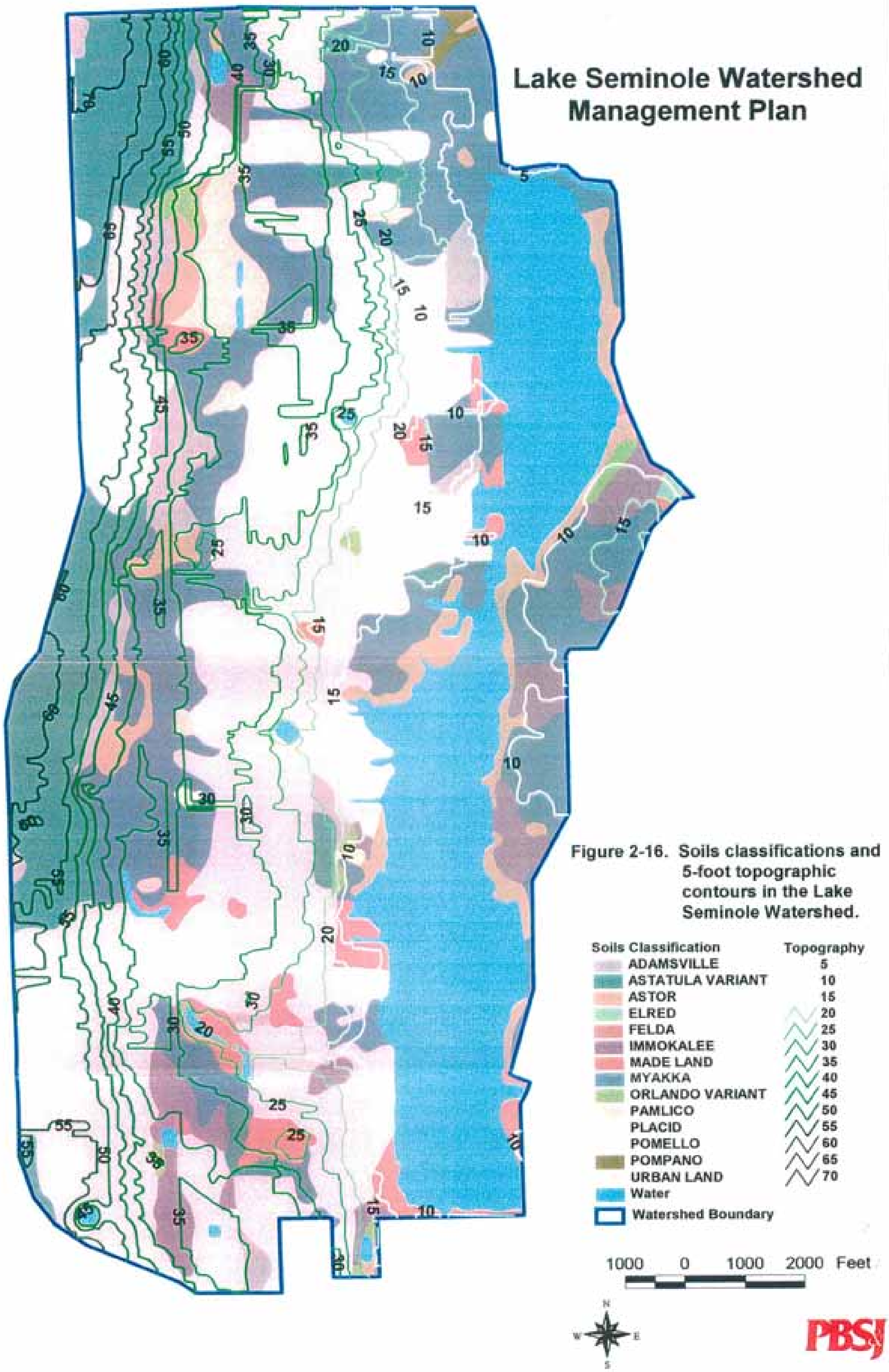

Figure 2-16. Soils classifications and 5-foot topographic contours in the Lake Seminole Watershed.

