North Palm Beach County Pollution Loading and Abatement Analysis

Model Selection Report

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1.0 INTRODUCTION

The North Palm Beach County Pollutant Loading and Abatement Analysis project area (project area) encompasses a total area of approximately 765 square miles along the southeastern coast of Florida extending inland to the eastern shore of Lake Okeechobee. The project area includes the historic watershed of the Loxahatchee River and the Lake Worth Lagoon. The project area has experienced dynamic land use changes and rapid population growth since the 1940's with no indications that this pattern will come to an end any time soon. The natural landscape and hydrology of the project area has undergone significant alterations associated with population growth and urban and agricultural development. Many of these changes in the landscape and hydrology were implemented to support this population growth.

Starting in the 1940's, the federal government and the State of Florida began construction of the Central and South Florida Project (C&SF) to develop a complex and interconnected system of reservoirs, canals, levees and control structures intended to provide for the various water related needs of south Florida including drainage for land reclamation, flood control, water supply management and recreation. While the C&SF has done a commendable job of fulfilling its original intended purposes, there have been related negative environmental consequences as well. Diminished or re-routed flows, altered hydroperiods of too little or too much water at the wrong times, elimination of habitat for wildlife, and diminished water quality are some of the negative consequences associated with growth in south Florida and construction of the C&SF.

In light of this situation, the State of Florida and the United States Army Corps of Engineers have undertaken an ambitious plan to address some of these negative environmental impacts while at the same time addressing the continuing water related needs confronting south Florida. The Comprehensive Everglades Restoration Plan (CERP) lays out an organizational framework, a conceptual plan and a timetable to achieve environmental restoration while simultaneously constructing the necessary infrastructure to support continued population growth in south Florida. The popular CERP mantra of "Getting the Water Right" implies that by providing the right quantities of the right quality water at the right times and the right places we will be able to achieve the multiple and sometimes competing objectives of CERP. Getting the water right will involve the planning, design and construction of roughly 68 individual components including above and below-ground water storage reservoirs, stormwater treatment areas, canal improvements, new pumps and water control structures, and aquifer storage and recovery wells (United States Army Corps of Engineers, 1999). The total cost to implement this plan over the next 30 to 40 years will likely exceed $12,000,000,000.

To facilitate the design, construction and operation of these CERP components, they have been clustered into particular geographic regions and time frames that are commonly referred to as Projects. A CERP Project is planned, designed and will be built under the guidance of a Project Delivery Team (PDT) that is composed of engineers, planners and scientists from numerous federal, state and local agencies. It is the job of these PDTs to ensure that the projects to be built will achieve the numerous design objectives set forth in the CERP.

The CERP North Palm Beach County Project, Part 1, (NPBC Project) is one of these CERP projects. The NPBC Project as currently envisioned is an assemblage of the following six components:

- L-8 Basin Modifications (Component K, Phase 1)
- C-51 and L-8 Basin Reservoir (Component GGG)
- C-17 Backpumping and Treatment (Component X6)

- C-51 Backpumping and Treatment (Component Y)
- Lake Worth Lagoon Restoration (Other Project Element)
- Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration (Other Project Element)

Some of the intended purposes of these components will be to operate them in an integrated manner to achieve the following:

- Prevent excess stormwater from being discharged to the Lake Worth Lagoon in harmful amounts and frequencies
- Capture this excess stormwater in surface water impoundments such as the proposed C-51 / L-8 reservoir and the Grassy Waters preserve (West Palm Beach Water Catchment Area) for use at a later time
- Re-direct or restore sufficient quantities of flow to the Loxahatchee Slough and Loxahatchee River for environmental benefits by improving the hydrologic connection of the Grassy Waters with the slough and river
- Provide increased water storage capacity, water conveyance and water supplies for the North Palm Beach County Improvement District
- Provide for improved flood control in areas currently receiving insufficient protection

1.1 Purpose of this Project

A great deal of planning, hydrologic modeling and preliminary design work is underway at the federal, state and local level to identify the most cost effective ways to achieve these objectives with the components listed above. Significant attention is being directed at how to get the quantity, timing and distribution of water right for the North Palm Beach County Project.

An outstanding critical question regarding the NPBC Project that must be addressed is how the efforts to alter the current hydrology of the project area will affect surface water quality. The Florida Department of Environmental Protection is the state agency responsible for issuing water quality certification for proposed CERP components. To the extent that construction and operation of the NPBC Project will direct new sources of water with unknown water quality characteristics to new locations, FDEP requires reasonable assurance that these changes will not cause or contribute to violations of state water quality standards immediately downstream of discharges or in the receiving waterbodies of importance such as the Grassy Waters Preserve (West Palm Beach Water Catchment), the Loxahatchee River and Estuary, and Lake Worth Lagoon. In addition, where opportunities exist to plan, design and operate CERP components to help address existing water quality problems, FDEP may encourage the PDT to optimize those water quality restoration opportunities where possible relative to other project goals and objectives.

The purpose of the North Palm Beach County Pollutant Loading and Abatement Analysis is to provide FDEP with the following:

- A technically based understanding of the current surface water quality conditions and water quality concerns within the study area that may be affected by implementation of the NPBC Project

- A surface water quality analysis / modeling tool that helps identify how the proposed NPBC Project may affect water quality within the project area in positive and negative ways.
- An identification of current internal and external loads and concentrations of nutrients and total suspended solids that move through the NPBC project area and are delivered to downstream receiving waterbodies.
- An identification of appropriate or optimum loads and/or concentrations of nutrients and total suspended solids that would be protective of critical waterbodies within the study area such as the Grassy Waters Preserve, Loxahatchee River and Loxahatchee Estuary.

Note that in this particular work, optimum loads and/or concentrations of nutrients and total suspended solids for Lake Worth Lagoon will not be determined. Since, the CERP project has as a specific goal the reduction of TSS loads and flow to Lake Worth Lagoon, it is assumed that the project will address the question of how much reduction is enough.

1.2 Purpose of this Report

One of the deliverables for this project is a "Report of Model Selection Findings" in which the contractor shall document all activities described in Task 2 of the Scope of Work. Task 2 activities are as follows:

Task 2.1 Develop Conceptual Model

Contractor shall develop a conceptual model of the watershed on the basis of site inspections and existing information. The conceptual model shall describe the general physical setting, hydrologic system and chemical characteristics of the watershed. The conceptual model shall also include a discussion of land use, likely pollutant sources, and model calibration target criteria.

Task 2.2 Review of EPA Approved Models

Contractor shall compare model codes approved by EPA for loading analyses to the conceptual model and data available for model construction. The review should identify those models that should be eliminated from further consideration. The review shall include a short list of those models that may be applicable to the watershed conditions and pollutants of concern.

Task 2.3 Discussion of Merits and Drawbacks, Capability to Handle Critical Conditions

Discuss the merits, drawbacks and capability to handle critical conditions of each model on the short list of EPA approved models.

Task 2.4 Model / Method Recommendation and Justification

Contractor shall recommend and justify a specific model or method for determining the loading analysis on the basis of the merits discussed in Task 2.3.

1.3 Report Structure

The remainder of this report fulfills the requirements for Tasks 2. A through D. Section 2 describes the general physical setting of the project area. Section 3 provides a Conceptual Model of the North Palm Beach County Project Area. Section 4 provides a description of available EPA approved models that were considered. Section 5 identifies the model selection criteria that were used to determine the best available model. Section 6 provides a comparison of the model selection criteria with the list of EPA approved models. Section 7 is a discussion of the selected models, their characteristics, merits and drawbacks to handle the critical factors at work within the project area. Section 8 provides a discussion of the calibration and validation approach and describes some of the methods to determine the relative accuracy of the model. Section 9 provides a summary for this Model Selection Report.

2.0 WATERSHED DESCRIPTION

2.1 General Physical Setting

The Northern Palm Beach County Pollutant Loading and Abatement Analysis project area is located in southeastern Florida between Lake Okeechobee on the west and the Atlantic Ocean on the east (Figure 2.1). The project area covers an area of approximately 765 square miles and connects Lake Okeechobee to the Atlantic Ocean via a system of canals that includes the L-8 Canal, the C-51 or North Palm Beach Canal, and the M-Canal. The project area also includes the historic watershed of the Loxahatchee River.

2.1.1 Climate

According to the Koppen Climate classification scheme, the climate of the project area is predominantly Tropical Savanna, with a small portion of Humid Subtropical climate along the western edge (Fernald, 1998). A tropical savanna climate is characterized by distinct wet and dry seasons that are indirectly associated with the migration of the intertropical convergence zone. The wet season is typically from May through October when precipitation occurs in the form of convective thunderstorms, while the dry season runs from November through April. Average annual rainfall within the Loxahatchee River watershed is approximately 61 inches. Approximately two-thirds of that amount (40.6 inches) falls during the wet season. The highest average monthly rainfall is 8.7 inches in September, and the lowest is 2.3 inches in December (SFWMD 2002a). In addition to seasonal rainfall, the tropical savanna and humid subtropical climates are characterized by warm temperatures, high humidity and high rates of evapotranspiration. Hurricanes can exert an infrequent but significant influence on seasonal and annual rainfall totals.

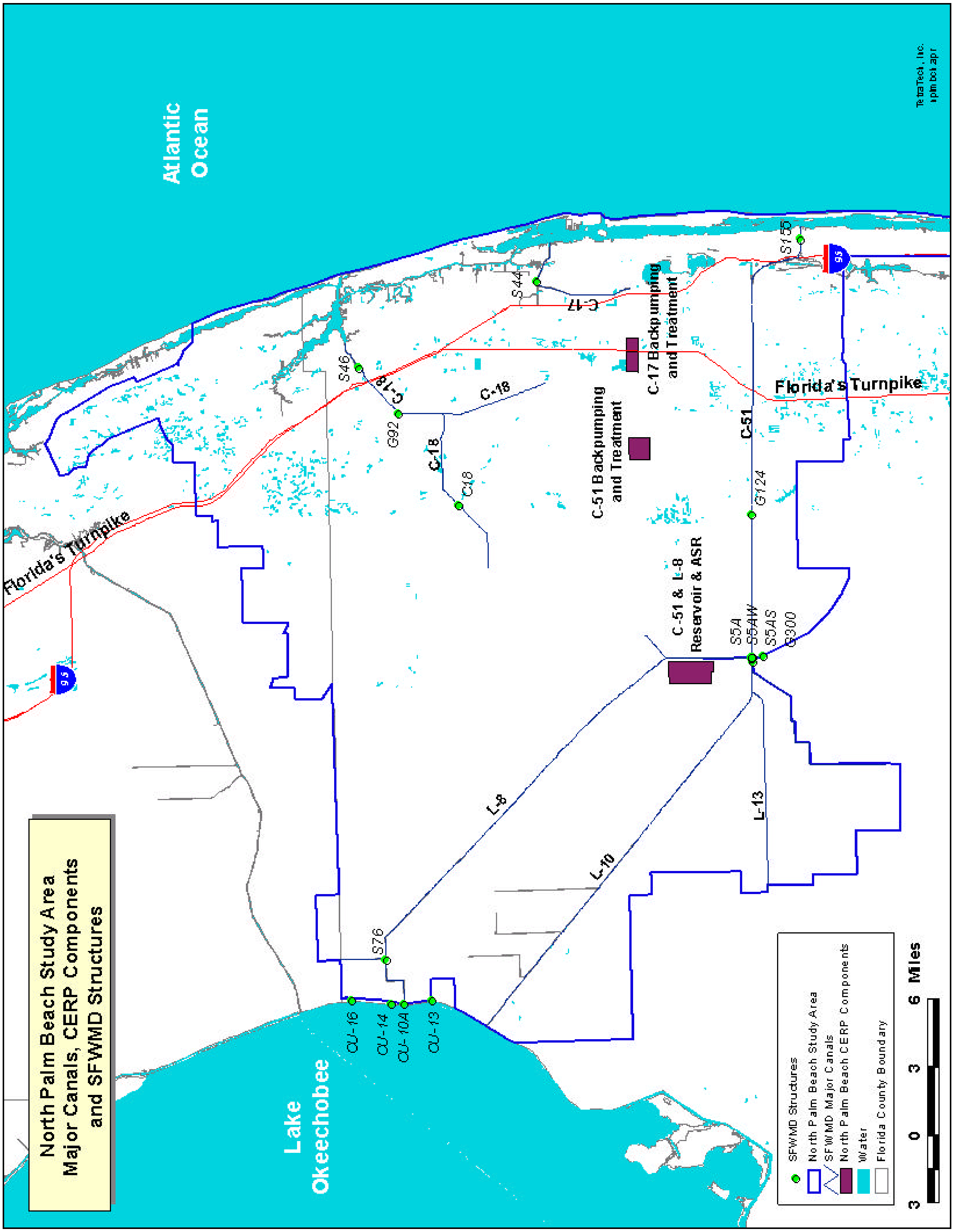
2.1.2 Topography

As with most of southern Florida, the topography of the project area is relatively subdued. Elevations within the Project Area range from a high around 35 feet in a few isolated places along the western shore of Lake Worth Lagoon to sea level. The drop in elevation from the western edge of the Project Area at Lake Okeechobee to the coast is roughly 20 feet.

