WATER QUALITY

1.0 INTRODUCTION

This section provides descriptions of the methodology, terminology, and rationale used to characterize the affected environment of surface and ground water quality within the study area. The status of historical and current water-quality conditions for the study area are described by means of water-quality parameters, Florida state water classifications, water-quality indices, and exceedences of Florida state water-quality criteria. Data for many parameters are sparse or missing entirely for certain years and in some cases decades. In short, they are inconclusive with respect to water quality trends for many watersheds discussed in the following sections. A discussion of parameters used to describe the watersheds within the study area follows. It is generally useful to have an understanding of each of these items prior to assessing water quality.

1.1 Water Quality Parameters

Water-quality parameters may be physical, chemical, or biological in nature, or a combination of the three. Understanding water quality through the use of measurable water-quality parameters provides a means of recording how a particular water body (lake, stream, canal, bay, nearshore water or estuary) responds to environmental and anthropogenic changes, as well as an indicator to specific water-quality problems. A brief description of some of the key water-quality parameters and their utility are discussed in the following sections:

Biochemical Oxygen Demand (BOD)
BOD is the amount of oxygen that is consumed by bacteria “feeding” on decomposable organic matter under aerobic conditions. Measures of BOD in rivers, lakes, and estuaries are used to predict potential negative impacts that stormwater runoff and other wastewater sources may have on natural waters (Sawyer and McCarty, 1978).

Chemical Oxygen Demand (COD)
COD is the amount of oxygen used by a strong oxidizing chemical during the decomposition of organic and inorganic matter (Water Quality Association, 1997). COD testing is often used as a substitute for BOD measurements, and is useful for determining the oxygen demand of polluted waters.

Chlorophyll a
Chlorophyll a is a plant pigment most responsible for the green color in plants including phytoplankton. The amount of chlorophyll a in the water column is an indicator of the abundance of free-floating. An increase in algae of this type can cause a reduction in light penetration through the water column, and a decline in BOD. In some estuaries, declines in seagrass acreage have been attributed to reduced light penetration attributed to increased algae concentrations in the water column. Nutrients, such as nitrogen, can trigger rapid algal growth known as blooms. Depending on the species,

large blooms of algae may release toxins into the water such as those that cause the red tide phenomenon (Boyer and Jones, 1996; Rice University, 1998).

Color

“True” color in water results from the contact of water with decomposing organic matter (leaves, pine needles, wood, etc.), and is mainly caused by the tannins, humic and fulvic materials, and humates which leach from these materials. Suspended sediments, such as red clay alter water color, but this type of color is termed “apparent” color. As color may normally increase with pH, it is important to record pH when measuring color. Wastewaters, particularly those from textile industries and pulping operations can increase water color as well. Aside from appearance, natural water coloring materials are generally not considered harmful. However, chlorination of naturally colored waters can result in the formation of harmful constituents such as chloroform (Sawyer and McCarty, 1978).

Conductivity

Conductivity is a measure of the ability of water to conduct an electrical current and is used to approximate salinity and total dissolved solids (Lee, 1992).

Dissolved Oxygen (DO)

It is commonly understood that most organisms depend on oxygen in some form. The solubility of oxygen or the amount of this gas that can be dissolved in water depends directly on the temperature and salinity of the water. Oxygen is less soluble in seawater than in freshwater, and is less soluble in warm than in cold water. Unpolluted water normally contains more oxygen than polluted water (Sawyer and McCarty, 1978). Municipal and industrial discharges, sewage leaks and overflows, and agricultural and urban stormwater runoff can deplete oxygen in surface waters. Aquatic plants produce oxygen through photosynthesis, and waters are aerated through movement such as wave action and surface ripples (Smith et al., 1994).

Fecal Coliform Bacteria

Fecal coliform bacteria are an important indicator of water quality because their presence indicates fecal contamination from warm-blooded animals. Such contamination in waters where people swim or harvest shellfish introduces serious potential risks of infection from disease causing organisms associated with fecal contamination (Smith et al., 1994). The acceptable limit for fecal coliform density in fresh and marine recreational waters is an average of 200 bacterial colonies/100 ml of water per month or that no more than 10% of samples exceed 400 colonies per 100 mls or no more than 800 colonies on any given day (FDEP, 1996b).

Nutrients (Total Nitrogen, Total Phosphorus)

Nitrogen is an important element in all living things, and is one of the nutrients essential to algal growth. Excess amounts of nitrogen in aquatic systems can lead to algal blooms. Phosphorus is another important nutrient in aquatic systems. It is usually the least available of all nutrients in freshwater systems, and because of this, it is termed a “limiting” nutrient with respect to algal growth. In marine environments, nitrogen is usually limiting. When phosphorus is available in larger quantities, algae increase such that light is blocked out and dissolved oxygen levels decrease, a detriment to animal life. This condition is known as eutrophication. Phosphorus sources include decomposing organic matter and phosphates from fertilizers and detergents. Sewage treatment discharges, industrial discharges, and agricultural and urban runoff are some point and non-point sources of these nutrients (Smith et al., 1994).

pH

The term for expressing the intensity, strength, or activity of hydrogen ions in an aqueous solution is pH. The pH measurement scale is expressed as a negative logarithm, where the lower the pH value, the more acidic a substance. The scale ranges from 0 to 14, with 0 the most acidic, 14 the most alkaline, and 7 being neutral (Sawyer and McCarty, 1978). Increased acidity in freshwater systems can upset the balance between plant and animal life, and many fish species cannot tolerate a pH below 5.0 (Lehninger, 1982). Estuarine and marine systems tend to contain higher amounts of pH stabilizing compounds, such as carbonates, than freshwater, and are not as subject to changes in pH as are freshwater systems (Lerman, 1986).

Salinity

Salinity is defined as the total amount of dissolved inorganic ionic material in water and is used primarily to reflect the salt content of water (Lerman, 1986). In estuaries, salinity can be an indicator of circulation, as well as certain aspects of the ecology. In fresh surface and ground waters, high salinity can be an indicator of saltwater intrusion into the aquifer. Salinity can be determined by measuring the electrical conductivity or by determining the degree of light refraction of water with a refractometer. Salinity is generally expressed in parts per thousand (ppt) (Rice University).

Total Suspended Solids (TSS)

Suspended solids are small particles floating in the water column usually consisting of sediments, organic matter, or plankton. The dry weight of these particles after filtration represents the total amount of suspended solids. Materials small enough to pass through the filter are the total dissolved solids and often include constituents such as ions of iron, chloride, sodium, sulfate, and others. There is a direct relationship between suspended solids and turbidity (Rice University, 1998).

Turbidity

Turbidity is the amount of suspended matter in water that interferes with the passage of light and visibility. Origins are organic and inorganic materials from soil, domestic and industrial wastewater, and runoff. Bacteria in the water feed on organic material, multiply, in turn supporting the growth of other microorganisms, thus further increasing turbidity. Nutrients such as phosphorus and nitrogen stimulate the growth of algae, another contributing factor to turbidity. Turbidity in domestic water drinking water supplies, e.g. East Caloosahatchee, can be difficult and costly to filter. High turbidity is often associated with wastewater pollution. Further, disease organisms can be shielded within suspended particles and be protected from disinfectant (Sawyer and McCarty, 1978).

1.2. Classification of Surface Waters and Designated Use

According to Florida Surface Water-quality Standards (F.A.C. 62-302), all surface waters in Florida are classified by a usage designation. These designations categorize the intended use of surface waters for specific water bodies within the state of Florida and are identified as follows:

Class I:
Potable water supplies

Class II:
Shellfish propagation or harvesting

Class III:
Recreation, propagation, and maintenance of a healthy, well-balanced, population of fish and wildlife

Class IV:
Agricultural water supplies

Class V:
Navigation, utility, and industrial use

Class I has the most stringent water-quality requirements, and Class V has the least. Classification by use does not preclude other types of use of a certain water body. Most state waters are classified as Class III unless otherwise stated in F.A.C. 62-302. Additional classification titles may be assigned to Class I, II, and III waters such as Outstanding Florida Waters (OFW), or Outstanding National Resource Water (ONRW). Outstanding Florida Waters are “deemed worthy” of special protection because of their natural attributes. Some examples of Outstanding Florida Waters may be waters in national parks, preserves, memorials, wildlife refuges, and wilderness areas. Other examples include waters in the state park system, waters on conservation lands obtained by donation through various state programs such as the Conservation and Recreation Lands (CARL) program or the Florida Scenic and Wild Rivers program, and waters in aquatic preserves. Outstanding National Resource Waters are of “such recreational or ecological significance that water quality should be protected under all circumstances” (FDEP, 1996b). No Outstanding National Waters occur within the study area, but the Everglades National Park, part of which lies in Collier County, is one of two such waters in the state. **Table 1** lists the classification of waters within Collier and Lee County. Water-quality criteria for selected parameters for Class I, II, and III waters are presented in **Table 2**.

TABLE 1. CLASS I AND CLASS II WATERS OF COLLIER AND LEE COUNTY. ALL OTHER WATER BODIES WITHIN COLLIER AND LEE COUNTY ARE DESIGNATED CLASS III

Collier County			**Lee County**		
Class I	**Class II**	**OFW**	**Class I**	**Class II**	**OFW**
None	Cocohatchee River	Waters within Florida Panther Wildlife Refuge	Caloosahatchee River from east Lee County line to Structure 79	Charlotte Harbor	Waters within Caloosahatchee Wildlife Refuge
	Connecting waterways from Wiggins Pass south to Outer Doctors Bay	Waters within Collier-Seminole State Park		Matanzas Pass, Hurricane Bay, and Peckney Bay	Waters within J.N. “Ding” Darling Wildlife Refuge
	Dollar Bay	Delnor-Wiggins Pass State Recreation Area		Matlacha Pass: Charlotte Harbor to San Carlos Bay	Waters within Matlacha Pass Wildlife Refuge
	Inner and Outer Clam Bay	Waters within Fahkahatchee Strand State Preserve		Pine Island Sound: Charlotte Harbor to San Carlos Bay	Waters within Pine Island Wildlife Refuge
	Little Hickory Bay	Barefoot Beach		San Carlos Bay from Point Ybel to Bodwitch Point to Punta Blanca Creek to Big Shell Island to Pine Island Sound	Waters within Cayo Costa State Park
	Tidal Bays and Passes: Naples Bay south and east through Rookery Bay and Ten Thousand Islands to Monroe County Line	Rookery Bay: Aquatic Preserve, Conservation Program, and National Estuarine Research Reserve			Waters within Gasparilla State Recreation Area
	Wiggins Pass	Waters within the Save Our Everglades Program			Waters within Lovers Key State Recreation Area

(Continued)

TABLE 1 (continued).

Collier County			Lee County		
Class I	**Class II**	**OFW**	**Class I**	**Class II**	**OFW**
		Cape Romano-Ten Thousand Islands Aquatic Preserve			Waters within Koreshan State Historic Site
		Waters within Big Cypress National Preserve			Estero Bay: Conservation Program Area, Aquatic Preserve
					Josslyn Island
					Cape Romano-Ten Thousand Islands Aquatic Preserve
					Gasparilla Sound-Charlotte Harbor Aquatic Preserve
					Matlacha Pass Aquatic Preserve
					Pine Island Sound Aquatic Preserve
					Estero Bay tributaries: Hendry Creek, Estero River, Spring Creek, and Imperial River
					Wiggins Pass Estuarine Area and Cocohatchee River System

Source: FDEP, 1996b

TABLE 2. WATER-QUALITY CRITERIA FOR CLASS I, II, AND III WATERS

Parameter	Units	Class I	Class II	Class III	
				Fresh	**Marine**
Turbidity	NTU	≤29 above background	≤29 above background	≤29 above background	≤29 above background
Dissolved Solids	mg/L	≤500 monthly average, ≤1000 maximum	None	None	None
PH	pH units	No change more than one unit above or below background	No more than one unit change for coastal waters or 0.2 unit change for open waters	No more than one unit change above or below background	No more than one unit change for coastal waters or 0.2 unit change for open waters
Chlorides	mg/L	≤250	No increase >10% above background	None	No increase >10% above background
Fluorides	mg/L	≤1.5	≤1.5	≤10.0	≤5.0
Conductivity	Micromho	No increase above 50% of background or 1275	None	No increase above 50% of background or 1275	None
Dissolved Oxygen	mg/L	Not less than 5.0	No average less than 5.0 and never less than 4.0	Not less than 5.0	No average less than 5.0 and never less than 4.0
BOD	mg/L	No increase such that DO drops below limit for any class			
Nutrients: Total Phosphorus, Total Nitrogen		No alteration in nutrients such that an imbalance in natural populations of aquatic flora or fauna results			
Total Coliform	#/100 ml	≤2,400 in any one sample	No more than 10% of samples exceed 230	≤2,400 in any one sample	≤2,400 in any one sample
Fecal Coliform	#/100 ml	≤800 in any one sample	≤800 in any one sample	≤800 in any one sample	≤800 in any one sample
Copper	µg/L	≤(.8545[ln hardness] – 1.465)	≤2.9	≤(.8545[ln hardness] – 1.465)	≤2.9
Iron	mg/L	≤0.3	≤0.3	≤1.0	≤0.3
Lead	µg/L	(1.273[ln hardness] – 4. 705)	≤5.6	(1.273[ln hardness] – 4. 705)	≤5.6
Zinc	µg/L	(0.8473[ln hardness] + 0.7614)	≤86	(0.8473[ln hardness] + 0.7614)	≤86
Mercury	µg/L	≤0.012	≤0.025	≤0.012	≤0.025

Source: FDEP, 1996b

1.3. Assessing Water Quality Through Indices

Streams, lakes and estuaries are evaluated by the Florida Department of Environmental Protection (FDEP) using two indices that combine data from selected water-quality parameters into single numeric values. Two indices are used because streams typically are flowing, and lakes and estuaries are more static. Normal conditions for one system may not be so for the other. The two indices are the United States Environmental Protection Agency (USEPA)-developed Water-Quality Index (WQI) for streams modified by the FDEP to fit Florida streams and the FDEP Trophic State Index (TSI). For this study, the FDEP WQI was further modified using data solely from south Florida waters.

FDEP: WQI

To assess water quality in streams, a Florida WQI was developed based on measurements of six categories: clarity, dissolved oxygen, oxygen-demanding substances, bacteria, nutrients, and biological diversity. Some categories have sub-categories. The yearly average data collected for streams is converted into percentile values ranging from 0 to 99 (**Table 3**). WQI values for a particular stream correspond to the percentile distribution of all Florida surface water-quality data. The 70th percentile level is used by FDEP to identify particular problem parameters and is termed the “screening level”. Data from STORET surface water locations from 1980 to 1995 were used to determine percentile distributions for various water-quality parameters. The overall WQI is an average of the six main categories. As an additional qualitative assessment measure, Good, Fair, and Poor water-quality data ratings were developed and assigned to water bodies that conformed to USEPA’s WQI for Florida data. Good water quality ranged 0 to less than 45; fair water quality ranged from 45 to less than 60; and poor water quality ranged from 60 to 99 (FDEP, 1996a). Over time, changes in water quality become evident through comparisons of yearly average WQIs. Much of the discussion within this report reflect data extracted from the FDEP’s 305b report (WQIs: Good, Fair, Poor) as well as valuable studies conducted by the water management district, universities, counties, and private organizations.

Study Area: Water-Quality Index

To evaluate more recent and geographically specific water-quality data available within the study area, supplemental data were gathered (including STORET) through June 1998 from various sources and water-quality indices were revisited. In a nearly identical manner, water-quality indices were again based on measurements of six water-quality categories: clarity, dissolved oxygen, oxygen-demanding substances, bacteria, nutrients, and biological diversity. To assess historical and current water-quality trends for the study area surface waters, WQIs were recalculated for the following time periods: 1970-1980, 1980-1990, and 1990-1998. Similarly, annual average data collected for surface waters were converted into values ranging from 0 to 99 (**Table 4**). Recognizing the potential geographic water-quality differences of South Florida, WQI values correspond to the percentile distribution of only South Florida water-quality data. The WQ data that was used to create a South Florida distribution was that of the HUCs that extended south of Lake Okeechobee. The qualitative assessments of Good, Fair, and Poor water quality were not assigned to these WQI’s, as these values were developed solely as a measure to compare potential changes in water quality with future land use alternatives.

TABLE 3. FDEP'S FLORIDA WATER-QUALITY INDEX CRITERIA (percentile distribution of STORET data)

Parameter			**Best Quality**				**Median Value**		**Worst Quality**	
	Unit	10%	20%	30%	40%	50%	60%	**70%***	80%	90%
Category: Water Clarity										
Turbidity	NTU	1.50	3.00	4.00	4.50	5.20	8.80	12.20	16.50	21.00
Total Suspended Solids	mg/L	2.00	3.00	4.00	5.50	6.50	9.50	12.50	18.00	26.50
Category: Dissolved Oxygen										
Dissolved Oxygen	mg/L	8.00	7.30	6.70	6.30	5.80	5.30	4.80	4.00	3.10
Category: Oxygen Demand										
Biochemical Oxygen Demand	mg/L	0.80	1.00	1.10	1.30	1.50	1.90	2.30	3.30	5.10
Chemical Oxygen Demand	mg/L	16.00	24.00	32.00	38.00	46.00	58.00	72.00	102.00	146.00
Total Organic Carbon	mg/L	5.00	7.00	9.50	12.00	14.00	17.50	21.00	27.50	37.00
Category: Nutrients										
Total Nitrogen	mg/L as N	0.55	0.75	0.90	1.00	1.20	1.40	1.60	2.00	2.70
Nitrate plus nitrite	mg/L as N	0.01	0.03	0.05	0.07	0.10	0.14	0.20	0.32	0.64
Total Phosphorus	mg/L as P	0.02	0.03	0.05	0.07	0.09	0.16	0.24	0.46	0.89
Category: Bacteria										
Total Coliform	#/100/Ml	100.0	250.0	250.0	425.0	600.0	1100.0	1600.0	3700.0	7600.0
Fecal Coliform	#/100/mL 2	10.0	20.0	35.0	55.0	75.0	135.0	190.0	470.0	960.0
Category: Biological Diversity										
Diversity Index—Natural Substrate	Index	3.50	3.10	2.80	2.60	2.40	2.15	1.95	1.50	1.20
Diversity Index—Artificial Substrate	Index	3.55	3.35	3.20	3.05	2.90	2.65	2.40	1.95	1.35
Beck's Biotic Index	Index	32.00	28.00	23.00	18.50	14.00	11.00	8.00	5.50	3.50

*Screening level

TABLE 4. SOUTH FLORIDA WATER-QUALITY INDEX CRITERIA (percentile distribution of data)

Parameter			**Best Quality**			**Median Value**			**Worst Quality**
	Unit	10%	20%	30%	40%	50%	60%	70%	80%	90%
Category: Water Clarity										
Turbidity	NTU	1.0	1.60	2.00	2.60	3.00	4.00	5.00	6.80	10.30
Total Suspended Solids	Mg/L	na	Na	na	na	na	na	na	na	na
Category: Dissolved Oxygen										
Dissolved Oxygen	Mg/L	8.70	7.90	7.20	6.70	6.10	5.50	4.80	3.90	2.50
Category: Oxygen Demand										
Biochemical Oxygen Demand	Mg/L	0.80	1.00	1.20	1.50	1.80	2.00	2.50	3.00	4.40
Chemical Oxygen Demand	Mg/L	25.85	36.70	42.60	46.30	51.05	55.75	61.00	68.45	81.25
Total Organic Carbon	Mg/L	na	Na	na	na	na	na	na	na	na
Category: Nutrients										
Total Nitrogen	Mg/L as N	0.59	0.82	1.02	1.20	1.39	1.59	1.84	2.22	3.12
Nitrate plus nitrite	Mg/L as N	na	Na	na	na	na	na	na	na	na
Total Phosphorus	Mg/L as P	0.01	0.03	0.04	0.06	0.09	0.14	0.22	0.38	0.74
Category: Bacteria										
Total Coliform	#/100/mL	4.00	18.00	79.00	100.00	200.00	400.00	900.00	1700.00	3100.00
Fecal Coliform	#/100/mL	2.00	5.00	10.00	30.00	69.00	100.00	120.00	300.00	920.00
Category: Biological Diversity										
Chlorophyll a	µg/L	1.74	3.10	4.77	6.84	9.60	13.20	18.74	27.20	43.30
Diversity Index—Natural Substrate	Index	na	Na	na	na	na	na	na	na	na
Diversity Index—Artificial Substrate	Index	na	Na	na	na	na	na	na	na	na
Beck's Biotic Index	Index	na	Na	na	na	na	na	na	na	na

na - not available

Trophic State Index
The Florida TSI is nutrient based in its approach. Lakes and estuaries are classified according to analysis of chlorophyll levels and nitrogen, and phosphorus concentrations. A ten unit change in the index represents a doubling or halving of algal biomass. Data from 313 Florida lakes were used to develop the lake criteria (FDEP, 1996a).

