# South Florida Water Management District

**April 2000**

# Caloosahatchee Water Management Plan

## Planning Document

# ACKNOWLEDGEMENTS

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# EXECUTIVE SUMMARY

The *Caloosahatchee Water Management Plan* (CWMP) is considered a subset of two of the four regional planning areas within the South Florida Water Management District (SFWMD, the District) the Lower East Coast and Lower West Coast areas. The region's population is projected to increase by 45 percent to 370,000 people in 2020. Agricultural acreage is expected to increase by 7 percent overall; however it is anticipated there will be conversion from pasture and row crops to citrus and sugarcane. The total average water demand is projected to increase by 45 percent to 232 billion gallons per year by 2020. The region receives approximately 52 inches of rainfall per year on average. Meeting water demands while addressing the water needs of the environment makes development of proactive water supply strategies imperative to the economic and environmental sustainability of the region. The District will be responsible for water resource development to facilitate development of source options at the local level; while, local governments, water users, and water utilities will be responsible for water supply development.

The CWMP is the product of a public process, which relied heavily on the Caloosahatchee Advisory Committee (CAC). The CAC consists of a diverse membership representing agricultural, urban, and environmental interests. The planning effort provided a forum to weigh projected water demands against available supplies and to discuss potential solutions to identified shortfalls.

Several alternatives were considered that would make additional surface water available to meet the water demands within the basin through 2020. Five components (regional reservoirs, Aquifer Storage and Recovery (ASRs), backpumping, distributed small-scale reservoirs, and water harvesting) were evaluated and combinations of the components were tested as alternatives. The nine alternatives, which were identified for assessment following preliminary screening, are:

- Do Nothing (A.01)
- Restudy Alternative (A.02)
- Restudy without Backpumping (A.03)
- Regional and Distributed Small-Scale Reservoirs (A.04)
- Regional Reservoir Only (A.05)
- Water Harvesting (A.06)
- Regional and Distributed Small-Scale Reservoirs with New Structure (S-78.5) (A.07)
- Regional Reservoir with New Structure (S-78.5) (A.08)
- Do Everything (A.09)

The analysis determined the projected surface water needs of the Caloosahatchee River Basin and Estuary can be met during a 1-in-10 drought condition with the development of water management and storage infrastructure that effectively captures and stores surface water flows in the basin. Existing surface water supplies from the C-43 are inadequate to meet existing as well as future demands, including the needs of the environment. The Caloosahatchee River (C-43) is heavily relied on for agricultural water supply, and to a much lesser extent, potable water supply. Surface water availability is essentially a function of climate and storage; there are excess amounts during the wet summer months, and insufficient supplies during dry winter months. This problem of timing is particularly illustrated by the impacts of freshwater discharges to the Caloosahatchee Estuary. Excessive discharges decrease the salinity of the estuary contributing to the loss of estuarine seagrasses. Insufficient freshwater discharges increase the salinity to essentially saltwater, impacting freshwater seagrasses. A Minimum Flow And Level (MFL) is being established for the Caloosahatchee River and Estuary.

Improved management of surface water through storage could increase fresh water availability in the region and reduce potential impacts resulting from water use. The evaluation of the nine alternatives based on the specified performance measures shows that some of the proposed water management components are more efficient in meeting the projected estuarine, irrigation, and public water supply demands. Analysis of the results indicate that it is possible to meet the projected estuarine, irrigation, and public water supply demands with a combination of regional and distributed reservoirs, ASR, and Structure S-78.5. Water table harvesting and the additional structure also offers value in attenuating flows and warrant further investigation. Based on the assumptions within the model, backpumping does not appear to be a cost-effective method for meeting basin demands.

Finally, other planning efforts are currently underway and are continuing to address some specific goals of this plan, including the *Lower East Coast (LEC) Regional Water Supply Plan*, the *Lower West Coast (LWC) Water Supply Plan*, the *Comprehensive Everglades Restoration Program*, and the *Southwest Florida Study* (SWFS). The proposed SWFS will evaluate flood control, water supply, environmental impacts, wildlife habitat including the needs of the estuaries, water quality, uplands, and others within Southwest Florida. The recommendations outlined in this plan should be implemented in partnership with these other efforts in order to ensure that water in the basin is prudently managed and available to meet the anticipated demands of the basin. The CWMP will be reviewed and updated every five years to ensure that the water needs of the basin are being met.

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| | |
|---|---|
| **AC-FT** | acre-feet |
| **ADAPS** | Automated Data Processing System (USGS) |
| **AFSIRS** | Agricultural Field Scale Irrigation Requirements Simulation |
| **AGWQMN** | Ambient Ground Water Quality Monitoring Network |
| **ANOVA** | Simple One-Factor Analysis of Variance |
| **ASR** | Aquifer Storage and Recovery |
| **ATRP** | Abandoned Tank Restoration Program |
| **AWWA** | American Water Works Association |
| **BCBB** | Big Cypress Basin Board |
| **BCBWMP** | Big Cypress Basin Water Management Plan |
| **BMPs** | Best Management Practices |
| **BOD** | Biochemical Oxygen Demand |
| **BOR** | Basis of Review |
| **CAC** | Caloosahatchee Advisory Committee |
| **CARL** | Conservation and Recreation Lands |
| **C&SF Project** | Central and Southern Florida Flood Control Project |
| **CCMP** | Comprehensive Conservation and Management Plan |
| **CERP** | Comprehensive Everglades Restoration Plan |
| **CFS** | cubic feet per second |
| **CHNEP** | Charlotte Harbor National Estuary Program |
| **COD** | Chemical Oxygen Demand |
| **CR** | County Road |
| **CRCA** | Caloosahatchee River Citizens Association |
| **CREW** | Corkscrew Regional Ecosystem Watershed |
| **CUP** | Consumptive Use Permit |
| **CWMP** | Caloosahatchee Water Management Plan |
| **DBP** | Disinfection By-Product |
| **D/DBPR** | Disinfectant/Disinfection By-Product Rule |
| **DEP** | Florida Department of Environmental Protection |

| | |
|---|---|
| **DHI** | Danish Hydraulic Institute |
| **District** | South Florida Water Management District |
| **DO** | Dissolved Oxygen |
| **DRI** | Developments of Regional Impact |
| **DWCD** | Disston Water Control District |
| **DWMP** | District Water Management Plan |
| **DWSA** | District Water Supply Assessment |
| **DWSRF** | Drinking Water State Revolving Funds |
| **DSS** | Domestic Self-Supplied |
| **EAA** | Everglades Agriculture Area |
| **EAR** | Evaluation Appraisal Report |
| **ECP** | Everglades Construction Project |
| **ECWCD** | East County Water Control District |
| **EEL** | Environmentally Endangered Lands |
| **EPA** | Everglades Protection Area |
| **ERP** | Environmental Resource Permitting |
| **F.A.C.** | Florida Administrative Code |
| **FAS** | Floridan Aquifer System |
| **FCD** | Central and Southern Florida Flood Control District |
| **FCES** | Florida Center for Environmental Studies |
| **FDACS** | Florida Department of Agriculture and Consumer Services |
| **FDEP** | Florida Department of Environmental Protection |
| **FDOH** | Florida Department of Health |
| **FDOT** | Florida Department of Transportation |
| **FEMA** | Federal Emergency Management Agency |
| **FFA** | Florida Forever Act |
| **FFG** | Functional Feeding Groups |
| **FFWCC** | Florida Fish and Wildlife Conservation Commission (*now known as FWC*) |
| **FGCU** | Florida Gulf Coast University |
| **FGFWFC** | Florida Game and Freshwater Fish Commission |
| **FGS** | Florida Geological Survey |

| | |
|---|---|
| **FDHRS** | Florida Department of Health and Rehabilitative Services |
| **FS** | Florida Department of Forestry |
| **F.S.** | Florida Statutes |
| **FWC** | Florida Wildlife Commission |
| **FY** | Fiscal Year |
| **GAC** | Granular Activated Carbon |
| **GAP** | Closing the Gaps in Wildlife Habitat Conservation System |
| **GIS** | Geographic Information System |
| **GOF** | Goodness of Fit |
| **GPD** | gallons per day |
| **GPM** | gallons per minute |
| **GWUDI** | Ground Water under the Direct Influence of Surface Water |
| **HDPE** | High-Density Polyethylene |
| **IAS** | Intermediate Aquifer System |
| **IESWRT** | Interim Enhanced Surface Water Treatment Rule |
| **IFAS** | Institute of Food and Agricultural Sciences |
| **ISGM** | Integrated Surface Water Ground Water Model |
| **KOE** | Kissimmee-Okeechobee-Everglades |
| **LAI** | Leaf Area Index |
| **LEC** | Lower East Coast |
| **LFA** | Lower Floridan Aquifer |
| **LOSA** | Lake Okeechobee Service Area |
| **LWC** | Lower West Coast |
| **MAT** | Model Advisory Team |
| **MIL** | Mobile Irrigation Laboratory |
| **MFLs** | Minimum Flows and Levels |
| **mg/L** | milligrams per liter |
| **MGD** | million gallons per day |
| **MGY** | million gallons per year |
| **MOA** | Memorandum of Agreement |
| **MOU** | Memorandum of Understanding |

| | |
|---|---|
| **NEP** | National Estuary Program |
| **NFIP** | National Flood Insurance Program |
| **NGVD** | National Geodetic Vertical Datum |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NPDES** | National Pollution Discharge Elimination System |
| **NPL** | National Priorities List |
| **NPS** | National Park Service |
| **NRCS** | Natural Resources Conservation Service |
| **O&M** | Operations and Maintenance |
| **P2000** | Preservation 2000 |
| **PAW** | Plant Available Water |
| **PIR** | Project Implementation Report |
| **PLRG** | Pollution Loading Reduction Goals |
| **PPT** | parts per trillion |
| **PSP** | Project Study Plan |
| **PWS** | Public Water Supply |
| **RAA** | Restricted Allocation Area |
| **RDF** | Root Mass Distribution |
| **RECOVER** | Restoration, Coordination, and Verification |
| **Restudy** | Central and Southern Florida Flood Control Project Comprehensive Review Study |
| **RIB** | Rapid Infiltration Basin |
| **RO** | Reverse Osmosis |
| **RTA** | Reduced Threshold Areas |
| **RTE** | Rare, Threatened, or Endangered Species |
| **SALT** | Saltwater Intrusion Database (SFWMD) |
| **SAS** | Surficial Aquifer System |
| **SAV** | Submerged Aquatic Vegetation |
| **SDWA** | Safe Drinking Water Act |
| **SFWMD** | South Florida Water Management District |
| **SFWMM** | South Florida Water Management Model |
| **SGGE** | South Golden Glades Estates |

| | |
|---|---|
| **SHCA** | Strategic Habitat Conservation Areas |
| **SJRWMD** | St. Johns River Water Management District |
| **SOR** | Save Our Rivers |
| **SOW** | Statement of Work |
| **STA** | Storm Water Treatment Area |
| **SWCD** | Soil and Water Conservation District |
| **SWFRPC** | Southwest Florida Regional Planning Council |
| **SWFS** | Southwest Florida Study |
| **SWFWMD** | Southwest Florida Water Management District |
| **SWIM** | Surface Water Improvement Management |
| **TAZ** | Traffic Analysis Zone |
| **TKN** | Total Kjeldahl Nitrogen |
| **TP** | Total Phosphorus |
| **TSS** | Total Suspended Solids |
| **UEC** | Upper East Coast |
| **UFA** | Upper Floridan Aquifer |
| **UIC** | Underground Injection Control |
| **USACE** | United States Army Corps of Engineers |
| **USDA** | United States Department of Agriculture |
| **USDW** | Underground Source of Drinking Water |
| **USEPA** | United States Environmental Protection Agency |
| **USFWS** | United States Fish and Wildlife Service |
| **USGS** | United States Geological Survey |
| **VEC** | Valued Ecosystem Component |
| **WATBAL** | Water Balance Model |
| **WCA** | Water Conservation Area |
| **WHPA** | Wellhead Protection Area |
| **WICC** | Water Independence for Cape Coral |
| **WRCA** | Water Resource Caution Area |
| **WSTB** | Water Science and Technology Board |
| **WWTP** | Wastewater Treatment Plant |

# Chapter 1
# INTRODUCTION

The Caloosahatchee Basin is considered a subset of two of the four regional planning areas within the South Florida Water Management District (SFWMD), the Lower West Coast (LWC) and the Lower East Coast (LEC) planning areas. The Caloosahatchee Planning Area covers approximately 1,400 square miles and includes significant areas of Glades and Hendry counties, a portion of Lee County and a small portion of Collier, Charlotte, and Palm Beach counties (**Figure 1**). Urban land use is primarily located in the western portion of the basin in Lee County. Agricultural land use is primarily located in the eastern portion of Hendry and Glades counties. Agriculture has been the predominant land use and is expected to remain so in the future. Citrus and sugarcane have become the dominant crops in the planning area and occupy over 86 percent of the irrigated agricultural acreage in the planning area. Interspersed with these land uses are over 437,000 acres of pasture, upland forests, and wetlands.

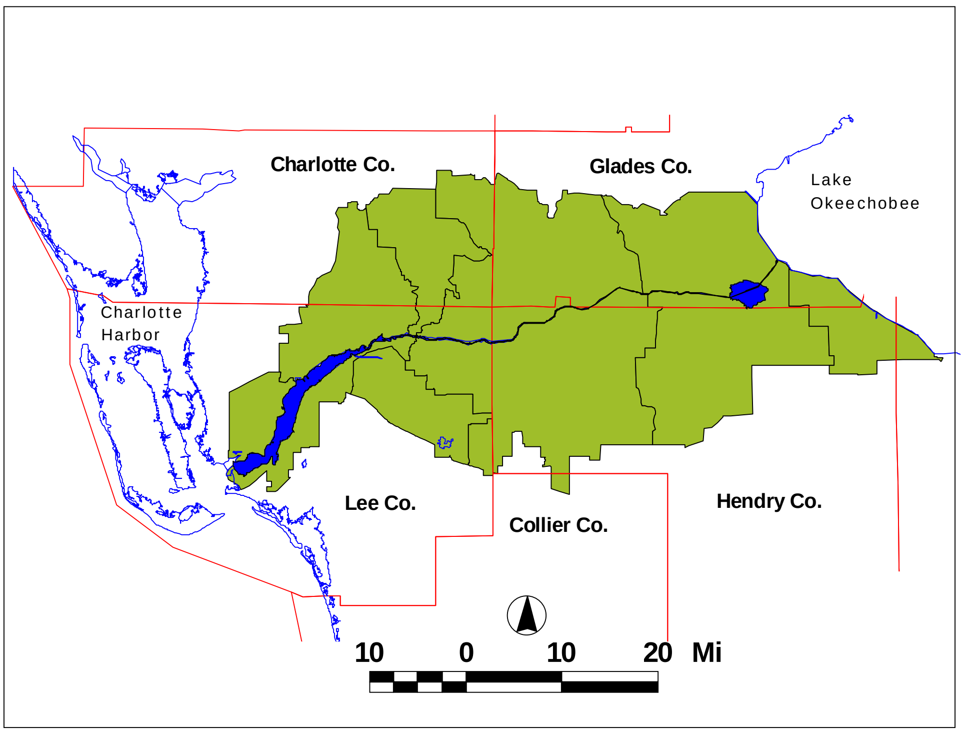


**Figure 1.** The Caloosahatchee Planning Area.

The planning area faces many challenges in maintaining adequate water supply for growing urban and agricultural demands while meeting the needs of the environment. The Caloosahatchee Basin is projected to experience substantial growth between now and 2020. The region's population is expected to increase by 45 percent to 370,000 people. Agricultural acreage is expected to increase by 7 percent overall; however, it is anticipated there will be conversion from pasture and row crops to citrus and sugarcane. The total average water demand is projected to increase by 45 percent to 232 billion gallons per year by 2020.

The modeling analysis for this plan uses several approaches. The 2010 projections from local governments and the agricultural industry were reviewed with more recent information in order to comply with statutory changes in 1997. In addition, a new modeling approach, which utilizes an Integrated Surface Water/Ground Water Model (ISGM) capable of simulating interaction of ground and surface water within the basin, was used in this study. The model, MIKE SHE developed and supported by the Danish Hydraulic Institute, is an ideal tool for investigative studies in areas such as the Caloosahatchee Basin where significant surface water/ground water interactions occur.

# PURPOSE

The purpose of the *Caloosahatchee Water Management Plan* (CWMP) is to provide a framework for future water use decisions to provide adequate surface water supply for urban areas, agriculture, and the environment through 2020 within the Caloosahatchee Basin. The plan estimates the future surface water supply needs of urban areas and agriculture, weighs those demands against historically used surface water sources, and identifies areas where these demands cannot be met without harming the resource and environment. This plan includes recommendations on how this surface water deficit can be ameliorated. This initial plan evaluates the potential of several alternative surface water supply and surface water management options to meet projected deficits and makes recommendations for their development and implementation. The initial planning efforts addressed in this document will be referred to as the <u>inner ring</u> and will be completed for inclusion in the LEC and LWC water supply plans. The items that will not be completed in time for inclusion into the plan will be referred to as <u>outer ring</u> activities and will be incorporated into the Southwest Florida Study (previously known as the Southwest Florida Feasibility Study) or future revisions to the CWMP. The Plan Goals section, later in this Introduction, will delineate the inner ring and outer ring goals.

An important part of the planning process has been identifying constraints to water supply and exploring opportunities to maximize use of the water resources. This involved extensive input from the Caloosahatchee Advisory Committee (CAC), whose members represent a variety of disciplines and interests, such as local governments, Public Water Supply (PWS) utilities, environmental interests, and agriculture, as well as the general public. In addition, a Model Advisory Team (MAT) was established consisting of representatives of the major stakeholders. The MAT reviewed each step of the modeling process for reasonableness and appropriateness. They discussed the assumptions and limitations of the model and modeling approach.

Water management in South Florida is multifunctional, reflecting the District's four main areas of responsibility: water supply, flood protection, water quality, and natural systems management. Due to the interrelationships of these areas of responsibility, this plan was coordinated with the LEC and LWC water supply plans, the Central and

Southern Florida Project Comprehensive Review Study, as well as other planning and research efforts in the region. The solutions of these studies will enhance regional water supply by increasing surface water availability and improving water quality. Other related studies include efforts to identify indicator species that will be evaluated to determine the health of the estuary and determine options that will increase the viability of those species in the estuary. This comprehensive, coordinated approach, combined with extensive public input throughout the planning process, ensures that solutions are balanced and consider all aspects of water management.

# BASIS OF WATER SUPPLY PLANNING

The Florida Legislature has delegated authority to the District to protect South Florida's water supply by managing use to meet the future demand. The District has undertaken a water supply planning initiative to ensure prudent management of South Florida's water resources. This initiative began with the development of a *District Water Supply Policy Document* (1991), and continued with the *District Water Management Plan* (1995), *District Water Supply Assessment* (1998), and regional water supply plans. The District's water supply planning functions are guided by the directives and policies embodied in the District's *Water Supply Policy Document* (SFWMD, 1991), State Water Policy (Chapter 62-40, F.A.C.), Chapter 373, F.S., the State Comprehensive Plan (Chapter 187, F.S.), and delegation of authority from Florida Department of Environmental Protection (FDEP). In addition, the plan meets the requirements of the 1996 Governor's Executive Order (96-297) and the 1997 legislative water supply amendments to Chapter 373, F.S. Legal authority and requirements, including new legislation, is further described in Chapter 1 of the CWMP Support Document.

# PLAN GOALS

The CAC adopted the following goals for the Caloosahatchee Basin:

## Goal 1. Meet the Requirements of House Bill 715

### Sub-goals (Inner Ring)

1.1 Include a surface water supply component in the plan.

1.2 Include a surface water resource development component in the plan.

1.3 Ensure that water is provided to all users on an equitable basis.

1.4 Provide 1-in-10 level of service for water supply (target level of service).

1.5 Establish minimum flows and levels (MFLs, established in the *LWC Water Supply Plan*).

1.6 Include a recovery and prevention strategy for minimum flows and levels (to be completed once MFLs are established).

1.7 Include a funding strategy for water resource development projects.

1.8 Identify 20 year planning horizon and plan updates every 5 years.

## Goal 2. Ensure Incorporation of Other Planning and Management Efforts

### Sub-goals (Inner Ring)

2.1.Compile local government assumptions and projections for the Caloosahatchee Basin and identify local ordinances that would directly implement or directly conflict with water supply development efforts.

2.2 Assess the recommendations of Sustainable South Florida Commission and the Charlotte Harbor National Estuary Program for inclusion into the CWMP.

2.3 Ensure the recommendations of the CWMP are the incorporated into the LWC and LEC water supply plans and the *Comprehensive Everglades Restoration Plan* (CERP) (previously known as the *Central and Southern Florida (C&SF) Project Comprehensive Review Study*) (Restudy), and *Southwest Florida Study* as well as all local, regional, and state planning programs within the Caloosahatchee Basin.

2.4 Obtain SFWMD Governing Board Approval of CWMP.

## Goal 3. Accommodate the Human Population

### Sub-goals (Inner and Outer Rings)

3.1 Identify the current and long-term water demands of public and private water utilities (Inner Ring).

3.2 Develop surface water supply source options through the application of water models (Inner Ring).

3.3 Ensure protection of public water supplies through the Water Supply Plan (Inner Ring) and Permitting (Outer Ring).

3.4 Identify multiple use strategies for all water supplies, and where practical, storm water and waste water systems (Outer Ring).

3.5 Identify areas with critical freshwater flood management needs and develop strategies to modify existing laws and regulation (Outer Ring).

3.6 Coordinate with the FDEP to identify water sources that have been identified as contributing to health problems (Outer Ring).

## Goal 4. Sustain Agriculture

### Subgoals (Inner and Outer Rings)

4.1 Quantify current surface water demands (Inner Ring).

4.2 Quantify future surface water demands and sources (Inner Ring).

4.3 Collect data and develop initial ground water/surface water model to answer surface water supply and storage questions (Inner Ring).

4.4 Develop and review current permitting criteria to address on-site agricultural water storage (Outer Ring).

4.5 Develop permitting criteria to address surface and ground water requirements (Outer Ring).

4.6 Review on-site retention to supplement surface water withdrawals from the river (Inner Ring).

4.7 Coordinate urban and agriculture surface water management (Outer Ring).

4.8 Search for and identify new surface water sources (Outer Ring).

## Goal 5. Sustain the Natural System

### Subgoals (Inner and Outer Rings)

5.1 Identify current and historic low, high, average, and median flows into the estuary and establish minimum flows and levels. (MFLs are being established in the *LWC Water Supply Plan*) (Inner Ring).

5.2 Identify interim C-43 operational modifications to minimize estuary degradation (Outer Ring).

5.3 Identify long-term C-43 operational modifications to minimize estuary degradation (Outer Ring).

5.4 Establish and implement water regimes to optimize estuarine health (Outer Ring).

5.5 Identify freshwater habitats (including wetlands and oxbows) and develop scientifically based management strategies to protect their natural function (Outer Ring).

5.6 Develop economic analysis of estuary resources (Outer Ring).

5.7 Coordinate with the Florida Department of Environmental Protection and other agencies to identify existing nutrient and harmful material inflows to the Caloosahatchee Estuary and ensure studies necessary to reduce harmful inflows are undertaken (Outer Ring).

5.8 Identify important estuary indicator species (Inner Ring), identify harmful items affecting the estuary and develop a monitoring plan to ensure the health of the indicator species (Outer Ring).

5.9 Identify impacts associated with Sanibel Causeway (Inner Ring) (The District is having a 3-dimensionsal model developed to assist Lee County in identifying impacts associated with the causeway).

## Goal 6. Develop and Implement Storage Alternative Test Sites

### Subgoals (Inner and Outer Rings)

6.1 Develop on-site field scale surface water storage evaluation sites (Inner Ring).

6.2 Evaluate field scale ASR potential (Outer Ring).

6.3 Develop surficial aquifer storage evaluation sites (Inner Ring).

## Goal 7. Identify Water Supply Options

### Subgoals (Inner and Outer Rings)

7.1 Establish a system of incentives for each category of user that encourages efficiencies among existing users and creates supplies (Outer Ring).

7.2 Develop a technically sound assessment of additional water sources. (Outer Ring).

7.3 Provide a list of geographically specific water supply development options (Outer Ring).

## Goal 8. Establish Minimum Flows for the Caloosahatchee Estuary (Inner Ring)

8.1 Will be completed as a part of the *LWC Water Supply Plan*. Adoption of MFLs is scheduled for December 2000.

**Goal 9. Protect Private Land** (Outer Ring)

**Goal 10. Protect Recreational and Commercial Use** (Outer Ring)

**Goal 11. Protect Land Adjacent to the River** (Outer Ring)

# Chapter 2
# WATER SUPPLY PLANNING PROCESS

## PLANNING PROCESS COMPONENTS

The planning process used in creating the *Caloosahatchee Water Management Plan* (CWMP) was divided into three comprehensive phases: assembling background information and development of analytical tools, identification and analysis of issues, and development of solutions. Public involvement has been constant throughout this process, from gathering background information from local governments to holding advisory committee meetings, where water supply issues and potential water supply alternatives were explored. The goals and objectives established by SFWMD staff and the Caloosahatchee Advisory Committee (CAC) provided the overall framework for the planning process (**Figure 2**).

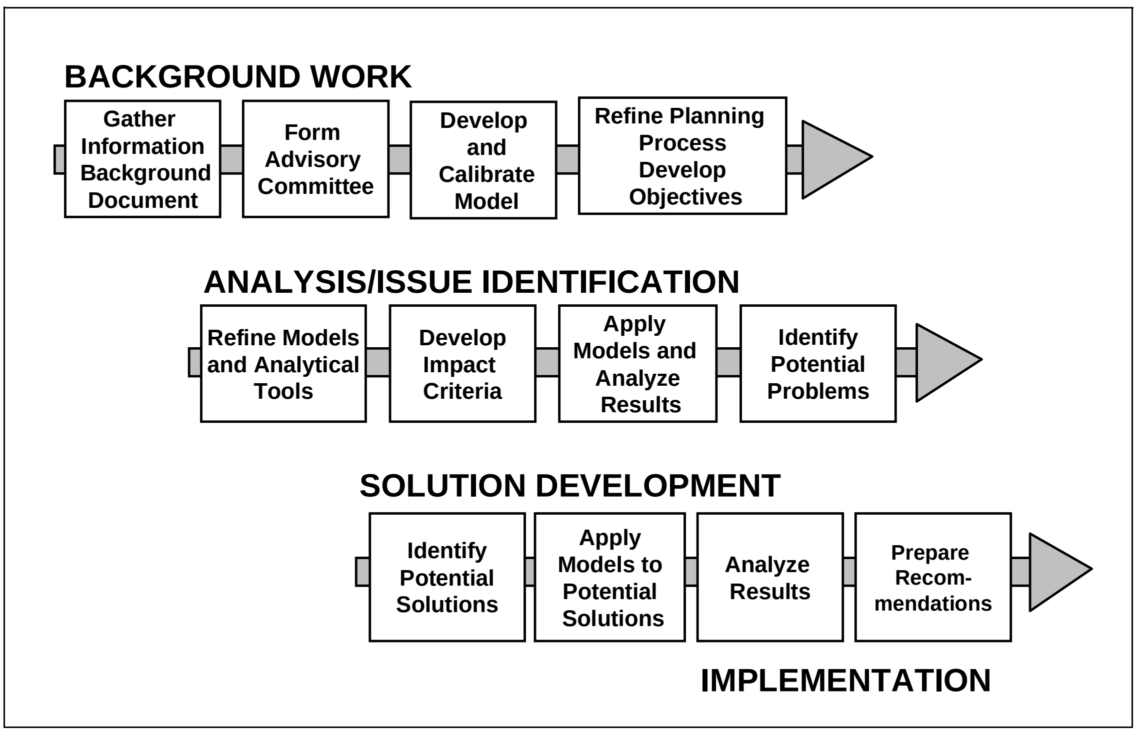


**Figure 2.** Planning Process Components.

## Background Work

### Background Information

The first phase of the CWMP was to compile extensive background information required for informed decision making later in the process. This background information included historical information, pertinent statutes and technical documents, land use and population information, rainfall data, water use demand projections, hydrogeologic and water resource information, water use permit information, details of utilities in the planning area, environmental information, and alternative water supply source concepts. The urban water-use demand projections were based on utility projections and local government comprehensive plans, while agricultural demand projections were based on land use analysis and water use by crop type.

### Tool Development

Another fundamental task was to identify, develop, and refine numerical tools needed for succeeding stages of the planning process. This included the development and calibration of the MIKE SHE Integrated Surface Water/Ground Water Model (ISGM) for the planning area. Model preparation also involved the assembly of information, including statistical analyses of rainfall events in the region, evapotranspiration, overland and channel flow components, crop irrigation types, crop growth, and descriptive data pertaining to aquifer characteristics such as transmissivity.

## Advisory Committee Formation

An advisory committee, with 33 members and approximately the same number of alternate members, was created to procure public participation in the planning process. Members of the CAC included representatives of federal, state, and local agencies, including planning officials; Public Water Supply (PWS) utilities; the local business community; agencies with environmental concerns; community leaders; and agricultural representatives. All committee meetings were advertised and open to the public.

The primary responsibilities of the CAC included providing input at each stage of the water supply planning process, contributing local knowledge and expertise, and deliberating on the collective concerns and interests of various stakeholders in the Caloosahatchee Planning Area. The role of SFWMD staff was to expedite the planning process, provide professional and technical support and guidance, and prepare the planning document recognizing the CAC's input.

The CAC spent about six months presenting and sharing background information, along with developing the plan's goals (a listing of the plan goals is provided in Chapter 1). These goals and objectives served as a framework for the succeeding planning process. Topics scheduled for CAC discussion, research and analytical work, and formulation of final recommendations centered on these goals. Completion of the plan's initial goals marked the progression into the analytical phase of the process. The CAC met a total of 21 times between September 1997 and April 2000.

In addition to regular CAC meetings, several technical workshops were conducted to respond to questions related to the ground water modeling associated with development of the CWMP and use of the MIKE SHE model for development of potential surface water resource alternatives.

It is recommended that the CAC remain in existence to help coordinate implementation of the CWMP with the proposed *Southwest Florida Study* (SWFS, previously known as the *Southwest Florida Feasibility Study*) and local planning efforts. The purpose of the SWFS is to provide a framework in which to address the health of aquatic ecosystems; water flows; water quality (including appropriate pollution reduction targets); water supply and resources; flood protection; wildlife and biological diversity; and, habitat protection and restoration. The U.S. Army Corps of Engineers (USACE) and the SFWMD are joint sponsors of the SWFS. The SWFS is scheduled for completion by the year 2005.

## Analysis and Identification of Issues

The Caloosahatchee Basin is a large watershed that lies to the southwest of Lake Okeechobee. The main hydrologic feature is the Caloosahatchee River, which serves as a conduit for both drainage and water supply. Agriculture is the predominant land use and the primary crops are citrus, sugarcane, vegetables, and improved pasture. Besides relying on the Caloosahatchee River and Lake Okeechobee as a source of water, there are significant ground water resources in the area that are heavily utilized for irrigation and PWS. The CWMP addresses the management of the surface water resources of the Caloosahatchee Basin. The revised *Lower West Coast (LWC) Water Supply Plan* deals with the region's ground water resources. Agriculture in the Caloosahatchee Basin expanded significantly in the 1980's and early 1990's and growth is expected to continue into the future. Part of the water needed to support this continued growth must come from Lake Okeechobee, unless regional storage is created within the Caloosahatchee Basin. According to projections in the Restudy, additional storage must be created in the form of retention ponds and Aquifer Storage and Recovery (ASR) to capture water to help meet future demands. A more detailed analysis of the basin was completed as a part of the CWMP. The Caloosahatchee Basin also contains extensive areas of wetlands and future development will have to conform to regulations regarding impacts on these wetlands. Two utilities, Fort Myers and Lee County take surface water from the Caloosahatchee River to meet some or all of their public supply demands. Other utilities in the basin use ground water as their source.

Due to the degree of interconnectivity of the surface and ground water resources in the Caloosahatchee Basin, an ISGM was constructed to analyze the effect of a number of proposed management scenarios. A lack of data in the study area resulted in additional field investigations including seepage studies, well construction, core analysis, seismic profiling, research of existing technical documents, and other analytical methods. Data from these studies was then used in the model development. A modeling subcommittee of the CAC was formed to assist with the model development. The subcommittee, comprised of agricultural and public utility users and other area experts, drew upon its local knowledge and experience with the local water resources to provide insight in model development. Preliminary results from the field investigations are summarized in the *CWMP Appendix Document*.

## Solution Development

Because large volumes of runoff occur within the Caloosahatchee Basin (an average of about 650,000 acre-foot per year), there is considerable potential to capture and use a portion of this water to help meet supply requirements, while maintaining ecologically necessary flows to the estuary. The Restudy recommended various storage options for capturing large amounts of runoff for later use as a substitute for Lake Okeechobee. One option may be to utilize Lake Hicpochee as a storage area for runoff. This option has cost advantages, since the land is already in public ownership (providing that the water storage function does not conflict with wildlife management goals for this area). Finding other suitable locations for surface storage areas may be limited to certain geographical locations with large areas of predominantly agricultural land. Much of the western basin is already intensively developed, and the basin has extensive wetland areas. These factors may limit the areal extent of storage areas in the western portions of the basin.

The Caloosahatchee ASR option, which consists of a combination of ASR facilities adjacent to a series of smaller reservoirs, is subject to questions concerning technical feasibility, efficiency evaluations, and permitting. To address these uncertainties, the Restudy includes a pilot ASR project for the Caloosahatchee Basin as one of the features recommended for initial construction.

Raising water levels in the Caloosahatchee River and the surficial aquifer adjacent to the river through construction of new structures or modification of existing structures raises questions regarding increases in flood vulnerability and the impact on permitted discharge rates, as well as navigation on the Okeechobee Waterway.

Larger storage facilities and greater storage capacity will provide additional benefits to the Caloosahatchee River Estuary through the attenuation of basin runoff and regulatory releases from Lake Okeechobee. These storage facilities will be designed to provide a source of' additional water to help meet baseflow water deliveries to the estuary during dry periods.

The initial scenarios included regional reservoirs, distributed reservoirs, ASR, backpumping into Lake Okeechobee, a new structure between S-78 and S-79, and emerging technologies (water harvesting). These scenarios were evaluated individually and in conjunction with each other. The CAC reviewed the preliminary analysis associated with each of the alternatives. From that review, a list of potential solutions was developed. It was then recommended that the potential solutions be incorporated into the SWFS for additional development and identification of a preferred solution (alternative).

# PLAN IMPLEMENTATION

Implementation is one of the most important phases of the CWMP. Strategies developed during the planning process must be carried out to ensure adequate water supply through 2020 as well as beyond 2020. Additional development, identification of a preferred solution (alternative through the SWFS), and implementation will follow approval of the plan by the SFWMD Governing Board. Implementation will involve coordination with other agencies, and additional development of the alternatives through the SWFS. Implementation may include additional data collection, research, cost-share projects, capital construction, and rulemaking when regulatory criteria are changed. A preliminary assessment of the potential solutions (alternatives) is discussed in Chapter 6 of this document.

# COORDINATION

Development of the CWMP was coordinated with several planning efforts in the region, as well as with many other entities, to ensure an integrated approach and compatibility with local and regional plans. In addition, this plan will be incorporated into the SFWMD *District Water Management Plan* (DWMP). The CWMP is intended to provide extensive long-range guidance for the actions of the SFWMD in implementing its obligation under state and federal laws.

## Related Planning Efforts

Water management planning efforts in the planning area include a variety of interrelated studies and activities, in both the public and private sectors. Each plan or study addresses unique water management issues while maintaining close relationships with water supply planning (**Table 1**). These include the *LWC Water Supply Plan*, the *Southwest Florida Study*, the *Central and Southern Florida (C&SF) Comprehensive Review Study, Lake Okeechobee (L.O.) SWIM Plan*, *Lake Okeechobee Regulation Schedule Environmental Impact Study*, *Lower East Coast (LEC) Regional Water Supply Plan*, and private sector initiatives.

The *LWC Water Supply Plan* is a guide for providing adequate and reliable water resources for future water demands in Southwest Florida between now and the year 2020. The purpose of the plan is to set a framework around which future water use decisions in the LWC Planning Area can take place. The LWC Planning Area extends across 4,300 square miles in Southwest Florida and includes all of Lee County, and portions of Charlotte, Collier, Glades, Hendry, Miami-Dade, and Monroe counties. It is scheduled for completion in the year 2000, and is intended to be evaluated in five-year increments.

The goal of the *LWC Water Supply Plan* is:

> To assure the availability of an adequate supply of water for all competing uses in the LWC Planning Area deemed reasonable and beneficial while restoring and maintaining the functions of natural systems.