2.1.3 Land Use

Land uses with the Project area are a mixture of urbanized, wetland and open waters, forest and range, and agricultural lands (Table 2.1). Figure 2.2 displays land uses within the project area in 1995. As the figure shows, the eastern portion of the project area is heavily urbanized, particularly along the coast from Jupiter and the Loxahatchee Estuary southward to Lake Worth Lagoon. Moving westward from the coast, land uses begin to transition into residential areas with the exception of the Grassy Waters Preserve or West Palm Beach Water Catchment area which shows up as a large rectangle of wetlands running north-south approximately 5 miles inland from Lake Worth Lagoon. West of the Grassy Waters Preserve there is a large area of residential land uses that rapidly transitions into a strip of agricultural land along the L-8 Canal on the margins of the Everglades Agricultural Area. Within the northwestern, north central and northeastern portions of the Project Area there are still large tracts of natural areas consisting of upland forests, wetlands and open water. These natural areas are the J.W. Corbett Wildlife

Figure 2.1 Northern Palm Beach County Pollutant Loading and Abatement Analysis Project Area

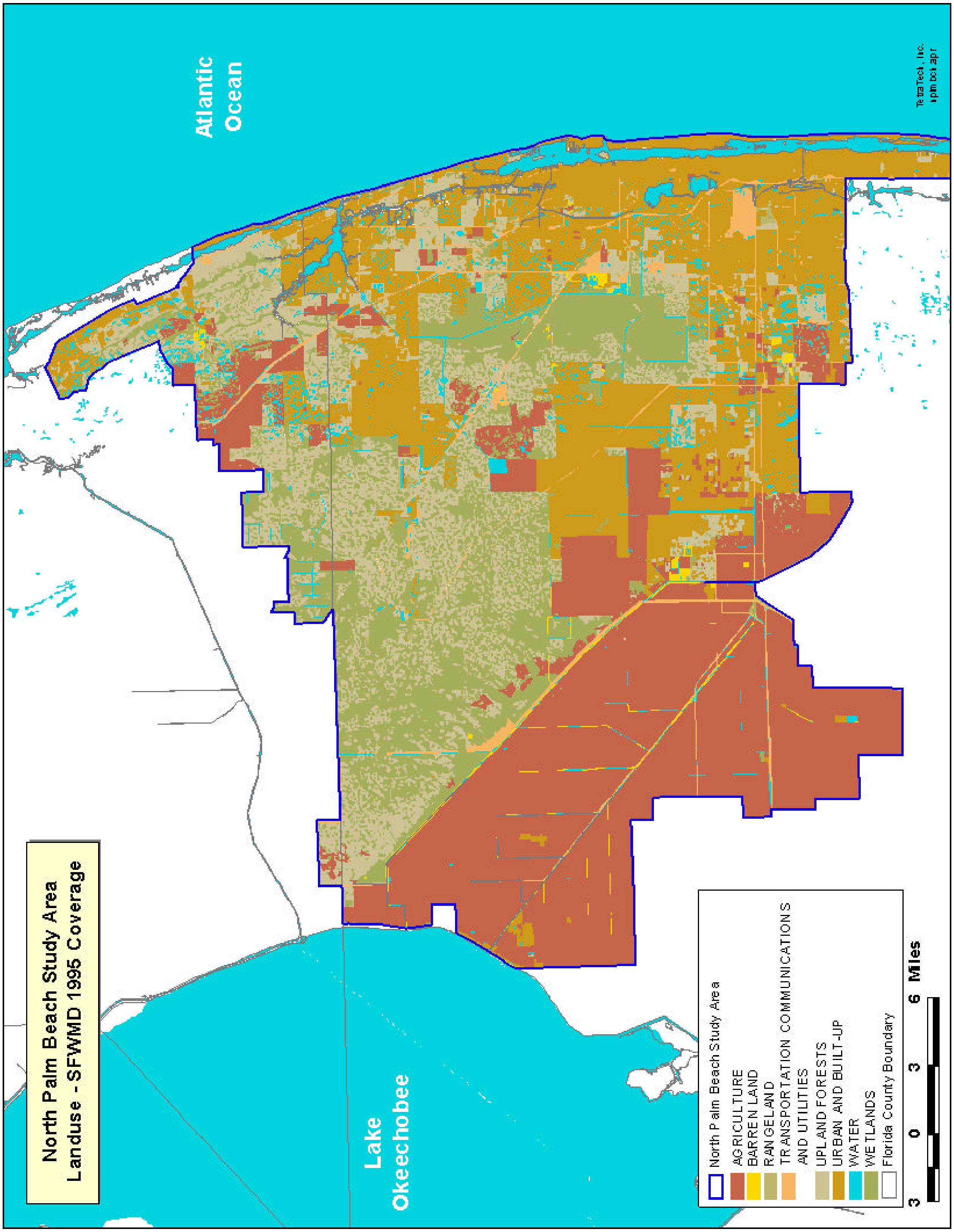


Management Area, the DuPuis Reserve in the northwest, the Pal Mar basin in the north central, the Loxahatchee River and Estuary and Jonathan Dickinson State Park in the northeast.

Table 2.1 1995 Land Uses within the Project Area

Primary Basin	Urban/Built and Transportation		Forest/Range/Barren		Agriculture		Water and Wetlands		Totals	
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Basin 2	3763	42%	2480	28%	410	5%	2340	26%	8993	2%
C-17	15602	74%	3200	15%	319	2%	2077	10%	21198	4%
C-18	11101	16%	24025	35%	5409	8%	28016	41%	68552	14%
C-51	67898	63%	12261	11%	18043	17%	9869	9%	108071	22%
Intracoastal	90501	84%	10293	10%	650	1%	6037	6%	107481	22%
Jonathan Dickinson	6219	16%	13842	37%	9222	24%	8530	23%	37812	8%
L-8	7615	9%	22223	25%	16834	19%	42123	47%	88795	18%
Loxahatchee River	989	75%	183	14%	7	1%	146	11%	1325	0%
Pal Mar	9	0%	7574	41%	429	2%	10598	57%	18610	4%
South Indian River	9400	58%	3876	24%	1283	8%	1543	10%	16102	3%
W.P.B. Water	133	1%	1015	8%	0	0%	11541	91%	12689	3%
Totals	213230	44%	100972	21%	52606	11%	122820	25%	489628	

Figure 2.2 Land Uses Within the Project Area



2.2 Hydrology

Section 2.2 describes surficial hydrology and Section 2.3 briefly describes groundwater hydrology within the project area.

2.2.1 Historic Drainage and Modifications

Original pre-disturbance flow patterns within the project area have been altered with the construction of roads, levees, canals and water control structures. Construction of the Central and Southern Florida Project began in the 1940's and gradually established an intricate network of canals and water control structures that have significantly altered historic flow patterns and hydroperiods throughout south Florida. Some areas in the vicinity of what is now the Grassy Waters Preserve that originally provided flows to the Loxahatchee Slough during wet years have been cut-off from their downstream segments, while other inland areas that historically flowed to the south and southwest as part of the greater Everglades ecosystem now discharge large pulses of freshwater to Lake Worth Lagoon (SFWMD 2002b). As early as the 1920's hydrologic alterations were occurring in the Loxahatchee River watershed that redirected flows from the Northwest Fork to the Southwest Fork. Since that time, numerous other efforts to control the movement of water within the watershed have resulted in diminished flows to the Northwest Fork of the Loxahatchee River and modified flows to the Loxahatchee Estuary. In addition to altering flow directions, the construction of canals to allow drainage for land reclamation has had noticeable effects on local surface water levels. Construction of the C-18 Canal in 1958 and the resultant drainage of the Loxahatchee Slough has reduced the amount of storage capacity within the C-18 Basin and diminished the base flow to the Northwest Fork of the Loxahatchee River. Where the historic watershed of the Loxahatchee was approximately 270 square miles in total area, it has now been reduced to an area of approximately 210 square miles (SFWMD 2002a).

2.2.2 Current Drainage

2.2.2.1 Canals and Structures

Within the project area there are four primary canals, several water control structures, and numerous locally managed secondary and tertiary canals that provide for drainage, flood control, water supply management, and salinity management. Moving from west to east to north, the primary canals managed by SFWMD include the L-8 Canal, the C-51 or West Palm Beach Canal, the C-17 Canal and the C-18 Canal. The L-8 Canal directs flows to the west into Lake Okeechobee and to the southeast into the C-51 Canal. The L-8 Canal also connects to the City of West Palm Beach M Canal via the L-8 Tieback and can convey water eastward to the Grassy Waters Preserve (USACE L-8 GRR Summary). The C-51 Canal drains the C-51 Basin and discharges to Lake Worth Lagoon via the S-155 structure. The C-17 Canal drains an area along the coast in the vicinity of Riviera Beach and North Palm Beach and discharges to Lake Worth Lagoon via the S-44 structure. The C-18 Canal drains the Loxahatchee and Hungryland Sloughs and can discharge high flows directly to the Southwest Fork of the Loxahatchee River via the S-46 structure (SFWMD 2002a).

Secondary and tertiary canals are typically owned and operated by local drainage districts and water control districts or more localized entities and are employed to provide drainage and flood control. These systems discharge to the primary canal system when necessary. The M Canal is owned and operated by the City of West Palm Beach and collects and routes water supplies to the Grassy Waters Preserve.

The most important water control structures within the project area may be the proposed structures and canal improvements as described in the NPBC Project and the NPBC Comprehensive Water Management Plan. These proposed features will have a significant positive impact on the quantities and directions of surface water flows within the project area from a water supply and flood control perspective. The remaining question is to what extent these modifications may affect surface water quality. These proposed features are discussed in more detail in the conceptual model presented in Section 3.

2.2.2.2 Inflows and Outflows

The only significant inflows to the project area from external sources come via the L-8 Canal or the L-10 / L-12 Canals. During dry periods, water may be drawn from Lake Okeechobee for water supply purposes such as wellfield replenishment, replenishment of the Grassy Waters Preserve for the City of West Palm Beach, or for control of salinity intrusion along the coast. During extreme wet periods water may be released from Lake Okeechobee to assist in maintaining the water level regulation schedule for the lake (SFWMD 2000).

Outflows from the project area are directed to the Lake Worth Lagoon via the S-155 and S-44 structures. Additional outflows from the Loxahatchee River watershed are directed to the Loxahatchee Estuary via the Northwest Fork or via the Southwest Fork along the C-18 Canal.

2.2.2.3 Hydrographic Subdivisions

Within the project area there are numerous ways to delineate hydrographic boundaries and subdivisions.