1.4. The Watershed Unit

The watershed is the hydrologic unit which was selected for this study to analyze water-quality impacts that may potentially result from changes in land use; primarily since water quality is influenced by many factors occurring throughout the surrounding watershed. By one definition, a watershed is “the land area that drains to a waterbody and affects its flow, water level, and loadings of pollutants” (USEPA, 1996). Within the study area, the very boundaries of the watersheds can be affected by the activities occurring within. This is largely due to the flat topography and the tendency for water to flow in sheets rather than through channels. Subtle changes in topography can cause directional changes in the sheet flow. Such changes have historically occurred within the study area as a result of development and wetland draining projects. In addition, man-made alterations such as drainage canals, dams, and other structures have impacted natural flow characteristics.

Multiple watershed boundaries have been developed by numerous agencies (USGS, SFWMD, and FDEP) in south Florida. To further complicate this issue, these watershed delineations have been dynamically changing through time, primarily a result of improved understanding of the watershed hydrology. Watershed boundaries within the study area include portions of the larger national watershed system (Caloosahatchee [HUC: 03090205] and Big Cypress Basin [HUC: 03090204]) as defined by the USGS, as well as the smaller hydrologic watersheds and basins as defined by the South Florida Water Management District (SFWMD) (**Figure 1**).

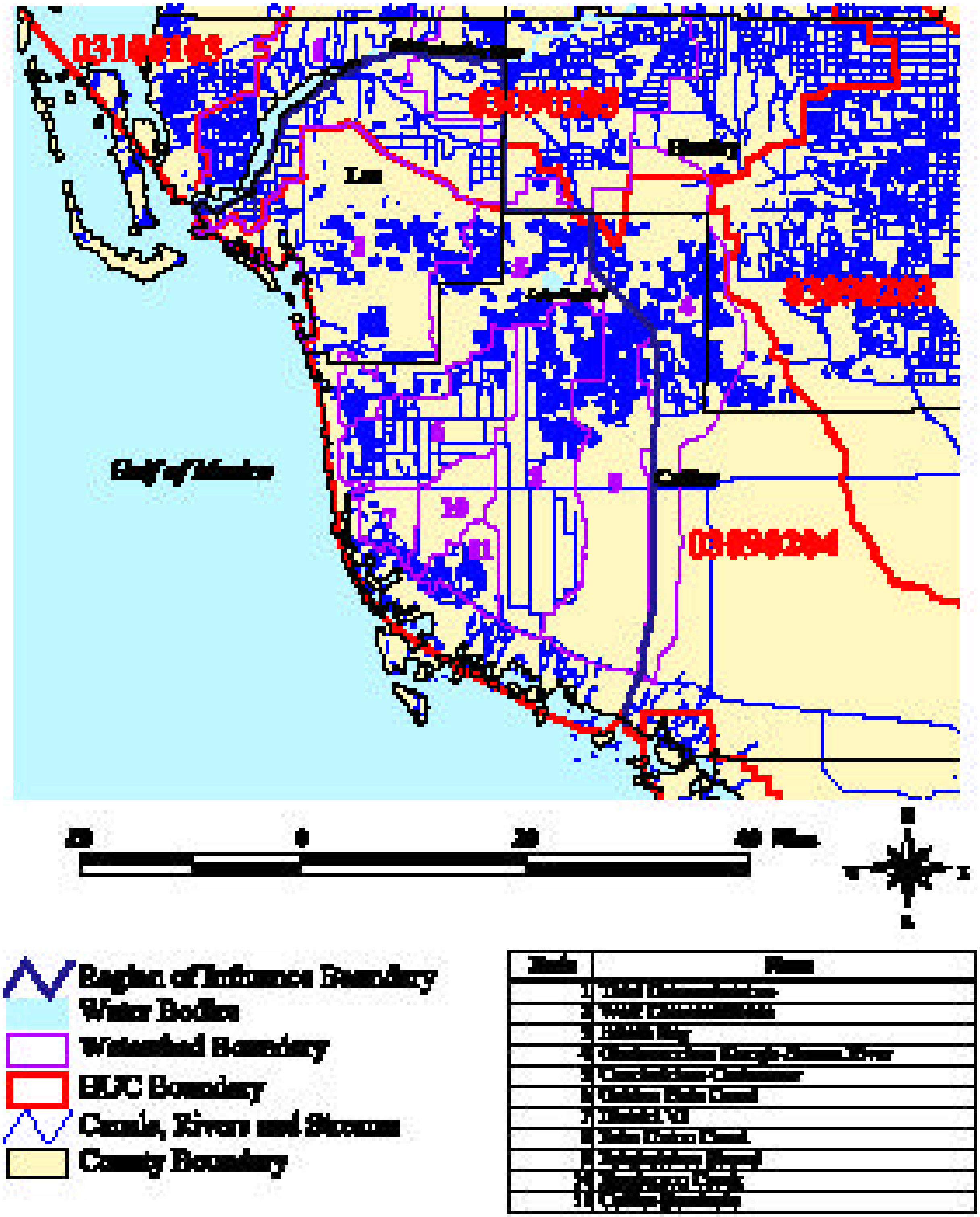


Figure 1. USGS and SFWMD Watersheds and Basins within the Study Area.

2.0 SURFACE WATERS

This section describes surface water quality as defined by physical and biological parameters, flow characteristics, pollutants, nutrients, and if known, biological indicators. The descriptions of water quality are largely based on STORET data summaries for individual watersheds within the larger study area watersheds. STORET is an Environmental Protection Agency (EPA) database of water-quality information collected by numerous agencies. Other water-quality studies were consulted as well (CDM, Inc., 1995; Gibson, 1997). Geography, topography, rainfall, evaporation, man-made alterations within the watershed such as hydrographic modifications (drainage canals, dams), development, and agriculture affect the quality of water. EPA and FDEP use STORET data to assess water-quality trends in watersheds by condensing certain parameters into one of two indices thereby facilitating year to year comparisons. Non-point source pollution, contaminant information, and exceedences of water-quality standards are also evaluated for trend determination. In the following sections, water quality of rivers, creeks, bays, canals, and swamps will be discussed for the three watersheds of interest to this study (**Table 5**).

TABLE 5. WATERSHEDS AND RECEIVING WATERS OF THE STUDY AREA

WATERSHED	DRAINAGE BASIN	RECEIVING WATER BODY	ULTIMATE ENDPOINT
Caloosahatchee Watershed	Tidal Caloosahatchee Basin	Tidal Caloosahatchee River	San Carlos Bay
	West Caloosahatchee Basin	West Caloosahatchee River	West Caloosahatchee River
Estero-Imperial Watershed	Estero Bay Basin	Estero River, Spring Creek	Estero Bay
	Imperial River Basin	Imperial River	Estero Bay
Big Cypress/West Collier Watershed	Corkscrew-Cocohatchee River Basin	Cocohatchee River, Corkscrew Swamp	Wiggins Pass/Gulf of Mexico
	Golden Gate Canal Basin	Golden Gate Canal	Naples Bay
	District VI Basin	Lely Canal	Gulf of Mexico
	Fahka-Union Canal Basin	Fahka-Union Canal	Fahka-Union Bay
	Henderson Creek Basin	Henderson Creek	Rookery Bay
	Collier-Seminole Basin	CR92 Canal	Gullivan Bay
	Fahkahatchee Strand Basin	Fahkahatchee Strand	Ten-Thousand Islands

For purposes of description and analyses, the study area watersheds have been identified as the Caloosahatchee, the Estero-Imperial Integrated, and the Big Cypress/West Collier, with various associated watershed basins as indicated in **Table 5**. Introductory information on the physical setting, surrounding land use, natural habitats, and physical characteristics of the various watershed systems have been provided to better assess historic and current water quality within the study area.

2.1 Caloosahatchee Watershed

The study area (**Figure 2**) incorporates portions of the Tidal Caloosahatchee and West Caloosahatchee watershed basins and sections of the Caloosahatchee River. The East Caloosahatchee River is also discussed since it drains into the study area impacting the water quality of the western and tidal sections of the Caloosahatchee.

The East and West portions of the freshwater segment of Caloosahatchee River have been restructured into a canal known as C-43. There are about 60 tributaries of varying water quality with respect to FDEP indices within the Caloosahatchee River watershed.

Physical Description

To accommodate navigation, flood control, and land reclamation needs, the Caloosahatchee River has been radically altered from its natural state. One of the most dramatic changes was the dredging that connected the Caloosahatchee to Lake Okeechobee in 1881, in order to lower the water level of Lake Okeechobee. In 1882, the channelization of the lower reaches of the river began. Due to intensive canal construction by 1910, shallow draft navigation from the Gulf of Mexico to the Atlantic Ocean was possible. Canal locks at Moore Haven were completed in 1918, and the locks at Ortoona were completed in 1937. The W. P. Franklin Lock was completed in 1969, preventing saline water from flowing upstream of Olga (Kimes and Crocker, 1998).

The discharge from Lake Okeechobee can vary greatly depending upon water needs of the Everglades Agricultural Area and precipitation levels. The 2-in-10 dry year discharge to the river is 106 million cubic feet (cu.ft.) while the 2-in-10 wet year discharge to the river is 29.3 billion cu.ft. All of this water is in addition to that naturally occurring in the river.

In addition to the alteration of the main channel, many canals have been constructed along the banks of the river. These canals were constructed for both water supply and land reclamation in order to support the many agricultural communities along the river.

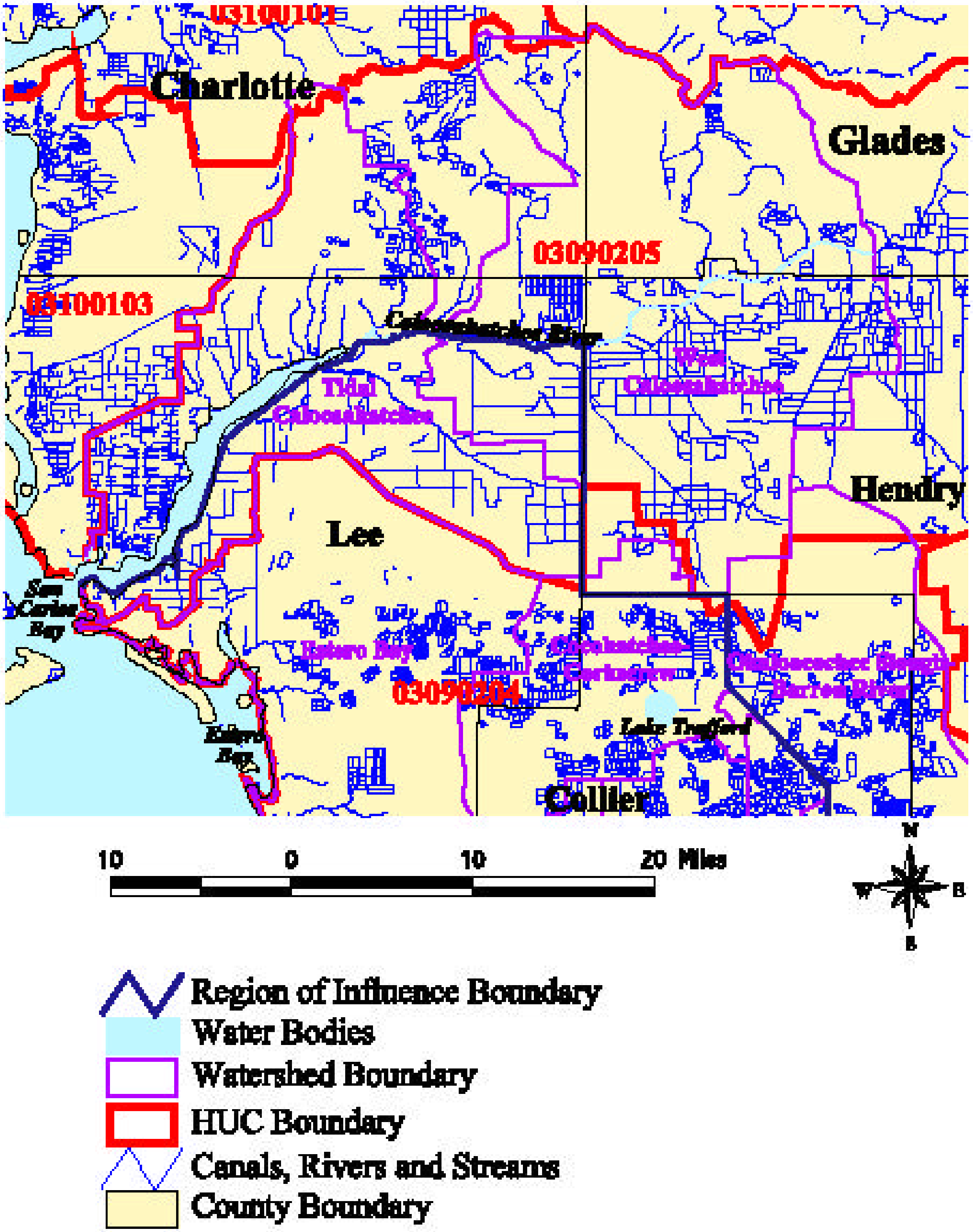


Figure 2. The Caloosahatchee watersheds and basins within the study area.

Land use within the Caloosahatchee watershed is dominated by rangeland and agriculture, particularly in the upper part of the basin (FDEP, 1996a). The major urban areas that occur along the tidal Caloosahatchee watershed basin are Ft. Myers, and across the river the large residential areas of Cape Coral and North Ft. Myers.

The primary habitat types of the Caloosahatchee watershed are pine flatwoods, dominated by slash pine (*Pinus ellioti* var. *densa*), cabbage palm (*Sabal palmetto*), and saw palmetto (*Serenoa repens*) (Drew and Schomer, 1984). Soils are predominantly Pamlico Formation, which consists of marine quartz sands and some hardened sandstone, and an estimated 25% Penholoway Formation, also consisting of marine quartz sands, but occurring at higher elevations than does the Pamlico (42 to 70 feet as opposed MSL to 25 feet) (Drew and Schomer, 1984).

Flow and stage height in the Caloosahatchee River is controlled by a series of locks. Agricultural practices and navigation channels have for many years dictated the patterns of surface water drainage. Canal, lock, and spillway construction and dredging have been occurring since the late 1800s, altering the natural watercourse of the Caloosahatchee River. Today, three primary locks function to regulate water level, usage, and saltwater intrusion. One, at Moore Haven, regulates Lake Okeechobee waters. The Ortoona Lock delineates the east river basin from the west and controls water on the adjoining land areas. The Franklin Lock at Ft. Myers prevents saltwater intrusion from the tidal Caloosahatchee River segment from proceeding eastward. The pattern and period of flow of the Caloosahatchee River is highly variable, based on demand. River flows are negative (from west to east) for a majority of the year, possibly resulting from heavy irrigation usage or losses to groundwater and/or evapotranspiration (Drew and Schomer, 1984).

Historical Description

Camp, Dresser and McKee (CDM), Inc. (1995) compared monitoring results of a 1993-94 study on the freshwater Caloosahatchee River with data from 1973-1980. Their conclusions are the basis for this historical description of water quality in the East and West Caloosahatchee River. CDM concluded that historical water quality differed from current water quality only with respect to small differences in nutrient concentrations. The report stated dissolved oxygen was historically low, as were suspended solids. Total phosphorus was comparable to other Florida water bodies, but nitrogen and chlorophyll a were generally high. Decreasing trends in total nitrogen were observed westward from Lake Okeechobee. Measurements of DO, pH, conductivity, and total phosphorus generally increased westward from Lake Okeechobee. FDEP nutrient indices indicated “poor” water quality but the WQI values are very close to “fair”. Algal blooms and high chlorophyll a measurements during the 1970s and 1980s were generally thought to result from agricultural runoff.

Historical information on the tidal Caloosahatchee from 1975-76 was available from Drew and Schomer (1984). Previous surveys indicated some aspects of water quality improved as one moved downstream away from the urbanized areas, such as DO. Seasonal water quality fluctuations have also been observed, with DO decreases in October and December. Chlorophyll a increased during the wet summer season as nutrient inputs increased from surface runoff and regulatory releases from Lake Okeechobee. Salinity measurements decreased with increases in freshwater flow. During winter, salinity increased, temperatures declined, and chlorophyll a decreased. DO stabilized in February, possibly allowing for an increase in oxygen demanding particulates to settle to the bottom, thus increasing the BOD values. During the 1970s, pollution was attributed to the following major sources: downstream flow from the Franklin Lock; Orange River inflow; the wastewater treatment plant (WWTP) effluent from the cities of Cape Coral and Fort Myers; and the residential development, Water Way Estates (Drew and Schomer, 1984).

Freshwater Systems

The freshwater systems of the Caloosahatchee River are discussed as the Eastern and Western Caloosahatchee (**Figure 2**). The Western Caloosahatchee begins at the point where Franklin Lock separates the tidally influenced waters from the upland waters. The Eastern Caloosahatchee begins at Ortoona Lock and extends to Lake Okeechobee. Before reaching Lake Okeechobee, the Eastern Caloosahatchee encounters Lake Hicpochee which is a small waterbody and historically (within the last twenty years) poor in water quality (FDEP, 1996a).

For data that has been extracted from STORET, water-quality parameters are expressed as annual averages and include physical and biological parameters, nutrients, and contaminants. Sediment quality data, if available, are also briefly discussed. Biological indicators such as important habitats, protected species, and pollution indicators may also be included under water quality. Known impaired usage of the basins is presented last. The majority of the current data discussion represent data collected from 1990 to 1995.

Eastern Caloosahatchee Basin

Eastern Caloosahatchee waters are usually above neutral in pH (>7), but tend towards low DO (<4.8 mg/L). CDM (1995) recorded seasonal lows from May through October. Water clarity is characterized by low turbidity and mostly low TSS, although color is higher than average (>71 PCUs) for Florida waters. Conductivity is above average for Florida waters (>335 micromhos), usually measuring above 500 for most stations in the Eastern Caloosahatchee (FDEP, 1996a). Ninemile Canal, which feeds into Lake Hicpochee, is of historically poor water quality having high color (120 PCUs), high conductivity (1195), and exceeding FDEP standards for DO (0.6 mg/L) (FDEP, 1996a).

The chlorophyll a content was high (32 μg/L), which is above 90% for other typical Florida waters. Average BOD concentrations (2.8 mg/L) also exceeded the screening level. Low diversity, pollution-tolerant species, and algal blooms have been reported from Ninemile Creek (FDEP, 1996a). Coliform bacteria levels are low in the Eastern

Caloosahatchee. However, Goodno Canal, a tributary with otherwise excellent water quality exceeds FDEP standards for fecal coliform.

The annual median total nitrogen was high (>1.89 mg/L) in the river and in the tributaries while phosphorus measured 0.08 mg/L (FDEP, 1996a). In 1993-94, total nitrogen values ranged from 1.1 to 2.2 mg/L and were highest from August through December. Total phosphorus was also highest during the summer with a range of 0.05 to 0.25 mg/L (CDM, 1995). Lake Hicpochee exhibits "poor" water quality due to excessive nutrient concentrations. The lake rated a TSI value of 74 due to high nitrogen (2.6 mg/L) and low DO. Ninemile Canal near Lake Hicpochee also exceeds the screening level for total nitrogen. The total nitrogen screening level is set at >1.6 mg/L as an exceedence.

Biological indicators are habitats, plants or animals that noticeably respond to environmental stresses such as changes in water quality. Loss of habitat acreage, changes in species diversity, and appearance of pollution tolerant species are examples of indicators. Habitat types within the East Caloosahatchee basin are dry prairie, pineland, freshwater marsh, and hammock (SFWMD, 1995). Agricultural runoff has been identified as a contributing to elevated nutrient concentrations in this area. (CDM, 1995).

West Caloosahatchee Basin

The western basin of the Caloosahatchee appears overall to have good water quality, but has been in a "degrading" trend for areas north of Townsend Canal (FDEP, 1996a). Reductions in pH and increased suspended solids are partially responsible for this observed trend. Chlorophyll a levels are improving and most other parameters are holding steady. Other areas of the basin rate "good" on the WQI scale.

Physical water-quality parameters throughout most of the basin are characterized by relatively neutral pH, DO readings mostly above 7.0 mg/L, good water clarity (i.e. low turbidity, low color, low TSS), and specific conductance between 500 and 700. No state standards for physical water quality are exceeded.

Biological oxygen demand is low (<2.3 mg/L) in the West Caloosahatchee and chlorophyll a ranges from 2-8 μg/L, an improvement over previous years.

Nutrients generally do not exceed screening levels, but at most basins are slightly higher than average for state waters. All waters in the West Caloosahatchee are rated "good" on the WQI scale.

Fecal and total coliform bacteria counts are low and do not exceed state standards. However, mercuryis present (FDEP, 1996a).