The *LWC Water Supply Plan*, initially published in 1994, is comprised of three documents: 1) Planning Document (Volume 1); 2) Background Document (Volume 2); and 3) Appendices (Volume 3). These documents provide a common set of preliminary data such as present and future water demands, assumptions, and potential water source

**Table 1.** Caloosahatchee River Water Management Planning Efforts.

| Planning Effort | Scope/Primary Goal | Relationship to CWMP | Timeframe |
|---|---|---|---|
| Caloosahatchee Water Management Plan | Provide 1 in 10 Level of Service Water Supplies for Urban and Agricultural Users and the Environment through 2020 | N/A | Completion of Initial Plan Scheduled December 1999 |
| Southwest Florida Study | Regional framework to address the health of aquatic systems; water quality and supply; flood protection, mitigation and other water resource concerns | -Evaluate options to protect the Caloosahatchee and Charlotte Harbor Estuary while maintaining water supply<br>-Evaluate supplemental water supply for agriculture<br>-Provide detailed information needed for implementation of preferred alternatives | 1999-2005 |
| Lake Okeechobee (L.O.) SWIM Plan | Protection and enhancement of Lake Okeechobee and its basin (water quality) | Backflow/inflow from C-43 if determined viable in SWFS. | Update completed 1997 |
| Lake Okeechobee Regulation Schedule Environmental Impact Study | Evaluates environmental and economic impacts associated with proposed L.O. Regulation Schedules (quantity) | Discharges from Lake Okeechobee to the Caloosahatchee Estuary | 1999 |
| Comprehensive Everglades Restoration Plan | Comprehensive review of environmental impacts of C&SF project | Discharges from Lake Okeechobee to the Caloosahatchee Estuary | 1995-1999 |
| Lower West Coast Water Supply Plan | Provide adequate and reliable water resources for addressing future water demands within the LWC Planning Area. | Quantify current and future water demands and supplies including the Caloosahatchee Basin | Completed 1994, 5-year revision completed April 2000 |
| Lower East Coast Regional Water Supply Plan | Adequate and reliable water resources for the Lower East Coast, for natural systems L.O. service area | Quantify current and future water demands and supplies including surface water in the Caloosahatchee Basin | Draft Document 1997, Interim Plan 1998, Revised Plan completed April 2000 |

options. The computer modeling and analysis used to develop the water supply plan are summarized in these documents. The revised *LWC Water Supply Plan* (approved April 2000), will allow local governments, water users, and utilities to use the plan to modify and update their local plans or ordinances.

The purpose of the *LEC Regional Water Supply Plan* is to provide a cost effective and implementable strategy for assuring that adequate water supplies are available to meet the demands of natural systems, agriculture, and urban areas within the LEC Planning Area through the year 2020. The LEC region includes all of Miami-Dade, Broward, and

Palm Beach counties, plus portions of Collier, Hendry, Glades, Martin, Monroe, and Okeechobee counties.

Similarly, the goal of the *LEC Regional Water Supply Plan* is stated as:

> Florida shall assure the availability of an adequate supply of water for all competing uses deemed reasonable and beneficial and shall maintain the functions of natural systems and the overall present level of surface water and ground water quality. Florida shall improve and restore the quality of waters not presently meeting water quality standards.

The *Central and Southern Florida (C&SF) Project Comprehensive Review Study* (Restudy) is a cooperative effort between the SFWMD and the USACE. The purpose of this study is to reexamine the C&SF Project to determine the feasibility of structural or operational modifications essential to the restoration of the Everglades and Florida Bay ecosystems while providing for other water-related needs such as urban and agricultural water supply and flood control. The Restudy Area encompasses approximately 18,000 square miles from Orlando to Florida Bay. Major areas within the Restudy Area include the Kissimmee River, Lake Okeechobee, St. Lucie and Caloosahatchee estuaries, Everglades Agricultural Area, Everglades National Park, Big Cypress National Preserve, and Florida Bay. The Kissimmee River, Lake Okeechobee, and the Everglades are the dominant basins that connect a mosaic of wetlands, uplands, coastal and marine areas. The Restudy includes an evaluation of the water demands on the Lake Okeechobee Basin.

The SWFS has been initiated as a result of the Restudy. The purpose of the SWFS is to describe and evaluate alternative plans to address Southwest Florida water resource problems and to develop a comprehensive plan for the system. The SWFS will include traditional features such as navigation, shoreline erosion, flood control, and the enhancement of water supplies, as well as environmental restoration features.

## Local and Regional Governments

### Counties and Cities within the Basin and Their Authorities

General-purpose (Constitutional) local government exists in two forms: county governments and incorporated (city/town) governments. There are significant portions of four counties within the Caloosahatchee Basin: Charlotte, Glades, Hendry, and Lee. Each county government has three branches: executive, legislative, and judicial.

The executive branch of county government is split, with each county having a separate Sheriff, Clerk of Court, Supervisor of Elections, Property Appraiser, and Tax Collector, as well as a Board of County Commissioners. This diffuse executive branch performs functions as directed by state law.

The legislative branch of each of the four counties within the basin is the Board of County Commissioners, which exercises the home rule powers of the State Constitution, within constraints provided by general law. Two counties, Lee and Charlotte, have adopted a home rule charter, which gives them certain authorities not provided to counties by general law. This authority includes being able to restructure the executive branch.

The judicial branch is the county court system, which is subordinate to the judicial system of the State of Florida, with its local representation through the circuit court system. The judicial system performs in accordance to general law, as well as the laws enacted by local general-purpose local governments. The entire basin is within the jurisdiction of the 20th Judicial Circuit of the State of Florida.

Incorporated areas commonly referred to as municipalities, cities, or towns become incorporated through charters approved by the legislature. General law provides for these procedures and the required content of a charter. Once approved, cities operate according to their charter, which can be amended by the city according to its charter provisions. Under general law, cities (and towns) have a restricted right to annex additional lands beyond those originally included within a municipal charter. Cities may have combined executive and legislative bodies, or they may be separated, depending upon the provisions of the city charter. There are five cities and one town within the planning area: the City of Cape Coral, Clewiston, Fort Myers, LaBelle, and Moore Haven.

Article VIII of the Florida Constitution describes the general powers of county and municipal government. Outside of these general powers, the Florida Legislature determines through the adoption of general law the minimum responsibilities and additional authorities of local governments.

## Charlotte County

Charlotte County is approximately 690 square miles in size and had a population of 131,307 in 1997. Only the southern and eastern portions of Charlotte County are located within the basin, approximately 216 square miles. This part of Charlotte County is sparsely settled with no population centers.

The county government is headed by a county administrator, and has an administrative structure to provide services to its growing population, including staffed departments of legal affairs, public works, transportation, community development, natural resources (in various forms), health, and waste disposal. The county government provides the equivalent services of a municipality for more than 90 percent of the county population, including those portions of the county within the Caloosahatchee Basin.

**Charlotte County Comprehensive Plan.** Charlotte County developed and adopted a three-volume comprehensive plan in 1988. The plan was initially determined to be not in compliance; through the hearing process and negotiations with the Florida Department of Community Affairs, the county adopted amendments to bring the plan into compliance by 1994. The plan's forecasts were to the year 2010.

The county prepared the mandated Evaluation and Appraisal Report (EAR) in 1995, which was found sufficient. The county then prepared and adopted a revised plan, which was found to be in compliance in 1997. The plan now uses a forecast year of 2020.

The plan forecasts little population growth for the Caloosahatchee Basin, and most land use densities are one unit per five or more acres.

The county has adopted a complete set of land development regulations pursuant to Chapter 163, Florida Statutes (F.S.).

### Glades County

Glades County is the least populous county in the planning area, with a 1997 population of 9,413. The county's total size is 763 square miles. The southern part of the county drains into the Caloosahatchee River, while the remainder drains into Fisheating Creek, the Rim Canal, or the Kissimmee River. The population of the county that is in the basin is located around Moore Haven (the county seat), Ortona, Muse, and Port LaBelle.

The county recently established the County Administrator position, which is part of a general evolution into a more standard organization of departments rather than functions. The county uses contract services for engineering support.

The county has adopted its Comprehensive Plan pursuant to Chapter 163, F.S., and has performed an EAR update. The county has not adopted updates to its various land development regulations.

**Moore Haven.** Moore Haven is the county seat for Glades County and its only municipality. The 1997 population was 1,554. The city, approximately one square mile in size, drains entirely into the Caloosahatchee River. Prior to the connection of the Caloosahatchee River to Lake Okeechobee, the city drained into the lake.

The city operates under the city commission system, with a mayor overseeing the functions of the city council. The chief city official is the Clerk. The city uses contract services for engineering support.

The city has adopted a city Comprehensive Plan. It has not adopted updated land development regulations. It does not have an EAR due until after the year 2000. The city does provide water service, and sewerage service is becoming available due to the recently constructed prison and a grant from the U.S. Economic Development Administration.

### Hendry County

Hendry County has the likelihood of having the most rapid land use changes within the basin, although currently a rural county, with a 1997 population of 30,308 people within an area of 1,163 square miles. The northern part of the county is the most populous portion, containing both Clewiston and LaBelle, and it drains into the Caloosahatchee Basin. The pending widening of State Road (SR) 80 in the county's northern portion will add to urbanization pressures.

The county has the County Administrator form of government, and has distinct departments to carry out county functions, including public works (which includes storm water) and community development, although planning is now a contract function.

The county has adopted its Comprehensive Plan, pursuant to Chapter 163, F.S.; and has adopted updated land development regulations. The county has also performed its EAR, but has not yet undertaken its required plan updates.

**Clewiston.** Clewiston is the most populous of the county's two cities, with a population of 6,354 in 1997, and a size of approximately four square miles. Directly on the shore of Lake Okeechobee, Clewiston has, like Moore Haven, been submerged once by storm surge off of the lake. Portions of Clewiston can drain into the Caloosahatchee Basin through the S-4 Basin.

Clewiston operates under the city administrator form of government. The city has centralized sewer and water, and has a public works department that addresses storm water management.

The city has adopted its comprehensive plan pursuant to Chapter 163, F.S., and has adopted its land development regulations. The city has prepared its EAR, which is going through adoption proceedings.

**LaBelle.** LaBelle is the county seat of Hendry County. Its size is approximately two square miles, and its 1997 population was 3,177. The entire city drains into the Caloosahatchee River.

The city operates under the city council form of government, with a separately elected mayor. The city engineer generally is responsible for resource and land management staff functions, which includes water and sewerage, storm water management, comprehensive planning, and land development regulations.

The city has adopted its Comprehensive Plan and Land Development Regulations pursuant to Chapter 163, F.S., and has prepared its EAR.

### Lee County

Lee County is the most populous part of the study area; in 1997, the county population was 394,244. The municipal areas of Cape Coral and Fort Myers, and the unincorporated areas of Lehigh Acres, Buckingham, North Fort Myers, South Fort Myers, and East Fort Myers constitute the bulk of the population within the basin. The greatest portion of the county population in the basin is located west of the Franklin Locks. The portion of the county population in the freshwater portion of the basin is relatively small, and is concentrated primarily in Alva, Charleston Park, and that part of Lehigh Acres within the Hickey's Creek subbasin.

The executive and legislative body for Lee County is the five member Board of County Commission. The County Commission also serves as the County Port Authority.

The county recently enacted a Charter, which did not significantly alter its statutory administrative framework. However, the Charter did require that the County Administrator become the County Manager and function as the Chief Executive Officer. The county seat is Fort Myers.

Lee County has an extensively developed administrative and services structure. The county departments that directly address water related issues in the basin include environmental services which includes natural resources and utilities, transportation, and community development.

Lee County has issues similar to other fast growing communities in Florida. The county has adopted a Comprehensive Plan that is approved by the state as the primary growth management tool. The recently enacted Conservation 2020 Plan gives the county an addition tool for resource protection.

**Lee County Comprehensive Plan and Land Development Regulations.** Lee County's Comprehensive Plan was determined to be in compliance as a result of a settlement agreement in 1990. Lee County has completed its EAR, which was determined to be sufficient. The county has adopted its EAR based amendments, and revised them after a hearing before the Land and Water Adjudicatory Commission.

The Plan now contains a forecast period to the year 2020. The county is in the process of scaling back some of its population forecasts to be more in accord with the median projections of the Bureau of Economic and Business Research (BEBR), University of Florida. The county does provide regional water and sewerage services to parts of the county.

The county has one area that functions as a town, but lacks a municipal charter. The county has developed overlay plans that guide development in the area known as Lehigh Acres. Lehigh Acres is an unincorporated community with 35,000 residents and over 100,000 vacant lots. It is a fast growing community served by the East County Water Control District. Lehigh Acres encompasses most of the drainage basin of the Orange River, a tributary to the estuarine portion of the Caloosahatchee River.

The county has an extensive set of land development regulations that have been codified. Sections of interest to the water management planning effort include overall administration (with a section on transfer of development rights and park impact fees), building regulations (with a section on flood hazards and a different one on coastal construction), development standards for Six Mile Cypress Basin, habitat and surface water management; a separate section on environment and natural resources, with provisions on wildlife and habitat, wellfield and wetland protection, and special vegetation provisions. The land use section provides recognition for environmentally sensitive areas, which reflects the designation on the future land use map.

## City of Cape Coral

Cape Coral is Florida's second largest city, physically, being 115 square miles in area, and divided between the Caloosahatchee River and the Matlacha Pass basins. Virtually the entire city was platted in the 1950s-1970s as one large subdivision, currently less than 30 percent developed. Its permanent population, presently estimated at 97,637 (November 1999), makes it the most populous city on Florida's West Coast south of St. Petersburg. The current population reflects an 8-fold increase since 1970. The city incorporated through a vote of its residents in the early 1970s to provide for local home rule, but most platting had already been completed. The city's original boundaries were holdings of the Gulf Guaranty Land and Title Corporation, but there have been annexations since that time.

The chief legislative body is the 8-member city council, with one member running for and being elected as Mayor. The city charter provides for a separate chief executive officer, the city manager, who is hired by the city council under contract.

The city administrative structure has been expanding to meet the city's growth. The public works department has taken water and sewerage services from a private utility, and has developed a domestic water reuse program. The city has a developed and matured community development department that addresses the varied needs of a city with Cape Coral's challenges.

The city's major initiatives are the water reuse program, managing the growth allowed by the extensive plats, and redeveloping land uses to be more balanced than the original plat.

**City of Cape Coral Comprehensive Plan and Land Development Regulations.** The City of Cape Coral's comprehensive plan was deemed in compliance through a settlement agreement in 1991. Since then the city has completed its EAR which has been deemed sufficient. The city's plat build out is forecasted well beyond long range (10-year) planning time frames.

The city is extensively platted in patterns that will lead to future environmental problems without expansion of utility services. These areas, which includes 135,000 buildable lots (with over 94,500 vacant) and lands annexed to the northwest and west will cause the build out population of the city to be approximately 350,000. The city has a policy structure to promote retrofitting, including its interceptor waterway, and expanding city sewer and water service to currently domestically served properties. However, areas outside of the water and sewer service areas are still developing as residential properties.

The city's land development regulations reflect the largely platted nature of the city. These plats in the 1950s-1970s resulted in extensive wetland loss. Habitat, however, had been largely disrupted through the activity of lumbering and has not had the opportunity to recover. Water quality, particularly in dredged canals, began degrading though storm water runoff and septic tanks, as well as through requirements that all canals be seawalled through vertical structures. Beginning in the 1970s, however, some water quality of open waters received protection through the institution of weirs, ostensibly to prevent saltwater intrusion. Further, sewerage became a city priority, and service has been extended throughout the older established parts of the city. Additionally, newer unplatted parts of the city are required to meet contemporary storm water standards.

#### Fort Myers

Fort Myers is the county's oldest municipality, constitutes the county seat, and is the site for most state and federal district offices. The city's population in 1997 was 46,522, which is nearly double its 1970 population. The city size is 30 square miles, which has been increasing as the city annexes lands to the south and east.

The chief legislative body is the six member city council, with a separately elected mayor. Fort Myers operates under the "strong mayor" form of government, which makes the Mayor the chief executive officer.

The city has the administrative infrastructure necessary for a matured community. It has a well-developed public works system, which provides transportation, water, sewerage, solid waste, and drainage for virtually the entire city. It has a separate community redevelopment agency, a downtown redevelopment authority, and a planning department that also addresses most components of land development not contained within public works. One of the city priorities is pursuing "Brownfields" designation through the U.S. Environmental Protection Agency (USEPA) and Florida Department of Environmental Protection (FDEP).

#### Fort Myers Comprehensive Plan and Land Development Regulations.

The Fort Myers Comprehensive Plan was determined to be in compliance through a settlement agreement in 1990. The plan acknowledged that it would be annexing lands to the east and south, which in turn would result in population increases. The plan included forecasts to the year 2010.

Since then the city has completed its EAR which has been determined to be sufficient. The city has initiated its EAR based amendments. Its new forecast year is the year 2020. Annexations are still expected to the east and south, with attendant increases in population.

Fort Myers, being one of the oldest communities on Southwest Florida's coast has been developed with water and sewerage services for virtually all of the community. Its land development regulations also reflect this.

### Special Districts

Independent, single purpose, special district forms of government exist throughout the state in many forms, the most pervasive being school districts, but water control, fire, library, lighting, mosquito control, are all common.

Independent special districts are also commonly chartered in the same manner as municipalities. However, under general law, their authorities are restricted to specific purposes as provided by the legislature.

There are also limited purpose special districts that can be enacted through the court system, and the most common of these are drainage districts, enacted in accord with Chapter 298 F.S. Chapter 298 F.S. requires each drainage district to have a Water Control Plan (formerly known as a Plan of Reclamation). There are a number of drainage districts within the basin, but not all are active. These drainage districts are as follows:

| District | County |
|---|---|
| Central County | Hendry |
| East Charlotte | Charlotte |
| LaBelle | Hendry/Glades |
| Mid County MSBU | Hendry |
| Diston Island WCD | Hendy/Glades |
| Cow Slough WCD | Hendry |
| Barron Collier WCD | Hendry/Glades |
| East Mulloch WCD | Lee |
| Bolles | Hendry |
| Collins Slough | Hendry |
| Clewiston | Hendry/Glades |
| Gerber Groves | Hendry |
| Hendry Hilliard | Hendry |
| County Line | Lee |
| Barron | Glades/Hendry |
| Devils Garden | Hendry |
| East County Water Control District | Lee |
| Flaghole | Hendry |
| Sugarland | Hendry |
| Gateway Services District | Lee |

A relatively new type of district, the Community Development District (Chapter 190 F.S.) was created to provide community services for lands that will be urbanizing, but will not initially be a formal municipality. Such areas are required to have an incorporation referendum when the population reaches a certain threshold. These areas are, however, subject to the general law of the local government of jurisdiction. The Port LaBelle Community Development District in Glades and Hendry counties is an example.

Of special note are the county based districts established through the Natural Resource Conservation Service. These (formerly, in some cases) Soil and Water Conservation Districts work with landowners to establish and implement "best management practices" for land and water users. These districts have elected boards and are active in most counties.

# PLANNING TIME FRAME

In mid-1997, the Florida Legislature passed new legislation pertaining to water supply plans. One requirement of the new legislation is that regional water supply plans should have at least a 20-year planning horizon. The planning horizon for the CWMP is 2020 and plan recommendations and strategies are intended to be relevant to projected conditions for 2020.

The preparation of water demand projections for the region and the development of the ISGM used for the simulation of hydrologic conditions were begun in 1997. Population projections for 2020 were obtained from the Southwest Florida Regional Planning Council (SWFRPC). Public water source demand projections used in the ground water models were based on the 2020 projections from regional and local governmental agencies. Agricultural projections for 2020 were completed at the same time using forecasts based on historical growth and acreage and future economic outlook.

Based on this information, it was concluded that the analysis conducted for this plan has reasonably represented current projected conditions in the year 2020. Therefore, the CAC and staff feel confident that the plan recommendations and strategies apply to the year 2020 planning horizon. It is also recommended that the plan be updated in five years and that the update base all analyses on 2025 demand projections.

# Chapter 3
# PLANNING AREA DESCRIPTION

## SUMMARY OF WATER RESOURCE SYSTEMS

Water for urban and agricultural uses in the *Caloosahatchee Water Management Plan* (CWMP) Planning Area is supplied from both ground water and surface water systems. Surface water is used primarily for agricultural irrigation, with ground water being used in areas that do not have access to the river. In addition, the Caloosahatchee River is a source for potable water supply in Lee County.

Ground water and surface water are dependent upon rainfall for recharge. The average annual rainfall in the CWMP Planning Area is about 52 inches. Two-thirds of this occurs during the wet season months, from May through October. In addition to seasonal variation, rainfall varies significantly from year to year with historic annual amounts ranging from 34 inches to in excess of 75 inches in the planning area. Rainfall also varies spatially, with rainfall amounts generally decreasing from east to west.

### Ground Water

The Caloosahatchee Basin is underlain by three aquifer systems: the Surficial Aquifer System (SAS), and the Intermediate Aquifer System (IAS), the Floridan Aquifer System (FAS). These aquifer systems are described in **Table 2**.

#### Surficial Aquifer System

The SAS consists of the water table aquifer and the lower Tamiami aquifer. In areas where they both occur, leaky semi-confining beds separate them. These beds are collectively referred to as the Tamiami confining zone. Because of its closeness to the surface, this aquifer is easily recharged by local rainfall.

The water table aquifer occurs throughout the Caloosahatchee Basin and is generally 20 to 40 feet thick but may be as thick as 80 feet. It is extremely variable in composition and hydraulic properties but is not heavily used in the basin. However, in some localized areas it represents the only viable water source.

The Tamiami confining zone is a leaky semi-confining zone that separates the water table aquifer from the underlying lower Tamiami aquifer. It is present throughout most of the Caloosahatchee Basin and occurs in thicknesses of up to 60 feet.

The lower Tamiami aquifer is a major source of ground water for most of the Caloosahatchee Basin. It behaves as a semi-confined aquifer except in those areas where the Tamiami confining zone is absent or has high values of vertical hydraulic conductivity.

**Table 2.** Generalized Hydrogeology of the Caloosahatchee Basin (Herr and Shaw, 1989).

| Hydrogeologic System | Hydrogeologic Unit | Thickness (feet) | Water Resources Potential |
|---|---|---|---|
| Surficial Aquifer System (SAS) | Water Table Aquifer | 20-75 | Important source of local irrigation water |
| | Tamiami Confining Zone | 20-75 | |
| | Lower Tamiami Aquifer | 50-150 | Important irrigation source in eastern Hendry County Disappears in western Hendry and Glades counties |
| Intermediate Aquifer System (IAS) | Upper Hawthorn Confining Zone | 300-500 | |
| | Sandstone Aquifer | | Water source in western Glades and Hendry counties. However, low yield and highly variable. |
| | Mid-Hawthorn Confining Zone | | |
| | Mid-Hawthorn Aquifer | | Water source in western Lee County, Absent elsewhere. |
| | Lower Hawthorn Confining Zone | | |
| Florida Aquifer System (FAS) | | Insufficient Data | Important irrigation source in northern Glades County Elsewhere too mineralized. |

## Intermediate Aquifer System

The IAS in Southwest Florida consists of the upper Hawthorn confining zone, the sandstone aquifer, the mid-Hawthorn confining zone, the mid-Hawthorn aquifer, and the lower Hawthorn confining zone. Together, these units act to confine the underlying FAS from the overlying SAS.

The upper Hawthorn confining zone is a zone of low permeability in the uppermost part of the Hawthorn group. It forms the bottom of the SAS and impedes the vertical flow of water into the underlying aquifers of the IAS or vice versa. In the basin, the upper Hawthorn confining zone ranges in thickness from 10 to 260 feet.

The sandstone aquifer occurs only in the western portion of the planning area. It usually occurs as two discrete lithologic zones, an upper clastic and a lower carbonate zone. In many locations, the two lithologic zones display good hydraulic connection and act as a single semi-confined aquifer. The sandstone aquifer in the basin varies in thickness between 0 and about 160 feet.

The mid-Hawthorn confining zone underlies the sandstone aquifer. In those areas where the sandstone aquifer does not occur, the mid-Hawthorn and upper Hawthorn confining appears as one unit. The mid-Hawthorn confining zone is a relatively thick heterogeneous mixture of clayey dolosilts demonstrating very low hydraulic conductivity.

Although present throughout the CWMP Planning Area, the mid-Hawthorn aquifer is not always productive. Its thickness is variable and relatively thin (it rarely exceeds 80 feet). This variability combined with the presence of interbedded low permeability layers, results in low productivity of the aquifer. In addition to low productivity, the aquifer experiences degradation in water quality as it dips to the south and east, yielding only saline water in much of the planning area. The mid-Hawthorn aquifer is underlaid by the lower Hawthorn confining zone that effectively separates the IAS from the FAS.

### Floridan Aquifer System

Although it is the principal source of water in Central Florida, the FAS yields only non-potable water throughout the CWMP Planning Area. The quality of water in the FAS deteriorates southward increasing in hardness and salinity. Salinity also increases with depth, making the deeper producing zones less suitable for development than those near the top of the system. Despite the lack of potable water, developments in desalination technology have made treatment of water from the upper portion of the FAS feasible where chloride concentrations are not prohibitively high. The most productive zones are the lower Hawthorn and Suwannee aquifers. Because water from these aquifers requires expensive desalination treatment for potable uses they have not been developed extensively within the Caloosahatchee Planning Area. Within the planning area, the City of Cape Coral obtains water from the FAS. The City of Fort Myers is developing a plan to shift the source of its potable supply from the Caloosahatchee River to the FAS.

## Surface Water

The hydrology of the Caloosahatchee Basin has been strongly affected by land and canal development during the past 100 years. In predevelopment times, the Caloosahatchee River was a sinuous river extending from Beautiful Island to a waterfall at the west-end of Lake Flirt. A sawgrass marsh extended from Lake Flirt to Lake Okeechobee. The predevelopment landscape had few tributaries east of LaBelle and Twelve-mile Slough connected the Okaloacoochee Slough to the Orange River (**Figure 3**). The area east of LaBelle is flat and there were few creeks to provide drainage. In the 1880s, the Disston Canal was dug from Lake Flirt to Lake Okeechobee to provide a navigable channel for steamboats from Lake Kissimmee through Lake Okeechobee to the Gulf of Mexico (USACE, 1957). The channel was enlarged to a 6-foot depth and 90-foot width during the period 1910 to 1930, and three locks were constructed along the canal in 1918 to improve navigation.

Today, the C-43 Canal (Caloosahatchee River) is the most significant source of surface water in the Caloosahatchee Basin. The C-43 Canal receives water from Lake

Okeechobee, runoff from the basin, and baseflow from the SAS. The river in turn supplies water for public supply, agriculture, and the environment. This source can be unreliable during the dry season or periods of inadequate rainfall, when releases are required from Lake Okeechobee to meet demand. The U.S. Army Corps of Engineers (USACE) manages the C-43 Canal via a regulation schedule, which presently accommodates navigational, flood protection, water supply, and environmental needs.

The Lake Okeechobee Demand (Service) Area, which is defined as the area that is or could be supplied by surface water from the Caloosahatchee River, is the primary source for agricultural irrigation and potable surface supply water in the Caloosahatchee Basin. This area extends from the Franklin Lock (S-79) eastward to the Moore Haven Lock (S-77) and includes land in Lee, Glades, and Hendry counties.

Other surface water bodies in the Caloosahatchee Planning Area include lakes, rivers, and canals. These areas provide storage and allow conveyance of surface water. Lake Hicpochee is the largest lake in the planning area and is bisected by C-43 just west of Lake Okeechobee. Numerous canals and tributaries in the planning area drain into the Caloosahatchee River. The major tributaries are the Orange River and Telegraph Slough, which drain into C-43 in the western portion of the basin, near W. P. Franklin Lock and Dam (S-79). The majority of the canals in the basin were constructed as surface water drainage systems rather than for water supply purposes. **Figure 3** shows the lakes, rivers, canals, and the Lake Okeechobee Demand Area.

### Surface Water Inflow and Outflow

Surface water flows in the basin are derived from rainfall within the basin and discharge from Lake Okeechobee. Runoff from the West Caloosahatchee Basin is slightly higher than runoff from the East Caloosahatchee Basin indicating the greater flow attenuation in eastern basin due to the flatness and thick, sandy soils (Fan and Burgess, 1983). Inflow from Lake Okeechobee is the primary flow in the river during the dry season. Water is released from the lake to meet the supplemental agricultural water demand as well as supplying water for municipal consumptive use. Water is also released to reduce lake stage before the hurricane season that may result in very high flows to the estuary. There is little water storage in the basin. The intensive drainage on the south side of the river provides little storage. The north side of the river is largely undeveloped west of Lake Hicpochee and although there is considerable wetland water storage it is not managed water storage.

### Exchange with Ground Water

Ground water is an important component of the agricultural water supply in the freshwater portion of the Caloosahatchee Basin. The ground water resources in the area include the SAS, the IAS, and the FAS. The yield and storage of the ground water is highly variable throughout the basin. Where possible, surface water has been used for irrigation. The SAS is used for some irrigation in eastern Hendry and Glades counties. The IAS is used primarily for irrigation in the western portion of Hendry County. There is local recharge to both the SAS and the IAS. The FAS is used in northern Glades County

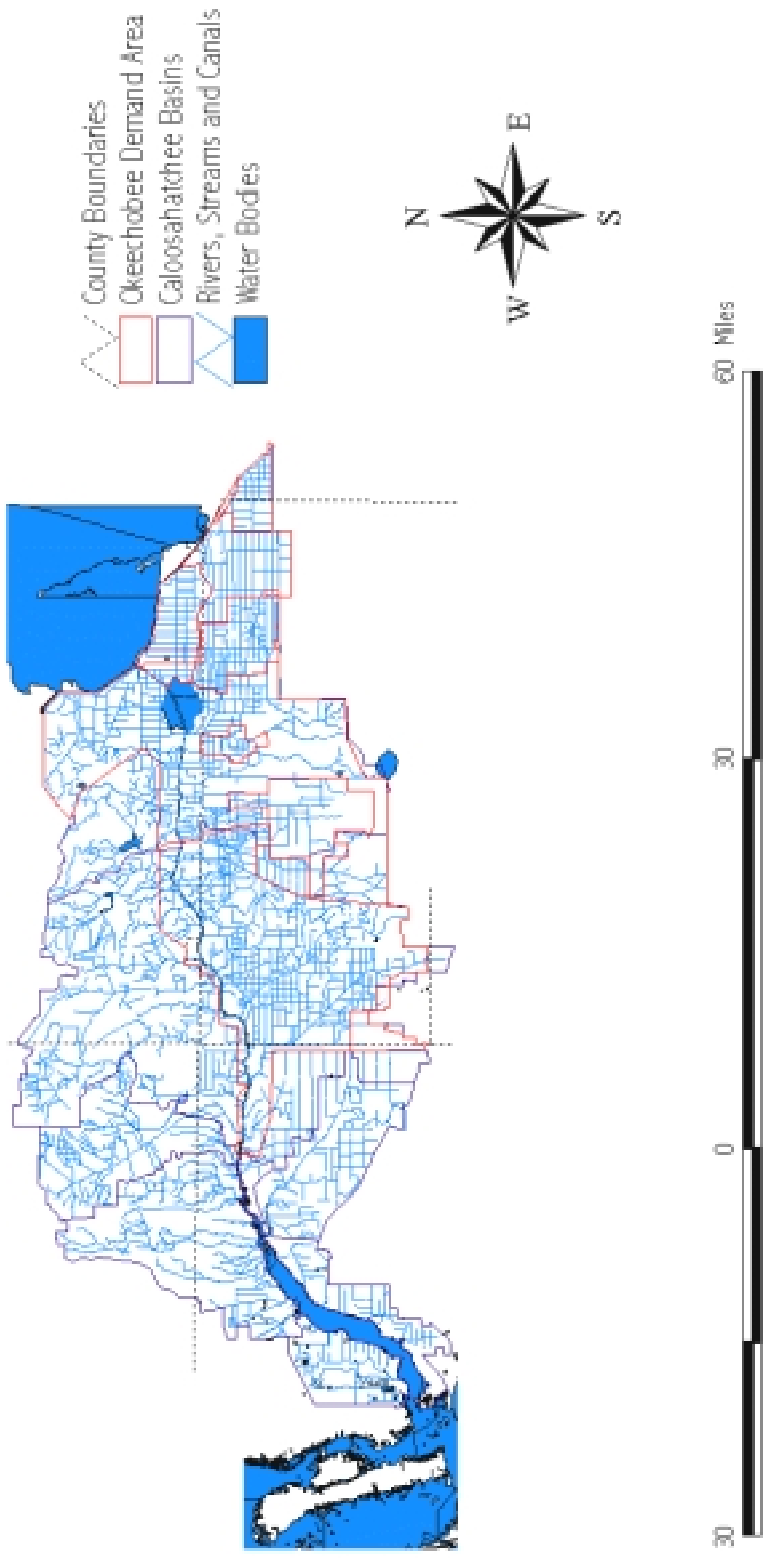


**Figure 3.** Lakes, Rivers, and Canals and the Lake Okeechobee Demand Area.

for irrigation and in the northwest corner of the basin and mixed with surface water for irrigation. The water from the FAS is too highly mineralized elsewhere in the basin. This deep aquifer is recharged from outside the area.

### Drainage Basins

By the 1930s, there was pressure for drainage projects that would allow land development in the basin. Analysis of flood conditions showed that there was good drainage downstream of Hendry County but insufficient drainage east of LaBelle (Hills, 1927). The landscape was too flat and the river channel provided little conveyance capacity resulting in prolonged inundation; for example, floods in the 1920s left water six feet deep in LaBelle. The canal was straightened and deepened in 1937, 1941, and 1966 and the Moore Haven Lock and Dam (S-77) and Ortona Lock and Dam (S-78) were completed in 1937 (Fan and Burgess, 1983). The current channel, C-43, was created to carry a maximum discharge of 10,000 cubic feet per second (cfs) from Lake Okeechobee. The channel was designed to remove runoff to reduce prolonged inundation, accommodate regulatory discharges from Lake Okeechobee, and provide a navigable channel. The project was completed in 1966 with the Franklin Lock and Dam Structure (S-79), which was designed to control water by reducing saltwater intrusion into the main channel, provide a freshwater head to reduce saltwater intrusion into the water table aquifer, and to maintain a higher water table in the lower region of the basin (USACE, 1957).

The primary system consists of the C-43 Canal (Caloosahatchee River) and the C-19 Canal, which were dug as part of the Central and South Florida Flood Control Project (**Figure 4**). The primary system also includes the C-20 and C-21 canals, and the L1 and L2 levee borrow canals in the S-4 Basin. There are several structures on these canals, which are designed to maintain upstream water levels (**Table 3**). The canals and water control structures were designed to provide 33 cfs per square mile or 1.25 inches of drainage for the Caloosahatchee Basin. The C-43 Canal was constructed to provide both navigation and drainage conveyance capacity. The canal consists primarily of a deep channel 150 feet wide and 25 feet deep. East of LaBelle the channel has high banks created by spoil and discharge to the river is conveyed through culverts with drop structures or weirs. The channel has been cut through Lake Hicpochee effectively creating two marshes. The C-19 Canal connects to C-43 in Lake Hicpochee and there is an irrigation canal connecting C-43 with lift pumps on the south side of Lake Hicpochee. West of LaBelle the riverbanks are populated and the tributaries flow into the river uncontrolled. There are fewer spoil banks along the river west of LaBelle. There are several remnant oxbows from the old river channel in this section of the river.

There is a secondary canal system that consists of several canals that provide drainage or irrigation (**Figure 5**). These canals are located in Hendry and Lee counties south of the river. Although these canals provide adequate flood protection for large areas of the basin there are many areas that flood extensively. Flooding is particularly a problem along the river west of LaBelle where upstream drainage projects flood residential areas along the river. There are large sections of Central Hendry County that

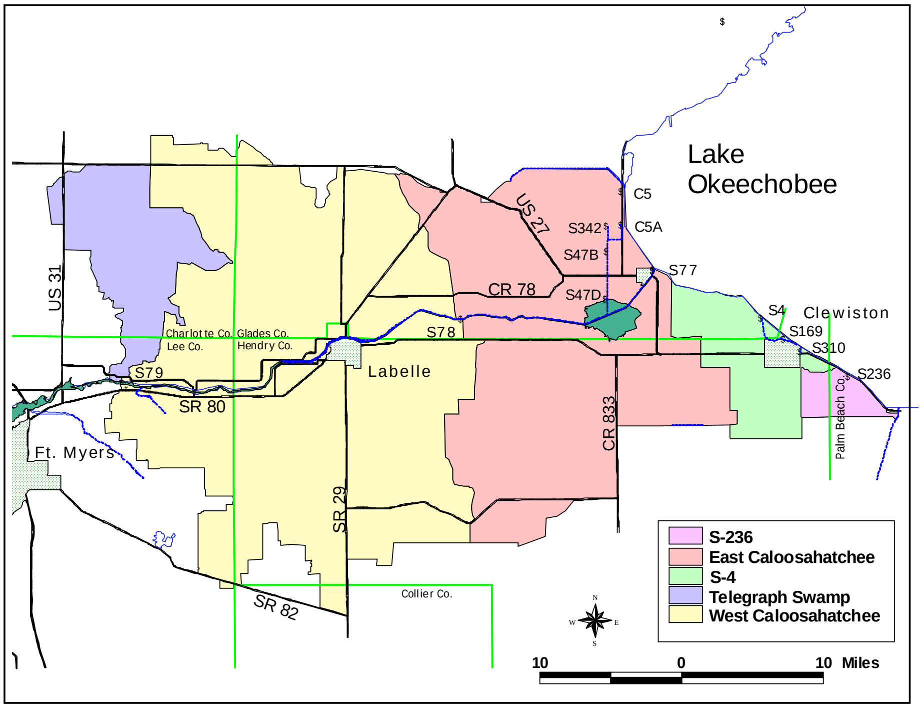


**Figure 4.** Drainage Basins and Project Structures of the Caloosahatchee Basin.

**Table 3.** Operating Schedules for the Primary Canal System.

| Structure | Canal | Operating Rule |
|---|---|---|
| S-77 | C-43 | Discharge rule follows Lake Okeechobee regulation schedule. |
| S-78 | C-43 | Maintain upstream canal stage between 10.8 and 11.3 feet NGVD |
| S-79 | C-43 | Maintain upstream canal stage between 2.8 and 3.4 feet NGVD. Rules allow lowering stage to 2.2 feet to accommodate anticipated runoff, however stage maintained above 2.5 feet to provide water for Lee Co. water supply intakes. |
| S-47D | C-19 | Maintain upstream water between 12.5 and 13.0 ft NGVD |
| S-47B | C-19 | Maintain upstream water between 14 and 15.5 ft. NGVD |
| S-342 | C-19 | Maintain upstream water above 16 ft NGVD |
| C-5 | | Release water from lake when Lake Okeechobee is above 14.5 and basin below 12.0 ft NGVD |
| C-5A | L-41 | Release water from lake when Lake Okeechobee is above 14.5 and basin below 12.0 ft NGVD |
| S-235 | C-43 & LD1 | Kept open when possible to provide water and drainage for S-4 Basin. Stage maintained in S-4 borrow canals between 11-14 feet NGVD. |
| S-4 | L-21 | Pump storm water runoff into lake when stage in C-20 exceeds 14 ft NGVD |
| S-169 | L-21 | Left open to lake when the lake is below 13.5 ft. |
| S-310 | L-21 | Left open when the lake is below 13.5 ft. |

do not have extensive drainage and drainage occurs as overland flow. North of the river, in Lee County, there is significant flooding in the tidal basin.