Adamsville soils occur predominantly near the base of the sloping ridge, consisting of nearly level, poorly drained sandy soils that formed in thick deposits of acid marine origin. As with the Astatula series, these sandy soils have rapid permeability, very low water holding capacity, low organic content and low natural fertility. Water tables vary seasonally between 10 to 40 inches in depth. Some areas exhibit seepage during seasonally high rainfall. The natural vegetative regime occurring in this soil series includes pine, oak, palmetto, scrubs and grasses. As with the Astatula series, these soils were favored for citrus production and have experienced urbanization.

The soils of the Myakka-Immokalee-Pomello Association are characterized by broad flats between sloughs, low ridges and knolls within the eastern watershed. These areas have small natural drainage ways and shallow grassy ponds in their natural setting. These soils are generally poorly drained with moderate to low permeability, with a water table within 10 to 30 inches of the surface. Natural vegetation consists of saw-palmetto, scattered stands of slash pine, gallberry, oak and grasses. Water tolerant hardwood trees, scrubs and grasses grow in lower elevations. The seasonally high water table is the main limiting factor in urbanization. While the high water table is a restraint to development activities, improved drainage has allowed for extensive development in these soils (Pinellas County Soil Survey, 1972). Soils classifications in the Lake Seminole watershed are also shown in Figure 2-16 above.

2.6.2 Vegetation Communities

Historic Habitats

A review of Pinellas County aerial photographs dating back to March 1926 indicates that the natural vegetative communities within the watershed area had already been extensively impacted by agricultural (citrus groves and pasture) activities. These aerial photographs show extensive citrus grove activity along the Pinellas Ridge area, as well as cleared lands with drainage improvements where shallow ephemeral ponds in natural pine flatwoods were being ditched and drained to create improved pasture. Prior to agricultural development, these upland areas supported pine flatwoods with slash, sand, and longleaf pine, scrub oaks, saw palmetto and a variety of scrubs and grasses typical of coastal ridge communities of the Gulf Coast Lowlands.

Areas with undisturbed native upland vegetative communities were widely distributed across the watershed in the 1926 aerial photographs. Remnants and/or second growth native vegetation still exists on County-owned lands east of the lake and where native trees remain within residential subdivisions. Remnants of the old growth citrus trees, dating from this early period, can be found in the residential subdivisions west of the lake.

The native vegetation in what is now Lake Seminole, prior to the impoundment that created the lake in the 1940s, was a narrow strip of red, white and black mangrove fringe in the southern lake area, and salt barrens with myrtle fringes adjacent to the upland pine flatwoods. This shallow estuarine system would have been similar to the existing vegetative and estuarine communities within Long

Bayou south of Park Boulevard in the vicinity of the lake. No evidence of these estuarine communities currently exists within or adjacent to Lake Seminole today because of the transition to a freshwater environment. The pine flatwoods community existing east of the lake within Lake Seminole County Park is second growth on improved pasture.

The 1926 and 1957 historical aerial photographs showed several poorly defined drainage features in the western portion of the watershed. These drainage features appeared to be shallow seasonal stream beds with narrow vegetated floodplains, many of which had been channelized as part of the agricultural improvements in the areas. These drainage features have since been incorporated into the urban stormwater management system and are not evident on current (1994) aerial photographs.

Existing Habitats

As part of the planning process, existing vegetation communities within the watershed were assessed with respect to habitat function and quality. The characterization of upland and wetland habitats recognized that the watershed was highly urbanized and that the remaining habitat units were diverse in nature, widely distributed throughout the watershed, and consisted of small isolated remnants of historical vegetative communities that existed prior to the development of the area. The methodology developed to perform the evaluation included both research of historical conditions and field inspection of each habitat area to determine existing conditions. A total of 121 habitat units were evaluated in the watershed. The resulting habitat classifications in the Lake Seminole watershed are shown in Figure 2-15 above using a modified Level-III of the Florida Land Use Cover and Classification System (FLUCCS). Table 2-7 provides a summary of the acreage of the various habitats types in the watershed.