Approximately 41% of the West Caloosahatchee Basin are agricultural lands. Wetlands and pine forests make up 12% and 16%, respectively. Water quality impacts in this basin primarily results from agricultural runoff.

Table 6 provides a summary of the water quality in the West Caloosahatchee Basin by decade for several water-quality parameters. The data from which Table 6 was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a)

TABLE 6. SUMMARY OF WATER-QUALITY DATA FOR THE WEST CALOOSAHATCHEE BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	115	2.331	0.4	17	0.87	36	55	1.294	0	3.4	0	14.9	7	1.379	0.5	2.2	0	15.8
PH	pH	149	7.628	6.55	8.6	0		40	7.737	6.4	9.65	0		212	7.42	6.5	8.0	0	
Salinity	ppt	N/A						N/A						4	0	0	0	0	
Temperature	deg. C	189	25.05	12	33	0		46	25.6	17.6	3.4	0		212	23.99	14	31.0	0	
Chlorides	mg/L	184	85.12	35	990	1.6		45	121.1	26.1	360	15.6		210	49.218	12	162	0	
Fluorides	mg/L	35	0.224	0	0.31	0		31	0.247	0.17	0.43	0		N/A					
Conductivity	micromho	206	712.6	456	3850	1.5		51	798.1	390	1840	13.7		7	524.3	436	745	0	
DO	mg/L	142	6.419	2	11.4	12.7	46	33	6.325	2.2	11.9	18.2	47	212	4.507	2.2	8	69.34	70
BOD	mg/L	16	1.294	0.5	4.1	12.5	30.9	6	1.083	0.4	1.6	0	22.8	205	1.454	0.05	6.4	15.6	42.5
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	153	1.426	0.21	6.49	56.9	52	27	1.602	0.71	3.15	66.7	60.5	207	.561	.005	2.14	10.15	13
Tot-P	mg/L	164	0.069	0	0.36	52.4	42	37	0.112	0	10	37.8	54	212	0.116	.005	.95	39.6	58.5
Tot-C	mg/L	17	9.271	2.4	15	0		2	6.5	3	10	0		N/A					
Tot-coli	/ 100 ml	2	120	108	132	100	46.5	N/A						N/A					
Fecal-coli	/ 100 ml	1	54	54	54	0	48	4	144.5	30	292	25	72.5	2	545	390	700	100	86.1
Cu	ug/l	2	2	2	2	0		3	10	2	20	66.7		207	49.22	12.0	162.0	23.7	
Fe	ug/l	65	8.246	0.07	490	1.5		27	23.89	0.05	350	3.4		207	0.783	0.5	25.0	1.5	
Pb	ug/l	2	3	3	3	0		3	3.667	0	9	33.3		N/A					
Zn	ug/l	2	10	0	20	0		3	93.33	10	240	33.3		207	9.807	5.0	600	1.5	
Chlor a	ug/l	N/A						6	0.833	0	1	0		N/A					
WQI	%						41.4						42.9						50.0

Estuarine Systems

Tidal Caloosahatchee Basin

The tidal Caloosahatchee extends 28 miles from Franklin Lock to San Carlos Bay, and is so named because its waters are subject to tidal forces (Drew and Schomer, 1984). Tributaries of the tidal Caloosahatchee include Billy Creek, Whiskey Creek, Orange River, Hickey Creek, Roberts Canal, and Daughtrey Creek (**Figure 2**).

Physical water quality of the tidal Caloosahatchee is represented by pH, DO, conductivity, and water clarity. pH ranges slightly above neutral at 7.3 – 7.8. Except for Deep Lagoon and Manuel Branch, the average DO of the tidal Caloosahatchee and its tributaries ranges from 6.5 to 7.4. The overall DO trend is stable. Conductivity is usually above 10,000 micromhos, which is typical for estuarine waters. The freshwater tributaries are lower in conductivity. Orange River is the lowest at 508 micromhos. Water clarity varies along the river and tributaries. Deep Lagoon color was highest at 130 PCUs. A low of 33 PCUs occurs in the lower tidal basin. TSS are generally low at 1-10 mg/L. The highest TSS occurs in Manuel Branch. Turbidity is generally low ranging between 1.3-6.3. The most turbid waters occur in Manuel Branch. Overall physical chemistry is stable (FDEP, 1996a).

Measured values of key biological parameters indicate degraded water quality in parts of the tidal Caloosahatchee and tributaries. Biochemical oxygen demand (BOD), fecal coliform bacteria, and chlorophyll a levels exceeded the screening level at several locations. Fecal coliform bacteria were above state standards in 1992 at Manuel Branch (2195 MPN/100 ml) and Billy Creek (1839 MPN/100 mlChlorophyll a was high (27 μg/L) in Deep Lagoon and Billy Creek (57 μg/L). Due to the poor biological parameters, the tidal Caloosahatchee only partially meets its designated use as a Class 2 water, suitable for shellfish harvesting (FDEP, 1996a).

Nutrient measurements for total nitrogen and total phosphorus in the tidal Caloosahatchee were highest at or east of Ft. Myers. Total nitrogen levels were exceeded in the Caloosahatchee at a station adjacent to Ft. Myers with an average measurement of 1.64 mg/L in 1991. Total nitrogen exceedences (>1.22 mg/L) were also observed east of Ft. Myers in the Caloosahatchee, and at Billy Creek and Deep Lagoon. Averages for total phosphorus exceeded screening levels (i.e. were >0.07) in most cases, with the exception of Orange River. The nutrient status as indicated by the TSI is “poor” for Deep Lagoon, “poor” for Billy Creek, and “fair” but close to “poor” for the tidal Caloosahatchee. The WQI for freshwater streams and rivers rated Orange River water quality “good” (FDEP, 1996a). **Table 7** provides a summary of the water quality in the tidal Caloosahatchee Basin by decade for several water-quality parameters. The data from which **Table 7** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a). **Table 8** additionally provides a summary of the water quality by decade for various water-quality parameters of the Tidal Caloosahatchee Coastal Area (San Carlos Bay) region.

Important natural habitats remaining within the tidal Caloosahatchee drainage basin include mangrove, saltmarsh, tidal ponds, and according to one 1988 assessment, a small percentage of rare/unique slash pine/midstory oak (Godschalk and Associates, 1988). The West Indian manatee (*Trichechus manatus*) is a federally endangered species that frequents the tidal Caloosahatchee River and winters in the Orange River (FDEP, 1996a).

Increased nutrient loading occurs from wastewater inputs from Ft. Myers WWTPs, high nutrient waters from upriver, inputs from tributaries, and stormwater runoff from cities. Algal blooms occur frequently because of excess nutrients (FDEP, 1996a).

TABLE 7. SUMMARY OF WATER-QUALITY DATA FOR TIDAL CALOOSAHATCHEE BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	93	3.14	0.1	22	2.2	50.5	33	1.78	13	31.8	0	22.8	23	3.09	1	8.7	0	50.5
PH	pH	121	7.61	6.4	8.5	0		32	1.6	0.8	2.2	0		314	7.56	4.6	N/A	0	
Salinity	ppt	20	0.9	0	4	0		N/A				0		6	0	0	0	0	
Temperature	deg. C	460	26.96	2	38	0		12	25.98	13	31.8	0		316	24.94	7.6	38.7	0	
Chlorides	mg/L	60	785.5	38	6000	50		27	1234	36.5	8200	59.3		303	241.39	6	8.500	20.1	
Fluorides	mg/L	N/A						6	0.21	0.17	0.31	0		2	0.16	0.15	0.16	0	
Conductivity	micromho	82	4226	0.1	38500	42.7		43	3502	420	21500	53.5		24	5179	378	21800	37.5	
DO	mg/L	108	5.46	0.6	9.9	41.7	61.5	34	5.61	1.5	9.1	32.4	59	316	4.8	0.6	11	56	75.2
BOD	mg/L	80	1.65	0.3	5.7	17.5	45.5	7	1.6	0.8	2.2	0	42	303	1.58	0.05	8.0	18.5	42.8
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	25	1.46	0.38	5	52	54	24	1.83	0.42	3.56	62.5	51.3	295	1.12	0.005	26.0	29.2	42
Tot-P	mg/L	90	0.21	0	2.37	78.9	69	32	0.11	0.01	0.8	46.9	54	316	0.20	0.005	1.96	54.1	69.5
Tot-C	mg/L	26	12.35	8	19.7	0		22	12.57	9.3	18.5	0		N/A					
Tot-coli	/ 100 ml	28	21663	10	99990	64.3	97.7	N/A						2	270	270	270	100	54.3
Fecal-coli	/ 100 ml	32	15676	2	99990	21.9	100	5	88.6	28	195	20	53.4	18	703.8	10	3505	55.6	88.1
Cu	ug/l	N/A						N/A						292	5.19	0.5	130	60.3	
Fe	ug/l	4	0.4	0.22	0.64	0		5	85.27	0.12	425	20						5.8	
Pb	ug/l	N/A						N/A						292	3.52	0.5	110		
Zn	ug/l	N/A						1	17	17	17	0		292	9.28	5.0	80	1.0	
Chlor a	ug/l	N/A						8	4.5	0	12	0	29	7	15.27	1	57.2	28.6	
WQI	%						63.5						46.0						59.1

TABLE 8. SUMMARY OF WATER-QUALITY DATA FOR THE TIDAL CALOOAHATCHEE COSTAL AREA (SAN CARLOS BAY)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	N/A						5	5.64	3.6	8	0		15	3.07	1.7	4.4	0	
PH	pH	7	7.82	7.41	8.1			5	8.1	7.9	8.2			68	8.13	7.15	9.18		
Salinity	ppt	N/A						N/A						16	30.44	15	36.3		
Temperature	deg. C	7	26.5	23	29.8			22	26.7	19.1	30.4			74	25.52	15.3	32.3		
Chlorides	mg/L	2	4525	1350	7700			22	16220.9	10000	20000			N/A					
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	7	36857.14	5000	50500			22	43480	29900	51900			15	47097.6	37434	54544		
DO	mg/L	5	6.33	5.3	8.8	0		18	6.62	5.6	8	0		65	6.71	1.5	8.6	4.6	
BOD	mg/L	2	1	0.1	1.9	0		N/A						N/A					
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						1	0.44	0.44	0.44		38.9	N/A					
Tot-P	mg/L	2	0.05	0.04	0.06	0		22	0.08	0.04	0.16	54.5	62	15	0.04	0.02	0.07	0	
Tot-C	mg/L	N/A						22	5.4	2.5	11			5	5.82	3.5	8.6	0	
Tot-coli	/ 100 ml	2	10	10	10	0		N/A											
Fecal-coli	/ 100 ml	2	10	10	10	0		N/A											
Cu	ug/l	N/A						3	1	1	1	0		N/A					
Fe	ug/l	N/A						2	210	210	210	0		N/A					
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						2	25	20	30	0		N/A					
Chlor a	ug/l	N/A						N/A						15	3.36	1	15.3	0	
TSI			TSI NOT CALCULATED										42				TSI NOT CALCULATED		

2.2. Estero-Imperial Integrated Watershed

Introduction

The Estero-Imperial Integrated Watershed is comprised of the Estero Bay Watershed and northern portions of the Big Cypress Watershed. The Caloosahatchee River Watershed to the north, the Golden Gate Canal Watershed to the south, and the Gulf of Mexico to the west border the area. Interstate 75 runs north to south through the westernmost portion of the Estero-Imperial Integrated Watershed and divides the more developed coastal areas from the less developed interior. Most of the watershed lies in Lee County with a small percentage located in Hendry County (**Figure 3**). The Estero and Imperial Rivers, and Spring Creek, though small, are the major tributaries within the Estero-Imperial Integrated watershed that drain into Estero Bay. Warm, slow moving, estuarine water bodies such as the Estero and Imperial Rivers have some naturally low water-quality characteristics such as low DO. Therefore, these may be more susceptible to water-quality impacts resulting from changes in land use.

Physical Description

Population centers include the towns of Bonita Springs and Immokalee with 13,600 and 14,120 persons, respectively (U.S. Department of Commerce, 1992). Bonita Springs is south of the Imperial River and above the Lee-Collier County border, and Immokalee is located along the eastern edge of the Estero-Imperial Integrated Watershed. Rapid growth is occurring in Bonita Springs where the population more than doubled from 1980 to 1990. Residential areas, cattle, and vegetable farms occupy the landscape, and except for the coastal areas, the population is low (FDEP, 1996a).

Native Estero River coastal habitats include abundant tidal wetlands consisting primarily of mangrove and some saltmarsh (Godschalk and Associates, 1988). Freshwater wetlands are dominated by sawgrass with patches of cypress or hardwoods (FDEP, 1996a). Palmetto prairie and pine flatwoods exist further upland. Rare and unique upland habitats include sand scrub and slash pine/midstory oak (Godschalk and Associates, 1988). Soils are mostly of the Pamlico formation, which are comprised of marine quartz sands and hardened sandstone (Drew and Schomer, 1984).

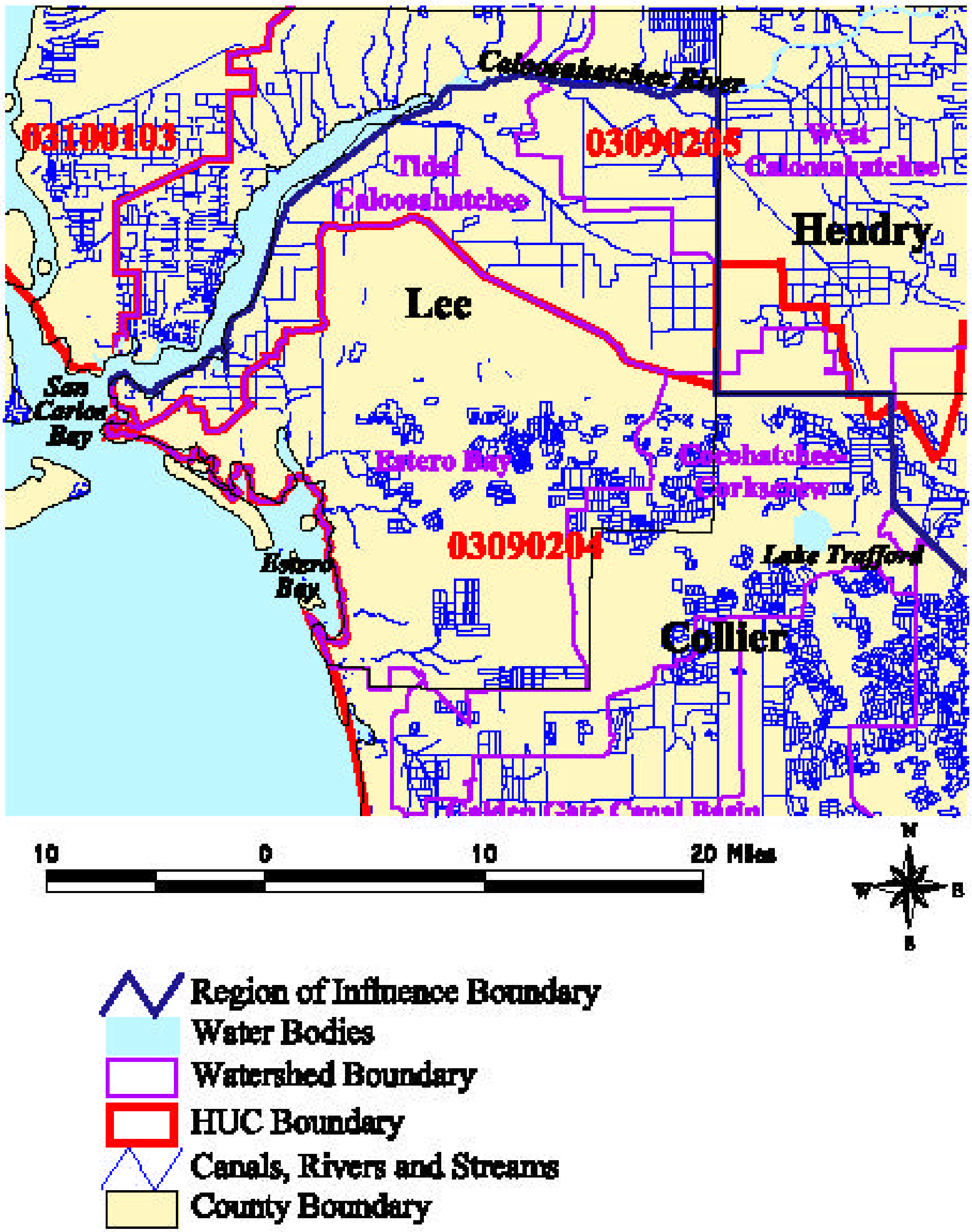


Figure 3. Estero-Imperial Watershed within the Study Area.

The Estero and Imperial Rivers, and Spring Creek provide minor freshwater flow into Estero Bay. The naturally low flow characteristics of these tributaries make Estero Bay notably susceptible to altered upland drainage water quality, volume, and seasonal inputs (Gissendanner, 1983). The topography of the watershed is relatively level thus accounting for the "sluggish" water movement in this part of the basin (FDEP, 1996a).

The highest freshwater inflows into Estero Bay occur in September with great variation in volume observed over the course of the year (Kenner and Brown, 1956; Drew and Schomer, 1984). At one time, tidally induced flows in Estero Bay exceeded the amount of freshwater inflow (Jones, 1980). Estero Bay tides are mixed and average about 0.54 m (1.75 ft) (Estevez et al., 1981), with velocities in the three major Bay-Gulf passes ranging from 0.64 m/s (ebb tide) to 1.52 m/s (flood tide). Flood tides can reach 1.07 m (3.5 ft) in height with volumes of 819 million cubic feet (measured for one pass in 1976) (Drew and Schomer, 1984). The low freshwater inflow into Estero Bay allows for generally high saline conditions year-round (around 34 ppt in the dry season), yet is high enough to prevent hypersaline conditions. Salinity seldom falls below 10 ppt even in the wet season (Tabb et al., 1974). Saltwater intrusion into local aquifers has resulted from inadequate recharge of groundwater. This occurrence has been attributed to surface hydrology modifications such as drainage canal construction. The construction of canals has increased surface water flow such that aquifers are not recharging, thereby allowing saltwater to infiltrate (Daltry and Burr, 1998). The Ten Mile Canal was constructed about 1920 to drain a 70 square mile area for agricultural uses. The canal directs this water into Mullock Creek a tributary of Estero Bay. Generally, this watershed does not have the extensive drainage network of the surrounding areas, but the construction of roads and other berms has still significantly altered the hydrology of the area. These changes have resulted in extensive flooding along the Imperial River. In addition, where flows from the Imperial and Estero Rivers into Estero Bay were once approximately equal, the proportional flow from the Estero River is now much less than that of the Imperial River (Johnson Engineering, Inc. et al., 1998). Surface water from the more interior areas of Flint Pen Strand and Bird Rookery Swamp are drained into Estero Bay and the Wiggins Pass/Cocohatchee River Estuarine System through the Imperial River, Spring Creek, and the Cocohatchee Canal (SFWMD, 1998a).

Historical Description

The Estero-Imperial Integrated Watershed was and in many areas still is typical of low, flat south Florida lands dominated by wetlands and characterized by slow, sheet-flow drainage patterns. In the past, the naturally dispersed water patterns served to distribute nutrients over broad areas of wetland vegetation. Thus, nutrient levels remained low in undrained areas of this watershed (Haag et al., 1996a). Seasonal fluctuations in flow due to rainfall created the necessary salinity regime in Estero Bay for good estuarine productivity. Estero Bay was recognized many years ago for it's natural qualities and became the state's first aquatic preserve in 1966 (Alleman in CHNEP, 1997). In 1983, the Estero Bay Aquatic Preserve Management Plan was implemented with emphasis placed on "enhancing the existing wilderness condition" (Gissendanner, 1983). Increasing development in the 1960s led to changes in the natural river systems around Estero Bay (Alleman in CHNEP, 1997). Changes in water quality and quantity have been observed. For example, the Imperial and Estero Rivers historically delivered less fresh water to Estero Bay. From 1940 to 1951, the maximum discharge from the Imperial River was 2,890 cu ft. Low flows were common and no flows occurred on occasion. Periodically, the rivers would flood (Kenner and Brown, 1956).

Freshwater Systems

Currently, physical water quality in the coastal areas of the Estero and Imperial Basins is characterized by clear water with neutral pH (7.1 to 7.3) but relatively high conductivity values (>16,000 micromhos). DO is slightly lower in the Imperial Basin (4.9 mg/L compared to 5.7 mg/L) than in the Estero Basin. Estero and Imperial Basin water clarity is characterized by low turbidity at <5.0 NTU/NTUs, generally low suspended solids at <10 mg/L, above average Secchi disc depths of 0.9 m to 1.5 m, and low color at 43 to 55 PCUs. Chloride measurements are not available, but conductivity indicates high dissolved mineral content in the Estero and Imperial Rivers. Biological parameters of chlorophyll a and 5-day biochemical oxygen demand (BOD-5) are of slightly lower quality in the Imperial River than in the Estero River. To clarify, BOD in the Imperial River is higher (2.4 mg/L over 1.4 mg/L) than in the Estero River; chlorophyll a is higher in the Imperial (12 µg/L over 2 µg/L), but generally, the two systems are comparable with respect to water quality. Water from the Estero and Imperial Rivers has a “residency time in the Bay of at least several days during the wet season” (Clark, 1987).