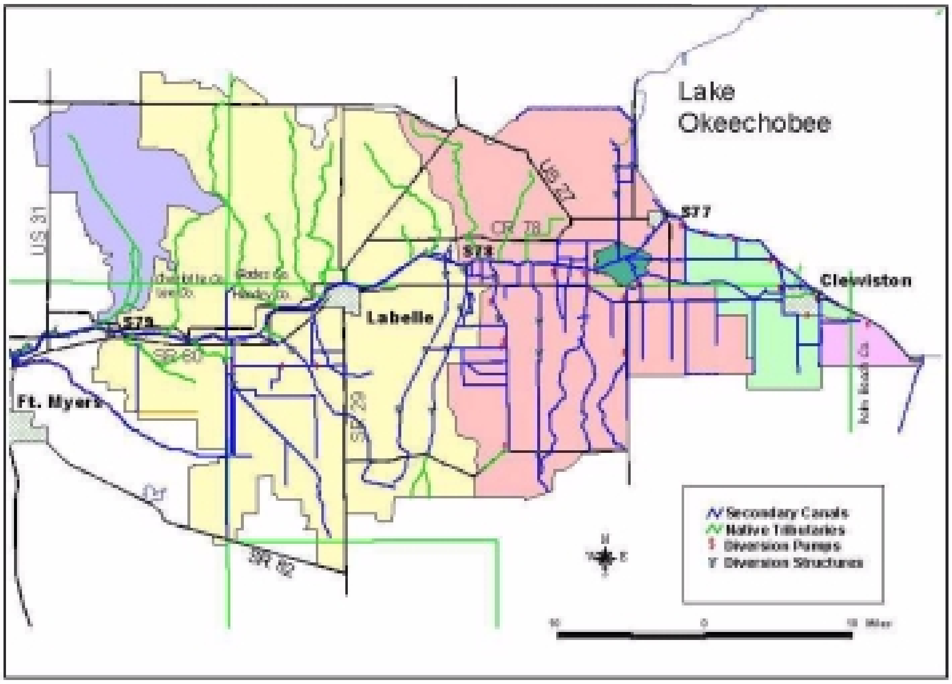


**Figure 5.** Secondary Canals and Diversion Structures in the Caloosahatchee Basin.

There is less extensive drainage north of the river. West of Lake Hicpochee in Glades County there is much less intensive drainage. This area has greater relief than Hendry County and historically experiences less persistent flooding. However, there are many field ditches and ditched sloughs and marshes to encourage runoff.

Throughout the rural portion of the basin, most of the water control structures are associated with agricultural development. In particular, most of the control structures are discharge structures for impoundments for citrus groves. There are few detention ponds associated with sand land sugarcane. Groves established before 1984 do not have detention facilities and control structures, either simple culverts or drop-structures with flashboard risers are located on farm ditches. The detention characteristics of these systems are uncertain. There are few water control structures on pastureland.

Impoundments developed to detain or retain storm water runoff are important landscape features that affect water resource management in the Caloosahatchee Basin. The impoundments were developed as part of the surface water permits to meet the requirement to detain surface water runoff so that it does not exceed predevelopment runoff behavior. Although impoundments are an integral part of recent permits, they were not required for permitting older developments either urban or agricultural. As a result, there are large areas in the basin that have few impoundments.

Approximately 40 percent land area of the basin can receive irrigation water from Lake Okeechobee through a network of canals. Diversion water pumps are important components of the irrigation network. The irrigation strategy in the basin has been to maintain the water levels in the irrigation supply canals for the growers to withdrawal water as needed. The pumps are operated on float-switches to maintain canal levels during critical dry periods. The pumps are located at structures that include weirs with gates or movable boards that facilitate drainage during wet periods. Description of the diversion pumps is provided in **Table 4**, and the location of the pumps is provided in **Figure 5**.

**Table 4.** Secondary Irrigation and Drainage Pumps in the Caloosahatchee Basin.

| Water Use Permit | Intake Elevation (feet, NGVD) | Upstream Elevation (feet, NGVD) | Water Source |
|---|---|---|---|
| 2600315W | 21 | 29 | C-3 |
| 2600139W | NA | 17 | C-43 |
| 2600139W | NA | 17.5 | C-43 |
| 2600003W | 9 | 14.5 | Hilliard Canal |
| 2600234W | 14.5 | 21 | C-43/ H-H Canal |
| 2200189W | 11 | 17 | Hilliard Canal |
| 2200135W | 12.5 | NA | C-43 |
| 2600510W | 12.5 | 14 | C-43/ Canal 3 |
| 2600176W | 14.5 | 20 | C-43/ Canal 3 |
| 2600176W | 14 | 18.5 | C-43/ Canal 3 |
| 2600179W | 18.5 | 21 | C-43/ Canal 3 |
| 2600082W | 3 | 21 | Townsend Canal |
| 2600106W | 10 | 22 | (C-43) |
| 2600222W | 22 | 25 | Townsend Canal |
| 2200063W | 7 | 10.5 | LD-1 |
| 2200063W | 7 | 13.5 | LD-3 |
| 2200063W | 6 | 13.5 | LD-3 |
| 2200063W | 9 | 13.5 | LD-3 |
| 2600024W | 6 | 13.5 | Okeechobee |
| 2600024W | 15 | 14 | Lateral No.16 |
| Sugarland | 15 | 13 | C-21 |
| Clewiston | 16 | 13 | C-21 |
| Clewiston | 11 | 13.5 | Industrial Canal |

The surface water sources include on-site ponds and canals and the water table aquifer, which are closely connected. Most of the irrigation water used in the Lake Okeechobee Service Area (LOSA) that is not obtained from the Caloosahatchee River is obtained from the sandstone aquifer, SAS, or the lower Tamiami aquifer. A few farms obtain irrigation water from the water table aquifer or on-site surface sources.

The Caloosahatchee Basin can be delineated into five primary basins (**Figure 6**):

- The S-4 Basin, which can, depending on hydrologic conditions, drain into or use irrigation from the Caloosahatchee River
- The East Caloosahatchee, defined as the land that drains into the C-43 between S-77 and S-78
- The West Caloosahatchee, defined as the land that drains into the C-43 between S-78 and S-79
- The Telegraph Swamp, which drains into the C-43 near S-79
- The Tidal Basin which drains into C-43 downstream of S-79 at the western extent of the basin

As a part of the CWMP current subbasin boundaries were reviewed and modified as necessary, based on review of the hydrography.

Each of these primary subbasins contains several tributaries. There are large tributaries defined by native streams, sloughs, and canals and many small tributaries that drain small areas adjacent to the C-43. There are also several small tributaries that drain directly to the estuary.

**S-4 Basin.** There are several locations where ambiguous or bidirectional drainage affects the Caloosahatchee Basin boundaries. In these areas, antecedent water levels, runoff volume, and location of man-made structures determine the direction of storm water drainage. A portion of the S-4 Basin (comprised of the C-21 and S-235 subbasins) may drain to the Caloosahatchee River. Drainage water from the C-21 Canal is released into the Caloosahatchee River through S-235 when the lake stage is greater than 15.5 ft or the stage exceeds Lake Regulation Schedule. The runoff is generated primarily from the Disston Water Control District (DWCD). Storm water runoff from DWCD may be discharged into the C-43 Canal through a private drainage pump or discharged to Lake Hicpochee through private drainage pumps.

The Caloosahatchee River also captures drainage from Nicodemous Slough when Lake Okeechobee stage is high or runoff exceeds the conveyance capacity of the L-19 and L-21 barrow canals. Drainage water is discharged through the C-19 Canal into Lake Hicpochee. In normal conditions, Nicodemous Slough drains to Lake Okeechobee.

**West and East Caloosahatchee Basin.** The West and East Caloosahatchee basins extend along the freshwater portion of the Caloosahatchee River (C-43 Canal), from S-79 (W. P. Franklin Lock and Dam) to S-77 at Lake Okeechobee. The basins include parts of Lee, Collier, Hendry, Glades, and Charlotte counties. The C-43 Canal is the major surface water resource within these basins. Although the C-43 is already allocated, it may be able to yield additional amounts of water during the wet season for

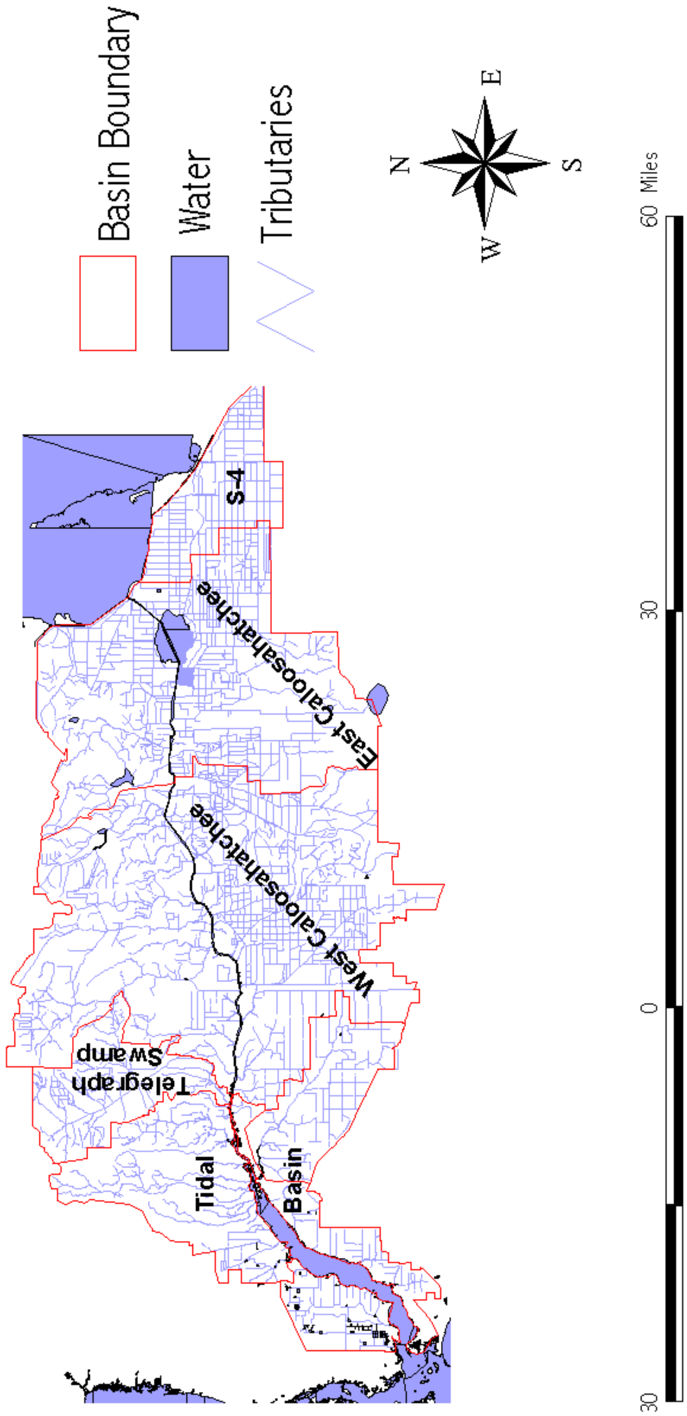


**Figure 6.** Major Subbasins in the Caloosahatchee Basin.

Aquifer Storage and Recovery (ASR), a technique which stores excess water by injecting it into an aquifer, where it can later be recovered when needed. However, there is significant institutional and technical uncertainty regarding the feasibility of utilizing untreated surface water ASR from a water quality and permitting standpoint. The *LWC Water Supply Plan* recommends that the SFWMD work with public water suppliers and local government in identifying additional sites for ASR projects, and with the FDEP to address regulatory issues associated with ASR in Florida laws.

The C-43 Canal provides drainage for numerous private drainage systems and local drainage districts within the combined drainage basins. The canal also provides irrigation water for agriculture projects within the basins and Public Water Supply (PWS) for the City of Fort Myers and part of Lee County. A primary purpose of the canal is to provide for regulatory releases of excess water from Lake Okeechobee. In the East Caloosahatchee Basin, Lake Hicpochee was severely impacted by the construction of the C-43 Canal. The canal was constructed through the lake's center, which resulted in lower lake water levels.

There are three structures that provide for navigation and water control in the C-43 Canal. These structures serve to control the water stages in C-43 from Lake Okeechobee and the Moore Haven Lock (S-77) to W. P. Franklin Lock and Dam (S-79). Water levels upstream of the Ortona Lock (S-78) are maintained at approximately 11 feet National Geodetic Vertical Datum (NGVD), and 3 feet NGVD downstream. The W. P. Franklin Lock and Dam (S-79) serves as a saltwater barrier and maintains an upstream level of approximately 3 feet while the downstream NGVD is generally near one foot. The operation schedule for these structures is dependent on rainfall conditions, agricultural practices, the need for regulatory releases from Lake Okeechobee, and the need to provide water quality control for the PWS facilities.

**Telegraph Swamp Basin.** The Telegraph Swamp Basin extends from Charlotte County southward to the Caloosahatchee River. The major feature of this basin is the Telegraph Cypress Swamp, which drains via sheetflow into Telegraph Creek in Lee County. Since this is a large basin with sheetflow discharge, there is a potential for this basin to be a good recharge area (Johnson Engineering et al., 1990).

**Tidal Caloosahatchee Basin.** The Tidal Caloosahatchee Basin extends on both sides of the saltwater portion of the Caloosahatchee Basin, northerly into Charlotte County. Numerous creeks drain into the Caloosahatchee River. These creeks are tidally influenced and are not suitable as a major source of surface water withdrawal. The Lee County Surface Water Management Plan (Johnson Engineering et al., 1990) recommends putting weirs in several of the creeks to maintain water levels in the dry season. This plan suggests that Trout Creek and the channeled portions of the Orange River have a potential for water supply. Trout Creek receives drainage from the C.M. Webb Area via sheetflow and a large canal; and placing a weir in the creek would enhance its water supply potential. In the Lehigh Acres area, the weirs in the Able Canal (the channelized portion of the Orange River) provide recharge to the area. An ASR system might be possible, if it is feasible to connect to the weir system.

The Orange River Basin, which is approximately 77 square miles, extends to the outfall of the Harn's Marsh detention area, where the upstream portion of the basin lies within the East County Water Control District. The Harn's Marsh detention facility is a primary outfall of the East County Water Control District's Able Drainage Way and Sailfish Drainage Way. The basin has not significantly changed since construction of the East County Water Control District drainage way system and the construction of the Townsend Canal in Hendry County. The northern basin boundary is adjacent to the Hickey Creek and Bedman Creek basins while the southern basin lies along SR 82 with the exception of a portion of the Mirror Lakes development, which lies south of SR 82. The western boundary of this basin lies along Interstate 75 in the northern portion of the basin and lies primarily along section lines from SR 82 north for approximately four miles.

## SURFACE WATER/GROUND WATER RELATIONSHIPS

The SAS is unconfined and directly connected with surface waters. The water table aquifer is recharged from infiltration and deep seepage from wetlands and canals. As such, surface water management has a direct impact on the water table aquifer. Excessive drainage may divert water to the estuary rather than to ground water recharge. The water table aquifer is hydraulically connected to the lower Tamiami aquifer and surface water management directly affects recharge to the lower Tamiami aquifer.

The IAS is partially connected with surface waters. The sandstone aquifer is separated from the Caloosahatchee River by confining layers; however, the sandstone aquifer is recharged from surface water in southeastern Lee County. Recharge also occurs in the Immokalee area from the water table aquifer and flows in a northwest direction toward the river as well as to the south. The mid-Hawthorn aquifer is recharged from an area as far away as 100 miles north of the basin.

The FAS is not hydraulically connected naturally to surface water or the other aquifer systems. However, there are approximately 200 flowing wells that discharge water into surface waters. Many of these wells are uncased or have corroded casings that allow mixing of highly mineralized water of the FAS with the IAS.

## Drainage Districts

Chapter 298, Florida Statutes authorized self-governing local water control districts (**Figure 7**). The water control districts, known as 298 districts, develop and implement plans for reclamation in the area of their jurisdiction. The 298 districts have the power to construct and maintain canals, divert flow of water, construct and connect works to canals or natural watercourses, and construct pumping stations. They are authorized to enter into contracts, adopt rules, collect fees, and hold, control, acquire, or condemn land and easements for the purpose of construction and maintenance. The plan of reclamation for each 298 district is on file at the county courthouse and Florida Department of Environmental Protection (FDEP). The 298 districts in the Caloosahatchee Basin were developed to meet drainage needs for both urban and agricultural development and in several cases the need for irrigation. In addition to the 298 districts, there are two private drainage districts.

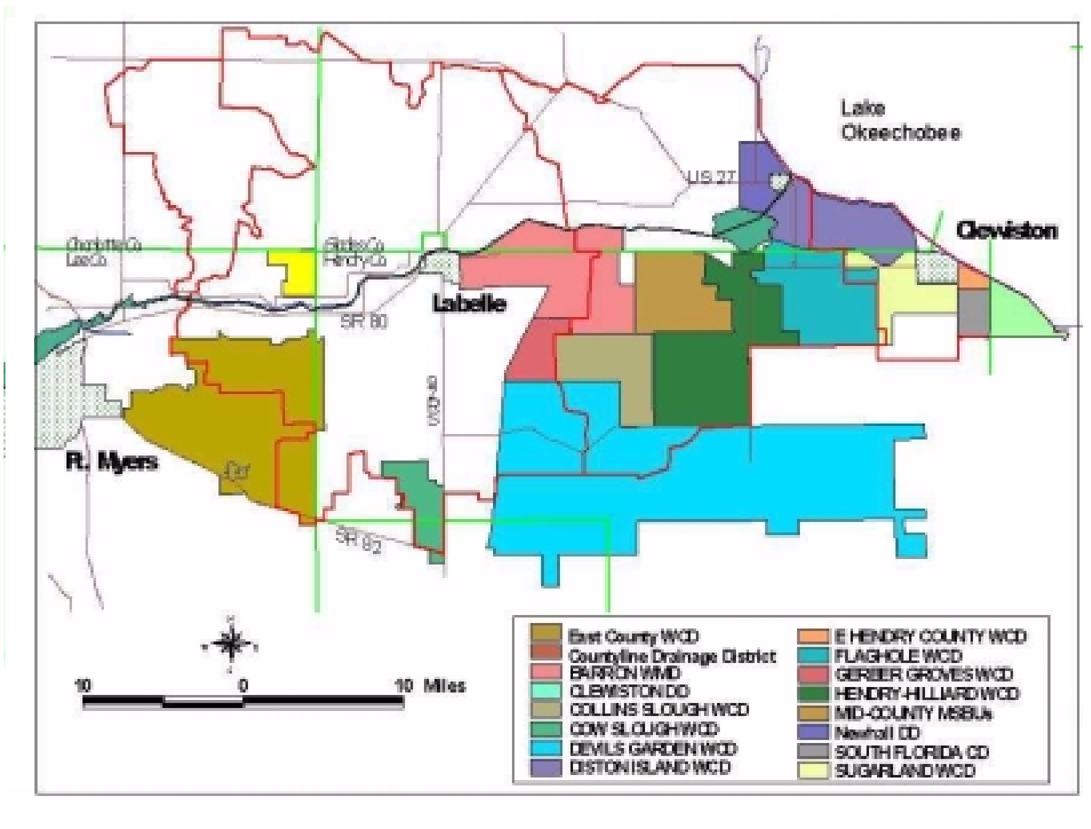


**Figure 7.** Chapter 298 Water Control Districts.

# SUMMARY OF NATURAL SYSTEMS

Natural systems within the Caloosahatchee Planning Area consist of wetland (freshwater swamps, sloughs, and marshes) and upland (flatwoods, tropical hammocks, and xeric scrub communities) regions. Although classified as different habitats, these systems are interdependent on each other. A number of these systems are relatively pristine areas and are recognized as having regional importance. These areas serve as important habitat for a wide variety of wildlife and have numerous hydrological functions.

## Wetlands

In general terms, wetlands are lands where saturation with water is the dominate factor determining the nature of soil development and the types of plants and animal communities present. The major types of freshwater wetland systems within the Caloosahatchee Basin are forested, scrub/shrub, and herbaceous wetlands.

Wetlands provide a wide variety of functions and values. These can be grouped into three general categories: biological, hydrological, and socioeconomic. All natural functions may not be apparent in every basin but that does not abate the importance of the system.

Wetland habitats provide a variety of usages for wildlife. Some organisms depend on wetlands for their entire existence. Others use the wetlands sporadically for wintering, feeding and reproduction, nursery areas, den sites, or corridors for movement. Wetlands are an important link in the aquatic food web. These freshwater systems are important sites for microorganisms, invertebrates, and forage fish, which are consumed by predators such as amphibians, reptiles, wading birds, and mammals.

The hydrological function of a wetland is to act as a receiving and storage area for surface water runoff. This function is important in controlling flooding, erosion, sedimentation, and the production of fish and wildlife on the regional scale. As surface water enters a wetland, water is stored until its overflow capacity is reached and water is released downstream. As water flows are weakened, sediment is deposited and nutrients are absorbed into the system, improving water quality. Some wetlands function as recharge areas, while others function primarily as ground water discharge areas.

Socioeconomic values refer to cultural and aesthetic qualities of wetlands, as well as man's monetary benefits associated with preserving the natural water resource functions of these areas. Wetlands are a rich source of information and education and can provide social and economic benefits such as nutritional components that may enhance commercial and sport fishing production, agricultural and aquacultural production, recreation, aesthetic and open space, and information on cultural heritage.

### Major Wetland Systems

The Twelve-Mile Slough is located in Hendry County and is a tributary to the much larger and regionally significant Okaloacoochee Slough. The Twelve-Mile Slough covers 3,300 acres and contains a mosaic of freshwater wetlands, as well as pine flatwoods and oak/cabbage palm hammocks. Surface water storage in the numerous wetlands provides for ground water recharge of the underlying SAS, and provides surface runoff to the Caloosahatchee River.

A portion of the Okaloacoochee Slough is located in the Caloosahatchee Basin, in Hendry County. It flows both north, toward the Caloosahatchee River, and south toward Collier County and is a major headwater for the Fakahatchee Strand and the Big Cypress National Preserve. Its extensive network of sloughs and isolated wetlands store wet-season runoff from the surrounding uplands and provide year-round baseflow to downstream natural areas.

## Uplands

Upland communities within the Caloosahatchee Basin include flatwoods and tropical hammocks. Flatwoods are the most dominant upland habitat and are divided into two types: dry and hydric. An open canopy of slash pine with an understory of saw palmetto characterizes dry flatwood communities. Hydric flatwood communities are vegetatively similar to dry flatwoods but are located in a slightly lower elevation and are seasonally inundated. Flatwoods are rich in vertebrate species and are important habitat for a number of rare, threatened, or endangered species, such as the Florida panther, eastern indigo snake, red-cockaded woodpecker, and gopher tortoise.

Tropical hammocks are diverse woody upland plant communities. They are scattered but not widespread throughout the Caloosahatchee Basin. Tropical hammocks occur on elevated areas, often on Indian shell mounds along the coast or on marl or limestone outcroppings inland. These are among the most endangered ecological communities in South Florida.

Upland plant communities serve as recharge areas, absorbing rainfall into soils where it is distributed into plant systems or stored underground within the aquifer. Ground water storage in upland areas reduces runoff during extreme rainfall events, while plant cover reduced erosion, and absorbs nutrient and other pollutants that might be generated during a storm event.

## Lake Okeechobee

Lake Okeechobee, which covers 730 square miles, is the largest freshwater lake in the southeastern United States. The lake receives significant volumes of runoff from the Kissimmee River, which begins near Orlando, the Upper Chain of Lakes, Lake Istokpoga and numerous small inflows along the north shore of the lake in the wet season. During the predevelopment period, Lake Okeechobee discharged to the south and west, into the Everglades and the Caloosahatchee Basin during high water periods. The USACE and the SFWMD now control the outfall from the lake. Numerous canals connect the lake to the east and west coasts as well as the Everglades.

The Caloosahatchee Canal receives water from Lake Okeechobee for flood control and water supply. Regulatory discharge via C-43 (**Table 5**), to lower lake stage for flood protection, is 37 percent of total surface water discharge from Lake Okeechobee (Fan and Burgess, 1983). In wet years, this has resulted in discharge as great as the total runoff from the basin. Water is also released to control alga blooms in the river (Miller et al., 1982). At low flow, alga blooms develop in the canal between S-78 and S-79, producing poor drinking water quality for Fort Myers and Lee County water supplies. Water is released from the lake to flush this water out of the river. Water also is released to push salt water out of the river section that has entered through the locks. The air bubbling system, when adequately maintained, assists in alleviating the problem. This salinity approaches federal drinking water standards at the freshwater intakes. Flushing has been shown to be effective and has been reduced due to use of the air curtain.

**Table 5.** Daily Discharge Pulse Release Schedule for the Caloosahatchee River.

| Day of Pulse | Level I | Level II | Level III |
|---|---|---|---|
| | (cfs) | | |
| 1 | 1,000 | 1,500 | 2,000 |
| 2 | 2,800 | 4,200 | 5,500 |
| 3 | 3,300 | 5,000 | 6,500 |
| 4 | 2,400 | 3,800 | 5,000 |
| 5 | 2,000 | 3,000 | 4,000 |
| 6 | 1,500 | 2,200 | 3,000 |
| 7 | 1,200 | 1,500 | 2,000 |
| 8 | 800 | 800 | 1,000 |
| 9 | 500 | 500 | 500 |
| 10 | 500 | 500 | 500 |

The standard water release schedule from Lake Okeechobee through S-77 to avoid dangerously high lake stages is as follows (**Figure 8**):

Zone A: Release up to 7,800 cfs, the maximum capacity of S-77

Zone B: Release 6,500 cfs

Zone C: Release non-harmful discharge, up to 4,500 cfs

Zone D: No regulatory release

In addition there are pulse releases prescribed in Zone D that lower lake stage with minimal impact to the estuary. The pulse releases consist of 10-day pulses that follow the release patterns that were designed to reflect the natural hydrology of storm water runoff. The release rate begins low on the first day and is increased to the highest release rate on the third day followed by reduced flow rates for days seven through ten. After day ten the pattern of discharge is repeated until the lake level is sufficiently lowered. The pulse releases increase from Level I to Level III. The level of release is determined by stage in Lake Okeechobee.

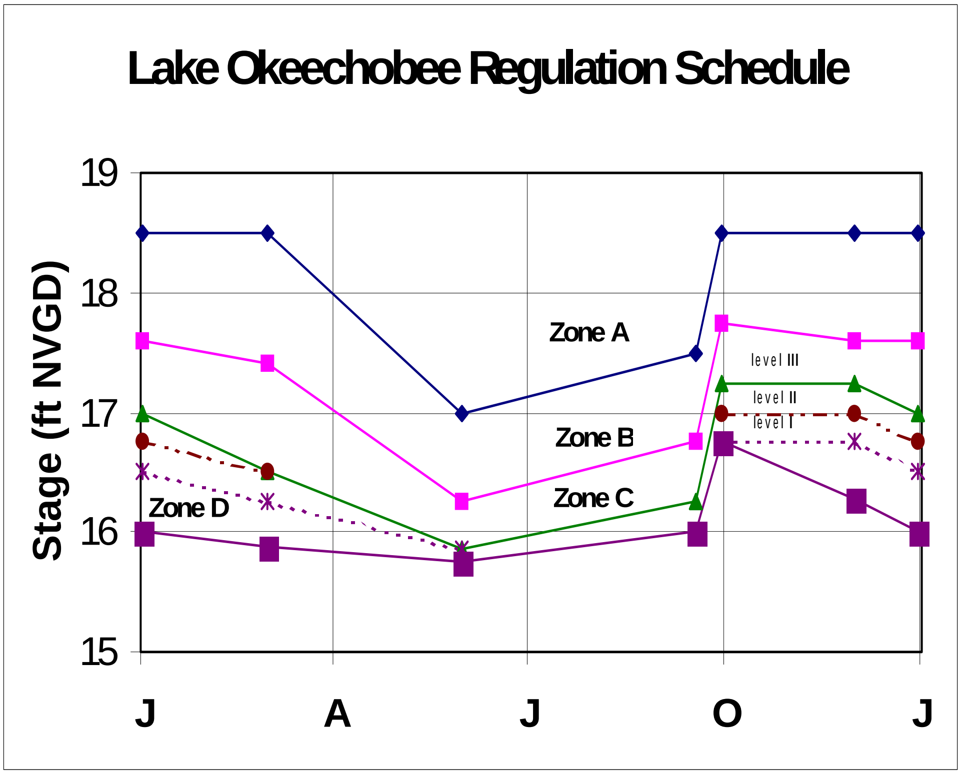


**Figure 8.** Lake Okeechobee Interim Regulation Schedule.

Lake Okeechobee is an important feeding and roosting area for wading birds and migratory fowl and is highly regarded for it's recreational and commercial fishing. Winter visitors from the northern United States who value the recreational fishing and the slower pace of interior South Florida visit the lake.

## Caloosahatchee Estuary

The Caloosahatchee River Estuary is a large system where the waters of the Gulf of Mexico mix with the freshwater inflows from the river, sloughs, and overland sheetflows in the basin. The area is characterized by a shallow bay, extensive seagrass beds, and sand flats. Extensive mangrove forests dominate undeveloped areas of the shoreline. Southwest Florida estuaries are used by more than 40 percent of Florida's rare, endangered, and threatened species.

Coastal areas subject to tidal inundation support extensive mangrove forests and salt marsh areas. Coastal mangroves discourage erosion from storms and high tides, and assimilate nutrients to produce organic matter, which forms the base of the food chain. Mangroves and salt marsh communities serve as important nursery and feeding grounds for many economically important species of finfish and shellfish, which in turn support migratory waterfowl, shore bird and wading bird populations. These brackish water communities were once commonly distributed along the entire coastline but are now found in greatest abundance in southwestern Collier County and southern Lee County.

Maintenance of appropriate freshwater inflows is essential for a healthy estuarine system. Preliminary findings indicate that optimum inflows to the Caloosahatchee Estuary should have mean monthly values between 300 and 2,800 cubic feet per second (cfs). Average daily flows between January 1988 and June 1999 were approximately 500 cfs. Low flows of 0 cfs and high flows as high as 17,283 cfs were recorded during the same period. Excessive freshwater inflows to the estuary result in imbalances beyond the tolerances of estuarine organisms. The retention of water within upland basins for water supply purposes can reduce inflows into the estuary and promote excessive salinities. Conversely, the inflow of large quantities of water into the estuary as a result of flood control activities can significantly reduce salinities and introduce storm water contaminants. In addition to the immediate impacts associated with dramatic changes in freshwater inflows, long-term cumulative changes in water quality constituents or water clarity may also adversely affect the estuarine community.

Estuarine biota is well adapted to and depends upon natural seasonal changes in salinity. The temporary storage and concurrent decrease in velocity of floodwaters within upstream wetlands aid in controlling the timing, duration, and quantity of freshwater flows into the estuary. Upstream wetlands and their associated ground water systems serve as freshwater reservoirs for the maintenance of baseflow discharges into the estuaries, providing favorable salinities for estuarine biota. During the wet season, upstream wetlands provide pulses of organic detritus, which are exported downstream to the brackish water zone. These materials are an important link in the estuarine food chain.

# WATER DEMANDS

To adequately plan for future surface water supply within the Caloosahatchee Basin, it is necessary to quantify current use and estimate future surface water demands. Non-environmental surface water demands within the basin are primarily agricultural with some PWS, commercial and industrial uses. The commercial and industrial demands vary greatly by type of business. In the CWMP Planning Area, commercial and industrial demands are about one percent of the overall water demands. Because the demand is relatively small and difficult to generalize, an average demand is not calculated for this use category. The emphasis is placed on estimation of agricultural and PWS uses.

In estimating public water use for 1995, metered data of withdrawals from the C-43 for the City of Fort Myers and Lee County Utilities at Olga were obtained from SFWMD records. Based on the 1995 data and planned future developments that the City of Fort Myers and Lee County utilities will serve, the 2020 PWS use from the C-43 was estimated.

A different procedure was adopted for estimating agricultural use in the CWMP Planning Area because measured withdrawal data were not available. The procedure used estimated current water use based on three approaches; evaluation of permitted water use allocation records, Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) water demand modeling, and integrated surface water/ground water modeling using MIKE SHE. In each approach, the demand was related to current land use. The resulting demands from each approach were reviewed to evaluate reasonableness. Based on the comparison, a methodology was developed that used both AFSIRS and MIKE SHE simulations to determine the current and 2020 agricultural demands.

The estimate of 2020 agricultural demand is dependent on the 2020 agricultural land use projections. Analysis of land use data was therefore a crucial component of the agricultural demand estimation within the CWMP Planning Area.

In all cases when and where possible, information from the Caloosahatchee Advisory Committee (CAC), representatives of PWS utilities, representatives of the agricultural community and other stakeholders, was used to augment or verify the estimates generated by SFWMD staff.

## Estimation of 1995 Demands

### Public Water Supply

The primary PWS utilities utilizing water from the C-43 Canal within the CWMP Planning Area are the City of Fort Myers and Lee County Utilities. The City of Fort Myers withdraws water from the river at Olga to recharge the surficial aquifer at its wellfield. The water is then pumped from the SAS for treatment using membrane-softening technology. The 1995 withdrawals by the City of Fort Myers are summarized in **Table 6**. Lee County Utilities withdraws surface water from the C-43 Canal at Olga and treats the water using lime softening technology at its Olga water treatment plant. The Lee County Utilities withdrawals are summarized in **Table 6**. The combined surface water usage by both utilities was approximately 10.5 MGD on average and more than 16-MGD maximum day in 1995.

### Agricultural Demands

Agricultural water use depends on the crops that are grown in the basin and on how those crops are managed and irrigated. An important factor in accurately estimating agricultural water use is determining the location and acreage of crops.

**Land Use.** Land use in the CWMP Planning Area is predominantly agricultural and is expected to remain so in the future.

Citrus is the dominant irrigated crop in the basin and occupies more than 91,000 acres, according to the SFWMD's 1995 Land Use Coverage. During the past two decades, Southwest Florida has had the fastest growing citrus acreage in the state. This growth is associated with the movement of citrus southward from Central Florida following several severe winter freezes in the early-1980s.

Sugarcane, with an estimated 75,000 acres, according to the SFWMD's 1995 Land Use Coverage, closely follows citrus in dominance of land area. Sugarcane is primarily grown in close vicinity to the Everglades Agricultural Area (EAA), in Hendry and Glades

**Table 6.** Monthly Public Water Supply Use from C-43.

| Month | Fort Myers | | | Lee County Olga Plant | | |
|---|---|---|---|---|---|---|
| | Total (MG) | Average (MGD) | Maximum (MGD) | Total (MG) | Average (MGD) | Maximum (MGD) |
| Jan-95 | 272.35 | 8.79 | 10.23 | 104.89 | 3.38 | 3.82 |
| Feb-95 | 252.75 | 9.03 | 10.21 | 104.11 | 3.72 | 4.13 |
| Mar-95 | | | | 112.64 | 3.63 | 4.03 |
| Apr-95 | 299.73 | 9.99 | 12.16 | 107.04 | 3.57 | 4.03 |
| May-95 | 314.93 | 10.16 | 11.66 | 98.89 | 3.19 | 3.76 |
| Jun-95 | 222.57 | 7.42 | 11.34 | 84.88 | 2.83 | 3.17 |
| Jul-95 | 177.62 | 5.73 | 11.33 | 82.87 | 2.67 | 3.28 |
| Aug-95 | 106.09 | 3.42 | 8.26 | 75.81 | 2.45 | 3.18 |
| Sep-95 | 109.77 | 3.66 | 9.36 | 75.01 | 2.50 | 2.88 |
| Oct-95 | 124.80 | 4.03 | 9.36 | 85.68 | 2.76 | 3.46 |
| Nov-95 | 275.41 | 9.18 | 11.05 | 97.75 | 3.26 | 3.78 |
| Dec-95 | 288.98 | 9.32 | 11.93 | 98.24 | 3.17 | 3.79 |
| Summary 1995 | 2,445.00 | 7.34 | 12.16 | 1,127.82 | 3.09 | 4.13 |
| Permitted 1999 | 4,043 | 11.08 | 15.72 | 1,124.20 | 3.08 | 5.00 |

counties, where transportation costs to sugar mills can be minimized. Sugarcane acreage has continued to increase since 1995, and is expected to continue in the future.