As shown in Table 2-7, two of the most dominant species within the watershed are Brazilian pepper, *(Schinus terebinthifolius*) and cattails *(Typha spp)*. Brazilian pepper is pervasive throughout the watershed, in that it is present in almost all vegetative communities and exists as a monoculture in many areas. Cattails are present in almost all shallow open water areas within Lake Seminole and isolated wetland systems within the watershed. Other nuisance species observed within various vegetative communities included Australian pine *(Casuarina equisetifolia)*, melaleuca *(Melaleuca quinquenervia)*, air potato *(Dioscorea bulbifera)*, jacaranda *(Jacaranda mimosifolia)* and mimosa *(Albizia julibrisson)* trees.

In general, all remaining habitats in the watershed have been impacted by past or present land use activities. The typical impacts sustained were hydraulic improvements in the vicinity of the habitat including drainage activities, roads, or filling and grading activities for adjacent land uses. The dominant type of physical alterations observed was the deposition of spoil materials and rubbish and the clearing of native vegetation. Chemical impacts on both upland and wetland communities were evident in portions of the watershed. Habitats adjacent to roads or drainage features were receiving chemicals from urban stormwater runoff while certain wetland communities appeared to have been treated with herbicides to eradicate cattails.

Table 2-7. Summary of habitat classifications in the Lake Seminole watershed.

Habitat Type	FLUCCS Code	Associations	Frequency of Occurrence	Acreage
Parklands	185		3	41.297
Open Lands	190		7	44.036
Improved Pasture	211		1	1.483
Citrus Groves	221		2	42.661
Tree Nurseries	241		1	2.606
Shrub and Brushland	320		1	0.871
Pine Flatwoods	411		6	70.888
Longleaf Pine	412		1	5.449
Pine Mesic Oak	414		5	19.165
Brazilian Pepper	422	212, 425, 429, 439	22	49.944
Oak-Pine	423		3	6.238
Live Oak	427		11	18.488
Cabbage Palm	428		1	0.465
Wax Myrtle	429	422	17	50.634
Australian Pine	437		1	0.742
Mixed Hardwood	438		5	13.431
Streams and Waterways	510		1	0.437
Open Water Greater than 500 Acres	521		1	639.912
Open Water Less than 10 Acres	524		39	39.083
Wetland Forested Mixed	630		1	12.061
Vegetated Non-Forested Wetlands	640	422, 429	1	2.224
Freshwater Marsh	641		1	9.967
Disturbed Lands	740		1	0.213
Baseball Fields	1861		1	16.988
Field Nursery	2412		3	2.971
Cattail	6412		30	60.236
Spatterdock	6442		1	2.788

As depicted in Figure 2-15, the urbanization of the watershed, especially the western portion, has left relatively small remnants of the native upland and wetland vegetative communities among the urban mix of land uses. Larger habitat segments within the watershed include Lake Seminole County Park and associated County owned lands to the north of the park. These habitats are predominantly pine flatwoods with a wetland fringe of carolina willow and cattails on Lake Seminole.

The St. Petersburg Junior College (SPJC) site is an approximately 100 acre tract located west of 113th Street. Dominant habitats on this tract include a remnant pine and bay wetland community along with successional vegetative growth in upland portions of the site where agricultural old fields and orange groves once dominated. This site is currently planned for development as a new Seminole Campus of SPJC. The conceptual development plan appears sensitive to the remnant wetland community on site.