The TSI for the Estero and Imperial Rivers was evaluated as “fair” water quality by FDEP based on their nutrient status as determined by chlorophyll a, total nitrogen, and total phosphorus measurements. The TSIs for the Estero and Imperial Rivers were 52 and 53 respectively where scores below 50 rated “good” and scores above 59 rated poor. Spring Creek was also rated as 52 (FDEP, 1996a).

Metals have been detected from limited sampling of the waters of the Estero-Imperial Integrated Watershed (Table 9). In addition, elevated levels of cadmium, chromium, lead, mercury, and zinc have been found in the sediments of Estero Bay and River, Imperial River, and Spring Creek as recently as 1986 (Clark, 1987). In general, analysis of metals, pesticides and PCBs is lacking for the Estero-Imperial Watershed, with metals having only been sampled six times (with the exception of iron) within the last 30 years.

The Imperial River is classified in terms of usage as a Class 3 water body, suitable for wildlife and recreation. Due to low DO, nonpoint pollution, and conventional pollutants, water quality only partially supports the Imperial River for this type of use (FDEP, 1996a). Likewise, Estero River and Spring Creek are only in partial support of use: Spring Creek because of conventional pollutants and low DO, and Estero River for low DO and fecal coliform.

Important biological data useful in understanding and interpreting water quality are indicator species, species diversity information, and concentrations of chlorophyll a and fecal coliform bacteria. Indicator species may be sensitive to degraded water quality or they may be tolerant of degraded water quality. Certain species of polychaete and oligochaete worms become dominant under degraded water quality conditions. In south Florida wetlands, decreasing wading bird populations such as the endangered wood stork often reflect changes in hydrology. Species diversity will decline with declines in habitat quality and thus can be a potential water quality indicator. Increased chlorophyll a concentrations can indicate algal blooms and high nutrient levels, a condition which can eventually lead to eutrophication.

Table 9 provides a summary of the water quality in the Estero-Imperial Basin by decade for several water quality parameters. The data from which Table 9 was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a "good", "fair" or "poor" basis; as typically included in the Florida's 305b water quality report (FDEP, 1996a).

Estuarine Systems

Estero Bay

Recent STORET data were not available, but Estero Bay waters are described as shallow, turbid, and of "fair" quality. Nutrients at levels that exceed screening levels tend to drive water-quality ratings down. Consequently, this water body only partially meets its Class 3 use designation (FDEP, 1996a). Measurements were available for one station at Big Carlos Pass in the Bay and therefore may not be indicative of other areas of the Bay.

Water clarity, as indicated by turbidity, TSS, and color (8.5 NTU/NTUs, 28 mg/L, 25 PCUs, respectively) is low. Waters were well oxygenated with mean DO levels at 6.5 mg/L. Conductivity was 37800 micromhos (FDEP, 1996a).

Low chlorophyll a and low BOD were observed in the past. The mean for chlorophyll a was 8 mg/L, and the mean BOD was 1.6 mg/L.

Historically, Estero Bay rated a TSI of 50, even with phosphorus levels that exceeded FDEP screening criteria, which is still "fair" but approaching "good". Estero Bay phosphorus levels were above FDEP screening concentrations. Phosphorus screening levels are >0.07 mg/L and Estero Bay concentrations were 0.10 mg/L. Total nitrogen measured 0.81 mg/L, which is considered low for estuaries.

Estero Bay has not had a problem with high bacterial counts as indicated by the low total and fecal coliform analyses.

Some contamination by cadmium, chromium, lead, mercury, and zinc in Estero Bay sediments has been observed. Concentrations of pesticides and PCBs were below minimum detection limits (Clark, 1987).

Table 10 provides a summary of the water quality in the Estero/Imperial Basin Coastal Area (Estero Bay) by decade for several water-quality parameters. The data from which

Table 10 was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a).

TABLE 9. SUMMARY OF WATER-QUALITY DATA FOR THE ESTERO/IMPERIAL BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	87	2.69	0	10	0	41	245	2.9	0.2	62	2.0	44	536	2.38	.18	48	2.1	38.8
PH	pH	90	7.33	5.95	8.3	0		237	7.52	6.0	10.73	0		1979	7.41	4.9	9.55	0	
Salinity	Ppt	10	1.8	0	8	0		N/A						10	5.48	0	31	0	
Temperature	Deg. C	53	25.7	20.5	31	0		90	25.80	15.0	35	0		1979	24.86	10.9	44	0	
Chlorides	Mg/L	32	1819	7.7	22300	56.3		305	403.64	5.8	17251.7	17.7		1903	802.2	1.5	75,500	15.7	
Fluorides	Mg/L	N/A						3	0.12	0.1	0.17	0.0		N/A					
Conductivity	Micromho	79	6133	200	51000	36.7		339	1589	56	46700	16.2		540	3657.7	83	54,800	13.0	
DO	Mg/L	84	4.68	0.8	11.2	53.6	72	242	6.06	0	20	37.6	51.4	1979	4.11	0.3	18.1	70.7	74.9
BOD	Mg/L	44	1.86	0.1	4	25	51.8	33	2.05	0	6	21.2	61.5	1942	2.01	0	16.5	26.1	62.1
COD	Mg/L	N/A						N/A						N/A					
Tot-N	Mg/L	42	1.42	0.5	4.33	56.2	51.5	236	1.16	0.24	5.11	33.5	37.5	1885	1.12	0.005	192	26.2	42
Tot-P	mg/L	78	0.03	0	0.17	5.1	20	249	0.04	0	0.5	8.8	30	1909	0.12	0.005	2.96	40.0	58.5
Tot-C	mg/L	44	12.82	3.4	27.9	4.5	N/A	71	14.58	8.2	25.2	2.8		2	15.98	6.1	25.85	50.0	
Tot-coli	/ 100 ml	13	295.1	6	1120	61.5	54.9	N/A						7	95.36	1.5	420	28.6	30.9
Fecal-coli	/ 100 ml	21	154.3	1	720	28.6	72.6	4	114.3	68	205	25	69.4	198	119.3	4	2600	20.2	68.9
Cu	ug/l	N/A						15	9.31	0.47	10.0	93.3		19.4	4.93	.500	130	55.9	
Fe	ug/l	6	0.58	0.19	1.04	0		181	0.36	0.02	1.32	0		4	213.5	136	304	25.0	
Pb	ug/l	N/A						20	9.04	0.4	10	90.0		1895	2.47	0	220	6.4	
Zn	ug/l	N/A						15	13.86	10	37.9	0.0		1904	10.55	5	260	1.6	
Chlor a	ug/l	N/A						2	1	1	1	0.0		29	10.65	1.10	44.90	17.2	
WQI	%						52.5						52.0						55.2

TABLE 10. SUMMARY OF WATER-QUALITY DATA FOR THE ESTERO / IMPERIAL COASTAL AREA (ESTERO BAY)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU/NTU	93	8.06	1	45	13.5		38	12.98	2.6	65	26.3		2	5.9	2.6	9.2	0	
PH	pH	96	8.05	7.1	8.7			36	7.95	7	8.3			2	7.75	7.6	7.9		
Salinity	ppt	36	30.9	20	40			2	25.5	20	31			N/A					
Temperature	deg. C	95	24.98	13.25	32			38	24.7	11	31			2	.5	24	25		
Chlorides	mg/L	21	19245.62	18	23700	95.2		1	20.8	20.8	20.8			N/A					
Fluorides	mg/L	14	0.9	0.78	1.12	0.0		10	0.74	0.17	0.91			N/A					
Conductivity	micromho	68	41491.3	28	57000	95.6		32	40621.9	23000	50000	100		1	49000	49000	49000	100	
DO	mg/L	98	6.64	0.2	10.6	8.2		38	6.6	3.9	8.6	10.5		2	6.7	6.1	7.3	0	
BOD	mg/L	16	3.40	2.4	4.4	100		1	1.6	1.6	1.6	0		2	1.5	1.4	1.6	0	
COD	mg/L	1	0.29	0.29	0.29	0.0		N/A						N/A					
Tot-N	mg/L	1	0.06	0.06	0.06	0.0		N/A						62	1.38	0.86	1.95	69.4	
Tot-P	mg/L	55	0.06	0	0.23	25.5		16	0.12	0.05	0.29	68.8		65	0.03	0	0.1	1.5	
Tot-C	mg/L	57	5.65	0	16	0.0		10	5.4	3	11	0		N/A					
Tot-coli	/ 100 ml	55	7.3	0	68	0.0		10	13	2	40	0		N/A					
Fecal-coli	/ 100 ml	70	8.65	0	210	1.4		17	16.2	2	120	0		2	3	2	4	0	
Cu	ug/l	10	10.9	5	17	100		4	33.8	10	50	100		N/A					
Fe	ug/l	40	2757.3	50	100000	32.5		4	282.8	84	724	25		N/A					
Pb	ug/l	27	1309.8	0	35000	88.9		4	33.8	10	50	100		N/A					
Zn	ug/l	29	3588.9	30	100000	86.2		4	25.8	25	28	0		N/A					
Chlor a	ug/l	38	9.05	0	67	5.3		12	7.64	0.0	19.0	0		64	46.5	2.18	78	98.4	
TSI							23.8		TSI NOT CALCULATED										64.3

Decreases in important estuarine habitats such as marine grassbeds, saltmarsh, and oyster bars may indicate declining water-quality trends (Clark, 1987; Gissendanner, 1983). Species with protected status may also provide an indication of improved or degraded water quality. Some of these include the Atlantic green turtle, Atlantic hawksbill, Atlantic Ridley, leatherback, Atlantic loggerhead, wood stork, West Indian manatee, southeastern snowy plover, eastern brown pelican, bald eagle, southeastern kestrel, least tern, and mangrove fox squirrel (Gissendanner, 1983; Wood, 1994).

Nutrient inputs from agricultural runoff (fertilizers) are cited as the source of high phosphorus. Habitat alteration through possible destruction of forests and wetlands, water flow changes, and pollution are listed as other impairments to use (Alleman in CHNEP, 1997).

2.3. Big Cypress/West Collier Watershed

Physical Description

The physical description of the Big Cypress/West Collier watershed includes brief descriptions of land use, habitat, soils, and water flow characteristics.

The Big Cypress/West Collier Watershed portion of the study area is situated in Big Cypress preserve, an area of low flat lands of cypress trees, pine forests, and wet and dry prairies. Agriculture and urban are the main types of human land use. However, it should be noted that lands that are zoned as agricultural may in actuality be swamp. Major urban areas situated along the coastal area of the watershed are Naples, East Naples, North Naples, Naples Park, Marco Island, and Golden Gate. The single most conspicuous feature of the area is the expansive system of roads and canals constructed during the 1960s for the Golden Gate Estates (GGE) land development project. The Golden Gate Estate canals channel drainage from approximately 200,000 acres into the Gordon River, Naples Bay, and the Fahka Union Bay (U.S. COE, 1980). Impacts from the Golden Gate Canal include overdrainage of surface waters, lowering of groundwater levels, altered traditional drainage patterns, reduction of habitats, and declines in agriculture potential (U.S. COE, 1980). Thus, the existing condition of water quality in the rivers and bays is undoubtedly linked to the major hydrological changes that have occurred in the past. Historically, the Big Cypress Basin was dominated by sheet flow but several land reclamation projects starting at the beginning of the century have dramatically changed the hydrology. The majority of Collier County inside of the study area has been drained through the construction of canal networks. The first of such projects was the creation of the Tamiami Trail during the earlier part of the century. The GGE project had the largest impact on the hydrology of the area. This area consists of hundreds of miles of large canals that drain approximately 300 square miles. The construction of GGE has dramatically lowered the groundwater table and changed salinity regimes of coastal areas of the Big Cypress/West Collier watershed.

Soil types are Pamlico formation sands and marl deposits with peat. Marls are silty calcium carbonate deposits, often with shell fragments, formed from eroded limestone (Drew and Schomer, 1984).

Cocohatchee River, Naples Bay, Gordon River, Blackwater River, Fahka Union Bay, Fahkahatchee Bay, Marco Bay, and Rookery Bay are the major natural water bodies within the study area. Barron Canal, Golden Gate Canal, Cocohatchee River Canal, Fahka Union Canal, Gordon River Canal, and Henderson Creek Canal are the major artificial drainage systems within this watershed. Flow direction and areas drained by canals are dependent upon rainfall amount. For example, the Cocohatchee River Canal drains an area southwest of Lake Trafford during dry periods and may have no flow during very dry years. During the rainy season, the Cocohatchee River Canal along with Henderson Creek Canal serves to collect excess drainage from the Golden Gate area (**Figure 4**).

Fahka Union Canal collects drainage from a series of smaller canals and discharges into the Ten Thousands Islands area. The Golden Gate Canal and Gordon River drain into Naples Bay, the periphery of which is lined with an extensive network of finger canals and residential developments. The Barron River Canal, built as a source of fill to make roads, drain strands and sloughs of the Big Cypress National Preserve (Drew and Schomer, 1984).

Historical Description

Without pre-canal water-quality data, little can be said about the original water quality within the Big Cypress/West Collier Watershed. In addition, it is recognized that good water quality can exist within areas of severely altered hydrology. However, there are some basic factors to consider related to the channelization of wetlands. Canal construction, which began in the 1920s, undoubtedly led to increased drainage of freshwater from wetlands into the estuaries and a subsequent increase in dissolved minerals. Possible changes in salinity, sedimentation, turbidity, and nutrients likely resulted. In lieu of more detailed pre-canal water quality descriptions, STORET data from the 1980s provides a historical description of post-canal water quality of the Golden Gate Watershed for comparison with the present day. Physical water quality was characterized by neutral pHs, DO levels that were on the average low (>5.0) at stations sampled in Naples Bay, Barron River Canal, Blackwater River, Gordon River, and Gordon River Canal, and conductivity above >1275 in some of the freshwater bodies (Cocohatchee River, Blackwater River). BOD and chlorophyll a were high in the Gordon River Canal and in the Blackwater River. Fecal coliform counts were high (>190 MPN/100 ml) in the Gordon River. Water quality in the Fahka Union canal was excellent, rating a very low 16 on the WQI scale. Naples Bay rated “fair” in terms of nutrient conditions according to the FDEP TSI with a 53. In general, the areas along the Blackwater River have the worst water quality.

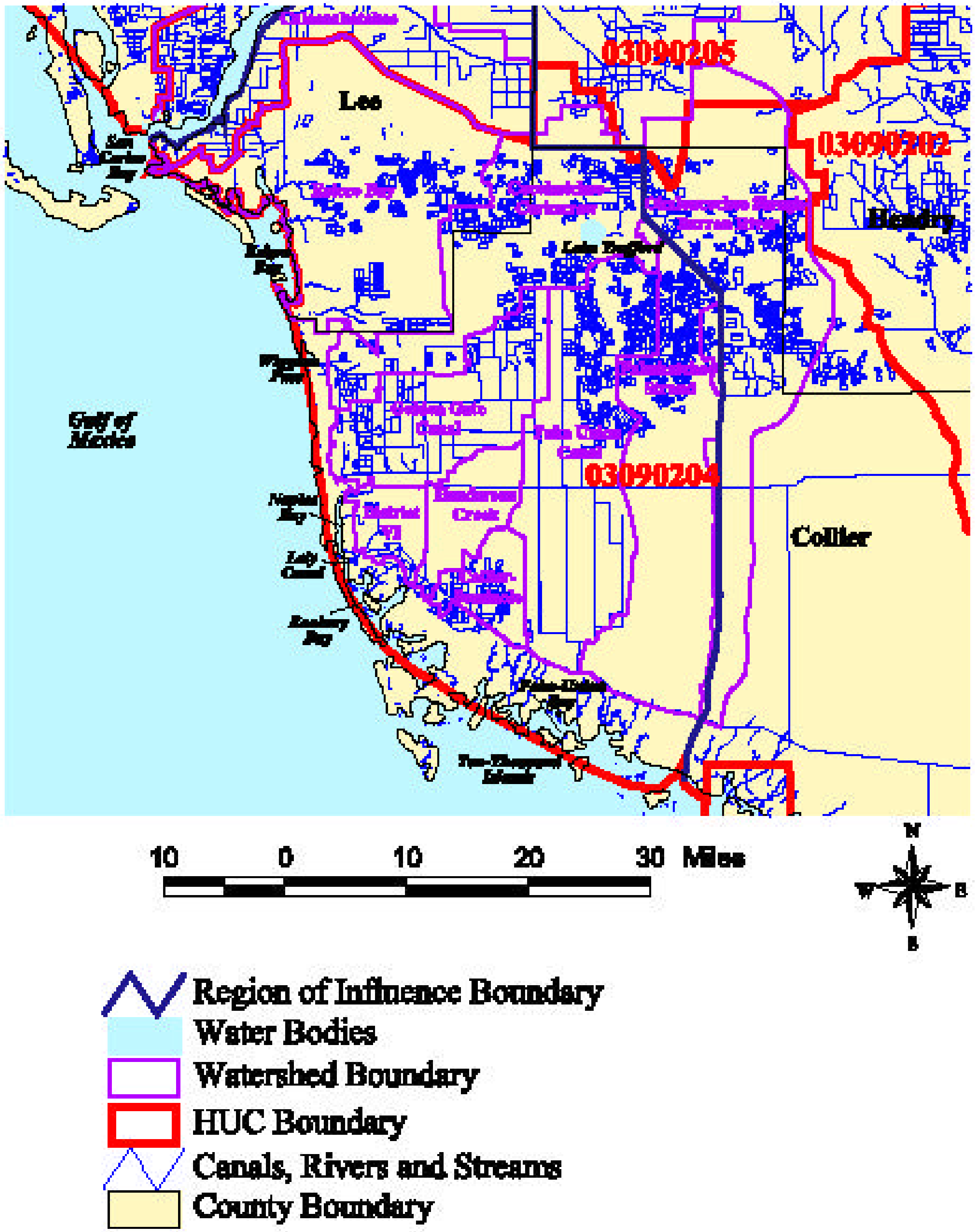


Figure 4. Big Cypress Basin Watershed within the Study Area.

Freshwater Systems

Corkscrew Swamp

Portions of Corkscrew Swamp are described as pristine due to its status as a National Audubon Society sanctuary. The Corkscrew Swamp Regional Ecosystem Watershed is a Southwest Florida Water Management District (SWFWMD) project that encompasses the sanctuary with goals to restore hydrologic conditions in impacted areas (Bird Rookery Swamp) and maintain flows and water quality in undisturbed areas of Corkscrew Swamp (SFWMD, 1998a). Lake Trafford, north of Corkscrew Swamp is of historically good to fair water quality that fully supports use designation as a Class 3 water.

Cocohatchee River

Current physical water quality of the Cocohatchee River is characterized relative to typical state waters by low turbidity (2.9-3.5 NTU/NTUs), low TSS (2 –10 mg/L), higher than average color (85 –100 PCUs), neutral pH, variable DO (3.2 to 7.0 mg/L), and variable conductivity (675 – 2650 micromhos (FDEP, 1996a). The low DO results from excessive aquatic vegetation in the canals using up more oxygen than what is produced through photosynthesis (Kirby et al., 1988).

Chlorophyll a levels were well below screening levels with a mean concentration of 5 µg/L. BOD was, at one location, higher than average for typical Florida waters but just shy of exceeding state criteria. BOD averaged between 1.6 and 2.0 for two stations in the Cocohatchee River. Total coliform bacteria levels were higher than average for state waters, and fecal coliform counts exceeded state standards with 2650 MPN/100 ml.

Nutrient levels are lower than average, with phosphorus and nitrogen levels below state screening levels. The WQI modified by FDEP from a similar EPA index, currently rates the river as “fair” with a rating of 48, and historically rates the Cocohatchee River canal as “good” with a rating of 33. Scores between 45 and 59 are classified as “fair”. Values below 45 are “good” and values above 59 are “poor”. Low DO (5.1 mg/L) and high fecal coliform counts (381 MPN/100 ml), averaged from two locations, drive the WQI rating for the Cocohatchee River down. The TSI for the Cocohatchee River also classified the river as “fair” with ratings of 50 and 58 for two sections. The Cocohatchee River is a Class 2 water, suitable for shellfish harvesting, which partially meets its designated use.

Cocohatchee River Canal

According to STORET data, the Cocohatchee River Canal has not been sampled since 1988. Therefore, a current account of water quality is not possible. Historical data collected from 1980 to 1988 provide the basis of the following description. The Cocohatchee River Canal is about 13 miles long and less than 5 feet deep with better water quality than its natural counterpart. Compared to other state waters, physical water quality is better than average for most state waters.