**Figure 9** shows the major land use types (1995) in the CWMP Planning Area.

**Permit Allocation Method.** The SFWMD issues water use permits for beneficial uses such as agriculture. As a part of the permit application process, an applicant presents an estimate of the anticipated water use over the permit period following the guidelines contained in the SFWMD *Permit Information Manual Volume III: Basis of Review for Water Use Permit Applications* (SFWMD, 1997). The basis of review uses the modified Blaney-Criddle method for estimating crop evaporation and irrigation requirement. The estimate is based on the cropped acreage, crop type, and rainfall corresponding to a 1-in-5 year drought event, and soil type. Factors to incorporate transmission losses and irrigation efficiencies are applied to the estimate of irrigation requirements to establish the recommended allocation.

The actual water use for 1995 was evaluated based on the permit allocation information. First, the actual water use values were evaluated. Pumping records that document actual water use were not readily available or were incomplete and could not be used. Second, the permitted water use was reviewed to determine how much water had been allocated. This value would indicate the amount of water that had been requested but not necessarily currently used. The permitted land included crop land and native land not

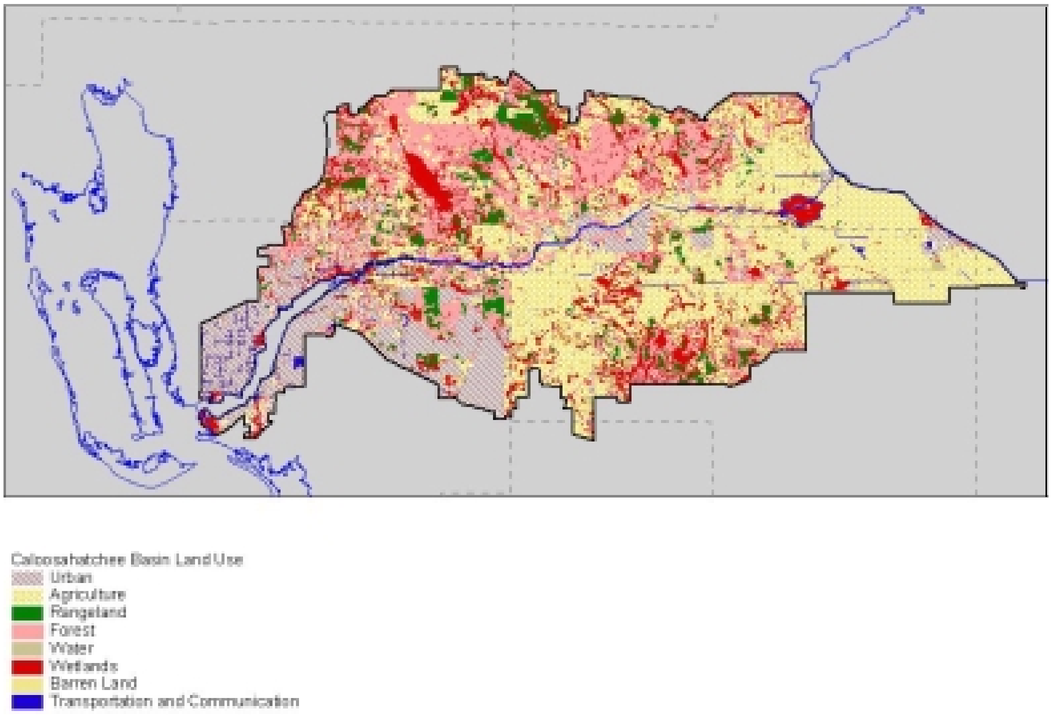


**Figure 9.** Major Land Use Types.

yet converted to cropland. As a check, a comparison was made between SFWMD permitted land maps and the SFWMD 1995 land use map developed from 1994 aerial photography to determine the accuracy of the permitted land maps. It was found that there was a large discrepancy between actual land use and permitted land area. It was concluded that water use demands would be more accurately estimated from the 1995 land use/land cover maps.

Water use demands were estimated using the water use permit allocation method applied to the 1995 land use coverage. First, the land areas for each major crop group (citrus, sugarcane, and row crops) were determined for the major basins within the CWMP Planning Area. The average per acre water use allocations for each crop type in each basin were determined from the permit records contained in the SFWMD permit database. The average per acre water use allocation accounted for the different soil types, rainfall records, and irrigation methods found in each basin. The use per area allocation was applied to the crop acreage to estimate the total basin demand.

**Table 7** summarizes the water use allocation for major agricultural land use categories for the CWMP Planning Area based on the permit application methodology.

This simple approach has some advantages and disadvantages. It is simple to compute and the data are readily available. It represents the accepted crop water use allocation procedure. The results account for the spatial variations in crop management techniques and water sources. It requires no modeling or model calibration but is also

**Table 7.** Summary of 1995 Water Use Allocation for Agricultural Land Use Categories.

| Crop | Water Use (1,000 acre-feet/year) |
|---|---|
| Citrus | 226 |
| Sugarcane | 216 |
| Vegetables | 32 |
| Total | 474 |

difficult to check for accuracy. This method requires careful interpretation of data and adjustment of data to meet the needs of the CWMP. Permitted information often represents proposed cases and may include both cropped and uncropped lands. The permit allocation method is based on the Blaney-Criddle method for estimating crop evapotranspiration, which is not considered the best technique for estimating crop evapotranspiration. Although this method incorporates the variability of soils, rain, and irrigation management the uncertainty associated with the average value is unknown. The uncertainty comes from errors in the permit database as well as uneven distribution of soils and irrigation management techniques in each basin. Establishing use per crop type involved averaging the effects of soil types and irrigation methods. The demands estimated using this method are based on a 1-in-5 year drought event and do not represent the average or the 1-in-10 conditions. This method is limited to currently planted crops.

Due to the limitations of this approach, it was not used in predicting the future irrigation needs of the Caloosahatchee Basin.

### AFSIRS (Agricultural Field Scale Irrigation Requirements Simulation) Modeling

The AFSIRS/WATBAL modeling approach is one of two hydrologic modeling procedures developed to investigate demands within the CWMP Planning Area. The AFSIRS (Smajstrla, 1990) model is a simple water budget model for estimating irrigation demands. The model predicts irrigation demands for specified crop type, irrigation method, soil, and climate information. AFSIRS simulates the hydrology of the root zone using daily rainfall and reference crop potential evapotranspiration as inputs. The model assumptions and functional components of AFSIRS make it applicable to irrigated lands. A separate model (WATBAL) was developed to complete the water balance by simulating runoff from nonirrigated lands. The WATBAL model includes a simple, 3-parameter "pot" model, which completes the water budget component of AFSIRS allowing for return flow to the river of excess irrigation water lost through irrigation inefficiency and transmission losses. WATBAL complements the AFSIRS model and when used in combination allows representation of irrigation demands and runoff from irrigated and non-irrigated lands within a basin. A detailed description of the AFSIRS/WATBAL model and its application for this plan is included in the Appendix Document.

The AFSIRS/WATBAL model is a hydrologic model that estimates demand based on basin specific data. It is capable of generating demand estimates for a 31-year simulation period (lengthy enough for statistical analyses) and can be directly compared to the corresponding data used in both the Restudy and *LEC Regional Water Supply Plan*. The results are significantly improved compared to the permit method since they are based on basin hydrology rather than a simple monthly water use demand estimate. AFSIRS has the additional advantage that the crop evapotranspiration values are based on the modified Penman-Montieth methods, which is considered more accurate than the Blaney-Criddle method. The AFSIRS methodology is easily applied to future land use data once the model is developed and calibrated. The model was used to estimate future irrigation requirements within the CWMP Planning Area.

The AFSIRS/WATBAL model developed for the plan was calibrated using measured flow in to and out of the Caloosahatchee Basin. A demand situation within the basin results in outflows lower than inflow. When there is runoff in excess of basin demands, then the reverse is the case and outflow exceeds inflow. The AFSIRS model results were compared to the deficits or excesses observed in historic data. Once calibrated, the model was used to estimate 1995 demands using 1995 land use data.

**Table 8** summarizes the 1995 Base Case water use allocation for major agricultural land use categories for the CWMP Planning Area based on the AFSIRS/ WATBAL approach. Note that this represents long-term average demands (31 years) based on 1995 land use, not actual demand in 1995.

**Table 8.** Summary of 1995 Base Water Demand From the C-43 Canal Based on AFSIRS/ WATBAL Simulations.

| Basin | Water Use by Source (1,000 acre-feet/year) | | | Total[a] |
|---|---|---|---|---|
| | Ground Water | Lake Okeechobee | C-43 | |
| East Caloosahatchee | 0.7 | 9 | 65 | 74 |
| West Caloosahatchee | 35 | 0 | 46 | 82 |
| S-4 | 0 | 69 | 0 | 69 |
| Total | 36 | 78 | 111 | 225 |

a. Note: This represents long-term average demands (31 years) based on 1995 land use, not actual demands in 1995.

A major advantage of the AFSIRS/WATBAL method is its simplicity and speed. The model is land use based, can simulate hydrology using long time periods, and can generate statistically meaningful estimates of a 1-in-10 year drought demand, which is directly comparable to Restudy estimates. The model does have a higher data requirement than the permit method but requires less data, time, and space than the MIKE SHE model. The speed of execution permits the evaluation of several scenarios within a reasonable time frame and at a reasonable computational cost. The AFSIRS/WATBAL model is applied to the CWMP Planning Area. In interpreting the demand estimates from the AFSIRS/WATBAL methodology, it should be noted that the basinwide implementation allows runoff from within the basin to offset the computed demand from the same basin thus reducing the simulated demand. The demands reported reflect this reduction.

### MIKE SHE Modeling

The Integrated Surface Water/Ground Water Model (ISGM), MIKE SHE, includes a module for estimating irrigation requirements based upon land use, soil type, crop type, rainfall and evapotranspiration. It has the capability to utilize a vast amount of raw and processed data to estimate crop needs. These data can be summarized under irrigated crop, irrigated area, and water use.

**Irrigated Crop.** The different crop types within the basin that are irrigated are specified within the MIKE SHE model. Three major crops are included in the vegetation classification as requiring irrigation. These are sugarcane, citrus, and truck crops (vegetables). A fourth, improved pasture may or may not be irrigated and is assumed not irrigated in the analyses.

**Irrigated Area.** The maximum expanse or extent of irrigated areas needed to be explicitly specified in the MIKE SHE model. The MIKE SHE model determines what portion of the specified irrigated area requires irrigation at each model time step. The determination is based on soil moisture that is affected by rainfall, soil type, and other factors that are specified in the model. The irrigated areas are specified using 1995 land use maps and the SFWMD water-use permit coverages. Acreage that is permitted but not cropped is therefore excluded from the analyses.

**Water Use.** The actual irrigation practices within the basin vary from farm to farm, at different periods of the year, from crop to crop, and at different stages of crop growth. Irrigation practices by individual users are largely unknown and can not be modeled. In general however, all practices ensure that crop losses through evapotranspiration can be minimized with irrigation. Using this premise, the MIKE SHE model computes irrigation demands based on estimates of actual evapotranspiration for each crop and growth stage. The computation of evapotranspiration is based on leaf area index, root depth, soil characteristics of the root zone, and potential evaporation. Detailed descriptions of the MIKE SHE model and data requirements are provided in the Appendix Document.

The MIKE SHE model has a higher data requirement than the other methods examined. The model requires the distribution of irrigation demands not only in space over the basin but in time as well (temporal distribution is the same as AFSIRS). The result is a process that can be replicated for any time period once the input data such as the crop type, soil type, and land area is known. This was considered desirable for estimating future irrigation requirements within the CWMP Planning Area.

The MIKE SHE model was calibrated using ground water levels and river discharges at S-79 and S-78 on the C-43 Canal. MIKE SHE output for inflow and outflow from the basin was used to estimate basin excesses and deficits in a manner similar to AFSIRS for the purpose of comparison.

**Table 9** summarizes the water use allocation for major agricultural land use categories for the CWMP area based on the ISGM.

**Table 9.** Summary of 1995 Water Use Demand Based on the ISGM for Major Agricultural Land Use Categories.

| Crop | Water Use[a] (1,000 acre-feet/year) |
|---|---|
| Citrus | 143 |
| Sugarcane | 110 |
| Vegetables | 36 |
| Total | 290 |

a. Based on 1995 land use, MIKE SHE results indicate an additional 30,000 acre-ft/year of irrigation in addition to citrus, sugarcane and vegetables.

The ISGM approach has several advantages. It however is spatial data intensive and requires knowledge of several parameters that affect crop water needs. Also, MIKE SHE is computationally intensive and requires a significant amount of time to complete model runs. Though simpler representations by utilizing uniform values throughout the basin can be achieved, the key advantage of this approach is its ability to adequately represent demands in a spatially and temporally varying manner, which is more reflective of reality. Unlike the AFSIRS/WATBAL approach, MIKE SHE does not adjust the computed irrigation demand based upon runoff within the basin. The estimated irrigation demand simulated by the MIKE SHE model represents irrigation required in excess of rainfall. The MIKE SHE estimate, unlike the estimate based on the water use permit methodology, actually simulates conveyance losses. These losses which vary by location and time are not reflected in the demand estimate presented.

The three methods described in this section show some differences in the estimated irrigation requirements for the 1995 period. These differences are a function of the degree of averaging that each method utilizes and the assumptions of each method. **Table 10** summarizes these results. Based on the assumptions, limitations, and range in the results, both the AFSIRS and the MIKE SHE approaches were used to estimate future agricultural demands.

**Table 10.** Summary of 1995 Water Use Allocation for Agricultural Land Use Categories.

| Crop | Water Use (1,000 acre-feet/year) | | |
|---|---|---|---|
| | Permit | AFSIRS/WATBAL | MIKE SHE |
| Total | 474 | 225 | 290 |

# Future Demands

## Public Water Supply

The primary PWS utilities utilizing water from the C-43 Canal within the CWMP Planning Area are the City of Fort Myers and Lee County Utilities. Based on the current planning efforts of both utilities, incorporating the projected population growth and allocation of sources, the CWMP established future PWS withdrawals from the C-43 Canal. Information from the City of Fort Myers, suggests that continued use of C-43 Canal water in the year 2020 is unlikely due to the city's move to a FAS source. City of Fort Myers surface water withdrawals were therefore removed from the future demands. Lee County Utilities, based on its updated master planning efforts, requires up to 22 MGD (maximum daily use) from the C-43 Canal by the year 2020. This increased demand was incorporated in the CWMP estimates for 2020 PWS demands from the C-43 Canal. The net effect of the reduction and increase is a minimal change in PWS needs from currently permitted usage. **Table 11** shows the projected future PWS demands from the C-43 Canal compared to the 1995 use and the currently permitted allocation.

**Table 11.** Projected 2020 Public Water Supply Demand from C-43 Canal Compared to 1995 Use and Currently Permitted.[a]

| Year | Fort Myers | | | Lee County Olga Plant/North County Treatment Plant | | |
|---|---|---|---|---|---|---|
| | Total (MG) | Average (MGD) | Maximum (MGD) | Total (MG) | Average (MGD) | Maximum (MGD) |
| Actual 1995 | 2445.00 | 7.34 | 12.16 | 1127.82 | 3.09 | 4.13 |
| Permitted 1999 | 4043.3 | 11.08 | 15.72 | 2607.1 | 7.14 | 10.00 |
| Projected 2020 | 0.00 | 0.00 | 0.00 | NA | 16.00 | 22.00 |

a. Lee County demands include Olga and North County treatment plants.

# Agricultural Demands

**Land Use.** The Southwest Florida Regional Planning Council (SWFRPC) has estimated that total agricultural acreage will increase between 3 and 7 percent between

1995 and 2020 while citrus acreage will increase between 54 and 81 percent and sugarcane between 62 and 190 percent. The increase in citrus and sugarcane acreage is due in a large part to conversion of existing irrigated acreage that is in other crop types to citrus and sugarcane. Based upon representation from the agricultural industry and CAC discussion and concurrence, a 2020 citrus and sugarcane acreage of 125,000 each was modeled. This represented a reduction from the SWFRPC estimate but an increase from the SFWMD *Districtwide Water Supply Assessment* (DWSA) completed by the SFWMD in July 1998.

A scientific procedure that considered existing land use, ownership, suitability for crop use, and proximity to existing agricultural lands was used to adjust the 1995 land use map to the 2020 land use projections. A technical memorandum summarizing the steps involved in development of the 2020 land use coverage is included in the Appendix Document. Based on the 2020 land use map, the two selected methodologies, AFSIRS/ WATBAL and MIKE SHE are used to estimate future agricultural demands.

**2020 Demands Based on AFSIRS/WATBAL.** The AFSIRS/WATBAL model that estimated 1995 demands was modified to incorporate the 2020 land use projections. The model, with the updated land use data was used to estimate daily irrigation demand and runoff from the CWMP Planning Area using 31 years of rainfall and evapotranspiration data. The resulting estimate of demand is summarized in **Table 12** and shows an increase of 35 percent compared to the 1995 estimated demands. As with the 1995 estimated demands, the 2020 estimated demand from the AFSIRS methodology represents a long-term average and not the demands from any one single year. Also, it is an estimate of net demand and incorporated a reduction in the estimated demand due to available runoff from within the basin.

**Table 12.** Summary of 2020 BASE Agricultural Water Demand Based on AFSIRS/WATBAL Simulations.

| Basin | Water Use by Source (1,000 acre-feet/year) | | | Total |
|---|---|---|---|---|
| | Ground Water | Lake Okeechobee | C-43 | |
| East Caloosahatchee | 3 | 6 | 129 | 138 |
| West Caloosahatchee | 34 | 0 | 62 | 95 |
| S-4 | 0 | 71 | 0 | 71 |
| Total | 37 | 77 | 190 | 305 |

**2020 Demands Based on MIKE SHE.** The MIKE SHE model developed for the CWMP was used to estimate the future demands by incorporating the 2020 land use information and modifying irrigated areas within the model to match the new land use. The MIKE SHE model, unlike the AFSIRS model, was used to simulate demand using an 8-year period (1988 - 1995). The selected period represents a combination of wet, dry, and average years representative of variations within the Caloosahatchee Basin. The resulting demands for the 2020 Base Case using the MIKE SHE methodology therefore represents probable demands based on 2020 land use and hydrologic data corresponding to an 8-year period. The resulting demands for the entire planning area, including both the Lake Okeechobee Service Area (LOSA) and non-LOSA portions of the basin, were obtained.

**Table 13** summarizes the simulated 2020 irrigation demand for major agricultural land use categories for the CWMP area based on the MIKE SHE model.

**Table 13.** Summary of 2020 Water Use Demand Based on the MIKE SHE for Major Agricultural Land Use Categories.

| Crop | Water Use (1,000 acre-feet/year) |
|---|---|
| Citrus | 242 |
| Sugarcane | 181 |
| Vegetables | 27 |
| Total | 450 |

The MIKE SHE estimate of demand is 47 percent greater than the AFSIRS estimates of net basin demand. The difference is attributed to the difference in the demand estimated by both methods. While the AFSIRS methodology estimates a net basin demand that adjusts field scale demands by runoff occurring within the same basin, MIKE SHE computed irrigation requirement in excess of precipitation. Analyses of output from AFSIRS shows that field scale demand estimates are between 15 percent and 70 percent greater than net basin demand estimates for the major crop types within the planning area.

### 31-Year MIKE SHE Basin Demand and Runoff Estimation.

Due to the significance of the irrigation demand and basin runoff estimation to the CWMP and other SFWMD plans including the *LEC Regional Water Supply Plan* and *LWC Water Supply Plan*, a long-term simulation of the 2020 Base Case conditions was conducted using MIKE SHE. The model setup used by MIKE SHE for this simulation facilitates direct comparison of demand predicted by MIKE SHE and AFSIRS.

The integrated surface water/ground water model of the Caloosahatchee Basin, developed using MIKE SHE and used to estimate the irrigation demands presented above, was used to conduct a 31-year simulation of hydrologic conditions between S-77 and S-79. This simulation represented projected 2020 Base Case conditions and was based on projected 2020 land use data and 2020 PWS demands. The emphasis of the simulation was estimation of basin runoff and surface water demands within the LOSA, a significant part of the CWMP Planning Area. A report describing the model approach, assumptions and limitations and the results is included in the Appendix Document.

Both MIKE SHE and AFSIRS were used to predict net basin demands using 2020 land use data and rainfall data corresponding to the 31 years of record from 1965 to 1995. The simulation thus represents the 2020 Base Case scenario with no infrastructure improvement and thirty-one years of weather. A comparison of the 2020 cumulative C-43 demands from the AFSIRS/WATBAL and MIKE SHE model is presented in **Figure 10**.

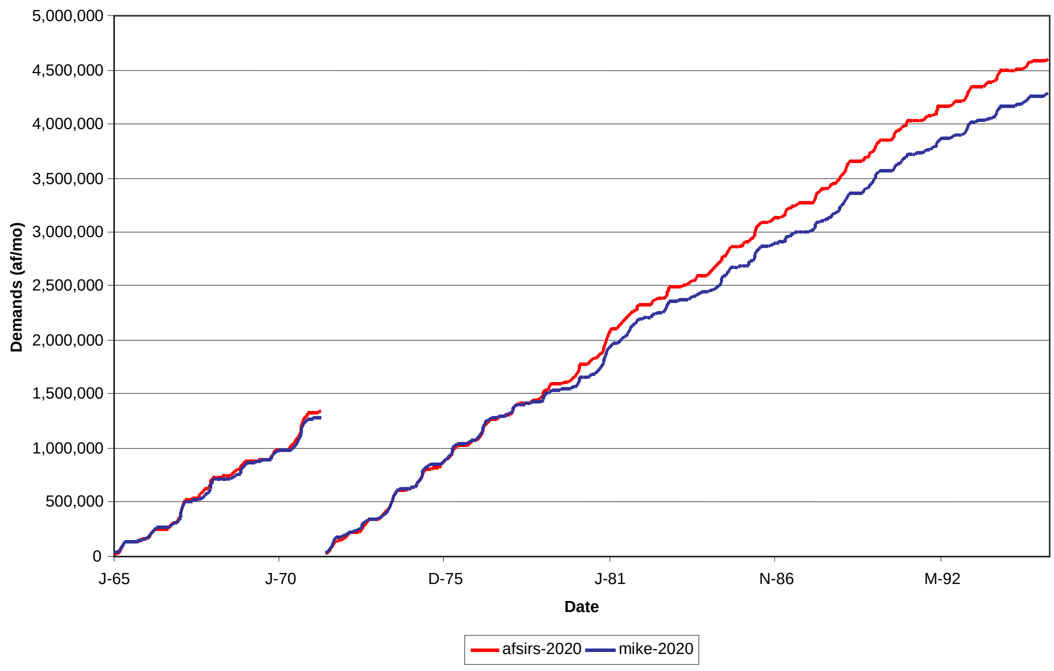


**Figure 10.** Comparison of 2020 Base Case Cumulative C-43 Demands.

The results based on the MIKE SHE methodology matches closely the results based on the AFSIRS methodology. MIKE SHE has the advantage of a spatially distributed estimate of demands and runtime response to changes in hydrology, land use and management practices. In addition, MIKE SHE computes the demand for the entire CWMP area and incorporate both surface and ground water interactions that impact the systems capability to satisfy irrigation demands within the study area. The MIKE SHE approach was therefore selected and used as the preferred approach for evaluation of the planning alternatives. The AFSIRS approach generates estimate of C-43 demands equivalent to MIKE SHE and is less computer intensive and faster to run. It is therefore better suited for repeated simulation of long-term scenarios. It was used within the CWMP to generate daily time series of demands and runoff that will be used in the SFWMD's South Florida Water Management Model (SFWMM).

The various approaches discussed in this section have assumptions and limitations that introduce a level of uncertainty in our estimates. However, they represent the most robust methodology for predicting future demands within the Caloosahatchee Basin.

Revisions to estimated demands will be made during plan updates as more information or improved estimation methodology become available.

# Chapter 4
# ANALYSIS

## ANALYTICAL TOOLS

Computer models were used extensively to assist in development of the *Caloosahatchee Water Management Plan* (CWMP). The models represent the performance of a real system through a series of equations that describe the physical processes that occur in the system; they represent a simplified version of the real world that may be used to predict the behavior of the modeled system under various conditions. Models were used to simulate the impact of 1995 estimated water demands and projected 2020 water demands on the environment, surface water, and ground water resources in the Caloosahatchee Basin during a 1-in-10 year drought condition and average rainfall conditions. Information from local comprehensive plans, the Southwest Florida Regional Planning Council (SWFRPC), Public Water Supply (PWS) utilities, University of Florida Institute of Food and Agricultural Sciences (IFAS), and the SFWMD's permitting data base were used to support this analysis.

Numerical tools used in this analysis included water budget modeling (Agricultural Field Scale Irrigation Requirements Simulation [AFSIRS] model), the Water Management Optimization model, and MIKE SHE, the Integrated Surface Water/Ground Water Model (ISGM). Surface water budget models were used to approximate surface water availability in each of the major surface water subbasins to quantify the demands that could not be satisfied by surface water. The Water Management Optimization model was used to determine how to best store and release water as needed for water demands and environmental needs. The ISGM was used to identify potential impacts of water use on the environment and water resources.

### Surface Water Budget Modeling

The CWMP uses the AFSIRS model for surface water budget modeling on irrigated lands (citrus, sugarcane, and vegetables). The surface water budget models indicate whether there is a surplus or deficit (a deficit of surface water would indicate there is insufficient surface water to meet demands) of surface water in each of the major irrigation basins. Deficits must be supplied by regional water sources such as Lake Okeechobee or a regional reservoir, while surpluses are available for regional storage or for release into the estuary. Because the timing of the surpluses and deficits must be compatible with deliveries of Lake Okeechobee waters, the Water Budget model simulates the same period of record (1965 through 1995 climate) as the South Florida Water Management Model (SFWMM) used in the Restudy and other SFWMD water supply plans.

The surface water budgets include public water supplies. They do not consider flows to the Caloosahatchee Estuary. The SFWMD will adopt Minimum Flows and

Levels (MFLs) for the Caloosahatchee Estuary by December 2000. There are numerous combinations of potential solutions to meet the minimum flow, which will be evaluated as a part of the *Southwest Florida Study* (SWFS) (formerly known as the *Southwest Florida Feasibility Study*). The results of these efforts will be incorporated into the five-year update of this Plan.

## Water Budget Optimization Model

The Water Budget Optimization model stores surplus water (from the Water Budget model) in regional storage systems (reservoirs and ASRs) and later releases these waters to meet demands and estuarine needs. The term "optimization modeling" as used here describes a computer algorithm that can find an optimal set of operating rules controlling the inflows and outflows from storage and release systems while satisfying a predefined objective function. Examples of storage and release systems are reservoirs, ASRs, deep well injection, backpumping of excess river flows into Lake Okeechobee, and field scale water-table management. The objective function includes desirable flow to the estuary as well as satisfying irrigation demands.

Optimization modeling is an assessment tool. It translates a set of general design goals (example: an adequately sized reservoir/ASR system in the West Caloosahatchee) into specific design elements (example: a 20,000 acre reservoir 8 foot deep with a 500 cfs second intake pump and ASR wells having a combined capacity of 200 MGD). It develops the best possible set of operating rules for a particular system. The user can test a wide variety of systems and select the system that best meets the competing objectives of water management.

## MIKE SHE Model

Due to the conjunctive use of surface water and ground water in the basin and the interaction between surface water bodies and the underlying aquifers, an integrated model was chosen to assess the total available water resources.

The integrated model developed for the CWMP is restricted to the freshwater portion of the basin, which stretches from Lake Okeechobee downstream to the Franklin Lock (S-79) (**Figure 11**). The integrated model was developed using a grid with 1,500-by-1,500-foot discreet grid cells that covers the entire planning area. The model incorporated the effects of irrigation on agricultural lands within the basin. A detailed surface water component to simulate surface water delivery functions and interactions with shallow ground water was also incorporated. The model area encompasses approximately 1,050 square miles (2,720 square kilometers). The model includes aquifers and confining units to an approximate depth of 300 feet.

The Caloosahatchee Basin was divided into two primary subbasins based on surface topography; the eastern part, which contributes to the flow at Ortona Lock (S-78) and the western part covering the runoff area between S-78 and Franklin Lock (S-79). In addition to these two major subbasins, the Telegraph Swamp and Telegraph Creek have

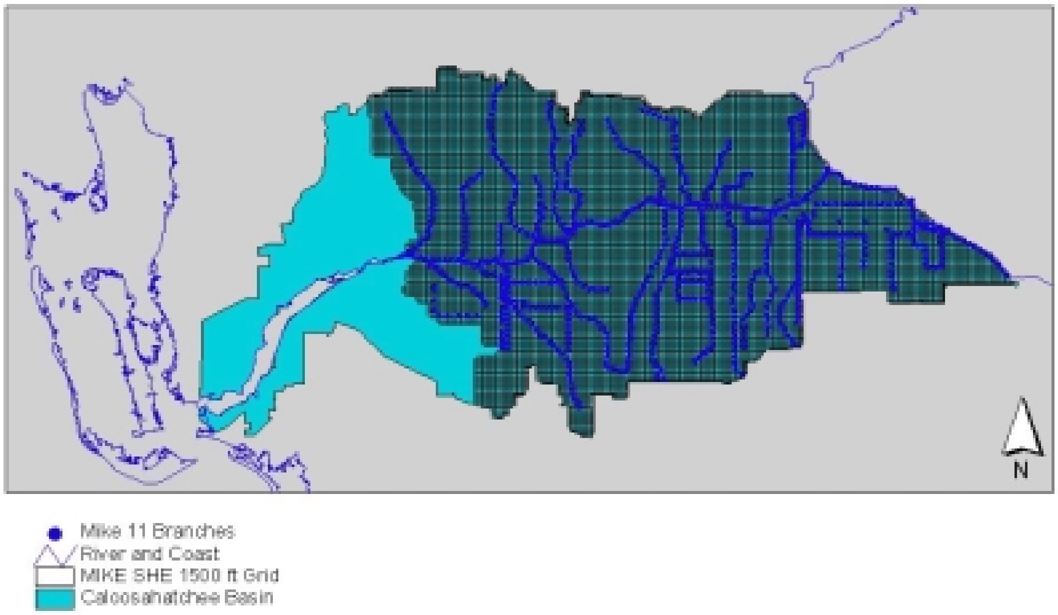


**Figure 11.** 1,500-by-1,500-Foot Grid Superimposed on Map of Model Area.

been included in the model to account for the cross boundary overland flow, which may take place during storm events.

Conjunctive use of surface and ground water for irrigation occurs in the basin. From a water resources perspective, surface water and ground water act as an integrated system and cannot be separated. The basin is generally well drained and a quick response in runoff is seen following rainfall events. Changes in water levels (e.g., caused by rainfall or irrigation diversions), quickly propagate through the basin. Water table fluctuations of the water table aquifer are closely linked to canal water levels.

The MIKE SHE model utilized in this plan is an integrated (surface and ground water flows are calculated) model. It is a distributed finite difference model (computations are made for each 1,500-by-1,500-foot model cell within the planning area). The area encompassed by the model is divided into cells by a model grid (defined by a system of rows and columns). MIKE SHE is modular in nature and comprises a number of components, which may be combined to describe flow within the entire land-based part of the hydrological cycle or tailored to studies focusing on parts of the hydrological system. For the Caloosahatchee Basin, the close link between river/canals and aquifers required that both surface and subsurface components be included.

The time scale of the surface water regime and the ground water regime are different. The model allows use of different time steps for calculation of river/canal flow, overland flow, and unsaturated and saturated ground water flow. The maximum time steps for the river hydraulics computation is in the order of minutes, (often specified between 5 and 15 minutes). The overland and unsaturated flow computations are solved in time steps in the order of hours (6-hour time steps would be typical). Time steps for the saturated ground water flow calculations are in the order of days or weeks (a typical simulation would employ daily time steps). The exchange of flow between the components is simulated on each coincident time step of the model.

The ground water component of the model generates two principal types of output typical of ground water models, computed head (water levels), which result from the conditions simulated, and water budgets for each active cell. The water budget shows the inflows and outflows for each of the cells. Due to the integrated nature of the model, additional output depicting the status of the unsaturated zone and flow in river/canals is generated. More detailed information on these models is available in the CWMP Support Document, Chapter 4.

A Model Advisory Team (MAT), consisting of representatives of the major stakeholders, was established. The MAT reviewed each step of the model creation for reasonableness and appropriateness. They discussed the assumptions and limitations of the model and model approach. The MAT concluded that the CWMP MIKE SHE model was acceptable, the post-calibration modeling activities were reasonable, and that the overall surface and ground water modeling effort was appropriate for development of this water management plan.

# WATER MANAGEMENT COMPONENTS

The various water management components considered in this plan include:

1. Backpumping and utilization of a portion of the storage capacity of Lake Okeechobee
2. ASR Systems
3. Regional Reservoirs
4. Distributed Reservoirs
5. Structure S-78.5 (new structure)
6. Water Harvesting

The performance of each of these components was analyzed and combinations of components were formed to best meet future surface water supply needs in the basin. The resulting combinations (referred to as Alternatives) were evaluated based on several parameters including water supply, basin environmental and resource protection, estuarine protection, and engineering costs. The alternatives are described in detail in Chapter 5 of the Planning Document.

# SCREENING PARAMETERS

## Water Supply Parameters

Water supply parameters were developed for urban and agricultural water uses based upon the level of service provided. The level of service criterion was used to evaluate how well water supply alternatives meet water demands. In ground water supplied areas, this parameter is based on meeting the demands during a drought of a specified return frequency (1-in-10 drought).

In surface water supplied areas, the parameter is based on meeting demands for twenty-eight seasons in the thirty-one years of simulation.

## Basin Environmental and Resource Protection Parameters

To assess the potential impacts (harm) of cumulative water use on the upland environment and ground water resources using the ground water modeling tools, the potential impacts must be defined in terms of water levels and duration and frequency of drawdowns. These water levels are referred to as resource protection parameters. The resource protection parameters are guidelines used to identify areas where there is potential for cumulative water use withdrawals to cause harm to wetlands and ground water resources. Areas where simulations show the resource protection parameters are exceeded during the selected level of service are areas where the water resource may not be sufficient to support the projected demand given the constraints.

Wetland protection parameters are defined as follows: ground water level drawdowns induced by cumulative pumping withdrawals in areas that are classified as a wetland should not exceed 1 foot at the edge of the wetland for more than 1 month during a 12-month drought condition that occurs as frequently as once every 10 years. For planning purposes, this criterion was applied to surficial aquifer drawdowns in areas that have been classified as a wetland according to the National Wetlands Inventory (updated by SFWMD in 1990 and 1995).

The Caloosahatchee Advisory Committee (CAC) endorsed the use of these parameters. The resource protection parameters define the severity, duration, and frequency of declines in ground water levels as the result of water use withdrawals. Drawdowns in the vicinity of ground water contamination sites were not evaluated in this plan.

## Estuarine Protection Parameters

Estuarine protection parameters (a subset of the MFLs Criteria) are based on a desired distribution of monthly freshwater inflows to the estuary. The following parameters were used to measure success in the estuary:

1. Monthly flow to the estuary should be less than 300 cfs no more than 16 percent of the time.
2. Monthly flow to the estuary should be greater than 2,800 cfs no more than 6 percent of the time.
3. Monthly flow to the estuary should be greater than 4,500 cfs no more than 1.6 percent of the time.

## Engineering Parameters

Engineering parameters were established for each of the possible components of any alternative. The components that were identified are:

- Regional Reservoirs
- ASR
- Backpumping facilities from the regional reservoir to Lake Okeechobee
- Distributed Small-Scale Reservoirs
- Water Harvesting

## Regional Reservoirs

The recommended Restudy Alternative identifies a need for 160,000 acre-feet (8-foot depth) of regional reservoir storage within the Caloosahatchee Basin. For regional-scale modeling the Restudy assumed that all seepage losses could be recaptured through the use of a perimeter ditch. They also assumed backpumping restrictions on inflow to the reservoir (an in-line reservoir). The engineering parameters that were used to assess the regional reservoir were:

Hydraulics - Is the reservoir 'in-line' or 'off-line'?

Geotechnical feasibility - Is lining or sealing of the reservoir needed? Are the perimeter seepage canals feasible? Is the soil suitable for berms?

Mechanical investment - Can pump size be kept below the 400 cfs low-cost threshold? Are gates adequate for flood control? Can structures provide the level of control needed?

Geography, topography - Is the proposed location feasible? Does the proposed location have an acceptable elevation?

Off-site impacts - What is the downstream flood risk (breach failure)? What is the local flood risk (are flow paths of existing drainage networks obstructed, are surrounding lands impacted)?

## Aquifer Storage and Recovery (ASRs)

The recommended Restudy Alternative identifies a need for 44 ASR wells within the Caloosahatchee Basin, each having an injection or withdrawal capacity of five million gallons per day. For regional-scale modeling, the Restudy assumed that these wells could recover 70 percent of the injected water. The regional reservoir acts as a surge tank that increases the effectiveness of the ASRs. The engineering parameters that were used to assess the ASRs were:

Hydrogeologic suitability - Does the location have the correct type of aquifer characteristics?

Proximity - Will wells require conveyance structures to connect them to the reservoir? What wellfield configuration is required to store and recover the required water volumes?

Water quality treatment facilities - What water treatment is needed (different in east and west basins)?

Flexibility - If the recovery rate is less than 70 percent (assumed in the Restudy) will the wells still function? If the dormant time is limited to 3-4 years will the wells still function?