Pinellas County also owns the narrow strip of land on the northeastern portion of the lake between the lake and Seminole Bypass Canal. The vegetative communities in this area are impacted remnants of pine flatwoods to the south and an oak dominant community farther to the north. The remaining habitats are impacted ruderal communities dominated by Brazilian pepper, elderberry, dog fennel, and castor bean. A review of the historical aerial photographs indicated that this area was probably unimproved pasture with scattered pines and a remnant wetland drainage feature that has been severed by pasture ditching and the construction of the Seminole Bypass Canal.

The Pinellas County Sheriff's Complex on Ulmerton Road contains approximately 20 acres of habitat, predominantly maintained grass training areas. Portions of this site support a remnant pine flatwoods surrounding an old borrow pit that serves as a stormwater management facility for the adjacent land uses including stormwater runoff from Ulmerton Road. Both the pine flatwoods and the areas surrounding the pond have various levels of Brazilian pepper encroachment ranging from a few individual plants on the fringe of the pine flatwood areas to extensive monoculture within the open fields and surrounding the pond.

As part of the planning process, habitat distribution and disturbance patterns were evaluated to determine the potential for special habitat management sites or habitats suitable for enhancement or restoration. The general findings from this evaluation were that the urbanized nature of the watershed does not provide notable opportunity for wildlife corridors or dispersal areas. The remnant habitats in the watershed are small and fragmented to the point where an opportunity for a unifying ecological corridor is no longer viable. Some opportunities do, however, exist for recreational corridor connections between Lake Seminole County Park and the Pinellas Trail that extends north-south along the western watershed boundary.

Of the approximately 120 habitat units evaluated, a high percentage exhibit nuisance species invasion in varying degrees. Therefore, nuisance species removal coupled with the enhancement and restoration of the habitats within the watershed as a whole is a needed and important activity. It should be noted that the habitat coverage by one of the nuisance species - Brazilian pepper - is high throughout the watershed. Because this species displaces viable native habitat, it should be controlled or removed so that habitats can ultimately be restored to their natural condition.

2.6.3 Wildlife

Table 2-8 provides a compilation of species observed during the field surveys plus species reported from various sources to occur within the area. This list probably represents a partial listing of wildlife in the Lake Seminole watershed, since common species and migratory waterfowl are not extensively identified. The dominant types of wildlife observed within the watershed were wading birds and waterfowl. In addition, numerous coastal and sea birds frequent the lake due to the proximity to the tidal waters of Boca Ciega Bay and the Gulf of Mexico.

As may be anticipated within a freshwater lake system the size of Lake Seminole, certain of the indigenous wildlife are listed species and require varying levels of protection. In total, eight (8) species are listed as species of special concern (SSC), two as threatened (T) and one as endangered (E) by the Florida Game and Fresh Water Fish Commission. The U.S. Fish and Wildlife Service identifies one species as endangered (E). The primary listed species within the watershed in terms of the level of protection afforded by the various listings is the southern bald eagle.

Two active bald eagle nesting sites exist within the watershed: one on the fenced parcel of County owned lands north of Lake Seminole County Park; and a second on the St. Petersburg Junior College tract west of 113th Street. The U.S. Fish and Wildlife Service's Southern Bald Eagle Guidelines typically require a 750 foot primary zone where no human activities can occur during nesting season from October through March yearly and a secondary zone of an additional 750 feet where certain restricted activities can occur.

Table 2-8. Wildlife species observed or reported to occur within the Lake Seminole watershed.