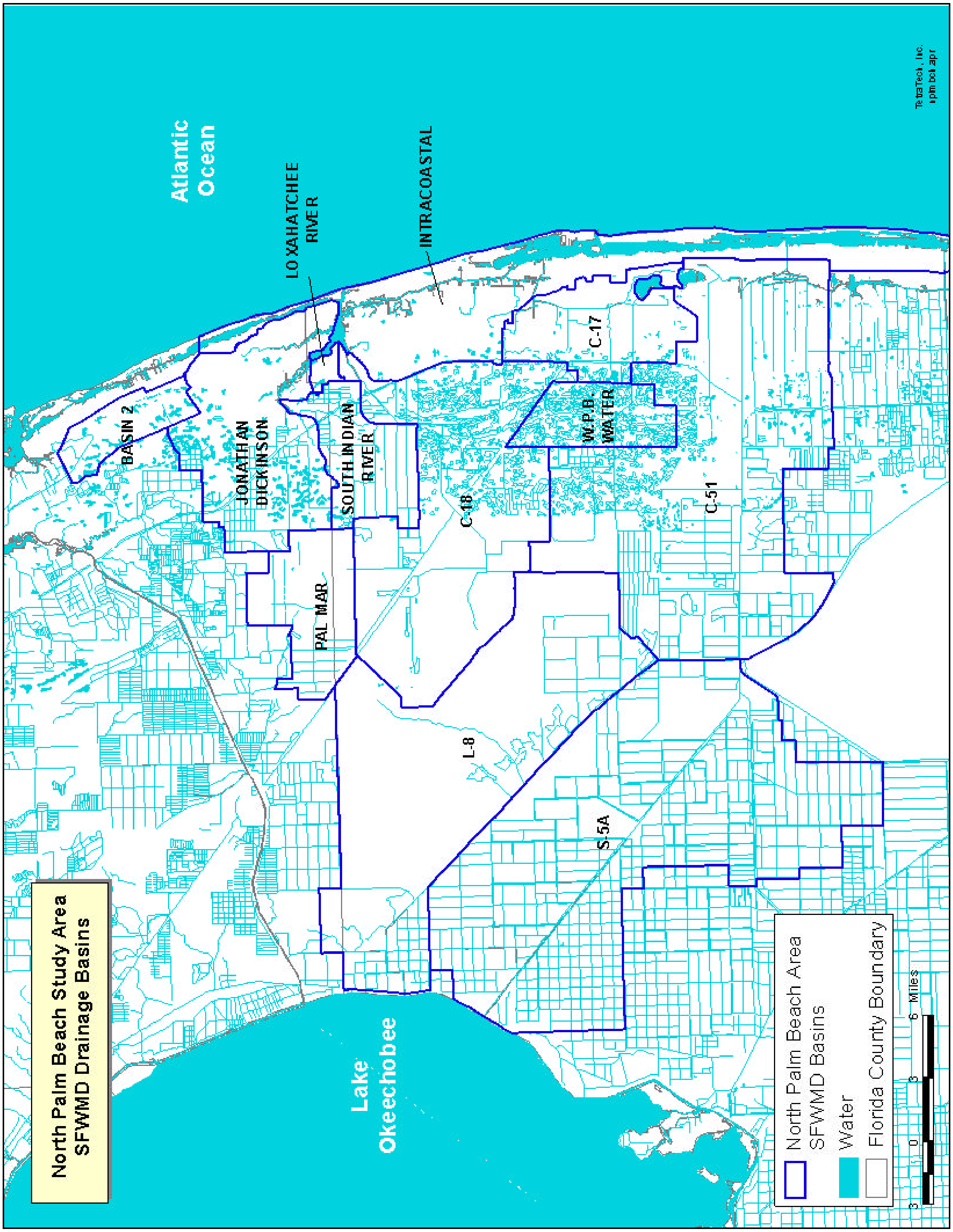
2.2.2.3.1 SFWMD Drainage Basins

There are 11 primary drainage basins within the Project Area (Table 2.2 and Figure 2.3). The C-51 is the largest basin, followed by the Intracoastal, L-8, C-18, Jonathan Dickinson, C-17, Pal Mar, South Indian River, West Palm Beach Water Catchment Area, Basin 2 and the Loxahatchee River. The S-5A Basin is also shown in Figure 2.3 as it is the likely location for the proposed L-8 / C-51 reservoir.

Table 2.2 Primary Drainage Basins within the Project Area

Primary Basin	Drains to:	Totals		
		Acres	**Sq. Miles**	**%**
C-51	Lake Worth Lagoon	108071	169	22.1%
Intracoastal	Lake Worth Lagoon	107481	168	22.0%
L-8	C-51 or Lake Okeechobee	88795	139	18.1%
C-18	NW or SW Fork of Loxahatchee River	68552	107	14.0%
Jonathan Dickinson	NW Fork or Loxahatchee Estuary	37812	59	7.7%
C-17	Lake Worth Lagoon	21198	33	4.3%
Pal Mar	NW Fork of Loxahatchee River	18610	29	3.8%
South Indian River	NW Fork of Loxahatchee River	16102	25	3.3%
W.P.B. Water Catchment Area	C-17, C-51 or C-18	12689	20	2.6%
Basin 2	Jonathan Dickinson	8993	14	1.8%
Loxahatchee River	Loxahatchee Estuary	1325	2	0.3%
Totals		**489628**	**765**	

Figure 2.3 Map of Drainage Basins within the Project Area



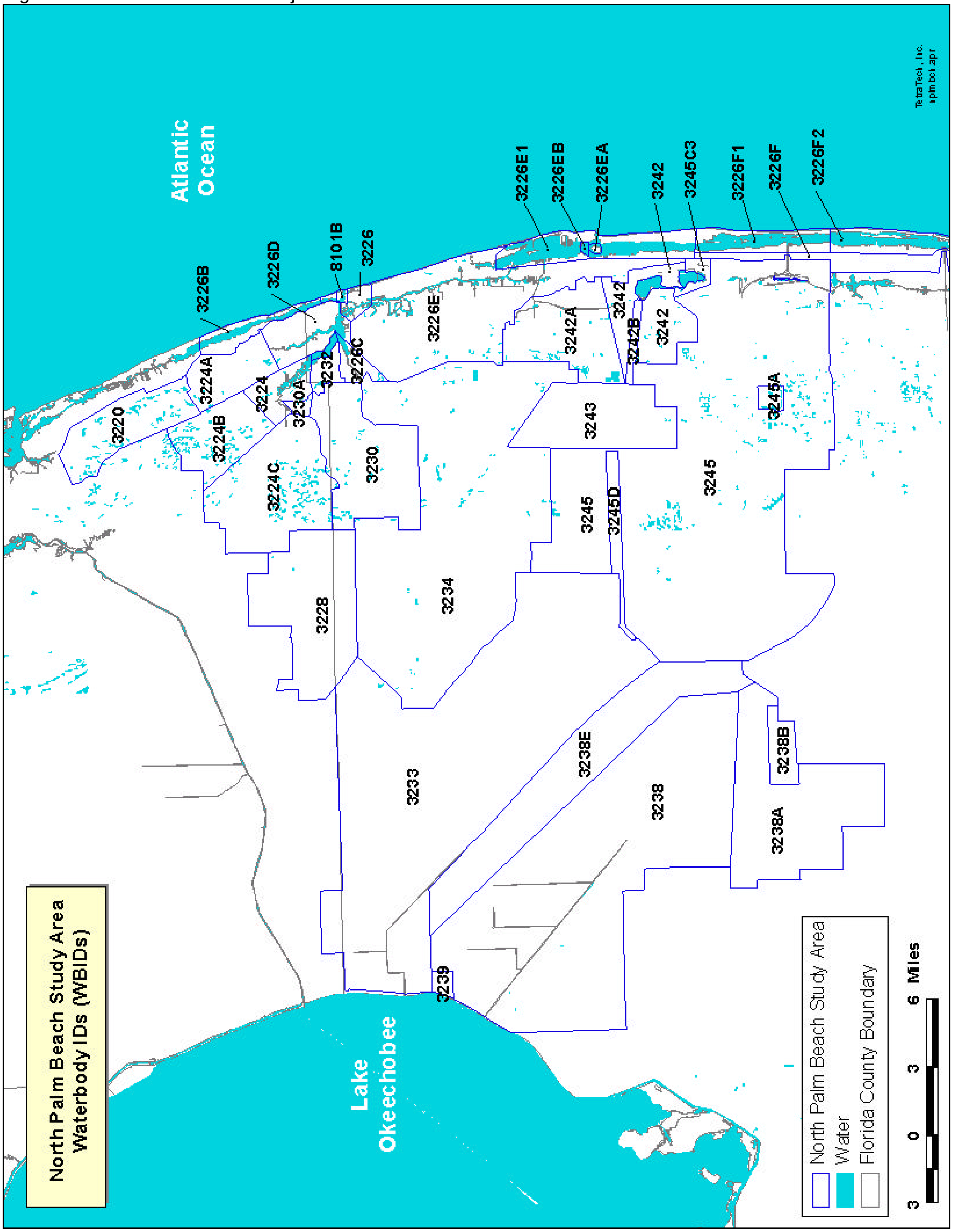
2.2.2.3.2 FDEP Basins, Planning Units and Waterbody Identification Units

The project area extends over three of FDEPs surface water watershed groups: the St. Lucie Loxahatchee Group 2 Basin, the Lake Worth Lagoon Palm Beach Coast Group 3 Basin, and the Everglades Group 5 Basin. Within these three watershed groups there are 8 Planning Units and 40 waterbody identification units (WBIDs). WBIDs are the basic unit for the determination of whether surface waterbodies are considered impaired relative to State of Florida water quality standards (62-302 and 62-303, F.A.C.). Table 2.4 provides a list of WBIDs within the project area and indicates their current status with regards to the FDEP Rotating Watershed Approach.

Table 2.3 Watershed Groups, Planning Units and WBIDs within the Project Area

Watershed Group	WBID Name	WBID #	Planning Unit	Class
Everglades	WEST PALM BEACH CANAL	3238		3F
Everglades	OCEAN CANAL	3238A		3F
Everglades	KNIGHTS FARM FIELD2	3238B		3F
Everglades	M CANAL	3238E		3F
Everglades	PELICAN LAKE DD	3239		3F
Lake Worth Lagoon - Palm Beach Coast	ICCW AB ROYAL PALM BRG	3226E	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	LWL NORTH SEGMENT	3226E1	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	PEANUT ISLAND	3226EA	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	PHIL FOSTER PARK	3226EB	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	ICCW AB POMPANO	3226F	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	LWL CENTRAL SEGMENT	3226F1	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	LWL SOUTH SEGMENT	3226F2	Intracoastal	3M
Lake Worth Lagoon - Palm Beach Coast	L-8	3233	L-8	3F
Lake Worth Lagoon - Palm Beach Coast	C-17 SEGMENT	3242	C-17	1
Lake Worth Lagoon - Palm Beach Coast	PB STATIONS/D CANALS	3242A	C-17	3F
Lake Worth Lagoon - Palm Beach Coast	M CANAL EAST	3242B	C-17	1
Lake Worth Lagoon - Palm Beach Coast	W.P.B. WATER	3243	WPB Water Catchment	1
Lake Worth Lagoon - Palm Beach Coast	C-51	3245	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	OKEEHEELEE PARK	3245A	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	LAKE CLARKE	3245B	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	LAKE MANGONIA	3245C1	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	CLEAR LAKE	3245C2	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	CLEAR LAKE DRAIN	3245C3	C-51	3F
Lake Worth Lagoon - Palm Beach Coast	M Canal West	3245D	C-51	1
St.Lucie – Loxahatchee	BASIN 2	3220	South St.Lucie -IRL	3F
St.Lucie – Loxahatchee	JONATHAN DICKINSON	3224	Loxahatchee	3M
St.Lucie – Loxahatchee	NORTH FORK LOXAHATCHEE	3224A	Loxahatchee	3F
St.Lucie – Loxahatchee	KITCHINGS CREEK	3224B	Loxahatchee	3F
St.Lucie – Loxahatchee	CYPRESS CREEK	3224C	Loxahatchee	3F
St.Lucie – Loxahatchee	JUPITER INLET	3226	Coastal	3M
St.Lucie – Loxahatchee	NW FORK LOXAHATCHEE	3226A	Loxahatchee	3M
St.Lucie – Loxahatchee	MARTIN CO. ICCW	3226B	Coastal	3M
St.Lucie – Loxahatchee	SW FORK LOXAHATCHEE	3226C	Loxahatchee	3M
St.Lucie – Loxahatchee	LOXAHATCHEE RIVER	3226D	Loxahatchee	3M
St.Lucie – Loxahatchee	PAL MAR	3228	Loxahatchee	3F
St.Lucie – Loxahatchee	FLOODPLN/JUPITER FARMS	3230	Loxahatchee	3F
St.Lucie – Loxahatchee	NW FORK LOXAHATCHEE	3230A	Loxahatchee	3F
St.Lucie – Loxahatchee	LOXAHATCHEE RIVER	3232	Loxahatchee	3F
St.Lucie – Loxahatchee	C-18	3234	Loxahatchee	1
St.Lucie – Loxahatchee	DUBOIS PARK	8101B	Coastal	3M

Figure 2.4 WBIDs within the Project Area



2.2.2.3.3 Waters Meriting Special Attention

Within the Project Area there are several surface water resources that merit special attention such as Outstanding Florida Waters (OFWs), Wild and Scenic Rivers, and Class II Shellfish Propagation and Harvesting areas.

According to the State of Florida water quality standards (62-302 F.A.C.), OFWs are to be afforded the highest protection from any water quality degradation, with very limited exceptions. Water quality conditions within OFWs should be maintained in a state similar to when the OFW was designated, which is March 1, 1979 unless otherwise indicated in 62-302.700(9) F.A.C.. Within the project area, the Loxahatchee River Aquatic Preserve and Jonathan Dickinson State Park are designated as OFWs.