Biological data for the Cocohatchee River Canal are absent from STORET for 1980-1988. Therefore, no BOD, coliform, or chlorophyll a information is presented.

Nutrients are present in amounts higher than average for most estuaries, but do not exceed screening levels. Total nitrogen measured between 0.99 and 1.08 for two stations, and total phosphorus measured 0.03 for both stations.

No contaminants have been recently detected according to STORET data. However, the database compiled for this study indicate copper and zinc exceeded state standards in 23% and 14% of samples respectively from 1990-1998 (**Table 11**). Water quality is exhibiting a stable trend, and fully supports designated use for a Class 3 water body (FDEP, 1996a). Sediment quality information is not available for the Cocohatchee River Canal.

Table 11 provides a summary of the water quality in the Corkscrew/Cocohatchee Basin by decade for several water-quality parameters. The data from which **Table 11** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a).

Golden Gate Canal:

Current water-quality data were not available for the Golden Gate Canal from the STORET database. However, historical STORET water-quality data from 1980-1989 are available. Physical water quality in the 1980s was characterized by relatively low turbidity (3.5-4.3 NTU/NTUs), low TSS (2-3 mg/L), higher color content than average (50-99 PCUs), neutral pH, and low to moderate levels of DO (4.8-6.0 mg/L). Conductivity was higher than average for typical state waters (572-650 micromhos).

BOD exceeded screening levels with an average of 2.4 mg/L at one canal sample location. The screening level is 2.3 mg/L. One location was sampled for chlorophyll a and was higher than average for typical state waters with 19 µg/L. Fecal coliform bacteria were lower than average (55 MPN/100 ml).

Total nitrogen and total phosphorus were below their screening levels and overall were lower than average for other state waters. Total nitrogen ranged from 0.81-1.07 and total phosphorus ranged from 0.02-0.03 for three locations along the Golden Gate Canal. The WQI for the Golden Gate Canal ranged from 36 to 40, an indication of “good” water quality (FDEP, 1996a). Sediment quality information was not available.

Table 12 provides a summary of the water quality in the Golden Gate Canal Basin by decade for several water-quality parameters. The data from which Table 12 was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a). **Table 13** provides a summary of the water quality in the Golden Gate Canal Coastal Area by decade for several water-quality parameters.

TABLE 11. SUMMARY OF WATER-QUALITY DATA FOR THE CORKSCREW/COCOHATCHEE BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	81	6.37	1	75	8.6	79.7	271	4.7	0.3	127	3.0	66.5	38	12.81	0.6	70	31.6	92.5
PH	pH	119	7.57	4.6	10.25	0		280	7.38	2.5	9.1	0		37	7.09	6.4	8.5	0	
Salinity	ppt	3	1.17	0	2.5	0		3	12.1	1.1	31.0			N/A					
Temperature	deg. C	172	26.77	14	240	0		133	24.6	0.24	34	0		293	25.89	16.8	35.35	0	
Chlorides	mg/L	70	154.38	5.8	3400	4.3		277	374.54	9.2	18,300	19.1		129	906.14	2.03	21500	17.8	
Fluorides	mg/L	N/A						9	0.24	0.17	0.44	0		89	0.13	0.025	0.59	0	
Conductivity	micromho	150	1943.43	70	51000	8.7		282	1767.62	80	46000	17.4		38	3173.92	179	36400	13.2	
DO	mg/L	106	6.22	1.1	14.4	34.0	44	280	4.19	0.1	14.3	62.1	71	3.4	6.21	0.1	20	43.3	43.9
BOD	mg/L	63	2.19	0.2	8.6	38.1	64j	15	1.89	0.8	4.1	26.7	52	239	5.56	0.5	43.3	67.4	94
COD	mg/L	5	7.6	0	20	0	2.8	N/A						N/A					
Tot-N	mg/L	45	0.96	0.01	5.52	33.3	27	258	1.15	0.1	3.95	33.3	37	113	1.28	0.02	3.76	39.8	50
Tot-P	mg/L	89	.25	0	2.64	44.9	74	373	0.51	0	8.3	45.3	85.8	319	.57	.005	10.35	60.8	87.5
Tot-C	mg/L	35	16.34	7.1	70	17.1	N/A	53	15.63	9.8	23.5	3.8	N/A	5	24	18	30	25.9	N/A
Tot-coli	/ 100 ml	31	88.9	1	1056	25.8	30.9	19	1181.11	0	11,000	68.4	75.8	88	430.86	0.75	3250	76.5	61.2
Fecal-coli	/ 100 ml	42	30.7	0	600	2.4	40	14	64.21	0	360	7.1	49.5	13	308.77	10	2224	30.8	81
Cu	ug/l	2	1	0	2	0		5	5.73	0.05	25	20.0		22	6.06	0.5	90.75	22.7	
Fe	ug/l	9	276.92	0.24	1700	11.1		233	1.21	0.04	157	0		118	0.68	0.043	8.62	0	
Pb	ug/l	7	7.71	0	19	57.1		5	0.64	0	2	0		110	1.78	0.5	4.0	0	
Zn	ug/l	N/A						4	31.03	23.1	43.8	0		109	8.930.013	421	2.8	13.6	
Chlor a	ug/l	N/A						11	14.75	5	33	27.3		6	47.4	2	147.7	50	
WQI	%						48.6						62.7						74.1

TABLE 12. SUMMARY OF WATER-QUALITY DATA FOR THE GOLDEN GATES CANAL BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	227	8.47	0	140	10.6	86.2	372	4.41	0.3	101	2.7	65	2	2.35	2.2	2.5	0	36.5
pH	pH	248	7.67	6	79.5	0		278	7.44	2.3	8.93	0		279	7.32	6.43	8.69	0	
Salinity	ppt	5	3.8	0	11	0		N/A						157	11.22	0	39	0	
Temperature	deg. C	276	24.14	13.8	32.5	0		15	24.1	7.5	31	0		320	25.97	3.3	37.1	0	
Chlorides	mg/L	188	639.05	16	17000	11.7		344	185.67	4	8171.9	7.3		89	1523.6	3.0	17,200	20.2	
Fluorides	mg/L	N/A						3	0.17	0.17	0.17	0		89	0.15	0.025	0.52	0	
Conductivity	micromho	301	2003.58	61	41500	10.6		370	1181.06	170	29900	9.5		59	38488.39	700	64465	96.6	
DO	mg/L	237	4.65	0.2	14.4	55.7	72	284	4.49	0.4	9.9	61.6	74	316	5.54	0	15.8	41.1	65.5
BOD	mg/L	113	1.72	0	7.3	16.8	48.2	7	1.74	0.7	3.8	14.3	48.4	220	2.84	0.500	39.6	34.5	76.4
COD	mg/L	N/A						0	N/A	N/A	N/A	N/A		N/A					
Tot-N	mg/L	135	1.09	0.37	7.88	22.2	33.5	362	1.22	0.37	7.18	36.5	41	89	1.63	0.02	27.3	32.6	66.5
Tot-P	mg/L	188	0.04	0	0.75	8	26	368	0.04	0	0.34	9	26	265	0.06	0.005	0.45	20.8	40.5
Tot-C	mg/L	160	322.15	0	17000	19.4		79	17.8	10.4	33.2	20.3		132	15.35	1.7	58.0	18.9	
Tot-coli	/ 100 ml	125	5251.12	4	65000	84	28.1	N/A						100	303.9	18.0	1600	75.7	56.1
Fecal-coli	/ 100 ml	117	98.35	0	800	16.2	54.5	6	202	8	480	50	76.1	3	297.33	12	824	33.3	79.9
Cu	ug/l	84	5.91	0	20	64.3		7	1.91	0.06	6	28.6		55	3.46	0.01	300	30.9	
Fe	ug/l	129	855.13	0.23	4800	61.2		339	2.4	0.02	320	0.3		90	8.52	0.002	717	1.1	
Pb	ug/l	79	12.02	0	85	64.6		7	3.05	0.4	11	28.6		144	2.53	0.5	13.15	7.6	
Zn	ug/l	86	71.63	0	1700	16.3		5	33.28	21	55.7	0		144	272	0.002	77	0.7	
Chlor a	ug/l	N/A						7	9.173	3	34	14.3		2	7.2	2.4	12	0	
WQI	%						55.5						59.4						60.0

TABLE 13. SUMMARY OF WATER-QUALITY DATA FOR GOLDEN GATES CANAL COASTAL AREA

		1970-1980						1980-1990						1990-1998					
WQ Parameters	**Units**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**WQI**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**WQI**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**WQI**
Turbidity	NTU	N/A						N/A						N/A					
pH	pH	1	7.1	7.1	7.1			1	7.85	7.85	7.85			12	8.05	7.825	8.21		
Salinity	ppt	2	32.3	32.2	32.4			1	33.7	33.7	33.7			355	24.89	0.0	38.2		
Temperature	deg. C	3	24.87	23.9	26.0			1	25.0	25.0	25.0			356	26.08	13.5	35.00		
Chlorides	mg/L	N/A						N/A						N/A					
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	N/A						N/A						345	38710	0.0	66072	96.5	
DO	mg/L	3	5.5	1.4	8.1	33.3	60	1	4.5	4.5	4.5	100		345	5.12	0.0	12.8	34.3	66
BOD	mg/L	N/A						1	2.65	2.65	2.65	100		3	1.88	1.5	2.45	33.3	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						N/A					
Tot-P	mg/L	N/A						1	0.055	0.055	0.055			11	0.31	0.03	1.269	72.7	
Tot-C	mg/L	N/A						N/A						6	8.15	4.20	18.67	0.0	
Tot-coli	/ 100 ml	N/A						N/A						N/A					
Fecal-coli	/ 100 ml	N/A						N/A						N/A					
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	N/A						1	0.040	0.040	0.040			3	0.05	0.04	0.07	0.0	
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						N/A						N/A					
Chlor a	ug/l	N/A						N/A						N/A					
WQI	%																		

Henderson Creek/Blackwater River

Henderson Creek appears to be of good water quality until it intersects Blackwater River, of historically fair to poor water quality, depending on which index is applied. The TSI rated Blackwater River a 61, which is "poor", while the WQI rated the river a 46, which is "fair", and close to "good". Low DO (3.5 mg/L) and high BOD (2.8) drive the index down. Because of these factors, FDEP states that Blackwater River only partially meets its use designation. However, the overall status (derived from a combination of indices, contaminant information, nonpoint source assessments, and expert opinion) of the Blackwater River is represented as "poor" in the 1996 305b report (FDEP, 1996a).

Fecal coliform bacteria counts from STORET data were 3 MPN/100 ml, averaged over five observations. The study area database compiled for this report indicates average fecal coliform levels from 1980 to 1990 was closer to 111 MPN/100 ml. No total coliform counts were available from STORET records for this period, but data summarized for Table 13 indicate high total coliform levels in Henderson Creek, averaging 1830 MPN/100 mls. Chlorophyll a levels measured 40 µg/L, which is higher than 90% of similar state waters. However, total nitrogen and total phosphorus levels remained low at 0.98 mg/L and 0.03 mg/L, respectively.

Sediment quality data was not available.

Table 14 provides a summary of the water quality in the Henderson Creek Basin by decade for several water-quality parameters. The data from which **Table 14** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a "good", "fair" or "poor" basis; as typically included in the Florida's 305b water quality report (FDEP, 1996a).

The literature provided very little historical or current water-quality data for the District VI Basin. **Table 15,** however, provides a summary of the water quality from the STORET database by decade for various water-quality parameters of the District VI Basin.

TABLE 14. SUMMARY OF WATER-QUALITY DATA FOR THE HENDERSON CREEK BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	9	8.33	1	25	22.2	85.4	59	3.25	0	29	3.4	52.3	36	2.22	.3	10.2	0	35.2
pH	pH	13	7.95	7.2	9.2	0		93	7.22	5.1	9	0		121	7.32	6.64	8.29	0	
Salinity	ppt	N/A						23	8.25	0	35.8	N/A		115	9.51	0.0	35.9	N/A	
Temperature	deg. C	51	25.1	14	31	0		96	26.58	17.5	33	0		126	26.47	16.7	33.3	0	
Chlorides	mg/L	20	94	11	250	0		17	97.01	27	334.7	5.9		24	4244.8	37.0	31,390	54.2	
Fluorides	mg/L	N/A						2	0.17	0.17	0.17	0		24	0.15	0.025	0.50	0	
Conductivity	micromho	47	1012.98	230	1750	12.8		96	308.87	.3	9500	3.1		94	31.36	.24	1350	1.1	
DO	mg/L	2	11.5	9.9	12.4	0	8.5	80	4.09	.7	9.85	70.0	78.1	123	4.83	0.53	9.00	50.4	65.7
BOD	mg/L	15	4.56	1.6	10.4	73.3	90.8	14	3.65	0.3	8.8	64.3	88.9	25	3.08	0.3	6.0	48.0	81.4
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	11	2.3	1.16	3.62	90.9	81.5	10	4.1	1.33	9.51	100	94.1	24	1.08	0.09	2.51	33.3	39.5
Tot-P	mg/L	7	0.06	0.02	0.14	28.6	37	14	0.05	0.02	0.13	35.7	32	33	0.07	0.002	0.54	15.2	44.5
Tot-C	mg/L	4	26.0	17.0	30.0	75		N/A						N/A				10.7	
Tot-coli	/ 100 ml	8	5650.24	2	22999.95	75	93.6	8	1830	100	6000	100	97.4	20	169.65	9.0	450.0	58.	48.0
Fecal-coli	/ 100 ml	8	1350.25	2	9399.98	37.5	91.7	13	111.54	0	300	38.5	69.1	1	135	135	135	0	70.5
Cu	ug/l	5	4.0	0	8	40		1	1.0	1.0	1.0	0		1	5.0	5.0	5.0	100	
Fe	ug/l	3	286.67	40	500	66.7		N/A						25	9.86	0.52	237	0	
Pb	ug/l	5	10.8	5	17	60		1	1.0	1.0	1.0	0		25	2.37	1.0	6.0	4.0	
Zn	ug/l	3	23.33	0	50	0		N/A						25	0.22	0.013	5.0	0	
Chlor a	ug/l	N/A						3	62.33	6	107	66.7		1	6.23	6.23	6.23	0	
WQI	%						67.3						73.1						56.7

TABLE 15. SUMMARY OF WATER-QUALITY DATA FOR THE DISTRICT VI BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	5	3.2	1	6	0	51	4	3.05	1.6	5.2	0	50.2	3	2.73	1	5.9	0	41
pH	pH	6	7.49	7	7.8	0		14	7.42	6.5	8.0	0		3	7.6	7	8.1	0	
Salinity	ppt	3	10.33	0	25	0		N/A						N/A					
Temperature	deg. C	8	25.73	21.1	29	0		15	25.61	13.2	34.0	0		74	26.04	13.9	32.65	0	
Chlorides	mg/L	6	3229.67	75	12800	66.7		8	109.6	55.0	165.0	0		22	3486.8	61	19400	54.5	
Fluorides	mg/L	N/A						N/A						19	0.20	0.025	0.54	0	
Conductivity	micromho	2	960	880	1040	0		4	23275	1600	39000	100		3	8481.33	444	13000	66.7	
DO	mg/L	6	5.08	1.9	7.1	33.3	67	15	5.20	1	10.2	46.7	60.5	73	5.03	0.4	10.8	49.3	62.7
BOD	mg/L	6	1.13	0.3	2.2	0	23	4	2.03	1.4	3.2	25	55	34	3.56	1.0	21.6	50.0	19.6
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						19	1.30	0.21	2.57	36.8	51
Tot-P	mg/L	4	0.03	0.02	0.05	0	20	15	0.07	0.01	0.22	40	44.5	74	0.12	0.005	1.25	43.2	58.5
Tot-C	mg/L	N/A						N/A						N/A				7.9	
Tot-coli	/ 100 ml	6	1250.83	90	3700	100	18.3	10	1234.6	43	4600	90.0	62.8	20	498.25	16	3650	60.9	62.8
Fecal-coli	/ 100 ml	2	70	20	120	0	50.9	4	637	220	1420	100	20.5	3	784	12	1910	66.7	88.9
Cu	ug/l	N/A						N/A						1	23.0	23.0	23.0	100	
Fe	ug/l	N/A						1	0.21	0.21	0.21	0		21	15.34	0.012	319	4.8	
Pb	ug/l	N/A						N/A						20	2.2	1.0	5.0	0	
Zn	ug/l	N/A						N/A						20	0.32	0.013	6.0	0	
Chlor a	ug/l	N/A						3	34.43	6.3	84	33.3		2	6.85	3.7	10	0	
WQI	%						39.1						58.4						50.8

Fahka Union Canal

No current data was available for Fahka Union Canal. Historical water-quality data from two stations from 1980 to 1989 indicate exceptional physical water quality. Turbidity measured less than 1 NTU/NTU, better than 90% of state waters, and color was low, between 10 and 30 PCUs. The DO was high (6.4 mg/L) and at one station it was above saturation (9.9). Conductivity was between 600 and 700, which is above average, but far from exceeding state standards.

Nutrient levels, bacterial contaminants, and BOD were all well within state standards and screening levels. Total nitrogen ranged from 0.51-0.73 mg/L and total phosphorus measured 0.01 mg/L. The WQI rated Fahka Union Canal a 17, an indication of "good" water quality. **Table 16** provides a summary of the water quality in the Fahka Union Canal Basin by decade for several water-quality parameters. The data from which **Table 16** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a "good", "fair" or "poor" basis; as typically included in the Florida's 305b water quality report (FDEP, 1996a).

The literature provided very little historical or current water-quality data for the Collier-Seminole Basin. **Table 17**, however, provides a summary of the water quality from the STORET database by decade for various water-quality parameters of the Collier-Seminole Basin. Sediment quality information was not available.

Estuarine Systems

Naples Bay

Current water-quality information is not available for Naples Bay. STORET data from 1989 are used to describe water quality. Water clarity is characterized by near average turbidity (3.6-4.5 NTU/NTUs), and slightly better than average color (40-80). No information on TSS was available from STORET for Naples Bay. Low DO was observed at two sample locations in the Bay. Average DO ranged from 4.5 to 6.0 mg/L.

Chlorophyll a was low, measuring 6-7 μg/L, while total nitrogen levels the screening level (1.31 mg/L), as did total phosphorus (0.10 mg/L).

Sediment quality information was not available.

Listed or otherwise protected species include the West Indian manatee (*Trichechus manatus*), protected under the Endangered Species Act; the Atlantic bottlenose dolphin (*Tursiops truncatus*), protected under the Marine Mammal Protection Act; and several species of wading birds.

Historically, the major sources of freshwater to Naples Bay were the Gordon River, Haldeman Creek, Rock Creek and direct run-off from the city of Naples providing a combined discharge of approximately 100 cubic feet per second (cfs). The construction of Golden Gate Canal has considerably increased the flow of freshwater into the Bay in the wet season to as much as 1,500 cfs. In contrast, during the dry season in April discharge to the Bay drops to near zero (Simpson et al., 1979). **Tables 18 and 19**, provide summaries of the water-quality data by decade for various water-quality parameters of the Corkscrew/Cocohatchee Coastal Area (Wiggins Pass) and the District VI Coastal Area (Naples Bay and Rookery Bay) estuaries, respectively. The data from which these tables were developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a).

Rookery Bay:
Current water-quality data is not available through STORET. Under the National Oceanic Atmospheric Association (NOAA) National Estuarine Reserve Research (NERR) National Monitoring Program, automated data collectors deployed throughout Rookery Bay will soon make continuously collected water-quality data available on the Internet. In addition to being part of the NERR program, Rookery Bay is designated by the state of Florida as an aquatic preserve, and as a National Audubon Society Wildlife Sanctuary.

Rookery Bay has been described as a “transitional” estuary in terms of its location between the high-energy (erosional forces) coastline to the north and the lower energy. Physical water quality is characterized by large fluctuations in salinity and low flushing due to the small size of the adjacent upstream watershed. Freshwater arrives into Rookery Bay via Henderson Creek to the west and Stopper Creek to the northwest. Tidal exchange is low due to the presence of oyster bars and low flushing of the shallow creeks that feed into the Bay. Hypersaline conditions can result during periods of drought (Drew and Schomer, 1984).