Common Name	Scientific Name	GFC	FDA	USFWS	CITES	Observed, or Reported
Snowy Egret	*Egretta thula*	SSC				R
Tricolored Heron	*Egretta tricolor*	SSC				R
Green Heron	*Butorides striatus*					O
Yellow Crowned Night Heron	*Nyctanassa violacea*					O
Great Egret*	*Casmerodius albus*					O
Great Blue Heron	*Ardea herodias*					O
Cattle Egret	*Bubulcus ibis*					O
White Ibis	*Eudocimus albus*	SSC				O
Sandhill Crane	*Grus canadensis pratensis*	T				R
Mallard	*Anas platyrhynchos*					O
Purple Martin	*Progne subis*					O
Roseate Spoonbill	*Ajaia ajaja*	SSC				R
Common Moorhen	*Gallinula chloropus*					O
Osprey	*Pandion haliaetus*				II	R
Little Blue Heron	*Egretta caerulea*	SSC				O
Southern Bald Eagle	*Haliaeetus leucocephalus*	T		E	I	O
Turkey Vulture	*Cathartes aura*					O
Wood Stork	*Mycteria americana*	E	E			R
Limpkin	*Aramus guarauna*	SSC				O
Boat-Tailed Grackle	*Quiscalus major*					O

Common Name	Scientific Name	GFC	FDA	USFWS	CITES	Observed, or Reported
Red Wing Black Bird	*Agelaius phoeniceus*					O
Mourning Dove	*Zenaida macroura*					O
Anhinga	*Anhinga anhinga*					O
Double-Crested Cormorant	*Phalacrocorax auritus*					O
Pileated Woodpecker	*Dryocopus pileated*					O
Downy Woodpecker	*Picoides pubescens*					O
Red-bellied Woodpecker	*Melanerpes carolinus*					O
Brown Pelican	*Pelecanus occidentialis*	SSC				O
Common Tern	*Sterna hirundo*					O
American Alligator	*Alligatoridae mississippiensis*					O
Southern Black Racer	*Coluber priapus*					O
Corn Snake	*Elaphe guttata*					O
Red Eared Slider	*Trachemys elegans*					O
Largemouth Bass	*Micropterus salmoides*					O
Bream	*Lepomis sp.*					R
Blue Gill	*Lepomis macrochirus*					R
Redear Sunfish	*Lepomis microlophus*					R
Channel Catfish**	*Ictalurus punctatus*					R

Common Name	Scientific Name	GFC	FDA	USFWS	CITES	Observed, or Reported
Sunshine Bass	*Morone saxatilis x M. chrysops*					R
Triploid Grass Carp	*Ctenopharygodon idella*					R
Tilapia	*Tilapia mossambica*					O
Gray Squirrel	*Sciurus carolinensis*					O
Marsh Rabbit	*Sylvilagus palustris*					O
Armadillo	*Dasypus novemcinctus*					O
Raccoon	*Procyon lotor*					O
Opossum	*Didelphis virginiana*					O

Notes:

GFC = Florida Game and Fresh Water Fish Commission
FDA = Florida Department of Agriculture and Consumer Affairs
USFWS = United States Fish and Wildlife Service
Cites = Convention on International Trade in Endangered Species of Wild Fauna and Flora
E = Endangered
SSC = Species of Special Concern
A = Anticipated to occur on site
O = Observed on site
R = Reported - incidental sighting by Pinellas County Park, PCDEM, or FGFWFC staff over extended observation period.
II = Appendix II Species (CITES)
C2 = A candidate for federal listing with some evidence of vulnerability, but for which not enough information exists to justify listing.

* Great Egret - formerly known as the "American Egret," and/or "Common Egret," this bird's official name in North America is now Great Egret.

* FGFWFC records indicate that Lake Seminole was stocked with channel catfish *(Ictalurus punctarus)* in 1966 and natural reproduction was documented two years later. Brown Bullhead *(Ictalurus nebulosus)* may also be present in the lake, but are not listed on current FGFWFC survey reports.

2.7 Recreation, Aesthetics, and Economic Valuation

The economic value of Lake Seminole to Pinellas County can be estimated by evaluating two interdependent variables - recreational use and aesthetic attributes. Recreational activities include the boating and fishing activities conducted on the lake as well as recreational visits to Lake Seminole County Park. Aesthetic attributes, on the other hand, can perhaps be best represented in increased property values for those residential and commercial properties located on the lake.