## Backpumping Facilities

The recommended Restudy Alternative identifies a need for a system of pumps with a capacity of 1,000 cfs. These pumps would a) lift water stored in the regional reservoir into the east Caloosahatchee Basin, b) lift water from the east basin to a Storm Water Treatment Area (STA), and c) lift water from a STA to Lake Okeechobee. The regional reservoir acts as a surge tank that increases the effectiveness of the backpumping facilities. The size of a STA limits the conveyance of the backpumping facilities. The engineering parameters that were used to assess the backpumping facilities were:

- Hydraulics - Do pump locations require modification of S-77 or S-78? What additional canals are needed? Is existing conveyance capacity acceptable or will canal excavations be required?
- STA feasibility - How efficient are the STAs (number of days operated per year)? Where are the STAs located and what local flood control problems will occur? Can dry-outs of an STA be prevented?
- Configuration and timing - Can sufficient water reach the backpumps at the controlled rate that makes backpumping effective?

## Distributed Reservoirs

The distributed reservoirs would be smaller, localized reservoirs located in both east and west basins, and on the north and south sides of the river to supply irrigation demands. Distributed reservoirs may be an effective method of reducing the size of the regional reservoir system. These are small-scale and relatively simple to build, possibly by retrofitting existing detention ponds. Seepage and shallow storage will likely limit the time that water can be kept in these reservoirs. The engineering parameters that were used to assess distributed reservoirs were:

- Hydraulics - Is the reservoir in-line or off-line?
- Geotechnical feasibility - Is lining or sealing of the reservoir needed? Are perimeter seepage canals required? Is soil suitable?
- Geography, topography - Are there sufficient suitable land areas available to justify distributed reservoirs?
- Off-site impacts - What is the local flood risk (are flow paths of existing drainage networks obstructed, are surrounding lands impacted)?
- Management of storage - Can proper reservoir management be assured? (Does private ownership raise regulatory issues?)
- Aquifer recharge - Will local reservoirs impact aquifer recharge? If yes, are there water quality issues?
- Design consideration - Greater than 4-foot depth requires more stringent permit criteria.
- Regulatory - Can additional storage be obtained in existing retention ponds (agricultural and urban) by modifying present requirements?

## Water Harvesting/Water Table Management

Water harvesting has been suggested as a viable low cost method of detaining water and reducing the size of the regional reservoir system. Two major concepts are incorporated into the Water Harvesting Alternative. Both concepts involve passive management of mostly undeveloped lands. One component is water table management, man made ditches and other drainage features are removed to facilitate on site storage capability. The second component is water harvesting which incorporates development of weirs or raising of weirs to provide in-channel and ground water storage in unused stream reaches. Several types of lands (wetlands, forests, and pasture) can tolerate temporary flooding with little loss in long-term productivity. The engineering parameters that were used to assess water harvesting were:

- Topography - Are facilities in the natural flow path or floodplain?
- Geography - Are there sufficient land areas available to justify water harvesting?

- Technical feasibility - New technology requires pilot studies.
- Flexibility - Who owns the land? Do privately owned lands provide the level of certainty needed for water management?
- Wetlands - Are wetlands negatively impacted?

A summary of the performance measures employed in evaluating the alternatives is presented in **Table 14**.

**Table 14.** Recommended Performance Measures for Comparison of Model Results.

| | Goal | Priority | Description |
|---|---|---|---|
| Environental Parameters | Monthly flow to the estuary should be less than 300 cfs no more than 16% of the time. | Required | Track number of months when the flows to the estuary fall below the prescribed minimum flow target. The Alternative that returns the number of low flows closest to the target is deemed to have performed best under these parameters. Within the MIKE SHE model, flow out of the model area (through the Franklin Lock) is considered as flow to the estuary. |
| | Monthly flow to the estuary should be greater than 2,800 cfs no more than 6% of the time. | Required | Track number of months when the flows to the estuary exceed the prescribed maximum flow target. The Alternative that returns the number of high flows closest to the target is deemed to have performed best given these parameters. |
| | Monthly flow to the estuary should be greater than 4,500 cfs no more than 1.6% of the time. | Required | Track number of months when the flows to the estuary exceed the prescribed maximum flow target. The Alternative that returns the number of high flows closest to the target is deemed to have performed best given these parameters. |
| | Limit drawdown below potentially impacted wetland areas to no more than 1 foot. | Required | Track drawdown in the water table aquifer (predicted by the MIKE SHE model of the Caloosahatchee Basin) and for cells representative of wetlands, track the number of times during the simulated 1-in-10 year drought period that the drawdown equals or exceeds 1 foot lower than during average conditions. |
| Agricultural Parameters | Provide a 1-in-10 level of service for 2020 agricultural demands. | Required | Track the agricultural (irrigation) supply (predicted by the MIKE SHE model of the Caloosahatchee Basin) and compare with the projected 2020 agricultural demand. Track number of times when the supply fails to meet the projected demand. An Alternative that results in no failure under a 1-in-10 drought (based upon rainfall) is deemed successful while one that has several failures is considered not desirable. When the optimization model or other tools utilizing long-term data is used, and then failure to meet demand no more that 3 seasons in 30 years is considered desirable. |
| PWS Parameters | Meet 2020 PWS needs. | Required | Projected PWS needs within the basin is withdrawn from the Caloosahatchee River in the model simulation. The effect on flows to the estuary is tracked. Alternatives that meet the projected PWS needs with no detrimental impacts to flow to the estuary or agricultural needs are deemed desirable. |

# ANALYSIS

To determine the potential effects of projected water demands on the environment and water resources, a series of base model runs were performed using the MIKE SHE model. The first set of runs represented the current demands (1995) under varying rainfall conditions (1988-1995) incorporating average and 1-in-10 year drought conditions, while the second represented future demands (for the year 2020) under identical rainfall conditions. Applying the resource protection parameters identified potential problem areas. Resulting ground water levels were compared to model runs without the demands to determine drawdowns resulting from water withdrawals. This difference was compared to the resource protection parameters. A measure of how often each alternative exceeded the resource protection parameters was made and used in evaluating the alternatives.

## Water Supply Needs

The 1995 demand level represents the estimated urban and agricultural water demand for the use type and acreage up to and through the end of 1995. For PWS, actual pumping information from SFWMD records was used. For irrigation uses, a combination of land use and permitted acreage was used and the associated demand was then calculated based on the rainfall event and resulting crop needs. The 2020 demand level is based on 2020 population projections from utilities, local government comprehensive plans, and estimated 2020 agricultural acreage.

The simulated irrigation demand is a function of soil characteristics, land use, irrigation practices, and the spatial and temporal distribution of rainfall and evapotranspiration. The irrigation water demand is calculated in each time step of the simulation based on soil water deficit in the root zone. The soil water deficit is specified as the field capacity minus the actual water content (i.e., soil specific). The water demand is a simulation result depending on soil, vegetation, and meteorological data rather than a predefined input. Irrigation demands were calculated using a number of approaches, including MIKE SHE and AFSIRS, and then compared for reasonableness.

Public water supply demands were based on historic per capita water use and monthly distribution patterns. The only PWS demands that were considered were those that were withdrawn from the Caloosahatchee River.

## Level of Service

An eight-year simulation was completed that included periods representative of a two-year wet period, two-year dry period, and two average rainfall years. One of the two dry years was considered to be similar to a 1-in-10 year drought. The CAC and staff concluded a 1-in-10-drought condition was a reasonable rainfall scenario for the plan to balance the needs of urban and agricultural users, and the environment, while maximizing the use of the resource. It also provides a uniform rainfall scenario on which to base demands and resource impacts. This level of service was codified as a planning goal in Chapter 373, F.S. during the 1997 legislative session.

### Wetland Protection

The wetland protection parameters were calculated as the number of times the drawdown caused by irrigation exceeds 1 foot. The model has initially been run without irrigation and the results form the basis for determining the drawdown from irrigation water use. The ground water heads for the surficial aquifer is stored once a month and maps are substracted to determine if the 1-foot parameter is exceeded. The resulting map represents the number of months where the simulated heads in the scenario simulation were more than 1 foot below the corresponding nonirrigation simulation. The frequency of exceedence is a measure for the potential wetland impact.

### Model Simulations

"Base case" model runs were conducted using both the 1995 estimated demand level (1995 Base Case) and the 2020 projected demand level (future base case). The future base case assumed water use characteristics and management conditions would remain unchanged. It was assumed that future water users would obtain water from the same sources as existing users. It was further assumed that existing water users would utilize the same sources for both their current and future demands unless information was made available indicating a change. Reductions in PWS/water use from the Caloosahatchee River resulting from planned changes in source by the City of Fort Myers was incorporated in the 2020 scenarios.

Base case runs represent the "do nothing" approach and are not necessarily the likely scenario. Public water supply demand for the projected population was taken from existing facilities and/or proposed facilities that were not necessarily intended to supply that level of demand.

## CHAPTER 373 RESOURCE PROTECTION TOOLS AND LEVEL OF CERTAINTY

Before discussing specific alternatives, it is important to understand the relationship between the different levels of harm referred to in statutes and the various programs the SFWMD has to protect the resources. The overall purpose of Chapter 373 is to ensure the sustainability of water resources of the state (Section 373.016, F.S.). To carry out this responsibility, Chapter 373 provides the SFWMD with several tools with varying levels of resource protection standards. Protection programs include the SFWMD's surface water management and consumptive use permitting regulatory programs, MFLs, and the SFWMD's Water Shortage Program. Determination of the role of each of these and the protection that they offer are discussed in the following section.

Sustainability is the umbrella of water resource protection standards (Section 373.016, F.S.). Each water resource protection standard must fit into a statutory niche to achieve this overall goal. Pursuant to Parts II and IV of Chapter 373, surface water management and consumptive use permitting regulatory programs must prevent harm to the water resource. Whereas water shortage statutes dictate that permitted water supplies must be restricted from use to prevent serious harm to the water resources. Other protection tools include reservation of water for fish and wildlife or health and safety (Section 373.223(3)), and aquifer zoning to prevent undesirable uses of the ground water (Section 373.036). By contrast, MFLs are set at the point at which significant harm to the water resources or ecology would occur. The levels of harm cited above, harm, significant harm, and serious harm are relative resource protection terms, each playing a role in the ultimate goal of achieving a sustainable water resource.

## Level of Certainty

Certainty that sufficient water supplies will be available to water users and the environment is provided by varying tools. Level of certainty is the level of assurance provided to consumptive users and the environment that water will be available to meet reasonable demands to specific hydrologic conditions. The level of certainty evaluated in the planning process defines the availability of water to reasonable beneficial uses and the level of protection afforded to the water resources. The following resource protection framework in **Figure 12** is discussed in terms of the level of certainty and the varying tools available under Chapter 373 to protect water resources.

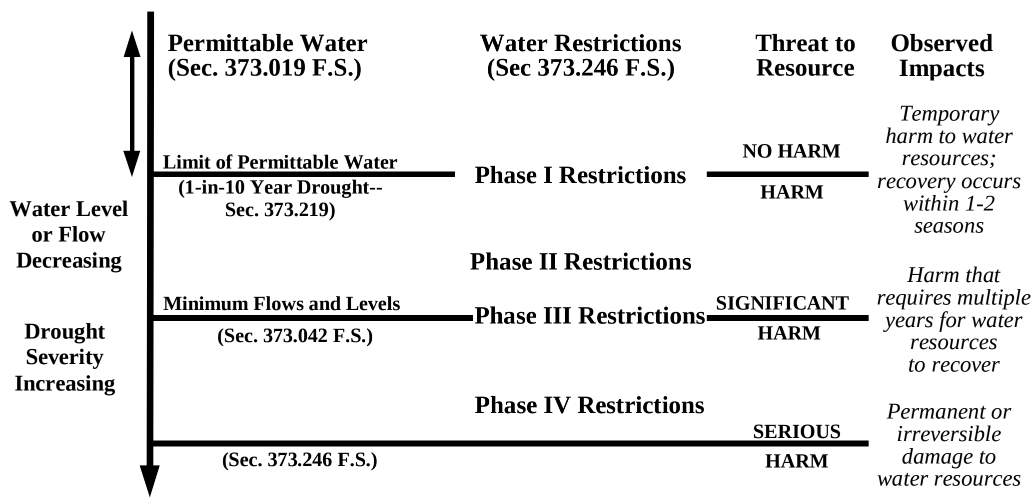


**Figure 12.** Conceptual Relationship among the Terms: Harm, Significant Harm, and Serious Harm.

## Water Supply Planning and Level of Certainty

Fundamental to water supply planning is the quantification of existing and projected demands under a level of certainty. The 1997 Water Supply Legislation (CS/HB 715, et al.) requires the water management districts to provide as a part of the regional water supply plan:

> [a] quantification of the water supply needs for all existing and reasonably projected future uses within the planning horizon. The level-of-certainty planning goal associated with identifying the water supply needs of existing and future reasonable-beneficial uses shall be based upon meeting those needs for a 1-in-10 year drought event.

These demands are evaluated by water availability assessment tools (ground water/surface water models) to estimate the potential impacts of the associated cumulative use. In this evaluation process, certain assumptions/constraints are defined to protect the water resources from over development. These constraints identify where in the planning area threats, such as salt water intrusion, wetland stress, pollution or others, to the water resources could potentially occur.

Another implication of the level of certainty in water supply planning is that it defines where water resource development and water supply development projects need to be implemented to meet the projected demands for the appropriate level of certainty (Section 373.0361, F.S.). Once the water supply plan is completed and the water resource development and water supply development projects are defined which assure all reasonable demands will be met, the regulatory process becomes one of several plan implementation tools. In order to be consistent with the plan, CUP applications are reviewed using the planning level of certainty and resource protection constraints on a local (project) scale.

## Consumptive Use Permitting Link to Level of Certainty

Under Section 373.219, F.S., the yield of the source, or amount of water which can be permitted for use, is limited by the resource protection criteria which defines when "harm" will occur to the resource. Resource protection criteria have been adopted by the water management districts under the three-prong test referred to in Section 373.223, F.S., and particularly the reasonable-beneficial use test. Such criteria are aimed at preventing saltwater intrusion and upconing, harm to wetlands and other surface waters, aquifer mining and pollution.

Based on statutory guidance, staff recommends harm be considered as the point at which adverse impacts to water resources occur during drought conditions that are sufficiently severe that they cannot be restored within a period of one to two years of average rainfall conditions. These short-term adverse impacts are addressed under the CUP program, which calculates allocations to meet demands up to the appropriate level of certainty.

## Water Shortage Link to Level of Certainty

By basing resource protection criteria on a specific uniform level of certainty, it is possible to predict when water uses may be restricted by water shortage declaration. In a drought more severe than the drought event associated with the level of certainty, consumptive users no longer have the assurances that water will be available for use in their permitted quantities. During these drought conditions, both consumptive users and the water resources will experience a shared adversity.

Pursuant to Section 373.246, F.S., water shortage declarations are designed to prevent serious harm from occurring to water resources. Serious harm, the ultimate harm to the water resources that was contemplated under Chapter 373, F.S., can be interpreted as long-term, irreversible, or permanent impacts. The water shortage trigger levels are tools used to "trigger" imposition of water shortage restrictions based on climatic events, continued decline in water levels and a need to curtail human demand to correspond to decreasing supplies. Each level corresponds to a level of water shortage restriction. These restrictions act to apportion among uses, including the environment, a shared adversity resulting from a drought event. Adoption of the resource protection criteria as water shortage trigger indicators also serves the purpose of notifying users of the risks of water shortage restrictions and potential for loss associated with these restrictions.

## Minimum Flow and Level Link to Level of Certainty

Minimum Flows and Levels (MFLs) are the point at which further withdrawals would cause significant harm to the water resources. Significant harm is recommended to be defined as a loss of specific water resource functions that take multiple years to recover, which result from a change in surface water or ground water hydrology. According to the resource protection framework above, this level of harm requires that consumptive uses be cutback heavily, imposing the potential for economic losses to prevent significant harm and serious harm. This shared adversity between the environment and water users is implemented through the water shortage program discussed above.

Section 373.0421, F.S. requires that once the MFL technical criteria have been established, the SFWMD must develop a recovery and prevention strategy for those water bodies that are expected to exceed the proposed criteria. It is possible that the proposed MFL criteria cannot be achieved immediately because of the lack of adequate regional storage and/or ineffective water distribution infrastructure. These storage and infrastructure shortfalls will be resolved through water resource development and water supply development projects, construction of facilities, and improved operational strategies that will increase the region's storage capacity and improve the existing delivery system. Planning and regulatory efforts will, therefore, include a programmed recovery process that will be implemented over time to improve water supply and distribution to protect water resources and functions. The process for establishing MFLs can be summarized as follows:

1. Identify water resource functions of water body.
2. Identify considerations/exclusions.
3. Identify narrative definition of significant harm.
4. Identify numeric criteria to reflect significant harm.

5. Conduct independent scientific peer review of the MFL Technical Criteria and incorporate the revisions suggested by the panel and deemed appropriate.
6. Develop MFL Recovery and Prevention Strategy.
7. As part of the development of the recovery strategy, conduct appropriate technical analyses to determine the water supply implications of the proposed MFL criteria on existing legal uses. These results will be integrated into the regional water supply plan analysis with appropriate implementation measures developed consistent with Section 373.0421, F.S.
8. Following completion of the scientific peer review process, initiate Rule Development after SFWMD Governing Board consideration of the peer review results and appropriate revisions.

## Minimum Flows and Levels Recovery and Prevention Strategy

Section 373.0421, F.S. requires that once the MFL technical criteria have been established, the SFWMD must develop a recovery and prevention strategy for those water bodies that are expected to exceed the proposed criteria. It is possible that the proposed MFL criteria cannot be achieved immediately because of the lack of adequate regional storage and/or ineffective water distribution infrastructure. These storage and infrastructure shortfalls will be resolved through water resource development and water supply development projects, construction of facilities and improved operational strategies that will increase the region's storage capacity and improve the existing delivery system. Planning and regulatory efforts will, therefore, include a programmed recovery process that will be implemented over time to improve water supply and distribution to protect water resources and functions. Development of a MFL recovery and prevention plan for the water resource will be incorporated into the regional water supply planning process to ensure consistency.

## Minimum Flows and Levels Analysis

The proposed Caloosahatchee River and Estuary MFL is based on maintaining salinity levels that would avoid significantly harmful levels in the Caloosahatchee Estuary. Research data were used to relate flow rates from S-79 to salinity distributions along the Caloosahatchee Estuary and to correlate biologic community responses to varying salinity distributions. These relationships were established for submerged aquatic vegetation, fish, and invertebrates, with major emphasis on the salinity requirements of the freshwater grass, *Vallisneria*. It was determined that the distribution and abundance of *Vallisneria* at a location 28 - 30 kilometers upstream of Shell Point is the best biological indicator addressing low flow needs for the restoration of the Caloosahatchee Estuary. The magnitude of die off that requires two years to recover from and the resulting impact to fisheries resulting from the loss of *Vallisneria* habitat was considered to be significantly harmful and formed the basis of the proposed MFL criteria.

A model was developed from field and laboratory information to determine the response of *Vallisneria* to various concentrations and duration of saltwater. This model was used to define low flow events that would produce salinity concentrations of sufficient duration and frequency that would result in significant die-off of *Vallisneria*. Significant die-off of *Vallisneria* would be defined as areas where the presence of *Vallisneria* is reduced to less than 20 shoots per square meter measured at a monitoring station located 28 - 30 kilometers upstream of Shell Point during the months of February through April. Significant harm to the Caloosahatchee Estuary is considered to occur when *Vallisneria* die-back, due to high salinity from low freshwater inflows, occurs for three years in a row. Harm to the Caloosahatchee Estuary is considered to occur when *Vallisneria* die back, due to high salinity from low freshwater inflows, occurs for two consecutive years measured at a monitoring station located 28-30 kilometers upstream of Shell Point. It was determined the freshwater inflow associated with preventing harm or significant harm is an average monthly flow of 300 cfs per day at the S-79 Structure from February through April.

An evaluation of projected flows to the Caloosahatchee River was conducted via the *LEC Regional Water Supply Plan* and the CWMP for 1990 base and 2020 base conditions. The results of these evaluations indicate that the proposed MFL criteria and the restoration baseflow needs of the Caloosahatchee Estuary are not being met. Pursuant to the direction provided in Section 373.042 F.S., a recovery plan is provided in the *LEC Regional Water Supply Plan*. The recovery plan consists of design and construction of enhanced basin storage capacity using surface water, ASR, and reservoirs as described in the Restudy and refined through the CERP and SWFS. A 31-year time series of flows that would result from the works of the Restudy were also simulated and used to define the proposed "Recovery and Prevention Strategy for Minimum Flows". In the interim, an adaptive management strategy, with discretionary releases through the S-77, will be utilized.

# Chapter 5
# SOLUTION DEVELOPMENT

In moving from issue identification/analysis to solution development, several alternatives were considered that would make additional surface water available to meet the water demands within the basin through 2020. Five components (regional reservoirs, Aquifer Storage and Recovery (ASRs), backpumping, distributed small-scale reservoirs, and water harvesting/water table management) were evaluated and combinations of the components were tested as alternatives. The components are described in Chapter 4 of the Planning Document. The nine alternatives, which were identified for assessment following preliminary screening are:

- Do Nothing (A.01)
- Restudy Alternative (A.02)
- Restudy without Backpumping (A.03)
- Regional and Distributed Small-Scale Reservoirs (A.04)
- Regional Reservoirs Only (A.05)
- Water Harvesting (A.06)
- Regional and Distributed Small-Scale Reservoirs with New Structure (S-78.5) (A.07)
- Regional Reservoirs with New Structure (S-78.5) (A.08)
- Do Everything (A.09)

## WATER RESOURCE DEVELOPMENT AND WATER SUPPLY DEVELOPMENT

Recent amendments to Chapter 373, F.S. require that water supply plans include a list or menu of water source options for water supply development from which local water users may choose. For each source option, the estimated amount of water available for use estimated costs, potential sources of funding, and a list of water supply development projects that meet applicable funding criteria should also be provided. In addition, water supply plans must also include a listing of water resource development projects that support water supply development. For each water resource development project, an estimate of the amount of water to become available, timetable, funding, and who will implement, should be provided. These amendments were passed in 1997 as this plan was being developed.

The statute defines water resource development and water supply development as follows:

> "Water resource development" means the formulation and implementation of regional water resource management strategies, including the collection and evaluation of surface water and ground water data; structural and nonstructural programs to protect and manage water resources; the development of regional water resource implementation programs; the construction, operation, and maintenance of major public works facilities to provide for flood control, surface and underground water storage, and ground water recharge augmentation; and related technical assistance to local governments and to government owned and privately owned water utilities.

And,

> "Water supply development" means the planning, design, construction, operation, and maintenance of public or private facilities for water collection, production, treatment, transmission, or distribution for sale, resale, or end use.

The CWMP addresses these issues in relationship to surface water supply. Issues associated with ground water issues and identification of additional availability are discussed in the *LWC Water Supply Plan*. The recommendations from this plan will be integrated with the *LWC Water Supply Plan* and the *LEC Regional Water Supply Plan*. For the purposes of this plan, the Caloosahatchee Advisory Committee (CAC) concluded the SFWMD is responsible for 1) water resource development to attain the maximum reasonable-beneficial use of surface water; 2) to assure the availability of an adequate supply of surface water for all competing uses deemed reasonable and beneficial; and 3) to maintain the functions of natural systems. Local users have primary responsibility for water supply development and choosing which water source options to develop to best meet their individual needs. For an alternative to be considered the CAC suggested the following issues be addressed:

- Opportunity to address more than one resource issue.
- Address a variety of use classes (e.g., environment, public water supply).
- Protect/enhance resource availability for allocation.
- Move water from water surplus areas to deficit areas.
- Broad application of technology ('broad-reaching').

# ALTERNATIVES

The nine alternatives, made up of one or more storage or water management component, were assessed as part of the surface water supply analysis for the CWMP. Each alternative was initially assessed through the modeling process and then screened by the CAC to determine its applicability and acceptability in the Caloosahatchee Planning Area. The CAC reviewed the components and resulting alternatives to assess those that have the most potential to address the greatest number of water supply issues, including regional and future demands and local restoration needs. (**Table 15**).

**Table 15.** Water Management Alternatives and Components.

| Alternative | Regional Reservoir | Distributed Reservoir | ASR | Backpumping | Structure S-78.5 | Water Harvesting |
|---|---|---|---|---|---|---|
| Do Nothing | | | | | | |
| Restudy | X | X | X | X | | |
| Restudy/No Backpumping | X | X | X | | | |
| Regional and Distributed Reservoirs | X | X | | | | |
| Regional Reservoir Only | X | | | | | |
| Water Harvesting | | | | | | X |
| Regional and Distributed Reservior with New Structure | X | X | | | | |
| Regional Reservior with New Structure | X | | | | | |
| Do Everything | X | X | X | X | X | X |

"X" denotes that storage option included.

## Do Nothing (A.01)

The Do Nothing Alternative represents the status quo and involves a projection of demands including environmental, agricultural, and urban to 2020 conditions while maintaining the current sources and infrastructure within the Caloosahatchee Basin. The 2020 demands were determined from 2020 land use coverage developed by SFWMD staff in cooperation with representatives from agricultural, Public Water Supply (PWS), and environmental groups and approved by the CAC. In evaluating this alternative, all future irrigation demands were supplied from the Caloosahatchee River (C-43) where practical. The projected 2020 PWS demands were extracted from the Caloosahatchee River upstream of the Franklin Lock.

There are no storage components considered as part of this alternative and there were no special considerations identified. Inflow from Lake Okeechobee corresponds with the Restudy 2020 "without Plan" Condition, which were developed using the South Florida Water Management and the Natural Systems models. The results of the Restudy modeling established the boundary conditions for the Do Nothing Alternative.

## Restudy Alternative (A.02)

The Restudy Alternative is based on the recommended Restudy Alternative D13R. It is made up of the components described in the D13R for the Caloosahatchee Basin and consists of a 160,000 acre-foot reservoir, 44 ASR wells with up to 5 MGD capacity, and backpumping of excess runoff to Lake Okeechobee following treatment in a Storm Water Treatment Area (STA). The CWMP considered an 8,000 acre reservoir 20 feet deep located in the western portion of the Caloosahatchee Basin. The Restudy suggested a 20,000 acre reservoir 8 feet deep. The modification in dimensions was based upon information specific to the Caloosahatchee Basin and preliminary investigation of a potential reservoir site in the vicinity of Berry Groves and Townsend Canal. The location of the regional reservoir in the western portion of the basin ensures maximum capture of runoff. Minor modification to the canal network was necessary to ensure that the stored water could be released to the East Caloosahatchee Basin when required for irrigation use. Two canal reaches, one between the upstream portion of Roberts Canal and Canal 1 and the other between Canal 1 and Canal 2, were added as part of this alternative.

This alternative assumes the location of the ASR facilities proximal to the reservoir and operated in association with the reservoir. A 70 percent recovery rate for the ASRs was assumed.

Backpumping to Lake Okeechobee was considered as an integral part of this alternative. A backpumping facility with a capacity of up to 2,000 cubic feet per second (cfs) that returns excess runoff to Lake Okeechobee during periods of high discharge was assumed.

Inflows from Lake Okeechobee for the Restudy Alternative were specified based upon the 2020 "with Plan" Condition (Restudy Alternative D-13R) discharge to the Caloosahatchee Basin. These discharges differ from the discharges applied for the Do Nothing Alternative due to the effects of the various management and storage components, which are scheduled for implementation through the Restudy.

The storage components that comprise this alternative are:

- Regional surface reservoir
- ASR
- Backpumping to Lake Okeechobee

The special considerations associated with Alternative A.02 are:

- Deeper reservoir with smaller surface area to volume considered to reduce evapotranspiration losses.
- Lined reservoir or reservoir constructed in clay or impermeable material to reduce seepage looses.
- ASR water quality treatment requirements and permit considerations require further investigation.
- Geologic investigation to ensure suitability of potential site for ASR use (including well capacity) requires additional studies and pilot demonstration project implementation.
- Backpumping to Lake Okeechobee requires water treatment using STA at or in the vicinity of Lake Hicpochee.

- A connection between Roberts Canal and Barron Water Control District Canal 1 and Canal 2 to transfer water between east and west basins is required and would need to be constructed as part of this alternative.
- Siting the regional reservoir at Berry Groves results in a reduction of citrus acreage within the planning area, thereby reducing irrigation.

The reservoir considered in this alternative is filled when discharge from S-79 approaches or exceeds 2,800 cfs. Discharge from the reservoir occurs to maintain water levels in C-43 at a 300 cfs minimum average monthly flow required to maintain acceptable estuarine salinity ranges.

Injection into the ASR wells would start during high flow periods when the reservoir is up to 70 percent full and continues until high flows stop. Discharge from the ASR into the reservoir starts when reservoir levels fall to within five feet of the reservoir bottom and flows to the estuary are lower than 300 cfs.

The operation of the backpumping facility would depend on storage capacity available in the STA and Lake Okeechobee as well as discharge at S-79 and storage within the regional reservoir.

## Restudy without Backpumping Alternative (A.03)

The Restudy without Backpumping Alternative is the same as Alternative A.02 (Restudy Alternative) with the backpumping component removed. The CAC suggested this alternative. The analysis of this alternative will determine the feasibility of meeting projected 2020 demands by providing additional storage within the Caloosahatchee Basin.

The inflow into the Caloosahatchee Basin from Lake Okeechobee for Alternative A.03, was the same for Alternative A.02. No adjustments were made to the lake discharge to accommodate the loss of backpumping from the basin to the lake.

The storage components that comprise this alternative are:

- Regional surface reservoir
- ASR

The special considerations and operational aspects of the alternative are the same as with Alternative A.02 except no backpumping to Lake Okeechobee will occur.

## Regional and Distributed Small-Scale Reservoirs Alternative (A.04)

The Regional and Distributed Small-Scale Reservoirs Alternative models one large regional and distributed smaller reservoirs. The regional reservoir is modeled with the same parameters and assumptions as in Alternative A.02 (Restudy Alternative) with additional distributed reservoirs located in east and west basins, and on the north and south sides of the river to supply irrigation demands. The reservoirs were sited by analysis of the irrigation shortages in the basin. By analyzing preliminary results from Alternative A.02 areas where demand was not met were delineated and a reservoir was sited in those areas to collect runoff for use as an irrigation source. For modeling purposes the reservoirs were sized from 10,000 acre-feet to 108,000 acre-feet. No backpumping or ASRs are associated with Alternative A.04.

Inflows from Lake Okeechobee for this alternative are the same as the Restudy Alternative that were specified based upon the 2020 "with Plan" Condition (Restudy Alternative D-13R) discharge to the Caloosahatchee Basin.

The storage components that comprise this alternative are:

- Regional surface reservoir
- Distributed surface reservoirs

The special considerations associated with Alternative A.04 are:

- Deeper reservoirs with smaller surface area were considered in order to reduce evapotranspiration losses.
- Assume the reservoirs will be lined or constructed in clay or impermeable material to reduce seepage losses.

The distributed reservoir system was operated to achieve satisfaction of both environmental demands (estuary flows) and agricultural demands (irrigation flows). Flows were captured during high flow events from canal reaches adjacent to the reservoirs. Release into the canal system for irrigation use or to augment low flows to the estuary were made based on flow or level within the canals.

## Regional Reservoirs Alternative (A.05)

The Regional Reservoirs Alternative considered the option of meeting the storage requirements within the Caloosahatchee Basin from a regional reservoir system. The regional reservoir would be similar to the regional reservoir considered for the Restudy Alternative (A.02) but would be larger in order to provide the storage that is provided by the ASR facility in Alternative A.02. For this alternative, an additional reservoir within close proximity to the Berry Grove Reservoir was required. As was the case with Alternative A.02, the regional reservoir system was located within the western basin to maximize the runoff that could be captured. The CAC suggested this alternative.

The storage component that comprises this alternative is:

- Regional surface reservoir

The special considerations associated with the regional reservoir system are similar to those that apply for both the Restudy Alternative and the Regional and Distributed Small-Scale Reservoirs Alternative. The assumptions regarding reservoir geometry and construction for Alternatives A.02, A.03 and A.04 also apply to A.05.

Operation of the regional reservoir system is identical to the operation of Alternative A.02 (Restudy Alternative) with the exception of the ASR releases.

## Water Harvesting Alternative (A.06)

The Water Harvesting Alternative investigated the volume of water that would be generated by returning some of the drained area north of the river to predevelopment conditions. Water harvesting/water table management was suggested as a viable low cost method of detaining water and reducing the size of the regional reservoir system. Two major concepts are incorporated into the Water Harvesting Alternative. Both concepts involve passive management of mostly undeveloped lands. One component is water table management, man made ditches and other drainage features are removed to facilitate on site storage capability. The second component is water harvesting which incorporates development of weirs or raising of weirs to provide in-channel and ground water storage in unused stream reaches. There are no reservoirs, ASRs, or backpumping associated with Alternative A.06.

This alternative includes restoration of public lands to predevelopment conditions when and where possible at candidate locations such as the Okaloacoochee Slough. Several types of lands (wetlands, forests, and pasture) can tolerate temporary flooding with little loss in long-term productivity. To be effective this alternative would require cooperation from private landowners to implement some of the changes on suitable portions of their properties.

The special considerations associated with Alternative A.06 are:

- Additional study is required to determine proper water table management guidelines for these areas.
- Could result in short-term storage (stalls runoff for one to two months).
- The restoration of regional water levels may have a greater regional effect.
- Could assist in the reduction of high flows to the estuary.
- Would require significant private sector/government cooperation.

## Regional and Distributed Small-Scale Reservoirs with a New Structure Alternative (A.07)

The Regional and Distributed Small-Scale Reservoirs with a New Structure Alternative considered a regional reservoir system, smaller distributed reservoirs, and a new structure situated between S-78 and S-79 upstream of LaBelle. As part of this alternative, the existing structure at S-78 will be raised by approximately 3 feet from elevation 11 to elevation 14. This will result in increased storage within the C-43 upstream of S-78 and within Lake Hicpochee. The additional structure, similar in function and operation to the existing structure at S-78, will be operated at elevation 8 providing an intermediate step down from elevation 14 upstream of the modified S-78 to elevation 3 upstream of S-79. By raising the structure at S-78 and adding a new structure between S-78 and S-79 this alternative attempts to maximize water retention in the river and water table aquifer.

Inflows into the basin from Lake Okeechobee are the same as in the Restudy Alternative (A.02).

The storage components that comprise this alternative are:

- Regional surface reservoir
- Distributed surface reservoirs
- Water control structure in the C-43 Canal at S-78.5
- Modification of S-78

The special considerations associated with Alternative A.07 are:

- Deeper reservoirs with smaller surface area were considered to reduce evapotranspiration losses.
- Assume the reservoirs will be lined or constructed in clay or impermeable material to reduce seepage losses.
- Raising the structure at S-78 would result in some flooding of low-lying areas upstream of S-78. A preliminary assessment of the flooded area is conducted as part of this plan. More detailed study of the flood implications (including impact to septic tanks, etc.) will be required should this alternative be selected for implementation.

The regional and distributed reservoir system was operated to achieve satisfaction of demands within the Caloosahatchee Basin. Filling and discharge from the reservoirs was based on flow and discharge conditions within the canals in the basin and irrigation requirements. The water control structures were operated with the goal of maintaining a constant pool at elevations 3, 8, and 14 between the S-79 Structure and the boundary with Lake Okeechobee. During low flow, high demand periods, the water levels within these pools dropped in response to basin demand and use.

## Regional Reservoir with a New Structure Alternative (A.08)

The Regional Reservoir with a New Structure Alternative considered a regional reservoir system and a new structure situated between S-78 and S-79 upstream of LaBelle. The structure is as described in Alternative A.07.

The storage components that comprise this alternative are:

- Regional surface reservoir
- Water Control structure in the C-43 Canal at S-78.5
- Modification of S-78

The special considerations and operational considerations are identical to those in the Regional and Distributed Small-Scale Reservoirs with a New Structure Alternative (A.07).

## Do Everything Alternative (A.09)

The Do Everything Alternative, as the name implies, considered all the storage components identified and discussed in Chapter 4.

The storage components that comprise this alternative are:

- Regional surface reservoir
- Distributed surface reservoirs
- ASRs
- Backpumping to Lake Okeechobee
- Water harvesting/water table management
- Water control structure in the C-43 Canal at S-78.5

This alternative incorporates all the components included in the previous alternatives. The special and operational considerations from all the previous alternatives therefor apply.

### Other Alternatives Considered

Several other alternatives were evaluated early in the planning process. These included such alternatives as:

- Structure between S-78 and S-79 alone with no modification to S-78 and no reservoir, ASR, or backpumping to Lake Okeechobee.
- ASR alone with no other components.

After initial evaluation SFWMD staff recommended that these alternatives not be considered for additional evaluation. The CAC concurred with the recommendation.

# OTHER WATER SUPPLY OPTIONS/CONSIDERATIONS

The CAC discussed several other water supply options and considerations which should be considered in the development of the *LWC Water Supply Plan* and the implementation of the *Southwest Florida Study* (SWFS).

## Southwest Florida Study

The *Southwest Florida Study* will describe and evaluate alternative plans to address water resource problems in Southwest Florida. The SFWMD in cooperation with the U.S. Army Corps of Engineers (USACE) are conducting the SWFS to develop a comprehensive plan for the system. As described in Chapter 2, this five-year study will address traditional features such as navigation, shoreline erosion, flood control, enhancement of water supplies, and environmental restoration features for the southwest region.