TABLE 16. SUMMARY OF WATER-QUALITY DATA FOR THE FAHKA UNION CANAL BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	83	9.51	0.3	68	15.7	88.3	102	1.3	0.1	10.2	0	15	3	0.767	0.4	1	0	5.7
pH	pH	95	7.2	4.1	8.45	0		75	7.7	6.8	9.8	0		3	7.7	7.6	8	0	
Salinity	ppt	1	6	6	6	0		N/A						91	1.119	0	34.3	0	
Temperature	deg. C	104	23.83	15.1	50.5	0		3	28	24	30	0		132	24.818	15.55	32.1	0	
Chlorides	mg/L	77	364.83	4	19999.96	5.2		94	52.3	18.7	199	0		109	668.042	1.4	20,300	11.9	
Fluorides	mg/L	N/A						3	0.17	0.17	0.17	0		91	0.141	0.025	0.42	0	
Conductivity	micromho	114	1933.99	70	52499	7.9		101	594.9	235	1490	0.99		3	770	700	810	0	
DO	mg/L	91	5.68	0.24	15.1	53.8	58.2	78	6.9	1.4	18.8	26.9	36	131	4.685	0.06	12.0	53.4	68.1
BOD	mg/L	3	1.63	1.5	1.7	0	45.3	3	1.3	0.9	2	0	31	94	4.595	0.40	64.8	45.7	91.0
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	61	1.41	0.1	11.02	34.4	51	100	0.796	0.1	2.99	12	19.1	91	1.048	0.02	10.5	25.3	38
Tot-P	mg/L	92	0.05	0	0.48	20.7	32	102	0.02	0	0.6	2	12	132	0.095	0.002	1.15	31.8	54
Tot-C	mg/L	53	177.25	1	9000	3.8		27	10.367	5.4	23.1	3.7	N/A	119	14.587	0.250	33.0	20.2	
Tot-coli	/ 100 ml	39	18497.18	40	91000	97.4	97.3	N/A						86	238.401	0.5	1314	68.5	52.8
Fecal-coli	/ 100 ml	39	36.72	2	180	0	42.5	1	4	4	4	0	12	3	28	4	68	0	38.9
Cu	ug/l	3	2.93	1	5.8	33.3		2	0.815	0.63	1	0		2	5	5	5	100	
Fe	ug/l	48	1243.78	0.03	7200	75		90	0.127	0.02	0.5	0		93	1.102	0.05	65	0	
Pb	ug/l	3	3.43	1	7.3	33.3		2	1.7	0.4	3	0		93	2.388	1	10	2.2	
Zn	ug/l	3	211.3	40	297	66.7		2	27.55	21	34.1	0		93	0.255	0.013	17	0	
Chlor a	ug/l	N/A						3	2	1	3	0	12	3	1.49	1.03	2.14	0	8.5
WQI	%						60.6						21.9						51.3

TABLE 17. SUMMARY OF WATER-QUALITY DATA FOR THE COLLIER/SEMINOLE BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	NO DATA						NO DATA						3	1.63	0.8	28	0	21.3
pH	pH													32	7.36	5.98	8.79		
Salinity	ppt													15	6.7	0.1	33.0		
Temperature	deg. C													32	25.76	18.05	34.3		
Chlorides	mg/L													18	2183.5	0.50	20625	33.3	
Fluorides	mg/L													18	20.19	0.05	0.70	0	
Conductivity	micromho													3	21666.7	2000	48000	100	
DO	mg/L													30	4.62	0.18	11.90	56.7	68.8
BOD	mg/L													11	3.07	0.8	6.6	45.5	81.2
COD	mg/L													N/A					
Tot-N	mg/L													8	1.24	0.10	1.87	50.0	48
Tot-P	mg/L													31	0.36	0.01	1.1	80.6	80.5
Tot-C	mg/L													13	13.32	0.05	27.0	23.4	
Tot-coli	/ 100 ml													12	1276.33	25	8750	78.6	76.2
Fecal-coli	/ 100 ml													3	94.67	28	136	0	53.8
Cu	ug/l													2	25.5	25	26	100	
Fe	ug/l													10	32.59	0.15	204	0	
Pb	ug/l													10	2.95	1.66	10	10	
Zn	ug/l													10	3.12	0.01	25	0	
Chlor a	ug/l													3	7.6	3.74	14.7	0	43
WQI	%																		60.1

TABLE 18. SUMMARY OF WATER-QUALITY DATA FOR THE CORKSCREW/COCOCHATCHEE COASTAL AREA (WIGGINS PASS)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	33	7.67	2	55	12.1		1	1.10	1.10	1.10	0.0		38	4.2	1.8	12.7	2.6	
pH	pH	53	8.06	6.75	8.7			1	7.25	7.25	7.25			120	7.72	6.4	9.38		
Salinity	ppt	11	31.68	26				N/A						49	22.35	0.2	34.25		
Temperature	deg. C	68	27.22	16.6	32.1			102	25.59	11.8	35.7			97	28.18	19.0	35.6		
Chlorides	mg/L	26	20907	12800	24500	100		8	232.75	116.0	457.0	37.5		2	166.25	129.5	203.0	0	
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	16	46287	5100	53000	100		N/A						38	32215	11721	48700	100	
DO	mg/L	54	6.5	3.7	10.8	3.7		80	5.721	0.900	11.9	35.0		98	4.95	0.1	11.75	57.1	
BOD	mg/L	43	2.9	0.4	8.0	62.8		1	0.80	0.80	0.80	0		15	2.56	1	5.7	53.3	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	20	0.10	0.01	0.98			N/A						20	.66	0.41	.89	0.0	
Tot-P	mg/L	N/A				20		100	0.095	0.01	0.86	37.0		94	0.19	0.01	1.9	41.5	
Tot-C	mg/L	N/A						N/A						39	14.42	3.35	40.0	15.4	
Tot-coli	/ 100 ml	37	25.68	2	180	10.8		14	0.078	0.025	0.13	78.6		N/A					
Fecal-coli	/ 100 ml	39	8.54	0	40.0			N/A						38	57.08	4	610	2.6	
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	N/A						2	0.078	0.025	0.13	0.0		5	0.15	0.10	0.24	0	
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						N/A						N/A					
Chlor a	ug/l	N/A						N/A						22	4.78	1.6	11.8	0.0	
TSI			TSI NOT CALCULATED						TSI NOT CALCULATED										45

TABLE 19. SUMMARY OF WATER-QUALITY DATA FOR THE DISTRICT IV COASTAL AREA (NAPLES BAY & ROOKERY BAY)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	48	7.18	1.0	40.0	14.6		475	7.70	1.0	44.0	8.0		332	4.47	0.5	21.0	2.4	
pH	pH	58	7.54	6.3	8.5			754	7.57	6.6	8.2			919	7.74	5.43	8.41		
Salinity	ppt	22	14.05	1.0	36.00			287	33.34	13.5	43.8			910	29.07	0.00	41.80		
Temperature	deg. C	72	27.44	21	31.0			754	25.61	15.6	32.81			944	26.27	15.8	33.9		
Chlorides	mg/L	45	9530.4	36.7	22500	88.9		N/A						20	11582.4	433	19,600	100	
Fluorides	mg/L	0	N/A					N/A						20	0.37	0.09	0.60	0	
Conductivity	micromho	27	32807	1070	53100	96.3		754	1105.7	4.98	53700	2.9		864	167.1	0.32	41000	0.6	
DO	mg/L	55	4.77	1.5	8	50.9		741	5.81	2.04	9.7	30.2		935	5.74	1.45	14.13	28.7	
BOD	mg/L	52	1.78	0.0	5.8	21.2		20	1.79	0.2	4.4	25.0		32	2.44	0.77	6.2	34.4	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						20	2.97	0.10	43.17	15.0	
Tot-P	mg/L	26	0.11	0.02	0.78	46.1		23	0.08	0.04	0.28	39.1		86	0.13	0.005	0.93	46.5	
Tot-C	mg/L	4	8.50	1.00	16.00	0.0		N/A						56	7.95	0.50	21.33	1.8	
Tot-coli	/ 100 ml	55	524.4	2.0	5000	76.4		N/A						18	286.06	17	1150	75.0	
Fecal-coli	/ 100 ml	18	169.9	2.0	1980	11.1		19	89.84	2	515	15.8		6	528.2	4.0	1220.0	66.7	
Cu	ug/l	N/A						N/A						2	16.5	8.0	25.0	100	
Fe	ug/l	N/A						N/A						28	21.05	0.008	484	3.6	
Pb	ug/l	N/A						N/A						22	3.13	1.0	12.0	13.6	
Zn	ug/l	N/A						N/A						22	1.47	0.013	25.0	0	
Chlor a	ug/l	N/A						22	12.59	3	40.5	18.2		4	15.4	2.4	31.4	25.0	
TSI		TSI NOT CALCULATED						TSI NOT CALCULATED											52.2

Table 20 provides a summary of the water quality for the Rookery Bay Estuary by decade for several water-quality parameters. The data from which **Table 20** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a).

Mangrove and seagrass are important habitats within and around Rookery Bay that are subject to changes in water quality, particularly altered freshwater flow. Based on recent nonpoint source assessments Rookery Bay fully meets its designated use as a Class 2 water body for support of shellfish harvesting (FDEP, 1996a).

Important habitat types listed in the Rookery Bay and Cape Romano-Ten Thousand Islands Aquatic Preserve Management Plan (Gardner, 1988) include seagrasses, saltmarsh, mangrove forests, and coastal strand. Seaturtles, manatees, several species of wading birds, the Florida panther, and the Florida black bear are some of the protected species that occur in or near Rookery Bay.

Marco Bay

Neither current nor historic water-quality data was available through STORET. However, Drew and Schomer (1984) presented some general information on the freshwater and tidal exchange, nutrients, and habitats of the estuary.

Freshwater flow into Marco Bay is through coastal wetlands, and from groundwater, between the freshwater aquifer and the saline coastal aquifer. Inputs from the wetlands are approximately 100 to 200 times that of the groundwater input, with some of this large surface volume attributed to man-made drainage operations (Drew and Schomer, 1984).

DO levels were frequently found to be lower in natural areas than in disturbed areas (i.e. canals). Accumulations of mangrove detritus and restricted backwater circulation were cited as the cause for the low DOs (Drew and Schomer, 1984).

Nutrients are low in natural and artificial waterways of the Marco Bay/Estuary system. Locally, high nutrient conditions are theorized to result from certain wind conditions mixing the water column and causing releases from sediments (Drew and Schomer, 1984). Chlorophyll a was highest in the canals. No data accompanied the descriptions.

TABLE 20. SUMMARY OF WATER-QUALITY DATA FOR THE HENDERSON CREEK COASTAL AREA (ROOKERY BAY)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	**Units**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**TSI**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**TSI**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**TSI**
Turbidity	NTU	4	11.25	3.0	19.0	50.0		186	155	0.60	28.5	14.5		141	4.19	0.50	13.0	0.71	
pH	pH	4	8.13	7.80	8.5			284	7.47	6.1	8.5			355	7.59	6.4	8.5		
Salinity	ppt	2	10.5	7.0	14.0			100	26.09	0.0	43.4			370	21.48	0.0	40.5		
Temperature	deg. C	4	38	3	30.5			284	25.85	15.6	32.4			377	26.61	16.98	34.17		
Chlorides	mg/L	2	1120	4500	18000	100		N/A						N/A					
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	2	42000	33000	51000	100		284	4601	0.40	64.4	0.0		373	33.62	0.28	60.30	0.0	
DO	mg/L	2	5.9	4.9	6.4	25.0		278	5.88	2.04	16.3	31.3		373	5.67	1.78	13.12	37.53	
BOD	mg/L	4	1.93	1.10	2.60	25.0		N/A						N/A					
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						N/A					
Tot-P	mg/L	2	0.04	0.04	0.04	0.0		N/A						4	0.2929	0.0015	0.975	50	
Tot-C	mg/L	N/A						N/A						1	2.7	2.7	2.7	0	
Tot-coli	/ 100 ml	2	19	6	32	0.0		N/A						N/A					
Fecal-coli	/ 100 ml	2	5.0	2.0	8.0	0.0		N/A						N/A					
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	N/A						N/A						N/A					
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						N/A						N/A					
Chlor a	ug/l	N/A						N/A						N/A					
TSI		TSI NOT CALCULATED						TSI NOT CALCULATED						TSI NOT CALCULATED					

Fahkahatchee Bay

Current water-quality information on Fahkahatchee Bay was not available from the STORET database. Relative comparisons between Fahkahatchee Bay and adjacent Fahka Union Bay were given in Drew and Schomer (1984) for freshwater input, salinity regimes, and nutrient loading. Salinity ranges from 0 to 40 ppt throughout the wet and dry seasons. Specific data on other water-quality parameters are lacking. Heavy metal analysis from data collected in the 1970s did not indicate contamination of the waters, but some sediments did contain detectable amounts of lead particularly those near areas receiving roadway runoff (Drew and Schomer, 1984). Pesticides were also detected in some of the sediment samples; waters were described as uncontaminated. No specific concentrations were given.

Habitat types include various benthic communities, seagrass meadows, mangrove forests, and saltmarsh.

Abbott and Nath (1996) cited increased freshwater from Fahka Canal and abnormal salinity levels to blame for disappearance of seagrass meadows, displaced benthic habitats and fish communities, and declines in shellfish harvests.

2.4. Southern Big Cypress Swamp: West Collier County

The Southern Big Cypress Swamp is located in the southern half of the Big Cypress National Preserve and is part of the Big Cypress Swamp Watershed, USGS unit 03090204. The study area is situated in the western part of the Southern Big Cypress Swamp. Interest will focus on the Collier-Seminole Basin, the Fahkahatchee Strand, Okaloacoochee Slough, and the Barron and Turner Rivers, two canals which hydrologically affect the western portion of the preserve. The Turner and Barron River canals were not originally designed for the specific purpose of draining land, but as a supply source for road construction materials (Drew and Schomer, 1984).

Physical Description

Perhaps the most important drainage feature of the Big Cypress Swamp is the Fahkahatchee Strand. A strand is an elongate area of large trees growing within drainage depression with no well-defined channel. The Fahkahatchee Strand is a natural community of mixed hardwood swamp about five miles wide and twenty miles long. Along with Okaloacoochee Slough, it is a principal drainage slough of the western Big Cypress Swamp (McElroy and Alvarez, 1975). It is notable for being the world's only royal palm-bald cypress forest, having the largest stand of native Florida royal palms and the largest concentration of native orchids in North America. Numerous threatened and endangered plant and animal species are found within the Fahkahatchee Strand (McElroy and Alvarez, 1975).

Land use within the Southern Big Cypress Swamp is primarily wetlands, with an estimated less than 5% of land under agricultural use and less than 5% in small towns. Census data record that in 1990, Everglades City, at which Barron Canal discharges, had a population of 317, and Chokoloskee, a small fishing town at which Turner River discharges, had a population of 240 (U.S. Department of Commerce, 1992).

It is estimated that greater than 80% of the area consists of wetland habitat types. Mangrove swamp and saltmarsh are found along the coast, while freshwater swamp and freshwater marsh begin about 5 miles inland from Chokoloskee. Some dry prairie exists along the Barron River canal (SFWMD, 1995).

General soil types within the Southern Big Cypress Swamp are mangrove peat in coastal areas, and marl interspersed with peat in inland areas. Mangrove peat is found in "very low, wet areas of organic, marly to mucky soils thinly overlying bedrock" (Drew and Schomer, 1984).

The Turner and Barron River canals drain freshwater from the strands and sloughs of the Big Cypress Swamp, and also receive additional freshwater input from the shallow water aquifer. Okaloacoochee Slough and Deep Lake Strand are two such features that contribute freshwater to the canals. The Barron River canal flow rate varies from 0 to 8.27 m^3/s (0 to 292 cfs) over the course of a year. During dry season, flows are low, from 1.42 to 2.84 m^3/s (50 to 100 cfs) but increase during the wet season to between 2.84 and 4.96 m^3/s (100 to 175 cfs). Over the long term (decades), flows average 2.89 m^3/s (102 cfs). Given the age of the canals, constructed over 50 years ago, water levels in the Barron and Turner River canal watersheds are assumed to have stabilized. A series of removable stop-log gates control flow along the Barron River canal, inserted during the dry season to conserve the aquifer, and removed during the wet season to accommodate increased drainage (Drew and Schomer, 1984).

The Collier-Seminole Basin drains primarily cypress wetlands ultimately into Gullivan Bay. The basin exists within the boundaries of the Collier-Seminole State Park. No water-quality data was available.

Historical Description

Historical data from STORET indicate that water quality within much of the Big Cypress has been "fair" to "good" with respect to physical and biological parameters, and nutrient condition. However, metals were detected in previous sample data from Chokoloskee Bay at levels higher than in other local estuaries. Monitoring data from 1980-89 indicate that Barron River canal had good water conditions with a pH of 7.6, good water clarity as indicated by low turbidity (2.0 NTUs), low TSS (1 mg/L), and low color (55 PCUs). However, DO levels failed to meet state criteria with an average of 4.2 mg/L. Conductivity was normal at 536 micromhos. The Turner River canal exhibits freshwater conditions inland and estuarine conditions nearer the coast. Samples of the Turner River collected near the Tamiami indicate that physical water quality is good with an average DO of 7.3, low turbidity of 1.0 NTUs, and pH of 8.4. Conductivityhad an average measurement of 1300 micromhos. Where Turner River flows into Oyster Bay, turbidity was higher at 4 NTUs, color was higher at 40, and conductivity was higher at 41250 micromhos due to higher concentration of salts. DO was high at 8.5.

Biological parameters, BOD, chlorophyll a, and fecal coliform bacteria, were 1.3 mg/L, 7 μg/L, and 14 MPN/100 ml, respectively. None of these values exceeded (i.e. failed to meet) state standards or screening levels. Nitrogen and phosphorus levels of Barron

River canal runoff into the Gulf has been historically low. The annual average for total nitrogen was 0.98 mg/L, and for total phosphorus, concentrations were low at 0.02 mg/L. The TSI for Barron River canal runoff into the Gulf was 46 and for Turner Canal, 47.

Freshwater Systems

Turner and Barron Canals

Current water-quality information for the Barron and Turner River canals is available from the Estuarine Receiving Water Quality Monitoring Program Data Summary (**Table 21**), Collier County for FY90-95 (Gibson, 1997). The STORET database does not contain data from this particular sampling phase of this program.

TABLE 21. WATER QUALITY MONITORING DATA OF BARRON AND TURNER CANALS (1990-95)

Location	PH	DO	Sal	Turb	TSS	TP	Chl A	Cond
April 1991								
Turner	7.9	6.6	33	.65	136	.15	BDL	N/A
Barron	7.8	5.4	31	.4	130	.12	BDL	50,000
August 1991								
Turner	7.7	3.7	15	2.3	25.5	.2	2.5	20,750
Barron	7.9	4.8	14	2	31	.13	11.5	25,000
April 1994								
Barron	7.8-8.1	4.9-6.0	27-28	4.3-14.4	22.0-40.0	N/A	N/A	43.6K-46K
Barron	7.3	3.6	1.2	1.0-2.0	1.0-1.5	N/A	N/A	2840-2850

No color, no Total nitrogen, no Fecal or Total coliform

The literature provided very little historical or current water-quality data for the Fahkahatchee Strand Basin. **Table 22**, however, provides a summary of the water quality in the Fahkahatchee Strand Basin by decade for several water-quality parameters. The data from which **Table 22** was developed are specific to the South Florida study area. The WQIs reflect changing water quality conditions over time only and are not intended to evaluate water quality on a “good”, “fair” or “poor” basis; as typically included in the Florida’s 305b water quality report (FDEP, 1996a).

TABLE 22. SUMMARY OF WATER-QUALITY DATA FOR THE FAHKAHATCHEE STRAND BASIN

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI	Obs	Mean	Min.	Max.	% Exc	WQI
Turbidity	NTU	73	4.41	0.35	63	5.5	52.1	N/A						3	2.5	1.8	3.5	0	38
pH	pH	84	7.38	6.7	8.2	0		74	7.492	2.5	9.05			92	7.34	6.28	8.43	0	
Salinity	ppt	1	0.0	0.0	0.0	0		N/A						51	4.97	0.0	33.2		
Temperature	deg. C	88	21.22	15	30	0		101	24.756	16.0	36.0			92	24.53	15.3	33.1	N/A	
Chlorides	mg/L	29	58.1	10	916	3.4		8	28.375	21.0	36.0	0		52	2644.27	70	19,700	26.9	
Fluorides	mg/L	N/A						N/A						9	0.17	0.03	0.53	0	
Conductivity	micromho	73	367.92	190	670	0		N/A						3	21333.33	9000	42000	100	
DO	mg/L	79	4.12	0.73	13	74.7	74.8	78	4.514	1.5	10.0	75.6	69.9	92	3.5	0.23	9.6	76.1	81
BOD	mg/L	3	2.83	2	4.2	33.3	76.3	N/A						3	2.2	1	4.5	33.3	64
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						49	1.17	0.01	4.31	32.7	44.5
Tot-P	mg/L	14	0.02	0.009	0.04	0	16	101	0.32	0.006	0.22	8.9	27.2	90	0.10	0	3.05	29.7	54.0
Tot-C	mg/L	72	11.9	1	45	13.9	N/A	N/A						84	14.92	0.05	43.85	10.7	
Tot-coli	/ 100 ml	60	17777.58	50	59000	98.3	97.3	14	771.929	4.0	2400	85.7	68.8	48	309.23	12	2250	83.7	56.5
Fecal-coli	/ 100 ml	61	146.13	2	1320	24.6	71.6	N/A						2	22	4	40	0	37
Cu	ug/l	N/A						N/A						2	17.5	10	25	100	
Fe	ug/l	60	201.67	100	1400	10		N/A						53	4.08	0.02	107	0	
Pb	ug/l	N/A						N/A						51	2.41	1.0	10	3.9	
Zn	ug/l	N/A						N/A						51	0.63	0.01	25	0	
Chlor a	ug/l	N/A						N/A						3	7.18	2.6	14.1	0	41.6
WQI	%						60.7						55.3						55.8

Estuarine Systems

Chokoloskee Bay

Recent water-quality information was obtained from Gibson (1997) for 1990-1995. Historical data were obtained from the STORET database and from Drew and Schomer (1984).