A portion of the Northwest Fork of the Loxahatchee River was designated as a National Wild and Scenic River in 1985. The Wild and Scenic River corridor extends downstream for approximately 7.5 miles from Indiantown Road to Trapper Nelson's. This designation is a recognition of the unique aesthetic, environmental and recreational qualities of the Northwest Fork that deserve protection and continued attention from resource management agencies.

In addition to OFW and Wild and Scenic designation, portions of the Loxahatchee River and Estuary are designated as a Class II Shellfish Propagation or Harvesting Areas. The most significant issue for this project is that these waters have more stringent criteria for fecal coliform and total coliform bacteria than other classes of waters.

It should also be noted that the Grassy Waters Preserve (West Palm Beach Water Catchment Area), The M Canal from the L-8 Canal to Lake Mangonia, Lake Mangonia and Clear Lake, and the freshwater portion of the C-18 Canal are designated as Class I Potable Water Supplies. Class I designation provides more stringent criteria for numerous parameters such as priority pollutants. However, it does not provide more stringent criteria for parameters such as nutrients, total suspended solids or dissolved oxygen that may be significantly affected by implementation of the NPBC Project. On the other hand, the State of Florida's Impaired Waters Rule (62-303, F.A.C.) does allow for the designation of impairment for a Class I waterbody if treatment costs increase by at least 25% in order to treat contaminants that exceed Class I criteria or to treat blue-green algae or other nuisance algae in the source water.

2.3 Groundwater Hydrology

The high water tables and historic sheet flow patterns of surface water runoff within large portions of the project area make it important to have some understanding of the surface water and ground water relationships. The construction of canals, drainage ditches and water control structures that allow intricate water resource management for water supply, drainage and flood control have had a negative impact on pre-existing surficial hydrology. By intersecting the surficial aquifer, these canals allow for more rapid transportation of potential recharge water away from the surficial system, thus decreasing surficial storage capacity. While the aquifers within the project area are variable in their depths, transmissivities and other characteristics, some generalizations can be made (SFWMD 2002a).

The aquifers within the project area can be broken out into two major components with an intervening confining unit. The Surficial Aquifer System (SAS) is a shallow mixture of sands, limestone, shell beds and marl that is approximately 100 to 200 feet thick extending from the ground surface. The SAS is a primary source of potable water for most public utilities within the project area, provides water for agricultural irrigation, and provides base flows for wetlands and streams (SFWMD 2000). Recharge of the SAS is provided by rainfall and canals. The SAS is separated from the underlying Floridan Aquifer by several hundred feet of less permeable confining layers referred to as the Hawthorn Confining Zone. The Floridan Aquifer system consists of several layers of limestone of varying ages and within the project area it generally contains highly mineralized water that can only be used for potable supplies if desalinated (SFWMD 2002a). It is the Floridan aquifer that is being considered as a possible storage zone for surface water to be injected via Aquifer Storage and Recovery (ASR) wells.

In order to develop reasonably accurate surface water quality models within the project area, it will be important to have a watershed model that is sensitive to the surface water - ground water interactions described above.

2.4 Point and Non-Point Sources

Information from the EPA Permit Compliance System and FDEP's WAFR database has been collected to identify the significant point source discharges within the study area (Table 2.4). There are 11 active NPDES permitted discharges within the project area. There are 3 domestic wastewater treatment plants, 7 industrial wastewater discharges, and STA 1 East. The permitted discharges will be verified through discussions with FDEP staff from South District and other knowledgeable professionals familiar with the project area. Useful discharge data will be obtained and will be incorporated in the watershed model in a spatially distributed framework where appropriate. Depending on the identification of critical conditions as determined in the ongoing water quality analysis, discharges from point sources will be input to the system in the most appropriate time step based upon available flow and water quality information.

Table 2.4 Active NPDES Facilities

NPDES Facility Name	Facility Type	WAFR ID	Design Capacity	Permitted Capacity	Major / Minor	City
EAST CENTRAL REGIONAL WWTP	DW	13674	55	55	MA	WEST PALM BEACH
FPL RIVIERA PLANT	IW	13719			MA	RIVIERA BEACH
OSCEOLA POWER L P COGENERATION	IW	15036	0	0.33	MI	PAHOKEE
BILTMORE CONDOMINIUM ASSOCIATION	IW	16093	1	1	MI	PALM BEACH
PRATT & WHITNEY (INDUSTRIAL WASTE)	IW	13759			MA	WEST PALM BEACH
VILLAGE OF TEQUESTA RO CONCENTRATE DISPOSAL	IW	16857	1	1.3	MI	TEQUESTA
PALM BEACH AGGREGATES (FKA GKK) SAND/LIMESTONE MINE (GP)	IW	16908	5	5	MI	LOXAHATCHEE
EVERGLADES STA 1W	IW	17796			MI	N/A
LOXAHATCHEE ENV CONTROL DIST WWTP	DW	13678	9	9	MA	JUPITER
SEACOAST UTILITIES PGA WWTP	DW	13764	12	12	MA	PALM BEACH GRDNS
JUPITER WATER TREATMENT PLANT	IW	13680	2	2	MI	JUPITER

Based on the small number of discrete point source discharges, non point sources are likely to be the more significant contribution to system-wide nutrient and sediment loads. The modeling system for this project will have to be sensitive and well suited to variable non point source inputs. Non point sources will be represented in the modeling system as spatially distributed land uses using 1995 land use coverages.

3.0 CONCEPTUAL MODEL OF THE STUDY AREA

The purpose of a conceptual model is to represent the critical physical, hydrologic and chemical processes that influence water quality conditions within the project area. The conceptual model also provides a simplified representation of the system to facilitate development of a technical modeling approach that can capture the critical processes and help provide decision makers with a management tool to address the water quality issues at hand. In a complex and interconnected system such as this project area that may experience a wide range of hydrologic alterations as a result of implementation of the NPBC Project, a simplified conceptual model is a necessity. Information describing these conceptual components has been assembled from various sources including the Northern Palm Beach County Comprehensive Water Management Plan (SFWMD 2002b), the Lower East Coast Water Supply Plan (SFWMD 2000), the Loxahatchee Minimum Flows and Levels Analysis (SFWMD 2002a), the draft Project Management Plan for the North Palm Beach County Project (USACE 2002), and a summary of the L-8 Basin General Reevaluation Report (USACE 2001).

3.1 Conceptual Model Components

The water quality conceptual model for the project area contains 8 components that represent drainage basins or proposed CERP features associated with the NPBC Project (Figure 3.1). Basins and features are not represented to scale, but they are generally arranged in the proper spatial framework. The individual components and important information regarding them are described briefly in this section. Section 3.2 describes conceptual processes and interactions that occur between the various conceptual components. Section 3.3 discusses some of the critical questions and resources that must be considered when developing the technical modeling approach. Section 3.4 describes the basic recommended technical approach for this project.

3.1.1 L-8 Basin

The L-8 Basin is approximately 139 square miles in area and contains a mixture of wetlands, forest, agriculture and urban land uses. Surface water runoff from the Upper L-8 Basin is typically directed westward towards Lake Okeechobee and runoff from the southern L-8 Basin is directed southward to the C-51 Canal or eastward via the M-Canal. The ongoing L-8 General Reevaluation Report, the North Palm Beach County Comprehensive Water Management Plan and the NPBC CERP Project are considering alterative scenarios that will allow excess runoff from the L-8 Basin to be stored in the proposed C-51 / L-8 Reservoir to the northwest of the junction of the L-8 and C-51 Canals. Excess water stored in the new reservoir could be utilized by urban, agricultural or environmental demands and/or could be directed back into the L-8 and eastward to GWP. In addition to storage in the new reservoir, there are conceptual plans to improve the conveyance and pumping capacity linking the L-8 Tieback to the M-Canal thus allowing increased deliveries of L-8 discharges to the GWP. These waters could also be directed through the GWP to provide additional flows to the NW Fork of the Loxahatchee River.

3.1.2 C-51 Basin

The C-51 Basin is approximately 169 square miles in area and contains a mixture of urban, agriculture, forest and wetlands. Surface water runoff is directed to the east via the C-51 Canal and is discharged to Lake Worth Lagoon. There are plans to direct runoff from the western portion of the basin into STA 1 East once it is operational. In addition, excess water generated within the C-51 Basin could be directed westward to the proposed C-51 / L-8 reservoir. This water could be made available for urban, agricultural and environmental needs and could be conveyed to GWP via improvements to the L-8 Tieback and M Canal. Re-directing stormwater flows that now discharge to Lake Worth Lagoon will provide a direct benefit to the Lagoon. Another proposed improvement is to build a more direct connection between the C-51 Canal and the GWP by constructing the E-1 Canal and linking it to a proposed STA that would intercept and treat those flows prior to discharge into GWP.

3.1.3 C-51 / L-8 Reservoir

The C-51 / L-8 Reservoir is a proposed component of the NPBC Project (GGG) that could store up to 48,000 acre-feet of excess water in a combination above-ground and below-ground reservoir. This reservoir would provide critical water storage capacity for flows from the L-8 and C-51 Basins and thus reduce the frequency and severity of freshwater discharges to Lake Worth Lagoon. The reservoir would also improve the level of service for flood control by lowering stages in the C-51 and L-8 Canals. Stored water would be released from the reservoir in the dry season to provide supplemental supplies for urban, agricultural and environmental needs and could be directed to GWP via the M-Canal and ultimately to the NW Fork of the Loxahatchee River. Pilot scale testing of the feasibility of this reservoir is already underway at the Palm Beach Aggregates site which is also referred to as the L-8 Rock Pit or L-8 Pilot Water Storage Project.

3.1.4 C-51 Backpumping and Treatment

The C-51 Backpumping and Treatment is a proposed component (Y) of the NPBC Project with an intended goal to reduce water shortages and improve level of service for the North Palm Beach County Service Area by directing excess water in the C-51 Basin to the GWP. This would be accomplished by moving the S-155A structure eastward and improving conveyance along the E-1 canal to the proposed 600 acre C-51 STA prior to discharge into GWP.

3.1.5 Grassy Waters Preserve

The Grassy Waters Preserve (GWP), also referred to as the West Palm Beach Water Catchment Area is an undeveloped wetland approximately 20 square miles in area. The GWP is owned and maintained by the City of West Palm Beach and serves as a large surface water storage area for water supplies that can be released to Lake Mangonia and Clear Lake and the drinking water treatment facility there. Historically, GWP water has been replenished by rainfall and from surface water flows directed eastward along the M Canal. However, the interconnected array of components proposed in the NPBC Project proposes to enhance deliveries to GWP via the M Canal, the E-1 Canal and from the C-17 Basin. These new supplies would be treated by two new STAs, if deemed necessary, prior to discharge into GWP. Increased water supplies within GWP could be used for urban, agricultural or environmental needs. The G-161 structure along the northern edge of GWP will be constructed to provide improved connection and conveyance to allow water to be moved northward for multiple purposes including increased flows to Northwest Fork of the Loxahatchee River.

3.1.6 C-17 Backpumping and Treatment

Similar in concept to the C-51 Backpumping and Treatment component, this NPBC CERP component (X) would backpump excess surface water flows generated in the C-17 Basin westward through a 550 acre STA and into GWP. The goal is to reduce water restrictions within the North Palm Beach County Service Area and provide additional flows to the NW Fork of the Loxahatchee River

3.1.7 C-18 Basin

The C-18 basin is approximately 107 square miles in area and contains wetlands, forests, urban and agricultural land uses. This basin contains a significant portion of the historic Loxahatchee

River watershed and its hydrology has been altered by construction of the C-18 Canal which intercepts flows in the Loxahatchee Slough and Hungryland Slough and can divert them to the Southwest Fork of the Loxahatchee via G-92 and the S-46 structure. Planning and hydrologic modeling efforts have been undertaken to determine means to direct sufficient flows to the NW Fork of the Loxahatchee River via the C-14 Canal.