The primary focus of the SWFS is environmental restoration. This focus includes evaluating several alternatives, such as surface water storage areas, to meet the salinity envelope for the Caloosahatchee Estuary, as well as enhancing surface water availability for water supply. The desired salinity envelope will be met through managing freshwater discharges to the Caloosahatchee Estuary. The salinity envelope and associated inflow are being refined in the *LWC Water Supply Plan* and development of the Minimum Flows and Levels (MFLs) for the Caloosahatchee Estuary. Pursuant to Chapter 373, F.S., the SFWMD has designated the Caloosahatchee Estuary as a priority water body for establishment of MFLs.

It is recommended that the SWFS be completed and implemented to address freshwater discharges to the Caloosahatchee Estuary and increase surface water availability for water use; and the recommendations of the Restudy and associated funding be pursued after detailed modeling supports the recommendation in the Restudy.

It was concluded that the primary purpose of the SWFS should be to provide a framework in which to address the health of aquatic ecosystems; water flows; water quality (including appropriate pollution reduction targets); water supply; flood protection; wildlife and biological diversity; and habitat protection and restoration. Evaluations of increasing surface water availability for water supply purposes should strive for providing a 1-in-10 level of certainty from surface water as an optimal goal. However, it is recognized this may not be cost-effective.

## Well Abandonment

It is recommended that the SFWMD look at the potential water savings that could be gained by reactivating the Well Abandonment Program. The Well Abandonment Program was responsible for locating and plugging existing abandoned wells within the Caloosahatchee Basin. The program documentation indicates that the well inventory identified 236 wells in Hendry County and 178 wells in Glades County. Of those wells, 170 in Glades County and 198 in Hendry County are large diameter wells (6 inches or greater in diameter). Approximately 40 wells were plugged of which 17 were free flowing with an average flow of 180 gallons per minute at land surface. Generally, the free flowing wells were located near the Caloosahatchee River. It is estimated that 4,900 acre-feet of saline water is prevented from contaminating potable water supplies through capping of the 17 free flowing wells.

The records estimate that approximately 50 percent of the large diameter wells are free flowing at land surface. The records do not indicate as to whether or not these wells were capped. Assuming that the large diameter wells were not capped and are flowing at 180 GPM, it appears that if half of them were plugged they would contribute an estimated net flow of 50,000 acre-feet per year to the water budget of the Caloosahatchee Basin.

In addition, the Florida Geological Survey, Bureau of Oil and Gas published a report in January 2000, *Report on Inadequately Plugged and Abandoned Oil Test Wells in Florida*, identifying oil test wells that were considered to be inadequately plugged and abandoned. A well was considered to be inadequately plugged if it was placed in a public supply source (any ground water that is less than or equal to 10,000 parts per million total dissolved solids) and not adequately protected by cement, casing and cement, and appropriately placed plugs. The report lists 60 wells in Hendry County, 8 in Charlotte County, 2 in Glades County, and 29 in Lee County that are inadequately plugged.

It was recommended that additional effort should be made to locate and properly abandon the free flowing wells in the Caloosahatchee Basin.

## Salt Water Influence

Saline water (in excess of 250 milligrams per liter [mg/L]) has been a recurring problem for the potable water intakes in the Caloosahatchee River (approximately one-mile upstream of S-79). During extended periods of low-flow, the chloride content of the shallow water increases well beyond the recommended limit of 250 mg/L for drinking water. Previous studies have shown that saline water from the tidal part of the Caloosahatchee River moves upstream during boat lockages at S-79 (Boggess, 1970). Salty water enters the lock chamber through opening of downstream sector gates. When the upstream gates open, some of the salty water moves into the upper pool. Repeated injections of salty water cause a progressive increase in the salinity of the upstream water. The salty water moves upstream within the deeper part of the river channel as far as 5 miles above the lock. Some mixing of the high chloride deeper water and the fresher shallow water can occur above the lock. This mixing is due to wind and waves and the turbulence created by boat traffic. Chloride contamination, from sources other than through the lock chamber, is only a minor factor contributing to the chloride contamination. A bubble curtain was installed at S-79 to limit the movement of saline water upstream. Analysis of the effect of the bubble curtain has proven that the bubble curtain reduces the need for flushing of freshwater when it is properly operated. A recent occurrence of water in excess of 250 mg/L occurred when the bubble curtain was not in operation.

The actual number of times that releases have been made from Lake Okeechobee in response to salt water in excess of 250 mg/L is relatively few. Recent studies by the SFWMD and USACE have shown that changing the flushing cycle can reduce the water required for flushing. In addition, controlling for minimum flows to meet estuary needs reduces the flushing needs. A number of modifications to these releases warrant further investigation. Among these are moving the intake farther upstream, modifications to the structure, and improved maintenance and operation of the bubble curtain. It was recommended that additional analysis of the saline water problem be initiated.

### Agricultural Conservation Methods

Within the agricultural industry, many efforts have been initiated to use water more efficiently. Since 1993, citrus and container nursery permittees have been required to use micro irrigation or other systems of equivalent efficiency. This requirement applies to new installations or modifications to existing irrigation systems. In addition, many existing operations have been retrofitted. These activities have resulted in more than 70 percent of the citrus in the LWC and Caloosahatchee planning areas currently using micro irrigation. Conversion of the remaining acres is occurring within the industry, where appropriate. In some situations, flood irrigation provides benefits to the hydrology of isolated wetlands through an elevated water table. In other situations, conversion to micro irrigation is not appropriate because of site-specific considerations. Some vegetable farms have also converted on a voluntary basis to a micro irrigation system.

A Mobile Irrigation Lab (MIL) also operates in the LWC and Caloosahatchee Planning Areas to assist growers in identifying additional opportunities to save water, such as water table management and determining irrigation frequency and needs. Within the industry, growers have implemented management practices that meet or exceed permitting requirements and agree favorably with University of Florida, Institute of Food and Agricultural Sciences (IFAS), recommendations.

## RELATED STRATEGIES

The SFWMD should consider the following to implement the CWMP:

**Coordination**. The SFWMD will continue coordination of the *LEC Regional Water Supply Plan*, *LWC Water Supply Plan*, SWFS, CERP, with local governments/ utilities, and other related efforts to promote compatibility.

**Caloosahatchee Water Management Plan Update**. It is recommended that the CWMP be updated following completion of the SWFS. The intent of this recommendation is to allow incorporation of the results of the SWFS into the CWMP.

# Chapter 6
# EVALUATION OF ALTERNATIVES

The *Caloosahatchee Water Management Plan* (CWMP) considers six water source options that provide opportunities to address surface water supply issues in the Caloosahatchee Basin. These options reflect the goals of the Caloosahatchee Advisory Committee (CAC) and the SFWMD. The water source options (components) are:

- Regional Reservoirs
- Distributed Reservoirs
- Aquifer Storage and Recovery (ASR)
- Structure S-78.5 (New Structure)
- Backpumping
- Water Harvesting

The CAC suggested that the SFWMD consider a number of alternatives that are made up of the various components by combining components to identify the best alternatives to meet future surface water supply demands within the Caloosahatchee Basin. Each of the components was analyzed utilizing an Integrated Surface Water/ Ground Water Model (ISGM) and the resulting alternatives were evaluated based on several parameters including water supply, environmental/resource protection, and estuarine protection. The SFWMD evaluation is a preliminary assessment and has resulted in a menu of alternatives to possibly address the 2020 surface water supply demands within the Caloosahatchee Basin. Additional and more detailed analyses should be performed and a preferred alternative developed as a part of the implementation of the *Southwest Florida Study* (SWFS).

The alternatives that were identified for preliminary assessment are:

- Do Nothing (A.01)
- Restudy Alternative (A.02)
- Restudy without Backpumping (A.03)
- Regional and Distributed Small-Scale Reservoirs (A.04)
- Regional Reservoirs Only (A.05)
- Water Harvesting (A.06)
- Regional and Distributed Small-Scale Reservoirs with New Structure (S-78.5) (A.07)
- Regional Reservoir with New Structure (S-78.5) (A.08)
- Do Everything (A.09)

The increasing future surface water demands in the Caloosahatchee Basin poses a significant water resource and management challenge. Furthermore, the environmental impact of future surface water management on wetlands, habitat, and the Caloosahatchee Estuary must be evaluated. The results of the preliminary assessment using ISGM are presented in this Chapter. In addition, a methodology to identify potential environmental impacts and general cost estimates have been included in this Chapter.

# MODELING ASSUMPTIONS

The Caloosahatchee Basin ISGM was run for an 8-year period using weather (precipitation and evapotranspiration) data corresponding to the period between 1988-1995. The period chosen is characterized by wet, average, and dry years and was considered representative of the annual variation encountered in the basin. The ISGM and other subregional models, unlike the regional models used in the Restudy, does not simulate a thirty-one year period, but shorter periods ranging from 2 to 8 years. The results of the Caloosahatchee Basin ISGM should therefore be interpreted with caution especially where comparisons with the results of the regional models and Restudy models are made.

In addition to the 8-year simulation a 31-year MIKE SHE model run was completed. Simulated irrigation demands and basin runoff were compared to results obtained from the AFSIRS/WATBAL analysis for the same period. The results of this comparison are presented in Appendix M. The methodology used for the AFSIRS analysis is also described in Appendix M.

The coupling of the ISGM to the regional system is achieved through the specification of inflows at the model boundary corresponding to releases from Lake Okeechobee. The inflow utilized in all of the alternative evaluation simulations corresponds to the deliveries of water from Lake Okeechobee from the South Florida Water Management Model (SFWMM) based on the 2020 with restudy components' and represents a reduction from historic releases. In addition to the general assumptions, specific considerations for representation of water management components are described in the following section.

## Reservoirs

Reservoirs, regional or distributed, were represented in the MIKE11 river hydraulics portion of the model. Wide and deep cross-sections were added to the river network to describe the reservoir storage. Weirs are added to allow overflow when the reservoir is full. The reservoir operation is achieved by simulating pumps for filling and emptying the reservoir during high flow and low flow periods.

The inflow pump was operated as a function of the available water at the intake point (canal adjacent to reservoir location). By using this representation, the reservoirs captured subbasin runoff. When the water level at the intake point dropped below a given level the pumps were automatically turned off by the model. This operation procedure ensured that the canals were not pumped dry to fill the reservoirs. In addition, where canals close to the reservoir are connected to the C-43 Canal (Caloosahatchee River), discharge in the river was used as a condition for filling the reservoirs. In this case, the pumps to fill the reservoir were turned on when flows in the Caloosahatchee River were high thus capturing both subbasin runoff and runoff from other upstream basins.

The release of water from the reservoirs was based primarily on demand considerations; including both environmental needs and agricultural demands. The release or discharge pumps were operated to meet estuary discharge parameters described in Chapter 5 and agricultural demands. The releases for the estuary were based on simulated flows in the Caloosahatchee River computed during model simulation at S-79. A release condition was triggered within the model when simulated flows at S-79 were low. The actual flow at which release pumpage commenced was iteratively selected to ensure that the estuary low flow parameters were achieved. In addition agricultural demands proximal to the reservoir were met from reservoir storage when other sources were depleted.

Seepage losses represent a major concern for successful reservoir operation within the Caloosahatchee Basin. For all reservoirs it was assumed that an effective lining will reduce seepage losses effectively and seepage losses, especially in the larger regional reservoir, will be intercepted and recycled to the reservoir. Applying a low leakage coefficient minimized seepage losses to the surficial aquifers.

The ISGM incorporates evaporation from surface waters. Evaporation losses from the reservoirs were achieved in the ISGM when the MIKE11 setup was coupled to the rest of the model. In the combined model, the evaporation losses to the atmosphere were calculated as a free water surface in the computational cells representing the reservoir.

## Aquifer Storage and Recovery

Within the Caloosahatchee Basin, ASR may be feasible only for deeper highly transmissive aquifers. The ISGM was developed to include the surface water and the Surficial Aquifer System (SAS) and does not extend to these deeper aquifers. The physical representation of injection into or withdrawal from the deeper aquifers was therefore not possible with the model. However, the ASR component was simulated with the ISGM as an isolated reservoir with infinite storage. The ASR wells were simulated as being adjacent to or connected to surface reservoirs and injection into and discharge from the ASR was into the associated surface reservoir. When the surface water reservoirs were full, water was pumped to the ASR reservoir at a specified capacity. Water was released from the ASR to the surface water reservoir at low water levels and the final release to the canal network is controlled by the reservoir release pump operation. It was assumed that the recovery efficiency was 70 percent of the water injected.

## Backpumping

The backpumping of Caloosahatchee Basin runoff to Lake Okeechobee is a component of the preferred Restudy initiatives. It is also included in the Do Everything Alternative (A.09). Representation of this component in the ISGM was simplistic in nature. The C-43 flows near the S-79 Structure were monitored during model simulations that included the backpumping components. When these flows exceed the estuary high flow requirement, a withdrawal from the C-43 close to S-79 was implemented. Within the model, this water was stored in a storage node and an accounting of the increased storage in this node was used to determine potential contribution to Lake Okeechobee. This representation ensured that the maximum runoff volume that would have been lost to tide was captured for backpumping to the lake. The actual mechanism of moving the water back to the lake including pump stations and a Storm Water Treatment Area (STA) at Lake Hicpochee was implied but not explicitly simulated.

## Water Harvesting/Water Table Management

The purpose of the Water Harvesting Alternative (A.06) was to detain runoff by increasing the water levels in natural streams and adjacent flood plains. Simple hydraulic structures such as weirs or boards in secondary or tertiary tributaries capture the runoff and temporarily increase storage. Representation of this component in the ISGM is achieved by varying the detention/overland storage capacity within those areas of the basin considered candidate locations for this management option. An additional component of this alternative is water table management where drainage features such as ditches are filled to restore the lands to predevelopment (predrainage) conditions resulting in an alteration of the runoff volume and timing characteristics of the affected lands. This was simulated in the model by a change in drain elevation within those areas of the basin considered candidate locations for this management option.

# PERFORMANCE MEASURES

In order to compare each of the alternatives and to evaluate their feasibility, a number of performance measures were specified. These were presented in Chapter 5. The performance measures are indicators of how well each alternative meets environmental, agricultural and Public Water Supply (PWS) demands. The implementation of these measures in the model is described in this section.

## Environmental Demand

The environmental performance measures include wetland drawdown parameters and discharge to the estuary parameters, which are described in greater detail in Chapter 5.

In order to extract model results to establish how well each alternative performed regarding the wetland drawdown parameters, two sets of model runs were required. In the first, the model was run without agricultural and PWS withdrawals. In the second run, these withdrawals were incorporated. All other model inputs such as rainfall and evaporation were held constant for both runs. The drawdown due to the withdrawals to meet agricultural and PWS needs was computed as the difference in simulated heads from the two model runs. The drawdown was computed at each cell in the model for each month of the simulation. A count was kept of each time drawdown exceeded 1-foot within each cell containing wetlands. The summation of the number of cells where the 1-foot drawdown parameter was exceeded for more than one month within the model was used as an indicator of potential wetland impact for each alternative evaluated. Alternatives with a smaller count were considered more favorable than alternatives with a larger count. Particular care should be taken when interpreting these results. The wetland cells in the model included those with wetlands covering less than 10 percent of the cell size to those that were 100 percent covered by wetlands. No attempt was made to distinguish between drawdown in any of the wetland cells. The ongoing isolated wetland study being conducted by the SFWMD will provide more detailed information on wetland impact and allow for improvement in the specification of wetland performance measure during CWMP update. It is anticipated that the studies will be completed in early summer of 2000.

The large variation in discharge to the estuary causes large variations in the salinity in the coastal waters. From a biological and ecological point of view it is desirable to control the discharge to the estuary to ensure it maintains desirable estuarine functions. Ongoing efforts to establish Minimum Flow and Level (MFL) parameters have resulted in the development of a desirable distribution of flow to the estuary. The tails (low-end and high-end) of this distribution based on long-term analyses (over 30 years) were used to establish desirable goals for simulating low flows and high flows to the estuary in the ISGM. While the statistical analyses were conducted using long-term data, the ISGM simulates an 8-year period, which is a subset of the long-term data. The desirable low-end and high-end flows to the estuary based on statistical analyses of long-term data are summarized in **Table 16**.

**Table 16.** Discharge Parameters for Estuarine Flows (1965-1995).

| Estuary Flow Requirements | Specification |
|---|---|
| Low Flow (Parameter 1) | Monthly Average Discharge at S-79 < 300 cfs no more than 16% of the time |
| High Flow (Parameter 2) | Monthly Average Discharge at S-79 > 2,800 cfs no more than 6% of the time |
| Very High Flow (Parameter 3) | Monthly Average Discharge at S-79 > 4,500 cfs no more than 1.6% of the time |

The estuary flow criteria for the alternatives was computed from the results of model simulation using the following procedure:

- First the daily flow over the S-79 Structure for the 8-year simulation was extracted.

- The daily flow was accumulated for each month of the simulation and the monthly average determined.
- The average monthly flow was then compared to the target flows of 300 cfs for the low flow parameter.
- The number of months with flows less than 300 cfs were counted and divided by the total number of months in the simulation.
- The resulting fraction was converted to a percentage and compared with the target frequency of 16 percent.

Using a similar procedure, the frequency of flows over 2,800 cfs and 4,500 cfs was determined and compared to the target flows of 6 percent and 1.6 percent respectively. Alternatives that come closest to meeting these targets were considered more desirable than those that miss the target by larger margins.

## Public Water Supply Demand

Lee County Utilities and the City of Fort Myers currently withdraw water from the Caloosahatchee River at Olga. The withdrawal point is situated within the Caloosahatchee River upstream of S-79. For each alternative simulated, flows and water levels in the Caloosahatchee River at the intake point are monitored to ensure sufficient flow at S-79 to meet the public water demand. No water quality considerations were included in this model implementation.

## Agricultural Demand

Based upon specified land use and irrigation parameters, the ISGM simulated the crop requirements and agricultural withdrawals. The projected land use changes between 1995 and 2020 resulted in an increase of irrigated lands and irrigation demand. For the purpose of model simulation, the primary and secondary irrigation sources were specified as canals, ground water wells, or both. The ISGM attempted to meet the growth in agricultural demands from surface water sources proximal to the irrigated lands. As a second alternative and for those areas where surface water was not available, ground water was considered as the source for meeting the increased demand. When the irrigation demands were not met by the specified sources, an irrigation deficit had occurred. The irrigation deficit was simulated as being met from an external source. A total of the irrigation usage from the external source indicated the deficit or unmet agricultural demand. Increasing storage within the basin during wet periods for use in dry periods minimized the volume of water from these idealized external sources. The minimization of external sources was used to evaluate the alternatives. Alternatives that required less use of external sources had less irrigation deficit and were therefore more desirable than those that required more use of external sources.

# ALTERNATIVE ANALYSIS

Each alternative was analyzed using the ISGM (MIKE SHE) to evaluate how well the alternative meets each of the performance measures. In response to requests from the CAC an additional analysis was completed for 1995 (A.10). This analysis simulated the response of the system based upon the demands generated from the 1995 land use.

## Model Results

### Alternative A.01: Do Nothing (Base Case 2020)

In this modeling scenario, projected 2020 land use and irrigation is applied with no changes in the infrastructure or management practices within the basin. Deliveries of water from Lake Okeechobee were held at the levels prescribed by the South Florida Water Management Model (SFWMM) simulation of "2020 Base". The total irrigated area was increased by approximately 40 percent over 1995 conditions with no additional storage facilities, such as reservoirs and associated canals to distribute the water within the basin.

#### Model Implementation

The GIS coverage of the projected 2020 land use was developed and used to identify irrigated areas in the year 2020. Vegetation properties and other irrigation parameters corresponding to the new projected land use were incorporated into the ISGM thereby updating the 1995 irrigation set to 2020 conditions. The allocation of water to new irrigation areas was based on the assumption that local surface water resources would be used first where proximal to the irrigated lands. Ground water would be used where surface water was not available or not available in sufficient quantities.

#### Results

The model results indicate a deficit in irrigation needs as well as unsatisfactory flows to the estuary. This deficit is not unexpected since there are no means of holding the high flows that occur during the wet periods thus curtailing high flows to tide, or augmenting low flows during dry periods.

A summary of the performance of this alternative with regards to the wetland parameters is presented in **Table 17**. The results indicate that more than one foot of drawdown was observed in 566 model cells for more than one month during the 1990 model year.

**Table 17.** Number of Cells with Drawdown Greater Than One Foot in Wetlands.

| Alternative | Total[a] |
|---|---|
| A.01 | 566 |

a. Total of 2,172 wetland cells in the model.

The estuary discharge parameters are summarized in **Table 18** and show higher than the desired frequency of both low and high flows. Also included in **Table 18** is the volumetric representation of flow to the estuary in excess of demands. This value represents accumulation of discharge greater than 4,500 cfs.

**Table 18.** Estuary Discharge Parameters (Alternative A.01).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 38% | 20% | 7% | 115,803 |

a. Average annual discharge based on analysis of data from 1988-1995.

Average annual irrigation demand and contribution from the various sources are shown in **Table 19**. These results show an irrigation deficit of approximately 23 percent of the total demand. Unmet demands are computed as the external demands less the demand calculated for the portion of the East Calaoosahatchee Basin which draws irrigation water directly from Lake Okeechobee (15,200 acre-feet). This area is irrigated directly from Lake Okeechobee while runoff from the basin discharges to the Caloosahatchee River.

**Table 19.** Mean Annual Irrigation Demands and Source (Alternative A.01).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 448 | 282 | 50 | 101 |

The results also suggest possible difficulty in meeting PWS needs during some portions of the simulated period. In the dry periods the water level drops significantly in the Caloosahatchee River. At the water supply intake point water levels drop to levels that might indicate potential problems from saltwater intrusion.

### Alternative A.02: Restudy Alternative

Alternative A.02 is the Restudy Alternative. The major components included in this alternative are 1) 160,000 acre-feet reservoir storage, 2) a 220 MGD ASR facility, and 3) backpumping from C-43 upstream of the Franklin Lock to Lake Okeechobee.

## Model Implementation

This alternative and subsequent alternatives use the irrigated areas described in Alternative A.01 to determine 2020 demands. The following components were included in this alternative: 1) a reservoir with a capacity of 160,000 acre-feet in the vicinity of Berry Groves, 2) a 220 MGD ASR wellfield adjacent to the Berry Groves Reservoir, and 3) a backpumping facility upstream of S-79 to pump excess flows into Lake Okeechobee. Deliveries of water from Lake Okeechobee were held at the levels prescribed by the SFWMM simulation of '2020 with Restudy Components' consistent with the *LEC Regional Water Supply Plan*. Results from optimization model simulations were used to determine the starting water volumes for the Berry Groves Reservoir and ASR facility. The Berry Groves Reservoir replaces part of a citrus grove and thus removes that area from the irrigation demand calculation. Filling of the reservoir is simulated within the model to commence when water levels in the intake canal are adequate and discharge in C-43 exceeds 1,225 cfs. The rate at which the reservoir is filled increases to a maximum of 2,625 cfs when flows in C-43 attain 7,000 cfs or higher. The model simulates inflow into the ASR when water levels in the reservoir permit. Backpumping from the C-43 is simulated to begin when discharge in C-43, close to S-79, is greater than 2,800 cfs. The rate of backpumping increases to a maximum of 2,000 cfs when simulated discharge at S-79 exceeds 4,500 cfs.

## Results

In designated wetland areas the number of model cells that show greater than one foot of drawdown for more than one month is shown in **Table 20**.

**Table 20.** Number of Cells with Drawdown Greater Than One Foot in Wetlands (Alternative A.02).

| Alternative | Total[a] |
|---|---|
| A.02 | 496 |

a. Total of 2,172 wetland cells in the model.

Compared to the Base Case (A.01) the estuary low flow parameter (Parameter 1) is improved and the peak flow parameters (Parameter 2 and 3) are shown to meet the specified targets (**Table 21**). There are two main reasons for the changes. The S-77 release has been reduced for both wet period releases and dry period releases. The accumulated release has been reduced by approximately 65 percent, which has a positive effect on the peak flow parameter but a negative effect on the low flow parameter. The operation of Berry Groves Reservoir does however compensate for some of the reduced low flow releases. Releases from the reservoir to meet low flow requirements during the first two years of the simulation result in low water level in the reservoir, which are insufficient to sustain the average monthly low flow target of 300 cfs during the simulated drought period.

**Table 21.** Estuary Discharge Parameters (Alternative A.02).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 32% | 5% | 2% | 35,306 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 22** sums up the simulated irrigation demands and corresponding source. This alternative results in better utilization of surface water to meet irrigation requirements. However, the storage is inadequate to meet total irrigation requirements. The reduction in total demand reflects a reduction in cropped acreage due to siting of the reservoir on lands previously used for agricultural purposes.

**Table 22.** Mean Annual Irrigation Demands and Source (Alternative A.02).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 430 | 295 | 50 | 71 |

The water level at C-43 upstream of S-79 was maintained at 3-ft. (0.9 m) for most of the simulated period. The releases from Berry Groves Reservoir to maintain the estuary flows during low flow periods add to the dry period flow at S-79. The releases based on the simulation results appear sufficient to maintain sufficiently high water levels to facilitate the PWS intake.

The model results show that flows in excess of 2,800 cfs occur 5 percent of the time and more than 4,500 cfs occur 2 percent of the time. During these periods flows at S-79 appear adequate to support backpumping. Review of the results show that the majority of the flows occur during the simulation period utilizing the 1995 rainfall distribution which has many significantly high rainfall events. The model activated the backpumping option 94 days during the year utilizing the 1995 rainfall, which was an unusually wet year, and only 10 to 15 per year for the rest of the simulation period. Additionally, the high volumes at S-79 coincide with periods during the simulation when the basin was wet, leaving little available storage. **Table 23** shows the number of days per year the backpumping facility operates based on the prescribed operation. The table indicates that most backpumping occurs during 1995.

The model results indicate that the system represented by Alternative A.02 fails to meet demands less than one year into the simulation. Several iterations to resolve the shortage failed to meet projected demands during the dry season simulated with the

**Table 23.** Number of Days Backpumping Occurs (Alternative A.02).

| Year | Number of Days of Backpumping |
|---|---|
| 1988 | 13 |
| 1989 | 10 |
| 1990 | 12 |
| 1991 | 31 |
| 1992 | 10 |
| 1993 | 7 |
| 1994 | 15 |
| 1995 | 94 |

hydrologic conditions of 1988-89, and 1989-90. Various runs with different assumed reservoir starting volumes failed to meet the irrigation and estuary demands. This deficit indicates that additional storage volume will be required. The extent of this additional storage will be investigated in subsequent model alternatives.

## Alternative A.03: Restudy without Backpumping

Alternative A.03 is the Restudy without Backpumping. The major components comprise the same components as the Restudy Alternative (A.02) with the exception of backpumping from C-43. The backpumping rule described in Alternative A.02 was disabled to simulate no backpumping. High flows within C-43 that can not be captured by the regional reservoir and ASR are allowed to flow to the estuary.

### Model Implementation

This alternative is the same as described in Alternative A.02 with the backpumping facility switched off. The surface water component of the MIKE SHE model setup used in Alternative A.02 was modified to reflect the no backpumping specification. No changes were made to reservoir or ASR operations.

### Results

The model results from Alternative A.03 are very similar to the results obtained for Alternative A.02. In designated wetland areas, the number of cells with drawdowns in excess of one foot is shown in **Table 24**, which shows that the number of cells with drawdown of greater than one foot was slightly reduced as compared to Alternative A.02.

**Table 24.** Number of Cells with Drawdown Greater Than One Foot in Wetlands (Alternative A.03).

| Alternative | Total[a] |
|---|---|
| A.03 | 491 |

a. Total of 2,172 wetland cells in the model.

Compared to Alternative A.02, the estuary low flow parameter (Parameter 1) is unchanged and the peak flow parameters (Parameter 2 and 3) are increased slightly (**Table 25**). This finding is what we would expect since backpumping only occurs when flow is greater than 2,800 cfs. Therefore in this alternative with no backpumping, the high flows (a portion of which is captured by backpumping in Alternative A.02) shows up at the estuary.

**Table 25.** Estuary Discharge Parameters (Alternative A.03).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 32% | 8% | 3% | 59,232 |

a. Average annual discharge based on analysis of data from 1988-1995.

A summary of the simulated irrigation demands and corresponding sources is presented in **Table 26**. The results are essentially identical to A.02. Unmet irrigation demand is unchanged. While limited backpumping to Lake Okeechobee is simulated in Alternative A.02, there is no change in available irrigation supply since inflow from Lake Okeechobee, a boundary condition to the model, is assumed to remain the same in both Alternatives.

**Table 26.** Mean Annual Irrigation Demands and Source (Alternative A.03).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 431 | 295 | 50 | 71 |

As was the case in Alternative A.02, the releases from the regional (Berry Groves) reservoir to maintain the estuary flows during the dry periods appear adequate to prevent low water level upstream of S-79.

The removal of backpumping had some effect on the high flow performance measure. There was little or no effect to all other performance measures. The results from this alternative show that additional storage within the basin is required to capture more of the high flows to meet the simulated unmet demand within the basin.

## Alternative A.04: Regional and Distributed Small-Scale Reservoirs

Alternative A.04 simulates a storage system comprising of the regional reservoir, which captures regional runoff from the Caloosahatchee Basin and a distributed reservoirs system that captures and stores subbasin runoff.

### Model Implementation

Alternative A.04, as did Alternatives A.01 to A.03, utilizes projected 2020 agricultural land use to determine agricultural demands. Alternative A.04 consists of regional and distributed reservoirs only. No backpumping or ASR facilities were simulated as part of this alternative. In this simulation, the regional reservoir is operated primarily to meet estuary flow requirements while the distributed reservoirs are used to store runoff primarily for local irrigation.

The locations of the distributed reservoirs were selected based on several considerations. Land use maps and irrigation demand maps generated from results of the Base Case (A.01) simulations were used to determine areas that had unmet demands and therefore would benefit from nearby local storage. Factors such as elevation (due to pumping needs), and proximity to intake canals with sufficient flows were also taken into consideration. Based on these considerations, seven additional reservoirs were incorporated into the Caloosahatchee ISGM in terms of enlarged channel cross-sections, and introduction of weirs, and pumps for filling and emptying the reservoirs. The surface water component of the ISGM was modified to represent the desired storage volume and reservoir operation for a distributed reservoir system. Approximate locations of the distributed reservoirs are shown in **Figure 13**.

Deliveries of water from Lake Okeechobee were held at levels prescribed by the SFWMM simulation of '2020 with Restudy Components" consistent with the other alternatives simulated. The regional reservoir simulated in Alternatives A.02 and A.03 was retained and operated in a similar fashion to Alternatives A.02 and A.03. Surface water for irrigation was taken directly from the distributed reservoirs where possible. Additionally, releases from the distributed reservoirs into adjacent canals were utilized for irrigation supply downstream of the release points and to meet estuary flows.

### Results

In designated wetland areas, the frequency and duration of drawdowns in excess of one foot is seen in **Table 27**. The distributed reservoirs raise water levels in the SAS in their vicinity when water levels in the reservoirs are high, and lower water level in the adjacent area when water levels in the reservoirs are low. The model simulations with no agriculture or PWS demands have extended periods of high water levels in the reservoirs. The simulations that incorporate demands have lower water levels in the reservoirs during periods when the stored volumes are used to meet irrigation needs. The difference in ground water elevation close to the reservoirs shows up as drawdown due to demands and is included in wetland criteria thus increasing the cell count for this alternative.

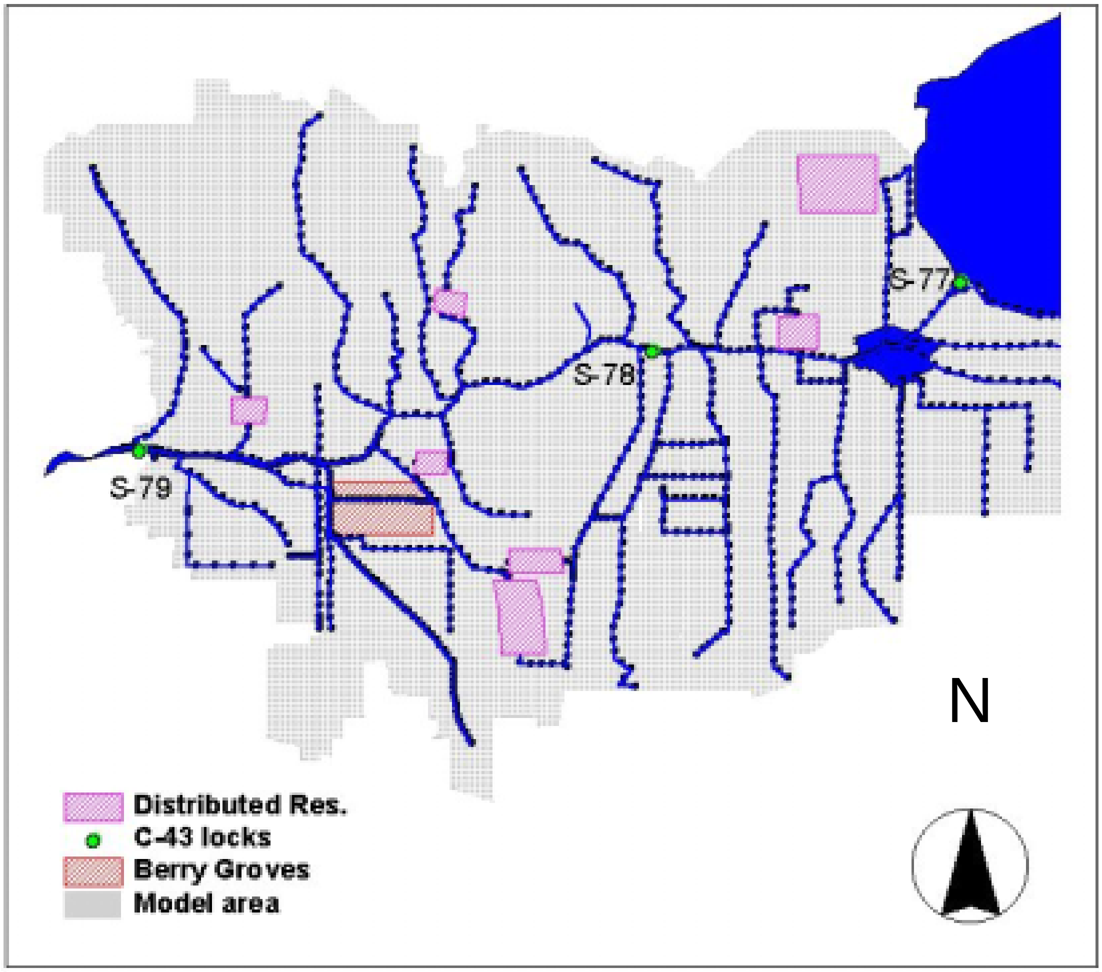


**Figure 13.** Location of Distributed Reservoirs (Alternative A.04).

**Table 27.** Number of Cells with Drawdowns Greater Than One Foot in Wetlands (Alternative A.04).

| Alternative | Total[a] |
|---|---|
| A.04 | 608 |

a. Total of 2,172 wetland cells in the model.

This alternative is successful in meeting the target flows to the estuary with the exception of the low flows, which exceed the target 16 percent of the time **Table 28**. Improvement of discharge to the estuary during low flow periods will be achieved by coupling ASR facilities with the regional reservoir (or distributed reservoirs) in this alternative. The coupling of facilities was investigated as part of the Alternative A.09 evaluation. A preliminary assessment obtained by running the model set up for Alternative A.04 with the inclusion of an ASR facility shows slight improvement. The low flow parameter was reduced from 21 percent to 18 percent with a corresponding reduction from 6 percent to 5 percent in the high flow parameter. Additional fine-tuning and "optimization" may result in successful attainment of all estuary performance measures with this combination of storage components.

**Table 28.** Estuary Discharge Parameters (Alternative A.04).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 21% | 6% | 2% | 55,021 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 29** sums up the simulated irrigation demands and corresponding source. The results show that the irrigation deficit has been reduced by 80 percent to 21,000 acre-feet per year in Alternative A.04.

**Table 29.** Mean Annual Irrigation Demands and Allocation (Alternative A.04).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 406 | 326 | 49 | 16 |

The releases from the reservoirs included in this alternative adds to the dry period flows at S-79. These releases are sufficient to maintain water levels to facilitate the PWS intake. The water levels are approximately 3 feet for a significant portion of the simulation period. However, water levels drop below 3 feet for some portions of the simulation period. Subsequent alternatives will attempt to minimize these occurrences.

### Alternative A.05: Regional Reservoirs Only

Alternative A.05 represents a storage system made up of two regional reservoirs without backpumping or ASR facilities. This alternative evaluates the feasibility of a second larger reservoir to make-up the storage provided by the ASR facility.

## Model Implementation

The storage components that comprise this alternative are a reservoir located at the Berry Grove site and a second reservoir at a proximal location adjacent to Dog Canal. The representation of the reservoirs within the model is consistent with the implementation in Alternative A.02. The regional reservoirs in this alternative are operated to meet flow requirement at the estuary as well as demands within the basin.

## Results

The number of cells within designated wetland areas that show drawdown of greater than one foot for more than one month is shown in **Table 30**. The number of cells impacted is less than in Alternative A.04 since the distributed reservoir system is not included. Redistribution of ground water withdrawals was made to meet demands in areas where it would not be practical to serve them by surface water sources. This results in an increase in cells impacted for the wetland performance measure.

**Table 30.** Number of Cells with Drawdowns Greater Than One Foot in Wetlands (Alternative A.05).

| Alternative | Total[a] |
|---|---|
| A.05 | 584 |

a. Total of 2,172 wetland cells in the model.