The hydrology or rates of flushing and mixing of Chokoloskee Bay are not well known (Drew and Schomer, 1984). Historically salinity has varied from 2.5 ppt to 20.2 ppt at the mouth of the bay. The water has been relatively clear as indicated by the average turbidity (3 NTUs), and color (30 PCUs). DO was high at 8.5 and the pH was normal for saline waters at 8.5. High conductivity (41250 micromhos) is normal for waters with high salt content. No historical bacterial analyses or chlorophyll a measurements were available.

Historically nutrients increase with the rainy season from apparent increased flow from the Barron River Canal. Other sources of nutrients are possibly the oxidation of drained soils and runoff from agricultural and roadways (Drew and Schomer, 1984). Total nitrogen has historically been lower than average at 0.64 mg/L compared to other Florida streams. Total phosphorus likewise has been lower than average at 0.03 mg/L. The TSI indicated that the overall nutrient status of Chokoloskee Bay was good, with a 46. Contaminants have been sampled in the Bay, but seasonal increases were theorized to result from "desorption by dissolved ions in seawater" as salinity varied (Drew and Schomer, 1984). Manganese, copper, lead, and zinc were metals that increased with an increase in salinity. Concentrations of these metals were reported to be 1.5 to 3 times higher than metal concentrations from estuaries that received natural drainage (Drew and Schomer, 1984).

Current water quality from Gibson (1997) are available for Chokoloskee Bay and presented in **Table 23**. Average salinity is higher, while average DO is lower than historical data measurements. Nutrient data were not available.

TABLE 23. AVERAGE WATER-QUALITY DATA FROM CHOKOLOSKEE BAY (1990-95)

pH	DO	Sal	Turb	TSS	TP	Chl A	Cond
8.0	5.2-5.3	29.9	10.3-13.0	33.0-34.0	N/A	N/A	48050 avg

The literature provided very little historical or current water-quality data for many of the bays and estuaries of southwest Florida. Limited data are available for the Ten Thousand Isles region, and the associated bays of Chokoloskee and Fahka Union. **Tables 24, 25, and 26** provide limited summaries of the water-quality data by decade for various water-quality parameters of the Seminole/Collier Coastal Area(10,000 Isles), Fahka Union Canal Coastal Area (Fahka Union Bay), and Fahkahatchee Strand Coastal Area (Chocoluskee Bay) regions.

TABLE 24. SUMMARY OF WATER-QUALITY DATA FOR THE COLLIER/SEMINOLE COASTAL AREA (TEN THOUSAND ISLES)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	71	4.61	0.42	46.0	9.9		18	8.74	2.40	30.0	22.2		87	7.04	0.60	40.50	9.2	
pH	pH	70	7.5	6.1	8.6			65	7.67	6.99	8.00			808	7.9	5.73	8.80		
Salinity	ppt	108	35.3	32.0	37.1			33	34.58	16.80	43.40			448	23.18	0.7	41.0		
Temperature	deg. C	205	28.75	10.0	35			65	26.039	17.76	32.76			995	25.87	15.36	34.56		
Chlorides	mg/L	66	18.4	3.0	153.0	0.0		N/A						N/A					
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	60	294.95	160	1190	0.0		62	50.82	6.34	64.30	0.0		157	48.44	23.50	60.60	0.0	
DO	mg/L	204	4.66	0.0	9.6	44.1		64	5.5678	2.49	8.08	34.4		876	5.68	0.10	11.97	27.7	
BOD	mg/L	N/A						3	1.7	1.35	2.05	0		9	1.51	0.5	2.65	22.2	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						N/A					
Tot-P	mg/L	193	0.112	0.00	2.90	62.2		3	0.1133	0.04	0.24	33.3		91	0.13	0.0015	0.8	36.3	
Tot-C	mg/L	193	10.64	2.40	120.0	5.7		N/A						67	7.69	0.05	20.5	0	
Tot-coli	/ 100 ml	N/A						N/A						115	9567.02	4.0	1,000,000	87.8	
Fecal-coli	/ 100 ml	N/A						NA						N/A					
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	64	202.5	10.0	2680.	10.9		N/A						6	0.05	0.0025	0.08	0	
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						N/A						N/A					
Chlor a	ug/l	N/A												42	4.49	0.20	11.20	0.0	
TSI		TSI NOT CALCULATED						TSI NOT CALCULATED						TSI NOT CALCULATED					

TABLE 25. SUMMARY OF WATER-QUALITY DATA FOR THE FAHKA UNION CANAL COASTAL AREA (FAHKA UNION BAY)

WQ Parameters	Units	1970-1980 Obs	Mean	Min.	Max.	% Exc	TSI	1980-1990 Obs	Mean	Min.	Max.	% Exc	TSI	1990-1998 Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	14	15.79	1.2	42.0	50.0		8	4.65	3.30	7.00	0.0		120	6.84	1.5	26.6	7.5	
PH	pH	12	7.34	6.8	8.1			9	7.789	7.4	7.81			724	8.11	6.84	8.8		
Salinity	ppt	N/A						9	32.95	27.50	37.0			339	26.37	0.1	40.20		
Temperature	deg. C	14	22.64	19.0	28.0			9	25.61	25.01	27.25			1086	25.47	14.76	34.2		
Chlorides	mg/L	6	855	42	3300	50.0		N/A						10	9280	76.0	21993	60	
Fluorides	mg/L	N/A						N/A						10	0.32	0.10	0.60	0	
Conductivity	micromho	12	1887.9	580	10400	25.0		8	49.59	42.7	52.2	0.0		N/A					
DO	mg/L	12	4.64	2.88	8.0	58.3		9	6.6656	5.05	7.58	0.0		929	6.27	0.6	12.16	16	
BOD	mg/L	N/A						1	0.8	0.8	0.8			13	2.10	0.75	7.2	23.1	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						N/A						10	0.45	0.01	1.22	0	
Tot-P	mg/L	N/A						1	0.21	0.21	0.21	100		151	0.06	0.0015	0.99	8.6	
Tot-C	mg/L	11	5.00	1.00	14.0	0.0		N/A						145	7.27	0.05	18.0	0.0	
Tot-coli	/ 100 ml	9	16456.7	2800	51000	100.0		N/A						10	83.4	10.0	210.0	50	
Fecal-coli	/ 100 ml	9	269.7	10	1600	33.0		N/A						N/A					
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	9	466.7	200.0	600.0	77.8		N/A						13	0.13	0.05	0.23	0	
Pb	ug/l	N/A						N/A						10	2.0	1.0	4.0	0	
Zn	ug/l	N/A						N/A						10	0.03	0.0125	0.06	0	
Chlor a	ug/l	N/A						N/A						126	3.23	0.10	9.30	0.0	
TSI		TSI NOT CALCULATED						TSI NOT CALCULATED											38.04

TABLE 26. SUMMARY OF WATER-QUALITY DATA FOR THE FAHKAHATCHEE STRAND COASTAL AREA (CHOKOLOSKEE BAY)

		1970-1980						1980-1990						1990-1998					
WQ Parameters	Units	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI	Obs	Mean	Min.	Max.	% Exc	TSI
Turbidity	NTU	5	16.1	2.2	48	40		5	3.20	2.40	4.00	0.0		60	6.70	1.70	25.00	10.0	
pH	pH	3	7.53	6.8	8			9	7.72	7.50	7.90			227	8.0754	6.94	8.70		
Salinity	ppt	N/A						3	35.6	31.8	37.75			113	25.412	3.00	38.40		
Temperature	deg. C	6	26.0	23.0	28.0			12	25.5	15.0	30.0			324	25.7	15.52	34.5		
Chlorides	mg/L	11	3158.2	1160	15000	100.0		20	5110.5	600	20000	100.0		N/A					
Fluorides	mg/L	N/A						N/A						N/A					
Conductivity	micromho	11	9709	3500	41000	100.0		17	14531.7	48.6	48500	94		N/A					
DO	mg/L	3	4.4	1.8	6.1	33.3		10	6.07	3.10	9.90	50		282	6.13	1.3	11.67	22	
BOD	mg/L	N/A						2	1.15	0.90	1.40	0		5	2.23	1.45	4.10	20	
COD	mg/L	N/A						N/A						N/A					
Tot-N	mg/L	N/A						8	0.84	0.45	1.1	0.0		N/A					
Tot-P	mg/L	N/A						10	0.06	0.02	0.14	20		86	0.1129	0.01	1.60	19.8	
Tot-C	mg/L	1	19	19	19	0		8	12.24	8.20	17.0	0.0		76	9.1296	4.9	23.0	1.3	
Tot-coli	/ 100 ml	N/A						N/A						N/A					
Fecal-coli	/ 100 ml	N/A						N/A						N/A					
Cu	ug/l	N/A						N/A						N/A					
Fe	ug/l	N/A						2	0.03	0.025	0.04	0		4	0.172	0.025	0.45	0	
Pb	ug/l	N/A						N/A						N/A					
Zn	ug/l	N/A						N/A						N/A					
Chlor a	ug/l	N/A						N/A						63	3.17	.020	7.70	0.0	
TSI		TSI NOT CALCULATED											55.2	TSI NOT CALCULATED					

3.0 GROUNDWATER (AQUIFERS)

The Surficial, Intermediate, and Floridan Aquifer systems are the principal aquifers within the study area (**Figure 5**). The Floridan Aquifer system is widely used for ground water supply in other areas of the state, but within the study area, it is of naturally poor quality, having a high degree of mineralization. Thus, only the Surficial and Intermediate Aquifer Systems are used for ground water supply (SFWMD, 1995). The Floridan Aquifer is separated from the Surficial and Intermediate Aquifers by several layers of confining beds. Recharge areas for the Floridan Aquifer are outside the study area.

Within the study area, the Surficial Aquifer system contains the undifferentiated water table aquifer and the confined lower Tamiami Aquifer. The Biscayne Aquifer is another principal aquifer system within the Surficial Aquifer that occurs outside the study area (SFWMD, 1995).

Florida Geological Survey: Water quality
The primary data and discussion material for aquifer water quality was provided from Florida's Ground Water Quality Monitoring Program. This program derives aquifer water-quality data from three sources; Background Network wells, Very Intensive Study Area (VISA) Network wells, and Private Well Surveys. Only preliminary data from the Background Network were available from 1984 through 1988. A summary of these water-quality data for the Surficial, Intermediate, and Floridan Aquifers is presented in **Table 27**. With the data available, it is not possible to determine the impact of septic tanks on groundwater quality.

Study Area: Water quality
To evaluate more recent and geographically specific water-quality data available within the study area, supplemental data (USGS) were gathered (including STORET) through June 1998 and water-quality trends were revisited. To assess historical and current water-quality trends for the study area aquifers, summary data statistics for various water-quality parameters were recalculated for the following time periods: 1970-1980, 1980-1990, and 1990-1998.

3.1. Surficial Aquifer System

The Surficial Aquifer System is located beneath and adjacent to the land surface and is composed of Pliocene to Holocene quartz sands, shell beds, and carbonates. It consists of porous unconsolidated quartz sand deposits mixed with hardened carbonated rocks belonging to the Upper Miocene to Holocene Series (Florida Department of Natural Resources). The carbonate rocks are the water-producing zones (SFWMD, 1995).

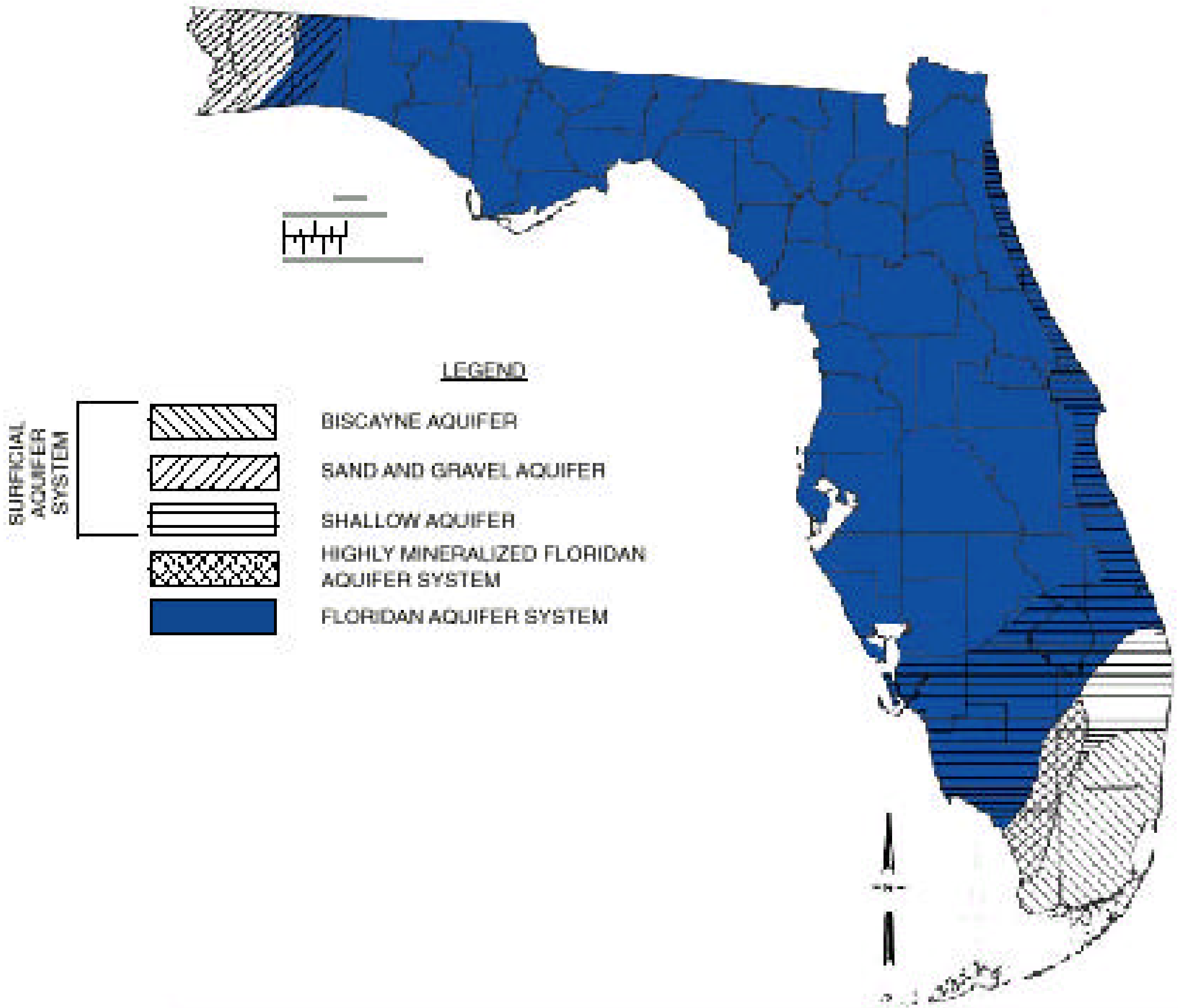


Figure 5. Surficial, Intermediate, and Floridan Aquifers (Source: Florida Department of Natural Resources, 1992).

TABLE 27. SUMMARY OF AQUIFER WATER-QUALITY DATA FOR THE SFWMD

Parameter	**Surficial**			**Intermediate**			**Floridan**		
	Median	**Min**	**Max**	**Median**	**Min**	**Max**	**Median**	**Min**	**Max**
Temperature	24.8	18.5	30.0	25.1	22.3	27.5	26.3	22.2	30.5
PH	6.9	**3.9**	**13.2**	7.3	**6.1**	8.5	7.4	**5.6**	8.9
Calcium	98.0	<0.1	756.0	70.5	2.5	478	67.2	5.9	227.0
Magnesium	3.9	<0.1	51.9	26.6	2.2	465.6	46.4	<0.1	264.2
Sodium	21.1	1.6	620.0	108.6	11.4	1264.0	220.5	2.7	2500.0
Potassium	1.3	<0.1	159.2	9.6	0.4	46.9	9.5	0.5	99.0
Iron	**0.88**	<0.01	**41.50**	<0.05	0.03	**26.6**	<0.05	<0.02	0.29
Mercury	<0.2	<0.1	**0.6**	<0.1	<0.1	<0.3	<0.1	<0.1	**0.2**
Lead	<2	<1	**173**	**1**	<1	**71**	<1	<1	**9**
Alkalinity	251	3	2260	234	111	445	130	10	287
Sulfate	11.8	<1.0	431	52.3	2.0	1754.0	176.4	3.3	713.1
Chloride	48.3	<0.4	**1100.0**	172.0	15.2	**2092.5**	**419.6**	3.5	**3785.0**
Phosphate	0.01	<0.01	4.0	<0.01	<0.01	2.28	<0.01	<0.01	0.15
Fluoride	0.20	0.02	3.73	0.82	<0.10	4.78	0.81	<0.10	3.70
Nitrate	<0.01	<0.01	**44.8**0	<0.01	<0.01	0.19	<0.01	<0.01	1.97
Total Dissolved Solids	388	26	**2537**	**508**	47	**4188**	**1138**	58	**7425**
Conductivity	619	41	8281	947	245	6920	1787	120	12204
Total Organic Carbon	17.0	<0.1	380.0	6.3	<0.1	71.0	1.9	<0.1	80.6
Total Synthetic Organics	0.00	0.00	995.00	<1.00	0.00	2.10	0.00	0.00	3.9
Total Pesticides	0.00	0.00	1100.00	<1.20	<0.01	<30.00	<1.30	<0.70	4.20

* - Bold values indicate an exceedence of maximum contaminant levels (MCL)

Within the Surficial Aquifer system, the water table is mostly unconfined, but in deeper regions some partially confined or locally confined conditions may predominate from beds of low permeability. Underneath the Surficial Aquifer are broad thick beds that are more confining. In south Florida, sediment beds of the Surficial Aquifer are the Tamiami, Caloosahatchee, Fort Thompson, and Anastasia Formation, the Key Largo, and Miami Limestones, and the undifferentiated sediments (Florida Department of Natural Resources, 1992). In general, Surficial Aquifer water levels slope downwards in a southwesterly direction towards the coast. Little seasonal fluctuation of the Surficial Aquifer water levels occurs (Dames and Moore).

Median values for water-quality measurements for the Surficial Aquifer are within state drinking water standards, with the exception of iron and lead. The MCL secondary standard for iron is 0.3 mg/L and the average for the Surficial Aquifer within the SFWMD was 0.88 mg/L. The high maximum values (>5mg/L) are likely the result of using unfiltered samples during analysis (Florida Department of Natural Resources, 1992). Iron is high in the Surficial Aquifer system due to its proximity to iron minerals, organic rich soil horizons, and dissolved humic substances (Florida Department of Natural Resources, 1992). Lead occurs in the surficial at “high” levels (Florida Department of Natural Resources, 1992). Given the lack of natural sources of lead in Florida, the presence of lead is attributed to human sources, most often lead weights used in water level recorders (Florida Department of Natural Resources, 1992).

Saltwater intrusion, incomplete flushing of seawater from the Everglades, and leftover irrigation water from the Floridan Aquifer system have created areas of increasing mineralization and high dissolved solids along the coast (SFWMD, 1995). The Surficial Aquifer System is susceptible to anthropogenic contamination due to its closeness to the land surface. Lack of confinement, high recharge, and relatively high permeability and high water table all increase contamination potential. The increasing demands heighten the constant threat of saltwater intrusion, often resulting in water usage restrictions to users of the Surficial Aquifer (SFWMD, 1995).

Physical and Geological Description

Water-quality data in this section is derived from the FY95/96 Trend Ground Water Quality Monitoring Program for Collier County (Gibson, 1997). Ground water samples from sixteen monitoring wells sampled quarterly were analyzed for “specific chemical analytes that are indicative of natural ground water geochemistry and potability” and compared to public water supply standards. In 1995-96, total dissolved solids, iron, chloride, and sulfate levels in the monitoring wells exceeded MCL standards (**Table 9**) established in F.A.C. 17-550 for treated community water supplies, but still compared favorably with historical data. The report concluded that these conditions “appear to represent the norm” for Surficial Aquifer waters in Collier County (Gibson, 1997). The lower Tamiami Aquifer supplies Collier County with most of its potable water supplies (Dames and Moore, 1997). **Table 28** provides a summary of the water-quality data by decade for various water-quality parameters of the Surficial Aquifer. The data from which **Table 28** was developed are specific to the South Florida study and reflect changing water quality conditions over time.