3.1.8 Loxahatchee River Watershed and Estuary

This conceptual component represents the remainder of the Loxahatchee River watershed (approximately 125 square miles) excluding the C-18 Basin. Flows to this component come externally from the C-18 Basin, and internally from the South Indian River, Pal Mar, Basin 2 and Jonathan Dickinson. Land uses within this component are a mixture of forest and wetland, some residential and urban lands, and some agriculture. Within this conceptual component is the proposed NPBC Project component referred to as the Pal-Mar and J.W. Corbett Wildlife Management Area Hydropattern Restoration (OPE). This component may create an improved connection between this basin and the Loxahatchee River and provide additional flows to the river. The most significant water resource issue within this conceptual component is adequate flows to control salinity intrusion within the Northwest Fork of the river. SFWMD has performed a detailed analysis of the watershed and developed hydrologic models to better understand sources and controls on freshwater inflows and the response of the salinity wedge within the Northwest Fork. This component contains the Loxahatchee River Aquatic Preserve Outstanding Florida Waters and an estuarine system with shellfish and seagrass communities.

3.2 Conceptual Processes and Critical Water Quality Questions

From a water quality perspective, there are several critical processes occurring within and between the conceptual components displayed in Figure 3.1. These critical processes include nutrient and sediment loads, concentrations and transport between components, nutrient uptake and sediment deposition within components, and the dynamic relationship between nutrient and sediment loads, concentrations and ecosystem response within critical water resources of the system. In addition, by directing flows to the Loxahatchee River and estuary that did not historically move in that direction, what water quality impacts if any may occur to the ultimate receiving waterbody of this proposed series of modifications? The circled numbers displayed in figure 3.1 represent these conceptual processes and locations that deserve attention from a water quality perspective as the NPBC Project is planned and designed.

1. External flows, loads and concentrations of nutrients and sediments delivered to the L-8 and C-51 Basins. How significant are the external loads to the system and at what times of the year do they come?
2. Nutrient and sediment loads, concentrations and flow to the C-51 / L-8 Reservoir from the L-8 and C-51 Basins. Excess stormwater from these basins will be directed to the proposed 48,000 acre-foot reservoir. How big are those loads? There are obvious benefits to capturing and reducing nutrient and sediment loads that are currently discharged to the Lake Worth Lagoon.
3. Nutrient uptake and response and sediment settling within the C-51 / L-8 Reservoir. How will the capture and storage of stormwater within the reservoir affect internal water quality? What type of chlorophyll response could be expected? What other water quality issues may arise within such a reservoir? Stratification, methylation of mercury, depressed dissolved oxygen?

4. Discharges from the G-51 / L-8 Reservoir to the L-8 Canal and M-Canal. What nutrient and sediment loads and concentrations from the reservoir will be discharged back into the canal system and what impacts might result?
5. Loads and concentrations of nutrients and sediments delivered to the G-51 Basin from the L-8 Basin.
6. Loads and concentrations of nutrients and sediments delivered to the C-51 and C-17 STA's from the C-51 and C-17 Basins.
7. Nutrient uptake and response and sediment settling within the proposed C-51 and C-17 STAs. Will the STAs be of sufficient size through a range of input conditions to successfully treat these inflows prior to being discharged to Grassy Waters Preserve?
8. Loads and concentrations of nutrients and sediments delivered from the STAs and other inflows directly to the GWP.
9. Nutrient uptake and response and sediment settling within Grassy Waters Preserve. How will the additional inflows from the L-8, C-51 and C-17 basins affect water quality within GWP? What optimum concentrations and loads would be protective of the natural resources of the GWP?
10. Nutrient loads and concentrations directed northward through the C-18 basin to the NW Fork of the Loxahatchee River. What flow volumes and associated nutrient loads will be directed out of GWP northward through the C-18 basin and into the NW Fork of the Loxahatchee River?
11. Nutrient and sediment loads and responses within the Loxahatchee River and Estuary. In addition to nutrients, will color be a factor influencing the downstream response of the Loxahatchee River and Estuary? The influence of color on nutrient dynamics within the river and estuary is a question that may deserve attention.

3.3 Critical Waterbodies

The water resources of primary importance in this conceptual model are the Grassy Waters Preserve, the Loxahatchee River and Estuary. The NPBC Project and associated infrastructure and operational changes propose to divert excess quantities of stormwater to these waterbodies that previously discharged to Lake Worth Lagoon. The objective of this project is not to determine how much sediment load or flow needs to be diverted from Lake Worth Lagoon, or the effect on Lake Worth Lagoon if lesser amounts are diverted. Recognizing that excessive nutrient loads and concentrations are perhaps the most problematic water quality issue in southern Florida, it is appropriate to consider how the proposed changes to the hydrology of the study area may affect overall nutrient loads and concentrations within that area. It would also be prudent to make an effort to determine what optimum concentrations and loads of nutrients and sediments can be delivered to the Grassy Waters Preserve and Loxahatchee River and Estuary without having a negative impact on those resources.

3.4 Recommended Technical Approach to Address Water Quality Issues

The project area has a complicated, interconnected, and highly managed surface water system. Flow, nutrient and sediment loads and concentrations will vary spatially and dynamically throughout the project area in response to seasonal rainfall and varied land uses. The implementation of the various structural and operational alternatives being proposed through the NPBC Project and the Northern Palm Beach County Comprehensive Water Management Plan may also have a significant influence on how these loads and concentrations will move through the system. The Grassy Waters Preserve, Loxahatchee River and Estuary will serve as the ultimate receiving waterbody for some of these nutrient and sediment loads. These loads may be different than the historic inputs experienced within those waterbodies.

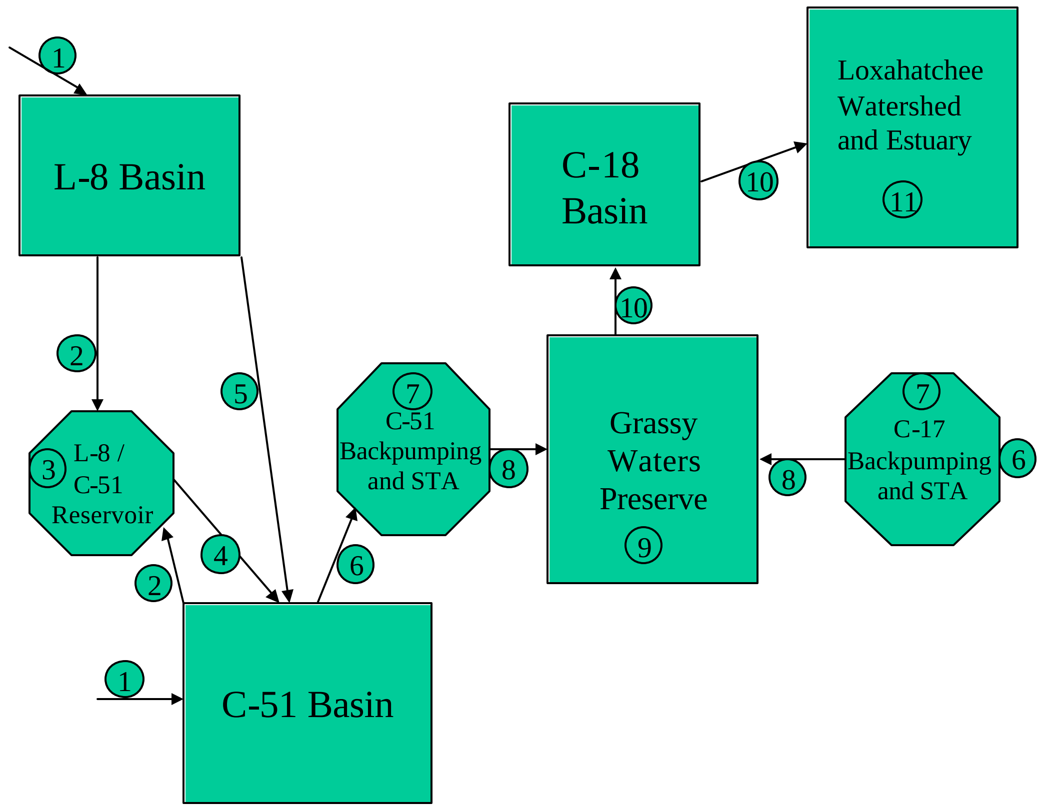
In order to assess the potential water quality impacts of the proposed alterations to the project area, the best technical approach is to develop a linked watershed model and estuarine receiving model capable of handling the critical conditions and able to represent nutrient and sediment processes. The critical modeling capabilities are discussed in detail in Section 5. In addition, it will be important to identify the optimum loads and / or concentrations of nutrients and sediments within the critical water resources that are protective of those aquatic resources. These water quality targets could be useful to help develop water quality performance measures for the NPBC Project Delivery Team.

Given the available budget and timeframes for this project, it will not be possible to develop a detailed water quality modeling system that represents all of the water quality processes represented in the conceptual model. However, a linked modeling system comprised of two tools will be applied to address the major processes of transport and water quality. The two tools are the Watershed Assessment Model (WAM) for the watershed loadings and the Environmental Fluid Dynamics Code (EFDC) for the receiving water. The linked modeling system is well suited to simulate the processes represented in steps 1, 2, 4, 5, 6, 8, 10 and 11. Detailed modeling of steps 3, 7 and 9 would be better represented by a reservoir model and an STA model such as DMSTA (Walker, 2002). Predictions of the water quality performance of the proposed reservoir and STAs will be driven by the range of configurations and operational plans developed by the Project Delivery Team and is beyond the scope of this pollutant loading analysis. The Tetra Tech team will work with FDEP to establish some basic assumptions regarding the performance of these features that can be input to the watershed model. Given the schedule of this project in relation to the schedule of the PDT, it will probably not be possible for Tetra Tech to wait for reservoir modeling results from the PDT. However, if that information does become available in a timely manner, Tetra Tech will work to incorporate those results in this effort.

3.5 Challenges to Developing a Useful Water Quality Modeling Tool

In order to develop a calibrated and validated water quality modeling tool it is necessary to develop an accurate representation of the hydrology of the watershed or system in question. Existing available flow and stage information should be sufficient to simulate the current system. However, in order to make some prediction of future water quality dynamics within the project area, it will be necessary to obtain a clearer understanding of how the proposed NPBC Project components will alter the timing, quantities and directions of surface water runoff. Some of that information may be contained in the Technical Appendix of the North Palm Beach County Comprehensive Water Management Plan that will be available soon. Other modeling assumptions may need to be identified and clarified between FDEP and the NPBC Project PDT in order to develop a future scenario that can be tested.

Figure 3.1 Conceptual Model of the Project Area



4.0 REVIEW OF AVAILABLE WATER QUALITY MODELS

This section reviews available EPA-approved water quality models that could be used to address the water quality issues identified within the conceptual model. Section 4.1 discusses watershed models, and section 4.2 discusses estuarine receiving models.

4.1 Watershed Models

The process for identifying the best available model for the North Palm Beach County Pollutant Loading Analysis occurred in multiple steps. The first step was to develop a comprehensive inventory of publicly available and EPA-approved models that have potential application to the watershed in question. The team considered public domain water quality and watershed models from the EPA Regional TMDL Toolbox that are potentially appropriate in southern Florida. The potential models meeting those criteria include:

- BASINS/HSPF
- Watershed Assessment Model (WAM)
- Loading Simulation Program in C++ (LSPC)
- Storm Water Management Model (SWMM)

4.1.1 BASINS/HSPF

Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) is an integrated loading and receiving watershed model developed by USEPA Office of Water to help regional, state and local agencies perform watershed studies. BASINS integrates data on water quality and quantity, land use, and point and nonpoint source loadings with supporting nonpoint and water quality models. BASINS has three major modules – screening and targeting, nonpoint source modeling to estimate loads, and point-nonpoint integration. The screening module considers drinking water supply sites, water quality monitoring stations, bacteria monitoring stations, USGS stations and Permit Compliance System sites and computed loadings. The nonpoint source module considers nutrients, sediment, bacteria and toxics. The nonpoint source module is linked to HSPF and then linked to ArcView. Nonpoint and point source loadings are integrated using TOXI-ROUTE, a screening-level stream routing model that performs dilution calculations under mean and low flow for entire watersheds. BASINS can also integrate QUAL2E for more complicated analyses that go beyond simple dilution calculations. BASINS was initially released in 1996 and has undergone subsequent upgrades (USEPA, 1997).