Compared to the Base Case (A.01) the estuary low flow parameter (Parameter 1) is improved and the peak flow parameters (Parameter 2 and 3) are shown to be close to the specified targets. The low flow measure represents an improvement over Alternative A.02 (Restudy component) but is poorer than was simulated for Alternative A.04 (with the distributed reservoir system). The combined operation of the reservoirs results in a reduction of occurrences in low flows to the estuary (**Table 31**).

**Table 31.** Estuary Discharge Parameters (Alternative A.05).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 26% | 8% | 3% | 64,449 |

a. Average annual discharge based on analysis of data from 1988-1995.

A summary of the simulated irrigation demand by source is presented in **Table 32**. The results show that the regional reservoir did not meet the agricultural demand in this simulation. The performance of Alternative A.02 and Alternative A.05 for this measure are approximately the same, 68,000 versus 71,000 acre-feet per year of unmet irrigation needs.

**Table 32.** Mean Annual Irrigation Demands and Source (Alternative A.05).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 440 | 307 | 51 | 68 |

The releases from the reservoirs included in this alternative, increase the dry period flow at S-79. These releases are sufficient to maintain adequate water levels to facilitate the PWS intake. The water levels are approximately 3 feet for a significant portion of the simulation period. However, water levels drop below 3 feet for some portions of the simulation period. Subsequent alternatives will attempt to minimize these occurrences.

## Alternative A.06: Water Harvesting

Alternative A.06 represents the water harvesting and water table management scenario. This alternative examines the effect of passive management strategies on flows to the estuary and improvements in storage for future demands. As described in Chapters 4 and 5, this alternative attempts to simulate the effect of drainage ditch removal from areas located to the north of the C-43 Canal. There are no reservoirs, ASR or backpumping associated with Alternative A.06. While it is suspected that this alternative by itself would not meet future demand within the Caloosahatchee Basin, it is desirable to evaluate its performance to determine if it should be considered as a low cost component of an overall regional strategy.

### Model Implementation

To implement this alternative an area of predominantly improved pasture north of the river was selected. In the selected area model features to simulate the removal of ditches was added and a number of weirs were added to streams providing some in-channel and ground water storage. The combination simulates the storage volume that could be gained by returning the area to predevelopment (undrained) conditions.

### Results

Number of cells with drawdowns in excess of one foot is presented in **Table 33**. This table shows an increase in cell count for the wetland performance measure in Alternative A.06. The introduction of weirs and modifications to the drainage within the area north of C-43 results in changes in the SAS with effects similar to the distributed reservoir described in Alternative A.04.

**Table 33.** Number of Cells with Drawdowns Greater Than Foot in Wetlands (Alternative A.06).

| Alternative | Total[a] |
|---|---|
| A.06 | 688 |

a. Total of 2,172 wetland cells in the model.

As is anticipated, this alternative has little impact on low flows to the estuary (**Table 34**). The Water Harvesting Alternative does not result in any long-term storage and appears only to hold water for a short period following rain events. This short holding period is evident in the flattening of peak discharges at S-79 observed in this simulation when compared to the Do Nothing Alternative (A.01) and a slight reduction in high flow and very high flow performance measures. By itself, Alternative A.06 does not significantly improve flow to the estuary. It does result in changes to the distribution of peak discharges, which might be desirable when combined with storage components that pump out of the C-43 during high flows.

**Table 34.** Estuary Discharge Parameters (Alternative A.06).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 39% | 18% | 6% | 92,141 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 35** shows a summary of the simulated irrigation demands and corresponding sources for Alternative A.06. This alternative does not improve the irrigation deficit situation. The results show that at best short-term storage is achieved, which is not available during the dry periods when irrigation is required.

**Table 35.** Mean Annual Irrigation Demands and Source (Alternative A.06).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 444 | 278 | 50 | 102 |

The results for Alternative A.06 suggest possible difficulty in meeting PWS needs during some portions of the simulated period. In the dry periods, as was the case with Alternative A.01, the water level drops significantly in the Caloosahatchee River. At the water supply intake point water levels drop to levels that might indicate potential problems from saltwater intrusion.

### Alternative A.07: Regional and Distributed Small-Scale Reservoirs and New Structure (S-78.5)

Alternative A.07 is the Regional and Distributed Small-Scale Reservoirs and New Structure (S-78.5) alternative. This alternative is identical to Alternative A.04 with the addition of a structure west of S-78 and east of LaBelle, and an increase in water level behind the S-78 Structure.

#### Model Implementation

The following storage components were included in this alternative: 1) regional surface reservoir, 2) distributed surface reservoirs, 3) water control structure in C-43 Canal at S-78.5, and 4) modification to S-78 to raise the water level behind the structure from approximately 11 to approximately 15 feet. This alternative was implemented to assess the effectiveness of raising the water levels in the river and the regional ground water table in the vicinity of the Ortona Lock. In this alternative the elevation of the Ortona Lock was raised from 11 to 15 feet and an additional water control structure similar to Ortona Lock was simulated east of LaBelle. The elevation of this additional structure (S-78.5) was simulated at 8 feet NGVD. In Alternative A.07, the structures were operated in tandem with the regional and distributed reservoirs. The representation and operation of the reservoirs is the same as in Alternative A.04.

#### Results

The number of wetland cells with drawdowns in excess of one foot is seen in **Table 36**. The performance of this alternative as in Alternative A.04 shows an increase in the wetland count. The addition of the structure results in an increase in the cell count for the wetland performance measure for this alternative. Raising the S-78 Structure results in elevated water levels behind the Ortona Lock including Lake Hicpochee and proximal wetlands. In computing drawdown these newly inundated areas show up as having more than one foot of drawdown.

**Table 36.** Number of Cells with Drawdowns Greater Than One Foot in Wetlands (Alternative A.07).

| Alternative | Total[a] |
|---|---|
| A.07 | 626 |

a. Total of 2,172 wetland cells in the model.

Alternative A.07 performs similarly to Alternative A.04. There is no marked improvement in the flow to the estuary resulting from the inclusion of a structure in the C-43 Canal (**Table 37**).

**Table 37.** Estuary Discharge Parameters (Alternative A.07).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 21% | 6% | 2% | 53,986 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 38** sums up the simulated irrigation demands and corresponding allocation. The performance of this alternative is similar to Alternative A.04 with a slightly reduced overall demand and a slight increase in surface water use.

**Table 38.** Mean Annual Irrigation Demands and Source (Alternative A.07).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 406 | 321 | 48 | 22 |

The releases from the reservoirs included in this alternative increase the dry period flow at S-79. These releases are sufficient to maintain adequate water levels to facilitate the PWS intake. The water levels are approximately 3 feet for a significant portion of the simulation period.

### Alternative A.08: Regional Reservoir and New Structure (S-78.5)

Alternative A.08 is the Regional Reservoir as described in Alternative A.05 and the structure as described in Alternative A.07 Structure (S-78.5).

#### Model Implementation

The storage components that comprise this alternative are 1) regional surface reservoir, 2) water control structure in C-43 Canal at S-78.5, and 3) modification to S-78 to raise the water level behind the structure from approximately 11 feet to approximately 15 feet. This alternative was implemented to assess the effectiveness of raising the water levels in the river and the regional ground water table in the vicinity of the Ortona Lock.

In this alternative the elevation of the Ortona Lock was raised from 11 to 15 feet and an additional water control structure similar to Ortona Lock was simulated east of LaBelle. The elevation of this additional structure (S-78.5) was simulated at 8 feet NGVD.

### Results

In designated wetland areas the frequency and duration of drawdowns in excess of one foot is seen in **Table 39**. The addition of the structure results in an increase in the cell count for the wetland performance measure for this alternative. Raising the S-78 Structure results in elevated water levels behind the Ortona Lock including Lake Hicpochee and proximal wetlands. In computing drawdown these newly inundated areas show up as having more than one foot of drawdown.

**Table 39.** Number of Cells with Drawdown Greater Than One Foot in Wetlands (Alternative A.08).

| Alternative | Total[a] |
|---|---|
| A.08 | 647 |

a. Total of 2,172 wetland cells in the model.

Alternative A.08 performs similarly to Alternative A.05. There is a slight decrease in the flow to the estuary resulting from the inclusion of a structure in the C-43 Canal and raising the S-78 Structure which results in elevated water levels behind the Ortona Lock (**Table 40**). The elevated structure prevents some flows from reaching the estuary during dry periods.

**Table 40.** Estuary Discharge Parameters (Alternative A.08).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 30% | 8% | 2% | 62,586 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 41** sums up the simulated irrigation demands and corresponding allocation. The performance of this alternative is similar to Alternative A.05 with a reduced overall demand and an increase in surface water use.

The releases from the reservoirs included in this alternative increase the dry period flow at S-79. These releases are sufficient to maintain adequate water levels to facilitate the PWS intake. The water levels are approximately 3 feet for a significant portion of the simulation period.

**Table 41.** Mean Annual Irrigation Demands and Source (Alternative A.08).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 436 | 314 | 51 | 56 |

## Alternative A.09: Do Everything

Alternative A.09 is Do Everything.

### Model Implementation

This alternative was the combination of components from Alternatives A.02-A.08. Based on analysis of the results from previous model runs, an attempt was made to optimize the operation of water storage components in this alternative. The modifications to the operation of the regional and distributed reservoir system, ASR facilities and structure were made to better meet the estuary flows, irrigation, and PWS demands within the basin.

### Results

In designated wetland areas the frequency and duration of drawdowns in excess of one foot are seen in **Table 42**. The wetland cell count is slightly higher than in Alternative A.04. This can be attributed to the addition of reservoirs, redistribution of ground water withdrawals, and inclusions of water harvesting as a storage component. The distributed reservoirs raise water levels in the SAS in their vicinity when water levels in the reservoirs are high and lower water levels in the adjacent area when water levels in the reservoirs are low. The model simulation with no demand has extended periods of high water levels in the reservoirs. The simulation that incorporates demands has lower water levels in the reservoirs during periods when the stored volumes are used to meet irrigation demands. The difference in ground water elevation close to the reservoirs shows up as drawdown due to demands and is used in computing the wetland cell count. A similar effect occurs with the water harvesting and water table management component.

**Table 42.** Number of Cells with Drawdown Greater Than One Foot in Wetlands (Alternative A.09).

| Alternative | Total[a] |
|---|---|
| A.09 | 623 |

a. Total of 2,172 wetland cells in the model.

The estuary low flow parameter (Parameter 1) approximates the performance target with a value of 16.66 percent and the peak flow parameter (Parameter 2) surpasses the performance measure, the very high flow parameter meets the specified target (**Table 43**). Additional optimization of the operation rules for the storage components would result in a better fit in the balance of the distribution of the flow.

**Table 43.** Estuary Discharge Parameters (Alternative A.09).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 17% | 2% | 2% | 23,615 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 44** sums up the simulated irrigation demands and corresponding allocation. The results show that the unmet irrigation needs have been reduced to 13,000 acre-feet from 101,000 acre-feet in the Do Nothing Alternative (A.01). Further optimization of the storage components could further minimize the unmet demands.

**Table 44.** Mean Annual Irrigation Demands and Source (Alternative A.09).

| Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|
| 409 | 332 | 49 | 13 |

The releases from the reservoirs included in this alternative increase the dry period flow at S-79. These releases are sufficient to maintain adequate water levels to facilitate the PWS intake. The water levels are approximately 3 feet for a significant portion of the simulation period. However, water levels drop below 3 feet for some portions of the simulation period.

**Table 45** shows the number of days per year the backpumping facility operates based on the prescribed operation. Review of the results show that the majority of the flows occur during the simulation period utilizing the 1995 rainfall distribution with many significantly high rainfall events. The model activated the backpumping option 88 days during the year utilizing the 1995 rainfall, which was an unusually wet year, and only 1 to 10 days per year for the rest of the simulation period. Additionally, the high volumes at S-79 coincide with periods during the simulation when the basin was wet, leaving little available storage volume in the basin.

**Table 45.** Number of Days Backpumping Occurs (Alternative A.09).

| Year | Number of Days of Backpumping |
|---|---|
| 1988 | 8 |
| 1989 | 6 |
| 1990 | 2 |
| 1991 | 10 |
| 1992 | 9 |
| 1993 | 1 |
| 1994 | 9 |
| 1995 | 88 |

## Alternative A.10: Base Case 1995

While it is not an alternative to evaluate water management strategies for meeting future demands, Alternative A.10 simulates 1995 land use with similar assumptions and model construct as Alternatives A.01-A.09. In this modeling scenario, 1995 land use and irrigation is applied with no changes in existing infrastructure or management practices within the basin. Deliveries of water from Lake Okeechobee within this simulation were specified based on measured flows for the simulated period. This alternative therefore represents the 1995 Base Case scenario.

### Model Implementation

The GIS coverage of the 1995 land use was used to identify irrigated areas. The 1995 irrigation set-up used in the alternative was developed using the identified irrigation areas and permit information as described previously in the model documentation.

### Results

A summary of the performance of this alternative with regards to the wetland parameters is presented in **Table 46**. The result indicates that more than one foot of drawdown was observed at model cells for one or more months during the 1990 model year simulation.

**Table 46.** Number of Cells with Drawdown Greater Than One Foot in Wetlands (Alternative A.10)[a].

| Alternative | Total |
|---|---|
| A.10 | 612 |

a. Total of 2,172 wetland cells in the model.

The estuary discharge parameters are summarized in **Table 47** and show higher than the desired frequency of both low and high flows. Also included in **Table 47** is the volumetric representation of flow to the estuary in excess of demands. This value represents accumulation of discharge in excess of 4,500 cfs. The results indicate that the 1995 Base Case simulation did not meet the estuarine performance measures.

**Table 47.** Estuary Discharge Parameters (Alternative A.10).[a]

| Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|
| 35% | 19% | 9% | 119,908 |

a. Average annual discharge based on analysis of data from 1988-1995.

Average annual irrigation demand and contribution from the various sources are shown in **Table 48**. Unmet demands are computed as the external demands less the demand calculated for the portion of the East Calaoosahatchee Basin that draws irrigation water directly from Lake Okeechobee (15,200 acre-feet). This area is irrigated directly from Lake Okeechobee while runoff from the basin discharges to the Caloosahatchee River. Unmet irrigation demands for 1995 are zero.

**Table 48.** Mean Annual Irrigation Demands and Source (Alternative A.10).

| Demand (1,000 acre-feet) | Surface water Allocation (1,000 acre-feet) | Ground Water Allocation (1,000 acre-feet) | Unmet Demands (1,000 acre-feet) |
|---|---|---|---|
| 321 | 230 | 76 | 0 |

The results for the 1995 Base Case suggest possible difficulty in meeting PWS needs during some portions of the simulated period. In the dry periods, as was the case with Alternative A.01, the water level drops significantly in the Caloosahatchee River. At the water supply intake point, water levels drop to levels that might indicate potential problems from saltwater intrusion

# SUMMARY OF ALTERNATIVE ANALYSIS

A summary of the estuary discharge parameter performance for all nine alternatives is presented in **Table 49**. The results show that Alternative A.09 at 16.6 (17 percent) comes closest to meeting the low flow target of 16 percent. Alternatives A.07 and A.04, which also incorporate distributed reservoirs, comes close to meeting the target. Further optimization of the component operations would improve the performance of these alternatives. Several of the alternatives, which incorporate storage in reservoirs and ASR are successful in meeting the high performance targets.

**Table 49.** Estuary Discharge Parameters (percent of time exceeding specified criteria).[a]

| Alternative | Low Flow (Parameter 1) | High Flow (Parameter 2) | Very High Flow (Parameter 3) | Discharge to Estuary in Excess of Demand (acre-feet) |
|---|---|---|---|---|
| Target | 16% | 6% | 1.6% | None Specified |
| A.01 | 38% | 20% | 7% | 115,840 |
| A.02 | 32% | 5% | 2% | 35,306 |
| A.03 | 32% | 8% | 3% | 59,232 |
| A.04 | 21% | 6% | 2% | 55,021 |
| A.05 | 26% | 8% | 3% | 64,449 |
| A.06 | 39% | 18% | 6% | 92,141 |
| A.07 | 21% | 6% | 2% | 53,986 |
| A.08 | 30% | 8% | 2% | 62,586 |
| A.09 | 17% | 2% | 2% | 23,615 |

a. Average annual discharge based on analysis of data from 1988-1995.

**Table 50** shows the number of wetland cells with greater than one-foot drawdown for all nine alternatives. The results indicate that several of the improvements to the system would have some impact on this parameter. Alternative A.09, which best meets the performance measures for the other parameters, shows an increase in the wetland drawdown parameter. This increase can be attributed to the addition of reservoirs and redistribution of ground water withdrawals. The distributed reservoirs raise water levels in the SAS in their vicinity when water levels in the reservoirs are high and lower water level in the adjacent area when water levels in the reservoirs are low. The model simulations with no demand have extended periods of high water levels in the reservoirs. The simulations that incorporate demands have lower water levels in the reservoirs during periods when the stored volumes are used to meet irrigation demands. The difference in ground water elevation close to the reservoirs shows up as drawdown due to demands and is used in computing the wetland criteria. If Alternative A.09 water levels were compared to the 2020 Base Case (A.01) with no demands the wetland parameter would be 471 instead of 623. The methodology for computing drawdown therefore affects this parameter. A performance measure incorporating information from the Isolated Wetland Study which would facilitate comparison among alternatives, should be developed for use in the SWFS.

The water harvesting option raises water levels in tributaries north of the river. The model simulations with no simulated demands have extended periods of high water

**Table 50.** Total Number of Exceedances of One Foot Wetland Drawdown Parameter.[a]

| Alternative | Total | Percent of Wetland Cells |
|---|---|---|
| A.01 | 566 | 26 |
| A.02 | 496 | 23 |
| A.03 | 491 | 23 |
| A.04 | 608 | 28 |
| A.05 | 584 | 27 |
| A.06 | 688 | 32 |
| A.07 | 627 | 29 |
| A.08 | 647 | 30 |
| A.09 | 623 | 29 |

a. Total of 2,172 wetland cells in the model.

levels in these tributaries. The simulations that incorporate demands have lower water levels in the tributaries. The difference shows up as drawdown due to demands and is included in the wetland criteria thus increasing the number of cells that appear to be impacted.

**Table 51** shows a summary of irrigation demands by source for each of the nine alternatives. Unmet demand is reduced to 13,000 acre-feet in Alternative A.09 incorporating all of the storage components. The other alternatives had unmet demands ranging from 22,000 acre-feet to 102,000 acre-feet. The alternatives that incorporate distributed reservoirs best meet irrigation demands. Inclusion of ASR and other components in Alternative A.09 results in a reduction in unmet demands of 44 percent from Alternative A.04, which incorporates regional and distributed reservoirs alone. Performance improvement can be achieved with further optimization of alternatives implementing distributed reservoirs in combination with ASR.

Water level close to the PWS intake point was used as an indicator of potential difficulty to meet PWS needs. Of the nine alternatives evaluated each alternative that incorporated active release strategy to meet estuary low flow requirements also improved PWS by maintaining adequate water levels on the upstream side of S-79.

## Discussion and Conclusion

The performance of the individual storage components is dependent on specified pump capacity. The pump capacity determines the ability to fill or empty the reservoirs and ASR facilities to meet demands. During periods of high flow in the C-43, the reservoirs, backpumping, and ASR facilities cannot capture the total volume of discharge from the basin. Bigger pumps would result in better capture during these high flow periods, but would be oversized for the majority of the time. Economic considerations associated with a larger pump would also need to be considered.

**Table 51.** Irrigation Demands and Source.

| Alternative | Demand (1,000 acre-feet) | Irrigation from Surface Water Sources (1,000 acre-feet) | Irrigation from Ground Water Sources (1,000 acre-feet) | Unmet Irrigation Demands (1,000 acre-feet) |
|---|---|---|---|---|
| A.01 | 448 | 282 | 50 | 101 |
| A.02 | 430 | 295 | 50 | 71 |
| A.03 | 431 | 295 | 50 | 71 |
| A.04 | 415 | 327 | 50 | 23 |
| A.05 | 441 | 307 | 51 | 68 |
| A.06 | 444 | 278 | 50 | 102 |
| A.07 | 414 | 328 | 49 | 23 |
| A.08 | 436 | 314 | 51 | 56 |
| A.09 | 409 | 332 | 49 | 13 |

Alternatives incorporating distributed reservoirs performed best and are most likely to meet irrigation and estuarine needs based on the assumptions of the CWMP. A regional reservoir with ASR is best suited to meet low flow requirements of the estuary, but cannot be effectively used to meet irrigation demands without significant infrastructure development to move the water from the regional reservoir to the demand areas in the eastern Caloosahatchee Basin.

High volumes of flow in the Caloosahatchee, in excess of 2,800 cfs, suggest volumes of water would be available for backpumping. These high flow situations occur between 10 and 15 times a year for most years and up to 94 times in a wet year (simulated using 1995 weather in Alternative A.02). These numbers drop to 1 to 10 for most years and 88 for the wet year in Alternative A.09 due to local storage of runoff in distributed reservoirs. Further evaluation of the data shows that the high flows occur during wet periods, during the year when there is little available storage volume in the basin based on assumptions in the model. For example most of the backpumping days in 1995, which was an unusually wet year, were centered around a period when releases from Lake Okeechobee were sustained at more than 6,000 cfs for 20 days (or more) stretches twice within an 80-day period and runoff was high due to high rainfall in the basin.

Based on the current evaluation using the regional model, water harvesting does not provide significant benefit in meeting estuarine flows and basin demands. A small scale, finer resolution model that represents farm ditches and operations would better evaluate the water harvesting option and may result in modification of this conclusion. The structure at S-78.5 provided small benefit in meeting agricultural demands. Economic considerations associated with the construction of the structure have to be balanced against the potential benefits.

An evaluation of the nine alternatives based on the specified performance measures shows that some of the proposed water management components are more efficient in meeting the projected estuarine, irrigation, and PWS demands. Analysis of the results from Alternative A.09 indicate that it is possible to meet the projected estuarine, irrigation, and PWS demands with a combination of regional and distributed reservoirs, ASR, and Structure S-78.5. Water table harvesting and the additional structure also offer value in attenuating flows and may warrant further investigation. Based on the assumptions within the model backpumping does not appear to be a cost-effective method for meeting basin demands.

# ENVIRONMENTAL IMPACTS

The environmental impact of the alternatives will be assessed in the SWFS by applying a methodology that will assign a numerical ranking of ecological value to each parcel of land involved in the implementation of the specific alternative. This rating index establishes a numerical ranking for individual ecological and anthropogenic variables. The numerical output for the variables will be used to make a preliminary evaluation of environmental impacts associated with the alternatives proposed in the CWMP.

Methodology for this assessment, as described below, is a series of analyses, one for each assessment variable using Department of Transportation, SFWMD, Florida Fish and Wildlife Conservation Commission, and University of Florida Geoplan GIS data. Following each variable description is a rating index containing descriptions and corresponding score points. A score of 3 is considered best and the most ecological valuable and a score of 0 is for a system that is severely impacted or developed.

## Wildlife Utilization

The Wildlife Utilization Variable is a measure of the number of "Focal Species" that occur in the area using the Florida Game and Freshwater Fish Commission's Biodiversity Hotspots GIS data. Focal Species is a term used to describe a group of 44 vertebrate taxa chosen by the Florida Game and Freshwater Fish Commission for analysis. Their decision was based on the following criteria: 1) whether habitat requirements for the species could be described using the land-cover map and other geographic data sets; 2) whether a species exhibited large home-range requirements and might be susceptible to increasing fragmentation of contiguous forest tracts; 3) whether a species was closely tied to a specific rare plant community; and whether the species is listed as endangered or threatened (Cox et al., 1994).

**Wildlife Utilization (Biodiversity hotspots)**

**0** 0-2 focal species present

**1** 3-4 focal species present

**2** 5-6 focal species present

**3** 7+ focal species present

## Listed Species

The Listed Species Variable is a measure of the presence or absence of endangered and threatened species in the area of concern. Information for this variable will be obtained using the Florida Game and Freshwater Fish Commission Closing the Gaps in Florida's Wildlife Habitat Conservation System (GAP) analysis GIS layers for individual listed species will be reviewed.

**Listed Species**

**0** No listed species present

**1** Habitat area for listed species

**2** Species of Special Concern present

**3** Federal or State Endangered Species present

## Habitat Type

The Habitat Type Variable will be based on the 1995 Department of Transportation Land Use/Cover Level 3 categories. The GIS coverages from the Department of Transportation and the University of Florida's Geoplan will be used in this analysis.

**Habitat type**

**0** Urban

**1** Agriculture and areas with >50 percent exotics

**2** Native with some impact and <50 percent exotics

**3** Rarest habitats and non-impacted native

## Adjacent Land Use

The Adjacent Land Use Variable will be based on the 1995 Department of Transportation Land Use/Cover Level 3 categories. The GIS coverages from the Department of Transportation, SFWMD, and South Florida Regional Planning Council will be used in this analysis.

**Adjacent Land Use**

**0** Not adjacent to Public Lands or Strategic Habitat Conservation Area (SHCA)

**1** Adjacent to Public Lands with major barriers

**2** Adjacent to Public Lands with minor barriers

**3** Adjacent to Public Land or SHCA

## Size of Habitat to be Altered or Impacted

The size of habitat to be altered or impacted variable will be based on the CWMP alternatives and will take into account the potential size of the parcel which would be altered or impacted by the implementation of the alternative.

**Size of Habitat to be Altered or Impacted (alternative data)**

**0** >21,000 acres

**1** 14,000-21,000 acres

**2** 7,000-14,000 acres

**3** Less than 7,000 acres

# COST ESTIMATES

These cost estimates are presented for informational purposes only. All costs associated with the recommendations were taken from the Restudy.

## Reservoirs

This component involves the capture and storage of excess surface water during rainy periods and subsequent release during drier periods for environmental and human uses. Regionally, surface water storage could be used to attenuate freshwater flows to the Caloosahatchee Estuary and other estuarine water bodies during rainy periods and meets minimum flows during drier periods. In addition, these facilities could increase surface water availability for current and projected uses, and decrease the demand on aquifer systems.

Locally, strategically located surface water storage (primarily storage in combination with improved storm water management systems) could recharge SAS wellfields, reduce the potential for saltwater intrusion and reduce drawdowns under wetlands. On-site storage in agricultural areas may reduce the need for water from the regional canal system and withdrawals from other water source options.

Reservoirs could also be colocated with ASR facilities. The reservoir would act as a holding tank capturing excess surface water during rainy periods and would be the source for the ASR facility.

### Reservoirs Estimated Costs

Costs associated with surface water storage vary depending on site-specific conditions of each reservoir. A site located near an existing waterway will increase the flexibility of design and management and reduce costs associated with water transmission infrastructure. Another factor related to cost would be the existing elevation of the site. Lower site elevations would allow for maximum storage for the facility while reducing costs associated with water transmission and construction excavation. Depth of the reservoir will have a large impact on the costs associated with construction. Deeper reservoirs result in higher levee elevations that can significantly increase construction costs, but results in lower land costs.

Costs associated with two types of reservoirs are depicted in **Table 52**. The first is a minor facility with pumping inflow structures and levees designed to handle a maximum water depth of four feet. It also has internal levees and infrastructure to control internal flows and discharges. The second type shown below is a major facility with similar infrastructure as the minor facility. However, the water design depths for this facility range from 10 to 12 feet. Costs increase significantly for construction of higher levees but can be offset somewhat by the reduced land requirements.

**Table 52.** Reservoir Costs.[a]

| Reservoir Type | Construction Cost $/Acre | Engineering/ Design Cost $/Acre | Construction Administration. $/Acre | Land $/Acre | Operations & Maintenance $/Acre |
|---|---|---|---|---|---|
| Minor Reservoir | 2,842 | 402 | 318 | 3,000 – 6,000 | 118 |
| Major Reservoir | 7,980 | 904 | 451 | 3,000 – 6,000 | 105 |

a. Source: SFWMD

Costs for the minor reservoir are based on actual construction bid estimates received and awarded for similar projects built in the Everglades Agricultural Area (EAA). Costs of these four STAs were averaged to develop the $/Acre costs. Land costs have been changed to generally reflect land values in the Lower West Coast Planning Area. Costs for the major reservoir were developed based on the average cost estimates from the proposed Ten Mile Creek project and from the Regional Attenuation Facility Task Force Final Report, April 30, 1997 estimates for major Water Preserve Areas.

## Liner Costs

The costs to install a High-density Polyethylene (HDPE) liner vary depending on the depth of the area to be lined. For depths of 20 feet or less, the liner will cost approximately $0.20 per square foot installed, whereas it will cost about $0.50 per square foot installed for depths between 20 and 40 feet. Eighteen inches of fill cover will cost about $3.00 per cubic yard and clearing, grubbing, and leveling (does include fill) will cost approximately $1,000 per acre. These cost estimates were based on a combination of manufacturer information, consultant experience, Everglades Construction Project experience, and Means Estimating Guide.

## Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) is the underground storage of injected water into an acceptable aquifer (typically the Floridan aquifer in southwest Florida) during times when water is available, and the subsequent recovery of this water when it is needed. In other words, the aquifer acts as an underground reservoir for the injected water, reducing water loss to evaporation. Current regulations require injected water to meet drinking water standards when the receiving aquifer is classified as an Underground Source of Drinking Water (USDW) aquifer, unless an aquifer exemption is obtained. Obtaining an aquifer exemption is a rigorous process and few have been approved.

### Aquifer Storage and Recovery Estimated Costs

Estimated costs for an ASR system largely depend on whether the system requires pumping equipment. As shown in **Table 53**, one system uses pressurized water from a utility, whereas the second ASR system uses unpressurized treated water, thus requiring pumping equipment as part of the system cost. The latter system with its associated pumping costs is more indicative of an ASR system in combination with surface water storage. There may also be additional costs for screening and filtering untreated surface water to remove floating and suspended matter.

**Table 53.** Aquifer Storage and Recovery System Costs.[a]

| System | Well Drilling Cost (per well) | Equipment Cost (per well) | Engineering Cost (per well) | Operation Maintenance (per 1,000 gallons) | Energy Cost (per 1,000 gallons) |
|---|---|---|---|---|---|
| Treated Water at System Pressure | $250,000 | $40,000 | $450,000 | $.005 | $.08 |
| Treated Water Requiring Pumping | $250,000 | $125,000 | $500,000 | $.008 | $.08 |

a. Costs based on a 900-foot, 16-inch well, with two monitoring wells using treated water.
Source: PBS&J, 1991, Water Supply Cost Estimates, converted to 1999 dollars.

### Quantity of Water Potentially Available from ASR

The volume of water that could be made available through ASR wells depends upon several local factors, such as well yield, water availability, variability in water supply, and variability in demand. Without additional information, it is not possible to accurately estimate the water that could be available through ASR in the CWMP Planning Area. Typical storage volumes for individual wells range from 10 to 500 million gallons (31 to 1,535 acre-feet) (Pyne, 1995). Where appropriate, multiple ASR wells could be operated as a wellfield, with the capacity determined from the recharge and/or recovery periods. There are potentially many different applications of ASR; however, all store sufficient volumes (adequate volumes to meet the desired need) during times when water is available and recover it from the same well(s) when needed. The storage time is usually seasonal, but can also be diurnal, long-term or for emergencies. The volume of water that could be made available by any specific user must be determined through the SFWMD's consumptive use permitting program.

## Backpumping

This feature includes pump stations and a STA with a total capacity of approximately 20,000 acre-feet. The system as designed would include a pump station to move water from the western to the eastern basin. A second pump station would move the water into a STA and a third pump station would move the water from the STA into Lake Okeechobee. The estimated cost of the proposed backpumping facility is $84,000,000. Based on the assumptions in the CWMP, model results indicate that backpumping has limited utility or benefit and therefore is not practical.

### Backpumping Estimated Costs

**Table 54.** Backpumping Facility ($1,000).

| Total Cost | Pump Construction | Land Acquisition | Levee Construction | Canal Construction | O&M Cost |
|---|---|---|---|---|---|
| $84,358 | $60,000 | $13,200 | $5,000 | $4,000 | 2,158 |

## New Structure (S-78.5)

No costs were available for construction of a new structure.

## Water Harvesting

No costs were available for construction of a new structure.

# CONCLUSIONS

The CWMP identified the need for storage within the basin using a regional optimization approach with underground storage of such amount that the ASR systems will tolerate extended withdrawals of 220 MGD and 220,000 acre-feet in above ground storage (reservoirs plus other storage options). The analysis in the CWMP indicates that more detailed evaluation using more site-specific information may result in changes to the sizing and combination of this storage and recommends that the detailed evaluation be continued as part of the SWFS.

Five types of potential storage options or components were identified: reservoirs (regional and distributed), ASR, backpumping to Lake Okeechobee, in-river storage due to Structure S-78.5 and water table harvesting. The five storage components were combined into nine alternatives that were evaluated utilizing reduced flows from Lake Okeechobee as modeled in the *LEC Regional Water Supply Plan* 2020 with Restudy components. Of these components, model results indicate that backpumping has limited utility or benefit and therefore is not practical, based on the assumptions in the CWMP. Addition of a structure in the Caloosahatchee River (S-78.5) and water table management showed minimal benefit but may be considered as part of an overall storage strategy. Regional and distributed reservoirs and ASR showed the greatest potential for meeting the storage needs in the Caloosahatchee Basin and are recommended for additional investigation and pilot testing within the basin.

Detailed assessment of the potential storage components is needed to identify a preferred alternative for meeting the demands in the Caloosahatchee Basin in 2020. It is recommended that the detailed assessment be completed as a part of the implementation of the SWFS.

The modeling conducted as part of the CWMP to evaluate the performance of various storage components utilized revised Caloosahatchee Basin hydrology and demands from that used in the Restudy. This assessment showed higher demands and lower runoff from the basin, and consequently less water was available to be placed in storage. The CWMP evaluated options that focused on additional storage within the basin coupled with limited water supply deliveries (matching the results of the Restudy) from Lake Okeechobee. Under these assumptions the proposed water supply backpumping option performed poorly. It is recommended that the SWFS and the analysis by the Comprehensive Everglades Restoration Plan (CERP) RECOVER process further investigate the recommendations of the CWMP concerning in-basin storage and backpumping for storage in Lake Okeechobee (coupled with reasonable assurances of adequate deliveries from the lake to the Caloosahatchee Basin) to confirm the best combination that meets the cost-effectiveness, water supply and environmental goals recommended in the Restudy for the Caloosahatchee Basin.

# REGIONAL WATER SUPPLY PLAN IMPLEMENTATION ASSURANCES

## Background

During the next 20 years, the SFWMD, the State of Florida, and consumptive users will be partners in implementing regional water supply plans per a directive of state statute in Section 373.0361, F.S. The regional water supply plans provide a guide map for meeting consumptive user demands and natural system demands projected in 2020. There are economic, technical and political uncertainties associated with implementing water resource development projects of the complexity and scope recommended in the regional water supply plans. These uncertainties will be particularly evident during the interim period during which the various elements will be implemented and become operational. Reasonable certainty is needed for the protection of existing legal users and the water resources during the interim period.

Water resource development projects, operational changes, consumptive use permitting, and rulemaking associated with the regional water supply plans are proposed to occur in phases. The increasing demands of consumptive users and the environment must, to the extent practicable, correspond with the timing of increased water availability. Where shifts from existing sources of water are required for environmental enhancement, it is crucial that replacement sources are available when such shifts occur.

Existing Florida law provides the framework and includes several tools to protect and maintain this phased or incremental consistency between increasing supplies and demands for both consumptive users and the environment. These include water reservations, consumptive use permits, minimum flows and levels recovery strategies, and water shortage declarations. The framework for implementing these tools for resource restoration and protection from harm, significant harm and serious harm.

A composite schedule for implementation of these water resource tools in concert with water resource development projects will be proposed in the regional water supply plans. This schedule will be further refined during the five year water resource development work plan, five year water supply plan updates, annual budget reviews, periodic rule updates, and consumptive use permit renewals. Processes for contingency planning will also be developed to address uncertainties in the fulfillment of the water supply plans with the goal of complying with State requirements for the protection of existing legal users and environmental resources.

## Water User and Natural System Assurances

Regional water supply plans are developed and implemented pursuant to Chapter 373, F.S. Likewise, the level of assurances in protecting existing legal water users and the natural systems ("assurances") while implementing the regional water supply plans must be consistent with this state law.

In this implementation process, the SFWMD Governing Board will be faced with many policy decisions regarding the application and interpretation of the law. The unique legal, technical, economical and political implications of the regional water supply plans will all be considered in making these policy decisions. The District will be facing many of these issues for the first time in terms of their scale and significance.

The subject of "assurances" has been addressed in other forums, particularly in the *Central and Southern Florida Project Comprehensive Review Study* (Restudy) (April 1999), which was approved by the SFWMD Governing Board. The language regarding "assurances" as incorporated into the Restudy was originally drafted by the Governor's Commission for a Sustainable South Florida and set forth in its final *Restudy Plan Implementation Report* (1999). This language is set forth in the following section.

Although these "assurances" were developed in the context of the Restudy implementation, such assurances are applicable to implementation of regional water supply plan recommendations under State law.