2.7.1 Recreation

The levels of use, potential areas of conflict, and the projected economic value of recreational activities have been assessed using three sources including the November 1992 Pinellas County Recreational Survey, the 1990-91 recreational survey by the Florida Game and Freshwater Fish Commission, and the historical visitor levels at Lake Seminole County Park.

The Pinellas County Department of Environmental Management conducted a user survey of Lake Seminole in November, 1992. The purpose of this survey was to evaluate the type of recreational activities being performed on the lake and the users' insight and preferences regarding the lake as a recreational resource. In total, 147 individuals participated in the survey over a 15 day period. The survey included both weekday and weekend visitors. The responses to this survey indicated that fishing is the primary activity with 62 responses, followed by boating (30 responses), jet skiing (21 responses), skiing (5 responses), and no specific water activities (29 responses). The individuals surveyed indicated that Lake Seminole was a primary recreational resource that they used an average of 61 days a year. The average number of hours spent on the lake during a typical day was estimated at 4.4 hours. The type of equipment used to pursue the recreational boating activities included an average boat length of 16.5 feet with a 98 horsepower engine.

The majority of lake users (91 percent) felt safe on the lake, however, a number of user conflicts were noted including problems with: jet skis (62 percent); water skiers (30 percent); fishermen (9 percent); boaters (2 percent); and non specified conflicts (9 percent). A total of 92 percent of user conflicts (jet skis 62 percent and water skiers 30 percent) were associated with the speed of the watercrafts. The problems created by boat speed include safety of operation and avoidance of accidents, wakes, and associated noise. In part, because of these user conflicts, 39 percent of the respondents felt that a speed limit or restricted speed zones are needed on the lake. The speed limit desired based on the survey was 29 miles per hour.

The fishermen using the lake indicated that bass was the primary species pursued (79 percent), followed by other types of fish (18 percent), and crappie (4 percent). A total of 55 percent of the fishermen surveyed felt that the fishing was good (21 percent) or fair (34 percent), while 45 percent, the largest single response group, felt that fishing was poor.

The FGFWFC also conducted a recreational user survey in 1990-91. The findings of this survey indicated that the type and relative popularity of recreational uses supported by Lake Seminole were: fishing (59 percent); boating (29 percent); skiing (9 percent); personal watercraft (2 percent); and sailing (1 percent). The total number of boats observed on the lake during the survey ranged from 0 to 46, with an average of 13 boats per survey. The highest number of boats observed on the lake during the survey was on weekends.

Sportfishing was the primary recreational use of the lake during the survey period, however, considering the size and urban location, angling pressure was lower than expected (210 hours/ha/year). The economic impact of the Lake Seminole fishery was estimated by FGFWFC at $520,000 per year. Bass anglers comprised 76 percent of the total fishing effort and had a poor success rate of 0.19 bass/hour. Annual catch rate was estimated at 17 bass/ha/year. Most anglers did not practice catch-and-release; 64 percent of all bass caught were kept, and only 23 percent of quality-size bass were recycled (FGFWFC, 1991).

Since these surveys were taken in the early to mid 1990s, perceived changes in lake recreational uses have become apparent. These include a significant increase in the number of personal watercraft and ultra-light aircraft on the lake during weekends and holidays, and a decline in fishing pressure. These changes may eventually cause conflicts with the more traditional uses due to the congestion and noise. This may be especially true with the projected increases in aesthetics and recreational potential once lake water quality and habitats have been restored through the actions recommended in this Plan. Frequent recreational surveys would be necessary to determine any increases in recreational conflicts resulting from these changes in use.

2.7.2 Aesthetics and Economic Valuation

As part of the planning process, an estimate of the economic value of Lake Seminole was made, with consideration of both direct and indirect economic benefits.