4.1.2 Watershed Assessment Model (WAM)

WAM is a tool that has been shown to be useful in the assessment of watershed-related properties. WAM was developed to allow engineers and planners to assess the water quality of both surface water and groundwater based on land use, soils, climate, and other factors. The model simulates the primary physical processes important for watershed hydrologic and pollutant transport. The integration of the WAM tool and ArcView is called WAMView. The WAMView GIS-based coverages include:

- Land use

- Soils
- Topography
- Hydrography
- Basin and sub-basin boundaries
- Point sources and service area coverages
- Climate data
- Land use and soils description files

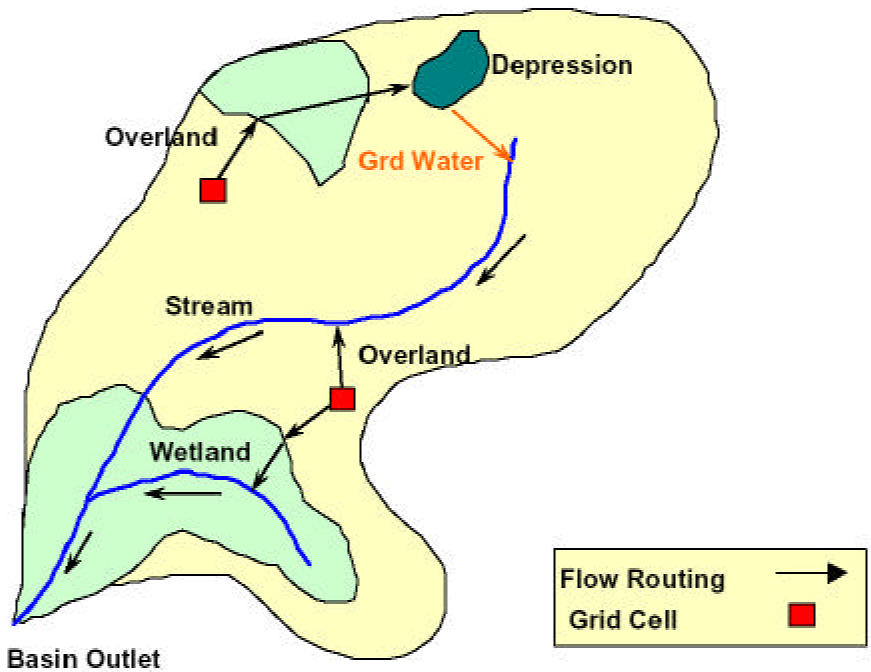
The coverages are used to develop data that can be used in the simulation of a variety of physical and chemical processes. The advantage of this model over others is its ability to:

- Use a grid-based system to assess the spatial impact of existing and modified land uses on water quality and quantity;
- If deemed necessary, develop load allocations for future total maximum daily loads (TMDLs) that will be acceptable to Florida Department of Environmental Protection (FDEP);
- Identify nutrient concentration "hot spots";
- Rank nutrient loadings by source, subbasins, and primary basins
- The model can be used to assess load strategies including the use of stormwater treatment areas (STAs) and reservoir assisted stormwater treatment areas (RASTAs). WAM also has the ability to aid in the assessment of the impact of growth changes in the watershed.

WAM is developed based on a grid cell representation of a watershed. The grid cell representation allows for the identification of surface and groundwater flow and parameter concentrations for each cell. The model then "routes" the surface water and groundwater flows from the cells to assess the flow and parameter concentrations throughout the watershed. Figure 4.1 shows the conceptual routing schemes and flow distances that are calculated for each cell. Thus, the model simulates the following elements:

- Surface water and ground water flow allowing for the assessment of flow and pollutant loading for a tributary reach at both the daily and hourly time increment as necessary.
- Water quality including particulate and soluble phosphorus (P), particulate and soluble nitrogen (N), total suspended solids (TSS), and chlorophyll_a.
- Time-series outputs at the source cells, subbasins, and individual tributary reaches including: source load maps (surface water and groundwater), attenuated subbasin and basin loads, ranking of land uses by load source, daily time series of flows and pollutants, and comparative displays of different BMP/Management Scenarios.

Figure 4.1 Flow Path Routing for Attenuation Distance Determination

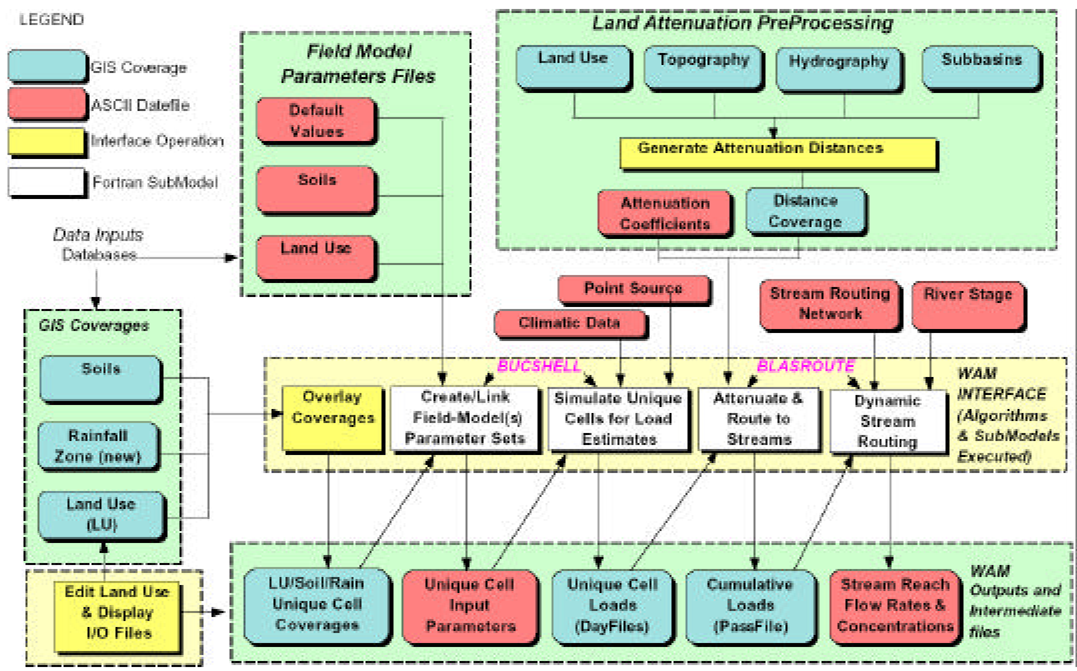


The model simulates the hydrology of the watershed using other imbedded models including "Groundwater Loading Effects of Agricultural Management Systems" (GLEAMS; Knisel, 1993), "Everglades Agricultural Area Model" (EAAMod; Botcher et al., 1998; SWET, 1999), and two submodels written specifically for WAM to handle wetland and urban landscapes. Dynamic routing of flows is accomplished through the use of an algorithm that uses a non-linear reservoir technique (Jacobson et al., 1998). Attenuation is based on the flow rate, characteristics of the flow path, and the distance of travel. The model provides many features that improve its ability to simulate the physical features in the generation of flows and loadings including:

- Flow structures simulation
- Generation of typical farms
- BMPs
- Rain zones built into unique cells definitions, which also allows use with NEXRAD data
- Full erosion/deposition and in-stream routing – used with pond/reservoirs
- Closed basins and depressions are simulated
- Separate simulation of vegetative areas in residential/urban
- Simulation of point sources with service areas
- Urban retention ponds
- Impervious sediment buildup and washoff
- Shoreline reaches for more precise delivery to rivers/lakes/estuaries

A schematic of WAM major components is shown in Figure 4.2 As seen, the overall operation of the model is managed by the ArcView-based interface. The interface allows the user to view available data, modify land use conditions, execute the model, and view results.

Figure 4.2 Schematic of WAM Layout



4.1.3 Loading Simulation Program in C++.

LSPC is a next generation version of the watershed model HSPF with certain limitations of the original modeling system eliminated. LSPC is a system designed to support TMDL development for areas impacted by nonpoint and point sources. The most critical component of LSPC is the dynamic watershed model, because it provides the linkage between source contributions, in-stream response during routing of flows, and delivery of loads to receiving streams. The comprehensive watershed model is used to simulate watershed hydrology and pollutant transport as well as stream hydraulics and in-stream water quality. It is capable of simulating flow, sediment, metals, nutrients, pesticides, and other conventional pollutants, as well as temperature and pH for pervious and impervious lands and waterbodies.

4.1.4 Storm Water Management Model (SWMM)

SWMM is a comprehensive watershed-scale model developed by EPA. Initially developed to look at urban stormwater and storm-event analysis to assist in developing design criteria for urban stormwater pollution, it has been upgraded to perform continuous simulations and to handle multiple land uses. The model can handle continuous simulations or storm events with user specified time steps. SWMM has been used to predict the impacts of combined sewer outflows, implementation of BMPs, and a variety of urban water quality and quantity issues. SWMM can handle up to 10 pollutants. EPA also distributes a version of SWMM with a windows interface and postprocessor for use on individual PC's (PCSWMM). (USEPA, 1997).

4.2 Estuarine Receiving Models

The estuarine receiving water model selection is important because this is the tool to simulate and quantify the downstream cumulative impacts of nutrient and sediment loads to the Loxahatchee River and Estuary. The model must have the capability to simulate salinity and its associated impact of mixing and water quality in a shallow, estuarine environment. Additionally, the receiving water model must be able to determine the impacts of nutrient and sediment loads on the natural resources of the estuary (sea grass beds). The process for identifying the best available model for the North Palm Beach County Pollutant Loading Analysis occurred in multiple steps as described for the watershed model. The team considered public domain models from the EPA Regional TMDL Toolbox that are potentially appropriate in southern Florida. The potential models meeting the criteria include:

- EFDC
- WASP 6.1
- CE-QUAL-ICM
- CE-QUAL-W2

4.2.1 EFDC

EFDC is a multifunctional, surface-water modeling system, which includes hydrodynamic, sediment-contaminant, and eutrophication components. The public domain EFDC model was originally developed at the Virginia Institute of Marine Science and is currently maintained by Tetra Tech with support from the EPA. EFDC has been used for more than 90 modeling studies of rivers, lakes, estuaries, coastal regions and wetlands in the US and abroad. The EFDC model is capable of 1, 2, and 3-dimensional spatial resolution. The model employs a curvilinear-orthogonal horizontal grid and a sigma vertical grid. The EFDC model is a nonproprietary model available through EPA and is included in the Regional TMDL Toolbox available to the public through EPA's website (http://www.epa.gov/region4/water/tmdl/tools/index.htm). EFDC includes a water quality component or it can be linked to WASP6.1 through a hydrodynamic linkage file. The water quality component of EFDC is the CE-QUAL-ICM code discussed below.

4.2.2 WASP 6.1

For simulation of complex water quality interactions, the EFDC, LSPC, and WAMView models have been linked to the EPA Water Quality Analysis Simulation Program (WASP6.1) through a hydrodynamic linkage file that contains the flows, volumes, and exchange coefficients between adjacent cells. WASP6.1, a windows based, enhancement of the original WASP model, a dynamic compartment model program for aquatic systems, including both the water column and the underlying benthos. The time varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange are represented in the basic program. WASP was integrated with WAMview and EFDC in the Myakka River Basin TMDL. WASP is also being linked directly to WAMView to make WAMView more a more robust watershed loading and receiving model.

4.2.3 CE-QUAL-ICM

The CE-QUAL-ICM water quality model was initially developed as one component of a model package employed to study eutrophication processes in Chesapeake Bay. Subsequent to employment in the Bay study, the model code was generalized and minor corrections and improvements were installed. ICM stands for "integrated compartment model," which is analogous to the finite volume numerical method. The model computes constituent concentrations resulting from transport and transformations in well-mixed cells that can be arranged in arbitrary one-, two-, or three-dimensional configurations. Thus, the model employs an unstructured grid system.

The model computes and reports concentrations, mass transport, kinetics transformations, and mass balances. Features to aid debugging include the ability to activate or deactivate model features, diagnostic output, and volumetric and mass balances. Computations can be restarted following interruption due to computer failure or similar circumstances. CE-QUAL-ICM is coded in ANSI Standard FORTRAN F77. The model operates on a variety of platforms including 486 PC, Silicon Graphics, and Hewlett Packard workstations. A multi-processor version is available but not generally released. The user must provide processors that prepare input files and process output for presentation.

The model does not compute hydrodynamics. Flows, diffusion coefficients, and volumes must be specified externally and read into the model. For simple configurations, flows may be entered through an ASCII input file. For more advanced applications, hydrodynamics are usually obtained from a hydrodynamics model such as the CH3D-WES model. The unstructured, finite volume structure of the model was selected to facilitate linkage to a variety of hydrodynamic models.

4.2.4 CE-QUAL-W2

CE-QUAL-W2 is a two-dimensional water quality and hydrodynamic code supported by the USACE Waterways Experiments Station. The model has been widely applied to stratified surface water systems such as lakes, reservoirs, and estuaries and computes water levels, horizontal and vertical velocities, temperature, and 21 other water quality parameters (such as dissolved oxygen, nutrients, organic matter, algae, pH, the carbonate cycle, bacteria, and dissolved and suspended solids). CE-QUAL-W2 Version 3 incorporates sloping riverine sections. Version 3 has the capability of modeling entire river basins with rivers and inter-connected lakes, reservoirs, and/or estuaries.