**The SFWMD Governing Board directs staff to develop the implementation of the CWMP in accordance with the following "assurances":**

***C&SF Project Comprehensive Review Study, Volume 1, Section 10.2.9 (April 1999)***

***10.2.9. Assurances To Water Users***

*The concept of "assurances" is key to the successful implementation of the Comprehensive Plan. Assurances can be defined in part as protecting, during the implementation phases of the Comprehensive Plan, the current level(s) of service for water supply and flood protection that exist within the current applicable Florida permitting statutes. Assurances also involve protection of the natural system.*

*The current C&SF Project has generally provided most urban and agricultural water users with a level of water supply and flood protection adequate to satisfy their needs. Florida law requires that all reasonable beneficial water uses and natural system demands be met. However, the C&SF Project, or regional system, is just one source of water for south Florida to be used in concert with other traditional and alternative water supplies.*

*The Governor's Commission for a Sustainable South Florida developed a consensus-based set of recommendations concerning assurances to existing users, including the natural system (GCFSSF, 1999). The following text is taken from the Commission's Restudy Plan Report, which was adopted on January 20, 1999:*

*"Assurances are needed for existing legal users during the period of plan implementation. It is an important principle that has helped gain consensus for the Restudy that human users will not suffer from the environmental restoration provided by the Restudy. At the same time, assurances are needed that, once restored, South Florida's natural environment will not again be negatively impacted by water management activities. Getting 'from here to there' is a challenge. The implementation plan will be the key to assuring predictability and fairness in the process.*

*Protecting Current Levels of Service (Water Supply and Flood Protection) during the Transition from the Old to the New C&SF Project.*

*The goal of a sustainable South Florida is to have a healthy Everglades ecosystem that can coexist with a vibrant economy and quality communities. The current C&SF Project has generally provided most urban and agricultural water users with a level of water supply and flood protection adequate to satisfy their needs. In fact, if properly managed, enough water exists within the South Florida system to meet restoration and future water supply needs for the region. However, past water management activities in*

*South Florida, geared predominantly toward satisfying urban and agricultural demands, have often ignored the many needs of the natural system (GCSSF, 1995; transmittal letter to Governor Chiles, p. 2). Specifically, water managers of the C&SF Project historically discharged vast amounts of water to tide to satisfy their mandate to provide flood protection for South Florida residents, oftentimes adversely impacting the region's estuarine communities.*

*The Commission recommended that in the Restudy, the SFWMD and the Corps should ensure that the redesign of the system allows for a resilient and healthy natural system (GCSSF, 1995; p. 51) and ensure an adequate water supply and flood protection for urban, natural, and agricultural needs (GCSSF, 1996a; p.14). In response to the need to restore South Florida's ecosystem, and in light of the expected future increase of urban and agricultural water demands, the Restudy aims to capture a large percentage of water wasted to tide or lost through evapotranspiration for use by both the built and natural systems. In order to maximize water storage, the Restudy intends to use a variety of technologies located throughout the South Florida region so that no one single area bears a disproportionate share of the storage burden. This direction reinforces the Commission's recommendation that water storage must be achieved in all areas of the South Florida system using every practical option (GCSSF, 1996a; p. 25).*

*However, concerns have been expressed that a water user would be forced to rely on a new water storage technology before that technology is capable of fully providing a water supply source or that existing supplies would otherwise be transferred or limited, and that the user would thereby experience a loss of their current legal water supply level of service. Any widespread use of a new technology certainly has potential limitations; however, the Restudy should address technical uncertainties prior to project authorization and resolve them before implementation in the new C&SF Project. With the addition of increased water storage capabilities, water managers will likely shift many current water users to different water sources.*

*Additionally, stakeholders are concerned that a preservation of the current level of service for legal uses would not encompass all the urban uses, some of which are not incorporated in the term 'legal' and covered by permit. Specifically, an adequate water supply is needed to address urban environmental preservation efforts as well as water level maintenance to reduce the impact of salt water intrusion.*

*The Commission believes that in connection with the Restudy, the SFWMD should not transfer existing legal water users from their present sources of supply of water to alternative sources until the new sources can reliably supply the existing legal uses. The SFWMD should implement full use of the capabilities of the new sources, as they become available, while continuing to provide legal water users as needed from current sources. It is the Commission's intent that existing legal water users be protected from the potential loss of existing levels of service resulting from the implementation of the Restudy, to the extent permitted by law.*

*The Commission also recognizes that the SFWMD cannot transfer the Seminole Tribe of Florida from its current sources of water supply without first obtaining the Tribe's* *consent. This condition exists pursuant to the Seminole Tribe's Water Rights Compact, authorized by Federal (P.L. 100-228) and State Law (Section 285.165, F.S.).*

*However, the issues surrounding the development of specific assurances to water users are exceedingly complex and will require substantial additional effort to resolve.*

*RECOMMENDATION*

- *The SFWMD and the Corps should work with all stakeholders to develop appropriate water user assurances to be incorporated as part of the Restudy authorizations. These water user assurances should be based on the following principles:*

A. *Physical or operational modifications to the C&SF Project by the federal government or the SFWMD will not interfere with existing legal uses and will not adversely impact existing levels of service for flood management or water use, consistent with state and federal law.*

B. *Environmental and other water supply initiatives contained in the Restudy shall be implemented through appropriate State (Chapter 373 F.S.) processes.*

C. *In its role as local sponsor for the Restudy, the SFWMD will comply with its responsibilities under State water law (Chapter 373 F.S.).*

D. *Existing Chapter 373 F.S. authority for the SFWMD to manage and protect the water resources shall be preserved.*

*Water Supply for Natural Systems*

*Concerns have been raised about long-term protection of the Everglades ecosystem. According to WRDA 1996, the C&SF Project is to be rebuilt 'for the purpose of restoring, preserving, and protecting the South Florida ecosystem' and 'to provide for all the water-related needs of the region, including flood control, the enhancement of water supplies, and other objectives served by the C&SF Project.'*

*Environmental benefits achieved by the Restudy must not be lost to future water demands. When project implementation is complete, there must be ways to protect the natural environment so that the gains of the Restudy are not lost and the natural systems, on which South Florida depends, remain sustainable.*

*A proactive approach which includes early identification of future environmental water supplies and ways to protect those supplies under Chapter 373 F.S. will minimize future conflict. Reservations for protection of fish and wildlife or public health and safety can be adopted early in the process and conditioned on completion and testing of components to assure that replacement sources for existing users are on line and dependable. The SFWMD should use all available tools, consistent with Florida Statutes,* *to plan for a fair and predictable transition and long-term protection of water resources for the natural and human systems.*

*Apart from the more general goals of the Restudy, there are specific expectations on the part of the joint sponsors - the State and the federal government. The more discussion that goes into an early agreement on expected outcomes, the less conflict there will be throughout the project construction and operation.*

*RECOMMENDATIONS*

- *The SFWMD should use the tools in Chapter 373 F.S. to protect water supplies necessary for a sustainable Everglades ecosystem. This should include early planning and adoption of reservations. These reservations for the natural system should be conditioned on providing a replacement water source for existing legal users which are consistent with the public interest. Such replacement sources should be determined to be on line and dependable before users are required to transfer.*
- *The SFWMD should expeditiously develop a 'recovery plan' that identifies timely alternative water supply sources for existing legal water users. The recovery plan should consist of water supply sources that can reliably supply existing uses and whose development will not result in a loss of current levels of service, to the extent permitted by law. To assure that long-term goals are met, the State and federal governments should agree on specific benefits to water users, including the natural system, that will be maintained during the recovery.*
- *In the short-term, the Restudy should minimize adverse effects of implementation on critical and/or imperiled habitats and populations of State and federally listed threatened and/or endangered species. In the long-term, the Restudy should contribute to the recovery of threatened species and their habitats.*

*Protecting Urban Natural Systems and Water Levels*

*Water supply for the urban environment is connected to water supply for the Everglades and other natural areas targeted for restoration and preservation under the Restudy.*

*It is essential that the Restudy projects proposed to restore and preserve the environment of the Everglades do not reduce the availability of water to such an extent in urban areas that the maintenance of water levels and the preservation of natural areas becomes physically or economically infeasible.*

*The successful restoration of Everglades functions is dependent not only upon the establishment of correct hydropatterns within the remaining Everglades, but also upon the preservation and expansion of wetlands, including those within urban natural areas that once formed the eastern Everglades. Some of the westernmost of these areas have been incorporated in the Restudy as components of the WPAs. However, the on-going preservation efforts of local governments have acquired hundreds of millions of dollars worth of additional natural areas for protection both inside and outside of the WPA footprint.*

*Water supplies for these urban wetlands are not covered by existing permits or reservations and are therefore, not adequately protected. Efforts are underway at both the SFWMD and the local level to preserve these vital areas and assure their continuing function as natural areas and in ecosystem restoration.*

*Detailed design for the Restudy, in particular the detailed modeling associated with the WPA Feasibility Study, will make possible plans to protect these urban wetlands from damage and to assure maximum integration with Restudy components.*

*RECOMMENDATIONS*

- *The SFWMD and the Corps should acknowledge the important role of urban natural areas as an integral part in the restoration of a functional Everglades system. As a part of the implementation plan, the SFWMD and the Corps should develop an assurance methodology in conjunction with the detailed design and modeling processes, such as the WPA Feasibility Study, to provide the availability of a water supply adequate for urban natural systems and water level maintenance during both implementation and long-term operations.*
- *Expand and accelerate implementation of the WPAs. Accelerate the acquisition of all lands within the WPA footprint to restore hydrologic functions in the Everglades ecosystem, and ensure hydrologic connectivity within the WPA footprint. The WPA Feasibility Study process should be given a high priority. The WPA concept should be expanded into other SFWMD planning areas such as the Upper East Coast.*
- *The Restudy should assure that the ecological functions of the Pennsuco wetlands are preserved and enhanced."*
- *There is a substantial body of law that relates to the operation of Federal flood control projects, both at the state and Federal level. Much of the Governor's Commission language is directed to the South Florida Water Management District and matters of state law. To the extent that the Governor's Commission's guidance applies to the Corps' actions, the Corps will give it the highest consideration as Restudy planning proceeds and as plan components are constructed and brought on-line consistent with*

*state and Federal law. The recommended Comprehensive Plan does not address or recommend the creation or restriction of new legal entitlements to water supplies or flood control benefits.*

- *The SWFS needs to be completed and implemented to address freshwater discharges to the Caloosahatchee Estuary and increase surface water availability for water use. The recommendations of the CWMP and Restudy and associated funding should be pursued after detailed modeling is performed.*
- *An evaluation of projected flows to the Caloosahatchee River was conducted via the LEC Regional Water Supply Plan and the CWMP for 1990 base and 2020 Base Case conditions. The results of these evaluations indicate that the proposed MFL criteria and the restoration baseflow needs of the Caloosahatchee Estuary are not being met. Pursuant to the direction provided in Chapter 373.042 F.S., a recovery plan is provided in the LEC Regional Water Supply Plan. The recovery plan consists of design and construction of enhanced basin storage capacity using surface water, ASR, and reservoirs as described in the Restudy and refined through the CERP and SWFS.*
- *Based on the recommended development of water management and storage infrastructure to effectively capture and store the surface water flows in the Caloosahatchee Basin, the projected surface water needs of the basin and the estuary can be met. Agricultural demands from surface water sources within the basin are estimated to increase from 230,000 acre-feet per year (200 MGD) based on 1995 land use, to approximately 320,000 acre-feet per year (285 MGD) on average based on projected 2020 land use. PWS needs from the Caloosahatchee River are projected to increase from 13,000 (12 MGD) in 1995 to 18,000 acre-feet per year (16 MGD) on average by 2020. The environmental needs of the Caloosahatchee Estuary have been estimated at 450,000 acre-feet (400 MGD) while average flows to the estuary are estimated to be approximately 650,000 acre-feet per year (580 MGD) on average. Flow to the estuary in excess of the needs can, therefore, be as high as 200,000 acre-feet per year (180 MGD) on average, which is adequate to meet the increased demand through year 2020. It was also concluded that the evaluated components, once constructed, would be adequate to meet the demands in the basin during a 1-in-10 drought event.*
- *The CWMP has identified that the future environmental, agricultural, and PWS needs of the Caloosahatchee Basin and estuary can be met from a combination of basin storage options with deliveries of water from Lake Okeechobee as identified in the South Florida Water Management Model (SFWMM) based on*

*the '2020 with restudy components'. The evaluation of storage components conducted as part of the study show that components capable of providing short-term and long-term storage are required. The finding suggests that regional and distributed reservoirs, as well as ASR systems, would form an integral part of any successful storage development within the basin. A pilot testing program should be developed to verify the feasibility and effectiveness of these storage methods within selected sites in the Caloosahatchee Basin through the SWFS.*

# CWMP RECOMMENDATIONS

**1.1 Comprehensive Everglades Restoration Plan:** The SFWMD should move forward with the implementation of the Caloosahatchee River ASR Pilot Project and C-43 Basin Storage Project Implementation Report (PIR) as identified in the Restudy. The PIR, acquisition, design, and plans and specifications should be completed by 2005 for inclusion in the update of the CWMP, *LWC Water Supply Plan*, and *LEC Regional Water Supply Plan*.

**1.1.1 Caloosahatchee River ASR Pilot Project.** The SFWMD should work cooperatively with the USACE to site, design, construct, and operate a pilot regional ASR project. Recovery performance and additional information obtained from the construction of and cycle testing at this facility will guide the design of the regional ASR wellfield.

Description: Construct a pilot ASR project in the Caloosahatchee Basin.

Total Cost: $2,998,000 (SFWMD portion only)

Funding Source: SFWMD and USACE

Implementing Agency: SFWMD and USACE

**Table 55.** Summary of Estimated Schedule and Costs for Recommendation 1.1.1.

| Caloosahatchee River ASR Pilot Project | | Plan Implementation Costs[a] ($1,000s) | | | | | |
|---|---|---|---|---|---|---|---|
| | | FY01 | FY02 | FY03 | FY04 | FY05 | Total |
| | | $ | $ | $ | $ | $ | $ |
| 1.1.1 | Pilot ASR project | 250 | 2,300 | 280 | 84 | 84 | 2,998 |
| | Total | 250 | 2,300 | 280 | 84 | 84 | 2,998 |

a. In-kind service includes FTEs for design and implementation of the ASR Pilot Project and will be applied against the SFWMD's portion of the 50/50 cost-share requirement.

**1.1.2 C-43 Storage Project.** The SFWMD should cooperate with the USACE in development of the Project Implementation Report (PIR), design, construction, and operation of a regional reservoir and ASR project within the Caloosahatchee Basin. A comprehensive geologic and geotechnical investigation should be completed, as a part of the PIR to provide the information needed to size and design the reservoir. Development of the PIR, land acquisition, design, and plans and specifications should be completed by 2005. Construction should be initiated in 2005.

Description: C-43 Regional Reservoir Project

Total Cost: $138,094,000 (SFWMD portion only)

Funding Source: SFWMD and USACE (50/50 cost share)

Implementing Agency: SFWMD and USACE

**Table 56.** Summary of Estimated Schedule and Costs for Recommendation 1.1.2.

| C-43 Storage Project | | Plan Implementation Costs[a] ($1,000s) | | | | | |
|---|---|---|---|---|---|---|---|
| | | FY01 | FY02 | FY03 | FY04 | FY05 | Total |
| | | $ | $ | $ | $ | $ | $ |
| 1.1.2 | C-43 Regional Reservoir Project | 2,154 | 2,163 | 23,925 | 66,386 | 43,466 | 138,094 |
| | Total | 2,154 | 2,163 | 23,925 | 66,386 | 43,466 | 138,094 |

a. In-kind service includes FTEs for design and implementation of the Project Implementation Report and will be applied against the SFWMD's portion of the 50/50 cost share requirement.

**2.1 Southwest Florida Study:** The SFWMD should work in cooperation with the USACE to initiate and complete the SWFS by the year 2005 as recommended in the CERP. The modeling work that has been completed as a part of the CWMP should be used as the basis for development of a preferred alternative to meet the demands within the Caloosahatchee Basin in 2020.

The primary purpose of the SWFS should be to provide a framework in which to address the health of aquatic ecosystems; water flows; water quality (including appropriate pollution reduction targets); water supply; flood protection; wildlife and biological diversity; and natural habitat. Evaluations involving surface water availability for water supply purposes should be based on providing a 1-in-10 level of certainty from surface water as an optimal goal.

Subtasks

2.1.1 Complete problem identification/Project Study Plan (PSP) phase by October 2000.

2.1.2 Complete development of a preferred alternative for the Caloosahatchee Basin by 2003.

2.1.2a It is recommended that the demand projections that were developed for the CWMP form the basis for evaluation of demands in the Caloosahatchee Basin in the SWFS.

2.1.2b The ISGM and other models that were developed to model the Caloosahatchee Basin should be incorporated into the SWFS and be utilized to evaluate the performance of water supply storage options, such as a distributed reservoir system. During the SWFS analysis the CWMP demands and ISGM should be refined and updated as needed for evaluation of alternatives for meeting demands in the Caloosahatchee Basin in 2020.

2.1.2c Continue development of the modeling tools that were developed for the CWMP. These tools include the ISGM (MIKE SHE), AFSIRS/WATBAL, and Optimization models that were developed for the Caloosahatchee Basin.

2.1.2d Continue the seepage study that was initiated during development of the CWMP.

2.1.2e The Plan of Study for the SWFS should include an evaluation of the feasibility of constructing a distributed reservoir system. In addition, the SFWMD should investigate the feasibility of public/private partnerships for funding and implementing a distributed reservoir system.

2.1.2f In some areas immediately adjacent to the CWMP Planning Area, distributed, small-scale reservoirs could be developed that can offer improved water resource management through increased environmental and flood protection, and increased surface water resource availability. This should be investigated in the SWFS.

Description: Complete the SWFS.

Total Cost: $6,100,000 (estimated) (SFWMD portion only)

Funding Source: SFWMD and USACE

Implementing Agency: SFWMD and USACE (50/50 Cost Share)

**Table 57.** Summary of Estimated Costs for Recommendation 2.1.

| Southwest Florida Study | | Plan Implementation Costs ($ and FTEs) | | | | | |
|---|---|---|---|---|---|---|---|
| | | FY01 | FY02 | FY03 | FY04 | FY05 | Total |
| | | $ | $ | $ | $ | $ | $ |
| 2.1 | Complete the Southwest Florida Study<br>Est. start date: 10/00<br>Est. finish date: 09/05 | 1,000 | 1,800 | 1,800 | 1,000 | 500 | 6,100 |
| | Total | 1,000 | 1,800 | 1,800 | 1,000 | 500 | 6,100 |

**3.1 Minimum Flows and Levels:** Establish MFLs for the Caloosahatchee River and Estuary by December 2000 in accordance with Section 373.042 F.S. MFLs will be incorporated into rulemaking, described in the *LWC Water Supply Plan* in Recommendation 8.1.1.

Subtotals

3.1.1 Continue with establishment process for the MFLs.

3.1.2 Incorporate proposed MFLs, and recovery strategy into the rulemaking process, Recommendation 8.1.1 in the *LWC Water Supply Plan* or other implementation process.

3.1.3 Incorporate into the 5-year update of the CWMP, *LWC Water Supply Plan*, and *LEC Regional Water Supply Plan*.

Description: Establish Minimum Flows and Levels.

Total Cost: This is an ongoing effort and will be completed within the first quarter of Fiscal Year 2001. FTE's: .3

Funding Source: SFWMD

Implementing Agency: SFWMD

**Table 58.** Summary of Estimated Schedule and Costs for Recommendation 3.1.

| Minimum Flows and Levels | | Plan Implementation Costs ($ and FTEs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FY01 | | FY02 | | FY03 | | FY04 | | FY05 | | Total | |
| | | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE |
| 3.1.1<br>3.1.2<br>3.1.3 | Completion of the District's MFL program for incorporation into rulemaking<br>Est. start date: ongoing<br>Est. finish date: 10/00 | | .3 | | | | | | | | | | .3 |
| | Total[a] | | .3 | | | | | | | | | | .3 |

a. Districtwide cost

## Related Strategies

**4.1 Well Abandonment Program:** The Well Abandonment Program that was administered by the SFWMD (ended in 1991) was a voluntary program that identified abandoned artesian wells, geophysically logged them, and plugged or rehabilitated the wells, as necessary, to prevent deterioration of the SAS through upland leakage or discharge to land surface. The program documentation indicates that there are unplugged wells remaining within the Planning Area and if plugged could contribute an estimated net flow of 50,000 acre-feet per year to the water budget of the Caloosahatchee Basin. In addition, the Florida Geological Survey, Bureau of Oil and Gas has identified oil test wells within the Planning Area that have not been adequately plugged.

Additional effort should be made to locate and properly abandon the free flowing wells in the Caloosahatchee Basin. The SFWMD should work with local and state officials to locate uncontrolled abandoned wells and identify plugging strategies and applicable funding sources for proper plugging of the wells.

Description: Coordinate with local and state agencies to identify abandoned, unplugged wells and to identify potential funding sources.

Total Cost: This involves staff support and coordination only. FTE's: .6

Funding Source: Landowners, local government, Water Resource Development Funds (potential sources).

Implementing Agency: SFWMD

**Table 59.** Summary of Estimated Schedule and Costs for Recommendation 4.1.

| Well Abandonment Program | | Plan Implementation Costs ($ and FTEs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FY01 | | FY02 | | FY03 | | FY04 | | FY05 | | Total | |
| | | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE |
| 4.1 | Coordinate identification of unplugged wells.<br>Est. start date: 10/00<br>Est. finish date: 09/05 | | .3 | | .3 | | | | | | | | .6 |
| | Total[a] | | .3 | | .3 | | | | | | | | .6 |

a. Districtwide cost

**5.1 Salt Water Influence:** Saline water (in excess of 250 milligrams per liter [mg/L]) has been a recurring problem for the potable water intakes in the Caloosahatchee River (approximately one-mile upstream of S-79). During extended periods of low-flow, the chloride content of the shallow water increases well beyond the recommended limit of 250 mg/L for drinking water. The actual number of times that releases have been made from Lake Okeechobee in response to salt water in excess of 250 mg/L is relatively few. A number of alternatives to refine these releases warrant further investigation and include moving the intake farther upstream, modifications to the structure, and improved maintenance and operation of the bubble curtain. Future freshwater releases for environmental purposes may also minimize salt water influence. Additional analysis of the saline front migration should be initiated.

Description: Coordinate additional analysis of the salt water influence problem at S-79.

Total Cost: This involves staff support and coordination only. FTE's: .3

Funding Source: USACE, local government.

Implementing Agency: SFWMD

**Table 60.** Summary of Estimated Schedule and Costs for Recommendation 5.1.

| Salt Water Influence | | Plan Implementation Costs ($ and FTEs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FY01 | | FY02 | | FY03 | | FY04 | | FY05 | | Total | |
| | | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE | $ | FTE |
| 5.1 | Coordinate identification of needed additional analysis<br>Est. start date: 10/00<br>Est. finish date: 09/01 | | .3 | | | | | | | | | | .3 |
| | Total[a] | | .3 | | | | | | | | | | .3 |

a. Districtwide cost

**6.1 Permitting Issues Associated with ASRs:** The SFWMD should continue working with other government entities, including the legislature, Congress, USEPA, and FDEP to explore rule changes to the federal and state Underground Injection Control (UIC) program to allow for (and encourage) injection of untreated or partially treated ground water or surface water with ASR. The level of treatment should be compatible with the water quality in the proposed storage zone. Funding is included in Recommendation 8.2 of the *LWC Water Supply Plan*.

# GLOSSARY

**Acre-foot** The volume would cover one acre to a depth of one foot; 43,560 cubic feet; 1,233.5 cubic meters; 325,872 gallons.

**Application Efficiency** The ratio of the volume of irrigation water available for crop use to the volume delivered from the irrigation system. This ratio is always less than 1.0 because of the losses due to evaporation, wind drift, deep percolation, lateral seepage (interflow), and runoff that may occur during irrigation.

**Aquifer** A portion of a geologic formation or formations that yield water in sufficient quantities to be a supply source.

**Aquifer Compaction** The reduction in bulk volume or thickness of a body of fine-grained sediments contained within a confined aquifer or aquifer system. The compaction of these fine-grained sediments results in subsidence, and sometimes fissuring, of the land surface.

**Aquifer Storage and Recovery (ASR)** The injection of freshwater into a confined aquifer during times when supply exceeds demand (wet season), and recovering it during times when there is a supply deficit (dry season).

**Aquifer System** A heterogeneous body of intercalated permeable and less permeable material that acts as a water-yielding hydraulic unit of regional extent.

**Artesian** When ground water is confined under pressure greater than atmospheric pressure by overlying relatively impermeable strata.

**Available Supply** The maximum amount of reliable water supply including surface water, ground water and purchases under secure contracts.

**Average-day Demand** A water system's average daily use based on total annual water production (total annual gallons or cubic feet divided by 365).

**Average Irrigation Requirement** Irrigation requirement under average rainfall as calculated by the District's modified Blaney-Criddle model.

**Backpumping** The practice of pumping water that is leaving the area back into a surface water body.

**Basin (Ground Water)** A hydrologic unit containing one large aquifer or several connecting and interconnecting aquifers.

**Basin (Surface Water)** A tract of land drained by a surface water body or its tributaries.

**BEBR** Bureau of Economic and Business Research is a division of the University of Florida, with programs in population, forecasting, policy research and survey.

**Best Management Practices (BMPs)** Agricultural management activities designed to achieve an important goal, such as reducing farm runoff, or optimizing water use.

**BOR** Basis of Review (for Water Use Applications with the South Florida Water Management District).

**Brackish** Water with a chloride level greater than 250 mg/L and less than 19,000 mg/L.

**Budget (water use)** An accounting of total water use or projected water use for a given location or activity.

**Central and Southern Florida Project Comprehensive Review Study (Restudy)** A five-year study effort that looked at modifying the current C&SF Project to restore the greater Everglades and South Florida ecosystem while providing for the other water-related needs of the region. The study concluded with the Comprehensive Plan being presented to the Congress on July 1, 1999. The recommendations made within the Restudy, that is, structural and operational modifications to the C&SF Project, are being further refined and will be implemented in the Comprehensive Everglades Restoration Plan (CERP).

**Cone of Influence** The area around a producing well which will be affected by its operation.

**Control Structures** A man-made structure designed to regulate the level and/or flow of water in a canal (e.g., weirs, dams).

**Conservation (water)** Any beneficial reduction in water losses, wastes, or use.

**Conservation Rate Structure** A water rate structure that is designed to conserve water. Examples of conservation rate structures include but are not limited to, increasing block rates, seasonal rates and quantity-based surcharges.

**Consumptive Use** Use that reduces an amount of water in the source from which it is withdrawn.

**Cryptobiosis** The ability of an organism to enter an inactive or quiescent state.

**Demand** The quantity of water needed to be withdrawn to fulfill a requirement.

**Demand Management (Water Conservation)** Reducing the demand for water through activities that alter water use practices, improve efficiency in water use, reduce losses of water, reduce waste of water, alter land management practices and/or alter land uses.

**Demographic** Relating to population or socioeconomic conditions.

**Desalination** A process which treats saline water to remove chlorides and dissolved solids.

**Domestic Use** Use of water for the individual personal household purposes of drinking, bathing, cooking, or sanitation.

**Drawdown** The distance the water level is lowered, due to a withdraw at a given point.

**DWMP** District Water Management Plan. Regional water resource plan developed by the District under Section 373.036, F. S.

**Effective Rainfall** The portion of rainfall that infiltrates the soil and is stored for plant use in the crop root zone, as calculated by the modified Blaney-Criddle model.

**Evapotranspiration** Water losses from the surface of soils (evaporation) and plants (transpiration).

**Exotic Nuisance Plant Species** A non-native species which tends to out-compete native species and become quickly established, especially in areas of disturbance or where the normal hydroperiod has been altered.

**FASS** Florida Agricultural and Statistics Service, a division of the Florida Department of Agriculture and Consumer Services.

**Flatwoods (Pine)** Natural communities that occur on level land and are characterized by a dominant overstory of slash pine. Depending upon soil drainage characteristics and position in the landscape, pine flatwoods habitats can exhibit xeric to moderately wet conditions.

**Florida Water Plan** State-level water resource plan developed by the FDEP under Section 373.036, F.S.

**Governing Board** Governing Board of the South Florida Water Management District.

**Ground Water** Water beneath the surface of the ground, whether or not flowing through known and definite channels.

**Harm** *(Term will be further defined during proposed Rule Development process)* An adverse impact to water resources or the environment that is generally temporary and short-lived, especially when the recovery from the adverse impact is possible within a period of time of several months to several years, or less.

**Hydroperiod** The frequency and duration of inundation or saturation of an ecosystem. In the context of characterizing wetlands, the term hydroperiod describes that length of time during the year that the substrate is either saturated or covered with water.

**IFAS** The Institute of Food and Agricultural Sciences, that is the agricultural branch of the University of Florida, performing research, education, and extension.

**Infiltration** The movement of water through the soil surface into the soil under the forces of gravity and capillarity.

**Inorganic** Relating to or composed of chemical compounds other than plant or animal origin.

**Irrigation** The application of water to crops, and other plants by artificial means.

**Irrigation Audit** A procedure in which an irrigation systems application rate and uniformity are measured.

**Irrigation Efficiency** The average percent of total water pumped or delivered for use that is delivered to the root zone. of a plant.

**Irrigation Uniformity** A measure of the spatial variability of applied or infiltrated water over the field.

**Lake Okeechobee** Largest freshwater lake in Florida. Located in Central Florida, the lake measures 730 square miles and is the second largest freshwater lake wholly within the United States.

**Leakance** Movement of water between aquifers or aquifer systems.

**Leak Detection** Systematic method to survey the distribution system and pinpoint the exact locations of hidden underground leaks.

**Levee** An embankment to prevent flooding, or a continuous dike or ridge for confining the irrigation areas of land to be flooded.

**Level of Certainty** Probability that the demands for reasonable-beneficial uses of water will be fully met for a specified period of time (generally taken to be one year) and for a specified condition of water availability, (generally taken to be a drought event of a specified return frequency). For the purpose of preparing regional water supply plans, the goal associated with identifying the water supply demands of existing and future reasonable beneficial uses is based upon meeting those demands for a drought event with a 1-in-10 year return frequency.

**Marsh** A frequently or continually inundated wetland characterized by emergent herbaceous vegetation adapted to saturated soil conditions.

**Micro Irrigation** The application of water directly to, or very near to the soil surface in drops, small streams, or sprays.

**Mobile Irrigation Laboratory** A vehicle furnished with irrigation evaluation equipment which is used to carry out on-site evaluations of irrigation systems and to provide recommendations on improving irrigation efficiency.

**NGVD** National Geodetic Vertical Datum, a nationally established references for elevation data relative to sea level.

**NRCS** The Natural Resources Conservation Service is a federal agency that provides technical assistance for soil and water conservation, natural resource surveys, and community resource protection

**One-in-Ten Year Drought Event** A drought of such intensity, that it is expected to have a return frequency of 10 years (see Level of Certainty).

**Organics** Being composed of or containing matter of, plant and animal origin.

**Overhead Sprinkler Irrigation** A pressurized system, where water is applied through a variety of outlet sprinkler heads or nozzles. Pressure is used to spread water droplets above the crop canopy to simulate rainfall.

**Per Capita Use** Total use divided by the total population served.

**Permeability** Defines the ability of a rock or sediment to transmit fluid.

**Potable Water** Water that is safe for human consumption (USEPA, 1992).

**Potentiometric Head** The level to which water will rise when a well is drilled into a confined aquifer.

**Potentiometric Surface** An imaginary surface representing the total head of ground water.

**Process Water** Water used for nonpotable industrial usage, e.g., mixing cement.

**Projection Period** The period over which projections are made. In the case of this document, the 25 year period from 1995 to 2020.

**Public Water Supply (PWS) Utilities** Utilities that provide potable water for public use.

**Rapid-Rate Infiltration Basin (RIB)** An artificial impoundment that provides for fluid losses through percolation/seepage as well as through evaporative losses.

**Rationing** Mandatory water-use restrictions sometimes used under drought or other emergency conditions.

**Reasonable-Beneficial Use** Use of water in such quantity as is necessary for economic and efficient utilization for a purpose and in a manner which is both reasonable and consistent with the public interest.

**Reclaimed Water** Water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility.

**RECOVER** A comprehensive monitoring and adaptive assessment program formed to perform the following for the Comprehensive Everglades Restoration Program: restoration, coordination, and verification.

**Reduced Allocation Areas** Areas in which a physical limitation has been placed on water use.

**Reduced Threshold Areas (RTAs)** Areas established by the District for which the threshold separating a General Permit from an Individual Permit has been lowered from the maximum limit of 100,000 GPD to 20,000 GPD. These areas are typically resource-depleted areas where there have been an established history of sub-standard water quality, saline water movement into ground or surface water bodies, or the lack of water availability to meet projected needs of a region.

**Regional Water Supply Plan** Detailed water supply plan developed by the District under Section 373.0361, F.S.

**Retrofit** The replacement of existing equipment with equipment that uses less water.

**Retrofitting** The replacement of existing water fixtures, appliances and devices with more efficient fixtures, appliances and devices for the purpose of water conservation.

**Restudy** Shortened name for C&SF Restudy.

**Reverse Osmosis (RO)** Process used to produce fresh water from a brackish supply source.

**Saline Water** Water with a chloride concentration greater than 250 mg/L, but less than 19,000 mg/L.

**Saline Water Interface** The hypothetical surface of chloride concentration between fresh water and saline water, where the chloride concentration is 250 mg/L at each point on the surface.

**Saline Water Intrusion** This occurs when more dense saline water moves laterally inland from the coast, or moves vertically upward, to replace fresher water in an aquifer.

**Sea Water** Water which has a chloride concentration equal to or greater than 19,000 mg/L.

**Seepage Irrigation Systems** Irrigation systems which convey water through open ditches. Water is either applied to the soil surface (possibly in furrows) and held for a period of time to allow infiltration, or is applied to the soil subsurface by raising the water table to wet the root zone.

**Semi-Closed Irrigation Systems** Irrigation systems which convey water through closed pipes, and distribute it to the crop through open furrows between crop rows.

**Semi-Confining Layers** Layers with little or no horizontal flow, and restrict the vertical flow of water from one aquifer to another. The rate of vertical flow is dependent on the head differential between the aquifers, as well as the vertical permeability of the sediments in the semi-confining layer.

**Sensitivity Analysis** An analysis of alternative results based on variations in assumptions (a "what if" analysis).

**Serious Harm** (*Term will be defined during proposed Rule Development process)* An extremely adverse impact to water resources or the environment that is either permanent or very long-term in duration. Serious harm is generally considered to be more intense than significant harm.

**Significant Harm** *(Term will be defined during proposed Rule Development process)* An adverse impact to water resources or the environment, when the period of recovery from the adverse impact is expected to take several years; more intense than harm, but less intense than serious harm.

**Slough** A channel in which water moves sluggishly, or a place of deep muck, mud or mire. Sloughs are wetland habitats that serve as channels for water draining off surrounding uplands and/or wetlands.

**Stage** The elevation of the surface of a surface water body.

**Storm Water** Surface water resulting from rainfall that does not percolate into the ground or evaporate.

**Subsidence** An example of subsidence is the lowering of the soil level caused by the shrinkage of organic layers. This shrinkage is due to biochemical oxidation.

**Surface Water** Water that flows, falls, or collects above the surface of the earth.

**Superfund Site** A contamination site, of such magnitude, that it has been designated by the federal government as eligible for federal funding to ensure cleanup.

**SWIM Plan** Surface Water Improvement and Management Plan, prepared according to Chapter 373, F. S.

**TAZ** Traffic analysis zone; refers to a geographic area used in transportation planning.

**Transmissivity** A term used to indicate the rate at which water can be transmitted through a unit width of aquifer under a unit hydraulic gradient. It is a function of the permeability and thickness of the aquifer, and is used to judge its production potential.

**Turbidity** The measure of suspended material in a liquid.

**Ultra-low-volume Plumbing Fixtures** Water-conserving plumbing fixtures that meet the standards at a test pressure of 80 psi listed below.

Toilets - 1.6 gal/flush

Showerheads - 2.5 gal/min.

Faucets - 2.0 gal/min.

**Uplands** Elevated areas that are characterized by non-saturated soil conditions and support flatwood vegetation.

**Voltinism** The number of generations per year.

**Wastewater** The combination of liquid and waterborne discharges from residences, commercial buildings, industrial plants and institutions together with any ground water, surface runoff or leachate that may be present.

**Water Resource Caution Areas** Areas that have existing water resource problems or where water resource problems are projected to develop during the next 20 years (previously referred to as critical water supply problem areas).

**Water Resource Development** The formulation and implementation of regional water resource management strategies, including: the collection and evaluation of surface water and ground water data; structural and nonstructural programs to protect and manage the water resource; the development of regional water resource implementation programs; the construction, operation, and maintenance of major public works facilities to provide for flood control, surface and underground water storage, and ground water recharge augmentation; and, related technical assistance to local governments and to government-owned and privately owned water utilities.

**Water Shortage Declaration** *Rule 40E-21.231, Fla. Admin. Code:* "If …there is a possibility that insufficient water will be available within a source class to meet the estimated present and anticipated user demands from that source, or to protect the water resource from serious harm, the Governing Board may declare a water shortage for the affected source class." Estimates of the percent reduction in demand required to match available supply is required and identifies which phase of drought restriction is implemented. A gradual progression in severity of restriction is implemented through increasing phases. Once declared, the District is required to notify permitted users by mail of the restrictions and to publish restrictions in area newspapers.

**Water Supply Plan** District plans that provide an evaluation of available water supply and projected demands, at the regional scale. The planning process projects future demand for 20 years and develops strategies to meet identified needs.

**Water Supply Development** The planning, design, construction, operation, and maintenance of public or private facilities for water collection, production, treatment, transmission, or distribution for sale, resale, or end use.

**Wetlands** Areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

**Wetland Drawdown Study** Research effort by the South Florida Water Mangement District to provide a scientific basis for developing wetland protection criteria for water use permitting.

**Xeriscape™** Landscaping that involves seven principles: proper planning and design; soil analysis and improvement; practical turf areas; appropriate plant selection; efficient irrigation; mulching; and appropriate maintenance.

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