The economic value of Lake Seminole is largely recreation based. Pursuit of recreational activities results in expenditures for gas, food, beverages, bait and tackle. The cost of a recreational visit to Lake Seminole County Park is estimated at $3.50 per day, while the cost of a boating trip on the lake is estimated at $35.00 per trip. By applying these cost estimates to the number of recreational visits and boating trips, the total annual expenditures within the local economy accruing from recreational uses of Lake Seminole is estimated at $5,264,887. Sales and gas tax revenues from these recreational expenditures are estimated at $632,855 to state and local government (PBS&J, 1998).

The aesthetic value of the lake was calculated by estimating the increased property values of residents with views on the lake versus comparable properties within the watershed with no views. The increased property values for lands surrounding Lake Seminole, including the potential value of existing public lands if these were in private ownership, is $10,560,000. This increased property value would contribute an estimated $224,000 annually in ad valorem taxes (PBS&J, 1998).

This analysis places the overall economic value of Lake Seminole at $16,123,000. This is an annualized figure that generates an estimated $856,855 in yearly taxes to state and local governments.

2.8 Flood Control

Section 2.1 above provides a brief history of Lake Seminole and the Seminole Bypass Canal. Following the creation of the lake in the mid-1940s, periodic flooding problems were experienced upstream of the lake, in the historic Long Creek basin. However, because the lake was hydrologically isolated from Long Creek flows, except for water pumped from the creek into the lake, flooding problems in the Lake Seminole basin were limited to small areas in the watershed where the local drainage infrastructure was inadequate.

As urbanization in the Lake Seminole area advanced during the 1960s and 1970s flooding problems became more frequent and severe in the upper Long Creek basin. By the mid-1970s, flooding concerns had become so great that construction of the Seminole Bypass Canal became a necessity. Since the construction of the Seminole Bypass Canal, flooding problems in the historic Long Creek basin have essentially been eliminated, and no additional flooding problems have been created in the Lake Seminole basin.

As part of the planning process, a review and update of the Pinellas County Master Drainage Plan for the Lake Seminole basin was conducted. Today, only minor flooding problems periodically occur in the Lake Seminole basin. These problems are limited to small areas where the local drainage infrastructure is inadequate. Figure 2-17 shows the location of identified flooding problem areas within the basin for the 25-year and 100-year flood. It should also be noted that the existing outfall structure at the south end of the lake is a fixed crest weir with an elevation of 5-feet NGVD. In the case of a coastal flood event, rising tidal waters and storm surges could overflow the structure and cause severe flooding in the low lying areas around the perimeter of the lake. These areas are, however, not depicted in Figure 2-17 due to the unpredictable elevation of a coastal storm surge.

Independent of the planning process, the Pinellas County Department of Public Works has initiated the design and permitting of a new outfall structure to replace the existing fixed crest weir. The new structure will be a slot gate design that will allow for lake levels to be fluctuated within an approximate range of 3-feet (e.g., between elevation 2.0 and 5.0, NGVD). This new outfall structure design was considered in the planning process as a means of controlling water levels for lake management purposes.