5.0 MODEL SELECTION CRITERIA

5.1 Watershed Models

The Tetra Tech team used the conceptual model of the project area and its critical processes, a review of the available data (see Data Summary Report), and an understanding of FDEP management needs for this project to develop a set of model selection criteria with which to select the optimum watershed model. The following is a brief discussion of the selection criteria and an explanation of why these considerations are important.

- Ability to handle complex hydraulics:

  As described earlier, the hydrology of the NPBC project area is complex. Numerous canals, locks, pumps, weirs and gates have been constructed that alter the timing, rate and even direction of flow within the project area. The model selected should be able to handle these types of structures.

- Ability to handle south Florida hydrology:

  In addition to the complex hydraulics, the model selected should be able to handle many of the complexities of south Florida hydrology. Issues such as high water tables, surface retention in wetlands, intermittent streams, very low gradients and complex drainage networks place demands that many common EPA approved watershed models cannot handle well.

- Evapotranspiration:

  Evapotranspiration (ET) is a significant component of the total water balance within the project area. ET rates are affected not only by spatially heterogeneous climatic variables but also by human management practices such as crop-type, irrigation method and irrigation frequency. In addition, the sources of water to supply ET needs can be structured in a hierarchy within the model that will influence surface water – soil water – groundwater interactions.

- Spatially distributed rainfall:

  Precipitation in south Florida exhibits significant spatial and temporal variability. Ideally, the model selected should be capable of handling spatially distributed precipitation to improve calibration and verification.

- Ability to handle groundwater – surface water interactions:

  Given the direct surface water – groundwater linkage within the project area, the watershed model needs to have the capability to handle those interactions in an adequate but not overly complex manner.

- Spatially distributed soil types:

  Review of available soils coverages for the project area indicates a wide variety of soils types with varied hydraulic characteristics. The model selected should be able to handle spatially variable soil types to improve calibration and performance.

- Ability to handle diverse agricultural land uses:

Agricultural activities in the project area include sugarcane, citrus orchards, row crops, pasture and rangelands scattered throughout the watershed. Each type of agricultural land use has distinctive water use and runoff characteristics that influence surface water quality and runoff. One of the policy questions that may need to be answered in this study is to identify the optimum locations to withdraw nutrient loads from the system. Thus, the water quality model should have the capability to simulate and predict pollutant loading in a spatially refined framework rather than as grouped loads from a few land use types.

- Ability to handle diverse urban land uses:

  Urban land uses within the project area include low to high density residential, commercial and industrial uses. As with agriculture, pollutant loads and runoff vary by urban land use type and the model should be capable of simulating and predicting pollutant loading in a spatially refined framework rather than treating them as grouped loads from a few land use types in a non-spatially distributed framework.

- Ability to handle diverse management practices:

  In addition to varied land use types, differing management practices on similar land uses also have the potential to significantly influence pollutant loading. The model should have the capability to increase or decrease pollutant loading from various land uses based on specific management practices such as fertilizer application rates and timing, irrigation practices, specific crop types, and nutrient management plans

- Ability to handle spatially distributed point sources:

  As mentioned with criterion #7, the model must have the capability to introduce pollutant loads to the system that accurately reflect where those loads originate in order to identify optimum locations to extract those loads from the system. Point sources may also have the added characteristic of introducing significant flow volumes to the system at the point of discharge.

- Atmospheric deposition:

  Studies of atmospheric deposition for the Lake Okeechobee TMDL and the Tampa Bay Estuary have demonstrated that dry and wet atmospheric deposition of nutrients can be a significant contributor to the overall nutrient loading in a watershed in Florida. The model should be able to handle spatially and temporally distributed atmospheric deposition in order to improve calibration and performance.

- Water quality parameters:

  Based on the ongoing water quality review and interim target development effort, the parameters of concern for this modeling effort include Nitrogen, Phosphorus, Total Suspended Solids, and Chlorophyll_a. The selected model should have the capability to simulate loading and transport of these parameters

- In-stream kinetics:

  Water quality models range from simple to complex in their ability to simulate in-stream water quality chemistry and nutrient cycling. Given the size of the watershed, the concerns with nutrient loads, and the transit times prior to discharge to the estuary, the model should be able to at-least simulate first-order decay of nutrients.

- Ability to incorporate new hydrologic features:

  The North Palm Beach County PDT will consider a wide range of structural and operational modifications to the system to achieve ecosystem restoration while also addressing other water related needs of the region. These modifications will include new hydrologic features such as reservoirs, gates and locks, pumps, canals and ASR wells. The model should be flexible enough to incorporate new hydrologic features to predict system responses without necessitating significant down time to alter model codes and recalibrate.

- Simulate modifications to management practices without recalibration:

  Similar to handling new hydrologic features, the model should provide the capability to allow the user to make adjustments to management practices in order to assess the resulting changes in pollutant loading and runoff. This capability provides the end-user with a modeling tool that facilitates rapid analysis of the performance of multiple alternative management practices scenarios.

- Process driven:

  Statistically-based models are appropriate for basins with large amounts of calibration data and conditions similar to well-studied basins. Process-based models are appropriate for basins with limited calibration data for calibration, but that have management, soils, hydrography, and weather data available. Process-based models are also able to reliably simulate the impacts of changes in management and hydrography that are not currently in use.

5.2 Estuarine Receiving Models

The selection criteria for the estuarine receiving models include the following:

- Ability to simulate hydrodynamics and water quality:

  The model must be able to solve the equations of motion (conservation of mass and momentum) and simulate the circulation of water movement in and around the estuary. The model must be able to simulate water quality parameters based on calibrated hydrodynamic conditions.

- Ability to handle complex, estuarine hydrodynamics:

  The Loxahatchee River and Estuary system is complex because of the mixing that occurs from the freshwater flows from the watershed and saline waters from the Atlantic Ocean. The salinity intrusion (or location of the salt wedge) is very sensitive to the amount of fresh water from the watershed. During dry time periods, the salinity front can advance farther upstream in the estuary.

- Ability to simulate salinity and temperature:

  In addition to the complex hydrodynamics, the model selected should be able to handle density driven circulation and vertical stratification of salinity and temperature.

- Ability to segment the waterbody in 3-dimensions:

  The model must have the ability to resolve the model domain into 3-dimensions so that longitudinal and lateral variations of the Loxahatchee River and Estuary can be represented.

- Water quality parameters:

  Based on the water quality review and interim target development effort, the parameters of concern for this modeling effort include carbon, nitrogen, phosphorus, total suspended solids, chlorophyll-a, dissolved oxygen, and color. The selected model should have the capability to simulate loading and transport of these parameters and the associated impact on algal growth and sea grass densities.

- Estuarine kinetics:

  Water quality models range from simple to complex in their ability to simulate in-stream water quality chemistry and nutrient cycling. The target will determine the extent of the water quality calibration. To model chlorophyll-a, the full eutrophication equations and parameters need to be utilized.

- Simulate chlorophyll-a:

  The need to simulate algae (via chlorophyll-a) is important to link the target to a load and a response variable. The load will be nutrients and color from the watershed. The target will be a function of sea grass bed densities for color and chlorophyll-a for nutrients.

- Simulate impacts of color and light transmission on sea grass beds:

  Color is an important factor when determining the target and how the target will be protective of sea grass beds in the lower estuary. The model needs to account for changes in color and its effect on sea grass beds.

- Publicly Available:

  The model must be publicly available for FDEP and other agencies to use for future management decisions.

6.0 COMPARISON OF AVAILABLE MODELS TO MODEL SELECTION CRITERIA

6.1 Watershed Models

Table 6.1 shows the model selection criteria discussed in section 5.1 and rates each of the models described in Section 4 that were identified as having potential for application within the project area. Each model was rated either YES, NO, or LE (Limited Extent) with respect to each criterion.

Table 6.1 Application of Model Selection Criteria to Selected Watershed Models

Model Selection Criteria	BASINS/HSPF	WAM	LSPC	SWMM
Handle Complex Hydraulics[1]	Limited Extent (LE)	YES	LE	LE
Handle South Florida Hydrology[2]	LE	YES	LE	LE
Evapotranspiration[3]	YES	YES	YES	YES
Spatially Variable Rainfall	YES	YES	YES	YES
Handle Groundwater – Surface water interactions[4]	LE	YES	LE	LE
Spatial Soil Variability	LE	YES	LE	LE
Handle Diverse Agricultural Land Use types	LE	YES	LE	LE
Urban Land Use types	YES	YES	YES	YES
Diverse Management Practices	LE	YES	YES	LE
Spatially Distributed Point Sources	YES	YES	YES	YES
Atmospheric Deposition	YES	YES	YES	YES
Water Quality source loading[5]	YES	YES	YES	YES
Instream kinetics[6]	YES	YES	YES	YES
Handle new hydrologic features	LE	YES	LE	LE
Simulate modifications to management practices without recalibration	LE	YES	LE	LE
Process Driven	NO	YES	NO	NO

[1] Capability to handle reverse flows, structures such as locks, pumps, weirs, gates, operational schedules.
[2] Handle high water tables, surface retention, intermittent streams, low gradients, complex drainage networks
[3] Can model handle land-use and crop specific ET calculations, ET on a daily basis, does it generate a hierarchy of supply sources to satisfy ET demand, can it provide ET from perched groundwater?
[4] Does the model have a decision tree to handle gw-sw interactions, is there a hierarchy of interactions that is adequate but not overly complex?
[5] For this study, Total Suspended Solids, Nitrogen, Phosphorus, Chlorophyll_a
[6] Can the model handle in-stream nutrient processes?

6.2 Estuarine Receiving Models

Table 6.2 shows the model selection criteria discussed in section 5.2 and rates each of the models described in Section 4 that were identified as having potential for application within the project area. Each model was rated either YES, NO, or LE (Limited Extent) with respect to each criterion.

Table 6.2 Application of Model Selection Criteria to Selected Estuarine Receiving Models

Model Selection Criteria	EFDC	WASP 6.1	CE-QUAL-ICM	CE-QUAL-W2
Simulate Hydrodynamics and Water Quality	YES	NO	LE[1]	YES
Ability to Handle Complex, Estuarine Hydrodynamics	YES	NO	NO	YES
Ability to Simulate Salinity and Temperature	YES	NO	LE[2]	YES
Segmentation of waterbody into 3-dimensions	YES	YES	YES	NO[3]
Water Quality Parameters	YES	YES	YES	YES
In-Stream Kinetics	YES	YES	YES	YES
Simulate Chlorophyll-a	YES	YES	YES	YES
Simulate impacts of color and light transmission on sea grass beds	YES	LE	YES	LE
Publicly Available	YES	YES	YES	YES

[1] CE-QUAL-ICM is a water quality model.
[2] CE-QUAL-ICM can simulate temperature but not salinity.
[3] CE-QUAL-W2 is a two-dimensional model.

7.0 SELECTED MODELS, THEIR LIMITATIONS AND ASSUMPTIONS

7.1 WAM

Of the six watershed models described, discussed and evaluated for application in this study, the WAM model is the only tool capable of meeting all sixteen of the model selection criteria. WAM has demonstrated its capability to handle the unique requirements and characteristics of southern Florida through its application to numerous other projects including the ongoing North of Lake Okeechobee Project Implementation Report, the Myakka River Basin Total Maximum Daily Load study, modeling of Best Management Practices within the C-139 Basin and modeling within the Everglades Agricultural Area. WAM has a proven ability to accurately simulate basins in Florida including the unique hydrography, hydrology, and management found in south Florida. WAM has also demonstrated its ability to aid in the assessment of the impacts of land use and management modifications.

7.1.1 Limitations of WAM for this project

WAM is not an integrated 3 dimensional surface water – ground water model. As such, assumptions will have to be made regarding the degree to which groundwater withdrawals influence surface water hydrology within the project area.

7.1.2 Assumptions of WAM

7.1.2.1 Hydrology network

Figure 7.1.2.1 displays the complex surficial hydrology of the project area. For the purposes of the WAM model, the surficial hydrology will be simplified and primary reach network will be developed. If provided, this project will utilize the surface hydrology used in the hydrology and hydraulics(H&H) model being developed for the CERP North Palm Beach County Project. If this coverage is not provided, then the primary canals, drainage ways and rivers will be built into the model. Lesser streams and canals will be used to determine transport of flow and pollutant runoff from individual grid cells to the primary drainage network. The model will also incorporate primary and secondary drainage structures and pumps. Again, if the information from the H&H model is provided that will be utilized.