Recharge of the Collier County area of the Surficial Aquifer occurs primarily by rainfall over virtually the entire land surface. Less than 20% results from lateral and upward vertical recharge from other aquifers and surface waters (Gibson and Preston, 1993). North of Immokalee is an area of high recharge known as Immokalee Rise (Dames and Moore, 1997). Discharges primarily occur at surface water bodies and along the coast (Dames and Moore, 1997). The degree of movement of water through an aquifer is defined in terms of conductivity and transmissivity values. Figure 6 shows these values for the aquifers within the Collier County portion of the study area (Gibson and Preston, 1993). In the Tamiami Aquifer, the hydraulic conductivity can vary from 0.124 ft/day to 0.008860 ft/day with steep hydraulic gradients occurring near the local wellfields. An unconfined area of the Tamiami Aquifer occurs near Immokalee (Dames and Moore, 1997).

TABLE 28. SUMMARY OF WATER-QUALITY DATA FOR THE SURFICIAL AQUIFER

		1970-1980					1980-1990					1990-1998				
WQ Parameters	**Units**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**
Temperature	deg. C	NO DATA					134	24.6	20.5	28.2		546	25.3	17	31	
PH	std pH						133	6.9	5.4	7.6		4	7.05	6.8	7.3	
Calcium	mg/L						120	100.4	10	171		19	94.8	54.3	126.5	
Magnesium	mg/L						NA									
Sodium	mg/L						121	49.6	3.9	498.8	0	19	92.2	5	504.5	0
Potassium	mg/L						120	2.43	0.06	20.6	0	19	4.3	0.2	259.5	0
Iron	mg/L						120	2117.08	20	25520	70	74	2747	15	18600	85.1
Mercury	mg/L						3	0.1	0.1	0.1	100	55	0.12	0.1	0.4	100
Lead	mg/L						83	12.76	0.1	99.1	37.3	55	16.3	0.2	140	36.4
Alkalinity	mg/L						121	258.5	66.2	358.4	0	19	248.1	143.7	298.2	0
Sulfate	mg/L						114	30.5	2	261	0	19	47.4	2	259.5	0
Chloride	mg/L						121	74.13	4.4	875.2	7.4	19	110.1	6.1	774.8	10.5
Phosphate	mg/L						21	0.04	0.004	0.21	14.3	19	0.05	0.005	0.2	21.1
Fluoride	mg/L						121	0.29	0.027	2.8	0.83	19	0.87	0.048	3.05	21.1
Nitrate	mg/L						108	0.02	0.004	0.41	1.9	18	0.01	0.004	0.04	0
TDS	ug/l						122	424.2	66.9	2032.9		66	510.9	56.4	1967	
Conductivity	Micromho						133	748.6	259	3320	12	545	991.1	62	3560	21.7
Total Carbon	mg/L						80	38.1	2.5	678	43.8	28	16.6	2	55	28.6
Synthetic Organics	g/l						900	65	65	65	0.11	500	6.49	5	37.3	0.2
Arsenic	ug/l						76	1.59	0.1	13.5	0	55	12.5	1	540	1.8
Pesticides	g/l						60	1.63	1.63	1.63	41.7	162	33.71	0.292	65.5	40.1

Withdrawals/Public Use

The principal source of urban water in Lee County is the Shallow Water Table Aquifer. The Shallow Water Table Aquifer is also used for agricultural irrigation. Transmissivities for the water table within Lee County range from 10,000 to 1,000,000 gpd/ft. Typical yields from public water supply wells are around 300 gpm (SFWMD, 1995) (**Table 29**).

TABLE 29. PERCENT EXCEEDENCES OF MCL STANDARDS FOR COLLIER CO.

Analyte	**MCL Value in mg/L**	**Percent Exceedences in FY 95/96**
	Physical	
Ph	6.5 – 8.5 pH units	0
	Metals	
Cadmium	0.005	0
Chromium	0.01	0
Copper	1.0	0
Iron	0.3	53
Lead	0.015	0
Manganese	0.05	0
Mercury	0.002	Detection limits not low enough
Sodium	160.0	0
Strontium	4.2	0
Zinc	5.0	0
	Inorganic	
Chloride	250	12.5
Fluoride	4.0*, 2.0**	0
Nitrate	10.0	0
Nitrite	1.0	Not analyzed
Sulfate	250	12.5
	Other	
Total Dissolved Solids	500	38

*Primary **Secondary N/A – Not applicable

The Tamiami is a major potable resource for Collier County serving as the primary source of municipal, industrial, and agricultural water supply (SFWMD, 1995). The water quality is similar to that of the water table aquifer, but often with lower iron concentrations, making it more suitable for potable supplies. Chloride concentrations may still be high in some coastal areas, with levels up to 10,000 mg/L. Aquifer thickness ranges from 150 ft to over 250 ft. Transmissivities range from 100,000 to 500,000 gpd/ft (Dames and Moore, 1997). Water use of the Surficial and Intermediate Aquifers by Collier and Lee Counties in 1995 is presented in **Table 30**. More water is used in agricultural irrigation than any other category for both counties. In Collier County, agricultural irrigation accounted for approximately 68% of all water use in 1995.

TABLE 30. 1995 WATER USE FOR COLLIER AND LEE COUNTY*

County	Public Supply	Domestic Self-Supply (private well)	Industry/ Commercial Self-Supply	Agricultural Irrigation Self-Supply	Recreation Self-Supply	TOTAL
Collier	14,250	1,785	2,181	51,985	16,641	**86,842**
Lee	14,673	2,081	1,974	22,063	12,011	**52,802**
TOTAL	**28,923**	**3,866**	**4,155**	**74,048**	**28,652**	**139,644**
% of Total	***20.7%***	***2.8%***	***3.0%***	***53.0%***	***20.5%***	***1%***

Source: SFWMD, 1998b * Note: Millions of Gallons per Year

3.2. Intermediate

The Intermediate Aquifer System is located in the Hawthorn group sediments and is comprised of two confined or in place semi-confined aquifers (Figure 6). The Sandstone Aquifer present in Lee County and Collier County north of Alligator Alley and the mid-Hawthorn aquifer underlie Collier County (Dames and Moore, 1997).

Physical and Geological Description

The Sandstone Aquifer is composed of sandy limestone, dolomites, and sandstone up to 100 feet thick and is possibly part of the Peace River Formation. The aquifer slopes southeastward, gradually thinning out. The transmissivity is generally below 100,000 gpd/ft with hydraulic gradients ranging from 0.5 feet per mile to 5 feet per mile. A recharge zone exists northeast of Immokalee. The iron content is relatively low and the chloride concentrations are usually less than 600 mg/L. Increases in hardness and alkalinity occur as one moves toward the coast. Water quality is described overall as good. Within Collier County, the direction of water flow in most confined layers is southwestward (Dames and Moore, 1997).

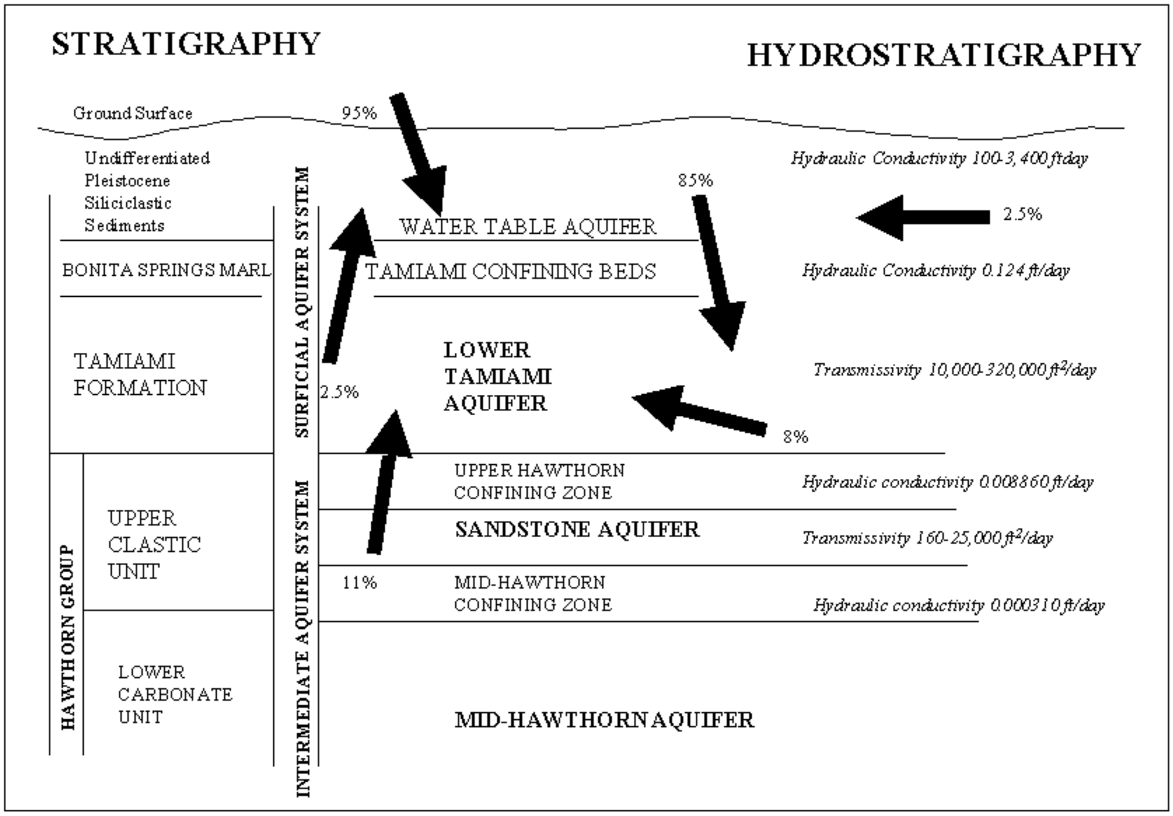
Limestone and dolomites from the Acadian Formation comprise the mid-Hawthorn Aquifer. Transmissivities are less than 50,000 gpd/ft. The mid-Hawthorn averages 100 feet in thickness with highly mineralized water. High levels of chlorides, calcium, magnesium, and sulfate are present within this aquifer. The mid-Hawthorn slopes toward the east-southeast and is under sufficient hydrostatic pressure to produce artesian conditions for wells drilling into this aquifer (Dames and Moore, 1997).

Mean water-quality parameters meet state drinking water standards with the exception of lead and total dissolved solids. Total dissolved solids in the Intermediate Aquifer range from 47 mg/L to 4188 mg/L within the SFWMD. Contact of water with carbonates and chemically unstable silicates (e.g. clays, opal), as well as saline intrusion are probable sources of high total dissolved solids (Florida Department of Natural Resources, 1992). **Table 31** provides a summary of the water-quality data by decade for various water-quality parameters of the Intermediate Aquifer. The data from which **Table 31** was developed are specific to the South Florida study area and reflect changing water quality conditions over time. **Figure 6** illustrates the Surficial and Intermediate Aquifer formations and confining layers.

3.3. Floridan Aquifer

The Floridan Aquifer within the study area is characterized by low hydraulic potential, low flushing, and saline intrusion from long contact/high dissolution of base strata of aquifer and coast (Florida Geological Survey, 1992). It is composed of Tampa Formation sediments and is connected to the underlying Suwannee and Ocala Limestone, and Avon Park, Oldsmar, and Cedar Keys Formations. It is separated from the Intermediate Aquifer through confining sediments of the Hawthorn Group. The transmissivity ranges from 75,000 to 450,000 gpd/ft in the upper areas of the Floridan. Water quality has been described as brackish, degrading with depth and towards the coast (Dames and Moore, 1997).

Mean chloride levels for Floridan Aquifer wells within the SFWMD exceed the states MCLs for drinking water. Median levels are 419.6 mg/L and the state standard is 250 mg/L. Median levels of total dissolved solids also exceed state standards (Florida Department of Natural Resources, 1992). **Table 32** provides a summary of the water-quality data by decade for various water-quality parameters of the Floridian Aquifer. The data from which **Table 32** was developed are specific to the South Florida study area and reflect changing water quality conditions over time. **Figure 7** illustrates the potential recharge areas of the Floridian Aquifer (Florida Geological Survey, 1992).



Source: Gibson et al., 1993

Figure 6. Surficial and Intermediate Aquifer Formations and Confining Layers.

TABLE 31. SUMMARY OF WATER-QUALITY DATA FOR THE INTERMEDIATE AQUIFER

		1970-1980					1980-1990					1990-1998				
WQ Parameters	**Units**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**	**Obs**	**Mean**	**Min.**	**Max.**	**% Exc**
Temperature	deg. C	No Data					91	25.4	23.2	27.6		227	25.43	19.5	29.3	
PH	std pH						91	7.3	6.6	8.3		2	7.2	7.1	7.3	
Calcium	mg/L						83	68.8	15	478	0	10	53	44.3	62.5	0
Magnesium	mg/L						N/A									
Sodium	mg/L						83	179.6	31.4	538	0	10	101.9	69.5	344	0
Potassium	mg/L						83	13.3	2.4	46.9	0	10	8.71	7	15.7	0
Iron	mg/L						81	453.2	30	9720	33.3	47	555.5	3	7600	19.1
Mercury	mg/L						5	0.1	0.1		100	37	0.1	0.1	79	100
Lead	mg/L						55	8.8	0.3	152	25.5	37	8.65	0.1	79	29.7
Alkalinity	mg/L						83	246.2	134	445	0	10	254.1	237	277	0
Sulfate	mg/L						78	106.8	4.7	1754	0	10	38.53	14	113	0
Chloride	mg/L						83	245.8	24.8	846	31.3	10	115.4	46.2	535	10
Phosphate	mg/L						11	0.06	0	0.25	18.2	10	0.05	0	0.18	30
Fluoride	mg/L						83	0.86	0.1	3.6	9.6	10	1.08	0.24	4.95	10
Nitrate	mg/L						77	0.01	0	0.07	0	9	0.01	0	0.03	0
TDS	ug/l						81	805.3	46.6	3329		36	715.6	258	2520	0
Conductivity	micromho						90	1315	431	3801	35.6	228	1191	257	3345	25.4
Total Carbon	mg/L						58	20	0.1	71	31	15	6.95	1.8	19	0
Synthetic Organics	g/l						650	65	65	65	0.15	260	5.74	5	19	0.4
Arsenic	ug/l						50	1.15	0.1	4.6	0	37	1.41	1	4	0
Pesticides	g/l						44	1.63	1.63	1.63	45.5	12	60.23	60.2	60.2	41.7

TABLE 32. SUMMARY OF WATER-QUALITY DATA FOR THE FLORIDIAN AQUIFER

WQ Parameters	Units	1970-1980 Obs	Mean	Min.	Max.	% Exc	1980-1990 Obs	Mean	Min.	Max.	% Exc	1990-1998 Obs	Mean	Min.	Max.	% Exc
Temperature	deg. C	No Data					41	27.1	24.9	28.8		79	26.79	21	31	
pH	std pH						40	7.25	6.6	7.8	0	2	7.45	7.4	7.5	0
Calcium	mg/L						36	92.66	28	170	0	9	98.9	47.7	164	0
Magnesium	mg/L						N/A					N/A				
Sodium	mg/L						36	534.9	60.3	931	0	9	576.6	347	716	0
Potassium	mg/L						36	25.84	4.53	33.9	0	9	27.96	23.3	34.7	0
Iron	mg/L						35	81.14	20	350	2.9	14	83.71	10	310	7.1
Mercury	mg/L						3	0.1	0.1	0.1	100	5	0.1	0.1	0.11	100
Lead	mg/L						21	1.02	0.3	3.1	0	5	1.4	1	3	0
Alkalinity	mg/L						36	170.7	116	287	0	9	173.4	114	213	0
Sulfate	mg/L						34	389.4	5.2	611	0	9	391.6	272	583	0
Chloride	mg/L						36	878.5	380	1335	100	9	818.1	167	1318	77.8
Phosphate	mg/L						9	0.01	0	0.01	0	9	0.01	0	0.02	0
Fluoride	mg/L						36	1.98	1.12	4.03	58.3	9	3.13	0.6	6.18	44.4
Nitrate	mg/L						32	0.01	0	0.06	0	9	0.06	0	0.46	11.1
TDS	ug/l						36	2190	1	3039	0	13	2036	197	2988	0
Conductivity	micromho						41	3071	1769	4920	100	79	4006	460	5100	98.7
Total Carbon	mg/L						23	6.93	0.9	48	8.7	3	1.53	1	1.9	0
Synthetic Organics	g/l						219	65	65	65	0.46	30	6.32	5	7	0
Arsenic							19	0.94	0.1	1.7	0	5	3.4	1	10	0
Pesticides	g/l						11	1.7	1.7	1.7	45	N/A				

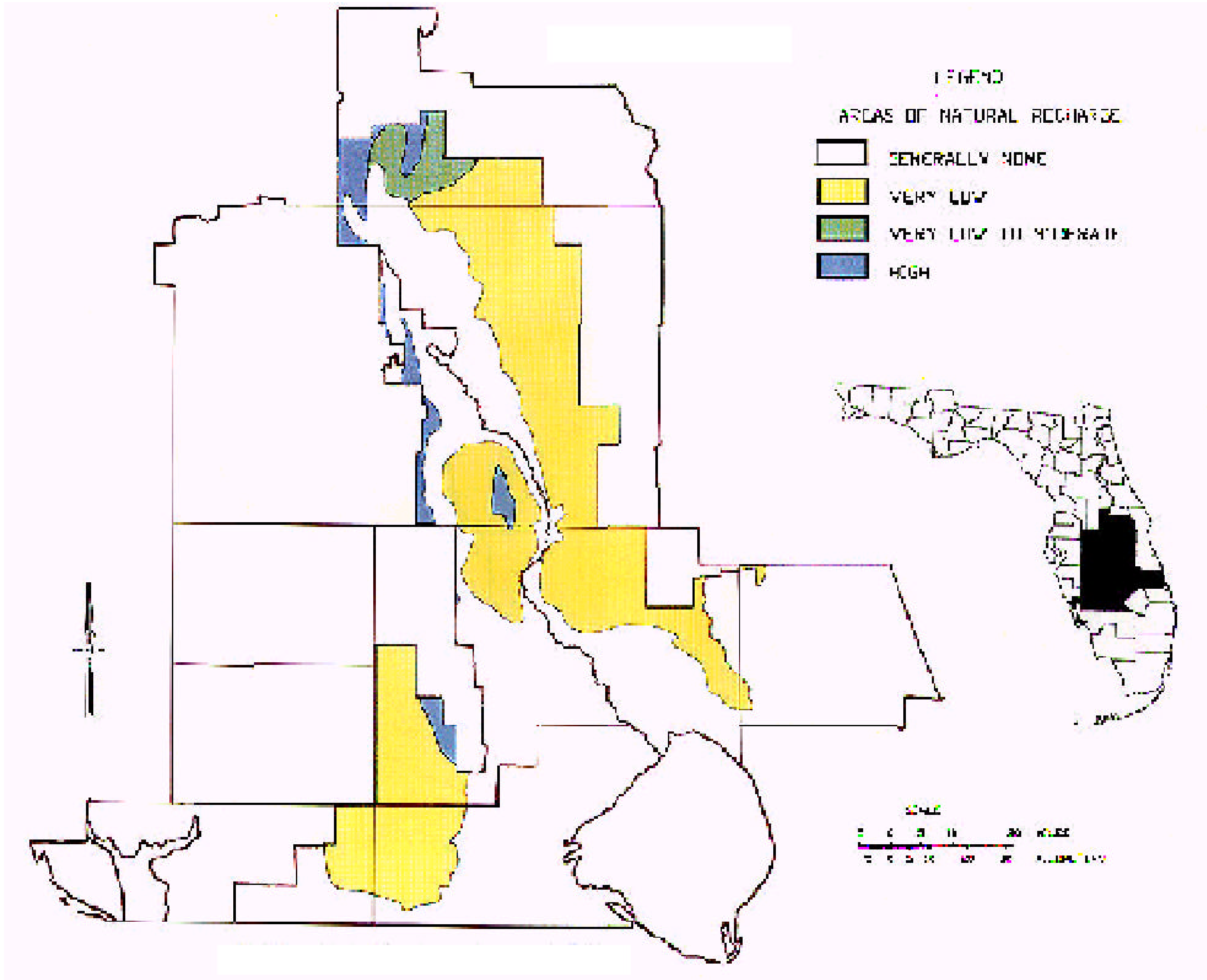


Figure 7. Recharge Potential of the Floridan Aquifer (Source: Florida Department of Natural Resources, 1992).

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