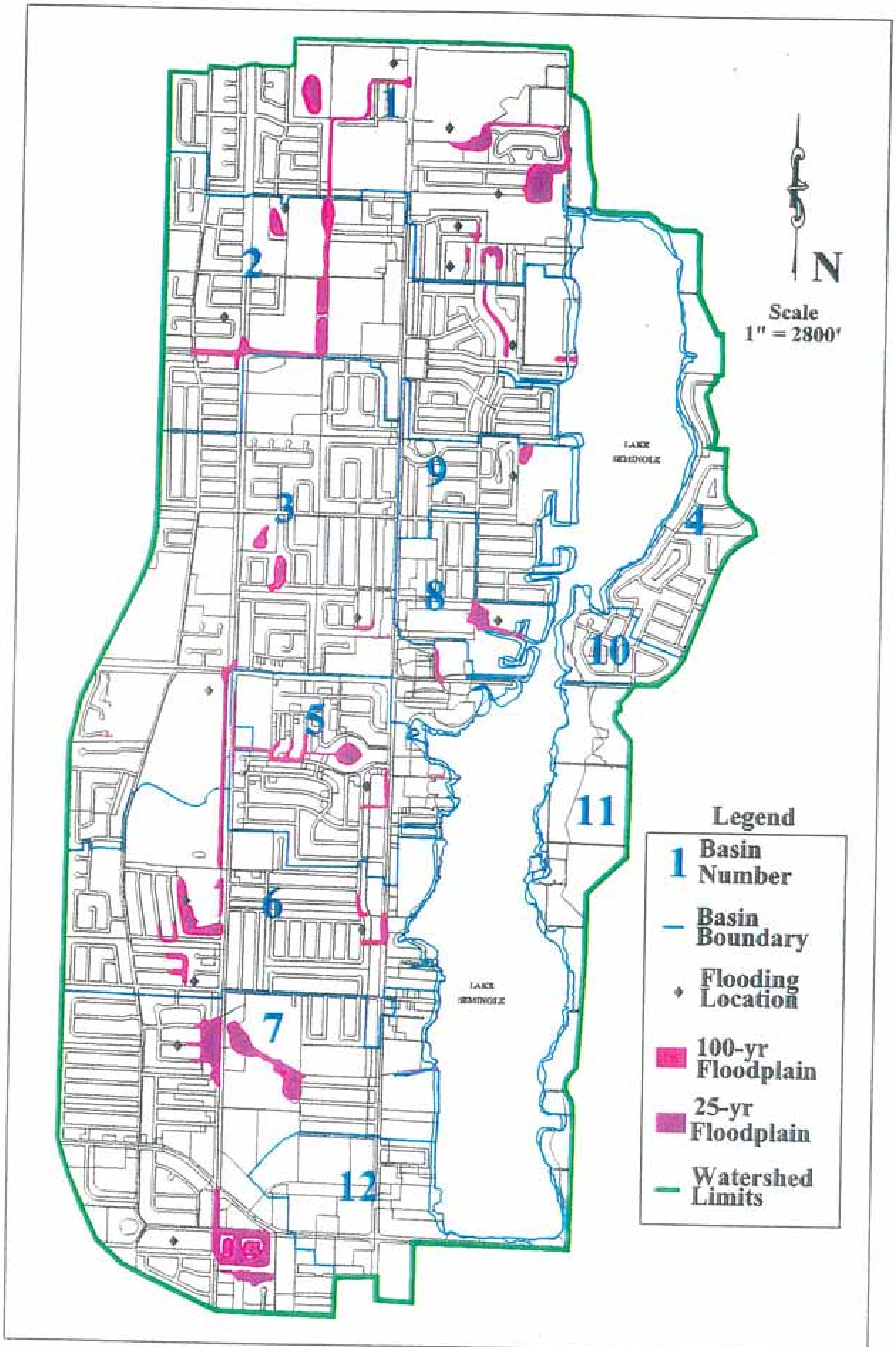

Figure 2-17 Existing flood prone areas in the Lake Seminole Watershed.

2.9 Public Education

No surveys of lakefront homeowners or recreational users of the lake have been conducted to specifically ascertain the level of public education on matters related to the ecology of Lake Seminole, or the watershed management process. The Pinellas County Department of Environmental Management has made attempts to improve public awareness of the lake and watershed management issues. These activities have included storm drain painting (e.g., "Dump No Waste - Drains to Lake") and the posting of signs along roadways indicating that drivers are entering the Lake Seminole Watershed Management Area. In addition, sign kiosks located in Lake Seminole Park have been used to display water quality data and other notices related to the lake and watershed management activities. Full implementation of the Plan recommended herein will require a more intense public education effort to solicit public support, cooperation, and involvement in the lake and watershed restoration and management activities.