7.1.2.2 Weather

Data regarding rainfall, temperature, net solar radiation, wind and evapotranspiration are available from several stations throughout the project area. These data have been assembled and will be applied to the modeling effort.

7.1.2.3 Soils

ArcView shapefiles regarding soils data developed by NRCS were obtained from SFWMD. The WAM model will incorporate soils characteristics at the soil series level. Soil characteristics include SCS curve number, hydraulic slope, effective rooting depth, etc. Soils characteristics for each horizon are also utilized, including horizon thickness, porosity and saturated conductivity.

7.1.2.4 Topography

If provided, the LIDAR based topography being used in the H&H model will be used. If not provided, then topography within the project area will be taken from existing shapefiles based on

United States Geologic Survey data. The shapefiles were provided by SFWMD and were obtained from the South Florida Geoplan project.

7.1.2.5 Land Use

Land uses in the basin are derived from the 1995 Florida Land Use and Land Cover Classification System (FLUCCS). Land uses will be applied to the model at the Level III classification level, and in some cases at Level IV.

7.1.2.6 Point Sources

Point source facilities, locations and water quality data were obtained from the USEPA PCS database. Facilities will be QAQC'd to ensure that all significant active facilities have been identified, and that facilities no longer active are excluded. Depending on availability of data as well as on critical watershed conditions and characteristics of the discharge, discharges may be averaged or continuously simulated.

7.1.2.7 Atmospheric Deposition

Atmospheric Deposition data is being obtained and reviewed to develop wet and dry deposition rates for the project area. This information will be applied to the model.

7.1.2.8 Management Practices

The Tetra Tech team will perform a survey of knowledgeable individuals within the project area to determine standard agricultural and operational practices that can be simulated in WAM. If information is not available, staff will apply standard assumptions based on best professional judgment of common practices in southern Florida.

7.1.2.9 Integration of CERP Components

WAM will provide flow and nutrient loadings throughout the project area for potential use in developing STA and RaSTA designs. Subsequent discharges from those future CERP components can be integrated into the modeling system in order to simulate the gross downstream impacts on water quantity and quality.

7.2 EFDC

Of the four receiving models described, discussed and evaluated for application to this study, EFDC is competent of meeting the requirements of the study. EFDC will be able to perform alternative evaluations of fresh water flow impacts on the salinity regime, nutrient and sediment load impacts, and corresponding response in algae through the surrogate of chlorophyll-a. EFDC is a widely accepted modeling tool for management and permitting studies. EFDC has been used in developing Comprehensive Resource Management Plans (CRMP) for three National Estuary Programs including Peconic Bays, NY, Morro Bay, CA, and Mobile Bay, AL. EFDC applications in support of TMDLs include Charles River, MA, Christina River Basin, MD, Neuse River, NC, Brunswick Harbor, GA, Fenholloway River, FL, St Johns River, FL, Flint Creek, AL, Yazoo River Basin, MS, Arroyo Colorado, TX, Tenkiller Lake, OK, Los Angeles River, CA, South Puget Sound, WA, and Ward Cove, AK. National Point Discharge Elimination (NPDES) permitting applications include Norwalk Harbor, CN, Potomac River, VA, and Cape Fear River, NC. EFDC has been used to evaluate effects of fresh water inflow alteration in the Indian River Lagoon, Lake Worth, and Florida Bay, FL. The EFDC model has been applied for sedimentation studies in the James River, VA, Stephens Passage, AL, and Lake Okeechobee, FL. Tetra Tech has been supporting EPA on contaminated sediment modeling including the Elliott Bay-Duwamish River, WA, Blackstone River, MA, the Housatonic River, MA, and Williamette River, OR superfund sites. The model has been extensively peer reviewed as evidenced by 12 peer reviewed journal articles and 17 peer reviewed conference proceedings articles.

7.2.1 Limitations of EFDC for this project

The first limitation of EFDC (and any model for that matter) will be the lack of time series data to calibrate the hydrodynamic model. The major forcing functions for the hydrodynamic portion of the model will be freshwater flows at the upstream boundary, tides at the downstream boundary, bathymetry of the bed, solar radiation, air temperature, and wind speed and direction. It does not appear that all of that time series data are available at this time. If the hydrodynamics are not tested with a good dataset, it will be difficult to tell if the magnitude and timing of the tidal volumes, and thereby flushing, are accurately represented. The model will, however, be a useful tool to look at relative impacts of various alternative scenarios. The salinity intrusion will be the major test for the simulation of lateral and longitudinal transport in the estuary.

The second limitation of the EFDC for the water quality model will be the lack of color data in the estuary and its direct impact on the sea grass targets. The relationship between color and light transmission (or extinction) will be developed through data and will be computed outside the model.

The third limitation of the EFDC model will be run times. For three-dimensional modeling of the Loxahatchee River and Estuary, with multiple vertical layers, the computational run times will be lengthy. Most likely on the order of 10-12 hours for each run. The grid scale will be kept at an appropriate resolution to maximizing model time steps and, therefore, reducing computational run times.

7.2.2 Assumptions of EFDC

An EFDC application was developed for the Lake Worth Lagoon by Scientific Environmental Applications, Inc. (part of the Tetra Tech team) to study salinity levels and impacts due to stormwater discharges from the North Palm Beach area. The work described herein will be an extension of the work performed in the lagoon for the Loxahatchee River and Estuary to simulate nutrient and sediment impacts.

The Loxahatchee River and Estuary will be segmented into computational grid cells representing three dimensions (x, y, z) for the hydrodynamic and water quality model. The hydrodynamic model utilizes a sigma coordinate system that allows for a fixed number of layers in the vertical direction, and as depth changes, the vertical layers stretch or shrink. The hydrodynamic and water quality models use the same grid domain to perform their calculations. The bathymetry of the model domain will be important to capturing the tidal volumes in the estuary. These data will be gathered from NOAA nautical charts. The hydrodynamic input files consist of pressure (tides), flows, atmospheric, salinity, and temperature forcing functions.

The hydrodynamic information are stored and read by the water quality component of EFDC. As mentioned in previous sections, the water quality component of EFDC is identical to that of the CE-QUAL-ICM model that was developed by WES on Chesapeake Bay.

8.0 MODEL PARAMETERIZATION AND EVALUATIONS OF MODEL ACCURACY

8.1 WAMView

8.1.1 Calibration or Parameterization

Because WAM is a process-based model, traditional statistical methods are not used for calibration of a new basin. Most of the parameters used in WAM are values that can be physically determined such soil properties, elevation and sizes of stream network, crop type and management, fertilizer rates, etc. For model parameters that cannot be directly measured, such as anaerobic phosphorus mineralization coefficients, these have been calibrated using high quality field plot data to determine appropriate values during model development. Other parameters, such as background nutrient concentrations have been calibrated over a large number of basins that had good water quality data, and therefore reasonable estimates are available for the NPBC project area.

When modeling a new basin, the "calibration stage" is more of an exercise in determining if the weather, soils, land use, and stream network have been appropriately represented in the model. For example, in a previous study of a basin along the Suwannee River, WAM was over-predicting soluble nitrogen in areas with improved pastures. The fertilizer management of improved pastures had been defined using IFAS fertilizer recommendations. Interviews with farmers and local extension agents and review of local fertilizer sales records revealed that little or no fertilizer was being applied to these pastures. The new simulations using adjusted fertilizer rates closely matched measured data.

Calibrations will be performed at monitoring sites in the basin with long periods of record and reliable data. Variables of interest include flow, stage, total suspended solids, soluble nitrogen, sediment nitrogen, soluble phosphorus, sediment phosphorus, and biological oxygen demand.

8.1.2 Model Validation or Evaluation of Model Accuracy

Determining the "goodness-of-fit" for a basin scale water quantity / quality model is a complex undertaking. Because the data are time series where the dependent variables are dependent on each other, traditional methods, such as coefficient of determination (a.k.a. R^2) and correlation coefficient, are not appropriate. Because slight positive and negative time lags between measured and simulated values should not be a major factor in model validation assessments of basin scale models, many other analyses, such as Chi-squared and Kolmogorov-Smirnov, are also not suitable. Additionally, the measured data are not always representative of the "real" conditions due to non-representative samples and limited accuracies of analyses.

Because of these limitations in traditional goodness-of-fit techniques, qualitative assessments are often employed for basin scale water quantity / quality modeling. The Modified Pearson Product-Moment Correlation Coefficient developed by McCuen and Snyder (1975) appears to address the major limitations of many other methods and will be utilized along with qualitative comparisons for this project. This technique modifies the Pearson product moment correlation coefficient using the ratio of the standard deviations of the data sets being compared. The Pearson product moment correlation coefficient is insensitive to the magnitudes of events. The modification increases the sensitivity of the coefficient to the magnitudes of events.

8.2 EFDC

8.2.1 Calibration or Parameterization

The calibration objectives for the hydrodynamic receiving model is to adequately represent the physics of the system by propagating momentum and energy based upon freshwater inflow, tides and wind. Because salinity and stratification play a major role in the water quality of the estuarine portion of the Loxahatchee River and Estuary, another calibration objective was to have the ability to predict salinity intrusion and stratification. For the water quality receiving water model, the model will be used to predict chlorophyll-a and color in the river and estuary. They will be utilized to develop the longitudinal distribution of color throughout the riverine portions, the estuary, and nearshore, and these color projections will have a direct feedback to other constituents, the accurate simulation of the transport of conservative substance (i.e. color) is important.

8.2.2 Model Validation or Evaluation of Model Accuracy

Similar to the watershed model, the qualitative assessments will be employed for the hydrodynamic and water quality modeling. The Modified Pearson Product-Moment Correlation Coefficient developed by McCuen and Snyder (1975) appears to address the major limitations of many other methods and will be utilized along with qualitative comparisons for this project. This technique modifies the Pearson product moment correlation coefficient using the ratio of the standard deviations of the data sets being compared. The Pearson product moment correlation coefficient is insensitive to the magnitudes of events. The modification increases the sensitivity of the coefficient to the magnitudes of events.

9.0 SUMMARY AND CONCLUSIONS

The Northern Palm Beach County Pollutant Loading and Abatement Analysis project area is a complicated, interconnected and highly managed hydrologic system with competing needs for drainage, flood control, water supply and the environment. A great deal of planning, modeling, preliminary design, pilot testing and more detailed design is underway within the project area to develop structural and operational solutions to meet these water resource needs. Information is readily available that describes the conceptual alternatives and provides estimates of how these proposed features will perform in a gross sense from a hydrologic perspective. What appears to be lacking is an associated technical analysis of how these proposed alternatives may affect surface water quality within the project area.

The Interim CERP Water Quality Guidance Memorandum 023.00 for the Implementation of Water Quality Features indicates that the critical water quality parameters that may be most affected by implementation of CERP components are nutrients and total suspended solids (USACE 2003). Within the project area there are five CERP components associated with the North Palm Beach County Project Part 1 that may influence nutrient and total suspended sediment loads and concentrations across the system (L-8 Basin Improvements, C-51 and L-8 Reservoir, C-51 Backpumping and Treatment, C-17 Backpumping and Treatment, and the Pal Mar and J.W. Corbett Hydropattern Restoration).

The NPBC PDT is responsible for performing a water quality evaluation for the project in accordance with CGM 023.00. However, the Everglades Technical Support Section of Florida Department of Environmental Protection requested that the North Palm Beach County Pollutant Loading and Abatement Analysis be conducted to help FDEP develop a technically based understanding of current water quality conditions in the system and the potential water quality ramifications associated with the conceptual plan of the NPBC Project. To that end, this model selection report describes the project area and the conceptual hydrologic alterations that may be implemented as part of the NPBC Project. This report identifies that changes to nutrient and sediment loads and concentrations are likely to occur within the project area, and that a linked watershed and estuarine receiving model system using WAM and EFDC could do an adequate job of simulating those changes.

Associated with the potential changes in nutrient and sediment loads and concentrations, it will be important to develop an understanding of how the critical surface water resources within the project area might respond to these changes. As part of this project, the Tetra Tech team will work with the Everglades Technical Support Section to help develop suggested optimum water quality load or concentration targets for the Grassy Waters Preserve, Loxahatchee River and Estuary. These types of water quality targets may be a useful tool for the NPBC PDT to assist in developing water quality performance measures for the NPBC Project.

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